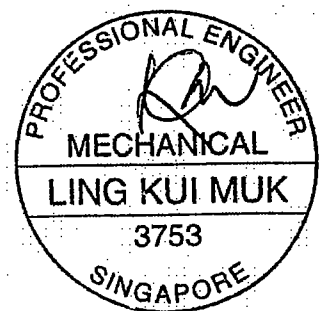


DESIGN CALCULATION
FOR
1140 TONNE S.W.L. SPREADER FRAME

DOCUMENT NO.: 9779-C-C3-020
REVISION NO.: 0



31 Dec '09



G00001



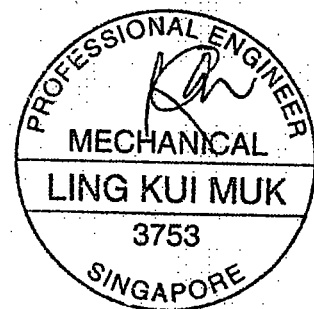
160160

TABLE OF CONTENT

- 1.0 Introduction
- 2.0 Design Consideration
- 3.0 Conclusion
- 4.0 References

Appendix

- A MULTIFRAME Model & Graphic Plot
- B SOLIDWORKS Model & Finite Element Analysis Report



31 DEC 109

1.0 Introduction

The purpose of this calculation report is to verify the adequacy of structural design of one existing unit of 1000 tonne S.W.L. spreader frame to load an additional of 140 tonne weight coming to a grand total of 1140 tonne. This spreader frame is designed for lifting 2 x 500 tonne spreader beam each with distribution of water bag loads in a single point lifting arrangement, with additional loads of 4x35 tonne load at each trunnion of the spreader frame during load testing of crane as illustrated in the lifting condition drawing.

2.0 Design Consideration

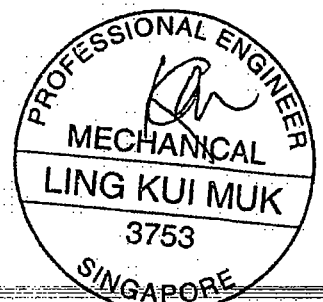
Loading conditions:

- a) This spreader frame is NOT designed and used for day-to-day transportation or handling of goods. No dynamic or impact loads is taken into account. Test loads by means of water bags are gradually filled up with water to achieve the required loading.
- b) Lifting is done by means of 4 endless round slings on 4 nos. of designated lifting trunnions.
- c) Additional 4 water bags are added to the trunnions of the spreader frame.

The designs for the structural members are based on Allowable Stress Design (ASD) in accordance with AISC.

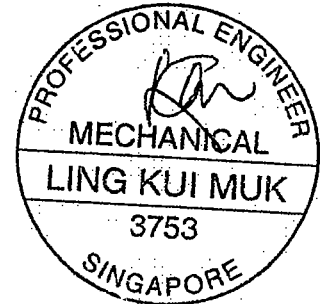
3.0 Conclusion

As detailed in attached reports in the Appendixes, the structural members meet the requirements of the design code base on the above design consideration.



4.0 References:

- a) 1140 Tonne Spreader Frame Lifting Arrangement
Drawing no.: RT-RM-DWG-120 (Rev1)

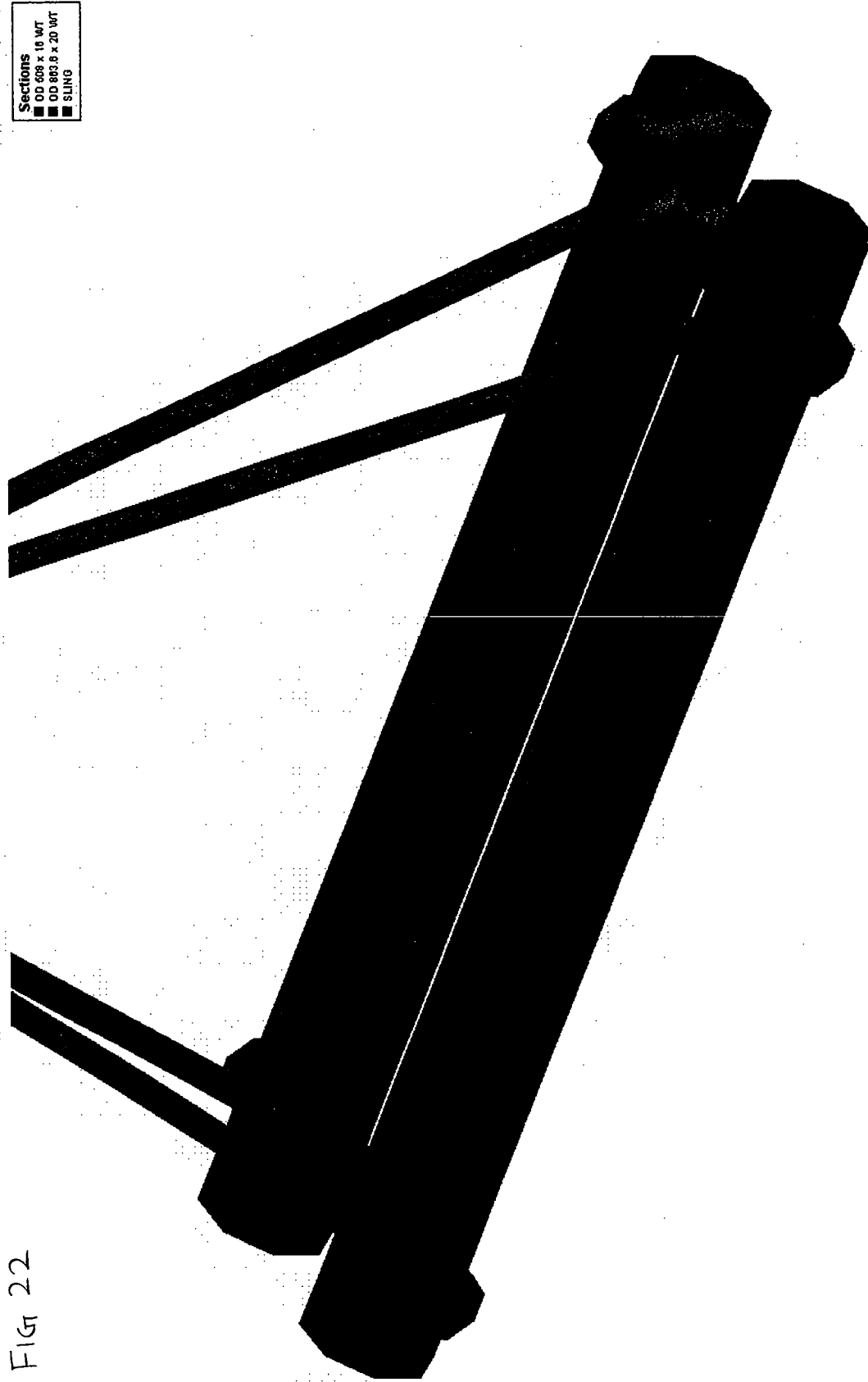


31 DEC '08

Appendix A

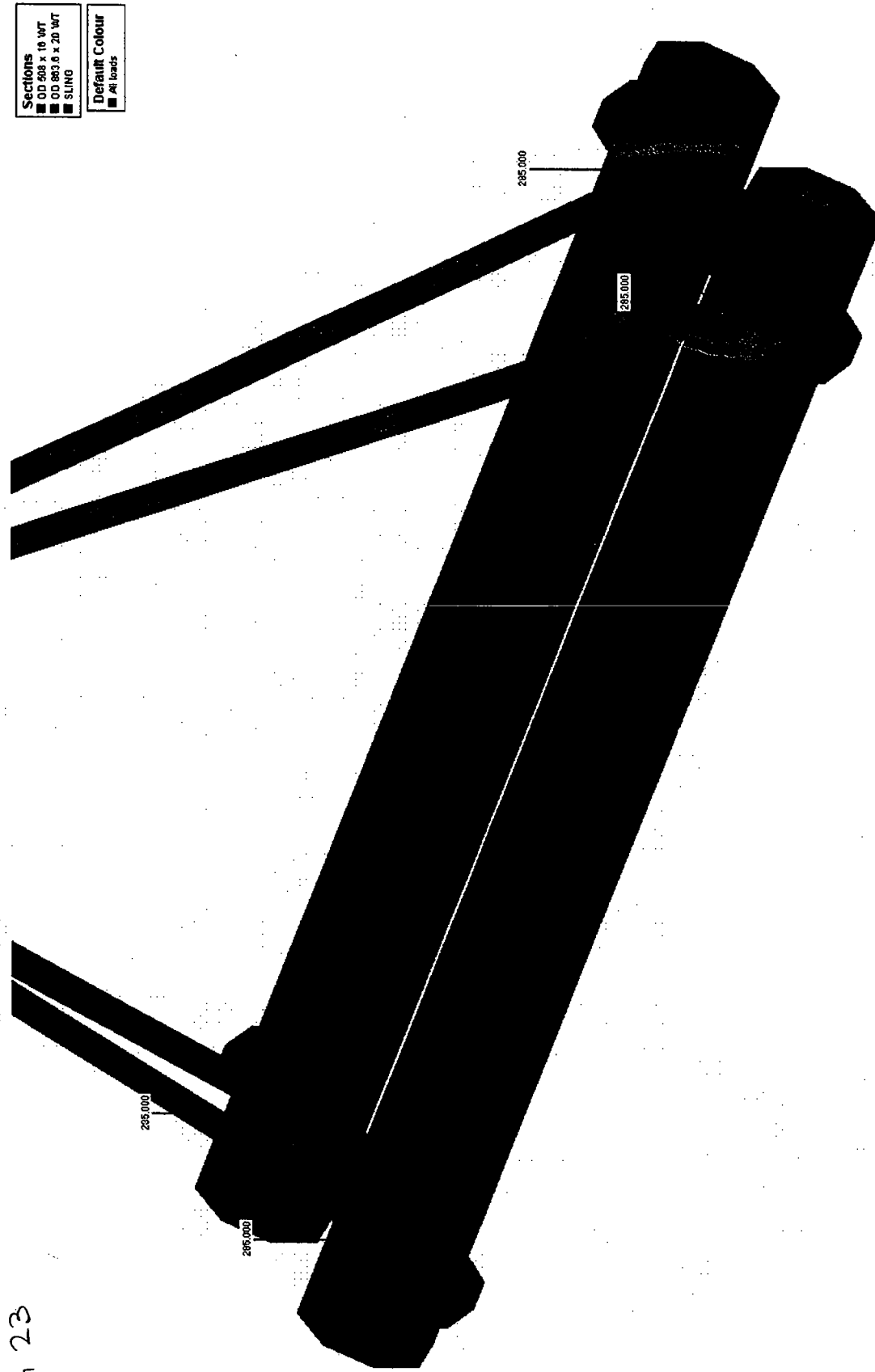
MULTIFRAME Model & Graphic Plot

Fig 22



FRAME MODEL & MEMBER DIAGRAM

FIG 23

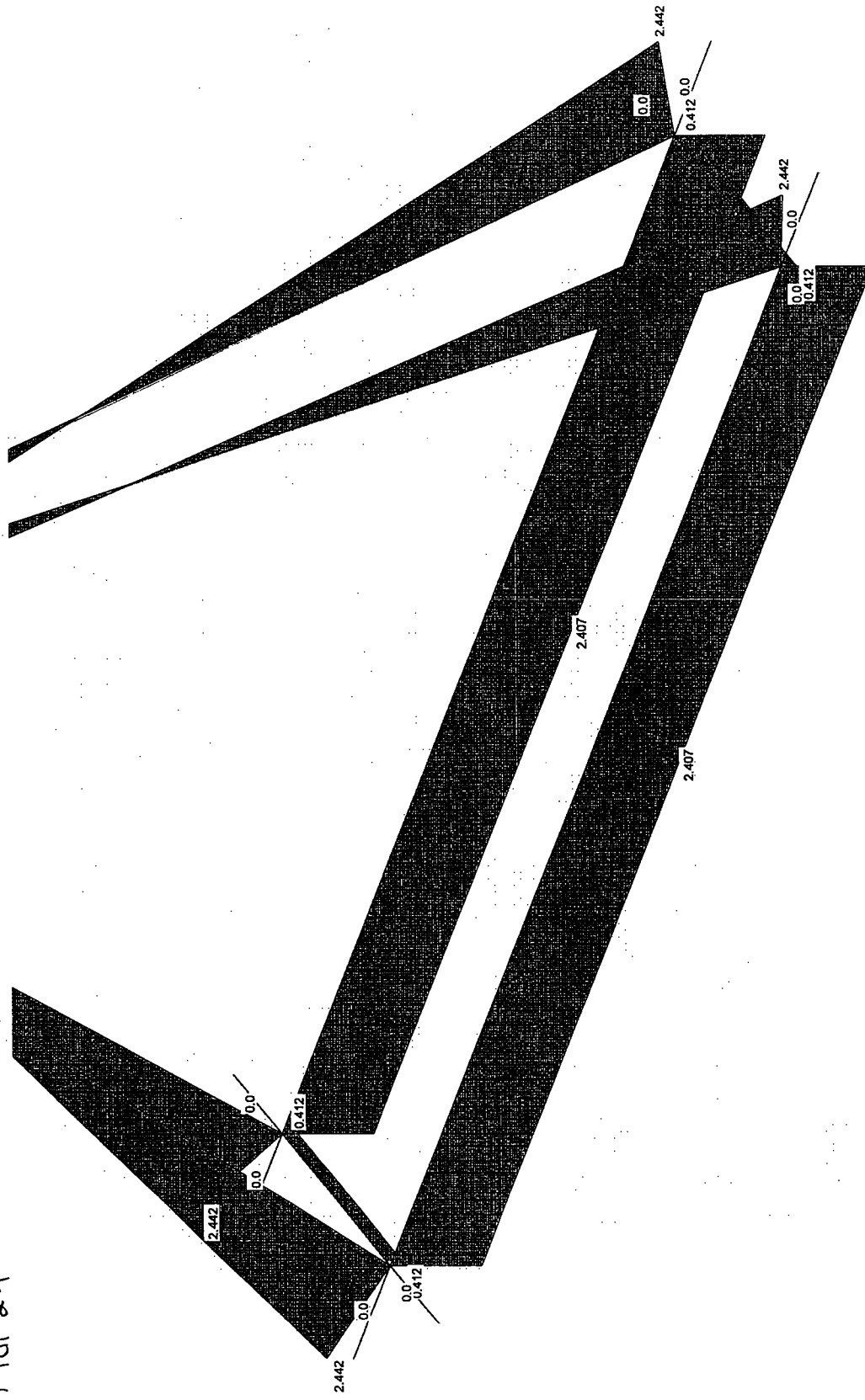


Sections	
■	OD 508 x 10 WT
■	OD 893.6 x 20 WT
■	SLING
Default Colour	
■	All loads

Load Case 1

LOAD DISTRIBUTION DIAGRAM

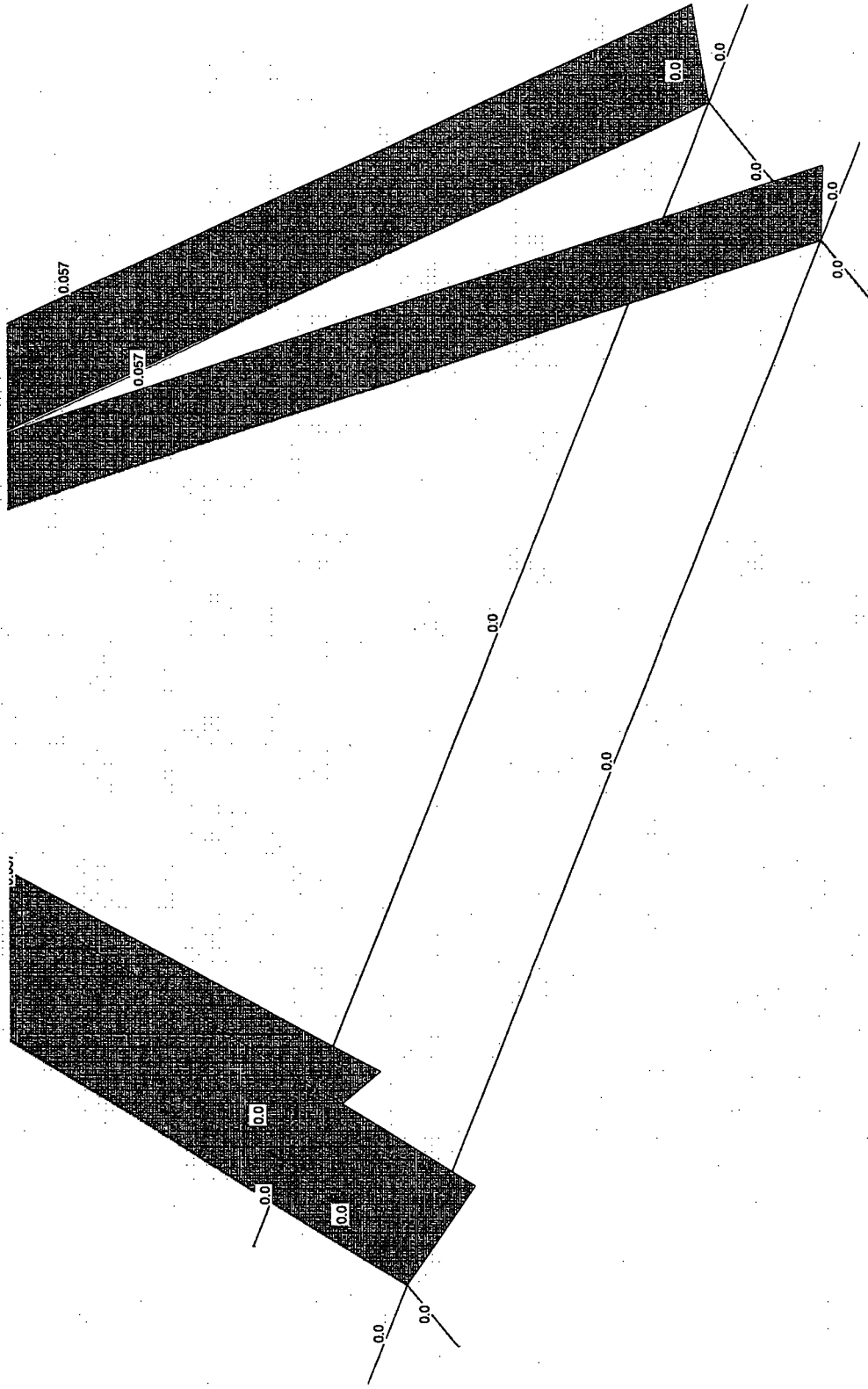
FIG 24



Static Case: Load Case 1 Mz (kN-m)

BENDING STRESS DIAGRAM

FIG 25



Static Case: Load Case 1 Vy (tonne)

SHEAR STRESS DIAGRAM

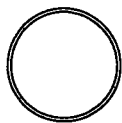
Appendix B

Steel design report to ASIC ASD

Steel Design Report

Checking design member 1

Members: 1
Group: Custom1
Section: OD 508 x 16 WT



Load Case: Load Case 1

$$F_y = 248.21 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 \cdot F_y = 0.6 \cdot 248.21 = 148.93 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 \cdot F_u = 0.5 \cdot 399.9 = 199.95 \text{ MPa}$$

$$F_v = 0.4 \cdot F_y = 0.4 \cdot 248.21 = 99.28 \text{ MPa}$$

$$Kl/r = \max(K_x \cdot l/r_x, K_y \cdot l/r_y) = \max(1.0 \cdot 632.0/174.04, 1.0 \cdot 632.0/174.04) = 3.63$$

$$F_a = (1 - (Kl/r)^2 / (2 \cdot C_c^2)) \cdot F_y / FS = (1 - 3.63^2 / (2 \cdot 126.1^2)) \cdot 248.21 / 1.68 = 147.91 \text{ MPa}$$

Major Axis:

$$F_b = 0.66 \cdot F_y = 0.66 \cdot 248.21 = 163.82 \text{ MPa}$$

Minor Axis:

$$F_b = 0.66 \cdot F_y = 0.66 \cdot 248.21 = 163.82 \text{ MPa}$$

Design Member 1, Load Case 1, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 0.0 \leq 163.82 \text{ OK } 100\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 0.0 \leq 163.82 \text{ OK } 100\% \text{ under}$$

Design Member 1, Load Case 1, Major Shear

$$f_v \leq F_v, 0.0 \leq 99.28 \text{ OK } 100\% \text{ under}$$

Design Member 1, Load Case 1, Major Deflection

$$\delta \leq L/250, 0.0 \leq 2.53 \text{ mm OK } 100\% \text{ under}$$

Design Member 1, Load Case 1, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 0.0 \leq 163.82 \text{ OK } 100\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 0.0 \leq 163.82 \text{ OK } 100\% \text{ under}$$

Design Member 1, Load Case 1, Minor Shear

$$f_v \leq F_v, 0.0 \leq 99.28 \text{ OK } 100\% \text{ under}$$

Design Member 1, Load Case 1, Minor Deflection

$$\delta \leq L/250, 0.0 \leq 2.53 \text{ mm OK } 100\% \text{ under}$$

Design Member 1, Load Case 1, Tension

$$\text{On gross area } f_t \leq F_t, 0.0 \leq 148.93 \text{ OK } 100\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 0.0 \leq 199.95 \text{ OK } 100\% \text{ under}$$

Design Member 1, Load Case 1, Slenderness

$$K_x \cdot L_x / r_x = 1.0 \cdot 632.0 / 174.04 = 3.63 \leq 200.0 \text{ OK } 98\% \text{ under}$$

$$K_y \cdot L_y / r_y = 1.0 \cdot 632.0 / 174.04 = 3.63 \leq 200.0 \text{ OK } 98\% \text{ under}$$

Design Member 1, Load Case 1, Compression

$$f_a \leq F_a, 0.0 \leq 147.91 \text{ OK } 100\% \text{ under}$$

Design Member 1, Load Case 1, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 0.0 / 199.95 + 0.0 / 163.82 + 0.0 / 163.82 = 0.0 \leq 1 \text{ OK } 100\% \text{ under}$$

Design Member 1, Load Case 1, Bending + Compression

$$f_a / F_a = 0.0 / 147.91 = 0.0 \leq 0.15 \therefore \phi 0$$

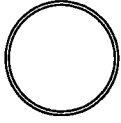
$$\phi_a / \Phi_a + \phi_{\beta x} / \Phi_{\beta x} + \phi_{\beta y} / \Phi_{\beta y} = 0.0 / 147.91 + 0.0 / 163.82 + 0.0 / 163.82 = 0.0 \leq 1 \text{ OK } 100\% \text{ under}$$

Design Member 1, Load Case 1, Sway

$$\Delta \leq Y/300.0, 0.47 \leq 0.0/300.0 = 0.0 \text{ mm OK } -2147483548\% \text{ under}$$

Checking design member 2

Members: 2
Group: Custom1
Section: OD 508 x 16 WT



Load Case: Load Case 1

$$F_y = 248.21 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 \cdot F_y = 0.6 \cdot 248.21 = 148.93 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 \cdot F_u = 0.5 \cdot 399.9 = 199.95 \text{ MPa}$$

$$F_v = 0.4 \cdot F_y = 0.4 \cdot 248.21 = 99.28 \text{ MPa}$$

$$K_l/r = \max(K_x \cdot l/r_x, K_y \cdot l/r_y) = \max(1.0 \cdot 1404.0/174.04, 1.0 \cdot 1404.0/174.04) = 8.07$$

$$F_a = (1 - (K_l/r)^2 / (2 \cdot C_c^2)) \cdot F_y / F_S = (1 - 8.07^2 / (2 \cdot 126.1^2)) \cdot 248.21 / 1.69 = 146.52 \text{ MPa}$$

Major Axis:

$$F_b = 0.66 \cdot F_y = 0.66 \cdot 248.21 = 163.82 \text{ MPa}$$

Minor Axis:

$$F_b = 0.66 \cdot F_y = 0.66 \cdot 248.21 = 163.82 \text{ MPa}$$

Design Member 2, Load Case 1, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 0.14 \leq 163.82 \text{ OK } 100\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 0.14 \leq 163.82 \text{ OK } 100\% \text{ under}$$

Design Member 2, Load Case 1, Major Shear

$$f_v \leq F_v, 0.0 \leq 99.28 \text{ OK } 100\% \text{ under}$$

Design Member 2, Load Case 1, Major Deflection

$$\delta \leq L/250, 0.0 \leq 5.62 \text{ mm OK } 100\% \text{ under}$$

Design Member 2, Load Case 1, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 0.0 \leq 163.82 \text{ OK } 100\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 0.0 \leq 163.82 \text{ OK } 100\% \text{ under}$$

Design Member 2, Load Case 1, Minor Shear

$$f_v \leq F_v, 0.0 \leq 99.28 \text{ OK } 100\% \text{ under}$$

Design Member 2, Load Case 1, Minor Deflection

$$\delta \leq L/250, 0.0 \leq 5.62 \text{ mm OK } 100\% \text{ under}$$

Design Member 2, Load Case 1, Tension

$$\text{On gross area } f_t \leq F_t, 0.0 \leq 148.93 \text{ OK } 100\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 0.0 \leq 199.95 \text{ OK } 100\% \text{ under}$$

Design Member 2, Load Case 1, Slenderness

$$K_x \cdot L_x / r_x = 1.0 \cdot 1404.0 / 174.04 = 8.07 \leq 200.0 \text{ OK } 96\% \text{ under}$$

$$K_y \cdot L_y / r_y = 1.0 \cdot 1404.0 / 174.04 = 8.07 \leq 200.0 \text{ OK } 96\% \text{ under}$$

Design Member 2, Load Case 1, Compression

$$f_a \leq F_a, 10.01 \leq 146.52 \text{ OK } 93\% \text{ under}$$

Design Member 2, Load Case 1, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 0.0 / 199.95 + 0.14 / 163.82 + 0.0 / 163.82 = 0.0 \leq 1 \text{ OK } 100\% \text{ under}$$

Design Member 2, Load Case 1, Bending + Compression

$$f_a / F_a = 10.01 / 146.52 = 0.07 \leq 0.15 \therefore \phi 0$$

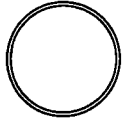
$$\phi_a / \Phi_a + \phi_{\beta_x} / \Phi_{\beta_x} + \phi_{\beta_y} / \Phi_{\beta_y} = 10.01 / 146.52 + 0.14 / 163.82 + 0.0 / 163.82 = 0.07 \leq 1 \text{ OK } 93\% \text{ under}$$

Design Member 2, Load Case 1, Sway

$$\Delta \leq Y/300.0, 0.47 \leq 0.0 / 300.0 = 0.0 \text{ mm OK } -2147483548\% \text{ under}$$

Checking design member 3

Members: 3
Group: Custom1
Section: OD 508 x 16 WT



Load Case: Load Case 1

$$F_y = 248.21 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 \cdot F_y = 0.6 \cdot 248.21 = 148.93 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 \cdot F_u = 0.5 \cdot 399.9 = 199.95 \text{ MPa}$$

$$F_v = 0.4 \cdot F_y = 0.4 \cdot 248.21 = 99.28 \text{ MPa}$$

$$Kl/r = \max(K_x \cdot l/r_x, K_y \cdot l/r_y) = \max(1.0 \cdot 632.0/174.04, 1.0 \cdot 632.0/174.04) = 3.63$$

$$F_a = (1 - (Kl/r)^2 / (2 \cdot Cc^2)) \cdot F_y / FS = (1 - 3.63^2 / (2 \cdot 126.1^2)) \cdot 248.21 / 1.68 = 147.91 \text{ MPa}$$

Major Axis:

$$F_b = 0.66 \cdot F_y = 0.66 \cdot 248.21 = 163.82 \text{ MPa}$$

Minor Axis:

$$F_b = 0.66 \cdot F_y = 0.66 \cdot 248.21 = 163.82 \text{ MPa}$$

Design Member 3, Load Case 1, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 0.0 \leq 163.82 \text{ OK } 100\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 0.0 \leq 163.82 \text{ OK } 100\% \text{ under}$$

Design Member 3, Load Case 1, Major Shear

$$f_v \leq F_v, 0.0 \leq 99.28 \text{ OK } 100\% \text{ under}$$

Design Member 3, Load Case 1, Major Deflection

$$\delta \leq L/250, 0.0 \leq 2.53 \text{ mm OK } 100\% \text{ under}$$

Design Member 3, Load Case 1, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 0.0 \leq 163.82 \text{ OK } 100\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 0.0 \leq 163.82 \text{ OK } 100\% \text{ under}$$

Design Member 3, Load Case 1, Minor Shear

$$f_v \leq F_v, 0.0 \leq 99.28 \text{ OK } 100\% \text{ under}$$

Design Member 3, Load Case 1, Minor Deflection

$$\delta \leq L/250, 0.0 \leq 2.53 \text{ mm OK } 100\% \text{ under}$$

Design Member 3, Load Case 1, Tension

$$\text{On gross area } f_t \leq F_t, 0.0 \leq 148.93 \text{ OK } 100\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 0.0 \leq 199.95 \text{ OK } 100\% \text{ under}$$

Design Member 3, Load Case 1, Slenderness

$$K_x \cdot L_x / r_x = 1.0 \cdot 632.0 / 174.04 = 3.63 \leq 200.0 \text{ OK } 98\% \text{ under}$$

$$K_y \cdot L_y / r_y = 1.0 \cdot 632.0 / 174.04 = 3.63 \leq 200.0 \text{ OK } 98\% \text{ under}$$

Design Member 3, Load Case 1, Compression

$$f_a \leq F_a, 0.0 \leq 147.91 \text{ OK } 100\% \text{ under}$$

Design Member 3, Load Case 1, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 0.0 / 199.95 + 0.0 / 163.82 + 0.0 / 163.82 = 0.0 \leq 1 \text{ OK } 100\% \text{ under}$$

Design Member 3, Load Case 1, Bending + Compression

$$f_a / F_a = 0.0 / 147.91 = 0.0 \leq 0.15 \therefore \phi 0$$

$$\phi_\alpha / \Phi_\alpha + \phi_{\beta\xi} / \Phi_{\beta\xi} + \phi_{\beta\psi} / \Phi_{\beta\psi} = 0.0 / 147.91 + 0.0 / 163.82 + 0.0 / 163.82 = 0.0 \leq 1 \text{ OK } 100\% \text{ under}$$

Design Member 3, Load Case 1, Sway

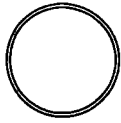
$$\Delta \leq Y/300.0, 0.47 \leq 0.0/300.0 = 0.0 \text{ mm OK } -2147483548\% \text{ under}$$

Checking design member 4

Members: 4

Group: Custom1

Section: OD 863.6 x 20 WT



Load Case: Load Case 1

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 * F_y = 0.6 * 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 * F_u = 0.5 * 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 * F_y = 0.4 * 355.0 = 142.0 \text{ MPa}$$

$$Kl/r = \max(K_x * l/r_x, K_y * l/r_y) = \max(1.0 * 704.0 / 298.34, 1.0 * 704.0 / 298.34) = 2.36$$

$$F_a = (1 - (Kl/r)^2 / (2 * Cc^2)) * F_y / FS = (1 - 2.36^2 / (2 * 105.44^2)) * 355.0 / 1.68 = 211.88 \text{ MPa}$$

Major Axis:

$$F_b = 0.66 * F_y = 0.66 * 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.66 * F_y = 0.66 * 355.0 = 234.3 \text{ MPa}$$

Design Member 4, Load Case 1, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 0.0 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 0.0 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Design Member 4, Load Case 1, Major Shear

$$f_v \leq F_v, 0.0 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 4, Load Case 1, Major Deflection

$$\delta \leq L/250, 0.01 \leq 2.82 \text{ mm OK } 100\% \text{ under}$$

Design Member 4, Load Case 1, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 0.0 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 0.0 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Design Member 4, Load Case 1, Minor Shear

$$f_v \leq F_v, 0.0 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 4, Load Case 1, Minor Deflection

$$\delta \leq L/250, 0.0 \leq 2.82 \text{ mm OK } 100\% \text{ under}$$

Design Member 4, Load Case 1, Tension

$$\text{On gross area } f_t \leq F_t, 0.0 \leq 213.0 \text{ OK } 100\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 0.0 \leq 245.0 \text{ OK } 100\% \text{ under}$$

