Advanced Computational Analysis

ACA

REPORT

REPORT NO: S2149-1

Revision B

Title: Structural Verification Of Portable 4-Person Bungee Trampoline Amusement Device

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Summary

This report describes the structural verification of the 4-person, bungee trampoline amusement device, as manufactured by Airmax LeisureZone.

The structural model of the bungee trampoline device was generated from drawings provided, see appendix O, with the modifications shown in figures 4.1, 4.3 and 5.1. Since no design calculations had been carried out by the manufacturer, initial in-house closed form calculations were carried out to substantiate the results of this analysis, ref ACA report S2149-2.

The analysis detailed below was carried out based on loadings from various combinations of ride operation, based on a maximum single passenger mass of 80 kg, bouncing with a maximum inertial acceleration equivalent to 2g.

The results of the analysis and the comparison of these results with the initial closed-form calculations, show that all structural and mechanical components have adequate load-carrying capacity, based on the loading prescribed above and provided the modifications detailed below are adopted.

Index

Description Of Ride

The 4-person bungee trampoline is an amusement device capable for use either by adult or child participants. The ride is lightweight and fully transportable and is trailer-mounted. It can easily be erected and dismantled for use on any suitable site, either outdoors or indoors (providing adequate headroom is available).

The ride operates by first positioning the passenger on the trampoline. The passenger harness is then fitted and attached to the bungee ropes, on either side of the passenger. The number of bungee ropes used is adjusted, depending on the estimated passenger mass, to give the appropriate ‘feel’ to the bounce of the participant, without exerting excessive inertial forces on the passenger. This is carried out based on the experience of the ride operator.

During the ride the participant bounces vertically until reaching a maximum height of approximately 6.5 m. At this point the participant experiences a feeling of partial weightlessness. As the passenger moves progressively higher with each bounce, the winding motor reduces the effective length of the ropes, to permit the passenger to release progressively more potential energy with each bounce.

The downwards motion of the participant, at the lowest point, is arrested by a combination of the contact between the participant and the trampoline and the moderate tension in the flexible bungee ropes. Note that it is not always necessary for the participant to make full contact with the trampoline; in some instances the vertical motion is arrested only by the bungee ropes. In this case the flexibility of the bungee ropes would ensure that the maximum inertial forces are reduced.

It is difficult to estimate the maximum passenger forces exerted by the device, due principally to the wide variation possible in participant mass. However an acceptable guide would be approximately 2g absolute maximum inertial acceleration, which would give the ride participant a sensation of twice body mass when bouncing.

A typical view of the 4-person bungee trampoline is shown in figure 1.1.

Method Of Analysis

The analysis of the 4-person bungee trampoline device was performed using the ANSYS finite element program. The structural model of the device was generated from drawings provided with the modification detailed in figures 4.1, 4.3 and 5.1.

The analysis of the bungee-trampoline structure was performed with regard to the initial in-house closed form verification, ref 2149-2.

1) Structural Analysis

The finite element model of the main structure was generated using a combination of BEAM4, LINK10, CONTACT52, MPC184, COMBIN14 and MASS21 element types. The BEAM4, 3-dimensional prismatic beam elements were used to model the majority of the ride which included; the trailer chassis, various connecting bolts and pins, the support arms and the aluminium poles. The cross-sectional properties of these elements were set to those of the frame and support pole members, as appropriate. The LINK10, 3-dimensional, tension-only elements were used to model the steel guy ropes which constrained the top of each support pole and the bungee ropes. This element type can sustain only tensile loads and is removed from the element formulation if the forces are equal to, or less than zero. The cross-sectional area of the element was set to that of the steel rope, as appropriate. The CONTACT52, 3-dimensional, compression-only contact elements were used to model the contact between the base frame and ground. The stiffness of these elements was set to ensure that there was no interpenetration between the frame and the ground. Also this ensured that should the frame lift from the ground during loading these elements would be removed from the element formulation. The MPC184 3-dimensional constraint elements were used to model various welded joints on the structure. This element was set to transfer all forces and moments between 2 nodal positions. The COMBIN14 3-dimsional torsional spring element was used to simulate the action of the pulleys at the top of the aluminium poles. The MASS21 3-dimension mass elements, without rotational inertia were used to model the mass of the winch motor and the mass of the trailer wheels and stub axles.

The finite element model comprised a total of 822 elements (762 beam elements, 24 tension-only elements, 6 contact elements, 16 constraint elements, 8 torsional spring elements and 6 mass elements) and 813 nodes. The finite element model of the device is shown in figure 1.2.

Note that due to the inherent flexibility of the structure a large deflexion analysis was performed, to ensure increased accuracy in predicting deflexions and also to include any secondary bending or tension effects in the results. Hence the analysis was non-linear (due to the use of large deflexion effects and non-linear element types) and the model reached convergence to within 0.5% of the overall load on the structure.

The verification of the steel components was undertaken in accordance with the requirements of BS449-2:1969, hence ensuring all working stresses are well within the elastic limit of the material. Therefore the following 4 load cases were used to verify the steel structure.

i) Load Case 1

This load case represented the first of two out-of-balance load conditions. In this load case a single passenger loading was applied at one passenger station. The loading on the passenger was equivalent to 2g, based on a passenger mass of 90 kg and as a worst case, the bungee ropes were assumed to be in the position where the participant would be in contact with the trampoline. This position would be concomitant with a passenger reaching these accelerations at the bottom of the bounce. Further details of the passenger loading are shown in calculation sheet 1.

In addition to the loads described above, the self-weight loading of the structure was included automatically by the finite element program, for all load cases, based on the steel and aluminium densities shown below and an acceleration due to gravity of 9.81 m/s^2

ii) Load Case 2

This load cases represented the second of two out-of-balance load conditions. This load case was similar to load case 1 except that the loading on the structure was derived from two passengers, positioned on adjacent sides of the structure. The purpose of this load case was to examine the effects on the structure due to unbalanced loading on the support poles, at adjacent sides of the frame.

iii) Load Case 3

This load case was again similar to load case 1, but with passenger loading applied at two opposite passenger stations. The purpose of this load case was to examine the effects on the structure due to extreme opposing loads

iv) Load Case 4

The purpose of this load case was to examine the effects on the structure due to the maximum imposed loading. Therefore forces were applied at all four stations.

To verify the aluminium sections the following 4 load cases were created in accordance with BS EN 1999-1:2007 and BS EN 1990:2002;

v) Load Case 5 = 1.35xDead load + 1.5x Imposed load detailed in load case 1

vi) Load Case 6 = 1.35xDead load + 1.5x Imposed load detailed in load case 2

vii) Load Case 7 = 1.35xDead load + 1.5x Imposed load detailed in load case 3

viii) Load Case 8 = 1.35xDead load + 1.5x Imposed load detailed in load case 4

2) Material Properties And Component Capacities

a) The material properties for the aluminium sections used for the analysis were based on grade 6060 T66 aluminium, as follows:

$E = 70000\ N/mm^2$ (Young's modulus)
$\nu = 0.316$ (Poisson's ratio)
$\sigma_{0.2} = 150\ N/mm^2$ (0.2% Proof strength)
$\rho = 2710\ kg/m^3$ (Density)
The material certificate for the aluminium sections is shown in Appendix A

b) The material properties for the steel sections used for the analysis were based on grade S235 structural steel (as specified by the device manufacturer), as follows:

$E = 207000\ N/mm^2$ (Young's modulus)
$\nu = 0.28$ (Poisson's ratio)
$\sigma_y = 235\ N/mm^2$ (Yield strength)
$\rho = 7850\ kg/m^3$ (Density)
The material certificate for the steel sections is shown in Appendix B

c) The steel ropes are a standard 6x19 configuration, with a fibre core, to DIN 3055, with a maximum capacity of 9.41 kN. Based on a maximum tensile force of 3.1 kN this will be acceptable. The certificate of conformity for the steel rope is shown in Appendix C.

