DORRIAN **E**NGINEERING **L**TD
56 KNOCKRAMER MEADOWS,
LURGAN
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BT 66 6SA

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Design Verification Calculations

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Stage Truck

Chassis no:	WMAL88ZZZYY055566
Registration no:	W437 JNB
Make:	MAN
Model:	18-224F (6.3m wheelbase)
Maximum G.V.W (Kgs)	18,000

Vehicle weight prior to build:	5,250 Kgs
Vehicle Weight after build:	17,250 Kgs
Therefore, body weight is	12,000 Kgs

As seen below, the estimated weight of the roof section that raises up is 3,717.5 Kgs. (see pages 6,7,8,)

With the roof weighing 3717.5 Kgs, it can be assumed that this loading will be split 50/50 between the front and rear uprights. Therefore 1,858.75 Kgs is loaded at a point 600mm (approx) in from either end of the chassis.
The remaining weight of the body, that is to say 12,000 – 3,717.5 = 8,282.5 Kgs is uniformly distributed over the length of the truck. The gives us a UDF of 8282.5Kgs/9.115m = 908.67 Kg/m.

For the purpose of analysis, the large truck chassis will be omitted from calculations and the body of the truck will be looked at independently. In addition, the two side chimes of the truck will be omitted, and it will be assumed all loading is being carried by the chassis runners, which are 200 x 75 RSC.
The point loads and UDL are halves, as there are two beams carrying the load. Therefore, the point loads are 930 Kgs, and the UDL is 454 Kg/m.

The beam is simply supported in 3 positions by the hydraulic jacking system. The end jacks are approximately 500mm in from each end, with the third jack in the middle of the truck.

The beam to be analysed is shown in figure 1.
The resultant beam analysis results are shown in figure 2, with the beam properties used in the analysis shown on page 5.

