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Client:

Rapid Response Solutions Ltd

Description:

**Calculations Report
Multilug Beam
WLL: 25t**

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J10486 – Multilug Beam Calculation Report

Summary

A 3-D structural analysis is conducted on the multilug beam to check the built up beam adequacy for different loading scenarios.

It is found that the stresses and deflections observed on the beam are within the limits than the maximum allowable values.

It was determined that the multilug beam is suitable for its respective proposed application.

Introduction

The following report outlines the 3-D structural analysis of a custom multilug beam as shown in the drawing J10486-01-GA01. The various sections of the report will document the parameters used within the study and then analyse the results to confirm that the beam meet the design specification.

Objectives

There are two main objectives that this report intends to complete:

1. Verify that the design of the multilug beam does not exhibit stresses above the yield value for 2x the working load limit.
2. Verify that the design of the multilug beam satisfies the requirements for deflection for 2x the working load limit.

In order to satisfy these two objectives, we will run two simulations for each loading case.

1. Spreader beam configuration: This will apply a load of 200% of the expected load by applying '1-point nodal load' to the centre of the beam. The self-weight of the beam is generated by the STAAD Pro. Design software. The model will compose of the fabricated custom section and 2 fixed but support nodes at the ends of the beam to simulate the top slings so the spreader beam behaviour under lifting condition can be seen accurately.
2. Lifting beam configuration: This will apply a load of 200% of the expected load by applying '2-point nodal loads' to the ends of the beam. The self-weight of the beam is generated by the STAAD Pro. Design software. The model will compose of the fabricated custom section and 1 central fixed support node to simulate top lifting point so the lifting beam behaviour under lifting condition can be seen accurately.

The values of design ratios at various points on the beam will be observed and recorded. We will extract the code check information from the STAAD Pro.

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Similarly, we can observe the expected deflection of the beam under the 200% loading and ensure that it meets the requirements of the design codes. The maximum relative displacement of the beam in any direction needs to be less than 9.3mm (calculated from Span/300)

As per Annex A of BS EN 13155:2003, the load case to be considered in analytical modelling of lifting equipment is:

$$X = \text{SDL} + 2 * \text{SWLL},$$

Where X is equal to the load case;

SDL is equal to the Loads due to the dead weight of the attachment; and

SWLL is equal to the loads due to the Working Load Limit.

In order to measure true values for deflection in the frame, the load case will be altered to:

$$X/2 = \text{SDL} + \text{SWLL}$$

This describes the loading as 100% of the load and 100% of the self-weight. Therefore, the values for displacement measured by this load case will represent the true values. Furthermore, when measuring the stress values from this load case, we need to ensure that the observed values are less than half the maximum allowable. The design ratios will be limited to less than 0.5.

Rearranging the load case demonstrates that this is actually more conservative than that specified within BS EN 1993:2003:

$$X/2 = \text{SDL} + \text{SWLL}$$

$$X = 2 * (\text{SDL} + \text{SWLL})$$

$$X = 2 * \text{SDL} + 2 * \text{SWLL}$$

Design Input Parameters and Design Basis of the Multilug Beam

Working Load Limit (WLL used as Spreader Beam) = 25t

Working Load Limit (WLL used as Lifting Beam) = 24.5t

Top Lifting Max Span = 2800 mm (for spreader beam configuration beam span is equal to 3150mm due to neutral axis intersection)

Bottom Lifting Max Span = 2800 mm

Strength Design Check = 2xWLL

Deflection Design Check = 2xWLL

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Multilug Beam Model

Model 3-D view

The image below shows the multilug beam geometry within the Solidworks software.