Design Member 4, Load Case 1, Slenderness

$$K_x * L_x / r_x = 1.0 * 704.0 / 298.34 = 2.36 \leq 200.0 \text{ OK } 99\% \text{ under}$$

$$K_y * L_y / r_y = 1.0 * 704.0 / 298.34 = 2.36 \leq 200.0 \text{ OK } 99\% \text{ under}$$

Design Member 4, Load Case 1, Compression

$$f_a \leq F_a, 0.0 \leq 211.88 \text{ OK } 100\% \text{ under}$$

Design Member 4, Load Case 1, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 0.0 / 245.0 + 0.0 / 234.3 + 0.0 / 234.3 = 0.0 \leq 1 \text{ OK } 100\% \text{ under}$$

Design Member 4, Load Case 1, Bending + Compression

$$f_a / F_a = 0.0 / 211.88 = 0.0 \leq 0.15 \therefore \phi 0$$

$$\phi_\alpha / \Phi_\alpha + \phi_{\beta\xi} / \Phi_{\beta\xi} + \phi_{\beta\psi} / \Phi_{\beta\psi} = 0.0 / 211.88 + 0.0 / 234.3 + 0.0 / 234.3 = 0.0 \leq 1 \text{ OK } 100\% \text{ under}$$

Design Member 4, Load Case 1, Sway

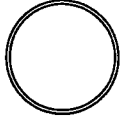
$$\Delta \leq Y/300.0, 0.47 \leq 0.0 / 300.0 = 0.0 \text{ mm OK } -2147483548\% \text{ under}$$

Checking design member 5

Members: 5

Group: Custom1

Section: OD 863.6 x 20 WT



Load Case: Load Case 1

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 \cdot F_y = 0.6 \cdot 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 \cdot F_u = 0.5 \cdot 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 \cdot F_y = 0.4 \cdot 355.0 = 142.0 \text{ MPa}$$

$$K_l/r = \max(K_x \cdot I/r_x, K_y \cdot I/r_y) = \max(1.0 \cdot 7484.0/298.34, 1.0 \cdot 7484.0/298.34) = 25.09$$

$$F_a = (1 - (K_l/r)^2 / (2 \cdot C_c^2)) \cdot F_y / F_S = (1 - 25.09^2 / (2 \cdot 105.44^2)) \cdot 355.0 / 1.75 = 196.64 \text{ MPa}$$

Major Axis:

$$F_b = 0.66 \cdot F_y = 0.66 \cdot 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.66 \cdot F_y = 0.66 \cdot 355.0 = 234.3 \text{ MPa}$$

Design Member 5, Load Case 1, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 0.22 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 0.22 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Design Member 5, Load Case 1, Major Shear

$$f_v \leq F_v, 0.0 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 5, Load Case 1, Major Deflection

$$\delta \leq L/250, 0.02 \leq 29.94 \text{ mm OK } 100\% \text{ under}$$

Design Member 5, Load Case 1, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 0.0 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 0.0 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Design Member 5, Load Case 1, Minor Shear

$$f_v \leq F_v, 0.0 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 5, Load Case 1, Minor Deflection

$$\delta \leq L/250, 0.0 \leq 29.94 \text{ mm OK } 100\% \text{ under}$$

Design Member 5, Load Case 1, Tension

$$\text{On gross area } f_t \leq F_t, 0.0 \leq 213.0 \text{ OK } 100\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 0.0 \leq 245.0 \text{ OK } 100\% \text{ under}$$

Design Member 5, Load Case 1, Slenderness

$$K_x \cdot L_x / r_x = 1.0 \cdot 7484.0 / 298.34 = 25.09 \leq 200.0 \text{ OK } 87\% \text{ under}$$

$$K_y \cdot L_y / r_y = 1.0 \cdot 7484.0 / 298.34 = 25.09 \leq 200.0 \text{ OK } 87\% \text{ under}$$

Design Member 5, Load Case 1, Compression

$$f_a \leq F_a, 24.88 \leq 196.64 \text{ OK } 87\% \text{ under}$$

Design Member 5, Load Case 1, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 0.0 / 245.0 + 0.22 / 234.3 + 0.0 / 234.3 = 0.0 \leq 1 \text{ OK } 100\% \text{ under}$$

Design Member 5, Load Case 1, Bending + Compression

$$f_a / F_a = 24.88 / 196.64 = 0.13 \leq 0.15 \therefore \phi 0$$

$$\phi_\alpha / \Phi_\alpha + \phi_{\beta x} / \Phi_{\beta x} + \phi_{\beta y} / \Phi_{\beta y} = 24.88 / 196.64 + 0.22 / 234.3 + 0.0 / 234.3 = 0.13 \leq 1 \text{ OK } 87\% \text{ under}$$

Design Member 5, Load Case 1, Sway

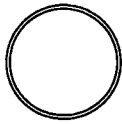
$$\Delta \leq Y/300.0, 0.47 \leq 0.0 / 300.0 = 0.0 \text{ mm OK } -2147483548\% \text{ under}$$

Checking design member 6

Members: 6

Group: Custom1

Section: OD 863.6 x 20 WT



Load Case: Load Case 1

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 \cdot F_y = 0.6 \cdot 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 \cdot F_u = 0.5 \cdot 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 \cdot F_y = 0.4 \cdot 355.0 = 142.0 \text{ MPa}$$

$$K_l/r = \max(K_x \cdot l/r_x, K_y \cdot l/r_y) = \max(1.0 \cdot 704.0/298.34, 1.0 \cdot 704.0/298.34) = 2.36$$

$$F_a = (1 - (K_l/r)^2 / (2 \cdot C_c^2)) \cdot F_y / F_S = (1 - 2.36^2 / (2 \cdot 105.44^2)) \cdot 355.0 / 1.68 = 211.88 \text{ MPa}$$

Major Axis:

$$F_b = 0.66 \cdot F_y = 0.66 \cdot 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.66 \cdot F_y = 0.66 \cdot 355.0 = 234.3 \text{ MPa}$$

Design Member 6, Load Case 1, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 0.0 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 0.0 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Design Member 6, Load Case 1, Major Shear

$$f_v \leq F_v, 0.0 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 6, Load Case 1, Major Deflection

$$\delta \leq L/250, 0.01 \leq 2.82 \text{ mm OK } 100\% \text{ under}$$

Design Member 6, Load Case 1, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 0.0 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 0.0 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Design Member 6, Load Case 1, Minor Shear

$$f_v \leq F_v, 0.0 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 6, Load Case 1, Minor Deflection

$$\delta \leq L/250, 0.0 \leq 2.82 \text{ mm OK } 100\% \text{ under}$$

Design Member 6, Load Case 1, Tension

$$\text{On gross area } f_t \leq F_t, 0.0 \leq 213.0 \text{ OK } 100\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 0.0 \leq 245.0 \text{ OK } 100\% \text{ under}$$

Design Member 6, Load Case 1, Slenderness

$$K_x \cdot L_x / r_x = 1.0 \cdot 704.0 / 298.34 = 2.36 \leq 200.0 \text{ OK } 99\% \text{ under}$$

$$K_y \cdot L_y / r_y = 1.0 \cdot 704.0 / 298.34 = 2.36 \leq 200.0 \text{ OK } 99\% \text{ under}$$

Design Member 6, Load Case 1, Compression

$$f_a \leq F_a, 0.0 \leq 211.88 \text{ OK } 100\% \text{ under}$$

Design Member 6, Load Case 1, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 0.0 / 245.0 + 0.0 / 234.3 + 0.0 / 234.3 = 0.0 \leq 1 \text{ OK } 100\% \text{ under}$$

Design Member 6, Load Case 1, Bending + Compression

$$f_a / F_a = 0.0 / 211.88 = 0.0 \leq 0.15 \therefore \phi 0$$

$$\phi_\alpha / \Phi_\alpha + \phi_{\beta_x} / \Phi_{\beta_x} + \phi_{\beta_y} / \Phi_{\beta_y} = 0.0 / 211.88 + 0.0 / 234.3 + 0.0 / 234.3 = 0.0 \leq 1 \text{ OK } 100\% \text{ under}$$

Design Member 6, Load Case 1, Sway

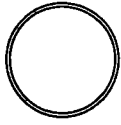
$$\Delta \leq Y/300.0, 0.47 \leq 0.0 / 300.0 = 0.0 \text{ mm OK } -2147483548\% \text{ under}$$

Checking design member 7

Members: 7

Group: Custom1

Section: OD 508 x 16 WT



Load Case: Load Case 1

$$F_y = 248.21 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 * F_y = 0.6 * 248.21 = 148.93 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 * F_u = 0.5 * 399.9 = 199.95 \text{ MPa}$$

$$F_v = 0.4 * F_y = 0.4 * 248.21 = 99.28 \text{ MPa}$$

$$Kl/r = \max(K_x * l/r_x, K_y * l/r_y) = \max(1.0 * 632.0 / 174.04, 1.0 * 632.0 / 174.04) = 3.63$$

$$F_a = (1 - (Kl/r)^2 / (2 * Cc^2)) * F_y / FS = (1 - 3.63^2 / (2 * 126.1^2)) * 248.21 / 1.68 = 147.91 \text{ MPa}$$

Major Axis:

$$F_b = 0.66 * F_y = 0.66 * 248.21 = 163.82 \text{ MPa}$$

Minor Axis:

$$F_b = 0.66 * F_y = 0.66 * 248.21 = 163.82 \text{ MPa}$$

Design Member 7, Load Case 1, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 0.0 \leq 163.82 \text{ OK } 100\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 0.0 \leq 163.82 \text{ OK } 100\% \text{ under}$$

Design Member 7, Load Case 1, Major Shear

$$f_v \leq F_v, 0.0 \leq 99.28 \text{ OK } 100\% \text{ under}$$

Design Member 7, Load Case 1, Major Deflection

$$\delta \leq L/250, 0.0 \leq 2.53 \text{ mm OK } 100\% \text{ under}$$

Design Member 7, Load Case 1, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 0.0 \leq 163.82 \text{ OK } 100\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 0.0 \leq 163.82 \text{ OK } 100\% \text{ under}$$

Design Member 7, Load Case 1, Minor Shear

$$f_v \leq F_v, 0.0 \leq 99.28 \text{ OK } 100\% \text{ under}$$

Design Member 7, Load Case 1, Minor Deflection

$$\delta \leq L/250, 0.0 \leq 2.53 \text{ mm OK } 100\% \text{ under}$$

Design Member 7, Load Case 1, Tension

$$\text{On gross area } f_t \leq F_t, 0.0 \leq 148.93 \text{ OK } 100\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 0.0 \leq 199.95 \text{ OK } 100\% \text{ under}$$

Design Member 7, Load Case 1, Slenderness

$$K_x * L_x / r_x = 1.0 * 632.0 / 174.04 = 3.63 \leq 200.0 \text{ OK } 98\% \text{ under}$$

$$K_y * L_y / r_y = 1.0 * 632.0 / 174.04 = 3.63 \leq 200.0 \text{ OK } 98\% \text{ under}$$

Design Member 7, Load Case 1, Compression

$$f_a \leq F_a, 0.0 \leq 147.91 \text{ OK } 100\% \text{ under}$$

Design Member 7, Load Case 1, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 0.0 / 199.95 + 0.0 / 163.82 + 0.0 / 163.82 = 0.0 \leq 1 \text{ OK } 100\% \text{ under}$$

Design Member 7, Load Case 1, Bending + Compression

$$f_a / F_a = 0.0 / 147.91 = 0.0 \leq 0.15 \therefore \phi 0$$

$$\phi_a / \Phi_a + \phi_{bx} / \Phi_{bx} + \phi_{by} / \Phi_{by} = 0.0 / 147.91 + 0.0 / 163.82 + 0.0 / 163.82 = 0.0 \leq 1 \text{ OK } 100\% \text{ under}$$

Design Member 7, Load Case 1, Sway

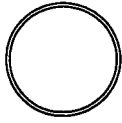
$$\Delta \leq Y/300.0, 0.47 \leq 0.0 / 300.0 = 0.0 \text{ mm OK } -2147483548\% \text{ under}$$

Checking design member 8

Members: 8

Group: Custom1

Section: OD 508 x 16 WT



Load Case: Load Case 1

$$F_y = 248.21 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 * F_y = 0.6 * 248.21 = 148.93 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 * F_u = 0.5 * 399.9 = 199.95 \text{ MPa}$$

$$F_v = 0.4 * F_y = 0.4 * 248.21 = 99.28 \text{ MPa}$$

$$Kl/r = \max(K_x * l/r_x, K_y * l/r_y) = \max(1.0 * 1404.0 / 174.04, 1.0 * 1404.0 / 174.04) = 8.07$$

$$F_a = (1 - (Kl/r)^2 / (2 * Cc^2)) * F_y / FS = (1 - 8.07^2 / (2 * 126.1^2)) * 248.21 / 1.69 = 146.52 \text{ MPa}$$

Major Axis:

$$F_b = 0.66 * F_y = 0.66 * 248.21 = 163.82 \text{ MPa}$$

Minor Axis:

$$F_b = 0.66 * F_y = 0.66 * 248.21 = 163.82 \text{ MPa}$$

Design Member 8, Load Case 1, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 0.14 \leq 163.82 \text{ OK } 100\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 0.14 \leq 163.82 \text{ OK } 100\% \text{ under}$$

Design Member 8, Load Case 1, Major Shear

$$f_v \leq F_v, 0.0 \leq 99.28 \text{ OK } 100\% \text{ under}$$

Design Member 8, Load Case 1, Major Deflection

$$\delta \leq L/250, 0.0 \leq 5.62 \text{ mm OK } 100\% \text{ under}$$

Design Member 8, Load Case 1, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 0.0 \leq 163.82 \text{ OK } 100\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 0.0 \leq 163.82 \text{ OK } 100\% \text{ under}$$

Design Member 8, Load Case 1, Minor Shear

$$f_v \leq F_v, 0.0 \leq 99.28 \text{ OK } 100\% \text{ under}$$

Design Member 8, Load Case 1, Minor Deflection

$$\delta \leq L/250, 0.0 \leq 5.62 \text{ mm OK } 100\% \text{ under}$$

Design Member 8, Load Case 1, Tension

$$\text{On gross area } f_t \leq F_t, 0.0 \leq 148.93 \text{ OK } 100\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 0.0 \leq 199.95 \text{ OK } 100\% \text{ under}$$

Design Member 8, Load Case 1, Slenderness

$$K_x * L_x / r_x = 1.0 * 1404.0 / 174.04 = 8.07 \leq 200.0 \text{ OK } 96\% \text{ under}$$

$$K_y * L_y / r_y = 1.0 * 1404.0 / 174.04 = 8.07 \leq 200.0 \text{ OK } 96\% \text{ under}$$

Design Member 8, Load Case 1, Compression

$$f_a \leq F_a, 10.01 \leq 146.52 \text{ OK } 93\% \text{ under}$$

Design Member 8, Load Case 1, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 0.0 / 199.95 + 0.14 / 163.82 + 0.0 / 163.82 = 0.0 \leq 1 \text{ OK } 100\% \text{ under}$$

Design Member 8, Load Case 1, Bending + Compression

$$f_a / F_a = 10.01 / 146.52 = 0.07 \leq 0.15 \therefore \phi 0$$

$$\phi_a / \Phi_a + \phi_{\beta\xi} / \Phi_{\beta\xi} + \phi_{\beta\psi} / \Phi_{\beta\psi} = 10.01 / 146.52 + 0.14 / 163.82 + 0.0 / 163.82 = 0.07 \leq 1 \text{ OK } 93\% \text{ under}$$

Design Member 8, Load Case 1, Sway

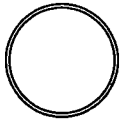
$$\Delta \leq Y/300.0, 0.47 \leq 0.0 / 300.0 = 0.0 \text{ mm OK } -2147483548\% \text{ under}$$

Checking design member 9

Members: 9

Group: Custom1

Section: OD 508 x 16 WT



Load Case: Load Case 1

$$F_y = 248.21 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 \cdot F_y = 0.6 \cdot 248.21 = 148.93 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 \cdot F_u = 0.5 \cdot 399.9 = 199.95 \text{ MPa}$$

$$F_v = 0.4 \cdot F_y = 0.4 \cdot 248.21 = 99.28 \text{ MPa}$$

$$Kl/r = \max(K_x \cdot l/r_x, K_y \cdot l/r_y) = \max(1.0 \cdot 632.0/174.04, 1.0 \cdot 632.0/174.04) = 3.63$$

$$F_a = (1 - (Kl/r)^2 / (2 \cdot Cc^2)) \cdot F_y / FS = (1 - 3.63^2 / (2 \cdot 126.1^2)) \cdot 248.21 / 1.68 = 147.91 \text{ MPa}$$

Major Axis:

$$F_b = 0.66 \cdot F_y = 0.66 \cdot 248.21 = 163.82 \text{ MPa}$$

Minor Axis:

$$F_b = 0.66 \cdot F_y = 0.66 \cdot 248.21 = 163.82 \text{ MPa}$$

Design Member 9, Load Case 1, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 0.0 \leq 163.82 \text{ OK } 100\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 0.0 \leq 163.82 \text{ OK } 100\% \text{ under}$$

Design Member 9, Load Case 1, Major Shear

$$f_v \leq F_v, 0.0 \leq 99.28 \text{ OK } 100\% \text{ under}$$

Design Member 9, Load Case 1, Major Deflection

$$\delta \leq L/250, 0.0 \leq 2.53 \text{ mm OK } 100\% \text{ under}$$

Design Member 9, Load Case 1, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 0.0 \leq 163.82 \text{ OK } 100\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 0.0 \leq 163.82 \text{ OK } 100\% \text{ under}$$

Design Member 9, Load Case 1, Minor Shear

$$f_v \leq F_v, 0.0 \leq 99.28 \text{ OK } 100\% \text{ under}$$

Design Member 9, Load Case 1, Minor Deflection

$$\delta \leq L/250, 0.0 \leq 2.53 \text{ mm OK } 100\% \text{ under}$$

Design Member 9, Load Case 1, Tension

$$\text{On gross area } f_t \leq F_t, 0.0 \leq 148.93 \text{ OK } 100\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 0.0 \leq 199.95 \text{ OK } 100\% \text{ under}$$

Design Member 9, Load Case 1, Slenderness

$$K_x \cdot L_x / r_x = 1.0 \cdot 632.0 / 174.04 = 3.63 \leq 200.0 \text{ OK } 98\% \text{ under}$$

$$K_y \cdot L_y / r_y = 1.0 \cdot 632.0 / 174.04 = 3.63 \leq 200.0 \text{ OK } 98\% \text{ under}$$

Design Member 9, Load Case 1, Compression

$$f_a \leq F_a, 0.0 \leq 147.91 \text{ OK } 100\% \text{ under}$$

Design Member 9, Load Case 1, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 0.0 / 199.95 + 0.0 / 163.82 + 0.0 / 163.82 = 0.0 \leq 1 \text{ OK } 100\% \text{ under}$$

Design Member 9, Load Case 1, Bending + Compression

$$f_a / F_a = 0.0 / 147.91 = 0.0 \leq 0.15 \therefore \phi 0$$

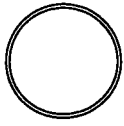
$$\phi_\alpha / \Phi_\alpha + \phi_{\beta\xi} / \Phi_{\beta\xi} + \phi_{\beta\psi} / \Phi_{\beta\psi} = 0.0 / 147.91 + 0.0 / 163.82 + 0.0 / 163.82 = 0.0 \leq 1 \text{ OK } 100\% \text{ under}$$

Design Member 9, Load Case 1, Sway

$$\Delta \leq Y/300.0, 0.47 \leq 0.0/300.0 = 0.0 \text{ mm OK } -2147483548\% \text{ under}$$

Checking design member 10

Members: 10
Group: Custom1
Section: OD 863.6 x 20 WT



Load Case: Load Case 1

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 \cdot F_y = 0.6 \cdot 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 \cdot F_u = 0.5 \cdot 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 \cdot F_y = 0.4 \cdot 355.0 = 142.0 \text{ MPa}$$

$$Kl/r = \max(K_x \cdot l/r_x, K_y \cdot l/r_y) = \max(1.0 \cdot 704.0/298.34, 1.0 \cdot 704.0/298.34) = 2.36$$

$$F_a = (1 - (Kl/r)^2 / (2 \cdot C_c^2)) \cdot F_y / FS = (1 - 2.36^2 / (2 \cdot 105.44^2)) \cdot 355.0 / 1.68 = 211.88 \text{ MPa}$$

Major Axis:

$$F_b = 0.66 \cdot F_y = 0.66 \cdot 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.66 \cdot F_y = 0.66 \cdot 355.0 = 234.3 \text{ MPa}$$

Design Member 10, Load Case 1, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 0.0 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 0.0 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Design Member 10, Load Case 1, Major Shear

$$f_v \leq F_v, 0.0 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 10, Load Case 1, Major Deflection

$$\delta \leq L/250, 0.01 \leq 2.82 \text{ mm OK } 100\% \text{ under}$$

Design Member 10, Load Case 1, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 0.0 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 0.0 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Design Member 10, Load Case 1, Minor Shear

$$f_v \leq F_v, 0.0 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 10, Load Case 1, Minor Deflection

$$\delta \leq L/250, 0.0 \leq 2.82 \text{ mm OK } 100\% \text{ under}$$

Design Member 10, Load Case 1, Tension

$$\text{On gross area } f_t \leq F_t, 0.0 \leq 213.0 \text{ OK } 100\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 0.0 \leq 245.0 \text{ OK } 100\% \text{ under}$$

Design Member 10, Load Case 1, Slenderness

$$K_x \cdot L_x / r_x = 1.0 \cdot 704.0 / 298.34 = 2.36 \leq 200.0 \text{ OK } 99\% \text{ under}$$

$$K_y \cdot L_y / r_y = 1.0 \cdot 704.0 / 298.34 = 2.36 \leq 200.0 \text{ OK } 99\% \text{ under}$$

Design Member 10, Load Case 1, Compression

$$f_a \leq F_a, 0.0 \leq 211.88 \text{ OK } 100\% \text{ under}$$

Design Member 10, Load Case 1, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 0.0 / 245.0 + 0.0 / 234.3 + 0.0 / 234.3 = 0.0 \leq 1 \text{ OK } 100\% \text{ under}$$

Design Member 10, Load Case 1, Bending + Compression

$$f_a / F_a = 0.0 / 211.88 = 0.0 \leq 0.15 \therefore \phi 0$$

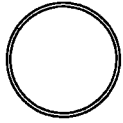
$$\phi_\alpha / \Phi_\alpha + \phi_{\beta\xi} / \Phi_{\beta\xi} + \phi_{\beta\psi} / \Phi_{\beta\psi} = 0.0 / 211.88 + 0.0 / 234.3 + 0.0 / 234.3 = 0.0 \leq 1 \text{ OK } 100\% \text{ under}$$

Design Member 10, Load Case 1, Sway

$$\Delta \leq Y/300.0, 0.47 \leq 0.0 / 300.0 = 0.0 \text{ mm OK } -2147483548\% \text{ under}$$

Checking design member 11

Members: 11
Group: Custom1
Section: OD 863.6 x 20 WT



Load Case: Load Case 1

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 \cdot F_y = 0.6 \cdot 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 \cdot F_u = 0.5 \cdot 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 \cdot F_y = 0.4 \cdot 355.0 = 142.0 \text{ MPa}$$

$$Kl/r = \max(K_x \cdot l/r_x, K_y \cdot l/r_y) = \max(1.0 \cdot 7484.0/298.34, 1.0 \cdot 7484.0/298.34) = 25.09$$

$$F_a = (1 - (Kl/r)^2 / (2 \cdot Cc^2)) \cdot F_y / FS = (1 - 25.09^2 / (2 \cdot 105.44^2)) \cdot 355.0 / 1.75 = 196.64 \text{ MPa}$$

Major Axis:

$$F_b = 0.66 \cdot F_y = 0.66 \cdot 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.66 \cdot F_y = 0.66 \cdot 355.0 = 234.3 \text{ MPa}$$

Design Member 11, Load Case 1, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 0.22 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 0.22 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Design Member 11, Load Case 1, Major Shear

$$f_v \leq F_v, 0.0 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 11, Load Case 1, Major Deflection

$$\delta \leq L/250, 0.02 \leq 29.94 \text{ mm OK } 100\% \text{ under}$$

Design Member 11, Load Case 1, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 0.0 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 0.0 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Design Member 11, Load Case 1, Minor Shear

$$f_v \leq F_v, 0.0 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 11, Load Case 1, Minor Deflection

$$\delta \leq L/250, 0.0 \leq 29.94 \text{ mm OK } 100\% \text{ under}$$

Design Member 11, Load Case 1, Tension

$$\text{On gross area } f_t \leq F_t, 0.0 \leq 213.0 \text{ OK } 100\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 0.0 \leq 245.0 \text{ OK } 100\% \text{ under}$$

Design Member 11, Load Case 1, Slenderness

$$K_x \cdot L_x / r_x = 1.0 \cdot 7484.0 / 298.34 = 25.09 \leq 200.0 \text{ OK } 87\% \text{ under}$$

$$K_y \cdot L_y / r_y = 1.0 \cdot 7484.0 / 298.34 = 25.09 \leq 200.0 \text{ OK } 87\% \text{ under}$$

Design Member 11, Load Case 1, Compression

$$f_a \leq F_a, 24.88 \leq 196.64 \text{ OK } 87\% \text{ under}$$

Design Member 11, Load Case 1, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 0.0 / 245.0 + 0.22 / 234.3 + 0.0 / 234.3 = 0.0 \leq 1 \text{ OK } 100\% \text{ under}$$

Design Member 11, Load Case 1, Bending + Compression

$$f_a / F_a = 24.88 / 196.64 = 0.13 \leq 0.15 \therefore \phi 0$$

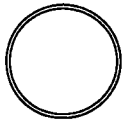
$$\phi_\alpha / \Phi_\alpha + \phi_{\beta\xi} / \Phi_{\beta\xi} + \phi_{\beta\psi} / \Phi_{\beta\psi} = 24.88 / 196.64 + 0.22 / 234.3 + 0.0 / 234.3 = 0.13 \leq 1 \text{ OK } 87\% \text{ under}$$

Design Member 11, Load Case 1, Sway

$$\Delta \leq Y/300.0, 0.47 \leq 0.0/300.0 = 0.0 \text{ mm OK } -2147483548\% \text{ under}$$

Checking design member 12

Members: 12
Group: Custom1
Section: OD 863.6 x 20 WT



Load Case: Load Case 1

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 \cdot F_y = 0.6 \cdot 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 \cdot F_u = 0.5 \cdot 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 \cdot F_y = 0.4 \cdot 355.0 = 142.0 \text{ MPa}$$

$$K_l/r = \max(K_x \cdot l/r_x, K_y \cdot l/r_y) = \max(1.0 \cdot 704.0/298.34, 1.0 \cdot 704.0/298.34) = 2.36$$

$$F_a = (1 - (K_l/r)^2 / (2 \cdot C_c^2)) \cdot F_y / F_S = (1 - 2.36^2 / (2 \cdot 105.44^2)) \cdot 355.0 / 1.68 = 211.88 \text{ MPa}$$

Major Axis:

$$F_b = 0.66 \cdot F_y = 0.66 \cdot 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.66 \cdot F_y = 0.66 \cdot 355.0 = 234.3 \text{ MPa}$$

Design Member 12, Load Case 1, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 0.0 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 0.0 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Design Member 12, Load Case 1, Major Shear

$$f_v \leq F_v, 0.0 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 12, Load Case 1, Major Deflection

$$\delta \leq L/250, 0.01 \leq 2.82 \text{ mm OK } 100\% \text{ under}$$

Design Member 12, Load Case 1, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 0.0 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 0.0 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Design Member 12, Load Case 1, Minor Shear

$$f_v \leq F_v, 0.0 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 12, Load Case 1, Minor Deflection

$$\delta \leq L/250, 0.0 \leq 2.82 \text{ mm OK } 100\% \text{ under}$$

Design Member 12, Load Case 1, Tension

$$\text{On gross area } f_t \leq F_t, 0.0 \leq 213.0 \text{ OK } 100\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 0.0 \leq 245.0 \text{ OK } 100\% \text{ under}$$

Design Member 12, Load Case 1, Slenderness

$$K_x \cdot L_x / r_x = 1.0 \cdot 704.0 / 298.34 = 2.36 \leq 200.0 \text{ OK } 99\% \text{ under}$$

$$K_y \cdot L_y / r_y = 1.0 \cdot 704.0 / 298.34 = 2.36 \leq 200.0 \text{ OK } 99\% \text{ under}$$

Design Member 12, Load Case 1, Compression

$$f_a \leq F_a, 0.0 \leq 211.88 \text{ OK } 100\% \text{ under}$$

Design Member 12, Load Case 1, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 0.0 / 245.0 + 0.0 / 234.3 + 0.0 / 234.3 = 0.0 \leq 1 \text{ OK } 100\% \text{ under}$$

Design Member 12, Load Case 1, Bending + Compression

$$f_a / F_a = 0.0 / 211.88 = 0.0 \leq 0.15 \therefore \phi 0$$

$$\phi_\alpha / \Phi_\alpha + \phi_{\beta x} / \Phi_{\beta x} + \phi_{\beta y} / \Phi_{\beta y} = 0.0 / 211.88 + 0.0 / 234.3 + 0.0 / 234.3 = 0.0 \leq 1 \text{ OK } 100\% \text{ under}$$

Design Member 12, Load Case 1, Sway

$$\Delta \leq Y/300.0, 0.47 \leq 0.0 / 300.0 = 0.0 \text{ mm OK } -2147483548\% \text{ under}$$

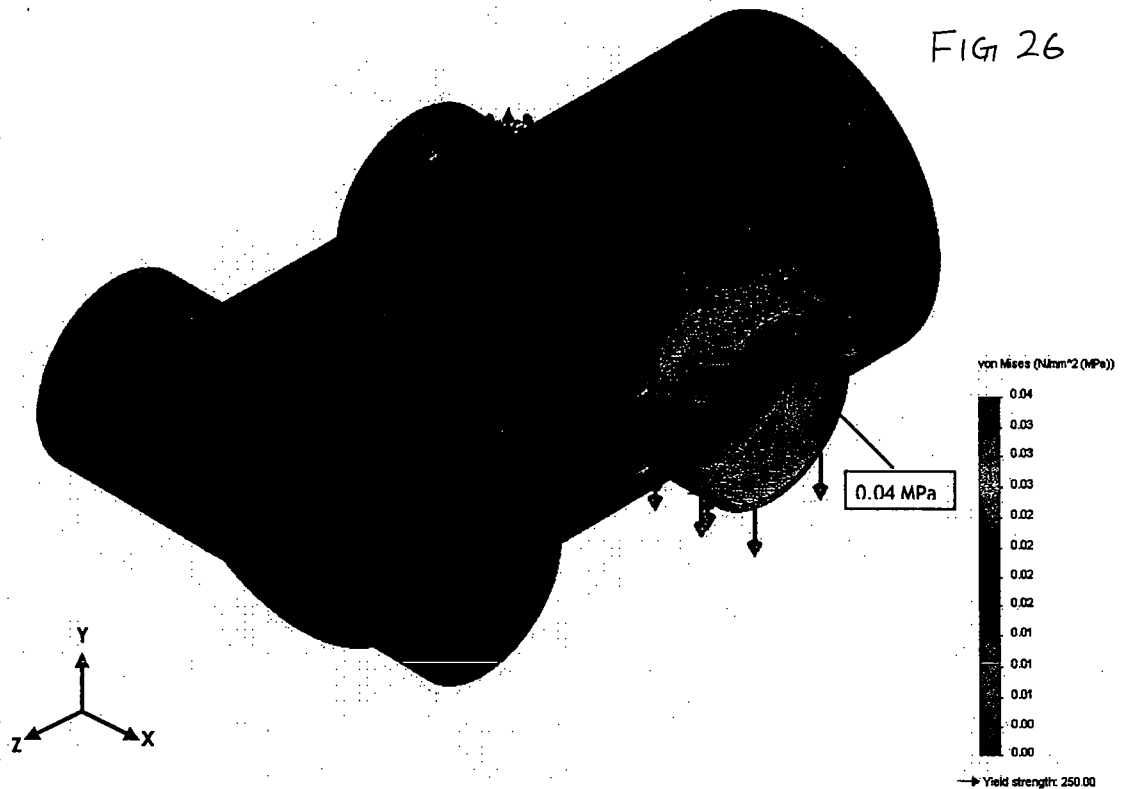
End of check

Appendix C

COSMOS Finite Element Analysis

1.0 Finite Element Analysis - Von Mises Stress plot on OD 508 x 16 WT lifting frame

Model name: OD 34 MAIN FRAME
Study name: Study 4
Plot type: Static nodal stress Stress1
Deformation scale: 1



A) Load & Restraint:

- Restraint on face of OD 508 circular structure within the main structure frame.
- Apply vertical load of - 35 tonnes (Y-direction) on OD 508 circular structure.