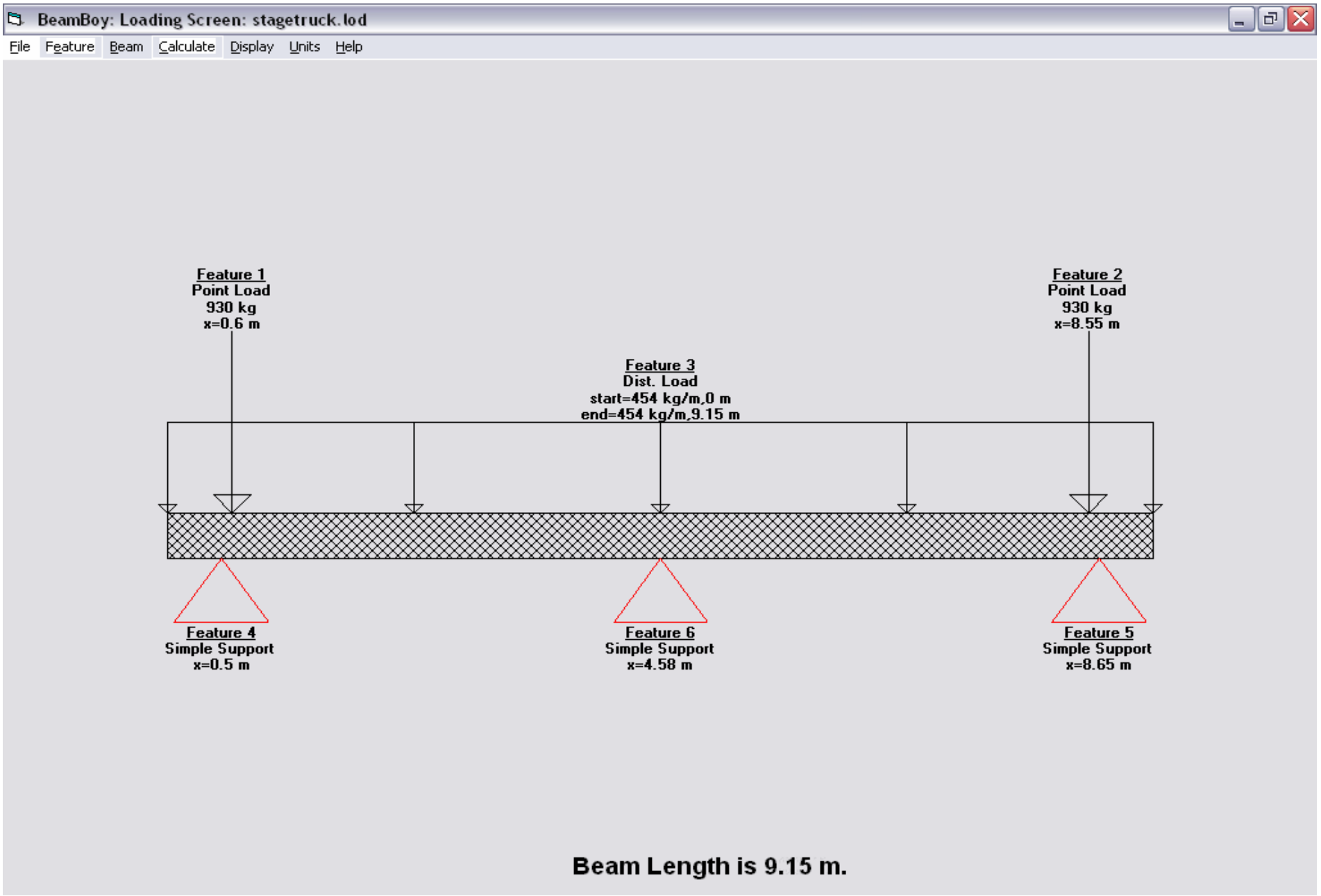


Figure 1 : Beam Layout

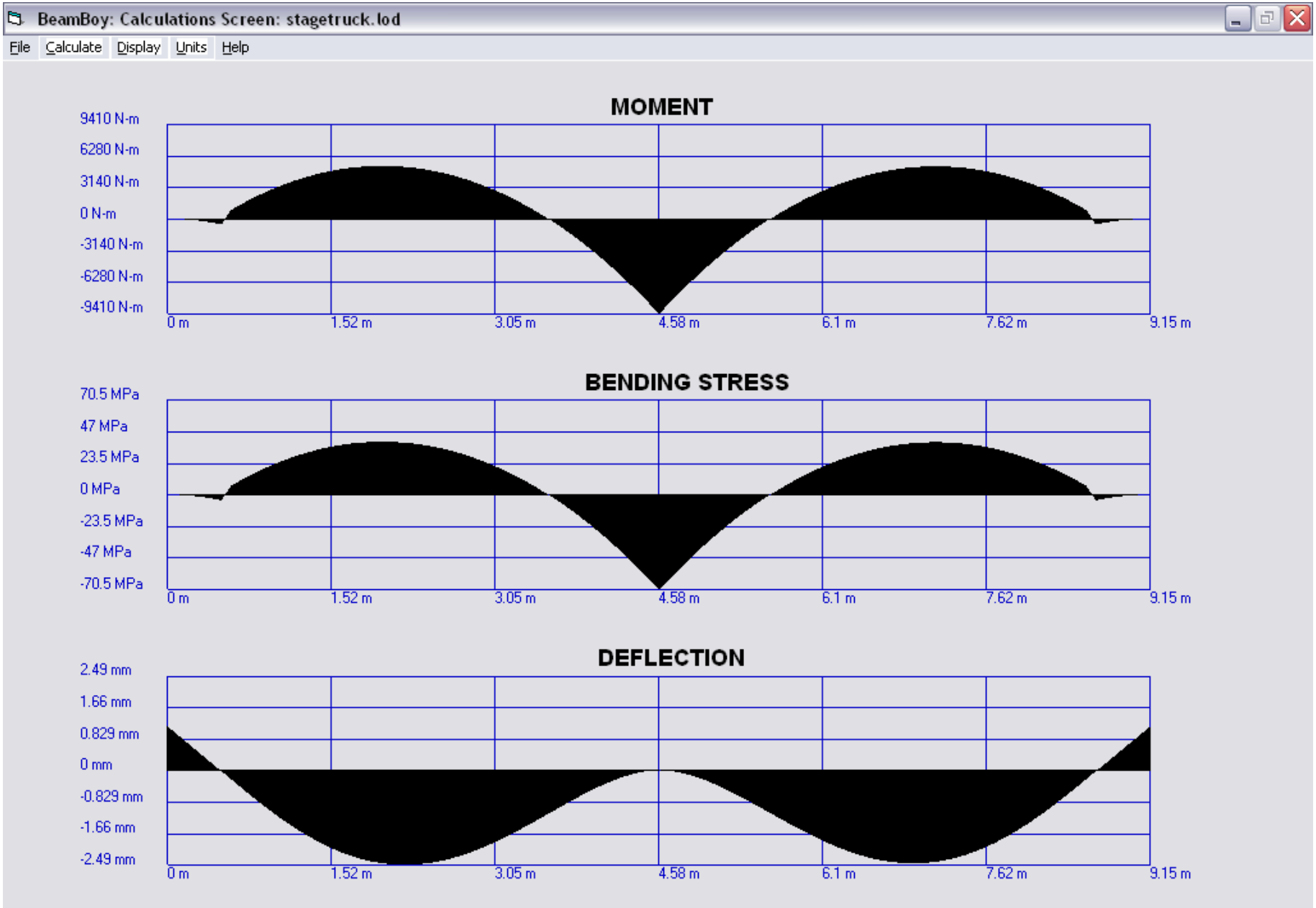


Figure 2 : Beam Analysis Results

BEAMBOY V2.2 REPORT

Stagetruck

BEAM PROPERTIES

Beam Length = 9.15 m
Moment of Inertia = 13600000 mm^4
Modulus of Elasticity = 205000 MPa
Distance From Neutral Axis to Furthest Fiber = 102 mm
LOAD CONFIGURATION