d) The certificate of conformity for the carabiner is shown in Appendix D. A carabiner of size 12 mm has a loading capacity of 4.4 kN, this will be satisfactory based on maximum load of 3.1 kN

e) The certificate of conformity for the bungee harness is shown in Appendix E and has a maximum load capacity of 7.8 kN. This will be satisfactory based on a maximum load of 1.76 kN. A number of harnesses are supplied to suit various body sizes. However, it is imperative that operator ensures that the appropriate size harness is fitted correctly

f) The certificate of conformity for the D-Shackle is shown in Appendix F. A D-Shackle of size 12 mm has a loading capacity of 5.1 kN, this will be satisfactory based on maximum load of 3.1 kN

g) The certificate of conformity for the eye-nut is shown in Appendix G. An M10 eye-nut has a loading capacity of 3.13 kN, this will be satisfactory based on maximum load of 3.1 kN

h) The certificate of conformity for the rope clip is shown in Appendix H. However once the steel ropes have been set to the correct length you will need to fit a swage clamp to ensure the steel rope cannot slip.

i) The certificate of conformity for the turnbuckle is shown in Appendix I. An M12 turnbuckle has a breaking load capacity of 7.6 kN, this will be satisfactory based on maximum load of 3.1 kN

j) The test certificate for the bungee cord is shown in Appendix J. The bungee cord has a safe working load of 1.9 kN, this will be satisfactory based on a maximum tensile load of 1 kN.

k) The certificate of conformity for the winch motor is shown in Appendix K. The winch motor has a working load capacity of 4.9 kg, this will be satisfactory based on maximum load of 1.76 kN

l) The worst case condition for alternating stress in a weld is 69 N/mm^2, as detailed in calculation sheet 15. This weld has been verified and given a fatigue life expectancy of 2 years.

The results of the analysis are presented below.

Results

Load Case	Stresses In Aluminium Beam Structure (N/mm^2)	Stress In Steel Plate Structure (N/mm^2)	Maximum Utilisation Factor In Steel And Aluminium Sections	Forces in Steel Ropes (kN)	Overall Deflexion In Structure (mm)	Maximum Reaction Forces (kN)		
						Fx	Fy	Fz
1	-	17.3	0.71*(figure 2.2)*	2.4	139.11*(figure 2.7)*	0.17	4.30	-0.15
2	-	21.3	0.87*(figure 2.3)*	3.1*(figure 2.6)*	231.77*(figure 2.8)*	-0.80	3.67	-0.79
3	-	21.6	0.62*(figure 2.4)*	2.3	49.74*(figure 2.9)*	0.04	4.38	0.04
4	-	21.9 *(figure 2.1)*	0.86*(figure 2.5)*	2.1	64.08*(figure 2.10)*	0.02	6.20	0.14
5	-25.6*(figure 2.11)*	-	0.51	-	-	-	-	-
6	-125.5*(figure 2.12)*	-	0.82	-	-	-	-	-
7	-48.1*(figure 2.13)*	-	0.56	-	-	-	-	-
8	-73.1*(figure 2.14)*	-	0.77	-	-	-	-	-

Table 1 – Summary Of Results For Stresses, Utilisation Factors Deflexions And Base Reaction Forces

Note:

i) The stresses quoted above are the most severe combination of bending and axial stress in any structural component.

ii) The stresses quoted in table 1 above for the plate structures are the von-Mises stress components and should be compared directly with the material yield or proof strength, when examining for elastic failure, i.e.

$$\sigma_{vM} = \sqrt{\frac{1}{2}\left[(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2\right]}$$

ii) The deflexion quoted above is the vector sum of the individual Cartesian deflexion components.

iii) The determination of the structural capacities of the various components of the device, the assessment of the critical joints and the fatigue assessment of the critical welds are shown in calculation sheets 2 to 18.

iv) The max reaction of 6.2 kN is equivalent to an average pressure on the ground of 155 kN/m^2 when a 200x200 mm packing point has been used

Conclusions

The forces determined from the present analysis are concomitant with those predicted by the in-house closed-form design verification report of this ride, ref ACA report S2149-2. The small discrepancies between the predictions from the closed-form verification and this analysis arise mainly from the method of analysis used in each case. The analysis carried out in the present study uses a non-linear approach, which more accurately predicts stresses and deflexions. In addition to this the closed-form calculations cannot account for the stabilising cables supporting the top of each aluminium pole. Notwithstanding this, the forces resulting from each individual analysis are sufficiently close to ensure that there is no major discrepancy in the resulting stresses and deflexions.

The stresses predicted in the aluminium support poles provide an utilisation factor of 0.82 (based on a limit state analysis to BS EN 1999-1-1:2007), which clearly is adequate based on the permissible value of unity.

For the base frame, the stresses in the steel plates forming the winch motor mounting points provide a minimum factor of safety of approximately 10.7 (for load case 4), this will be acceptable based on a yield strength of 235 N/mm^2. In addition to this the combination of axial force and bending moments in any member provided a maximum utilisation factor of 0.87. Based on the permissible value of unity this again will be acceptable. ***However it is imperative that you adopt the modifications to the winch motor fixing detail and trailer chassis as shown in figures 4.3 and 5.1***

The maximum deflexion in the structure represents approximately $^1/_{26}$ of the overall height of the device (for load case 2). Whilst this would be excessive for a static structure the deflexions result from dynamic loads and sway of the structure, rather than static vertical deflexion. Hence, since the stresses are relatively low in this component the dynamic deflexion is fully recoverable and will be acceptable.

The welds connecting the 30x30x3 SHS supporting the winch motors to the 30x30x2 SHS forming the trailer chassis, shown in figure 4.5, were identified as the critical welds on the structure. They have been given a predicted fatigue life of approximately 2 years, based on a Miner's rule summation for operation of the device for 240 days per year at 5 working hours per day (see calculation sheet 18). ***However it is imperative that an additional 80x80x6 gusset plate be welded at the base of each outrigger as shown in figure 4.1.***

The analysis of the critical pin and bolted connections, shown in calculation sheets 15 and 16, demonstrates that the stresses in the pin connection have adequate strength for the proposed maximum loading.

The material and component certificates provided by the manufacturer and owner demonstrate that those components have adequate load–carrying capacity for the proposed maximum loading. Note that since the trampoline structure is a proprietary item that is TUV certified no further analysis has been undertaken. However the operator must ensure that trampolines do not move laterally during use. It is recommended that the trampolines are secured and anchored in position or weights are used to prevent movement. Additionally it is the responsibility of the operator to ensure the participants are using the device correctly within the confines of the trampoline.

Note finally that the operator should be vigilant to ensure no passengers greater than 80 kg in mass are allowed to use the ride.

It is clear therefore that all components have sufficient strength to provide a satisfactory working life for the device, based on the assumed maximum loading, providing the recommendations detailed below are adopted.

Recommendations

From the results of the analysis clearly there are no principal structural components on the device which require specific detailed periodic inspection or other detailed investigation, other than the critical welds detailed below.

Nevertheless it would be prudent to periodically check the integrity of all components on a regular basis. Hence the operator should periodically (daily) inspect for parent material or weld cracks, particularly the critical welds. The critical welds on the trailer and outriggers should be inspected non-destructively on an annual basis.

Additionally, all fixing ropes and bungee ropes should be inspected daily and replaced as necessary if there is any evidence of damage and/or fraying.

Whilst the ride could not be classed as extremely boisterous there would be a category of people for which the ride would not be suitable. For example it would be suggested that the following should not be allowed to participate in the ride experience:

Very small children (unless under strict supervision from the operator).

People with a history of neck/back or other skeletal injuries, or other medical problems.

People with a history of heart problems.

Pregnant women.

People with obvious physical and/or mental disabilities, for whom the ride clearly would not be suitable and whose use of the ride would be likely to cause injury (this is the responsibility of the operator, who clearly must be experienced in making this judgment).

It would be appropriate to display signage at the ride atrium, indicating the ride would not be suitable for the above category of participants.

The maximum ground bearing pressure, beneath the ride base, is predicted to be an average of 155 kN/m^2, based on a 200 mm x 200 mm footprint. This bearing pressure is adequate for most sites on consolidated ground. However it is the responsibility of the ride operator to ensure that the site is capable of carrying this ground pressure.