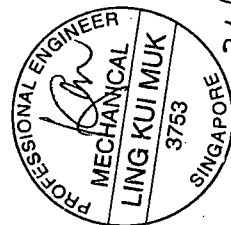
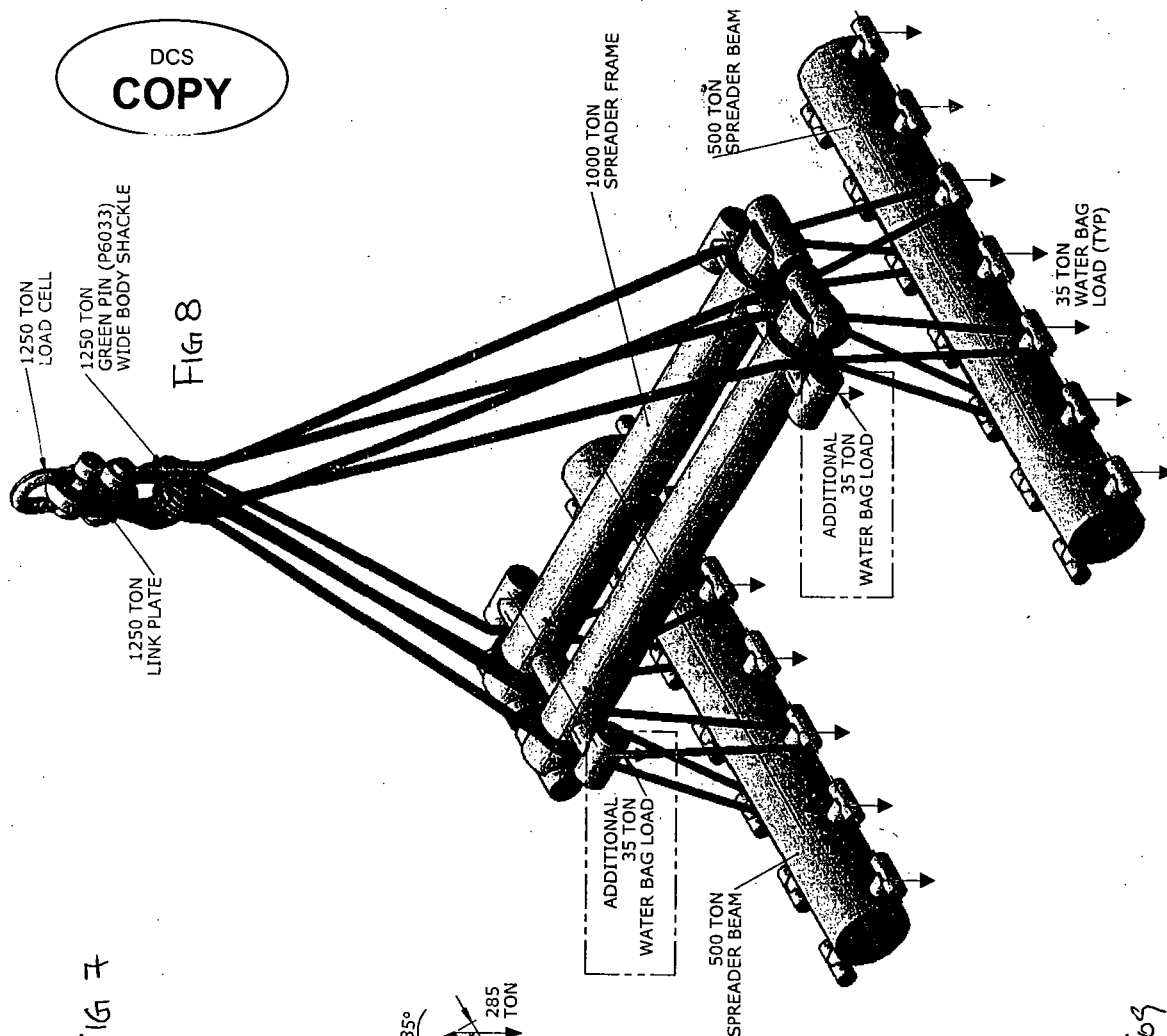
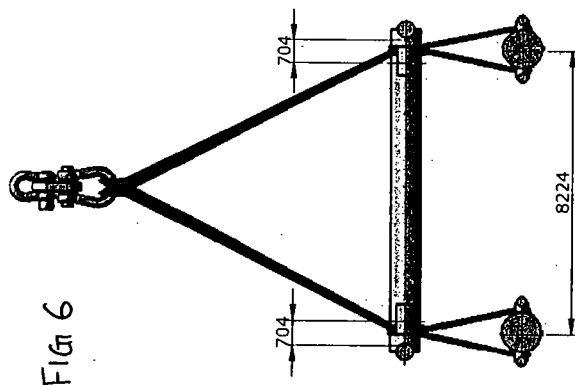
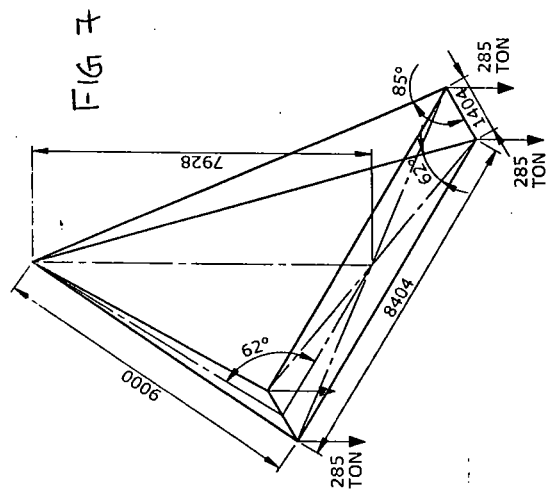
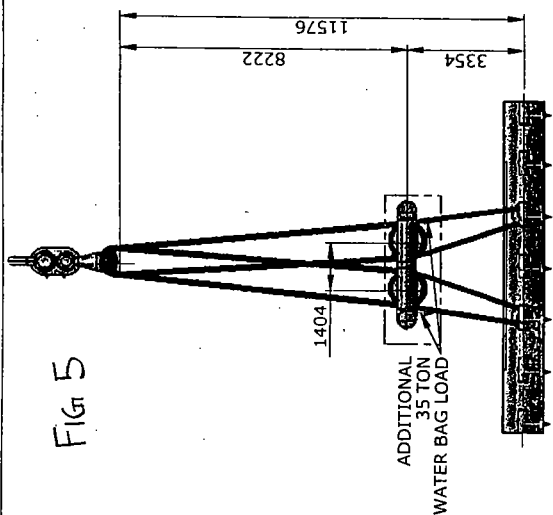
B) Material yield strength:

- OD 508 X 16 WT circular structure - allowable yield strength 255 MPa
- Weldment - min. guarantee yield strength 480 MPa

C) Conclusion:

- Maximum Von Mises equivalent stress at OD 508 circular structure is 0.04 MPa < 255 MPa.

DCS
COPY



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- General Notes
1. ALL DIMENSION IN mm UNLESS OTHERWISE NOTED.
 2. SPREADER BEAM WEIGHT : 8250 KG
 3. LIFTING FRAME WEIGHT : 10500 KG

Rev.	Description	Drawn	Check	Approve	Date
1	ADDITIONAL LOAD ADDED	S.K.	S.J.W.	T.T.	15/12/09
0	ISSUE FOR CONSTRUCTION	S.K.	S.J.W.	T.T.	25/07/08
C	CHANGE IN LIFTING CONDITION	S.K.	S.J.W.	T.T.	07/07/08
B	ISSUE FOR APPROVAL	S.K.	S.J.W.	T.T.	04/07/08
A	ISSUE FOR APPROVAL	S.K.	S.J.W.	T.T.	18/06/08

REALTEC
exploring infinity

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Tel : +65 6753 8878, Fax : +65 6853 8280

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Title				
1140 TON SPREADER FRAME LIFTING ARRANGEMENT				
Scale	1 : 75	Size	A3	Drawing No.
Rev.	1	RT-RM-DWG-120		

TRANSMITTAL

To:	RIGGING & MARINE SERVICES PTE LTD	Date:	06/01/10
Attention:	MR. LIM	Ref No.:	9779-TR-002
From:	SIDNEY KONG	Our job Ref.:	9779

The following drawing(s) / document(s) are forwarded to you for;

- | | |
|-----------------------------------|---------------------|
| 1. Construction / Fabrication () | 5. Comments () |
| 2. Approval () | 6. Submission (X) |
| 3. Reference / Information () | 7. Review () |
| 4. Printing () | |

Others: Documents are endorsed by the PE

Reply Required (Yes / No) Date: ASAP

Project: 9779 - 1140 SPREADER BEAM & 700 TONNE LIFTING FRAME

No. of Copies	Drawing / Documents	Rev	Description	Remarks
1	9779-C-C3-010	0	DESIGN CALCULATION for 700 TON LIFTING FRAME	6
1	9779-C-C3-020	0	DESIGN CALCULATION for 1140 TON SPREADER FRAME	6

----- LAST ENTRY -----

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The documents document(s) / Drawing(s) were issued by:

Prepared by:

Sidney Kong

Name / Signature

Received by:

[Signature]

Name / Signature / Company Stamp / Date



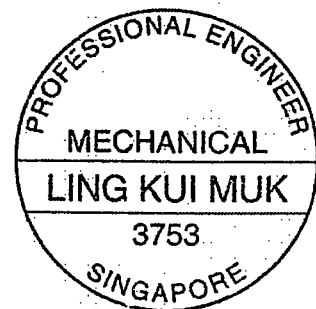
6/1/2010

Co. Reg No.
200205743M
GST Reg No.
20-0205743-M



**DESIGN CALCULATION
FOR
700 TONNE S.W.L. LIFTING FRAME**

**DOCUMENT NO.: 9779-C-C3-010
REVISION NO.: 0**



1.0 Introduction

The purpose of this calculation report is to verify the adequacy of structural design of one unit of 700 tonne S.W.L. lifting frame. This lifting frame is designed for lifting 4 x 140 tonne and 4 x 35 tonne offset at 2.7m, using lifting lugs design at a single point lifting arrangement as illustrated in the lifting condition drawing.

2.0 Design Consideration

Loading conditions:

- a) This spreader frame is NOT designed and used for day-to-day transportation or handling of goods. No dynamic or impact loads is taken into account. Test loads by means of water bags are gradually filled up with water to achieve the required loading.
- b) Lifting is done by means of lifting lugs provided. Lifting lugs are design based on appropriate size as illustrated in the lifting condition drawing

The designs for the structural members are based on Allowable Stress Design (ASD) in accordance with AISC.

3.0 Conclusion

As detailed in attached reports in the Appendixes, the structural members meet the requirements of the design code base on the above design consideration.

4.0 References:

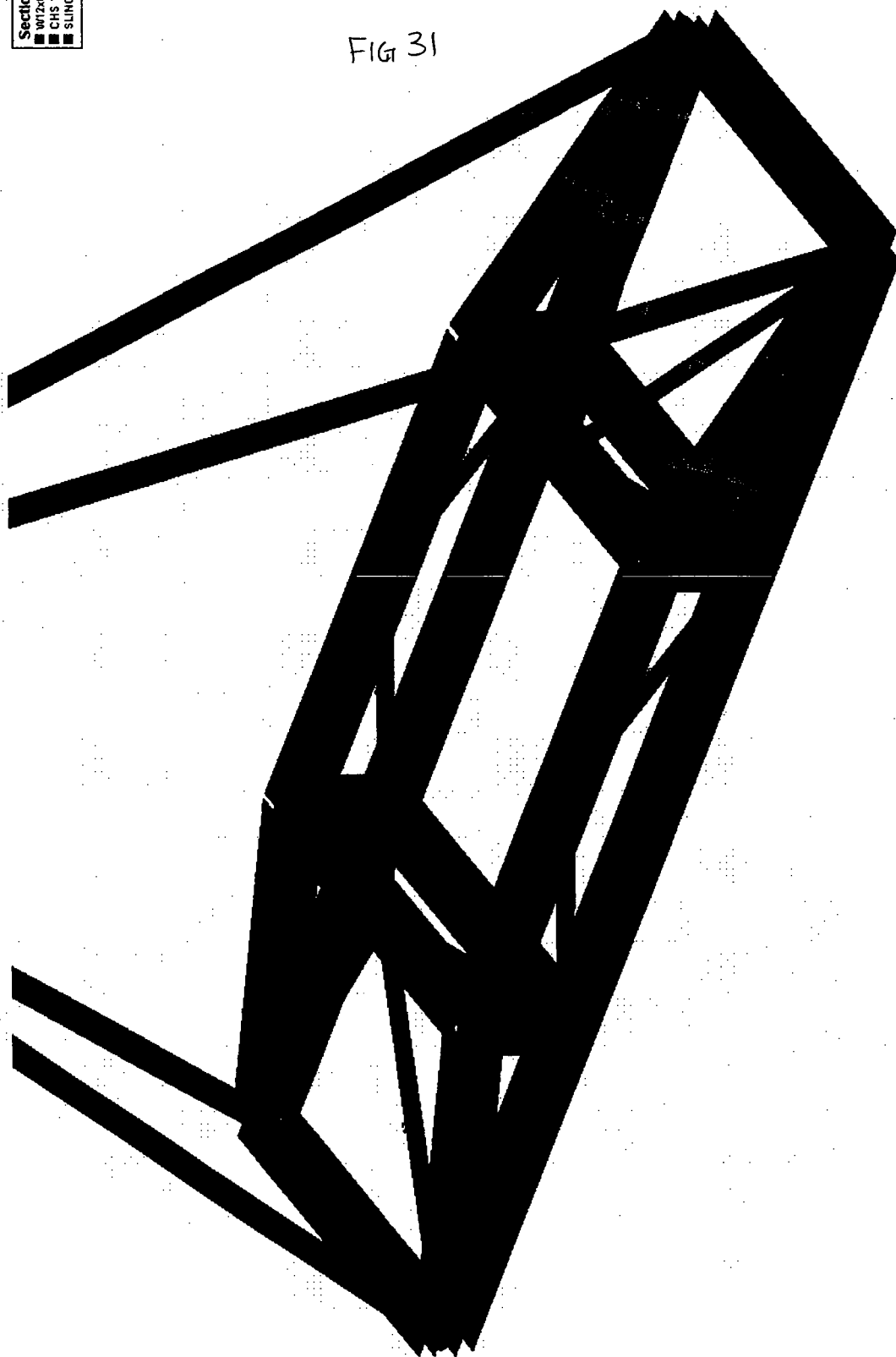
- a) 700 Tonne Spreader Frame Lifting Arrangement
Drawing no.: 9779-D-D1-020



31 DEC '09

Sections	
■	WT2x87
■	CHS 114.3 x 6
■	SLING

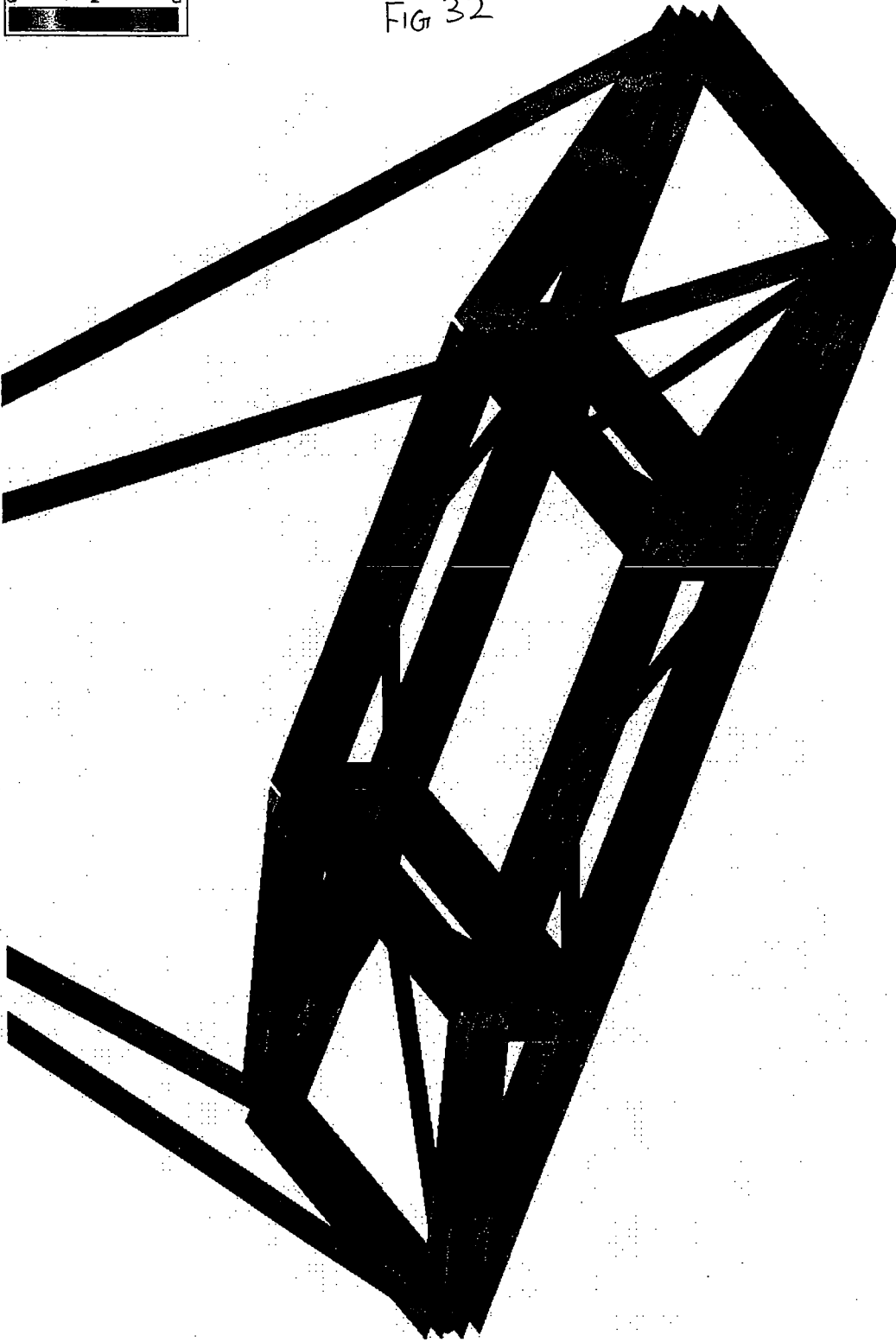
FIG 31



FRAME MODEL & MEMBER DIAGRAM



FIG 32



Static Case: EQUAL LOAD Mx (kN-m)

BENDING STRESS DIAGRAM

Appendix B

MULTIFRAME Model & Graphic Plot Unequal Loading Condition

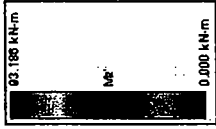
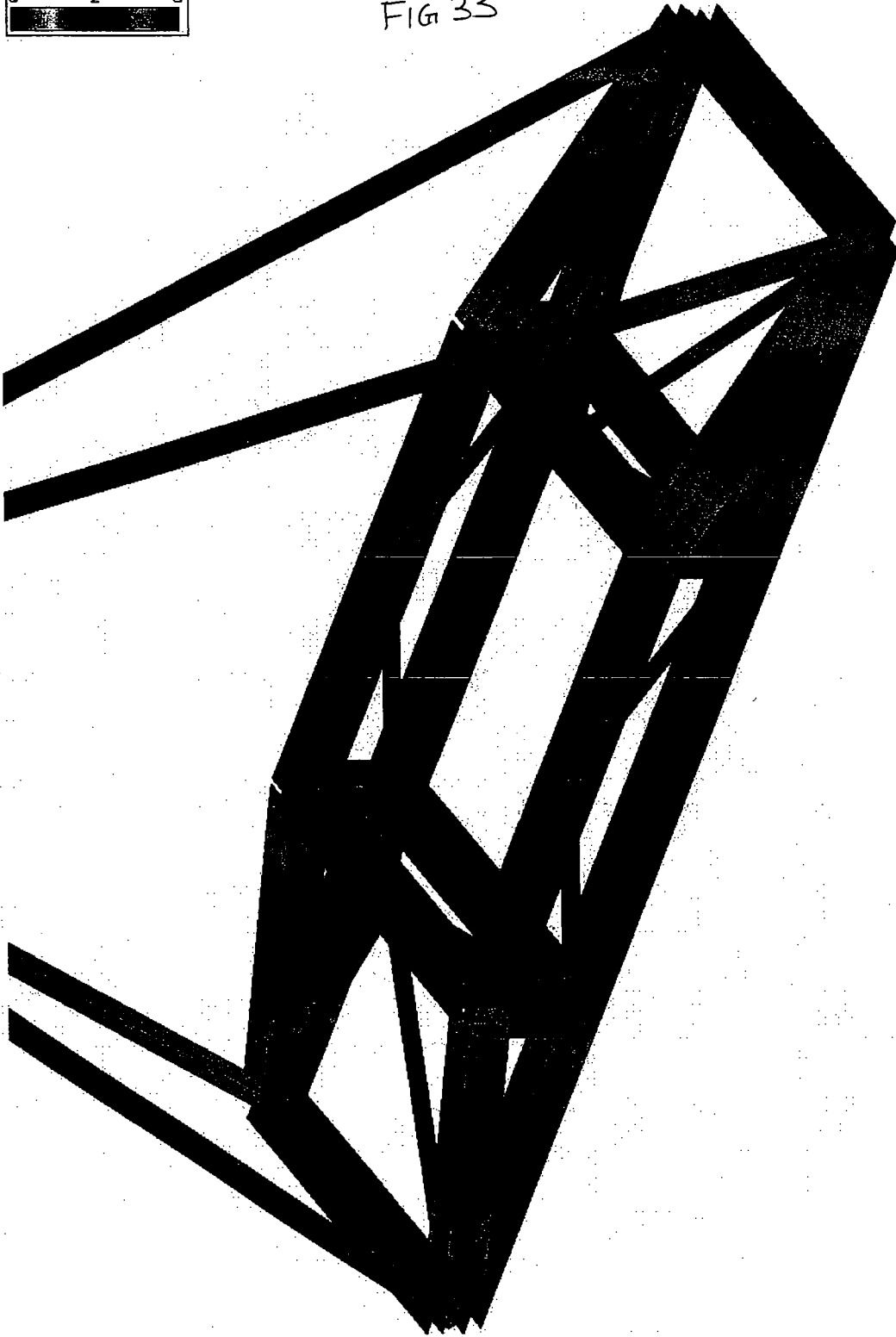


FIG 33



Static Case: UNEQUAL LOAD MZ (kN-m)

BENDING STRESS DIAGRAM

Appendix C

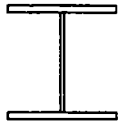
**Steel design report to ASIC ASD
Equal Loading Condition**

Checking design member 2

Members: 2

Group: W

Section: W12x87



Load Case: EQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 \cdot F_y = 0.6 \cdot 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 \cdot F_u = 0.5 \cdot 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 \cdot F_y = 0.4 \cdot 355.0 = 142.0 \text{ MPa}$$

$$Kl/r = \max(K_x \cdot l/r_x, K_y \cdot l/r_y) = \max(1.0 \cdot 4000.0/136.65, 1.0 \cdot 4000.0/77.98) = 51.3$$

$$F_a = (1 - (Kl/r)^2 / (2 \cdot C_c^2)) \cdot F_y / FS = (1 - 51.3^2 / (2 \cdot 105.44^2)) \cdot 355.0 / 1.83 = 170.59 \text{ MPa}$$

$$b/t = 153.67/20.57 = 7.47 \leq 65/\sqrt{F_y} = 65/\sqrt{355.0} = 9.06 \therefore \phi 0 \text{ Σεχτιον ισ Χομπαχτ}$$

Μαφop Aξισ:

$$\Lambda_\beta > \Lambda_\chi \therefore \phi 0 \quad \Phi_\beta = 0.6 \cdot F_y = 0.6 \cdot 355.0 = 213.0 \text{ MPa}$$

$$F_b = (2/3 - F_y \cdot (l/r)^2 / (1530 \times 10^3 \cdot C_b)) \cdot F_y = (2/3 - 355.0 \cdot (4000.0/84.78)^2 / (1530 \times 10^3 \cdot 1.0)) \cdot 355.0 = 210.07 \text{ MPa}$$

$$F_b = 12 \times 10^3 \cdot C_b / (l \cdot d / A_f) = 12 \times 10^3 \cdot 1.0 / (4000.0 \cdot 317.5 / 63.23) = 411.94 \text{ MPa}$$

$$F_b > 0.6 \cdot F_y \therefore \phi 0 \quad \Phi_\beta = 0.6 \cdot F_y = 0.6 \cdot 355.0 = 213.0 \text{ MPa}$$

Minor Axis:

$$F_b = 0.75 \cdot F_y = 0.75 \cdot 355.0 = 266.25 \text{ MPa}$$

Design Member 2, EQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 17.67 \leq 213.0 \text{ OK } 92\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 17.67 \leq 213.0 \text{ OK } 92\% \text{ under}$$

Design Member 2, EQUAL LOAD, Major Shear

$$f_v \leq F_v, 0.0 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 2, EQUAL LOAD, Major Deflection

$$\delta \leq L/250, 1.11 \leq 16.0 \text{ mm OK } 93\% \text{ under}$$

Design Member 2, EQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 0.84 \leq 266.25 \text{ OK } 100\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 0.84 \leq 266.25 \text{ OK } 100\% \text{ under}$$

Design Member 2, EQUAL LOAD, Minor Shear

$$f_v \leq F_v, 0.0 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 2, EQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 0.05 \leq 16.0 \text{ mm OK } 100\% \text{ under}$$

Design Member 2, EQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 14.49 \leq 213.0 \text{ OK } 93\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 14.49 \leq 245.0 \text{ OK } 94\% \text{ under}$$

Design Member 2, EQUAL LOAD, Slenderness

$$K_x \cdot L_x / r_x = 1.0 \cdot 4000.0 / 136.65 = 29.27 \leq 300.0 \text{ OK } 90\% \text{ under}$$

$$K_y \cdot L_y / r_y = 1.0 \cdot 4000.0 / 77.98 = 51.3 \leq 300.0 \text{ OK } 83\% \text{ under}$$

Design Member 2, EQUAL LOAD, Compression

$$f_a \leq F_a, 0.0 \leq 170.59 \text{ OK } 100\% \text{ under}$$

Design Member 2, EQUAL LOAD, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 14.49 / 213.0 + 17.67 / 213.0 + 0.84 / 266.25 = 0.15 \leq 1 \text{ OK } 85\% \text{ under}$$

Design Member 2, EQUAL LOAD, Bending + Compression

$$f_a / F_a = 0.0 / 170.59 = 0.0 \leq 0.15 \therefore \phi 0$$

$$\phi_\alpha / \Phi_\alpha + \phi_{\beta x} / \Phi_{\beta x} + \phi_{\beta y} / \Phi_{\beta y} = 0.0 / 170.59 + 17.67 / 213.0 + 0.84 / 266.25 = 0.09 \leq 1 \text{ OK } 91\% \text{ under}$$

Design Member 2, EQUAL LOAD, Sway

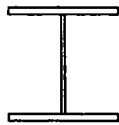
$$\Delta \leq Y/300.0, 0.14 \leq 0.0/300.0 = 0.0 \text{ mm OK } -2147483548\% \text{ under}$$

Checking design member 4

Members: 4

Group: W

Section: W12x87



Load Case: EQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 * F_y = 0.6 * 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 * F_u = 0.5 * 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 * F_y = 0.4 * 355.0 = 142.0 \text{ MPa}$$

$$KL/r = \max(K_x * L_x / r_x, K_y * L_y / r_y) = \max(1.0 * 2700.0 / 136.65, 1.0 * 2700.0 / 77.98) = 34.63$$

$$F_a = (1 - (KL/r)^2 / (2 * C_c^2)) * F_y / F_s = (1 - 34.63^2 / (2 * 105.44^2)) * 355.0 / 1.79 = 188.12 \text{ MPa}$$

$$b/t = 153.67 / 20.57 = 7.47 \leq 65 / \sqrt{F_y} = 65 / \sqrt{355.0} = 9.06 \therefore \phi 0 \text{ Σεχτιον ις Χομπαχτ}$$

Μαφορ Αξισ:

$$\Lambda_p \leq L_c \therefore \phi 0 \quad \Phi_p = 0.66 * F_y = 0.66 * 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.75 * F_y = 0.75 * 355.0 = 266.25 \text{ MPa}$$

Design Member 4, EQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 0.05 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 0.05 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Design Member 4, EQUAL LOAD, Major Shear

$$f_v \leq F_v, 0.0 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 4, EQUAL LOAD, Major Deflection

$$\delta \leq L/250, 0.0 \leq 10.8 \text{ mm OK } 100\% \text{ under}$$

Design Member 4, EQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 1.45 \leq 266.25 \text{ OK } 99\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 1.45 \leq 266.25 \text{ OK } 99\% \text{ under}$$

Design Member 4, EQUAL LOAD, Minor Shear

$$f_v \leq F_v, 0.0 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 4, EQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 0.04 \leq 10.8 \text{ mm OK } 100\% \text{ under}$$

Design Member 4, EQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 0.0 \leq 213.0 \text{ OK } 100\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 0.0 \leq 245.0 \text{ OK } 100\% \text{ under}$$

Design Member 4, EQUAL LOAD, Slenderness

$$K_x * L_x / r_x = 1.0 * 2700.0 / 136.65 = 19.76 \leq 200.0 \text{ OK } 90\% \text{ under}$$

$$K_y * L_y / r_y = 1.0 * 2700.0 / 77.98 = 34.63 \leq 200.0 \text{ OK } 83\% \text{ under}$$

Design Member 4, EQUAL LOAD, Compression

$$f_a \leq F_a, 13.87 \leq 188.12 \text{ OK } 93\% \text{ under}$$

Design Member 4, EQUAL LOAD, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 0.0 / 245.0 + 0.05 / 234.3 + 1.45 / 266.25 = 0.01 \leq 1 \text{ OK } 99\% \text{ under}$$

Design Member 4, EQUAL LOAD, Bending + Compression

$$f_a / F_a = 13.87 / 188.12 = 0.07 \leq 0.15 \therefore \phi 0$$

$$\phi_\alpha / \Phi_\alpha + \phi_{\beta x} / \Phi_{\beta x} + \phi_{\beta y} / \Phi_{\beta y} = 13.87 / 188.12 + 0.05 / 234.3 + 1.45 / 266.25 = 0.08 \leq 1 \text{ OK } 92\% \text{ under}$$

Design Member 4, EQUAL LOAD, Sway

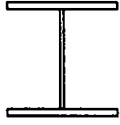
$$\Delta \leq Y/300.0, 0.26 \leq 0.0 / 300.0 = 0.0 \text{ mm OK } -2147483548\% \text{ under}$$

Checking design member 6

Members: 6

Group: W

Section: W12x87



Load Case: EQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 \cdot F_y = 0.6 \cdot 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 \cdot F_u = 0.5 \cdot 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 \cdot F_y = 0.4 \cdot 355.0 = 142.0 \text{ MPa}$$

$$Kl/r = \max(K_x \cdot l/r_x, K_y \cdot l/r_y) = \max(1.0 \cdot 2700.0/136.65, 1.0 \cdot 2700.0/77.98) = 34.63$$

$$F_a = (1 - (Kl/r)^2 / (2 \cdot C_c^2)) \cdot F_y / F_s = (1 - 34.63^2 / (2 \cdot 105.44^2)) \cdot 355.0 / 1.79 = 188.12 \text{ MPa}$$

$$b/t = 153.67/20.57 = 7.47 \leq 65/\sqrt{F_y} = 65/\sqrt{355.0} = 9.06 \therefore \phi 0 \text{ Σεχτιον ις Χομπαχτ}$$