Point Loads
---
930 kg, x=0.6 m
930 kg, x=8.55 m
Distributed Loads

Start=454 kg/m, x=0 m; End=454 kg/m, x=9.15 m
Moments

Supports

Simple support; 0.5 m
Simple support; 8.65 m
Simple support; 4.58 m
MAXIMUM VALUES

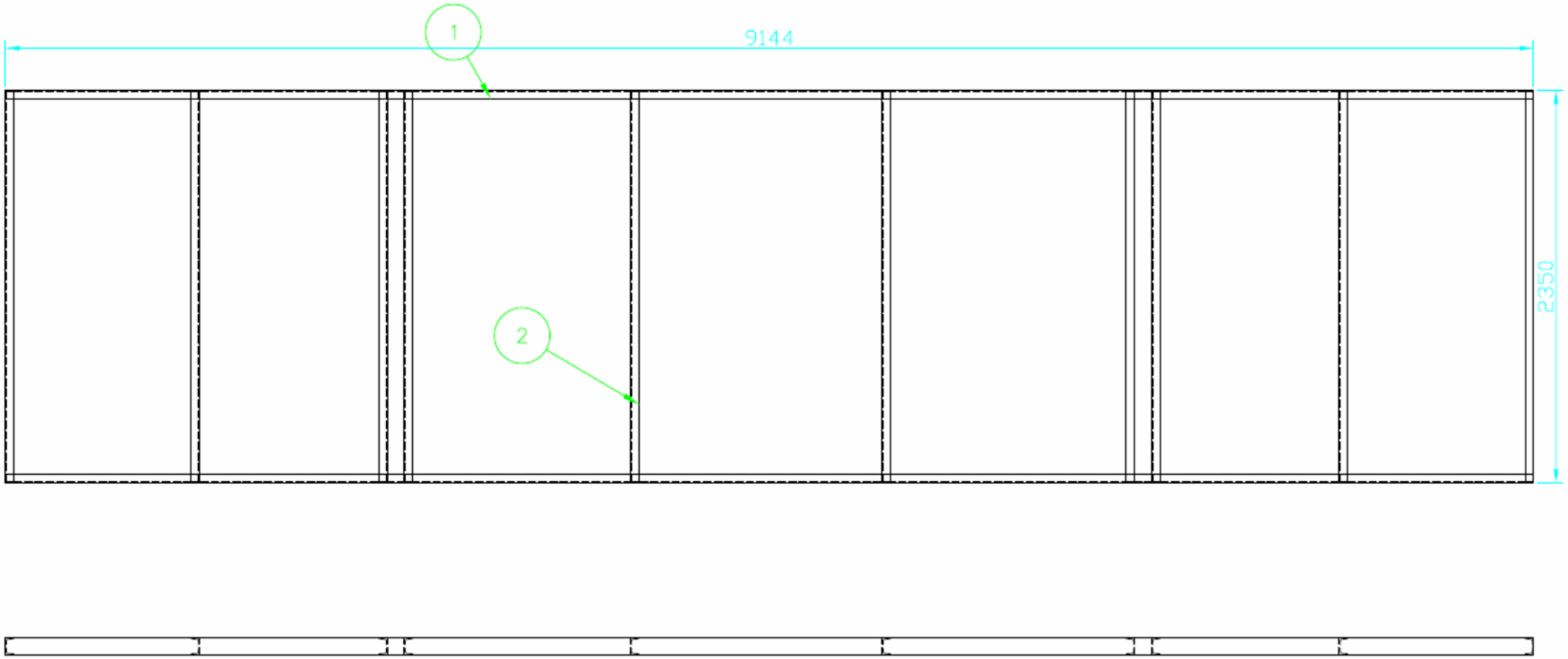
Maximum Bending Moment = -9410 N-m at x=4.58 m
Maximum Bending Stress = 70.5 MPa at x=4.58 m
Maximum Deflection = -2.49 mm at x=2.21 m
Maximum Slope = -0.137 degrees at x=0.535 m
07/08/2006

From the results, the maximum deflection when it is assumed that there is no supporting truck chassis and no side chimes is only 2.49mm over a 9.15m bed.
The maximum bending stress of 70.5 MPa (E:205,000 MPa) is well within the limits of the steel used.

It can be said that with the additional support of the side chimes and the chassis of the truck, the stage is comfortably fit for purpose.