For passenger safety and to prevent overturning, the device should not be operated in wind speeds greater than 8 m/s.

By the nature of the ride, the inertial forces experienced by the ride participants are governed by the set-up of the bungee rope arrangement, which is strictly under the control of the operator. It is imperative therefore that only very experienced operators should be allowed to control the ride.

Additionally, to prevent collision with spectators, suitable barriers must be placed at least 1.5 m from the extreme outer edges of the trampolines or operating envelope of the bungee. Also the operator must be vigilant to misuse by the participants and/or spectators. If this should occur the device must be halted immediately.

R. Anderson

Figures

Figure 1.1 – Typical View Of Bungee Trampoline

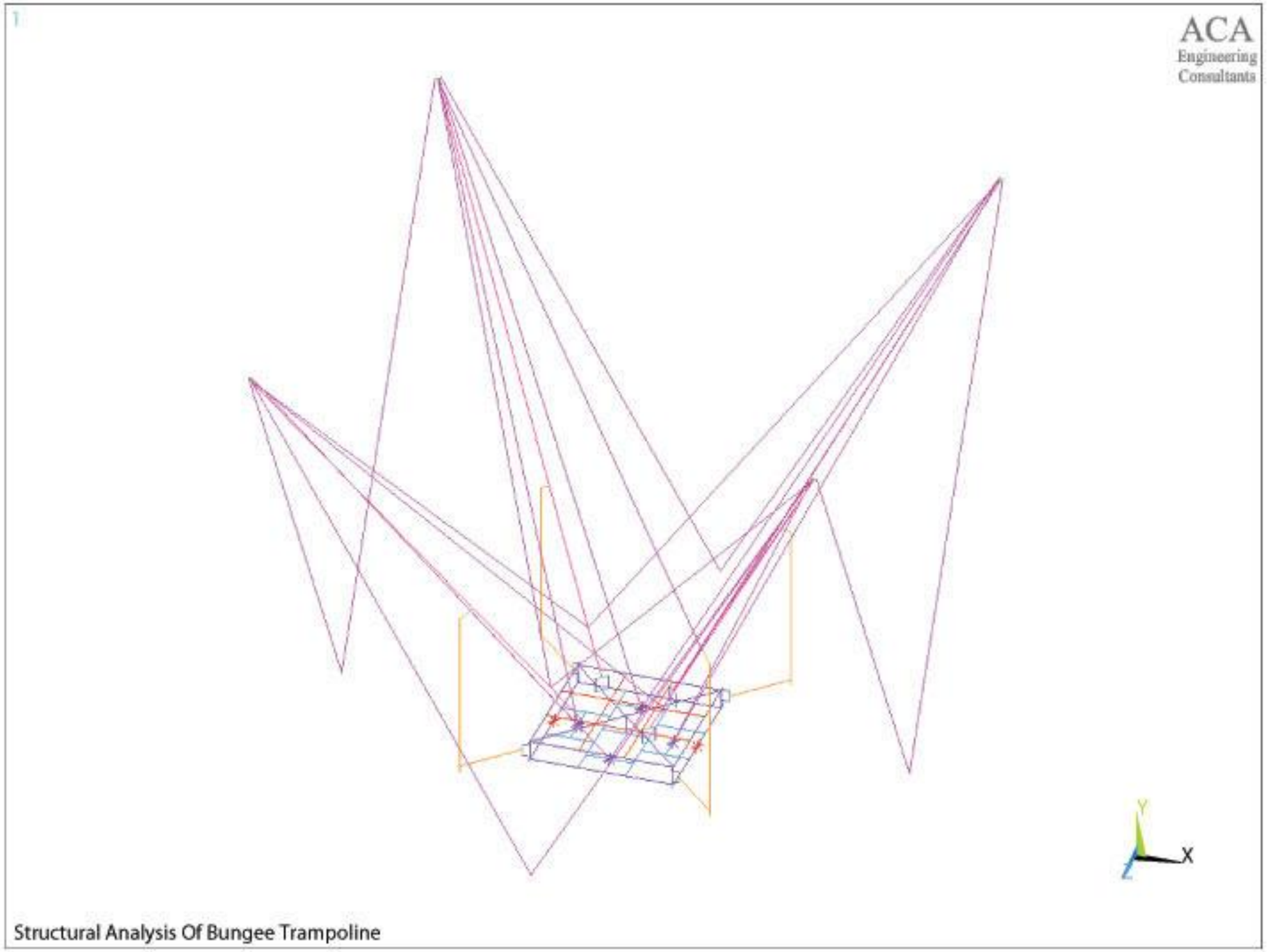


Figure 1.2 – Finite Element Model Of Bungee Trampoline

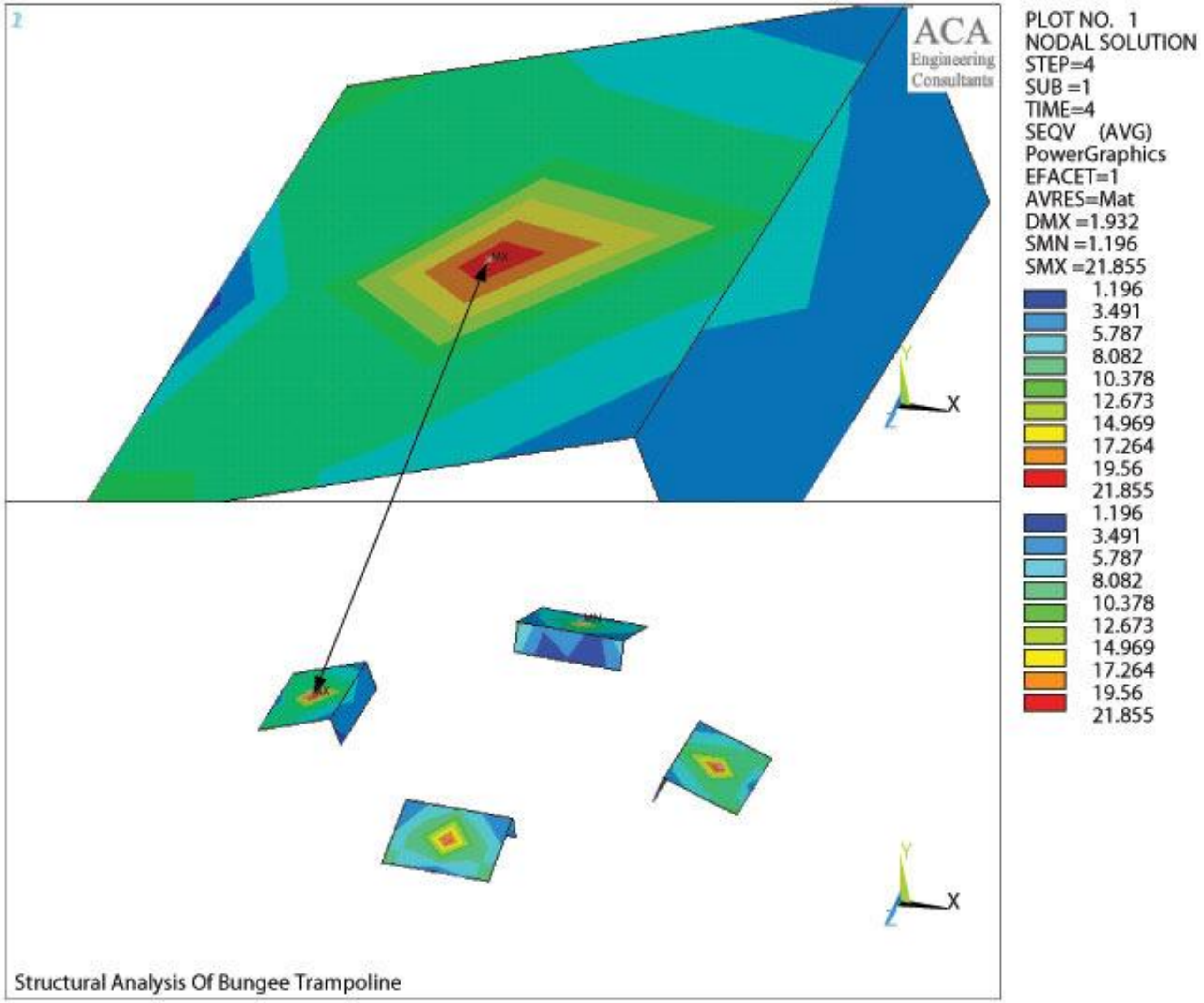


Figure 2.1 – Stresses In Steel Plate Structure, Due To Load Case 4

Maximum Stress = 21.9 N/mm^2

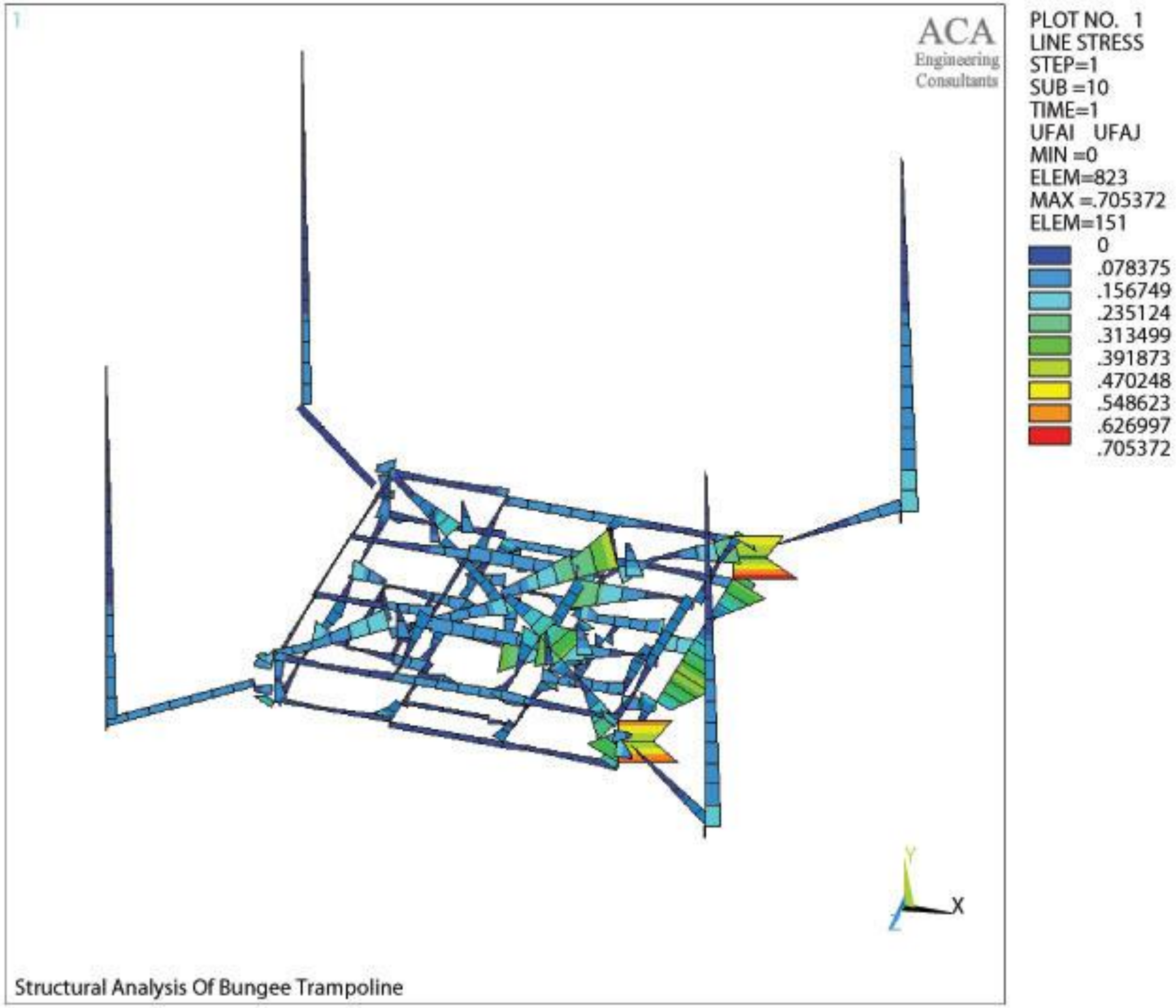


Figure 2.2 – Utilisation Factors In Steel beam Structure, Due To Load Case 1

Maximum Utilisation Factor = 0.71

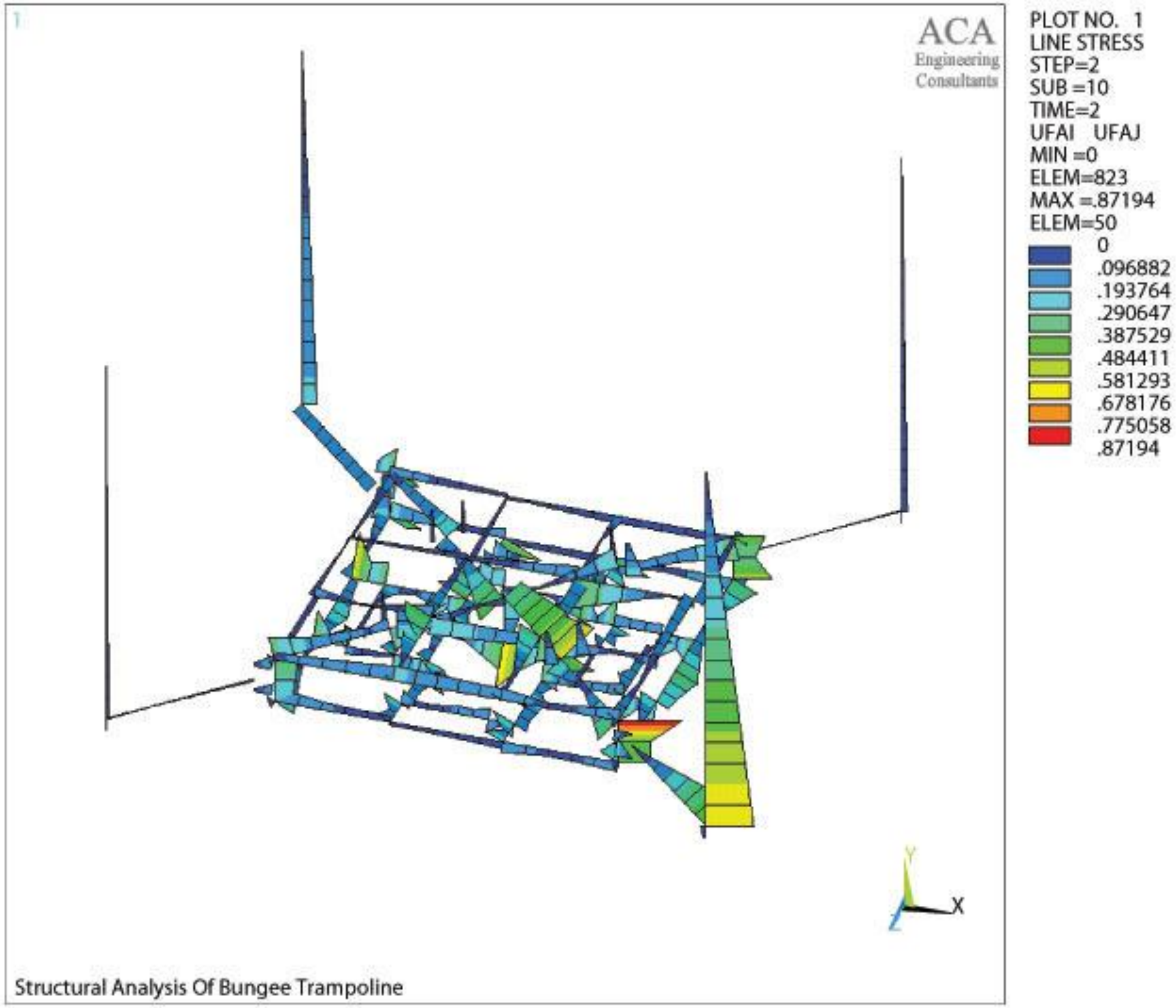