Μαφορ Αξισ:

$$\Lambda_\beta \leq L_c \therefore \phi 0 \quad \Phi_\beta = 0.66 \cdot F_y = 0.66 \cdot 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.75 \cdot F_y = 0.75 \cdot 355.0 = 266.25 \text{ MPa}$$

Design Member 6, EQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 0.2 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 0.2 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Design Member 6, EQUAL LOAD, Major Shear

$$f_v \leq F_v, 0.0 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 6, EQUAL LOAD, Major Deflection

$$\delta \leq L/250, 0.01 \leq 10.8 \text{ mm OK } 100\% \text{ under}$$

Design Member 6, EQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 1.25 \leq 266.25 \text{ OK } 100\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 1.25 \leq 266.25 \text{ OK } 100\% \text{ under}$$

Design Member 6, EQUAL LOAD, Minor Shear

$$f_v \leq F_v, 0.0 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 6, EQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 0.04 \leq 10.8 \text{ mm OK } 100\% \text{ under}$$

Design Member 6, EQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 0.0 \leq 213.0 \text{ OK } 100\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 0.0 \leq 245.0 \text{ OK } 100\% \text{ under}$$

Design Member 6, EQUAL LOAD, Slenderness

$$K_x \cdot L_x / r_x = 1.0 \cdot 2700.0/136.65 = 19.76 \leq 200.0 \text{ OK } 90\% \text{ under}$$

$$K_y \cdot L_y / r_y = 1.0 \cdot 2700.0/77.98 = 34.63 \leq 200.0 \text{ OK } 83\% \text{ under}$$

Design Member 6, EQUAL LOAD, Compression

$$f_a \leq F_a, 0.59 \leq 188.12 \text{ OK } 100\% \text{ under}$$

Design Member 6, EQUAL LOAD, Bending + Tension

$$f_a/F_t + f_{bx}/F_{bx} + f_{by}/F_{by} = 0.0/245.0 + 0.2/234.3 + 1.25/266.25 = 0.01 \leq 1 \text{ OK } 99\% \text{ under}$$

Design Member 6, EQUAL LOAD, Bending + Compression

$$f_a/F_a = 0.59/188.12 = 0.0 \leq 0.15 \therefore \phi 0$$

$$\phi_\alpha/\Phi_\alpha + \phi_{\beta x}/\Phi_{\beta x} + \phi_{\beta y}/\Phi_{\beta y} = 0.59/188.12 + 0.2/234.3 + 1.25/266.25 = 0.01 \leq 1 \text{ OK } 99\% \text{ under}$$

Design Member 6, EQUAL LOAD, Sway

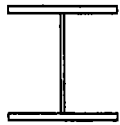
$$\Delta \leq Y/300.0, 0.14 \leq 0.0/300.0 = 0.0 \text{ mm OK } -2147483548\% \text{ under}$$

Checking design member 8

Members: 8

Group: W

Section: W12x87



Load Case: EQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 * F_y = 0.6 * 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 * F_u = 0.5 * 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 * F_y = 0.4 * 355.0 = 142.0 \text{ MPa}$$

$$Kl/r = \max(K_x * l/r_x, K_y * l/r_y) = \max(1.0 * 2700.0 / 136.65, 1.0 * 2700.0 / 77.98) = 34.63$$

$$F_a = (1 - (Kl/r)^2 / (2 * C_c^2)) * F_y / F_S = (1 - 34.63^2 / (2 * 105.44^2)) * 355.0 / 1.79 = 188.12 \text{ MPa}$$

$$b/t = 153.67 / 20.57 = 7.47 \leq 65 / \sqrt{F_y} = 65 / \sqrt{355.0} = 9.06 \therefore \phi 0 \text{ Σεχτιον ισ Χομπαχτ}$$

Μαφορ Αξισ:

$$\Lambda_\beta \leq L_c \therefore \phi 0 \quad \Phi_\beta = 0.66 * F_y = 0.66 * 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.75 * F_y = 0.75 * 355.0 = 266.25 \text{ MPa}$$

Design Member 8, EQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 41.5 \leq 234.3 \text{ OK } 82\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 41.5 \leq 234.3 \text{ OK } 82\% \text{ under}$$

Design Member 8, EQUAL LOAD, Major Shear

$$f_v \leq F_v, 8.15 \leq 142.0 \text{ OK } 94\% \text{ under}$$

Design Member 8, EQUAL LOAD, Major Deflection

$$\delta \leq L/250, 5.94 \leq 10.8 \text{ mm OK } 45\% \text{ under}$$

Design Member 8, EQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 3.93 \leq 266.25 \text{ OK } 99\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 3.93 \leq 266.25 \text{ OK } 99\% \text{ under}$$

Design Member 8, EQUAL LOAD, Minor Shear

$$f_v \leq F_v, 0.1 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 8, EQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 0.09 \leq 10.8 \text{ mm OK } 99\% \text{ under}$$

Design Member 8, EQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 7.04 \leq 213.0 \text{ OK } 97\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 7.04 \leq 245.0 \text{ OK } 97\% \text{ under}$$

Design Member 8, EQUAL LOAD, Slenderness

$$K_x * L_x / r_x = 1.0 * 2700.0 / 136.65 = 19.76 \leq 300.0 \text{ OK } 93\% \text{ under}$$

$$K_y * L_y / r_y = 1.0 * 2700.0 / 77.98 = 34.63 \leq 300.0 \text{ OK } 88\% \text{ under}$$

Design Member 8, EQUAL LOAD, Compression

$$f_a \leq F_a, 0.0 \leq 188.12 \text{ OK } 100\% \text{ under}$$

Design Member 8, EQUAL LOAD, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 7.04 / 213.0 + 41.5 / 234.3 + 3.93 / 266.25 = 0.22 \leq 1 \text{ OK } 78\% \text{ under}$$

Design Member 8, EQUAL LOAD, Bending + Compression

$$f_a / F_a = 0.0 / 188.12 = 0.0 \leq 0.15 \therefore \phi 0$$

$$\phi_\alpha / \Phi_\alpha + \phi_{\beta_x} / \Phi_{\beta_x} + \phi_{\beta_y} / \Phi_{\beta_y} = 0.0 / 188.12 + 41.5 / 234.3 + 3.93 / 266.25 = 0.19 \leq 1 \text{ OK } 81\% \text{ under}$$

Design Member 8, EQUAL LOAD, Sway

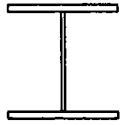
$$\Delta \leq Y/300.0, 0.15 \leq 0.0 / 300.0 = 0.0 \text{ mm OK } -2147483548\% \text{ under}$$

Checking design member 10

Members: 10

Group: W

Section: W12x87



Load Case: EQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 * F_y = 0.6 * 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 * F_u = 0.5 * 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 * F_y = 0.4 * 355.0 = 142.0 \text{ MPa}$$

$$Kl/r = \max(K_x * l/r_x, K_y * l/r_y) = \max(1.0 * 2700.0 / 136.65, 1.0 * 2700.0 / 77.98) = 34.63$$

$$F_a = (1 - (Kl/r)^2 / (2 * C_c^2)) * F_y / F_s = (1 - 34.63^2 / (2 * 105.44^2)) * 355.0 / 1.79 = 188.12 \text{ MPa}$$

$$b/t = 153.67 / 20.57 = 7.47 \leq 65 / \sqrt{F_y} = 65 / \sqrt{355.0} = 9.06 \therefore \phi 0 \text{ Σεχτιον ισ Χομπαχτ}$$

Μαφop Aξισ:

$$\Lambda_\beta \leq L_c \therefore \phi 0 \quad \Phi_\beta = 0.66 * F_y = 0.66 * 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.75 * F_y = 0.75 * 355.0 = 266.25 \text{ MPa}$$

Design Member 10, EQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 41.5 \leq 234.3 \text{ OK } 82\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 41.5 \leq 234.3 \text{ OK } 82\% \text{ under}$$

Design Member 10, EQUAL LOAD, Major Shear

$$f_v \leq F_v, 8.15 \leq 142.0 \text{ OK } 94\% \text{ under}$$

Design Member 10, EQUAL LOAD, Major Deflection

$$\delta \leq L/250, 5.94 \leq 10.8 \text{ mm OK } 45\% \text{ under}$$

Design Member 10, EQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 3.93 \leq 266.25 \text{ OK } 99\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 3.93 \leq 266.25 \text{ OK } 99\% \text{ under}$$

Design Member 10, EQUAL LOAD, Minor Shear

$$f_v \leq F_v, 0.1 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 10, EQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 0.11 \leq 10.8 \text{ mm OK } 99\% \text{ under}$$

Design Member 10, EQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 7.04 \leq 213.0 \text{ OK } 97\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 7.04 \leq 245.0 \text{ OK } 97\% \text{ under}$$

Design Member 10, EQUAL LOAD, Slenderness

$$K_x * L_x / r_x = 1.0 * 2700.0 / 136.65 = 19.76 \leq 300.0 \text{ OK } 93\% \text{ under}$$

$$K_y * L_y / r_y = 1.0 * 2700.0 / 77.98 = 34.63 \leq 300.0 \text{ OK } 88\% \text{ under}$$

Design Member 10, EQUAL LOAD, Compression

$$f_a \leq F_a, 0.0 \leq 188.12 \text{ OK } 100\% \text{ under}$$

Design Member 10, EQUAL LOAD, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 7.04 / 213.0 + 41.5 / 234.3 + 3.93 / 266.25 = 0.22 \leq 1 \text{ OK } 78\% \text{ under}$$

Design Member 10, EQUAL LOAD, Bending + Compression

$$f_a / F_a = 0.0 / 188.12 = 0.0 \leq 0.15 \therefore \phi 0$$

$$\phi_\alpha / \Phi_\alpha + \phi_{\beta x} / \Phi_{\beta x} + \phi_{\beta y} / \Phi_{\beta y} = 0.0 / 188.12 + 41.5 / 234.3 + 3.93 / 266.25 = 0.19 \leq 1 \text{ OK } 81\% \text{ under}$$

Design Member 10, EQUAL LOAD, Sway

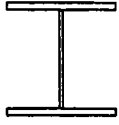
$$\Delta \leq Y/300.0, 0.26 \leq 0.0 / 300.0 = 0.0 \text{ mm OK } -2147483548\% \text{ under}$$

Checking design member 12

Members: 12

Group: W

Section: W12x87



Load Case: EQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 \cdot F_y = 0.6 \cdot 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 \cdot F_u = 0.5 \cdot 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 \cdot F_y = 0.4 \cdot 355.0 = 142.0 \text{ MPa}$$

$$Kl/r = \max(K_x \cdot l/r_x, K_y \cdot l/r_y) = \max(1.0 \cdot 800.0 / 136.65, 1.0 \cdot 800.0 / 77.98) = 10.26$$

$$F_a = (1 - (Kl/r)^2 / (2 \cdot C_c^2)) \cdot F_y / FS = (1 - 10.26^2 / (2 \cdot 105.44^2)) \cdot 355.0 / 1.7 = 207.46 \text{ MPa}$$

$$b/t = 153.67 / 20.57 = 7.47 \leq 65 / \sqrt{F_y} = 65 / \sqrt{355.0} = 9.06 \quad \therefore \phi_0 \text{ Σεχτιον ις Χομπαχτ}$$

Μαφορ Αξις:

$$\Lambda_\beta \leq L_c \quad \therefore \phi_0 \quad \Phi_\beta = 0.66 \cdot F_y = 0.66 \cdot 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.75 \cdot F_y = 0.75 \cdot 355.0 = 266.25 \text{ MPa}$$

Design Member 12, EQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 23.68 \leq 234.3 \text{ OK } 90\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 23.68 \leq 234.3 \text{ OK } 90\% \text{ under}$$

Design Member 12, EQUAL LOAD, Major Shear

$$f_v \leq F_v, 22.5 \leq 142.0 \text{ OK } 84\% \text{ under}$$

Design Member 12, EQUAL LOAD, Major Deflection

$$\delta \leq L/250, 0.78 \leq 3.2 \text{ mm OK } 76\% \text{ under}$$

Design Member 12, EQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 0.84 \leq 266.25 \text{ OK } 100\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 0.84 \leq 266.25 \text{ OK } 100\% \text{ under}$$

Design Member 12, EQUAL LOAD, Minor Shear

$$f_v \leq F_v, 0.07 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 12, EQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 0.01 \leq 3.2 \text{ mm OK } 100\% \text{ under}$$

Design Member 12, EQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 19.09 \leq 213.0 \text{ OK } 91\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 19.09 \leq 245.0 \text{ OK } 92\% \text{ under}$$

Design Member 12, EQUAL LOAD, Slenderness

$$K_x \cdot L_x / r_x = 1.0 \cdot 800.0 / 136.65 = 5.85 \leq 300.0 \text{ OK } 98\% \text{ under}$$

$$K_y \cdot L_y / r_y = 1.0 \cdot 800.0 / 77.98 = 10.26 \leq 300.0 \text{ OK } 97\% \text{ under}$$

Design Member 12, EQUAL LOAD, Compression

$$f_a \leq F_a, 0.0 \leq 207.46 \text{ OK } 100\% \text{ under}$$

Design Member 12, EQUAL LOAD, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 19.09 / 213.0 + 23.68 / 234.3 + 0.84 / 266.25 = 0.19 \leq 1 \text{ OK } 81\% \text{ under}$$

Design Member 12, EQUAL LOAD, Bending + Compression

$$f_a / F_a = 0.0 / 207.46 = 0.0 \leq 0.15 \quad \therefore \phi_0$$

$$\phi_\alpha / \Phi_\alpha + \phi_{\beta_x} / \Phi_{\beta_x} + \phi_{\beta_y} / \Phi_{\beta_y} = 0.0 / 207.46 + 23.68 / 234.3 + 0.84 / 266.25 = 0.1 \leq 1 \text{ OK } 90\% \text{ under}$$

Design Member 12, EQUAL LOAD, Sway

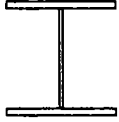
$$\Delta \leq Y/300.0, 0.63 \leq 800.0 / 300.0 = 2.67 \text{ mm OK } 76\% \text{ under}$$

Checking design member 14

Members: 14

Group: W

Section: W12x87



Load Case: EQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 \cdot F_y = 0.6 \cdot 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 \cdot F_u = 0.5 \cdot 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 \cdot F_y = 0.4 \cdot 355.0 = 142.0 \text{ MPa}$$

$$Kl/r = \max(K_x \cdot l/r_x, K_y \cdot l/r_y) = \max(1.0 \cdot 800.0/136.65, 1.0 \cdot 800.0/77.98) = 10.26$$

$$F_a = (1 - (Kl/r)^2 / (2 \cdot C_c^2)) \cdot F_y / F_S = (1 - 10.26^2 / (2 \cdot 105.44^2)) \cdot 355.0 / 1.7 = 207.46 \text{ MPa}$$

$$b/t = 153.67/20.57 = 7.47 \leq 65/\sqrt{F_y} = 65/\sqrt{355.0} = 9.06 \therefore \phi 0 \text{ Σεχτιον ισ Χομπαχτ}$$

Μαφop Aξιo:

$$\Lambda_\beta \leq L_c \therefore \phi 0 \quad \Phi_\beta = 0.66 \cdot F_y = 0.66 \cdot 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.75 \cdot F_y = 0.75 \cdot 355.0 = 266.25 \text{ MPa}$$

Design Member 14, EQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 23.68 \leq 234.3 \text{ OK } 90\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 23.68 \leq 234.3 \text{ OK } 90\% \text{ under}$$

Design Member 14, EQUAL LOAD, Major Shear

$$f_v \leq F_v, 22.5 \leq 142.0 \text{ OK } 84\% \text{ under}$$

Design Member 14, EQUAL LOAD, Major Deflection

$$\delta \leq L/250, 0.78 \leq 3.2 \text{ mm OK } 76\% \text{ under}$$

Design Member 14, EQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 0.84 \leq 266.25 \text{ OK } 100\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 0.84 \leq 266.25 \text{ OK } 100\% \text{ under}$$

Design Member 14, EQUAL LOAD, Minor Shear

$$f_v \leq F_v, 0.07 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 14, EQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 0.01 \leq 3.2 \text{ mm OK } 100\% \text{ under}$$

Design Member 14, EQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 19.09 \leq 213.0 \text{ OK } 91\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 19.09 \leq 245.0 \text{ OK } 92\% \text{ under}$$

Design Member 14, EQUAL LOAD, Slenderness

$$K_x \cdot L_x / r_x = 1.0 \cdot 800.0 / 136.65 = 5.85 \leq 300.0 \text{ OK } 98\% \text{ under}$$

$$K_y \cdot L_y / r_y = 1.0 \cdot 800.0 / 77.98 = 10.26 \leq 300.0 \text{ OK } 97\% \text{ under}$$

Design Member 14, EQUAL LOAD, Compression

$$f_a \leq F_a, 0.0 \leq 207.46 \text{ OK } 100\% \text{ under}$$

Design Member 14, EQUAL LOAD, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 19.09 / 213.0 + 23.68 / 234.3 + 0.84 / 266.25 = 0.19 \leq 1 \text{ OK } 81\% \text{ under}$$

Design Member 14, EQUAL LOAD, Bending + Compression

$$f_a / F_a = 0.0 / 207.46 = 0.0 \leq 0.15 \therefore \phi 0$$

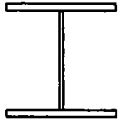
$$\phi_\alpha / \Phi_\alpha + \phi_{\beta x} / \Phi_{\beta x} + \phi_{\beta y} / \Phi_{\beta y} = 0.0 / 207.46 + 23.68 / 234.3 + 0.84 / 266.25 = 0.1 \leq 1 \text{ OK } 90\% \text{ under}$$

Design Member 14, EQUAL LOAD, Sway

$$\Delta \leq Y/300.0, 0.63 \leq 800.0/300.0 = 2.67 \text{ mm OK } 76\% \text{ under}$$

Checking design member 16

Members: 16
Group: W
Section: W12x87



Load Case: EQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 \cdot F_y = 0.6 \cdot 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 \cdot F_u = 0.5 \cdot 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 \cdot F_y = 0.4 \cdot 355.0 = 142.0 \text{ MPa}$$

$$KL/r = \max(K_x \cdot L_x / r_x, K_y \cdot L_y / r_y) = \max(1.0 \cdot 2000.0 / 136.65, 1.0 \cdot 2000.0 / 77.98) = 25.65$$

$$F_a = (1 - (KL/r)^2 / (2 \cdot C_c^2)) \cdot F_y / FS = (1 - 25.65^2 / (2 \cdot 105.44^2)) \cdot 355.0 / 1.76 = 196.17 \text{ MPa}$$

$$b/t = 153.67 / 20.57 = 7.47 \leq 65 / \sqrt{F_y} = 65 / \sqrt{355.0} = 9.06 \therefore \phi 0 \text{ Σελχιον ις Χομπαχτ}$$

Μαφop Aξισ:

$$\Lambda_\beta \leq L_c \therefore \phi 0 \quad \Phi_\beta = 0.66 \cdot F_y = 0.66 \cdot 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.75 \cdot F_y = 0.75 \cdot 355.0 = 266.25 \text{ MPa}$$

Design Member 16, EQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 21.97 \leq 234.3 \text{ OK } 91\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 21.97 \leq 234.3 \text{ OK } 91\% \text{ under}$$

Design Member 16, EQUAL LOAD, Major Shear

$$f_v \leq F_v, 2.81 \leq 142.0 \text{ OK } 98\% \text{ under}$$

Design Member 16, EQUAL LOAD, Major Deflection

$$\delta \leq L/250, 0.87 \leq 8.0 \text{ mm OK } 89\% \text{ under}$$

Design Member 16, EQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 7.09 \leq 266.25 \text{ OK } 97\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 7.09 \leq 266.25 \text{ OK } 97\% \text{ under}$$

Design Member 16, EQUAL LOAD, Minor Shear

$$f_v \leq F_v, 0.02 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 16, EQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 0.43 \leq 8.0 \text{ mm OK } 95\% \text{ under}$$

Design Member 16, EQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 0.0 \leq 213.0 \text{ OK } 100\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 0.0 \leq 245.0 \text{ OK } 100\% \text{ under}$$

Design Member 16, EQUAL LOAD, Slenderness

$$K_x \cdot L_x / r_x = 1.0 \cdot 2000.0 / 136.65 = 14.64 \leq 200.0 \text{ OK } 93\% \text{ under}$$

$$K_y \cdot L_y / r_y = 1.0 \cdot 2000.0 / 77.98 = 25.65 \leq 200.0 \text{ OK } 87\% \text{ under}$$

Design Member 16, EQUAL LOAD, Compression

$$f_a \leq F_a, 63.45 \leq 196.17 \text{ OK } 68\% \text{ under}$$

Design Member 16, EQUAL LOAD, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 0.0 / 245.0 + 21.97 / 234.3 + 7.09 / 266.25 = 0.12 \leq 1 \text{ OK } 88\% \text{ under}$$

Design Member 16, EQUAL LOAD, Bending + Compression

$$\text{Axial Ratio} = f_a / F_a = 63.45 / 196.17 = 0.32$$

$$\text{Major Ratio} = C_m \cdot f_{bx} / ((1 - f_a / F'_{ex}) \cdot F_{bx}) = 0.85 \cdot 21.97 / ((1 - 63.45 / 4806.82) \cdot 234.3) = 0.08$$

$$\text{Minor Ratio} = C_m \cdot f_{by} / ((1 - f_a / F'_{ey}) \cdot F_{by}) = 0.85 \cdot 7.09 / ((1 - 63.45 / 1565.2) \cdot 266.25) = 0.02$$

$$\text{Axial Ratio} + \text{Major Ratio} + \text{Minor Ratio} = 0.32 + 0.08 + 0.02 = 0.43 \leq 1 \text{ OK } 57\% \text{ under}$$

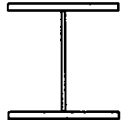
$$f_a / (0.6 \cdot F_y) + f_{bx} / F_{bx} + f_{by} / F_{by} = 63.45 / (0.6 \cdot 355.0) + 21.97 / 234.3 + 7.09 / 266.25 = 0.42 \geq 1 \text{ OK } 58\% \text{ under}$$

Design Member 16, EQUAL LOAD, Sway

$$\Delta \leq Y/300.0, 0.43 \leq 800.0/300.0 = 2.67 \text{ mm OK } 84\% \text{ under}$$

Checking design member 18

Members: 18
Group: W
Section: W12x87



Load Case: EQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 \cdot F_y = 0.6 \cdot 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 \cdot F_u = 0.5 \cdot 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 \cdot F_y = 0.4 \cdot 355.0 = 142.0 \text{ MPa}$$

$$KL/r = \max(K_x \cdot l/r_x, K_y \cdot l/r_y) = \max(1.0 \cdot 2816.03/136.65, 1.0 \cdot 2816.03/77.98) = 36.11$$

$$F_a = (1 - (KL/r)^2 / (2 \cdot C_c^2)) \cdot F_y / FS = (1 - 36.11^2 / (2 \cdot 105.44^2)) \cdot 355.0 / 1.79 = 186.68 \text{ MPa}$$

$$b/t = 153.67/20.57 = 7.47 \leq 65/\sqrt{F_y} = 65/\sqrt{355.0} = 9.06 \quad \therefore \phi 0 \text{ Σεχτιον ισ Χομπαχτ}$$

Μαφop Αξισ:

$$\Lambda_\beta \leq L_c \quad \therefore \phi 0 \quad \Phi_\beta = 0.66 \cdot F_y = 0.66 \cdot 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.75 \cdot F_y = 0.75 \cdot 355.0 = 266.25 \text{ MPa}$$

Design Member 18, EQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 36.9 \leq 234.3 \text{ OK } 84\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 36.9 \leq 234.3 \text{ OK } 84\% \text{ under}$$

Design Member 18, EQUAL LOAD, Major Shear

$$f_v \leq F_v, 6.13 \leq 142.0 \text{ OK } 96\% \text{ under}$$

Design Member 18, EQUAL LOAD, Major Deflection

$$\delta \leq L/250, 5.87 \leq 11.26 \text{ mm OK } 48\% \text{ under}$$

Design Member 18, EQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 14.91 \leq 266.25 \text{ OK } 94\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 14.91 \leq 266.25 \text{ OK } 94\% \text{ under}$$

Design Member 18, EQUAL LOAD, Minor Shear

$$f_v \leq F_v, 0.35 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 18, EQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 0.22 \leq 11.26 \text{ mm OK } 98\% \text{ under}$$

Design Member 18, EQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 0.0 \leq 213.0 \text{ OK } 100\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 0.0 \leq 245.0 \text{ OK } 100\% \text{ under}$$

Design Member 18, EQUAL LOAD, Slenderness

$$K_x \cdot L_x / r_x = 1.0 \cdot 2816.03/136.65 = 20.61 \leq 200.0 \text{ OK } 90\% \text{ under}$$

$$K_y \cdot L_y / r_y = 1.0 \cdot 2816.03/77.98 = 36.11 \leq 200.0 \text{ OK } 82\% \text{ under}$$

Design Member 18, EQUAL LOAD, Compression

$$f_a \leq F_a, 58.81 \leq 186.68 \text{ OK } 68\% \text{ under}$$

Design Member 18, EQUAL LOAD, Bending + Tension

$$f_a/F_t + f_{bx}/F_{bx} + f_{by}/F_{by} = 0.0/245.0 + 36.9/234.3 + 14.91/266.25 = 0.21 \leq 1 \text{ OK } 79\% \text{ under}$$

Design Member 18, EQUAL LOAD, Bending + Compression

$$\text{Axial Ratio} = f_a/F_a = 58.81/186.68 = 0.32$$

$$\text{Major Ratio} = C_{mx} \cdot f_{bx} / ((1 - f_a/F'_{ex}) \cdot F_{bx}) = 0.85 \cdot 36.9 / ((1 - 58.81/2424.62) \cdot 234.3) = 0.14$$

$$\text{Minor Ratio} = C_{my} \cdot f_{by} / ((1 - f_a/F'_{ey}) \cdot F_{by}) = 0.85 \cdot 14.91 / ((1 - 58.81/789.51) \cdot 266.25) = 0.05$$

$$\text{Axial Ratio} + \text{Major Ratio} + \text{Minor Ratio} = 0.32 + 0.14 + 0.05 = 0.5 \leq 1 \text{ OK } 50\% \text{ under}$$

$$f_a/(0.6 \cdot F_y) + f_{bx}/F_{bx} + f_{by}/F_{by} = 58.81/(0.6 \cdot 355.0) + 36.9/234.3 + 14.91/266.25 = 0.49 \leq 1 \text{ OK } 51\% \text{ under}$$

Design Member 18, EQUAL LOAD, Sway

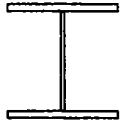
$$\Delta \leq Y/300.0, 0.63 \leq 800.0/300.0 = 2.67 \text{ mm OK } 76\% \text{ under}$$

Checking design member 20

Members: 20

Group: W

Section: W12x87



Load Case: EQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 \cdot F_y = 0.6 \cdot 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 \cdot F_u = 0.5 \cdot 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 \cdot F_y = 0.4 \cdot 355.0 = 142.0 \text{ MPa}$$

$$KL/r = \max(K_x \cdot L/r_x, K_y \cdot L/r_y) = \max(1.0 \cdot 1350.0/136.65, 1.0 \cdot 1350.0/77.98) = 17.31$$

$$F_a = (1 - (KL/r)^2 / (2 \cdot C_c^2)) \cdot F_y / F_S = (1 - 17.31^2 / (2 \cdot 105.44^2)) \cdot 355.0 / 1.73 = 202.71 \text{ MPa}$$

$$b/t = 153.67/20.57 = 7.47 \leq 65/\sqrt{F_y} = 65/\sqrt{355.0} = 9.06 \therefore \phi 0 \text{ Σεχτιον ισ Χομπαχτ}$$

Μαφop Aξιo:

$$\Lambda_\beta \leq L_c \therefore \phi 0 \quad \Phi_\beta = 0.66 \cdot F_y = 0.66 \cdot 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.75 \cdot F_y = 0.75 \cdot 355.0 = 266.25 \text{ MPa}$$

Design Member 20, EQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 1.14 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 1.14 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Design Member 20, EQUAL LOAD, Major Shear

$$f_v \leq F_v, 0.78 \leq 142.0 \text{ OK } 99\% \text{ under}$$

Design Member 20, EQUAL LOAD, Major Deflection

$$\delta \leq L/250, 0.01 \leq 5.4 \text{ mm OK } 100\% \text{ under}$$

Design Member 20, EQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 41.56 \leq 266.25 \text{ OK } 84\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 41.56 \leq 266.25 \text{ OK } 84\% \text{ under}$$

Design Member 20, EQUAL LOAD, Minor Shear

$$f_v \leq F_v, 2.4 \leq 142.0 \text{ OK } 98\% \text{ under}$$

Design Member 20, EQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 0.61 \leq 5.4 \text{ mm OK } 89\% \text{ under}$$

Design Member 20, EQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 0.21 \leq 213.0 \text{ OK } 100\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 0.21 \leq 245.0 \text{ OK } 100\% \text{ under}$$

Design Member 20, EQUAL LOAD, Slenderness

$$K_x \cdot L_x / r_x = 1.0 \cdot 1350.0 / 136.65 = 9.88 \leq 300.0 \text{ OK } 97\% \text{ under}$$

$$K_y \cdot L_y / r_y = 1.0 \cdot 1350.0 / 77.98 = 17.31 \leq 300.0 \text{ OK } 94\% \text{ under}$$

Design Member 20, EQUAL LOAD, Compression

$$f_a \leq F_a, 0.0 \leq 202.71 \text{ OK } 100\% \text{ under}$$

Design Member 20, EQUAL LOAD, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 0.21 / 213.0 + 1.14 / 234.3 + 41.56 / 266.25 = 0.16 \leq 1 \text{ OK } 84\% \text{ under}$$

Design Member 20, EQUAL LOAD, Bending + Compression

$$f_a / F_a = 0.0 / 202.71 = 0.0 \leq 0.15 \therefore \phi 0$$

$$\phi_\alpha / \Phi_\alpha + \phi_{\beta x} / \Phi_{\beta x} + \phi_{\beta y} / \Phi_{\beta y} = 0.0 / 202.71 + 1.14 / 234.3 + 41.56 / 266.25 = 0.16 \leq 1 \text{ OK } 84\% \text{ under}$$

Design Member 20, EQUAL LOAD, Sway

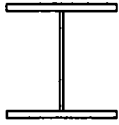
$$\Delta \leq Y/300.0, 0.63 \leq 800.0/300.0 = 2.67 \text{ mm OK } 76\% \text{ under}$$

Checking design member 22

Members: 22

Group: W

Section: W12x87



Load Case: EQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 \cdot F_y = 0.6 \cdot 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 \cdot F_u = 0.5 \cdot 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 \cdot F_y = 0.4 \cdot 355.0 = 142.0 \text{ MPa}$$

$$Kl/r = \max(K_x \cdot l/r_x, K_y \cdot l/r_y) = \max(1.0 \cdot 1350.0/136.65, 1.0 \cdot 1350.0/77.98) = 17.31$$

$$F_a = (1 - (Kl/r)^2 / (2 \cdot C_c^2)) \cdot F_y / FS = (1 - 17.31^2 / (2 \cdot 105.44^2)) \cdot 355.0 / 1.73 = 202.71 \text{ MPa}$$

$$b/t = 153.67/20.57 = 7.47 \leq 65/\sqrt{F_y} = 65/\sqrt{355.0} = 9.06 \therefore \phi 0 \text{ Σεχτιον ις Χομπαχτ}$$

Μαφop Aξισ:

$$\Lambda_\beta \leq L_c \therefore \phi 0 \quad \Phi_\beta = 0.66 \cdot F_y = 0.66 \cdot 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.75 \cdot F_y = 0.75 \cdot 355.0 = 266.25 \text{ MPa}$$

Design Member 22, EQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 1.14 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 1.14 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Design Member 22, EQUAL LOAD, Major Shear

$$f_v \leq F_v, 0.78 \leq 142.0 \text{ OK } 99\% \text{ under}$$

Design Member 22, EQUAL LOAD, Major Deflection

$$\delta \leq L/250, 0.01 \leq 5.4 \text{ mm OK } 100\% \text{ under}$$

Design Member 22, EQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 41.56 \leq 266.25 \text{ OK } 84\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 41.56 \leq 266.25 \text{ OK } 84\% \text{ under}$$