DO NOT SCALE, IF IN DOUBT ASK

Parts List							
Item	Qty	Part_No	Description	Material	Length (mm)	Mass (kg)	Price (£)
1	2	SECONDARY ROOF BEARERS	SECONDARY ROOF BEARERS	100 X 50 RSC	9144	184.9	60.47
2	10	SIDE ROOF BEARERS	SIDE ROOF BEARERS	100 X 50 RSC	2338	236.4	77.31
						421.4	137.78



Rev	Revision note	Date	Dwn.	Ckd.

Drawing Size A1	Dimensions in Millimetres Unless Stated Otherwise Remove all Burrs and Sharp Corners	DORRIAN ENGINEERING LTD Tel : 028 38344190 - Fax : 028 38344190
		Date 13.05.05 | Drawn J.D. | Checked | Scale DNS
This Drawing is Confidential and is Supplied on the Understanding that it is not Copied or Shown to Other Persons or Companies Without the Written Consent of D.E.L. ©2006		Title/Name SIDE ROOF PANEL (SHEETING BOX SECTION & PANELS NOT INC'L)
		Drawing No. --- | Sheet 1 of 1 | Rev. —

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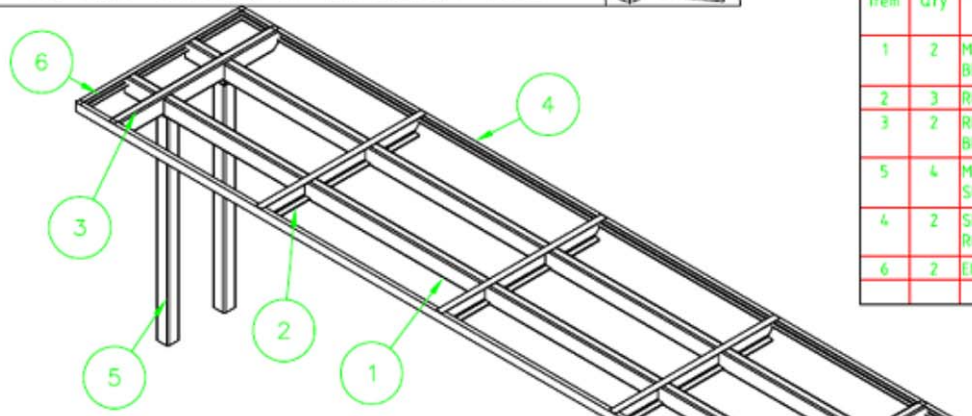
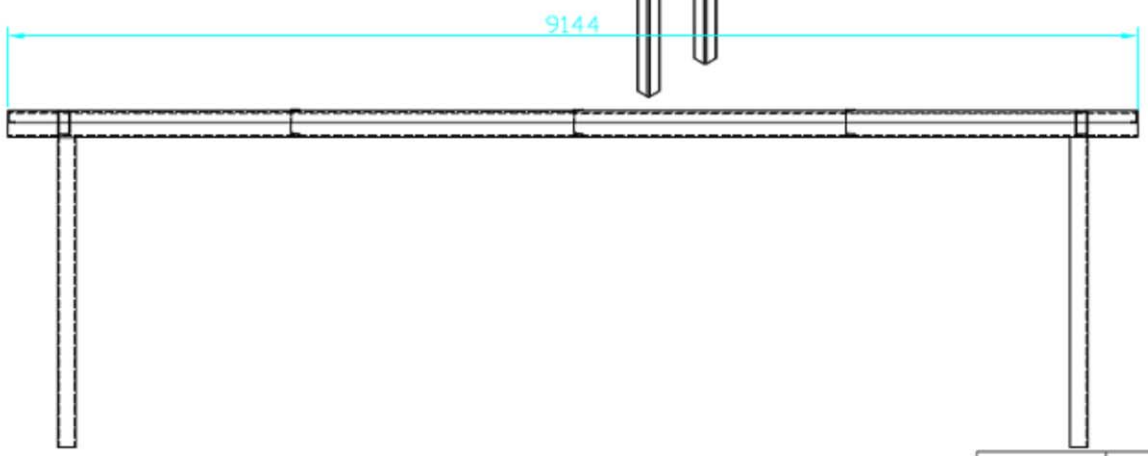
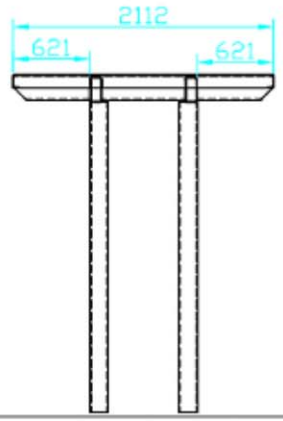