Figure 2.3 – Utilisation Factors In Steel beam Structure, Due To Load Case 2

Maximum Utilisation Factor = 0.87

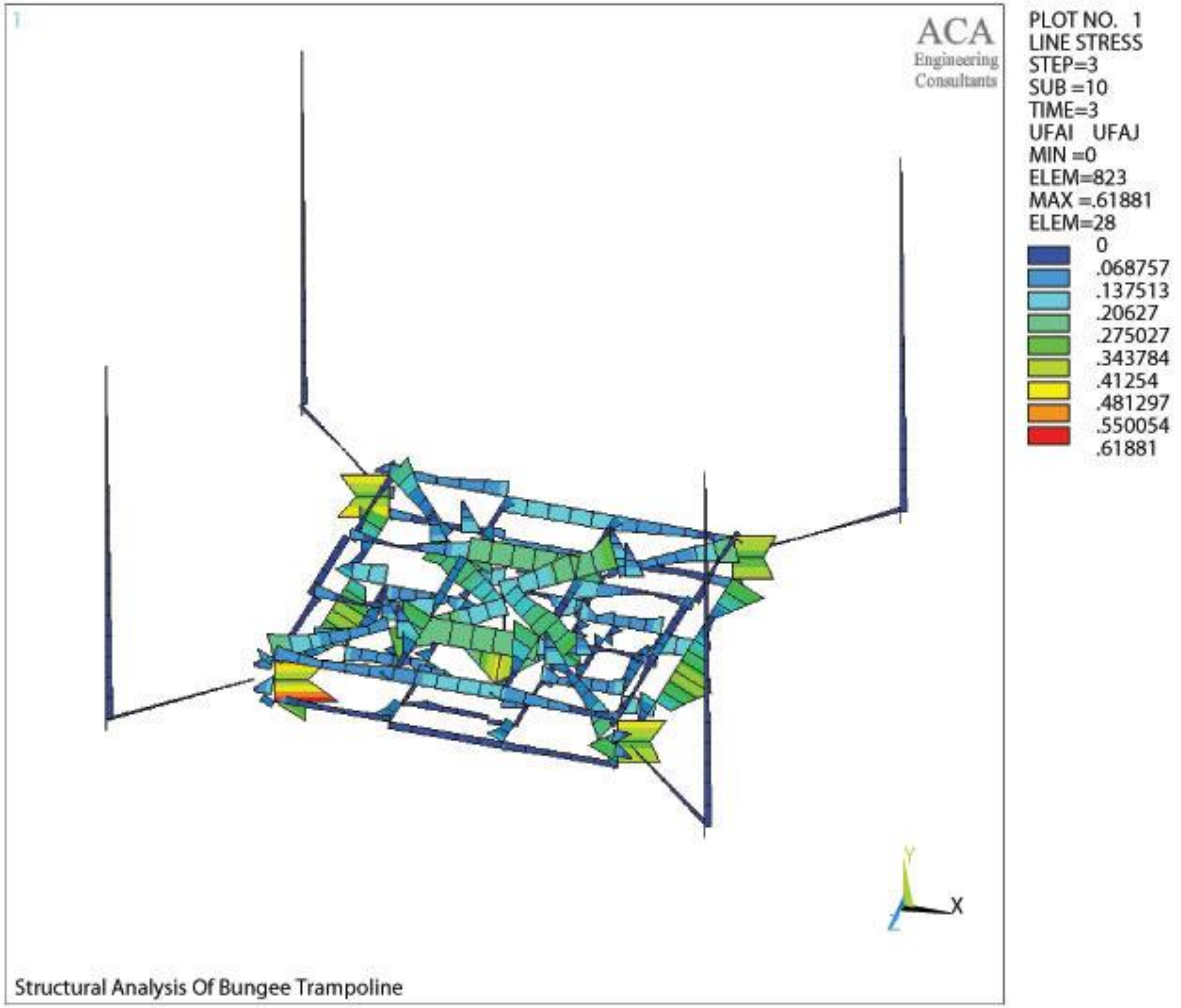


Figure 2.4 – Utilisation Factors In Steel beam Structure, Due To Load Case 3

Maximum Utilisation Factor = 0.62

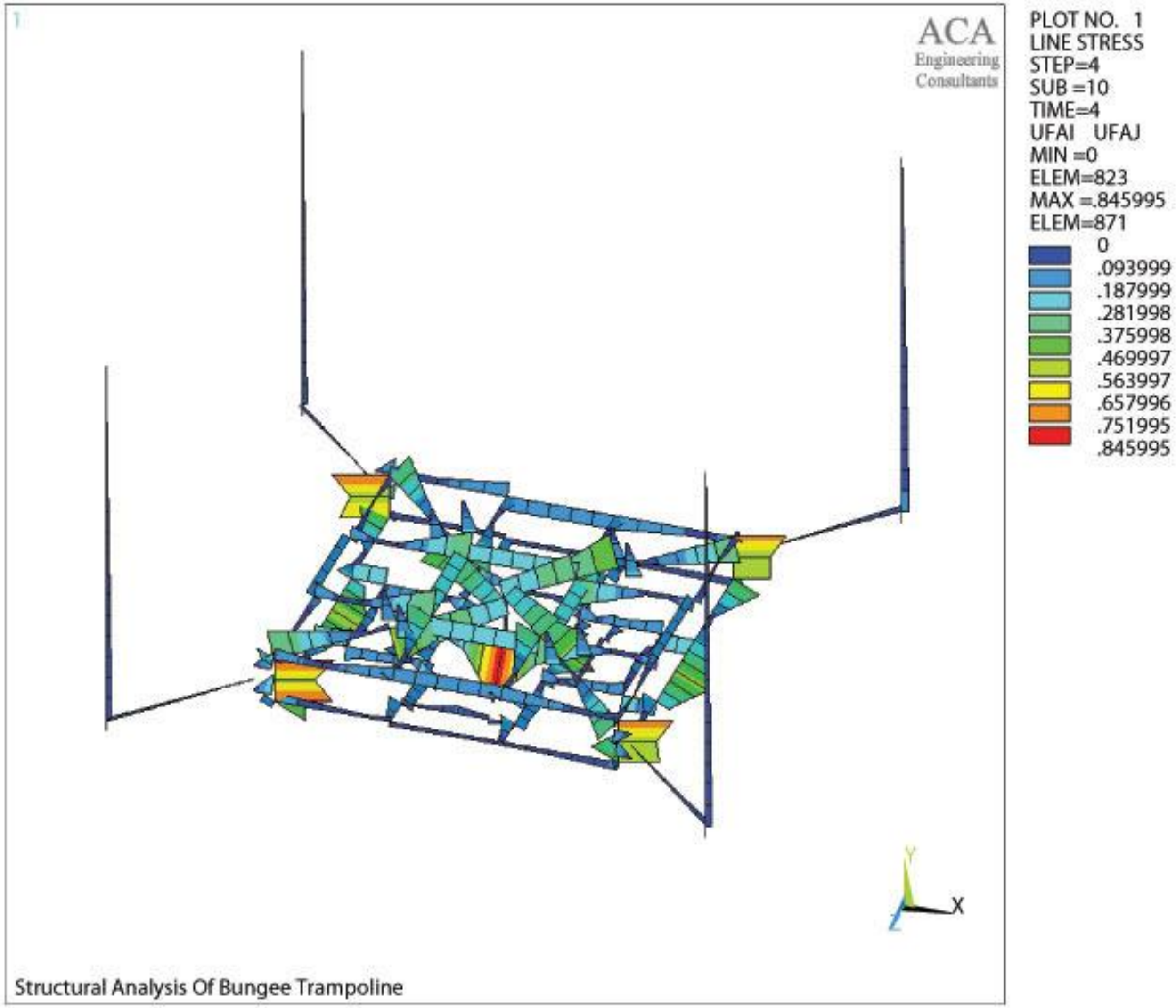


Figure 2.5 – Utilisation Factors In Steel beam Structure, Due To Load Case 4

Maximum Utilisation Factor = 0.85