Design Member 22, EQUAL LOAD, Minor Shear

$$f_v \leq F_v, 2.4 \leq 142.0 \text{ OK } 98\% \text{ under}$$

Design Member 22, EQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 0.61 \leq 5.4 \text{ mm OK } 89\% \text{ under}$$

Design Member 22, EQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 0.21 \leq 213.0 \text{ OK } 100\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 0.21 \leq 245.0 \text{ OK } 100\% \text{ under}$$

Design Member 22, EQUAL LOAD, Slenderness

$$K_x \cdot L_x / r_x = 1.0 \cdot 1350.0 / 136.65 = 9.88 \leq 300.0 \text{ OK } 97\% \text{ under}$$

$$K_y \cdot L_y / r_y = 1.0 \cdot 1350.0 / 77.98 = 17.31 \leq 300.0 \text{ OK } 94\% \text{ under}$$

Design Member 22, EQUAL LOAD, Compression

$$f_a \leq F_a, 0.0 \leq 202.71 \text{ OK } 100\% \text{ under}$$

Design Member 22, EQUAL LOAD, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 0.21 / 213.0 + 1.14 / 234.3 + 41.56 / 266.25 = 0.16 \leq 1 \text{ OK } 84\% \text{ under}$$

Design Member 22, EQUAL LOAD, Bending + Compression

$$f_a / F_a = 0.0 / 202.71 = 0.0 \leq 0.15 \therefore \phi 0$$

$$\phi_\alpha / \Phi_\alpha + \phi_{\beta\xi} / \Phi_{\beta\xi} + \phi_{\beta\psi} / \Phi_{\beta\psi} = 0.0 / 202.71 + 1.14 / 234.3 + 41.56 / 266.25 = 0.16 \leq 1 \text{ OK } 84\% \text{ under}$$

Design Member 22, EQUAL LOAD, Sway

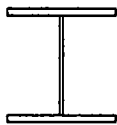
$$\Delta \leq Y/300.0, 0.63 \leq 800.0/300.0 = 2.67 \text{ mm OK } 76\% \text{ under}$$

Checking design member 24

Members: 24

Group: W

Section: W12x87



Load Case: EQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 * F_y = 0.6 * 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 * F_u = 0.5 * 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 * F_y = 0.4 * 355.0 = 142.0 \text{ MPa}$$

$$Kl/r = \max(K_x * l/r_x, K_y * l/r_y) = \max(1.0 * 2000.0 / 136.65, 1.0 * 2000.0 / 77.98) = 25.65$$

$$F_a = (1 - (Kl/r)^2 / (2 * Cc^2)) * F_y / FS = (1 - 25.65^2 / (2 * 105.44^2)) * 355.0 / 1.76 = 196.17 \text{ MPa}$$

$$b/t = 153.67 / 20.57 = 7.47 \leq 65 / \sqrt{F_y} = 65 / \sqrt{355.0} = 9.06 \therefore \phi 0 \text{ Σεχτιον ις Χομπαχτ}$$

Μαφορ Αξισ:

$$\Lambda_\beta \leq L_c \therefore \phi 0 \quad \Phi_\beta = 0.66 * F_y = 0.66 * 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.75 * F_y = 0.75 * 355.0 = 266.25 \text{ MPa}$$

Design Member 24, EQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 21.97 \leq 234.3 \text{ OK } 91\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 21.97 \leq 234.3 \text{ OK } 91\% \text{ under}$$

Design Member 24, EQUAL LOAD, Major Shear

$$f_v \leq F_v, 2.81 \leq 142.0 \text{ OK } 98\% \text{ under}$$

Design Member 24, EQUAL LOAD, Major Deflection

$$\delta \leq L/250, 0.87 \leq 8.0 \text{ mm OK } 89\% \text{ under}$$

Design Member 24, EQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 7.09 \leq 266.25 \text{ OK } 97\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 7.09 \leq 266.25 \text{ OK } 97\% \text{ under}$$

Design Member 24, EQUAL LOAD, Minor Shear

$$f_v \leq F_v, 0.02 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 24, EQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 0.43 \leq 8.0 \text{ mm OK } 95\% \text{ under}$$

Design Member 24, EQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 0.0 \leq 213.0 \text{ OK } 100\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 0.0 \leq 245.0 \text{ OK } 100\% \text{ under}$$

Design Member 24, EQUAL LOAD, Slenderness

$$K_x * L_x / r_x = 1.0 * 2000.0 / 136.65 = 14.64 \leq 200.0 \text{ OK } 93\% \text{ under}$$

$$K_y * L_y / r_y = 1.0 * 2000.0 / 77.98 = 25.65 \leq 200.0 \text{ OK } 87\% \text{ under}$$

Design Member 24, EQUAL LOAD, Compression

$$f_a \leq F_a, 63.45 \leq 196.17 \text{ OK } 68\% \text{ under}$$

Design Member 24, EQUAL LOAD, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 0.0 / 245.0 + 21.97 / 234.3 + 7.09 / 266.25 = 0.12 \leq 1 \text{ OK } 88\% \text{ under}$$

Design Member 24, EQUAL LOAD, Bending + Compression

$$\text{Axial Ratio} = f_a / F_a = 63.45 / 196.17 = 0.32$$

$$\text{Major Ratio} = C_{mx} * f_{bx} / ((1 - f_a / F'_{ex}) * F_{bx}) = 0.85 * 21.97 / ((1 - 63.45 / 4806.82) * 234.3) = 0.08$$

$$\text{Minor Ratio} = C_{my} * f_{by} / ((1 - f_a / F'_{ey}) * F_{by}) = 0.85 * 7.09 / ((1 - 63.45 / 1565.2) * 266.25) = 0.02$$

$$\text{Axial Ratio} + \text{Major Ratio} + \text{Minor Ratio} = 0.32 + 0.08 + 0.02 = 0.43 \leq 1 \text{ OK } 57\% \text{ under}$$

$$f_a / (0.6 * F_y) + f_{bx} / F_{bx} + f_{by} / F_{by} = 63.45 / (0.6 * 355.0) + 21.97 / 234.3 + 7.09 / 266.25 = 0.42 \leq 1 \text{ OK } 58\% \text{ under}$$

Design Member 24, EQUAL LOAD, Sway

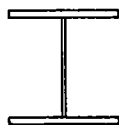
$$\Delta \leq Y/300.0, 0.43 \leq 800.0/300.0 = 2.67 \text{ mm OK } 84\% \text{ under}$$

Checking design member 26

Members: 26

Group: W

Section: W12x87



Load Case: EQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 \cdot F_y = 0.6 \cdot 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 \cdot F_u = 0.5 \cdot 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 \cdot F_y = 0.4 \cdot 355.0 = 142.0 \text{ MPa}$$

$$Kl/r = \max(K_x \cdot l/r_x, K_y \cdot l/r_y) = \max(1.0 \cdot 2816.03/136.65, 1.0 \cdot 2816.03/77.98) = 36.11$$

$$F_a = (1 - (Kl/r)^2 / (2 \cdot C_c^2)) \cdot F_y / FS = (1 - 36.11^2 / (2 \cdot 105.44^2)) \cdot 355.0 / 1.79 = 186.68 \text{ MPa}$$

$$b/t = 153.67/20.57 = 7.47 \leq 65/\sqrt{F_y} = 65/\sqrt{355.0} = 9.06 \therefore \phi 0 \text{ Σεχτιον ις Χομπαχτ}$$

Μαφορ Αξισ:

$$\Lambda_\beta \leq L_c \therefore \phi 0 \quad \Phi_\beta = 0.66 \cdot F_y = 0.66 \cdot 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.75 \cdot F_y = 0.75 \cdot 355.0 = 266.25 \text{ MPa}$$

Design Member 26, EQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 36.9 \leq 234.3 \text{ OK } 84\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 36.9 \leq 234.3 \text{ OK } 84\% \text{ under}$$

Design Member 26, EQUAL LOAD, Major Shear

$$f_v \leq F_v, 6.13 \leq 142.0 \text{ OK } 96\% \text{ under}$$

Design Member 26, EQUAL LOAD, Major Deflection

$$\delta \leq L/250, 5.87 \leq 11.26 \text{ mm OK } 48\% \text{ under}$$

Design Member 26, EQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 14.91 \leq 266.25 \text{ OK } 94\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 14.91 \leq 266.25 \text{ OK } 94\% \text{ under}$$

Design Member 26, EQUAL LOAD, Minor Shear

$$f_v \leq F_v, 0.35 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 26, EQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 0.22 \leq 11.26 \text{ mm OK } 98\% \text{ under}$$

Design Member 26, EQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 0.0 \leq 213.0 \text{ OK } 100\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 0.0 \leq 245.0 \text{ OK } 100\% \text{ under}$$

Design Member 26, EQUAL LOAD, Slenderness

$$K_x \cdot L_x / r_x = 1.0 \cdot 2816.03/136.65 = 20.61 \leq 200.0 \text{ OK } 90\% \text{ under}$$

$$K_y \cdot L_y / r_y = 1.0 \cdot 2816.03/77.98 = 36.11 \leq 200.0 \text{ OK } 82\% \text{ under}$$

Design Member 26, EQUAL LOAD, Compression

$$f_a \leq F_a, 58.81 \leq 186.68 \text{ OK } 68\% \text{ under}$$

Design Member 26, EQUAL LOAD, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 0.0/245.0 + 36.9/234.3 + 14.91/266.25 = 0.21 \leq 1 \text{ OK } 79\% \text{ under}$$

Design Member 26, EQUAL LOAD, Bending + Compression

$$\text{Axial Ratio} = f_a / F_a = 58.81/186.68 = 0.32$$

$$\text{Major Ratio} = C_m \cdot x \cdot f_{bx} / ((1 - f_a / F'_{ex}) \cdot F_{bx}) = 0.85 \cdot 36.9 / ((1 - 58.81/2424.62) \cdot 234.3) = 0.14$$

$$\text{Minor Ratio} = C_m \cdot y \cdot f_{by} / ((1 - f_a / F'_{ey}) \cdot F_{by}) = 0.85 \cdot 14.91 / ((1 - 58.81/789.51) \cdot 266.25) = 0.05$$

$$\text{Axial Ratio} + \text{Major Ratio} + \text{Minor Ratio} = 0.32 + 0.14 + 0.05 = 0.5 \leq 1 \text{ OK } 50\% \text{ under}$$

$$f_a / (0.6 \cdot F_y) + f_{bx} / F_{bx} + f_{by} / F_{by} = 58.81 / (0.6 \cdot 355.0) + 36.9/234.3 + 14.91/266.25 = 0.49 \geq 1 \text{ OK } 51\% \text{ under}$$

Design Member 26, EQUAL LOAD, Sway

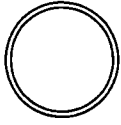
$$\Delta \leq Y/300.0, 0.63 \leq 800.0/300.0 = 2.67 \text{ mm OK } 76\% \text{ under}$$

Checking design member 28

Members: 28

Group: Custom2

Section: CHS 114.3 x 6



Load Case: EQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 * F_y = 0.6 * 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 * F_u = 0.5 * 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 * F_y = 0.4 * 355.0 = 142.0 \text{ MPa}$$

$$K_l/r = \max(K_x * l/r_x, K_y * l/r_y) = \max(1.0 * 3122.9/38.35, 1.0 * 3122.9/38.35) = 81.43$$

$$F_a = (1 - (K_l/r)^2 / (2 * C_c^2)) * F_y / F_S = (1 - 81.43^2 / (2 * 108.06^2)) * 355.0 / 1.9 = 134.08 \text{ MPa}$$

Major Axis:

$$F_b = 0.66 * F_y = 0.66 * 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.66 * F_y = 0.66 * 355.0 = 234.3 \text{ MPa}$$

Design Member 28, EQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 3.82 \leq 234.3 \text{ OK } 98\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 3.82 \leq 234.3 \text{ OK } 98\% \text{ under}$$

Design Member 28, EQUAL LOAD, Major Shear

$$f_v \leq F_v, 0.02 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 28, EQUAL LOAD, Major Deflection

$$\delta \leq L/250, 5.99 \leq 12.49 \text{ mm OK } 52\% \text{ under}$$

Design Member 28, EQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 0.6 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 0.6 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Design Member 28, EQUAL LOAD, Minor Shear

$$f_v \leq F_v, 0.01 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 28, EQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 0.75 \leq 12.49 \text{ mm OK } 94\% \text{ under}$$

Design Member 28, EQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 0.0 \leq 213.0 \text{ OK } 100\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 0.0 \leq 245.0 \text{ OK } 100\% \text{ under}$$

Design Member 28, EQUAL LOAD, Slenderness

$$K_x * L_x / r_x = 1.0 * 3122.9/38.35 = 81.43 \leq 200.0 \text{ OK } 59\% \text{ under}$$

$$K_y * L_y / r_y = 1.0 * 3122.9/38.35 = 81.43 \leq 200.0 \text{ OK } 59\% \text{ under}$$

Design Member 28, EQUAL LOAD, Compression

$$f_a \leq F_a, 17.45 \leq 134.08 \text{ OK } 87\% \text{ under}$$

Design Member 28, EQUAL LOAD, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 0.0/245.0 + 3.82/234.3 + 0.6/234.3 = 0.02 \leq 1 \text{ OK } 98\% \text{ under}$$

Design Member 28, EQUAL LOAD, Bending + Compression

$$f_a / F_a = 17.45/134.08 = 0.13 \leq 0.15 \therefore \phi 0$$

$$\phi_\alpha / \Phi_\alpha + \phi_{\beta_x} / \Phi_{\beta_x} + \phi_{\beta_y} / \Phi_{\beta_y} = 17.45/134.08 + 3.82/234.3 + 0.6/234.3 = 0.15 \leq 1 \text{ OK } 85\% \text{ under}$$

Design Member 28, EQUAL LOAD, Sway

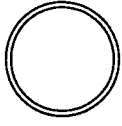
$$\Delta \leq Y/300.0, 1.24 \leq 800.0/300.0 = 2.67 \text{ mm OK } 53\% \text{ under}$$

Checking design member 30

Members: 30

Group: Custom2

Section: CHS 114.3 x 6



Load Case: EQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 * F_y = 0.6 * 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 * F_u = 0.5 * 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 * F_y = 0.4 * 355.0 = 142.0 \text{ MPa}$$

$$KL/r = \max(K_x * l/r_x, K_y * l/r_y) = \max(1.0 * 1569.24/38.35, 1.0 * 1569.24/38.35) = 40.92$$

$$F_a = (1 - (KL/r)^2 / (2 * C_c^2)) * F_y / FS = (1 - 40.92^2 / (2 * 108.06^2)) * 355.0 / 1.8 = 182.89 \text{ MPa}$$

Major Axis:

$$F_b = 0.66 * F_y = 0.66 * 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.66 * F_y = 0.66 * 355.0 = 234.3 \text{ MPa}$$

Design Member 30, EQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 2.13 \leq 234.3 \text{ OK } 99\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 2.13 \leq 234.3 \text{ OK } 99\% \text{ under}$$

Design Member 30, EQUAL LOAD, Major Shear

$$f_v \leq F_v, 0.11 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 30, EQUAL LOAD, Major Deflection

$$\delta \leq L/250, 0.08 \leq 6.28 \text{ mm OK } 99\% \text{ under}$$

Design Member 30, EQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 8.22 \leq 234.3 \text{ OK } 96\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 8.22 \leq 234.3 \text{ OK } 96\% \text{ under}$$

Design Member 30, EQUAL LOAD, Minor Shear

$$f_v \leq F_v, 0.33 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 30, EQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 1.39 \leq 6.28 \text{ mm OK } 78\% \text{ under}$$

Design Member 30, EQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 5.51 \leq 213.0 \text{ OK } 97\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 5.51 \leq 245.0 \text{ OK } 98\% \text{ under}$$

Design Member 30, EQUAL LOAD, Slenderness

$$K_x * L_x / r_x = 1.0 * 1569.24/38.35 = 40.92 \leq 300.0 \text{ OK } 86\% \text{ under}$$

$$K_y * L_y / r_y = 1.0 * 1569.24/38.35 = 40.92 \leq 300.0 \text{ OK } 86\% \text{ under}$$

Design Member 30, EQUAL LOAD, Compression

$$f_a \leq F_a, 0.0 \leq 182.89 \text{ OK } 100\% \text{ under}$$

Design Member 30, EQUAL LOAD, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 5.51/213.0 + 2.13/234.3 + 8.22/234.3 = 0.07 \leq 1 \text{ OK } 93\% \text{ under}$$

Design Member 30, EQUAL LOAD, Bending + Compression

$$f_a / F_a = 0.0/182.89 = 0.0 \leq 0.15 \therefore \phi 0$$

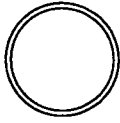
$$\phi_\alpha / \Phi_\alpha + \phi_{\beta x} / \Phi_{\beta x} + \phi_{\beta y} / \Phi_{\beta y} = 0.0/182.89 + 2.13/234.3 + 8.22/234.3 = 0.04 \leq 1 \text{ OK } 96\% \text{ under}$$

Design Member 30, EQUAL LOAD, Sway

$$\Delta \leq Y/300.0, 1.24 \leq 800.0/300.0 = 2.67 \text{ mm OK } 53\% \text{ under}$$

Checking design member 32

Members: 32
Group: Custom2
Section: CHS 114.3 x 6



Load Case: EQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 * F_y = 0.6 * 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 * F_u = 0.5 * 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 * F_y = 0.4 * 355.0 = 142.0 \text{ MPa}$$

$$K_l/r = \max(K_x * l/r_x, K_y * l/r_y) = \max(1.0 * 2154.07/38.35, 1.0 * 2154.07/38.35) = 56.17$$

$$F_a = (1 - (K_l/r)^2 / (2 * C_c^2)) * F_y / F_s = (1 - 56.17^2 / (2 * 108.06^2)) * 355.0 / 1.84 = 166.5 \text{ MPa}$$

Major Axis:

$$F_b = 0.66 * F_y = 0.66 * 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.66 * F_y = 0.66 * 355.0 = 234.3 \text{ MPa}$$

Design Member 32, EQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 12.41 \leq 234.3 \text{ OK } 95\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 12.41 \leq 234.3 \text{ OK } 95\% \text{ under}$$

Design Member 32, EQUAL LOAD, Major Shear

$$f_v \leq F_v, 0.25 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 32, EQUAL LOAD, Major Deflection

$$\delta \leq L/250, 0.79 \leq 8.62 \text{ mm OK } 91\% \text{ under}$$

Design Member 32, EQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 4.48 \leq 234.3 \text{ OK } 98\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 4.48 \leq 234.3 \text{ OK } 98\% \text{ under}$$

Design Member 32, EQUAL LOAD, Minor Shear

$$f_v \leq F_v, 0.17 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 32, EQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 0.44 \leq 8.62 \text{ mm OK } 95\% \text{ under}$$

Design Member 32, EQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 0.0 \leq 213.0 \text{ OK } 100\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 0.0 \leq 245.0 \text{ OK } 100\% \text{ under}$$

Design Member 32, EQUAL LOAD, Slenderness

$$K_x * L_x / r_x = 1.0 * 2154.07/38.35 = 56.17 \leq 200.0 \text{ OK } 72\% \text{ under}$$

$$K_y * L_y / r_y = 1.0 * 2154.07/38.35 = 56.17 \leq 200.0 \text{ OK } 72\% \text{ under}$$

Design Member 32, EQUAL LOAD, Compression

$$f_a \leq F_a, 15.77 \leq 166.5 \text{ OK } 91\% \text{ under}$$

Design Member 32, EQUAL LOAD, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 0.0 / 245.0 + 12.41 / 234.3 + 4.48 / 234.3 = 0.07 \leq 1 \text{ OK } 93\% \text{ under}$$

Design Member 32, EQUAL LOAD, Bending + Compression

$$f_a / F_a = 15.77 / 166.5 = 0.09 \leq 0.15 \therefore \phi 0$$

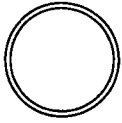
$$\phi_\alpha / \Phi_\alpha + \phi_{\beta_x} / \Phi_{\beta_x} + \phi_{\beta_y} / \Phi_{\beta_y} = 15.77 / 166.5 + 12.41 / 234.3 + 4.48 / 234.3 = 0.17 \leq 1 \text{ OK } 83\% \text{ under}$$

Design Member 32, EQUAL LOAD, Sway

$$\Delta \leq Y/300.0, 0.43 \leq 800.0/300.0 = 2.67 \text{ mm OK } 84\% \text{ under}$$

Checking design member 34

Members: 34
Group: Custom2
Section: CHS 114.3 x 6



Load Case: EQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 * F_y = 0.6 * 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 * F_u = 0.5 * 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 * F_y = 0.4 * 355.0 = 142.0 \text{ MPa}$$

$$Kl/r = \max(K_x * l/r_x, K_y * l/r_y) = \max(1.0 * 2154.07/38.35, 1.0 * 2154.07/38.35) = 56.17$$

$$F_a = (1 - (Kl/r)^2 / (2 * C_c^2)) * F_y / FS = (1 - 56.17^2 / (2 * 108.06^2)) * 355.0 / 1.84 = 166.5 \text{ MPa}$$

Major Axis:

$$F_b = 0.66 * F_y = 0.66 * 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.66 * F_y = 0.66 * 355.0 = 234.3 \text{ MPa}$$

Design Member 34, EQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 12.41 \leq 234.3 \text{ OK } 95\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 12.41 \leq 234.3 \text{ OK } 95\% \text{ under}$$

Design Member 34, EQUAL LOAD, Major Shear

$$f_v \leq F_v, 0.25 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 34, EQUAL LOAD, Major Deflection

$$\delta \leq L/250, 0.79 \leq 8.62 \text{ mm OK } 91\% \text{ under}$$

Design Member 34, EQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 4.48 \leq 234.3 \text{ OK } 98\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 4.48 \leq 234.3 \text{ OK } 98\% \text{ under}$$

Design Member 34, EQUAL LOAD, Minor Shear

$$f_v \leq F_v, 0.17 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 34, EQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 0.44 \leq 8.62 \text{ mm OK } 95\% \text{ under}$$

Design Member 34, EQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 0.0 \leq 213.0 \text{ OK } 100\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 0.0 \leq 245.0 \text{ OK } 100\% \text{ under}$$

Design Member 34, EQUAL LOAD, Slenderness

$$K_x * L_x / r_x = 1.0 * 2154.07/38.35 = 56.17 \leq 200.0 \text{ OK } 72\% \text{ under}$$

$$K_y * L_y / r_y = 1.0 * 2154.07/38.35 = 56.17 \leq 200.0 \text{ OK } 72\% \text{ under}$$

Design Member 34, EQUAL LOAD, Compression

$$f_a \leq F_a, 15.77 \leq 166.5 \text{ OK } 91\% \text{ under}$$

Design Member 34, EQUAL LOAD, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 0.0 / 245.0 + 12.41 / 234.3 + 4.48 / 234.3 = 0.07 \leq 1 \text{ OK } 93\% \text{ under}$$

Design Member 34, EQUAL LOAD, Bending + Compression

$$f_a / F_a = 15.77 / 166.5 = 0.09 \leq 0.15 \therefore \phi 0$$

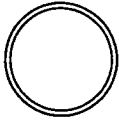
$$\phi_a / \Phi_a + \phi_{bx} / \Phi_{bx} + \phi_{by} / \Phi_{by} + \phi_{\psi} / \Phi_{\psi} = 15.77 / 166.5 + 12.41 / 234.3 + 4.48 / 234.3 = 0.17 \leq 1 \text{ OK } 83\% \text{ under}$$

Design Member 34, EQUAL LOAD, Sway

$$\Delta \leq Y/300.0, 0.43 \leq 800.0/300.0 = 2.67 \text{ mm OK } 84\% \text{ under}$$

Checking design member 36

Members: 36
Group: Custom2
Section: CHS 114.3 x 6



Load Case: EQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 * F_y = 0.6 * 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 * F_u = 0.5 * 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 * F_y = 0.4 * 355.0 = 142.0 \text{ MPa}$$

$$Kl/r = \max(K_x * l/r_x, K_y * l/r_y) = \max(1.0 * 1569.24/38.35, 1.0 * 1569.24/38.35) = 40.92$$

$$F_a = (1 - (Kl/r)^2 / (2 * C_c^2)) * F_y / FS = (1 - 40.92^2 / (2 * 108.06^2)) * 355.0 / 1.8 = 182.89 \text{ MPa}$$

Major Axis:

$$F_b = 0.66 * F_y = 0.66 * 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.66 * F_y = 0.66 * 355.0 = 234.3 \text{ MPa}$$

Design Member 36, EQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 2.13 \leq 234.3 \text{ OK } 99\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 2.13 \leq 234.3 \text{ OK } 99\% \text{ under}$$

Design Member 36, EQUAL LOAD, Major Shear

$$f_v \leq F_v, 0.11 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 36, EQUAL LOAD, Major Deflection

$$\delta \leq L/250, 0.08 \leq 6.28 \text{ mm OK } 99\% \text{ under}$$

Design Member 36, EQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 8.22 \leq 234.3 \text{ OK } 96\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 8.22 \leq 234.3 \text{ OK } 96\% \text{ under}$$

Design Member 36, EQUAL LOAD, Minor Shear

$$f_v \leq F_v, 0.33 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 36, EQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 1.39 \leq 6.28 \text{ mm OK } 78\% \text{ under}$$

Design Member 36, EQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 5.51 \leq 213.0 \text{ OK } 97\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 5.51 \leq 245.0 \text{ OK } 98\% \text{ under}$$

Design Member 36, EQUAL LOAD, Slenderness

$$K_x * L_x / r_x = 1.0 * 1569.24/38.35 = 40.92 \leq 300.0 \text{ OK } 86\% \text{ under}$$

$$K_y * L_y / r_y = 1.0 * 1569.24/38.35 = 40.92 \leq 300.0 \text{ OK } 86\% \text{ under}$$

Design Member 36, EQUAL LOAD, Compression

$$f_a \leq F_a, 0.0 \leq 182.89 \text{ OK } 100\% \text{ under}$$

Design Member 36, EQUAL LOAD, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 5.51/213.0 + 2.13/234.3 + 8.22/234.3 = 0.07 \leq 1 \text{ OK } 93\% \text{ under}$$

Design Member 36, EQUAL LOAD, Bending + Compression

$$f_a / F_a = 0.0/182.89 = 0.0 \leq 0.15 \therefore \phi 0$$

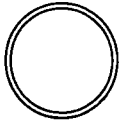
$$\phi_\alpha / \Phi_\alpha + \phi_{\beta_x} / \Phi_{\beta_x} + \phi_{\beta_y} / \Phi_{\beta_y} = 0.0/182.89 + 2.13/234.3 + 8.22/234.3 = 0.04 \leq 1 \text{ OK } 96\% \text{ under}$$

Design Member 36, EQUAL LOAD, Sway

$$\Delta \leq Y/300.0, 1.24 \leq 800.0/300.0 = 2.67 \text{ mm OK } 53\% \text{ under}$$

Checking design member 38

Members: 38
Group: Custom2
Section: CHS 114.3 x 6



Load Case: EQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 * F_y = 0.6 * 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 * F_u = 0.5 * 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 * F_y = 0.4 * 355.0 = 142.0 \text{ MPa}$$

$$Kl/r = \max(K_x * l/r_x, K_y * l/r_y) = \max(1.0 * 3122.9/38.35, 1.0 * 3122.9/38.35) = 81.43$$

$$F_a = (1 - (Kl/r)^2 / (2 * C_c^2)) * F_y / F_S = (1 - 81.43^2 / (2 * 108.06^2)) * 355.0 / 1.9 = 134.08 \text{ MPa}$$

Major Axis:

$$F_b = 0.66 * F_y = 0.66 * 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.66 * F_y = 0.66 * 355.0 = 234.3 \text{ MPa}$$

Design Member 38, EQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 3.82 \leq 234.3 \text{ OK } 98\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 3.82 \leq 234.3 \text{ OK } 98\% \text{ under}$$

Design Member 38, EQUAL LOAD, Major Shear

$$f_v \leq F_v, 0.02 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 38, EQUAL LOAD, Major Deflection

$$\delta \leq L/250, 5.99 \leq 12.49 \text{ mm OK } 52\% \text{ under}$$

Design Member 38, EQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 0.6 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 0.6 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Design Member 38, EQUAL LOAD, Minor Shear

$$f_v \leq F_v, 0.01 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 38, EQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 0.75 \leq 12.49 \text{ mm OK } 94\% \text{ under}$$

Design Member 38, EQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 0.0 \leq 213.0 \text{ OK } 100\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 0.0 \leq 245.0 \text{ OK } 100\% \text{ under}$$

Design Member 38, EQUAL LOAD, Slenderness

$$K_x * L_x / r_x = 1.0 * 3122.9/38.35 = 81.43 \leq 200.0 \text{ OK } 59\% \text{ under}$$

$$K_y * L_y / r_y = 1.0 * 3122.9/38.35 = 81.43 \leq 200.0 \text{ OK } 59\% \text{ under}$$

Design Member 38, EQUAL LOAD, Compression

$$f_a \leq F_a, 17.45 \leq 134.08 \text{ OK } 87\% \text{ under}$$

Design Member 38, EQUAL LOAD, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 0.0/245.0 + 3.82/234.3 + 0.6/234.3 = 0.02 \leq 1 \text{ OK } 98\% \text{ under}$$

Design Member 38, EQUAL LOAD, Bending + Compression

$$f_a / F_a = 17.45/134.08 = 0.13 \leq 0.15 \therefore \phi 0$$

$$\phi_\alpha / \Phi_\alpha + \phi_{\beta x} / \Phi_{\beta x} + \phi_{\beta y} / \Phi_{\beta y} = 17.45/134.08 + 3.82/234.3 + 0.6/234.3 = 0.15 \leq 1 \text{ OK } 85\% \text{ under}$$

Design Member 38, EQUAL LOAD, Sway

$$\Delta \leq Y/300.0, 1.24 \leq 800.0/300.0 = 2.67 \text{ mm OK } 53\% \text{ under}$$

End of check

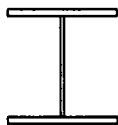
Steel Design Report

Checking design member 1

Members: 1

Group: W

Section: W12x87



Load Case: UNEQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 * F_y = 0.6 * 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 * F_u = 0.5 * 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 * F_y = 0.4 * 355.0 = 142.0 \text{ MPa}$$

$$Kl/r = \max(K_x * l/r_x, K_y * l/r_y) = \max(1.0 * 2700.0 / 136.65, 1.0 * 2700.0 / 77.98) = 34.63$$

$$F_a = (1 - (Kl/r)^2 / (2 * C_c^2)) * F_y / FS = (1 - 34.63^2 / (2 * 105.44^2)) * 355.0 / 1.79 = 188.12 \text{ MPa}$$

$$b/t = 153.67 / 20.57 = 7.47 \leq 65 / \sqrt{F_y} = 65 / \sqrt{355.0} = 9.06 \therefore \phi 0 \text{ Σεχτιον ισ Χομπαχτ}$$

Μαφop Aξισ:

$$\Lambda_\beta \leq L_c \therefore \phi 0 \quad \Phi_\beta = 0.66 * F_y = 0.66 * 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.75 * F_y = 0.75 * 355.0 = 266.25 \text{ MPa}$$

Design Member 1, UNEQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 43.52 \leq 234.3 \text{ OK } 81\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 43.52 \leq 234.3 \text{ OK } 81\% \text{ under}$$

Design Member 1, UNEQUAL LOAD, Major Shear

$$f_v \leq F_v, 8.46 \leq 142.0 \text{ OK } 94\% \text{ under}$$

Design Member 1, UNEQUAL LOAD, Major Deflection

$$\delta \leq L/250, 5.16 \leq 10.8 \text{ mm OK } 52\% \text{ under}$$

Design Member 1, UNEQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 25.29 \leq 266.25 \text{ OK } 91\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 25.29 \leq 266.25 \text{ OK } 91\% \text{ under}$$