Parts List

Item	Qty	Part_No	Description	Material	Length (mm)	Mass (kg)	Price (£)
1	2	MAIN ROOF BEARERS	MAIN ROOF BEARERS	200x100x10 SHS	9144	778.8	346.35
2	3	ROOF BRACES	RSC CROSS BRACES	200 X 75 CHANNEL	2100	132.3	43.26
3	2	ROOF END BRACES	END ROOF BRACE	200x100x10 SHS	2100	160.0	71.18
5	4	MAIN ROOF SUPPORTS	MAIN ROOF SUPPORTS	150x150x10 SHS	2500	425.8	189.39
4	2	SECONDARY ROOF BEARERS	SECONDARY ROOF BEARERS	100 X 50 RSC	9144	184.9	60.47
6	2	END BEAMS	END BEAMS	100 X 50 RSC	2112	42.7	13.96
						1724.7	724.63





Rev	Revision note	Date	Dwn.	Chd.

Drawing Size A1	Dimensions in Millimetres Unless Stated Otherwise Remove all Burrs and Sharp Corners	DORRIAN ENGINEERING LTD Tel : 028 38344190 - Fax : 028 38344190
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		Drawing No. --- | Sheet 1 of 1 | Rev. -

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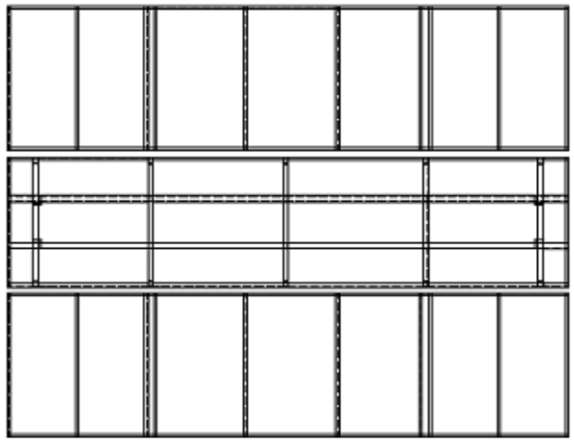
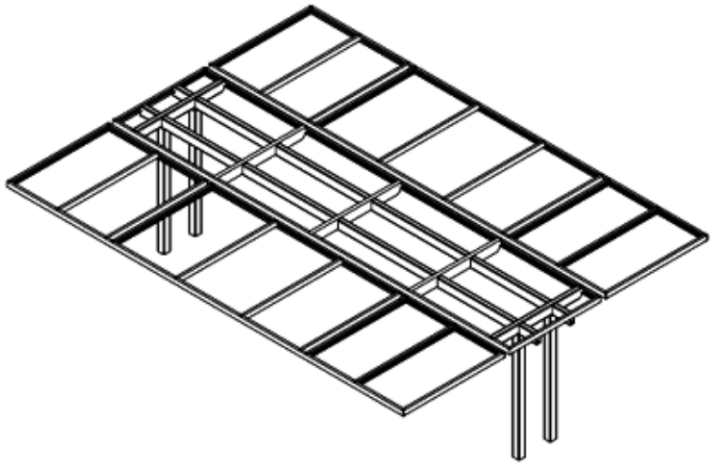
Drawing No. ASSEMBLY

CONSETVATIVE WEIGHT ESTIMATE FOR ROOF SECTION

MAIN ROOF :	1724.7 KGS
SIDE WINGS:	842.8 KGS
SHEETING BOX SECTION:	130 KGS (EST)
ALUMINIUM SHEETING:	80 KGS (EST)
10mm GUSSET PLATES:	220 KGS (EST)
WELDING ALLOWANCE:	180 KGS (EST)
RAMS, PINS, PIPES:	240 KGS (EST)
FRONT AND REAR PANELS	300 KGS (EST)

TOTAL LIFTED WEIGHT: 3717.5 KGS





SHEETING BOX SECTION (30X30X2.9 SHS), RAMS, RAM BRACKETS, AND HINGES ARE NOT SHOWN. 2mm ALUMINIUM SHEETING WAS USED TO SHEET THE COMPLETED UNIT. (NOT ILLUSTRATED)

Rev	Revision note	Date	Dwn.	Chk.

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This Drawing is Confidential and is Supplied on the Understanding that it is not Copied or Shown to Other Persons or Companies Without the Written Consent of DEL. ©2006		Title/Name ROOF ASSEMBLY			
		Drawing No. ASSEMBLY	Sheet 1 of 1	Rev. –	

The flip down side sections of the stage have been manufactured in a heavy duty steel frame. The weakest ling in this part is the hinge pins. A simple shear calculation will be compiled on the side panels to obtain the maximum permissible loading on these sections.

When the panels are set-up for stage use, the inside edge is supported on 5 hinge pins, whilst the outer edge is supported a steel from with adjustable legs.