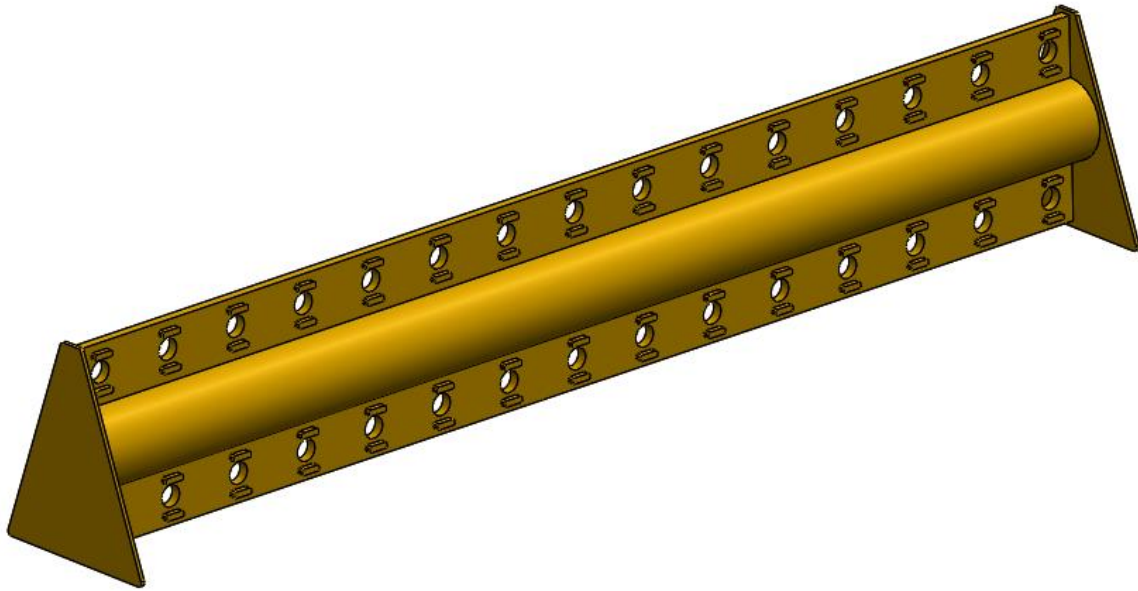


Figure 1 – 3-D Rendered Model View

Material Details

For this model, all components are assigned the material designation of Structural Steel with properties in accordance with the table below. While the yield strength of the Structural steel material is smaller than that of S355, this will not matter. The only relevant material property for the steel is the Young's Modulus (E).

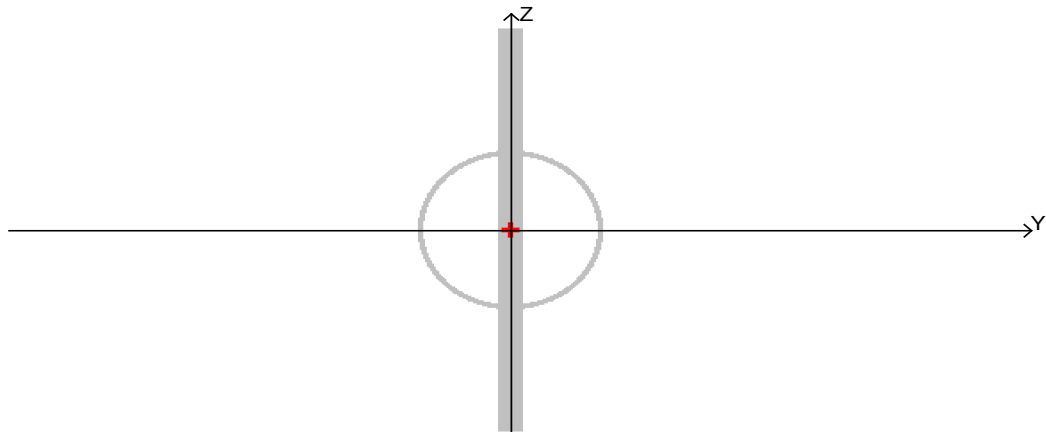
Model Properties

The beam is modelled with custom fabricated section and 1 central node is modelled to simulate the lifting configurations.

The main plate = 490x25mm

The split tubes = CHS Ø193.7x6

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Section element	Rotation angle	Mirror	Material	E (kN/mm ²)
Sheet 490 x 25	90.0		Steel	205.0
Circular Hollow Sections 193.7x6.0			Steel	205.0

Figure 2 – Beam Section Properties

Type of Analysis:

The analysis type used in this simulation is a Static Structural Analysis. As such we will consider this to be a linear analysis.