Design Member 1, UNEQUAL LOAD, Minor Shear

$$f_v \leq F_v, 0.53 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 1, UNEQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 1.53 \leq 10.8 \text{ mm OK } 86\% \text{ under}$$

Design Member 1, UNEQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 12.09 \leq 213.0 \text{ OK } 94\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 12.09 \leq 245.0 \text{ OK } 95\% \text{ under}$$

Design Member 1, UNEQUAL LOAD, Slenderness

$$K_x * L_x / r_x = 1.0 * 2700.0 / 136.65 = 19.76 \leq 300.0 \text{ OK } 93\% \text{ under}$$

$$K_y * L_y / r_y = 1.0 * 2700.0 / 77.98 = 34.63 \leq 300.0 \text{ OK } 88\% \text{ under}$$

Design Member 1, UNEQUAL LOAD, Compression

$$f_a \leq F_a, 0.0 \leq 188.12 \text{ OK } 100\% \text{ under}$$

Design Member 1, UNEQUAL LOAD, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 12.09 / 213.0 + 43.52 / 234.3 + 25.29 / 266.25 = 0.34 \leq 1 \text{ OK } 66\% \text{ under}$$

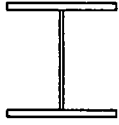
Design Member 1, UNEQUAL LOAD, Bending + Compression

$$f_a / F_a = 0.0 / 188.12 = 0.0 \leq 0.15 \therefore \phi 0$$

$$\phi_\alpha / \Phi_\alpha + \phi_{\beta x} / \Phi_{\beta x} + \phi_{\beta y} / \Phi_{\beta y} + \phi_{\beta w} / \Phi_{\beta w} = 0.0 / 188.12 + 43.52 / 234.3 + 25.29 / 266.25 = 0.28 \leq 1 \text{ OK } 72\% \text{ under}$$

Checking design member 3

Members: 3
Group: W
Section: W12x87



Load Case: UNEQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 \cdot F_y = 0.6 \cdot 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 \cdot F_u = 0.5 \cdot 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 \cdot F_y = 0.4 \cdot 355.0 = 142.0 \text{ MPa}$$

$$Kl/r = \max(K_x \cdot l/r_x, K_y \cdot l/r_y) = \max(1.0 \cdot 2700.0/136.65, 1.0 \cdot 2700.0/77.98) = 34.63$$

$$F_a = (1 - (Kl/r)^2 / (2 \cdot C_c^2)) \cdot F_y / FS = (1 - 34.63^2 / (2 \cdot 105.44^2)) \cdot 355.0 / 1.79 = 188.12 \text{ MPa}$$

$$b/t = 153.67/20.57 = 7.47 \leq 65/\sqrt{F_y} = 65/\sqrt{355.0} = 9.06 \therefore \phi 0 \text{ Σεχτιον ις Χομπαχτ}$$

Μαφop Aξισ:

$$\Lambda_\beta \leq L_c \therefore \phi 0 \quad \Phi_\beta = 0.66 \cdot F_y = 0.66 \cdot 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.75 \cdot F_y = 0.75 \cdot 355.0 = 266.25 \text{ MPa}$$

Design Member 3, UNEQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 48.18 \leq 234.3 \text{ OK } 79\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 48.18 \leq 234.3 \text{ OK } 79\% \text{ under}$$

Design Member 3, UNEQUAL LOAD, Major Shear

$$f_v \leq F_v, 9.42 \leq 142.0 \text{ OK } 93\% \text{ under}$$

Design Member 3, UNEQUAL LOAD, Major Deflection

$$\delta \leq L/250, 8.02 \leq 10.8 \text{ mm OK } 26\% \text{ under}$$

Design Member 3, UNEQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 17.63 \leq 266.25 \text{ OK } 93\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 17.63 \leq 266.25 \text{ OK } 93\% \text{ under}$$

Design Member 3, UNEQUAL LOAD, Minor Shear

$$f_v \leq F_v, 0.34 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 3, UNEQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 1.39 \leq 10.8 \text{ mm OK } 87\% \text{ under}$$

Design Member 3, UNEQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 19.79 \leq 213.0 \text{ OK } 91\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 19.79 \leq 245.0 \text{ OK } 92\% \text{ under}$$

Design Member 3, UNEQUAL LOAD, Slenderness

$$K_x \cdot L_x / r_x = 1.0 \cdot 2700.0 / 136.65 = 19.76 \leq 300.0 \text{ OK } 93\% \text{ under}$$

$$K_y \cdot L_y / r_y = 1.0 \cdot 2700.0 / 77.98 = 34.63 \leq 300.0 \text{ OK } 88\% \text{ under}$$

Design Member 3, UNEQUAL LOAD, Compression

$$f_a \leq F_a, 0.0 \leq 188.12 \text{ OK } 100\% \text{ under}$$

Design Member 3, UNEQUAL LOAD, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 19.79 / 213.0 + 48.18 / 234.3 + 17.63 / 266.25 = 0.36 \leq 1 \text{ OK } 64\% \text{ under}$$

Design Member 3, UNEQUAL LOAD, Bending + Compression

$$f_a / F_a = 0.0 / 188.12 = 0.0 \leq 0.15 \therefore \phi 0$$

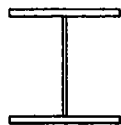
$$\phi_\alpha / \Phi_\alpha + \phi_{\beta x} / \Phi_{\beta x} + \phi_{\beta y} / \Phi_{\beta y} = 0.0 / 188.12 + 48.18 / 234.3 + 17.63 / 266.25 = 0.27 \leq 1 \text{ OK } 73\% \text{ under}$$

Checking design member 5

Members: 5

Group: W

Section: W12x87



Load Case: UNEQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 \cdot F_y = 0.6 \cdot 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 \cdot F_u = 0.5 \cdot 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 \cdot F_y = 0.4 \cdot 355.0 = 142.0 \text{ MPa}$$

$$KL/r = \max(K_x \cdot L_x / r_x, K_y \cdot L_y / r_y) = \max(1.0 \cdot 2700.0 / 136.65, 1.0 \cdot 2700.0 / 77.98) = 34.63$$

$$F_a = (1 - (KL/r)^2 / (2 \cdot C_c^2)) \cdot F_y / F_s = (1 - 34.63^2 / (2 \cdot 105.44^2)) \cdot 355.0 / 1.79 = 188.12 \text{ MPa}$$

$$b/t = 153.67 / 20.57 = 7.47 \leq 65 / \sqrt{F_y} = 65 / \sqrt{355.0} = 9.06 \therefore \phi_0 \text{ Σεχτιον ις Χομπαχτ}$$

Μαφορ Αξισ:

$$\Lambda_\beta \leq L_c \therefore \phi_0 \quad \Phi_\beta = 0.66 \cdot F_y = 0.66 \cdot 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.75 \cdot F_y = 0.75 \cdot 355.0 = 266.25 \text{ MPa}$$

Design Member 5, UNEQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 2.26 \leq 234.3 \text{ OK } 99\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 2.26 \leq 234.3 \text{ OK } 99\% \text{ under}$$

Design Member 5, UNEQUAL LOAD, Major Shear

$$f_v \leq F_v, 0.71 \leq 142.0 \text{ OK } 99\% \text{ under}$$

Design Member 5, UNEQUAL LOAD, Major Deflection

$$\delta \leq L/250, 1.52 \leq 10.8 \text{ mm OK } 86\% \text{ under}$$

Design Member 5, UNEQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 86.56 \leq 266.25 \text{ OK } 67\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 86.56 \leq 266.25 \text{ OK } 67\% \text{ under}$$

Design Member 5, UNEQUAL LOAD, Minor Shear

$$f_v \leq F_v, 3.26 \leq 142.0 \text{ OK } 98\% \text{ under}$$

Design Member 5, UNEQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 1.27 \leq 10.8 \text{ mm OK } 88\% \text{ under}$$

Design Member 5, UNEQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 0.0 \leq 213.0 \text{ OK } 100\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 0.0 \leq 245.0 \text{ OK } 100\% \text{ under}$$

Design Member 5, UNEQUAL LOAD, Slenderness

$$K_x \cdot L_x / r_x = 1.0 \cdot 2700.0 / 136.65 = 19.76 \leq 200.0 \text{ OK } 90\% \text{ under}$$

$$K_y \cdot L_y / r_y = 1.0 \cdot 2700.0 / 77.98 = 34.63 \leq 200.0 \text{ OK } 83\% \text{ under}$$

Design Member 5, UNEQUAL LOAD, Compression

$$f_a \leq F_a, 0.58 \leq 188.12 \text{ OK } 100\% \text{ under}$$

Design Member 5, UNEQUAL LOAD, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 0.0 / 245.0 + 2.26 / 234.3 + 86.56 / 266.25 = 0.33 \leq 1 \text{ OK } 67\% \text{ under}$$

Design Member 5, UNEQUAL LOAD, Bending + Compression

$$f_a / F_a = 0.58 / 188.12 = 0.0 \leq 0.15 \therefore \phi_0$$

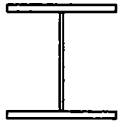
$$\phi_\alpha / \Phi_\alpha + \phi_{\beta\xi} / \Phi_{\beta\xi} + \phi_{\beta\psi} / \Phi_{\beta\psi} = 0.58 / 188.12 + 2.26 / 234.3 + 86.56 / 266.25 = 0.34 \leq 1 \text{ OK } 66\% \text{ under}$$

Checking design member 7

Members: 7

Group: W

Section: W12x87



Load Case: UNEQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 \cdot F_y = 0.6 \cdot 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 \cdot F_u = 0.5 \cdot 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 \cdot F_y = 0.4 \cdot 355.0 = 142.0 \text{ MPa}$$

$$KL/r = \max(K_x \cdot L/r_x, K_y \cdot L/r_y) = \max(1.0 \cdot 2700.0/136.65, 1.0 \cdot 2700.0/77.98) = 34.63$$

$$F_a = (1 - (KL/r)^2 / (2 \cdot C_c^2)) \cdot F_y / FS = (1 - 34.63^2 / (2 \cdot 105.44^2)) \cdot 355.0 / 1.79 = 188.12 \text{ MPa}$$

$$b/t = 153.67/20.57 = 7.47 \leq 65/\sqrt{F_y} = 65/\sqrt{355.0} = 9.06 \therefore \phi 0 \text{ Σεχτιον ις Χομπαχτ}$$

Μαφορ Αξισ:

$$\Lambda_\beta \leq L_c \therefore \phi 0 \quad \Phi_\beta = 0.66 \cdot F_y = 0.66 \cdot 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.75 \cdot F_y = 0.75 \cdot 355.0 = 266.25 \text{ MPa}$$

Design Member 7, UNEQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 0.64 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 0.64 \leq 234.3 \text{ OK } 100\% \text{ under}$$

Design Member 7, UNEQUAL LOAD, Major Shear

$$f_v \leq F_v, 0.2 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 7, UNEQUAL LOAD, Major Deflection

$$\delta \leq L/250, 4.39 \leq 10.8 \text{ mm OK } 59\% \text{ under}$$

Design Member 7, UNEQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 28.93 \leq 266.25 \text{ OK } 89\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 28.93 \leq 266.25 \text{ OK } 89\% \text{ under}$$

Design Member 7, UNEQUAL LOAD, Minor Shear

$$f_v \leq F_v, 1.04 \leq 142.0 \text{ OK } 99\% \text{ under}$$

Design Member 7, UNEQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 1.26 \leq 10.8 \text{ mm OK } 88\% \text{ under}$$

Design Member 7, UNEQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 0.0 \leq 213.0 \text{ OK } 100\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 0.0 \leq 245.0 \text{ OK } 100\% \text{ under}$$

Design Member 7, UNEQUAL LOAD, Slenderness

$$K_x \cdot L_x / r_x = 1.0 \cdot 2700.0/136.65 = 19.76 \leq 200.0 \text{ OK } 90\% \text{ under}$$

$$K_y \cdot L_y / r_y = 1.0 \cdot 2700.0/77.98 = 34.63 \leq 200.0 \text{ OK } 83\% \text{ under}$$

Design Member 7, UNEQUAL LOAD, Compression

$$f_a \leq F_a, 10.97 \leq 188.12 \text{ OK } 94\% \text{ under}$$

Design Member 7, UNEQUAL LOAD, Bending + Tension

$$f_a/F_t + f_{bx}/F_{bx} + f_{by}/F_{by} = 0.0/245.0 + 0.64/234.3 + 28.93/266.25 = 0.11 \leq 1 \text{ OK } 89\% \text{ under}$$

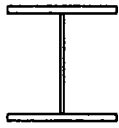
Design Member 7, UNEQUAL LOAD, Bending + Compression

$$f_a/F_a = 10.97/188.12 = 0.06 \leq 0.15 \therefore \phi 0$$

$$\phi_\alpha / \Phi_\alpha + \phi_{\beta\xi} / \Phi_{\beta\xi} + \phi_{\beta\psi} / \Phi_{\beta\psi} = 10.97/188.12 + 0.64/234.3 + 28.93/266.25 = 0.17 \leq 1 \text{ OK } 83\% \text{ under}$$

Checking design member 9

Members: 9
Group: W
Section: W12x87



Load Case: UNEQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 * F_y = 0.6 * 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 * F_u = 0.5 * 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 * F_y = 0.4 * 355.0 = 142.0 \text{ MPa}$$

$$KL/r = \max(K_x * l/r_x, K_y * l/r_y) = \max(1.0 * 4000.0 / 136.65, 1.0 * 4000.0 / 77.98) = 51.3$$

$$F_a = (1 - (KL/r)^2 / (2 * C_c^2)) * F_y / FS = (1 - 51.3^2 / (2 * 105.44^2)) * 355.0 / 1.83 = 170.59 \text{ MPa}$$

$$b/t = 153.67 / 20.57 = 7.47 \leq 65 / \sqrt{F_y} = 65 / \sqrt{355.0} = 9.06 \therefore \phi 0 \text{ Σεχτιον ις Χομπαχτ}$$

Μαφop Αξις:

$$\Lambda_\beta > \Lambda_\chi \therefore \phi 0 \quad \Phi_\beta = 0.6 * F_y = 0.6 * 355.0 = 213.0 \text{ MPa}$$

$$F_b = 12 \times 10^3 * C_b / (l * d / A_f) = 12 \times 10^3 * 1.2 / (4000.0 * 317.5 / 63.23) = 494.95 \text{ MPa}$$

$$F_b > 0.6 * F_y \therefore \phi 0 \quad \Phi_\beta = 0.6 * F_y = 0.6 * 355.0 = 213.0 \text{ MPa}$$

Minor Axis:

$$F_b = 0.75 * F_y = 0.75 * 355.0 = 266.25 \text{ MPa}$$

Design Member 9, UNEQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 23.88 \leq 213.0 \text{ OK } 89\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 23.88 \leq 213.0 \text{ OK } 89\% \text{ under}$$

Design Member 9, UNEQUAL LOAD, Major Shear

$$f_v \leq F_v, 1.0 \leq 142.0 \text{ OK } 99\% \text{ under}$$

Design Member 9, UNEQUAL LOAD, Major Deflection

$$\delta \leq L/250, 2.08 \leq 16.0 \text{ mm OK } 87\% \text{ under}$$

Design Member 9, UNEQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 84.64 \leq 266.25 \text{ OK } 68\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 84.64 \leq 266.25 \text{ OK } 68\% \text{ under}$$

Design Member 9, UNEQUAL LOAD, Minor Shear

$$f_v \leq F_v, 2.16 \leq 142.0 \text{ OK } 98\% \text{ under}$$

Design Member 9, UNEQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 10.53 \leq 16.0 \text{ mm OK } 34\% \text{ under}$$

Design Member 9, UNEQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 23.87 \leq 213.0 \text{ OK } 89\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 23.87 \leq 245.0 \text{ OK } 90\% \text{ under}$$

Design Member 9, UNEQUAL LOAD, Slenderness

$$K_x * L_x / r_x = 1.0 * 4000.0 / 136.65 = 29.27 \leq 300.0 \text{ OK } 90\% \text{ under}$$

$$K_y * L_y / r_y = 1.0 * 4000.0 / 77.98 = 51.3 \leq 300.0 \text{ OK } 83\% \text{ under}$$

Design Member 9, UNEQUAL LOAD, Compression

$$f_a \leq F_a, 0.0 \leq 170.59 \text{ OK } 100\% \text{ under}$$

Design Member 9, UNEQUAL LOAD, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 23.87 / 213.0 + 23.88 / 213.0 + 84.64 / 266.25 = 0.54 \leq 1 \text{ OK } 46\% \text{ under}$$

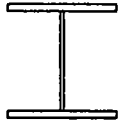
Design Member 9, UNEQUAL LOAD, Bending + Compression

$$f_a / F_a = 0.0 / 170.59 = 0.0 \leq 0.15 \therefore \phi 0$$

$$\phi_\alpha / \Phi_\alpha + \phi_{\beta x} / \Phi_{\beta x} + \phi_{\beta y} / \Phi_{\beta y} = 0.0 / 170.59 + 23.88 / 213.0 + 84.64 / 266.25 = 0.43 \leq 1 \text{ OK } 57\% \text{ under}$$

Checking design member 11

Members: 11
Group: W
Section: W12x87



Load Case: UNEQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 \cdot F_y = 0.6 \cdot 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 \cdot F_u = 0.5 \cdot 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 \cdot F_y = 0.4 \cdot 355.0 = 142.0 \text{ MPa}$$

$$KL/r = \max(K_x \cdot l/r_x, K_y \cdot l/r_y) = \max(1.0 \cdot 800.0/136.65, 1.0 \cdot 800.0/77.98) = 10.26$$

$$F_a = (1 - (KL/r)^2 / (2 \cdot C_c^2)) \cdot F_y / F_S = (1 - 10.26^2 / (2 \cdot 105.44^2)) \cdot 355.0 / 1.7 = 207.46 \text{ MPa}$$

$$b/t = 153.67/20.57 = 7.47 \leq 65/\sqrt{F_y} = 65/\sqrt{355.0} = 9.06 \therefore \phi 0 \text{ Σεχτιον ις Χομπαχτ}$$

Μαφop Aξισ:

$$\Lambda_\beta \leq L_c \therefore \phi 0 \quad \Phi_\beta = 0.66 \cdot F_y = 0.66 \cdot 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.75 \cdot F_y = 0.75 \cdot 355.0 = 266.25 \text{ MPa}$$

Design Member 11, UNEQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 28.01 \leq 234.3 \text{ OK } 88\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 28.01 \leq 234.3 \text{ OK } 88\% \text{ under}$$

Design Member 11, UNEQUAL LOAD, Major Shear

$$f_v \leq F_v, 27.95 \leq 142.0 \text{ OK } 80\% \text{ under}$$

Design Member 11, UNEQUAL LOAD, Major Deflection

$$\delta \leq L/250, 0.49 \leq 3.2 \text{ mm OK } 85\% \text{ under}$$

Design Member 11, UNEQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 6.27 \leq 266.25 \text{ OK } 98\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 6.27 \leq 266.25 \text{ OK } 98\% \text{ under}$$

Design Member 11, UNEQUAL LOAD, Minor Shear

$$f_v \leq F_v, 0.72 \leq 142.0 \text{ OK } 99\% \text{ under}$$

Design Member 11, UNEQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 0.41 \leq 3.2 \text{ mm OK } 87\% \text{ under}$$

Design Member 11, UNEQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 18.81 \leq 213.0 \text{ OK } 91\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 18.81 \leq 245.0 \text{ OK } 92\% \text{ under}$$

Design Member 11, UNEQUAL LOAD, Slenderness

$$K_x \cdot L_x / r_x = 1.0 \cdot 800.0 / 136.65 = 5.85 \leq 300.0 \text{ OK } 98\% \text{ under}$$

$$K_y \cdot L_y / r_y = 1.0 \cdot 800.0 / 77.98 = 10.26 \leq 300.0 \text{ OK } 97\% \text{ under}$$

Design Member 11, UNEQUAL LOAD, Compression

$$f_a \leq F_a, 0.0 \leq 207.46 \text{ OK } 100\% \text{ under}$$

Design Member 11, UNEQUAL LOAD, Bending + Tension

$$f_a/F_t + f_{bx}/F_{bx} + f_{by}/F_{by} = 18.81/213.0 + 28.01/234.3 + 6.27/266.25 = 0.23 \leq 1 \text{ OK } 77\% \text{ under}$$

Design Member 11, UNEQUAL LOAD, Bending + Compression

$$f_a/F_a = 0.0/207.46 = 0.0 \leq 0.15 \therefore \phi 0$$

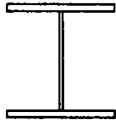
$$\phi_\alpha / \Phi_\alpha + \phi_{\beta\xi} / \Phi_{\beta\xi} + \phi_{\beta\psi} / \Phi_{\beta\psi} = 0.0/207.46 + 28.01/234.3 + 6.27/266.25 = 0.14 \leq 1 \text{ OK } 86\% \text{ under}$$

Checking design member 13

Members: 13

Group: W

Section: W12x87



Load Case: UNEQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 * F_y = 0.6 * 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 * F_u = 0.5 * 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 * F_y = 0.4 * 355.0 = 142.0 \text{ MPa}$$

$$KL/r = \max(K_x * l/r_x, K_y * l/r_y) = \max(1.0 * 800.0 / 136.65, 1.0 * 800.0 / 77.98) = 10.26$$

$$F_a = (1 - (KL/r)^2 / (2 * C_c^2)) * F_y / FS = (1 - 10.26^2 / (2 * 105.44^2)) * 355.0 / 1.7 = 207.46 \text{ MPa}$$

$$b/t = 153.67 / 20.57 = 7.47 \leq 65 / \sqrt{F_y} = 65 / \sqrt{355.0} = 9.06 \therefore \phi 0 \text{ Σεχτιον ις Χομπαχτ}$$

Μαφop Aξιc:

$$\Lambda_\beta \leq L_c \therefore \phi 0 \quad \Phi_\beta = 0.66 * F_y = 0.66 * 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.75 * F_y = 0.75 * 355.0 = 266.25 \text{ MPa}$$

Design Member 13, UNEQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 24.26 \leq 234.3 \text{ OK } 90\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 24.26 \leq 234.3 \text{ OK } 90\% \text{ under}$$

Design Member 13, UNEQUAL LOAD, Major Shear

$$f_v \leq F_v, 23.5 \leq 142.0 \text{ OK } 83\% \text{ under}$$

Design Member 13, UNEQUAL LOAD, Major Deflection

$$\delta \leq L/250, 1.25 \leq 3.2 \text{ mm OK } 61\% \text{ under}$$

Design Member 13, UNEQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 6.7 \leq 266.25 \text{ OK } 97\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 6.7 \leq 266.25 \text{ OK } 97\% \text{ under}$$

Design Member 13, UNEQUAL LOAD, Minor Shear

$$f_v \leq F_v, 0.86 \leq 142.0 \text{ OK } 99\% \text{ under}$$

Design Member 13, UNEQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 0.4 \leq 3.2 \text{ mm OK } 88\% \text{ under}$$

Design Member 13, UNEQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 18.72 \leq 213.0 \text{ OK } 91\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 18.72 \leq 245.0 \text{ OK } 92\% \text{ under}$$

Design Member 13, UNEQUAL LOAD, Slenderness

$$K_x * L_x / r_x = 1.0 * 800.0 / 136.65 = 5.85 \leq 300.0 \text{ OK } 98\% \text{ under}$$

$$K_y * L_y / r_y = 1.0 * 800.0 / 77.98 = 10.26 \leq 300.0 \text{ OK } 97\% \text{ under}$$

Design Member 13, UNEQUAL LOAD, Compression

$$f_a \leq F_a, 0.0 \leq 207.46 \text{ OK } 100\% \text{ under}$$

Design Member 13, UNEQUAL LOAD, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 18.72 / 213.0 + 24.26 / 234.3 + 6.7 / 266.25 = 0.22 \leq 1 \text{ OK } 78\% \text{ under}$$

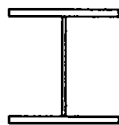
Design Member 13, UNEQUAL LOAD, Bending + Compression

$$f_a / F_a = 0.0 / 207.46 = 0.0 \leq 0.15 \therefore \phi 0$$

$$\phi_\alpha / \Phi_\alpha + \phi_{\beta x} / \Phi_{\beta x} + \phi_{\beta y} / \Phi_{\beta y} = 0.0 / 207.46 + 24.26 / 234.3 + 6.7 / 266.25 = 0.13 \leq 1 \text{ OK } 87\% \text{ under}$$

Checking design member 15

Members: 15
Group: W
Section: W12x87



Load Case: UNEQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 \cdot F_y = 0.6 \cdot 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 \cdot F_u = 0.5 \cdot 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 \cdot F_y = 0.4 \cdot 355.0 = 142.0 \text{ MPa}$$

$$Kl/r = \max(K_x \cdot l/r_x, K_y \cdot l/r_y) = \max(1.0 \cdot 2816.03/136.65, 1.0 \cdot 2816.03/77.98) = 36.11$$

$$F_a = (1 - (Kl/r)^2 / (2 \cdot C_c^2)) \cdot F_y / FS = (1 - 36.11^2 / (2 \cdot 105.44^2)) \cdot 355.0 / 1.79 = 186.68 \text{ MPa}$$

$$b/t = 153.67/20.57 = 7.47 \leq 65/\sqrt{F_y} = 65/\sqrt{355.0} = 9.06 \therefore \phi 0 \text{ Σεχτιον ις Χομπαχτ}$$

Μαφop Αξισ:

$$\Lambda_\beta \leq L_c \therefore \phi 0 \quad \Phi_\beta = 0.66 \cdot F_y = 0.66 \cdot 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.75 \cdot F_y = 0.75 \cdot 355.0 = 266.25 \text{ MPa}$$

Design Member 15, UNEQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 38.51 \leq 234.3 \text{ OK } 84\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 38.51 \leq 234.3 \text{ OK } 84\% \text{ under}$$

Design Member 15, UNEQUAL LOAD, Major Shear

$$f_v \leq F_v, 6.34 \leq 142.0 \text{ OK } 96\% \text{ under}$$

Design Member 15, UNEQUAL LOAD, Major Deflection

$$\delta \leq L/250, 5.06 \leq 11.26 \text{ mm OK } 55\% \text{ under}$$

Design Member 15, UNEQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 21.26 \leq 266.25 \text{ OK } 92\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 21.26 \leq 266.25 \text{ OK } 92\% \text{ under}$$

Design Member 15, UNEQUAL LOAD, Minor Shear

$$f_v \leq F_v, 0.37 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 15, UNEQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 1.94 \leq 11.26 \text{ mm OK } 83\% \text{ under}$$

Design Member 15, UNEQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 0.0 \leq 213.0 \text{ OK } 100\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 0.0 \leq 245.0 \text{ OK } 100\% \text{ under}$$

Design Member 15, UNEQUAL LOAD, Slenderness

$$K_x \cdot L_x / r_x = 1.0 \cdot 2816.03/136.65 = 20.61 \leq 200.0 \text{ OK } 90\% \text{ under}$$

$$K_y \cdot L_y / r_y = 1.0 \cdot 2816.03/77.98 = 36.11 \leq 200.0 \text{ OK } 82\% \text{ under}$$

Design Member 15, UNEQUAL LOAD, Compression

$$f_a \leq F_a, 58.28 \leq 186.68 \text{ OK } 69\% \text{ under}$$

Design Member 15, UNEQUAL LOAD, Bending + Tension

$$f_a/F_t + f_{bx}/F_{bx} + f_{by}/F_{by} = 0.0/245.0 + 38.51/234.3 + 21.26/266.25 = 0.24 \leq 1 \text{ OK } 76\% \text{ under}$$

Design Member 15, UNEQUAL LOAD, Bending + Compression

$$\text{Axial Ratio} = f_a/F_a = 58.28/186.68 = 0.31$$

$$\text{Major Ratio} = C_{mx} \cdot f_{bx} / ((1 - f_a/F'_{ex}) \cdot F_{bx}) = 0.85 \cdot 38.51 / ((1 - 58.28/2424.62) \cdot 234.3) = 0.14$$

$$\text{Minor Ratio} = C_{my} \cdot f_{by} / ((1 - f_a/F'_{ey}) \cdot F_{by}) = 0.85 \cdot 21.26 / ((1 - 58.28/789.51) \cdot 266.25) = 0.07$$

$$\text{Axial Ratio} + \text{Major Ratio} + \text{Minor Ratio} = 0.31 + 0.14 + 0.07 = 0.53 \leq 1 \text{ OK } 47\% \text{ under}$$

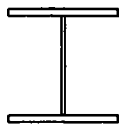
$$f_a/(0.6 \cdot F_y) + f_{bx}/F_{bx} + f_{by}/F_{by} = 58.28/(0.6 \cdot 355.0) + 38.51/234.3 + 21.26/266.25 = 0.52 \geq 1 \text{ OK } 48\% \text{ under}$$

Checking design member 17

Members: 17

Group: W

Section: W12x87



Load Case: UNEQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 * F_y = 0.6 * 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 * F_u = 0.5 * 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 * F_y = 0.4 * 355.0 = 142.0 \text{ MPa}$$

$$Kl/r = \max(K_x * l/r_x, K_y * l/r_y) = \max(1.0 * 2000.0 / 136.65, 1.0 * 2000.0 / 77.98) = 25.65$$

$$F_a = (1 - (Kl/r)^2 / (2 * C_c^2)) * F_y / FS = (1 - 25.65^2 / (2 * 105.44^2)) * 355.0 / 1.76 = 196.17 \text{ MPa}$$

$$b/t = 153.67 / 20.57 = 7.47 \leq 65 / \sqrt{F_y} = 65 / \sqrt{355.0} = 9.06 \therefore \phi 0 \text{ Σεχτιον ισ Χομπαχτ}$$

Μαφορ Αξισ:

$$\Lambda_\beta \leq L_c \therefore \phi 0 \quad \Phi_\beta = 0.66 * F_y = 0.66 * 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.75 * F_y = 0.75 * 355.0 = 266.25 \text{ MPa}$$

Design Member 17, UNEQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 27.12 \leq 234.3 \text{ OK } 88\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 27.12 \leq 234.3 \text{ OK } 88\% \text{ under}$$

Design Member 17, UNEQUAL LOAD, Major Shear

$$f_v \leq F_v, 3.27 \leq 142.0 \text{ OK } 98\% \text{ under}$$

Design Member 17, UNEQUAL LOAD, Major Deflection

$$\delta \leq L/250, 1.79 \leq 8.0 \text{ mm OK } 78\% \text{ under}$$

Design Member 17, UNEQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 80.71 \leq 266.25 \text{ OK } 70\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 80.71 \leq 266.25 \text{ OK } 70\% \text{ under}$$

Design Member 17, UNEQUAL LOAD, Minor Shear

$$f_v \leq F_v, 1.91 \leq 142.0 \text{ OK } 99\% \text{ under}$$

Design Member 17, UNEQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 4.45 \leq 8.0 \text{ mm OK } 44\% \text{ under}$$

Design Member 17, UNEQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 0.0 \leq 213.0 \text{ OK } 100\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 0.0 \leq 245.0 \text{ OK } 100\% \text{ under}$$

Design Member 17, UNEQUAL LOAD, Slenderness

$$K_x * L_x / r_x = 1.0 * 2000.0 / 136.65 = 14.64 \leq 200.0 \text{ OK } 93\% \text{ under}$$

$$K_y * L_y / r_y = 1.0 * 2000.0 / 77.98 = 25.65 \leq 200.0 \text{ OK } 87\% \text{ under}$$

Design Member 17, UNEQUAL LOAD, Compression

$$f_a \leq F_a, 63.72 \leq 196.17 \text{ OK } 68\% \text{ under}$$

Design Member 17, UNEQUAL LOAD, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 0.0 / 245.0 + 27.12 / 234.3 + 80.71 / 266.25 = 0.42 \leq 1 \text{ OK } 58\% \text{ under}$$

Design Member 17, UNEQUAL LOAD, Bending + Compression

$$\text{Axial Ratio} = f_a / F_a = 63.72 / 196.17 = 0.32$$

$$\text{Major Ratio} = C_{mx} * f_{bx} / ((1 - f_a / F_{ex}) * F_{bx}) = 0.85 * 27.12 / ((1 - 63.72 / 4806.82) * 234.3) = 0.1$$