For a worst case scenario, it will be assumed that two pins are missing, and the remaining pins have worn down to a diameter of 15mm. It will also be assumed that the pins are mild steel.

Therefore
Total area in shear is $(\Pi D^2/4) * 3$ where D is the diameter in meters

$(\Pi * 0.015^2/4) * 3 = 5.301 \times 10^{-4}\ m^2$

The maximum load on the pins in double shear is given by

$\sigma \times 2 \times A = P$,

Where
P = load in Kgs
A= Area in shear in m^2
σ = yield strength of mild steel in Kg/ m^2

$(36.9 \times 10^6) \times 2 \times (5.301 \times 10^{-4}) = 39{,}124$ kgs

The flip down sections of the stage are safe to take any load up to 3.9 tonnes with a factor of safety of 10.

The stage is fit for purpose.

Roof Pins in Shear.

A key to this design is that all parts of the stage operate hydraulically. Lock /burst valves are fitted to all rams, so that should the pipes fail, the pressure will be locked in the ram, which will keep the stage in position. In addition, all parts held up by rams are also mechanically supported.

A key area in this design is the back-up pins in the main roof uprights. Should the seals in the rams or the pins in the rams fail, this pin will support the roof.

Pin check

Pin Diameter 50mm in mild steel. Again, it will be assumed that the pins have worn down to 45mm., and that there is only one pin in place at either end
Total area in shear is $(\Pi D^2/4) * 2$ where D is the diameter in meters

$(\Pi * 0.045^2/4) * 2 = 31.8 \times 10^{-4}\ m^2$

Pin in double shear

$\sigma \times 2 \times A = P,$

Where
P = load in Kgs
A= Area in shear in m^2
σ = yield strength of mild steel in Kg/ m^2

$(36.9 \times 10^6) \times 2 \times (31.8 \times 10^{-4}) = 234{,}747$ kgs

Even with worst case scenario, the pins will easily take the 3,717.5 Kgs of dead roof weigh and any weather and wind loading.

The stage is fit for purpose.

Wind loading

The greatest load applied to this truck will come in the form of wind. Design wind speed can be calculated by the formula:

$V_s = V + S_1 + S_2 + S_3$, formula:

Where
V = the velocity being considered (70 mph gust in this case, which is 31.29 m/s)
S_1 = the Topography factor (=1) This is true if the slope does not exceed 0.05. As the stage is levelled prior to use, 1 will be used in this case.
S_2 = the ground roughness and building height factor. In this case a factor of 0.78 will be used which is the std factor for "country with many wind breaks, such as small towns or outskirts of cities". These are the area's in which the stage is normally used.
S_3 = the statistical factor between 0 and 1 on the likelihood that wind will occur. In our case, we want to assume it is windy and therefore a factor of 1 is assumed

Therefore : $V_s = 31.29 \times 1 \times 0.78 \times 1$
$V_s = 24.41$ m/s

The dynamic pressure of the wind above standard atmospheric pressure (q) can be calculated with the formula

$$q = 0.613 \times (V_s)^2$$
$$q = 0.613 \times (24.41)^2$$
$$q = 365.25 \text{ N/m}^2$$

Therefore, a 70 mph gust of wind will apply a force of 365.25 N/m^2
The largest are to catch a gust of wind I the rear of the stage (i.e. the driver side)
The main support for the back panel is the 4 telescopic uprights.
For analysis, we will look at the inner member (smaller beam size) as a cantilever beam (i.e fixed at one end) and check both the bending, shear and deflection of these 3 parts.

The rear section is 9.15 meter long x 4.1m high when the stage is erected, giving an area of 37.515 m^2 under win load. Based on q calculated above, the wind load exerted on the rear of the stage whilst erected is

365.25 N/m^2x 37.515 m^2 = 13702 n (13.7 KN)
We will assume that the entire cantilever beam when the stage is erected is 150 x 150 x 10mm SHS (inner telescopic material) at a length of 4.25m (height in the middle).

A load of 13.7Kn/2 is being exerted ant both ends, and as there are 2 beam at each end the load on each beam is therefore 13.7KN/4
The beam being analysed is shown in figure 3 below