Loads for Spreader Beam Configuration

For the purpose of this simulation, the self-weight of the beam is generated through the Self-Weight Command in STAAD Pro.

The weight generated of the custom section from STAAD Pro. Model = 385 kg

Lift weight is applied on the central node of the beam as shown in the below image.

WLL = 25t

Therefore, load/node = $(25 \times 9.81) / 1 = 245.25 \text{ kN}$

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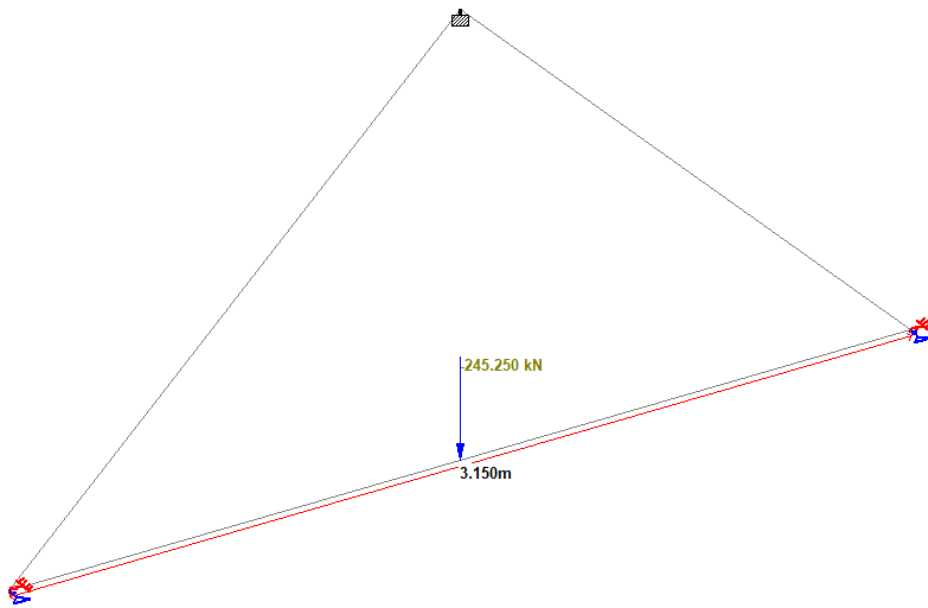


Figure 3 – Typical loading diagram for spreader beam configuration

The beam is analysed for 200% of the expected load, the results are concluded at the end of this report based on the design stress ratios and deflections.

Load Combination 1 – 2 x (SDL+SWLL)