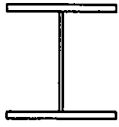
$$\text{Minor Ratio} = C_{my} * f_{by} / ((1 - f_a / F_{ey}) * F_{by}) = 0.85 * 80.71 / ((1 - 63.72 / 1565.2) * 266.25) = 0.27$$

$$\text{Axial Ratio} + \text{Major Ratio} + \text{Minor Ratio} = 0.32 + 0.1 + 0.27 = 0.69 \leq 1 \text{ OK } 31\% \text{ under}$$

$$f_a / (0.6 * F_y) + f_{bx} / F_{bx} + f_{by} / F_{by} = 63.72 / (0.6 * 355.0) + 27.12 / 234.3 + 80.71 / 266.25 = 0.72 \geq 1 \text{ OK } 28\% \text{ under}$$

Checking design member 19

Members: 19
Group: W
Section: W12x87



Load Case: UNEQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 \cdot F_y = 0.6 \cdot 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 \cdot F_u = 0.5 \cdot 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 \cdot F_y = 0.4 \cdot 355.0 = 142.0 \text{ MPa}$$

$$Kl/r = \max(K_x \cdot l/r_x, K_y \cdot l/r_y) = \max(1.0 \cdot 1350.0/136.65, 1.0 \cdot 1350.0/77.98) = 17.31$$

$$F_a = (1 - (Kl/r)^2 / (2 \cdot C_c^2)) \cdot F_y / FS = (1 - 17.31^2 / (2 \cdot 105.44^2)) \cdot 355.0 / 1.73 = 202.71 \text{ MPa}$$

$$b/t = 153.67/20.57 = 7.47 \leq 65/\sqrt{F_y} = 65/\sqrt{355.0} = 9.06 \therefore \phi 0 \text{ Σεχτιον ις Χομπαχτ}$$

Μαφορ Αξισ:

$$\Lambda_\beta \leq L_c \therefore \phi 0 \quad \Phi_\beta = 0.66 \cdot F_y = 0.66 \cdot 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.75 \cdot F_y = 0.75 \cdot 355.0 = 266.25 \text{ MPa}$$

Design Member 19, UNEQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 3.67 \leq 234.3 \text{ OK } 98\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 3.67 \leq 234.3 \text{ OK } 98\% \text{ under}$$

Design Member 19, UNEQUAL LOAD, Major Shear

$$f_v \leq F_v, 1.59 \leq 142.0 \text{ OK } 99\% \text{ under}$$

Design Member 19, UNEQUAL LOAD, Major Deflection

$$\delta \leq L/250, 0.77 \leq 5.4 \text{ mm OK } 86\% \text{ under}$$

Design Member 19, UNEQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 46.47 \leq 266.25 \text{ OK } 83\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 46.47 \leq 266.25 \text{ OK } 83\% \text{ under}$$

Design Member 19, UNEQUAL LOAD, Minor Shear

$$f_v \leq F_v, 0.27 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 19, UNEQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 0.54 \leq 5.4 \text{ mm OK } 90\% \text{ under}$$

Design Member 19, UNEQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 2.27 \leq 213.0 \text{ OK } 99\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 2.27 \leq 245.0 \text{ OK } 99\% \text{ under}$$

Design Member 19, UNEQUAL LOAD, Slenderness

$$K_x \cdot L_x / r_x = 1.0 \cdot 1350.0 / 136.65 = 9.88 \leq 300.0 \text{ OK } 97\% \text{ under}$$

$$K_y \cdot L_y / r_y = 1.0 \cdot 1350.0 / 77.98 = 17.31 \leq 300.0 \text{ OK } 94\% \text{ under}$$

Design Member 19, UNEQUAL LOAD, Compression

$$f_a \leq F_a, 0.0 \leq 202.71 \text{ OK } 100\% \text{ under}$$

Design Member 19, UNEQUAL LOAD, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 2.27 / 213.0 + 3.67 / 234.3 + 46.47 / 266.25 = 0.2 \leq 1 \text{ OK } 80\% \text{ under}$$

Design Member 19, UNEQUAL LOAD, Bending + Compression

$$f_a / F_a = 0.0 / 202.71 = 0.0 \leq 0.15 \therefore \phi 0$$

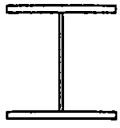
$$\phi_\alpha / \Phi_\alpha + \phi_{\beta x} / \Phi_{\beta x} + \phi_{\beta y} / \Phi_{\beta y} = 0.0 / 202.71 + 3.67 / 234.3 + 46.47 / 266.25 = 0.19 \leq 1 \text{ OK } 81\% \text{ under}$$

Checking design member 21

Members: 21

Group: W

Section: W12x87



Load Case: UNEQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 * F_y = 0.6 * 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 * F_u = 0.5 * 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 * F_y = 0.4 * 355.0 = 142.0 \text{ MPa}$$

$$Kl/r = \max(K_x * l/r_x, K_y * l/r_y) = \max(1.0 * 1350.0 / 136.65, 1.0 * 1350.0 / 77.98) = 17.31$$

$$F_a = (1 - (Kl/r)^2 / (2 * C_c^2)) * F_y / FS = (1 - 17.31^2 / (2 * 105.44^2)) * 355.0 / 1.73 = 202.71 \text{ MPa}$$

$$b/t = 153.67 / 20.57 = 7.47 \leq 65 / \sqrt{F_y} = 65 / \sqrt{355.0} = 9.06 \therefore \phi 0 \text{ Σεχτιον ισ Χομπαχτ}$$

Μαφop Aξισ:

$$\Lambda_\beta \leq L_c \therefore \phi 0 \quad \Phi_\beta = 0.66 * F_y = 0.66 * 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.75 * F_y = 0.75 * 355.0 = 266.25 \text{ MPa}$$

Design Member 21, UNEQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 1.49 \leq 234.3 \text{ OK } 99\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 1.49 \leq 234.3 \text{ OK } 99\% \text{ under}$$

Design Member 21, UNEQUAL LOAD, Major Shear

$$f_v \leq F_v, 0.08 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 21, UNEQUAL LOAD, Major Deflection

$$\delta \leq L/250, 0.75 \leq 5.4 \text{ mm OK } 86\% \text{ under}$$

Design Member 21, UNEQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 88.41 \leq 266.25 \text{ OK } 67\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 88.41 \leq 266.25 \text{ OK } 67\% \text{ under}$$

Design Member 21, UNEQUAL LOAD, Minor Shear

$$f_v \leq F_v, 4.94 \leq 142.0 \text{ OK } 97\% \text{ under}$$

Design Member 21, UNEQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 0.78 \leq 5.4 \text{ mm OK } 85\% \text{ under}$$

Design Member 21, UNEQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 0.0 \leq 213.0 \text{ OK } 100\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 0.0 \leq 245.0 \text{ OK } 100\% \text{ under}$$

Design Member 21, UNEQUAL LOAD, Slenderness

$$K_x * L_x / r_x = 1.0 * 1350.0 / 136.65 = 9.88 \leq 200.0 \text{ OK } 95\% \text{ under}$$

$$K_y * L_y / r_y = 1.0 * 1350.0 / 77.98 = 17.31 \leq 200.0 \text{ OK } 91\% \text{ under}$$

Design Member 21, UNEQUAL LOAD, Compression

$$f_a \leq F_a, 1.88 \leq 202.71 \text{ OK } 99\% \text{ under}$$

Design Member 21, UNEQUAL LOAD, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 0.0 / 245.0 + 1.49 / 234.3 + 88.41 / 266.25 = 0.34 \leq 1 \text{ OK } 66\% \text{ under}$$

Design Member 21, UNEQUAL LOAD, Bending + Compression

$$f_a / F_a = 1.88 / 202.71 = 0.01 \leq 0.15 \therefore \phi 0$$

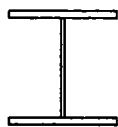
$$\phi_a / \Phi_a + \phi_{\beta\xi} / \Phi_{\beta\xi} + \phi_{\beta\psi} / \Phi_{\beta\psi} = 1.88 / 202.71 + 1.49 / 234.3 + 88.41 / 266.25 = 0.35 \leq 1 \text{ OK } 65\% \text{ under}$$

Checking design member 23

Members: 23

Group: W

Section: W12x87



Load Case: UNEQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 * F_y = 0.6 * 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 * F_u = 0.5 * 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 * F_y = 0.4 * 355.0 = 142.0 \text{ MPa}$$

$$KL/r = \max(K_x * l/r_x, K_y * l/r_y) = \max(1.0 * 2816.03 / 136.65, 1.0 * 2816.03 / 77.98) = 36.11$$

$$F_a = (1 - (KL/r)^2 / (2 * C_c^2)) * F_y / FS = (1 - 36.11^2 / (2 * 105.44^2)) * 355.0 / 1.79 = 186.68 \text{ MPa}$$

$$b/t = 153.67 / 20.57 = 7.47 \leq 65 / \sqrt{F_y} = 65 / \sqrt{355.0} = 9.06 \therefore \phi 0 \text{ Σεχτιον ισ Χομπαχτ}$$

Μαφop Aξισ:

$$\Lambda_\beta \leq L_c \therefore \phi 0 \quad \Phi_\beta = 0.66 * F_y = 0.66 * 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.75 * F_y = 0.75 * 355.0 = 266.25 \text{ MPa}$$

Design Member 23, UNEQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 43.22 \leq 234.3 \text{ OK } 82\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 43.22 \leq 234.3 \text{ OK } 82\% \text{ under}$$

Design Member 23, UNEQUAL LOAD, Major Shear

$$f_v \leq F_v, 7.29 \leq 142.0 \text{ OK } 95\% \text{ under}$$

Design Member 23, UNEQUAL LOAD, Major Deflection

$$\delta \leq L/250, 8.05 \leq 11.26 \text{ mm OK } 29\% \text{ under}$$

Design Member 23, UNEQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 9.72 \leq 266.25 \text{ OK } 96\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 9.72 \leq 266.25 \text{ OK } 96\% \text{ under}$$

Design Member 23, UNEQUAL LOAD, Minor Shear

$$f_v \leq F_v, 0.32 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 23, UNEQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 1.79 \leq 11.26 \text{ mm OK } 84\% \text{ under}$$

Design Member 23, UNEQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 0.0 \leq 213.0 \text{ OK } 100\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 0.0 \leq 245.0 \text{ OK } 100\% \text{ under}$$

Design Member 23, UNEQUAL LOAD, Slenderness

$$K_x * L_x / r_x = 1.0 * 2816.03 / 136.65 = 20.61 \leq 200.0 \text{ OK } 90\% \text{ under}$$

$$K_y * L_y / r_y = 1.0 * 2816.03 / 77.98 = 36.11 \leq 200.0 \text{ OK } 82\% \text{ under}$$

Design Member 23, UNEQUAL LOAD, Compression

$$f_a \leq F_a, 56.89 \leq 186.68 \text{ OK } 70\% \text{ under}$$

Design Member 23, UNEQUAL LOAD, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 0.0 / 245.0 + 43.22 / 234.3 + 9.72 / 266.25 = 0.22 \leq 1 \text{ OK } 78\% \text{ under}$$

Design Member 23, UNEQUAL LOAD, Bending + Compression

$$\text{Axial Ratio} = f_a / F_a = 56.89 / 186.68 = 0.3$$

$$\text{Major Ratio} = C_{mx} * f_{bx} / ((1 - f_a / F'_{ex}) * F_{bx}) = 0.85 * 43.22 / ((1 - 56.89 / 2424.62) * 234.3) = 0.16$$

$$\text{Minor Ratio} = C_{my} * f_{by} / ((1 - f_a / F'_{ey}) * F_{by}) = 0.85 * 9.72 / ((1 - 56.89 / 789.51) * 266.25) = 0.03$$

$$\text{Axial Ratio} + \text{Major Ratio} + \text{Minor Ratio} = 0.3 + 0.16 + 0.03 = 0.5 \leq 1 \text{ OK } 50\% \text{ under}$$

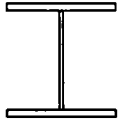
$$f_a / (0.6 * F_y) + f_{bx} / F_{bx} + f_{by} / F_{by} = 56.89 / (0.6 * 355.0) + 43.22 / 234.3 + 9.72 / 266.25 = 0.49 \geq 1 \text{ OK } 51\% \text{ under}$$

Checking design member 25

Members: 25

Group: W

Section: W12x87



Load Case: UNEQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 \cdot F_y = 0.6 \cdot 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 \cdot F_u = 0.5 \cdot 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 \cdot F_y = 0.4 \cdot 355.0 = 142.0 \text{ MPa}$$

$$KL/r = \max(K_x \cdot l/r_x, K_y \cdot l/r_y) = \max(1.0 \cdot 2000.0/136.65, 1.0 \cdot 2000.0/77.98) = 25.65$$

$$F_a = (1 - (KL/r)^2 / (2 \cdot C_c^2)) \cdot F_y / FS = (1 - 25.65^2 / (2 \cdot 105.44^2)) \cdot 355.0 / 1.76 = 196.17 \text{ MPa}$$

$$b/t = 153.67/20.57 = 7.47 \leq 65/\sqrt{F_y} = 65/\sqrt{355.0} = 9.06 \quad \therefore \phi 0 \text{ Σεχτιον ισ Χομπαχτ}$$

Μαφop Aξισ:

$$\Lambda_\beta \leq L_c \quad \therefore \phi 0 \quad \Phi_\beta = 0.66 \cdot F_y = 0.66 \cdot 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.75 \cdot F_y = 0.75 \cdot 355.0 = 266.25 \text{ MPa}$$

Design Member 25, UNEQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 18.57 \leq 234.3 \text{ OK } 92\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 18.57 \leq 234.3 \text{ OK } 92\% \text{ under}$$

Design Member 25, UNEQUAL LOAD, Major Shear

$$f_v \leq F_v, 1.28 \leq 142.0 \text{ OK } 99\% \text{ under}$$

Design Member 25, UNEQUAL LOAD, Major Deflection

$$\delta \leq L/250, 0.26 \leq 8.0 \text{ mm OK } 97\% \text{ under}$$

Design Member 25, UNEQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 67.02 \leq 266.25 \text{ OK } 75\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 67.02 \leq 266.25 \text{ OK } 75\% \text{ under}$$

Design Member 25, UNEQUAL LOAD, Minor Shear

$$f_v \leq F_v, 1.88 \leq 142.0 \text{ OK } 99\% \text{ under}$$

Design Member 25, UNEQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 5.28 \leq 8.0 \text{ mm OK } 34\% \text{ under}$$

Design Member 25, UNEQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 0.0 \leq 213.0 \text{ OK } 100\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 0.0 \leq 245.0 \text{ OK } 100\% \text{ under}$$

Design Member 25, UNEQUAL LOAD, Slenderness

$$K_x \cdot L_x / r_x = 1.0 \cdot 2000.0 / 136.65 = 14.64 \leq 200.0 \text{ OK } 93\% \text{ under}$$

$$K_y \cdot L_y / r_y = 1.0 \cdot 2000.0 / 77.98 = 25.65 \leq 200.0 \text{ OK } 87\% \text{ under}$$

Design Member 25, UNEQUAL LOAD, Compression

$$f_a \leq F_a, 62.25 \leq 196.17 \text{ OK } 68\% \text{ under}$$

Design Member 25, UNEQUAL LOAD, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 0.0 / 245.0 + 18.57 / 234.3 + 67.02 / 266.25 = 0.33 \leq 1 \text{ OK } 67\% \text{ under}$$

Design Member 25, UNEQUAL LOAD, Bending + Compression

$$\text{Axial Ratio} = f_a / F_a = 62.25 / 196.17 = 0.32$$

$$\text{Major Ratio} = C_{mx} \cdot f_{bx} / ((1 - f_a / F'_{ex}) \cdot F_{bx}) = 0.85 \cdot 18.57 / ((1 - 62.25 / 4806.82) \cdot 234.3) = 0.07$$

$$\text{Minor Ratio} = C_{my} \cdot f_{by} / ((1 - f_a / F'_{ey}) \cdot F_{by}) = 0.85 \cdot 67.02 / ((1 - 62.25 / 1565.2) \cdot 266.25) = 0.22$$

$$\text{Axial Ratio} + \text{Major Ratio} + \text{Minor Ratio} = 0.32 + 0.07 + 0.22 = 0.61 \leq 1 \text{ OK } 39\% \text{ under}$$

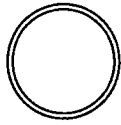
$$f_a / (0.6 \cdot F_y) + f_{bx} / F_{bx} + f_{by} / F_{by} = 62.25 / (0.6 \cdot 355.0) + 18.57 / 234.3 + 67.02 / 266.25 = 0.62 \geq 1 \text{ OK } 38\% \text{ under}$$

Checking design member 27

Members: 27

Group: Custom2

Section: CHS 114.3 x 6



Load Case: UNEQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 * F_y = 0.6 * 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 * F_u = 0.5 * 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 * F_y = 0.4 * 355.0 = 142.0 \text{ MPa}$$

$$Kl/r = \max(K_x * l/r_x, K_y * l/r_y) = \max(1.0 * 3122.9/38.35, 1.0 * 3122.9/38.35) = 81.43$$

$$F_a = (1 - (Kl/r)^2 / (2 * C_c^2)) * F_y / FS = (1 - 81.43^2 / (2 * 108.06^2)) * 355.0 / 1.9 = 134.08 \text{ MPa}$$

Major Axis:

$$F_b = 0.66 * F_y = 0.66 * 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.66 * F_y = 0.66 * 355.0 = 234.3 \text{ MPa}$$

Design Member 27, UNEQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 1.86 \leq 234.3 \text{ OK } 99\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 1.86 \leq 234.3 \text{ OK } 99\% \text{ under}$$

Design Member 27, UNEQUAL LOAD, Major Shear

$$f_v \leq F_v, 0.05 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 27, UNEQUAL LOAD, Major Deflection

$$\delta \leq L/250, 4.18 \leq 12.49 \text{ mm OK } 67\% \text{ under}$$

Design Member 27, UNEQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 16.11 \leq 234.3 \text{ OK } 93\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 16.11 \leq 234.3 \text{ OK } 93\% \text{ under}$$

Design Member 27, UNEQUAL LOAD, Minor Shear

$$f_v \leq F_v, 0.36 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 27, UNEQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 2.21 \leq 12.49 \text{ mm OK } 82\% \text{ under}$$

Design Member 27, UNEQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 0.0 \leq 213.0 \text{ OK } 100\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 0.0 \leq 245.0 \text{ OK } 100\% \text{ under}$$

Design Member 27, UNEQUAL LOAD, Slenderness

$$K_x * L_x / r_x = 1.0 * 3122.9/38.35 = 81.43 \leq 200.0 \text{ OK } 59\% \text{ under}$$

$$K_y * L_y / r_y = 1.0 * 3122.9/38.35 = 81.43 \leq 200.0 \text{ OK } 59\% \text{ under}$$

Design Member 27, UNEQUAL LOAD, Compression

$$f_a \leq F_a, 69.58 \leq 134.08 \text{ OK } 48\% \text{ under}$$

Design Member 27, UNEQUAL LOAD, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 0.0/245.0 + 1.86/234.3 + 16.11/234.3 = 0.08 \leq 1 \text{ OK } 92\% \text{ under}$$

Design Member 27, UNEQUAL LOAD, Bending + Compression

$$\text{Axial Ratio} = f_a / F_a = 69.58/134.08 = 0.52$$

$$\text{Major Ratio} = C_{mx} * f_{bx} / ((1 - f_a / F'_{ex}) * F_{bx}) = 0.85 * 1.86 / ((1 - 69.58/163.06) * 234.3) = 0.01$$

$$\text{Minor Ratio} = C_{my} * f_{by} / ((1 - f_a / F'_{ey}) * F_{by}) = 0.85 * 16.11 / ((1 - 69.58/163.06) * 234.3) = 0.1$$

$$\text{Axial Ratio} + \text{Major Ratio} + \text{Minor Ratio} = 0.52 + 0.01 + 0.1 = 0.63 \leq 1 \text{ OK } 37\% \text{ under}$$

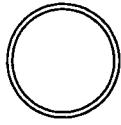
$$f_a / (0.6 * F_y) + f_{bx} / F_{bx} + f_{by} / F_{by} = 69.58 / (0.6 * 355.0) + 1.86/234.3 + 16.11/234.3 = 0.4 \geq 1 \text{ OK } 60\% \text{ under}$$

Checking design member 29

Members: 29

Group: Custom2

Section: CHS 114.3 x 6



Load Case: UNEQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 * F_y = 0.6 * 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 * F_u = 0.5 * 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 * F_y = 0.4 * 355.0 = 142.0 \text{ MPa}$$

$$KL/r = \max(K_x * l/r_x, K_y * l/r_y) = \max(1.0 * 1569.24/38.35, 1.0 * 1569.24/38.35) = 40.92$$

$$F_a = (1 - (KL/r)^2 / (2 * C_c^2)) * F_y / FS = (1 - 40.92^2 / (2 * 108.06^2)) * 355.0 / 1.8 = 182.89 \text{ MPa}$$

Major Axis:

$$F_b = 0.66 * F_y = 0.66 * 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.66 * F_y = 0.66 * 355.0 = 234.3 \text{ MPa}$$

Design Member 29, UNEQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 1.61 \leq 234.3 \text{ OK } 99\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 1.61 \leq 234.3 \text{ OK } 99\% \text{ under}$$

Design Member 29, UNEQUAL LOAD, Major Shear

$$f_v \leq F_v, 0.07 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 29, UNEQUAL LOAD, Major Deflection

$$\delta \leq L/250, 0.93 \leq 6.28 \text{ mm OK } 85\% \text{ under}$$

Design Member 29, UNEQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 15.55 \leq 234.3 \text{ OK } 93\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 15.55 \leq 234.3 \text{ OK } 93\% \text{ under}$$

Design Member 29, UNEQUAL LOAD, Minor Shear

$$f_v \leq F_v, 0.56 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 29, UNEQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 0.88 \leq 6.28 \text{ mm OK } 86\% \text{ under}$$

Design Member 29, UNEQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 12.53 \leq 213.0 \text{ OK } 94\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 12.53 \leq 245.0 \text{ OK } 95\% \text{ under}$$

Design Member 29, UNEQUAL LOAD, Slenderness

$$K_x * L_x / r_x = 1.0 * 1569.24/38.35 = 40.92 \leq 300.0 \text{ OK } 86\% \text{ under}$$

$$K_y * L_y / r_y = 1.0 * 1569.24/38.35 = 40.92 \leq 300.0 \text{ OK } 86\% \text{ under}$$

Design Member 29, UNEQUAL LOAD, Compression

$$f_a \leq F_a, 0.0 \leq 182.89 \text{ OK } 100\% \text{ under}$$

Design Member 29, UNEQUAL LOAD, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 12.53/213.0 + 1.61/234.3 + 15.55/234.3 = 0.13 \leq 1 \text{ OK } 87\% \text{ under}$$

Design Member 29, UNEQUAL LOAD, Bending + Compression

$$f_a / F_a = 0.0/182.89 = 0.0 \leq 0.15 \therefore \phi_0$$

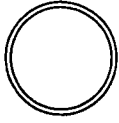
$$\phi_\alpha / \Phi_\alpha + \phi_{\beta\xi} / \Phi_{\beta\xi} + \phi_{\beta\psi} / \Phi_{\beta\psi} = 0.0/182.89 + 1.61/234.3 + 15.55/234.3 = 0.07 \leq 1 \text{ OK } 93\% \text{ under}$$

Checking design member 31

Members: 31

Group: Custom2

Section: CHS 114.3 x 6



Load Case: UNEQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 * F_y = 0.6 * 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 * F_u = 0.5 * 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 * F_y = 0.4 * 355.0 = 142.0 \text{ MPa}$$

$$K_l/r = \max(K_x * l/r_x, K_y * l/r_y) = \max(1.0 * 2154.07/38.35, 1.0 * 2154.07/38.35) = 56.17$$

$$F_a = (1 - (K_l/r)^2 / (2 * C_c^2)) * F_y / F_S = (1 - 56.17^2 / (2 * 108.06^2)) * 355.0 / 1.84 = 166.5 \text{ MPa}$$

Major Axis:

$$F_b = 0.66 * F_y = 0.66 * 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.66 * F_y = 0.66 * 355.0 = 234.3 \text{ MPa}$$

Design Member 31, UNEQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 11.22 \leq 234.3 \text{ OK } 95\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 11.22 \leq 234.3 \text{ OK } 95\% \text{ under}$$

Design Member 31, UNEQUAL LOAD, Major Shear

$$f_v \leq F_v, 0.2 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 31, UNEQUAL LOAD, Major Deflection

$$\delta \leq L/250, 0.36 \leq 8.62 \text{ mm OK } 96\% \text{ under}$$

Design Member 31, UNEQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 31.3 \leq 234.3 \text{ OK } 87\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 31.3 \leq 234.3 \text{ OK } 87\% \text{ under}$$

Design Member 31, UNEQUAL LOAD, Minor Shear

$$f_v \leq F_v, 0.78 \leq 142.0 \text{ OK } 99\% \text{ under}$$

Design Member 31, UNEQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 5.69 \leq 8.62 \text{ mm OK } 34\% \text{ under}$$

Design Member 31, UNEQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 0.0 \leq 213.0 \text{ OK } 100\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 0.0 \leq 245.0 \text{ OK } 100\% \text{ under}$$

Design Member 31, UNEQUAL LOAD, Slenderness

$$K_x * L_x / r_x = 1.0 * 2154.07/38.35 = 56.17 \leq 200.0 \text{ OK } 72\% \text{ under}$$

$$K_y * L_y / r_y = 1.0 * 2154.07/38.35 = 56.17 \leq 200.0 \text{ OK } 72\% \text{ under}$$

Design Member 31, UNEQUAL LOAD, Compression

$$f_a \leq F_a, 19.21 \leq 166.5 \text{ OK } 88\% \text{ under}$$

Design Member 31, UNEQUAL LOAD, Bending + Tension

$$f_a / F_a + f_{bx} / F_{bx} + f_{by} / F_{by} = 0.0/245.0 + 11.22/234.3 + 31.3/234.3 = 0.18 \leq 1 \text{ OK } 82\% \text{ under}$$

Design Member 31, UNEQUAL LOAD, Bending + Compression

$$f_a / F_a = 19.21/166.5 = 0.12 \leq 0.15 \therefore \phi 0$$

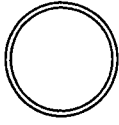
$$\phi_\alpha / \Phi_\alpha + \phi_{\beta\zeta} / \Phi_{\beta\zeta} + \phi_{\beta\psi} / \Phi_{\beta\psi} = 19.21/166.5 + 11.22/234.3 + 31.3/234.3 = 0.3 \leq 1 \text{ OK } 70\% \text{ under}$$

Checking design member 33

Members: 33

Group: Custom2

Section: CHS 114.3 x 6



Load Case: UNEQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 * F_y = 0.6 * 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 * F_u = 0.5 * 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 * F_y = 0.4 * 355.0 = 142.0 \text{ MPa}$$

$$Kl/r = \max(K_x * l/r_x, K_y * l/r_y) = \max(1.0 * 2154.07/38.35, 1.0 * 2154.07/38.35) = 56.17$$

$$F_a = (1 - (Kl/r)^2 / (2 * C_c^2)) * F_y / FS = (1 - 56.17^2 / (2 * 108.06^2)) * 355.0 / 1.84 = 166.5 \text{ MPa}$$

Major Axis:

$$F_b = 0.66 * F_y = 0.66 * 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.66 * F_y = 0.66 * 355.0 = 234.3 \text{ MPa}$$

Design Member 33, UNEQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 13.43 \leq 234.3 \text{ OK } 94\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 13.43 \leq 234.3 \text{ OK } 94\% \text{ under}$$

Design Member 33, UNEQUAL LOAD, Major Shear

$$f_v \leq F_v, 0.23 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 33, UNEQUAL LOAD, Major Deflection

$$\delta \leq L/250, 1.82 \leq 8.62 \text{ mm OK } 79\% \text{ under}$$

Design Member 33, UNEQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 22.52 \leq 234.3 \text{ OK } 90\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 22.52 \leq 234.3 \text{ OK } 90\% \text{ under}$$

Design Member 33, UNEQUAL LOAD, Minor Shear

$$f_v \leq F_v, 0.45 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 33, UNEQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 4.84 \leq 8.62 \text{ mm OK } 44\% \text{ under}$$

Design Member 33, UNEQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 0.0 \leq 213.0 \text{ OK } 100\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 0.0 \leq 245.0 \text{ OK } 100\% \text{ under}$$

Design Member 33, UNEQUAL LOAD, Slenderness

$$K_x * L_x / r_x = 1.0 * 2154.07/38.35 = 56.17 \leq 200.0 \text{ OK } 72\% \text{ under}$$

$$K_y * L_y / r_y = 1.0 * 2154.07/38.35 = 56.17 \leq 200.0 \text{ OK } 72\% \text{ under}$$

Design Member 33, UNEQUAL LOAD, Compression

$$f_a \leq F_a, 6.39 \leq 166.5 \text{ OK } 96\% \text{ under}$$

Design Member 33, UNEQUAL LOAD, Bending + Tension

$$f_a / F_a + f_{bx} / F_{bx} + f_{by} / F_{by} = 0.0 / 245.0 + 13.43 / 234.3 + 22.52 / 234.3 = 0.15 \leq 1 \text{ OK } 85\% \text{ under}$$

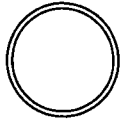
Design Member 33, UNEQUAL LOAD, Bending + Compression

$$f_a / F_a = 6.39 / 166.5 = 0.04 \leq 0.15 \therefore \phi 0$$

$$\phi_\alpha / \Phi_\alpha + \phi_{\beta\zeta} / \Phi_{\beta\zeta} + \phi_{\beta\psi} / \Phi_{\beta\psi} = 6.39 / 166.5 + 13.43 / 234.3 + 22.52 / 234.3 = 0.19 \leq 1 \text{ OK } 81\% \text{ under}$$

Checking design member 35

Members: 35
Group: Custom2
Section: CHS 114.3 x 6



Load Case: UNEQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 * F_y = 0.6 * 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 * F_u = 0.5 * 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 * F_y = 0.4 * 355.0 = 142.0 \text{ MPa}$$

$$KL/r = \max(K_x * l/r_x, K_y * l/r_y) = \max(1.0 * 1569.24/38.35, 1.0 * 1569.24/38.35) = 40.92$$

$$F_a = (1 - (KL/r)^2 / (2 * C_c^2)) * F_y / FS = (1 - 40.92^2 / (2 * 108.06^2)) * 355.0 / 1.8 = 182.89 \text{ MPa}$$

Major Axis:

$$F_b = 0.66 * F_y = 0.66 * 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.66 * F_y = 0.66 * 355.0 = 234.3 \text{ MPa}$$

Design Member 35, UNEQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 3.18 \leq 234.3 \text{ OK } 99\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 3.18 \leq 234.3 \text{ OK } 99\% \text{ under}$$

Design Member 35, UNEQUAL LOAD, Major Shear

$$f_v \leq F_v, 0.15 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 35, UNEQUAL LOAD, Major Deflection

$$\delta \leq L/250, 0.78 \leq 6.28 \text{ mm OK } 88\% \text{ under}$$

Design Member 35, UNEQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 30.28 \leq 234.3 \text{ OK } 87\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 30.28 \leq 234.3 \text{ OK } 87\% \text{ under}$$

Design Member 35, UNEQUAL LOAD, Minor Shear

$$f_v \leq F_v, 1.11 \leq 142.0 \text{ OK } 99\% \text{ under}$$

Design Member 35, UNEQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 2.04 \leq 6.28 \text{ mm OK } 68\% \text{ under}$$

Design Member 35, UNEQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 0.0 \leq 213.0 \text{ OK } 100\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 0.0 \leq 245.0 \text{ OK } 100\% \text{ under}$$

Design Member 35, UNEQUAL LOAD, Slenderness

$$K_x * L_x / r_x = 1.0 * 1569.24 / 38.35 = 40.92 \leq 200.0 \text{ OK } 80\% \text{ under}$$

$$K_y * L_y / r_y = 1.0 * 1569.24 / 38.35 = 40.92 \leq 200.0 \text{ OK } 80\% \text{ under}$$