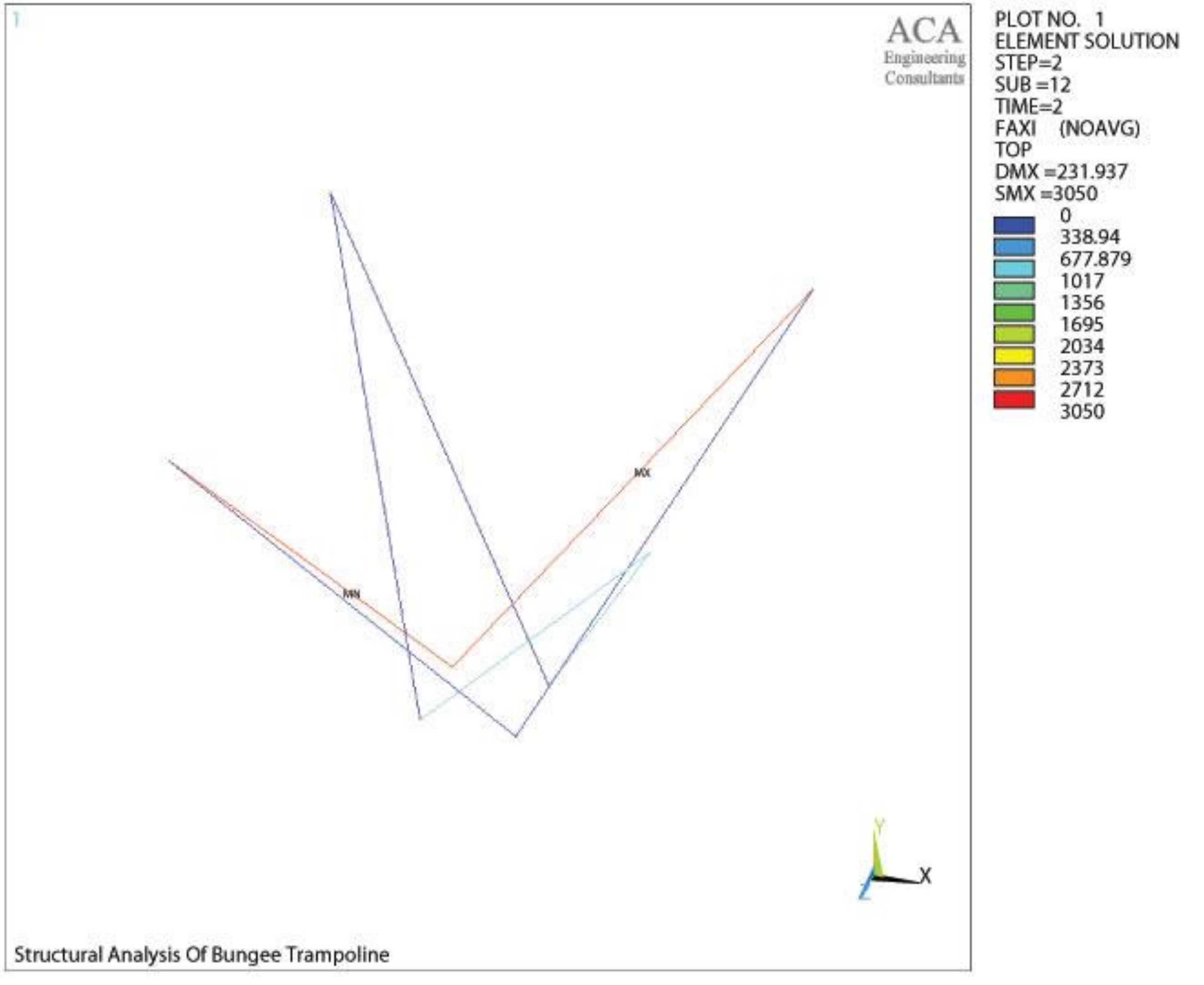


Figure 2.6 – Forces In Steel Ropes, Due To Load Case 2

Maximum Force = 3.1 kN

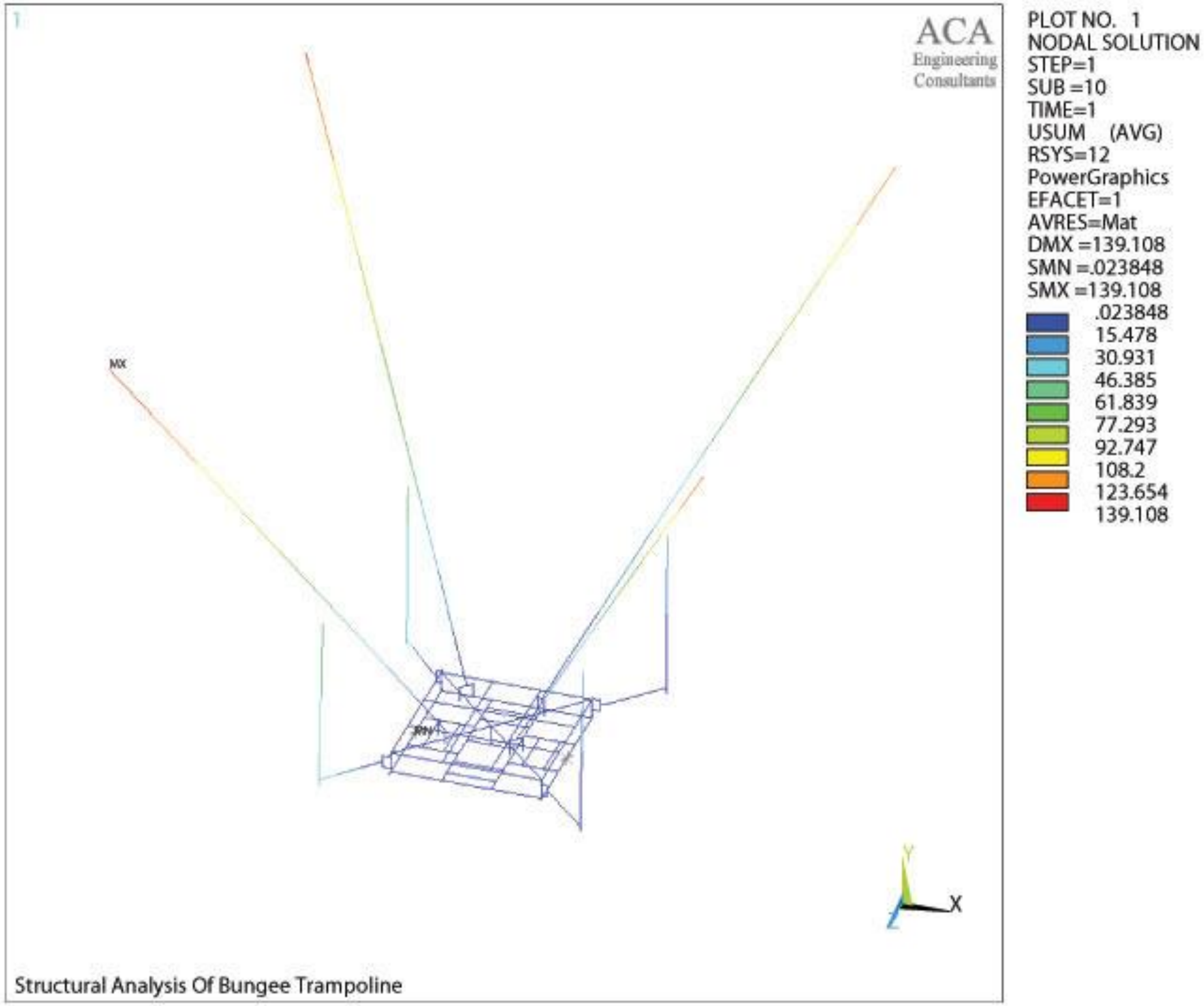


Figure 2.7 – Overall Deflexion In Structure, Due To Load Case 1

Maximum Deflexion = 139.11 mm

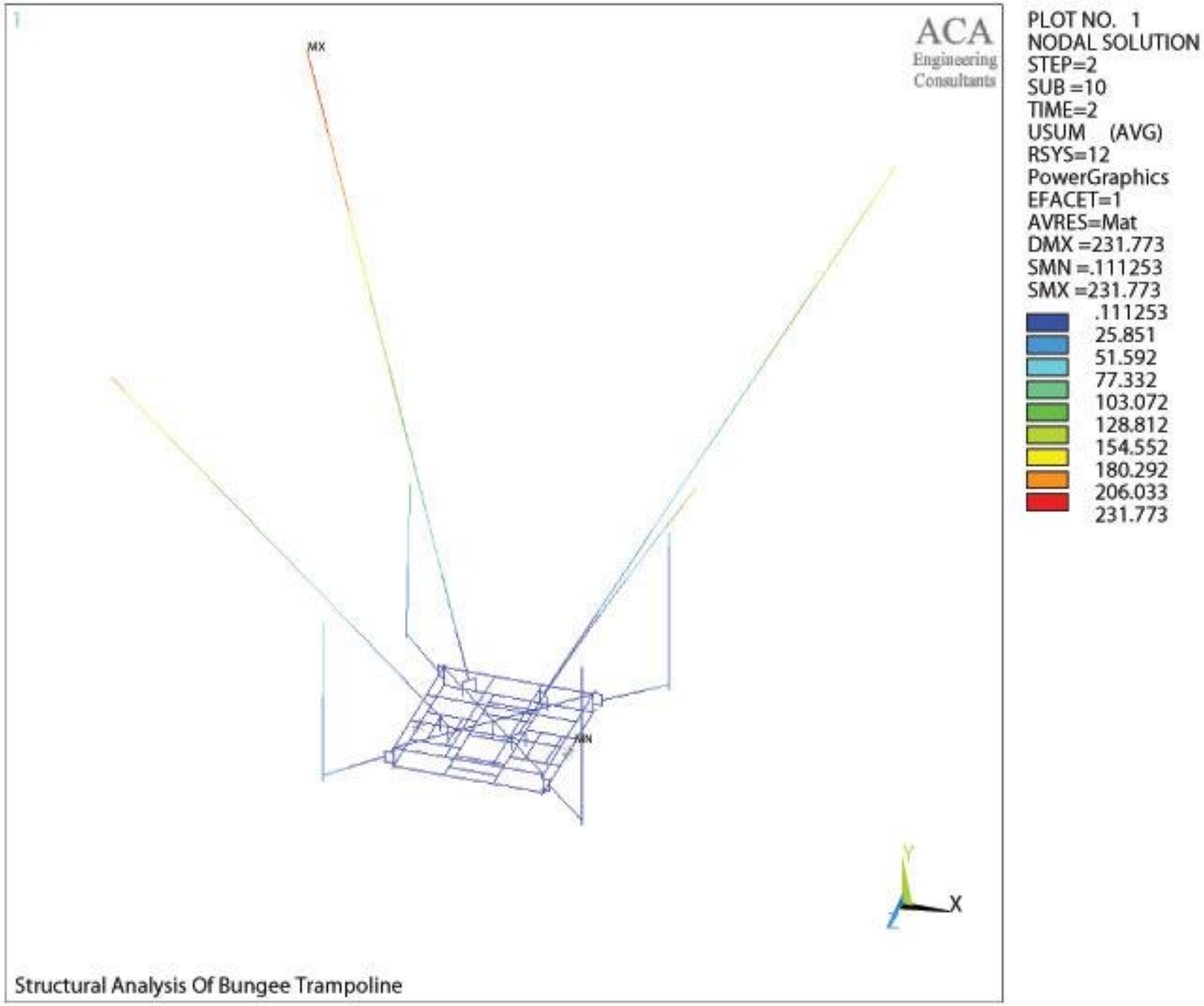


Figure 2.8 – Overall Deflexion In Structure, Due To Load Case 2

Maximum Deflexion = 231.77 mm