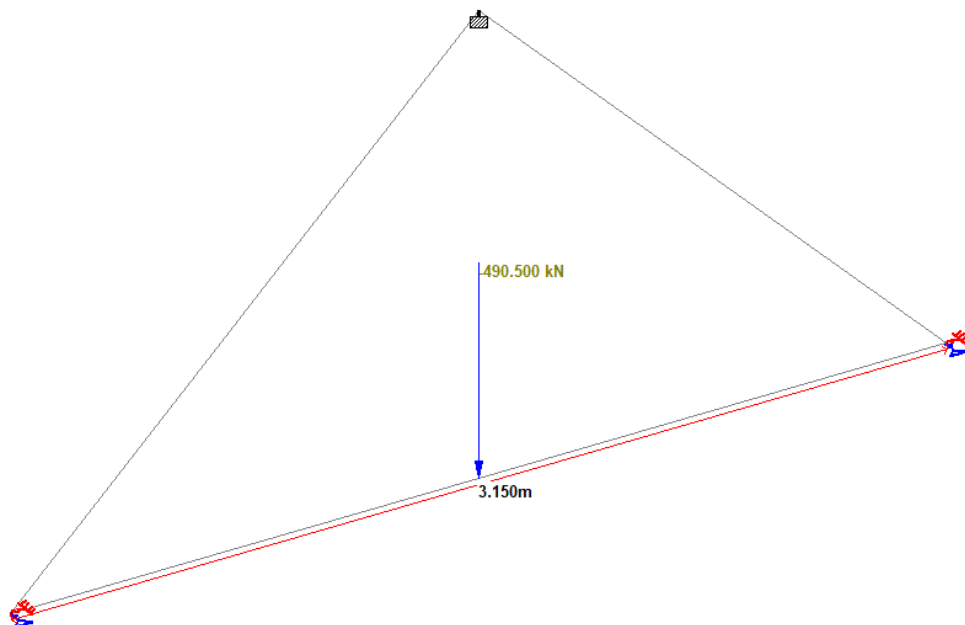


Figure 4 – Loads applied: LC 1

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Loads for Lifting Beam Configuration

For the purpose of this simulation, the self-weight of the beam is generated through the Self-Weight Command in STAAD Pro.

The weight generated of the custom section from STAAD Pro. Model = 385 kg

Lift weight is applied on the 2 end nodes of the beam as shown in the below image.

WLL = 24.5t

Therefore, load/node = $(24.5 \times 9.81) / 2 = 120.2 \text{ kN}$

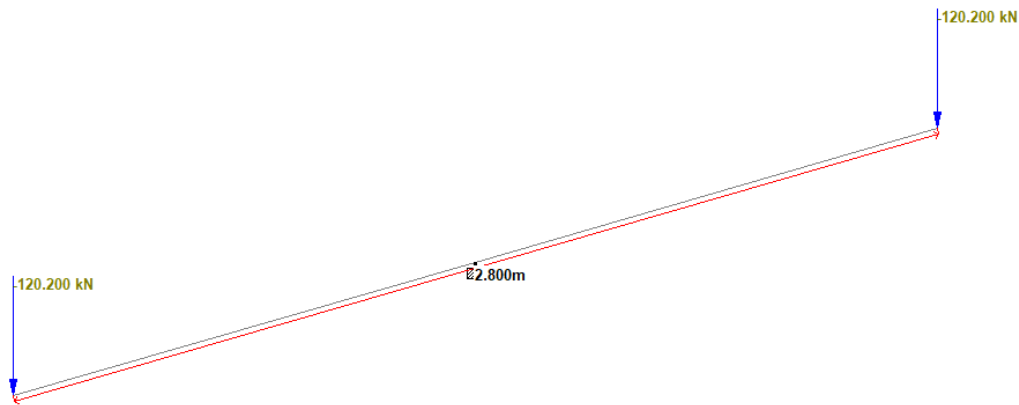


Figure 5 –Typical loading diagram for lifting beam configuration

The beam is analysed for 200% of the expected load, the results are concluded at the end of this report based on the design stress ratios and deflections.

Load Combination 2 – 2 x (SDL+SWLL)

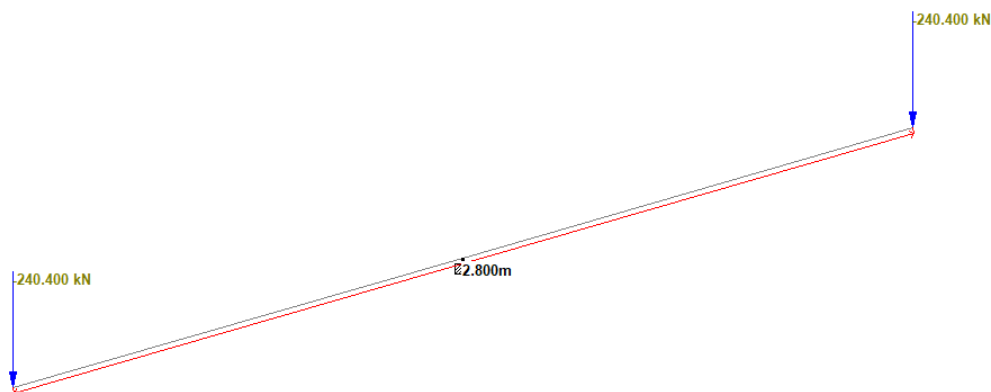


Figure 6 – Loads applied: LC 2

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Analysis Results – Spreader Beam Case

The spreader beam case is more critical than the lifting beam case as seen from the design ratios and displacement summary. Hence the detailed design results are plotted only for the spreader beam case.