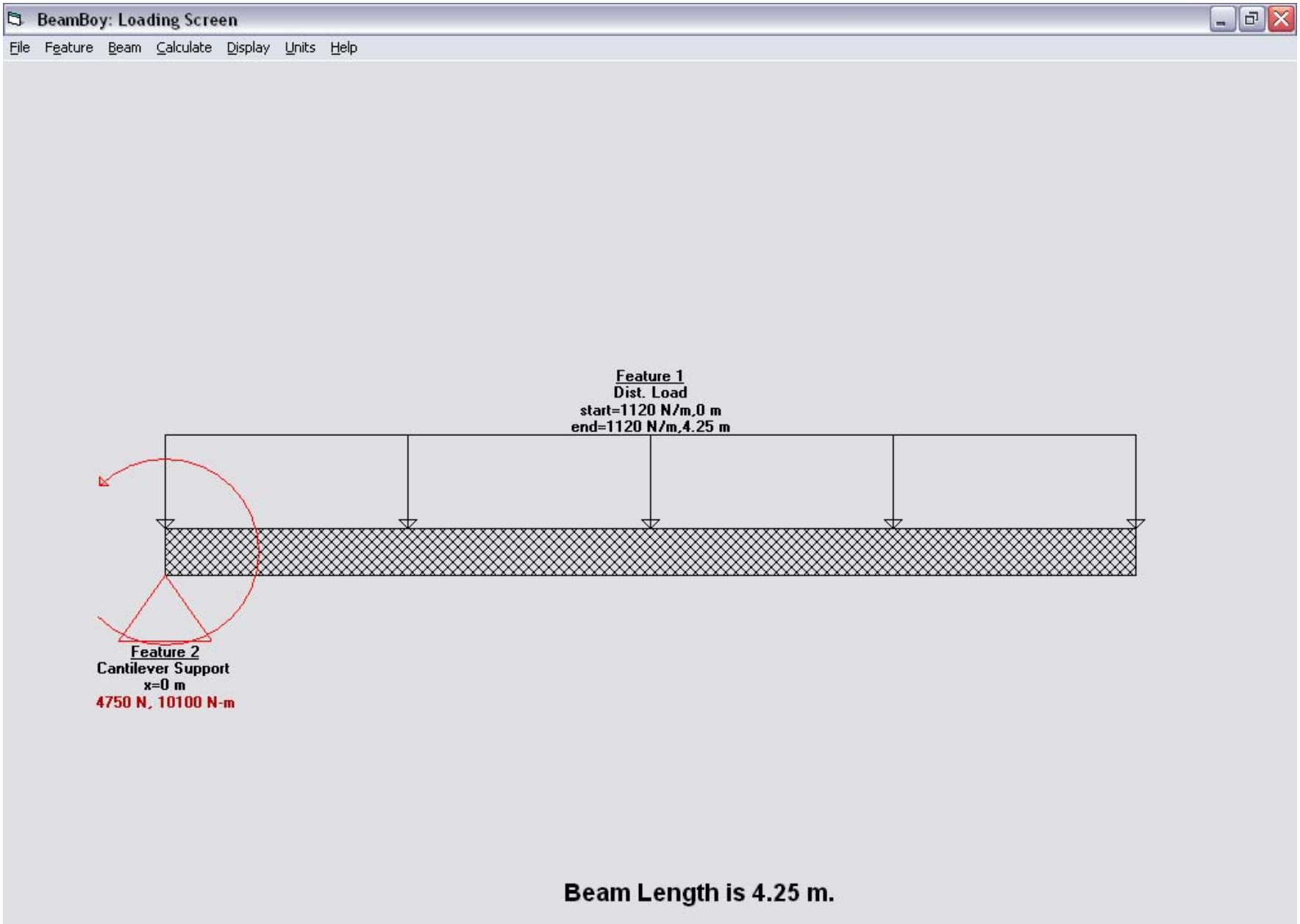

Figure 3 – Main upright

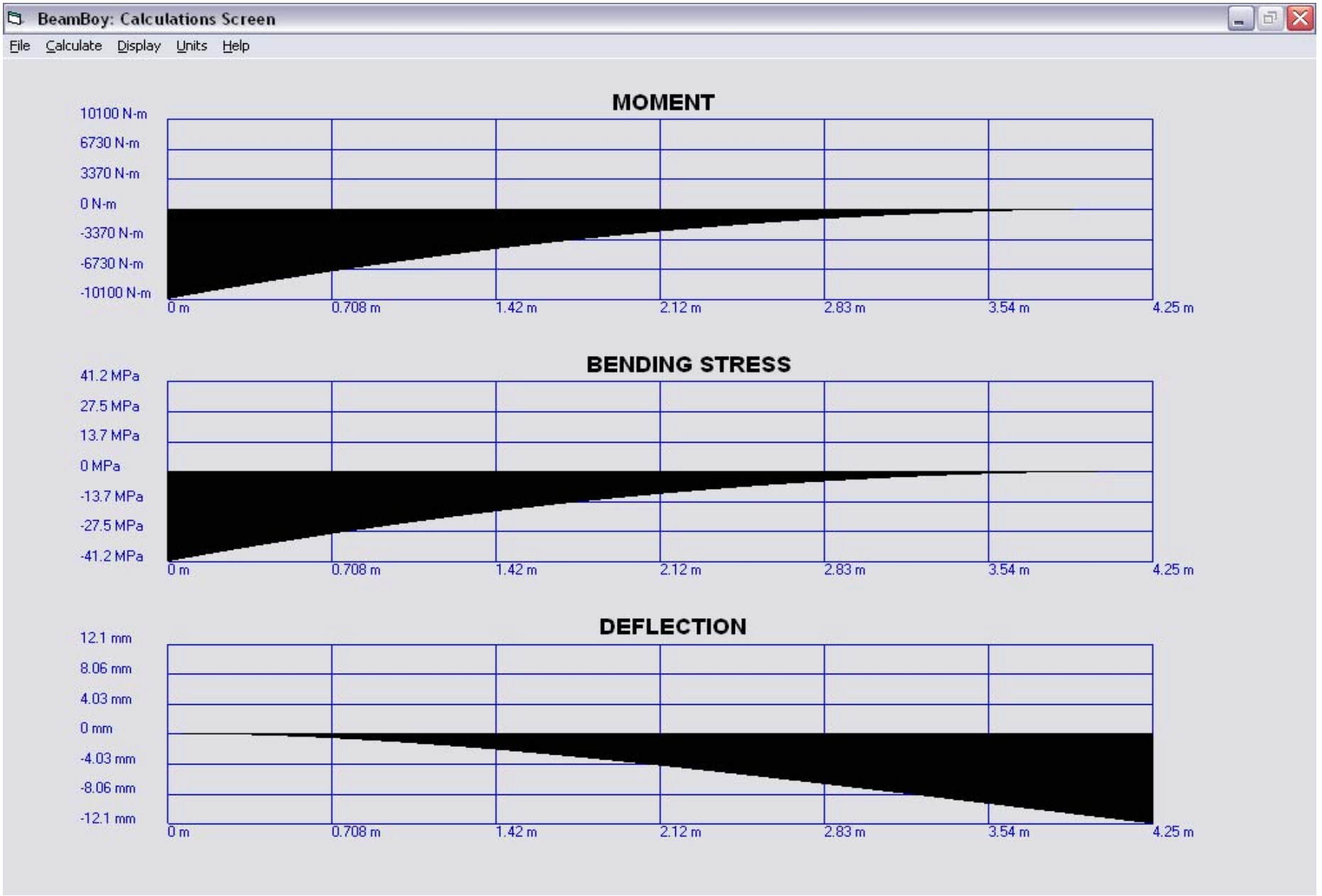

Figure 4 – Main upright Analysis Results

BEAMBOY V2.2 REPORT

StageTruck-Cantilever

BEAM PROPERTIES

Beam Length = 4.25 m
Moment of Inertia = 18400000 mm^4
Modulus of Elasticity = 205000 MPa
Distance From Neutral Axis to Furthest Fiber = 75 mm
LOAD CONFIGURATION

Point Loads

Distributed Loads

Start=1120 N/m, x=0 m; End=1120 N/m, x=4.25 m
Moments

Supports

Cantilever support; 0 m, Reaction=4750 N, 10100 N-m
MAXIMUM VALUES

Maximum Bending Moment = -10100 N-m at x=0 m
Maximum Bending Stress = 41.2 MPa at x=0 m
Maximum Deflection = -12.1 mm at x=4.25 m
Maximum Slope = -0.217 degrees at x=4.25 m
08/08/2006

The analysis of the beam shows that the stress and the bending moment are acceptable, given that the bottom of the beam is gusted to relieve the bending moment. The maximum deflection is 12.1mm which is also acceptable, given that the beam is assumed to be free standing, where is actual fact it is tied to the other beam, and the actual maximum values will be lower than that theoretically calculated.
It can also be said that before the beams will reach the values, the straps on the canvas cover will have ripped at the rear of the stage, preventing such a wind load being generated.

However if we assume the simple beam analysis above, a worst case scenario (i.e. no tie to the second upright, no gusset plates, and the rear canvas cover holds) then the truck is still fit for purpose.

The final calculation is to consider the uplift generated by the roof and the rear of the truck in a 70 Mph wind. From above we know that the rear panel exerts a force of 13702 N (13.7 KN)

I addition to this force, the roof opened out could catch a full swirling up lift wind (worst case)
Therefore, in addition to the 13.7 KN generated, the roof will generated an upward load of

Roof: q x roof area

Roof: 365.25 N/m^2 x (9.15 x 6.812) = 22,769 N (22.8KN)

The total load by wind trying to lift (or overturn the truck) is 36.5 KN

The total anchorage mass (weight of the stage and truck) is 17,250 Kgs (17,250 x 9.81N = 169.22 KN)

The FOS is therefore 169.22/36.5 = 4.64,

The stage is therefore easily fit for purpose.

For the purposes of safety, the stage should not be erected when wind speeds are reaching 50 mph.

These calculations have been compiled by:

Jimmy Dorrian Beng, Ceng MIMechE