Design Member 35, UNEQUAL LOAD, Compression

$$f_a \leq F_a, 1.76 \leq 182.89 \text{ OK } 99\% \text{ under}$$

Design Member 35, UNEQUAL LOAD, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 0.0 / 245.0 + 3.18 / 234.3 + 30.28 / 234.3 = 0.14 \leq 1 \text{ OK } 86\% \text{ under}$$

Design Member 35, UNEQUAL LOAD, Bending + Compression

$$f_a / F_a = 1.76 / 182.89 = 0.01 \leq 0.15 \therefore \phi 0$$

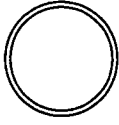
$$\phi_\alpha / \Phi_\alpha + \phi_{\beta\zeta} / \Phi_{\beta\zeta} + \phi_{\beta\psi} / \Phi_{\beta\psi} = 1.76 / 182.89 + 3.18 / 234.3 + 30.28 / 234.3 = 0.15 \leq 1 \text{ OK } 85\% \text{ under}$$

Checking design member 37

Members: 37

Group: Custom2

Section: CHS 114.3 x 6



Load Case: UNEQUAL LOAD

$$F_y = 355.0 \text{ MPa}$$

$$\text{On gross area } F_t = 0.6 * F_y = 0.6 * 355.0 = 213.0 \text{ MPa}$$

$$\text{On net area } F_t = 0.5 * F_u = 0.5 * 490.0 = 245.0 \text{ MPa}$$

$$F_v = 0.4 * F_y = 0.4 * 355.0 = 142.0 \text{ MPa}$$

$$KL/r = \max(K_x * l/r_x, K_y * l/r_y) = \max(1.0 * 3122.9/38.35, 1.0 * 3122.9/38.35) = 81.43$$

$$F_a = (1 - (KL/r)^2 / (2 * C_c^2)) * F_y / FS = (1 - 81.43^2 / (2 * 108.06^2)) * 355.0 / 1.9 = 134.08 \text{ MPa}$$

Major Axis:

$$F_b = 0.66 * F_y = 0.66 * 355.0 = 234.3 \text{ MPa}$$

Minor Axis:

$$F_b = 0.66 * F_y = 0.66 * 355.0 = 234.3 \text{ MPa}$$

Design Member 37, UNEQUAL LOAD, Major Bending

Tensile Bending Stress:

$$f_b \leq F_b, 7.99 \leq 234.3 \text{ OK } 97\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 7.99 \leq 234.3 \text{ OK } 97\% \text{ under}$$

Design Member 37, UNEQUAL LOAD, Major Shear

$$f_v \leq F_v, 0.02 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 37, UNEQUAL LOAD, Major Deflection

$$\delta \leq L/250, 9.14 \leq 12.49 \text{ mm OK } 27\% \text{ under}$$

Design Member 37, UNEQUAL LOAD, Minor Bending

Tensile Bending Stress:

$$f_b \leq F_b, 14.87 \leq 234.3 \text{ OK } 94\% \text{ under}$$

Compressive Bending Stress:

$$f_b \leq F_b, 14.87 \leq 234.3 \text{ OK } 94\% \text{ under}$$

Design Member 37, UNEQUAL LOAD, Minor Shear

$$f_v \leq F_v, 0.34 \leq 142.0 \text{ OK } 100\% \text{ under}$$

Design Member 37, UNEQUAL LOAD, Minor Deflection

$$\delta \leq L/250, 0.77 \leq 12.49 \text{ mm OK } 94\% \text{ under}$$

Design Member 37, UNEQUAL LOAD, Tension

$$\text{On gross area } f_t \leq F_t, 35.71 \leq 213.0 \text{ OK } 83\% \text{ under}$$

$$\text{On net area } f_t \leq F_t, 35.71 \leq 245.0 \text{ OK } 85\% \text{ under}$$

Design Member 37, UNEQUAL LOAD, Slenderness

$$K_x * L_x / r_x = 1.0 * 3122.9 / 38.35 = 81.43 \leq 300.0 \text{ OK } 73\% \text{ under}$$

$$K_y * L_y / r_y = 1.0 * 3122.9 / 38.35 = 81.43 \leq 300.0 \text{ OK } 73\% \text{ under}$$

Design Member 37, UNEQUAL LOAD, Compression

$$f_a \leq F_a, 0.0 \leq 134.08 \text{ OK } 100\% \text{ under}$$

Design Member 37, UNEQUAL LOAD, Bending + Tension

$$f_a / F_t + f_{bx} / F_{bx} + f_{by} / F_{by} = 35.71 / 213.0 + 7.99 / 234.3 + 14.87 / 234.3 = 0.27 \leq 1 \text{ OK } 73\% \text{ under}$$

Design Member 37, UNEQUAL LOAD, Bending + Compression

$$f_a / F_a = 0.0 / 134.08 = 0.0 \leq 0.15 \therefore \phi 0$$

$$\phi_\alpha / \Phi_\alpha + \phi_{\beta_x} / \Phi_{\beta_x} + \phi_{\beta_y} / \Phi_{\beta_y} = 0.0 / 134.08 + 7.99 / 234.3 + 14.87 / 234.3 = 0.1 \leq 1 \text{ OK } 90\% \text{ under}$$

Appendix C

Lifting Lugs Design Report to ASIC ASD

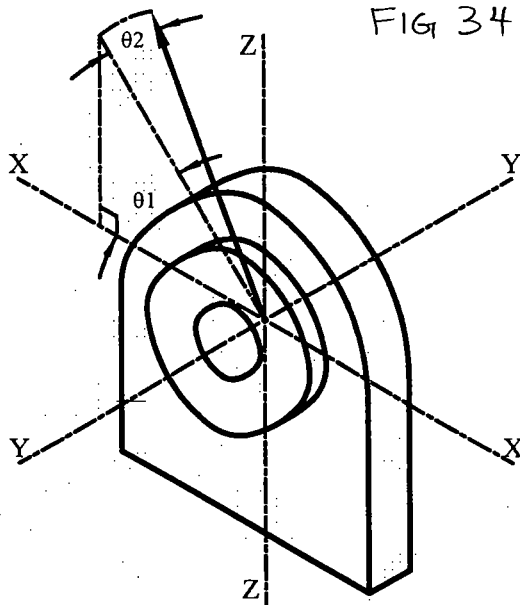
LIFTING LUG DATA

FIG 34

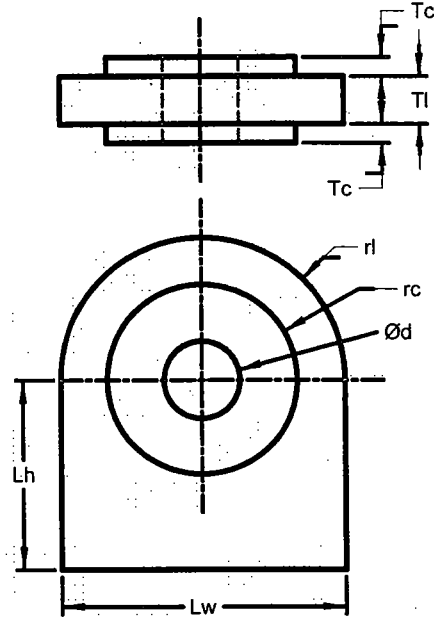


FIG 35

Material used for lug:

GL-E36

Minimum yield strength of lug material:

$\sigma_{\text{yield}} := 340\text{MPa}$

Minimum tensile strength of lug material:

$\sigma_{\text{tensile}} := 490\text{MPa}$

Minimum design lifting sling angle:

$\theta_1 := 90\text{deg}$

Maximum allowable side swing angle:

$\theta_2 := 0\text{deg}$

Lug hole diameter used:

$d := 60\text{mm}$

Height of lug hole above lug base:

$L_h := 100\text{mm}$

Radius of lug used:

$r_l := 100\text{mm}$

Radius of cheek plate used:

$r_c := 0\text{mm}$

Width of lug at base of attachment:

$L_w := 278\text{mm}$

Thickness of lug used:

$T_l := 50\text{mm}$

Thickness of cheek plate used:

$T_c := 0\text{mm}$

ALLOWABLE STRESS FOR LUG AS PER AISC - ASD MANUAL OF STEEL CONSTRUCTION

Allowable tensile stress:	$\sigma_t := 0.6 \cdot \sigma_{yield}$	$\sigma_t = 2.04 \times 10^8 \text{ Pa}$
Allowable shear stress:	$\sigma_s := 0.4 \cdot \sigma_{yield}$	$\sigma_s = 1.36 \times 10^8 \text{ Pa}$
Allowable bending stress:	$\sigma_b := 0.66 \cdot \sigma_{yield}$	$\sigma_b = 2.244 \times 10^8 \text{ Pa}$
Allowable bearing stress:	$\sigma_{bear} := 0.9 \cdot \sigma_{yield}$	$\sigma_{bear} = 3.06 \times 10^8 \text{ Pa}$

STRESSES IN LUG

Vertical design load of Lug:	$F_z := \frac{\text{Load}}{n_{lug}} \cdot g$	$F_z = 3.776 \times 10^5 \text{ N}$
Horizontal force in X direction:	$F_x := \frac{F_z}{\tan(\theta_1)}$	$F_x = 2.312 \times 10^{-11} \text{ N}$
Horizontal force in Y direction:	$F_y := F_z \cdot \tan(\theta_2)$	$F_y = 0 \text{ N}$
Resultant Force at lug:	$F_r := \sqrt{F_z^2 + F_x^2 + F_y^2}$	$F_r = 3.776 \times 10^5 \text{ N}$
Resultant load at shackle @ minimum sling angle		$\frac{F_r}{g} = 3.85 \times 10^4 \text{ kg}$
Bending moment about X-axis:	$M_x := F_y \cdot L_h$	$M_x = 0 \text{ J}$
Bending moment about Y-axis:	$M_y := F_x \cdot L_h$	$M_y = 2.312 \times 10^{-12} \text{ J}$
Bending stress about X-axis at lug base::	$S_{bx} := \frac{M_x}{\frac{T_1^2}{L_w} \cdot \frac{6}{6}}$	$S_{bx} = 0 \text{ Pa}$
Bending stress about Y-axis at lug base:	$S_{by} := \frac{M_y}{\frac{L_w^2}{6} \cdot T_1}$	$S_{by} = 3.59 \times 10^{-9} \text{ Pa}$
Tensile stress at lug base:	$S_t := \frac{F_z}{L_w \cdot T_1}$	$S_t = 2.716 \times 10^7 \text{ Pa}$
Shear Stress at lug base:	$\tau := \frac{\sqrt{F_x^2 + F_y^2}}{T_1 \cdot L_w}$	$\tau = 1.663 \times 10^{-9} \text{ Pa}$

DESIGN VERIFICATION - LIFTING LUG**ITEM IN THIS ANALYSIS :** 150 Tonne Lifting Lug for 700 Tonne Lifting Frame**DESIGN DATA****LOAD DATA**

Expected lifting load:

$$W_{\text{expect}} := 150 \cdot \text{tonne}$$

Load contingency:

$$f_{\text{contingency}} := 10\%$$

Dynamic Impact Factor:

$$f_{\text{lift}} := 1.5$$

Design lifting load:

$$\text{Load} := W_{\text{expect}} \cdot (1 + f_{\text{contingency}})$$

$$\text{Load} = 1.65 \times 10^5 \text{ kg}$$

No. of lugs

$$n_{\text{lug}} := 1$$

DETAIL OF MASTER LINK

Load Cell size & type considered: 150 Tonne JCL Load Shackle

Shackle inside width at pin, A

$$\text{Dim}_A := 170 \text{ mm}$$

Shackle pin diameter, B

$$\text{Dim}_B := 108 \text{ mm}$$

Shackle inside height above pin, C

$$\text{Dim}_C := 400 \text{ mm}$$

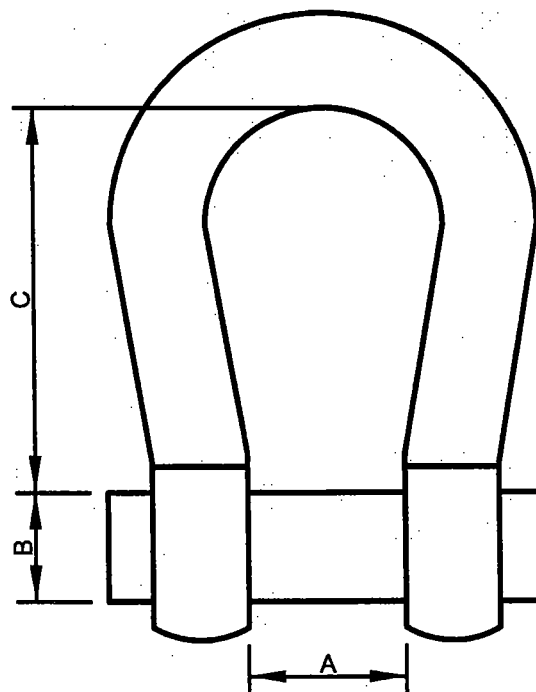


Fig 36

CHECK ON LIFTING LUG TO SHACKLE DIMENSION INTERFACE

$$\frac{T_l + 2 \cdot T_c}{\text{Dim}_A} = 0.588 < 1$$

***** LUG THICKNESS TO SHACKLE INTERNAL WIDTH IS O.K. *****

$$\frac{\text{Dim}_B}{d} = 0.939 < 1$$

***** LUG HOLE TO SHACKLE PIN DIMETER IS O.K. *****

$$\frac{2 \cdot r_l}{\text{Dim}_C} = 0.875 < 1$$

***** LUG RADIUS TO SHACKLE INTERNAL HEIGHT IS O.K. *****

Unity Check:

$$\frac{S_{bx}}{\sigma_b} + \frac{S_{by}}{\sigma_b} + \frac{S_t}{\sigma_t} + \frac{\tau}{\sigma_s} = 0.232 < 1$$

***** BENDING STRESS AT LUG BASE IS ACCEPTABLE *****

Tensile stress above pin:

$$S_{tl} := \frac{F_r \cdot f_{lift}}{T_l \cdot (2 \cdot r_l - d) + 2 \cdot T_c \cdot (2 \cdot r_c - d)} \quad S_{tl} = 1.191 \times 10^8 \text{ Pa}$$

Unity Check:

$$\frac{S_{tl}}{0.45 \cdot \sigma_{yield}} = 0.778 < 1$$

***** TENSILE STRESS ABOVE PIN IS ACCEPTABLE *****

Shear stress above pin:

$$S_s := \frac{F_r \cdot f_{lift}}{T_l \cdot (2 \cdot r_l - d) + 2 \cdot T_c \cdot (2 \cdot r_c - d)} \quad S_s = 1.191 \times 10^8 \text{ Pa}$$

Unity Check:

$$\frac{S_s}{\sigma_s} = 0.876 < 1$$

***** SHEAR STRESS ABOVE PIN IS ACCEPTABLE *****

Cross sectional area at the thinnest section of lug:

$$A_l := T_l \cdot \left(r_l - \frac{d}{2} \right) + 2 \cdot T_c \cdot \left(r_c - \frac{d}{2} \right) \quad A_l = 0.01 \text{ m}^2$$

Cross sectional area of shackle pin used:

$$A_s := \pi \left(\frac{\text{Dim}_B}{2} \right)^2 \quad A_s = 9.161 \times 10^{-3} \text{ m}^2$$

$$\frac{A_s}{A_l} = 0.899 < 1$$

***** SECTIONAL AREA CHECK IS ACCEPTABLE *****

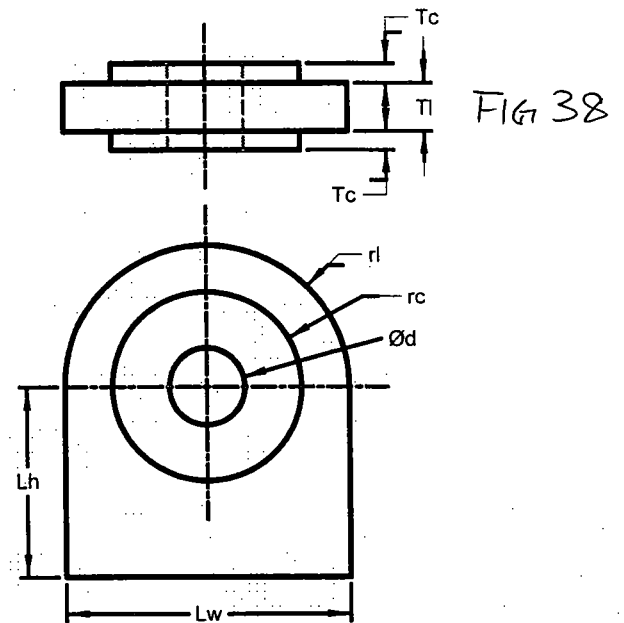
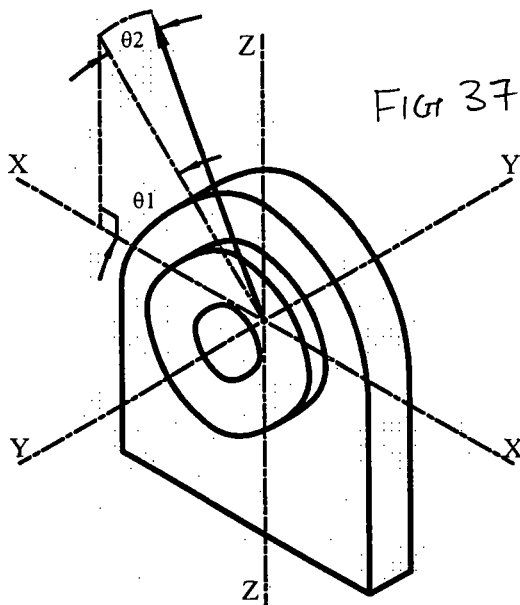
Bearing stress at pin:

$$S_b := \frac{F_r \cdot f_{lift}}{\text{Dim}_B \cdot (T_l + 2 \cdot T_c)} \quad S_b = 2.247 \times 10^8 \text{ Pa}$$

Unity Check:

$$\frac{S_b}{\sigma_{bear}} = 0.734 < 1$$

***** BEARING STRESS IS ACCEPTABLE *****

LIFTING LUG DATA

Material used for lug:

Minimum yield strength of lug material:

Minimum tensile strength of lug material:

Minimum design lifting sling angle:

Maximum allowable side swing angle:

Lug hole diameter used:

Height of lug hole above lug base:

Radius of lug used:

Radius of cheek plate used:

Width of lug at base of attachment:

Thickness of lug used:

Thickness of cheek plate used:

GL-E36

$\sigma_{\text{yield}} := 340\text{MPa}$

$\sigma_{\text{tensile}} := 490\text{MPa}$

$\theta_1 := 60\text{deg}$

$\theta_2 := 0\text{deg}$

$d := 140\text{mm}$

$L_h := 175\text{mm}$

$r_l := 225\text{mm}$

$r_c := 150\text{mm}$

$L_w := 450\text{mm}$

$T_l := 76\text{mm}$

$T_c := 40\text{mm}$

ALLOWABLE STRESS FOR LUG AS PER AISC - ASD MANUAL OF STEEL CONSTRUCTION

Allowable tensile stress:	$\sigma_t := 0.6 \cdot \sigma_{yield}$	$\sigma_t = 2.04 \times 10^8 \text{ Pa}$
Allowable shear stress:	$\sigma_s := 0.4 \cdot \sigma_{yield}$	$\sigma_s = 1.36 \times 10^8 \text{ Pa}$
Allowable bending stress:	$\sigma_b := 0.66 \cdot \sigma_{yield}$	$\sigma_b = 2.244 \times 10^8 \text{ Pa}$
Allowable bearing stress:	$\sigma_{bear} := 0.9 \cdot \sigma_{yield}$	$\sigma_{bear} = 3.06 \times 10^8 \text{ Pa}$

STRESSES IN LUG

Vertical design load of Lug:	$F_z := \frac{\text{Load}}{n_{lug}} \cdot g$	$F_z = 1.955 \times 10^6 \text{ N}$
Horizontal force in X direction:	$F_x := \frac{F_z}{\tan(\theta_1)}$	$F_x = 1.129 \times 10^6 \text{ N}$
Horizontal force in Y direction:	$F_y := F_z \cdot \tan(\theta_2)$	$F_y = 0 \text{ N}$
Resultant Force at lug:	$F_r := \sqrt{F_z^2 + F_x^2 + F_y^2}$	$F_r = 2.258 \times 10^6 \text{ N}$
Resultant load at shackle @ minimum sling angle		$\frac{F_r}{g} = 2.302 \times 10^5 \text{ kg}$
Bending moment about X-axis:	$M_x := F_y \cdot L_h$	$M_x = 0 \text{ J}$
Bending moment about Y-axis:	$M_y := F_x \cdot L_h$	$M_y = 1.975 \times 10^5 \text{ J}$
Bending stress about X-axis at lug base::	$S_{bx} := \frac{M_x}{L_w \cdot \frac{T_1^2}{6}}$	$S_{bx} = 0 \text{ Pa}$
Bending stress about Y-axis at lug base:	$S_{by} := \frac{M_y}{\frac{L_w^2}{6} \cdot T_1}$	$S_{by} = 7.702 \times 10^7 \text{ Pa}$
Tensile stress at lug base:	$S_t := \frac{F_z}{L_w \cdot T_1}$	$S_t = 5.717 \times 10^7 \text{ Pa}$
Shear Stress at lug base:	$\tau := \frac{\sqrt{F_x^2 + F_y^2}}{T_1 \cdot L_w}$	$\tau = 3.301 \times 10^7 \text{ Pa}$

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A circular professional engineer seal. The outer ring contains the text "PROFESSIONAL ENGINEER" at the top and "SINGAPORE" at the bottom. The inner circle is divided into three sections: "MECHANICAL" on the left, "LING KUI MUK" in the center, and "3753" on the right. A stylized signature is written across the "MECHANICAL" and "LING KUI MUK" sections.

31 Dec '09

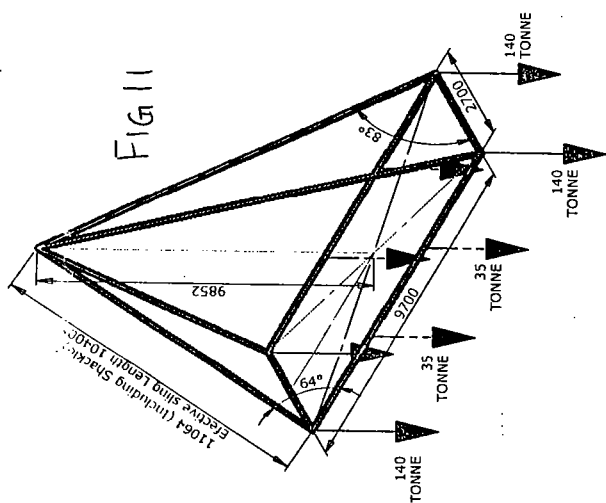


FIG 10

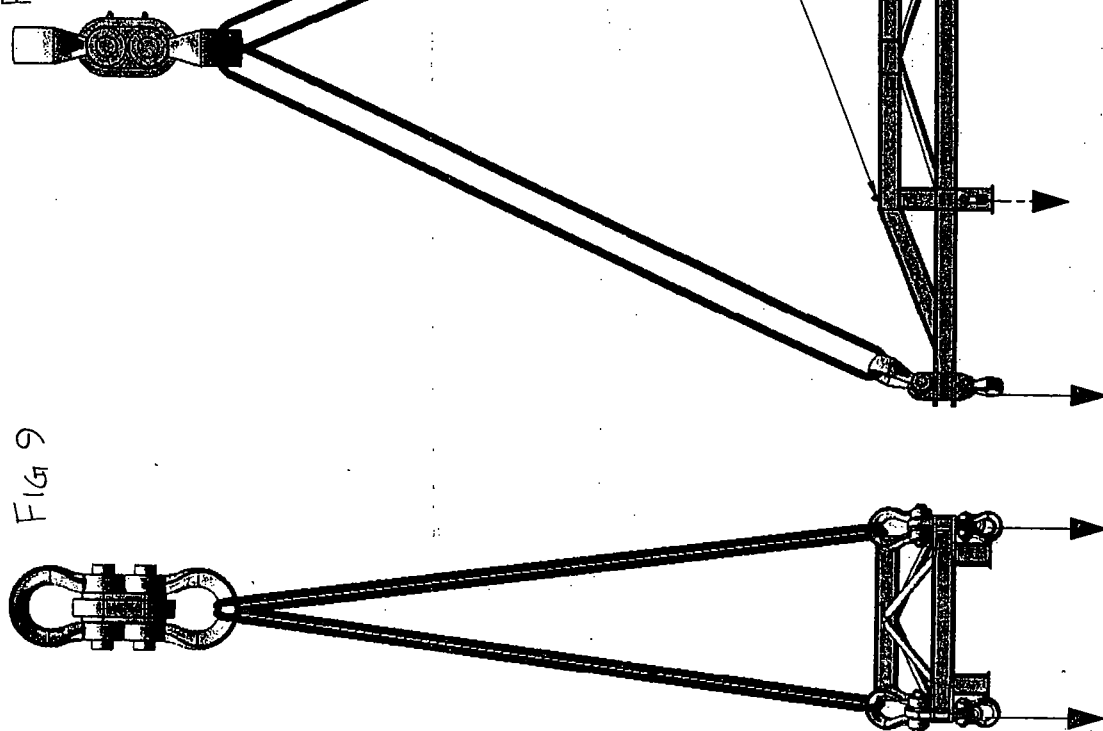
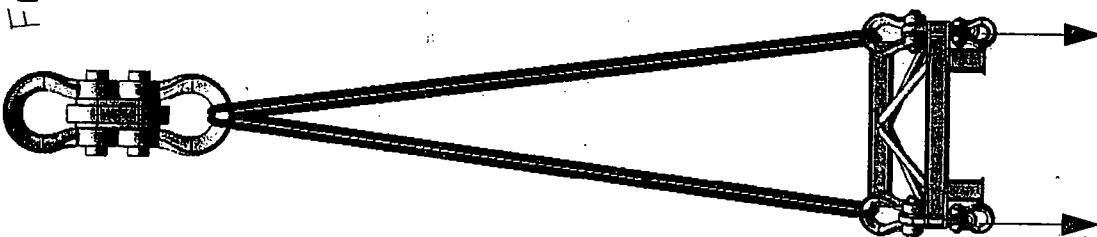


FIG 9



FRONT VIEW

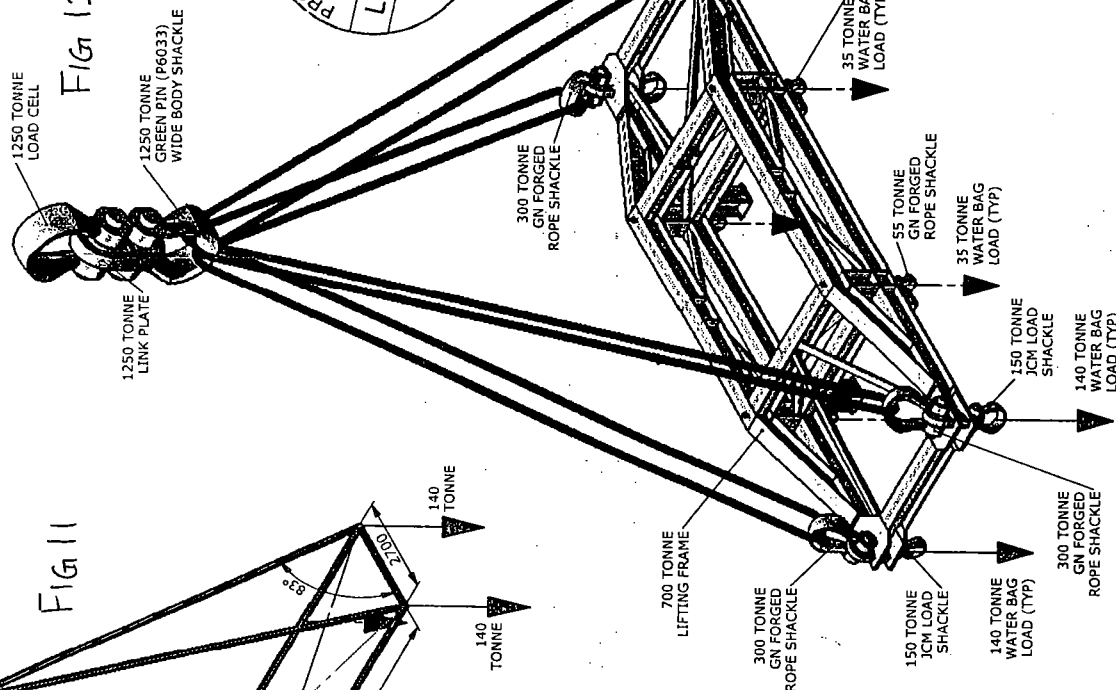


Fig 12

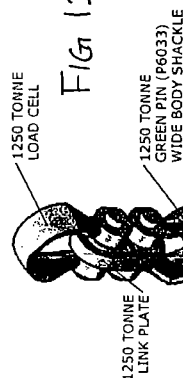


FIG 11

General Notes :

1. All dimension in mm Unless Otherwise Noted.
Weight - 9582 Kg.
2. Loading Conditions:
3. • Water Bags are gradually filled.
• Lifting Frame is **NOT** designed for day-to-day transportation or handling of goods.

REALTEC
exploring infinity

10 Admiralty Street, #03-88/89, North Link Building, Singapore 757695
Tel : +65 675 8878, Fax : +65 6853 8280

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Title

700 TONNE LIFTING FRAME GENERAL LIFTING ARRANGEMENT

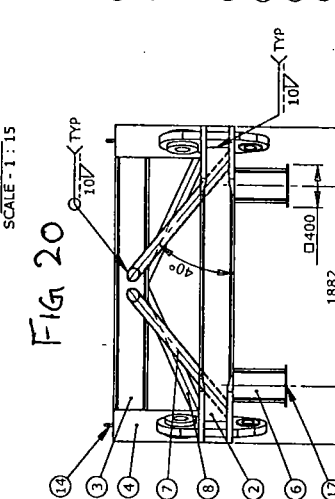
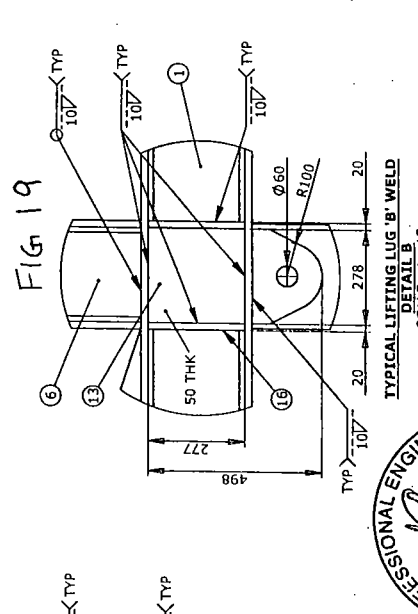
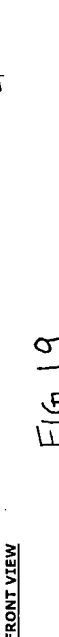
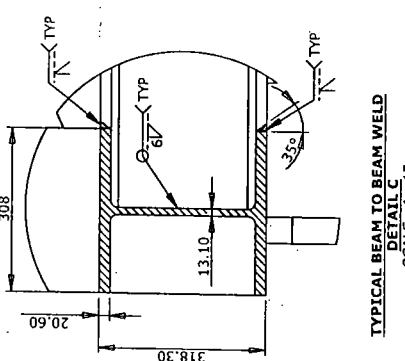
Scale
1 : 10

Drawing No.

20

iv. A

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General Notes						exploring infinity 10 Admiralty Street, #03-88/89 North Link Building, Singapore 757695 Tel : +65 6753 8878, Fax : +65 6853 8280		Title	
1. All dimension in mm Unless Otherwise Noted (U.O.M.).									
2. 100% MPI on all Weld.									
3. Abbreviation: UB - Universal Beam. CHS - Circular Hollow Section. PL - Plate. UT - Ultrasonic Test (In Accordance to AWS).									
Finishing - Primal Coating.									
		A. ISSUE FOR QUOTATION Description		S.K. S.J.W. Drawn Check Approved Date		T.T. 15/12/09		Scale 1 : 50	
		Rev.						Size A3	
								Dra...g No. 9779-D-022-010	
								Rev. A	

LIFTING FRAME
CONSTRUCTION DRAWING

REALTEC

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