After setting up the simulation with the aforementioned input parameters, the solver was run and the results logged. The respective bending moment and shear force diagrams are plotted and detailed design output is also published.

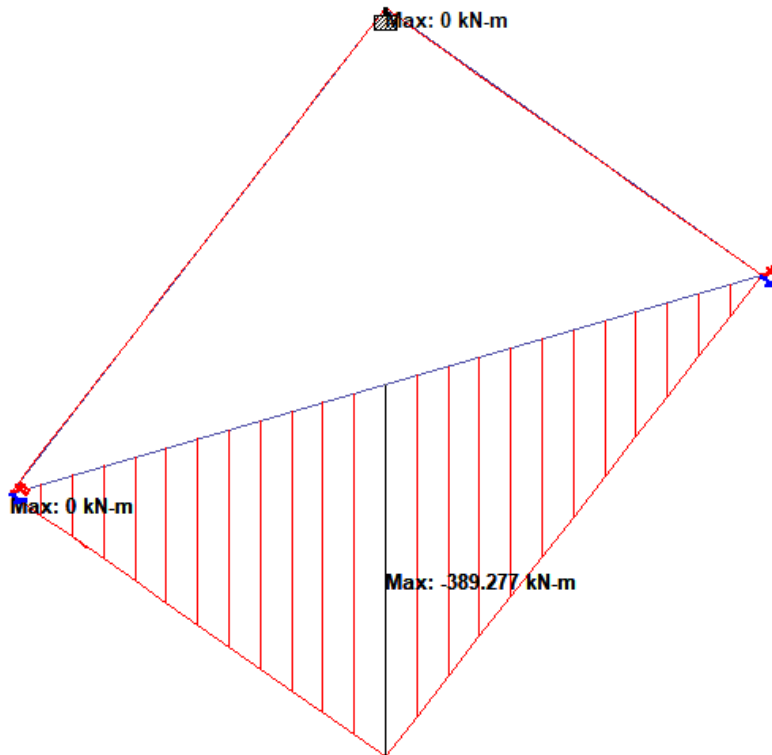


Figure 7 – Bending Moment diagram

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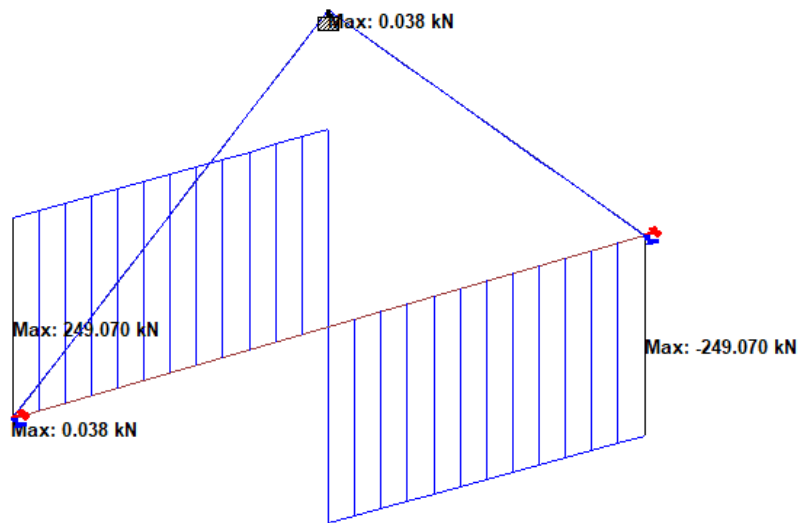


Figure 8 –Shear Force diagram

The below sections look at the design ratios and net displacements caused by the different loading scenario.

Design Ratios and Displacements

In order to have a safety factor of 2, the greatest design ratio value the beam can exhibit is 1.0 this is because the beam will be made of S355 material.

The beam design can be seen to have design ratio values below 1.0

Load Combination 1 – Design Ratios

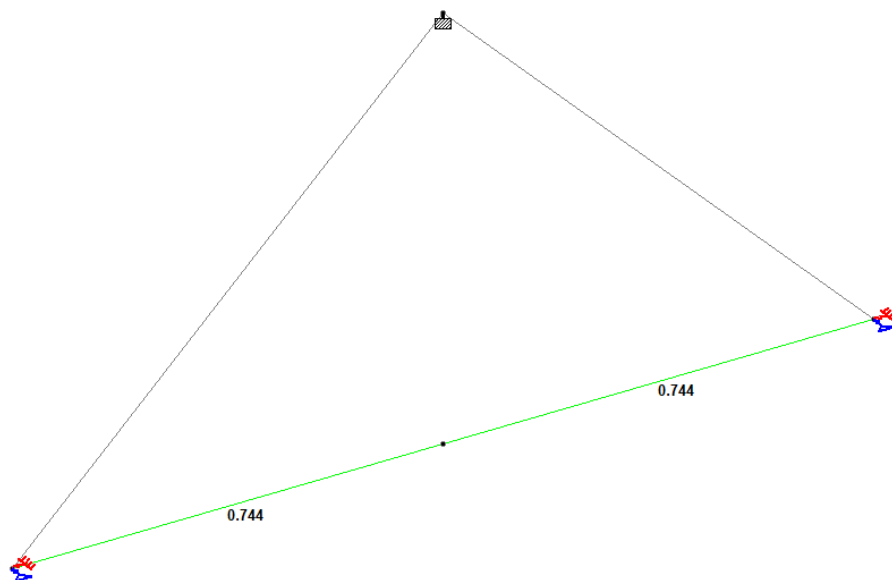


Figure 9 – Design Ratios

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Load Combination 1 – Node displacement Summary

Net displacement = $23.7 - 17.4 = 6.3\text{mm}$ (which is acceptable as less than 9.3mm)

The displacements are very nominal for 2 x SWLL which satisfies the high integrity design requirement.

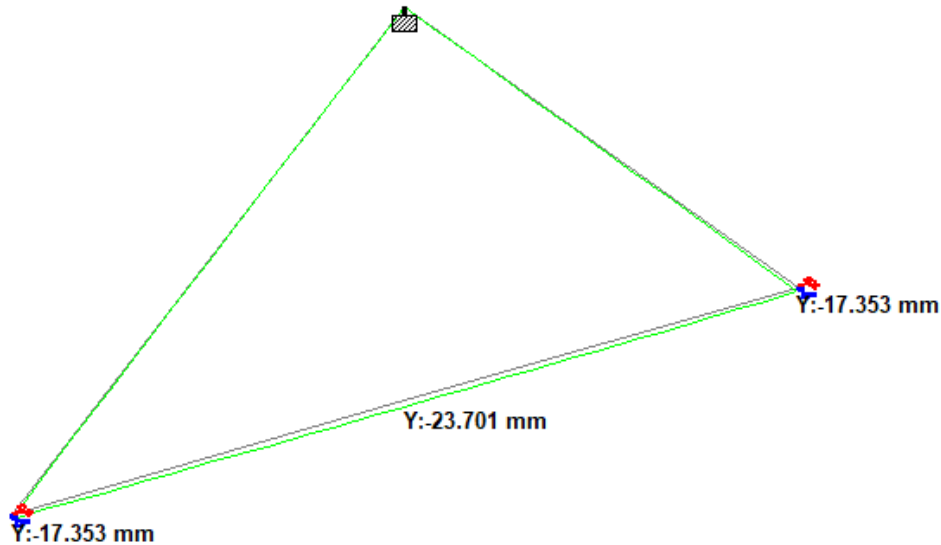


Figure 10 – Node Displacements

Conclusion

After looking at the results from the simulation, it can be seen that the beam is strong enough to hold the required load without yielding and stiff enough to hold the load without deflecting more than the maximum allowable.

The spreader beam case governs over the lifting beam case.

The 4mm fillet weld between the main plate and split tubes is adequate to bond the beam and keep all the stresses within the allowable limits.

The design of the beam is suitable to meet the specification required.

Thus, this beam is adequately designed to function as High Integrity Lifting Equipment.

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