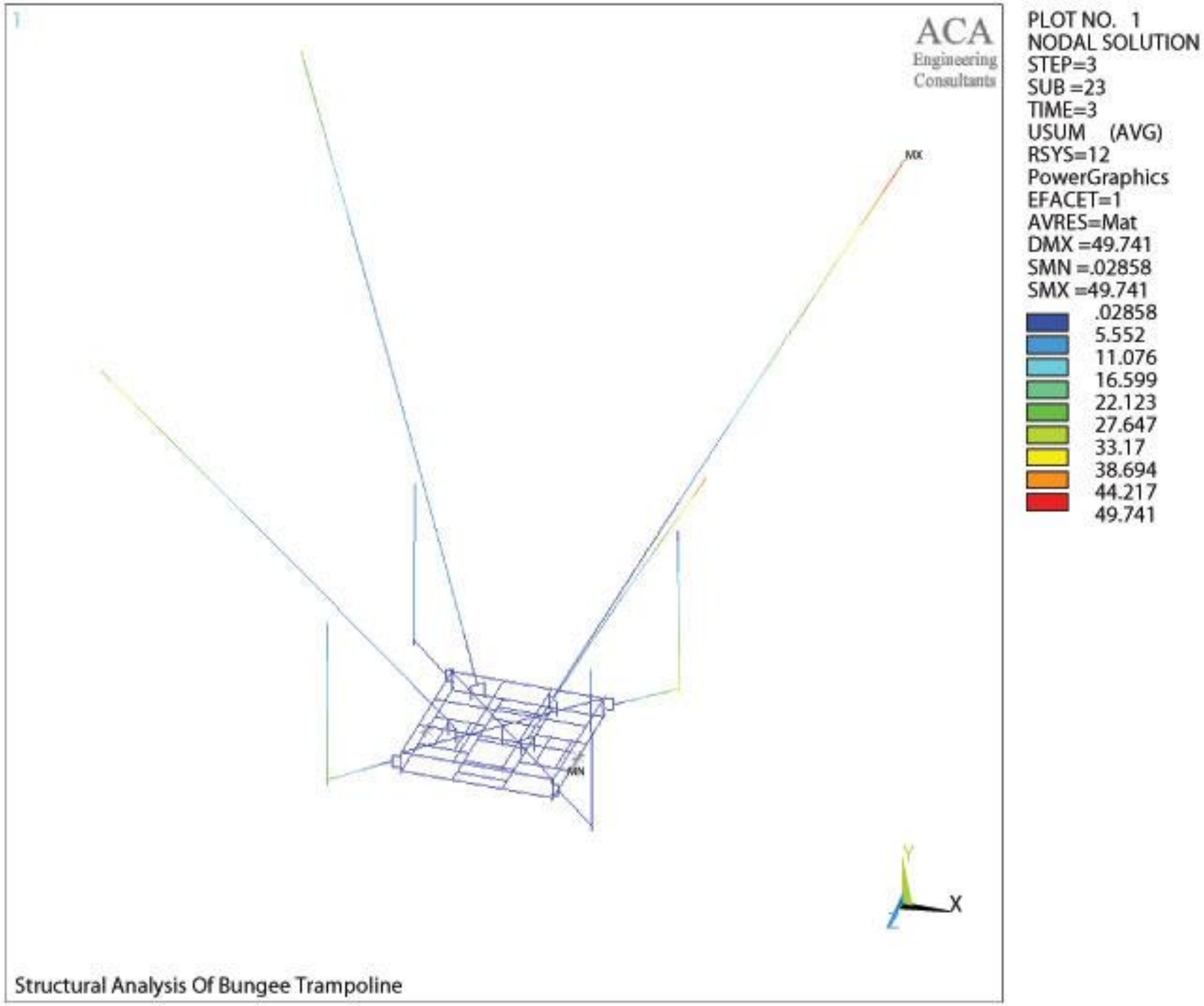


Figure 2.9 – Overall Deflexion In Structure, Due To Load Case 3

Maximum Deflexion = 49.74 mm

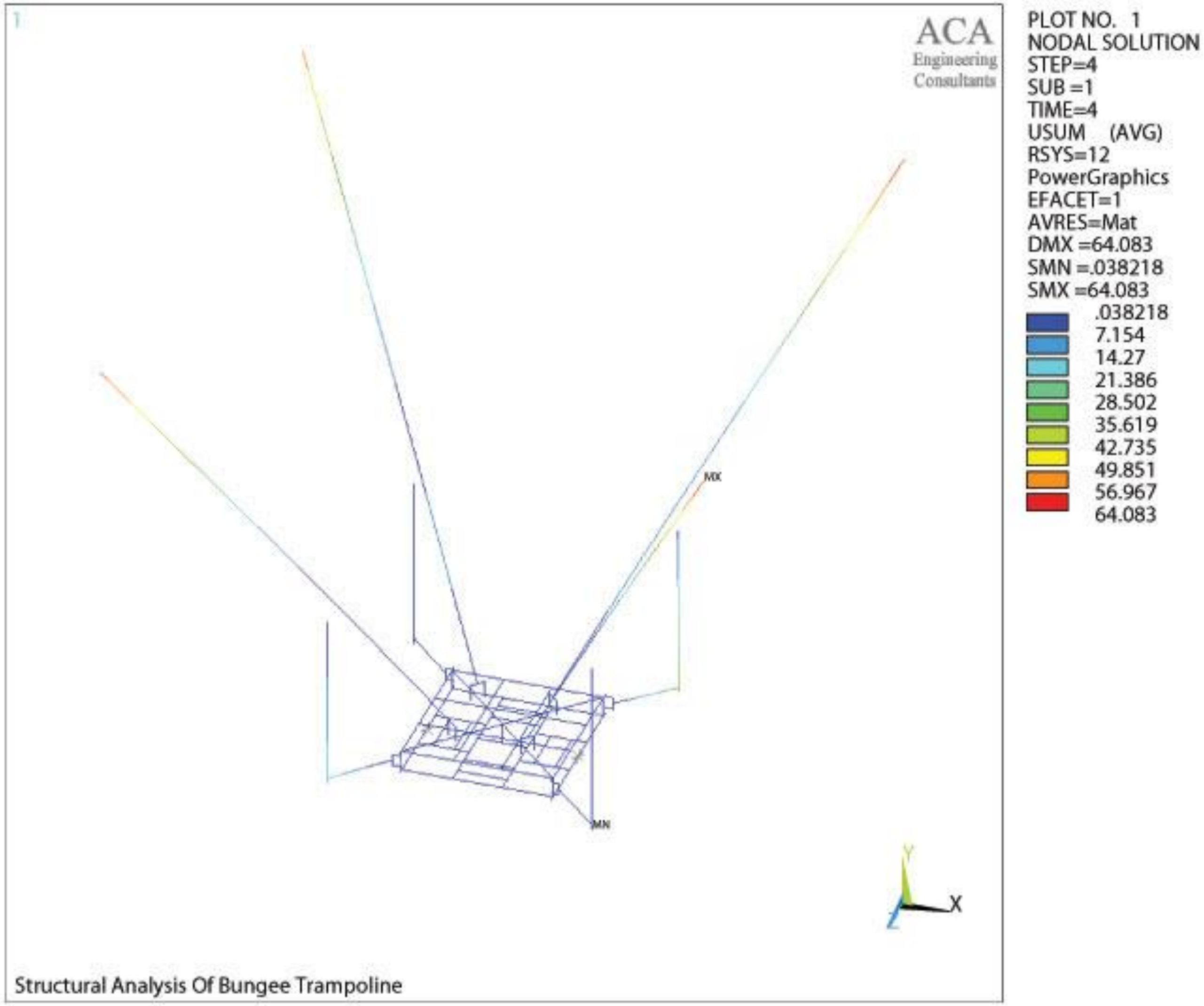


Figure 2.10 – Overall Deflexion In Structure, Due To Load Case 4

Maximum Deflexion = 64.08 mm

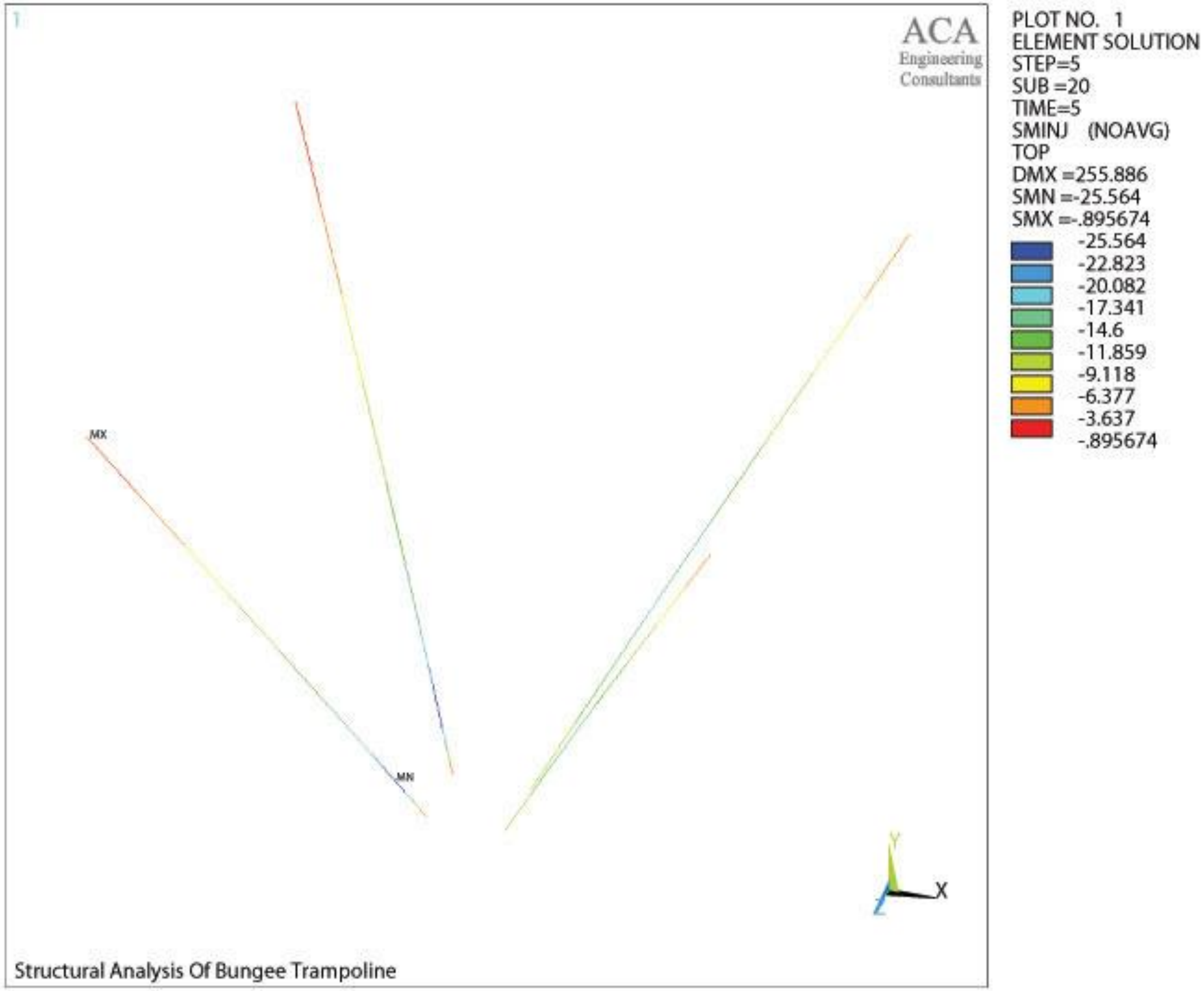


Figure 2.11 – Stresses In Aluminium Beam Structure, Due To Load Case 5

Maximum Stress = 25.6 N/mm^2

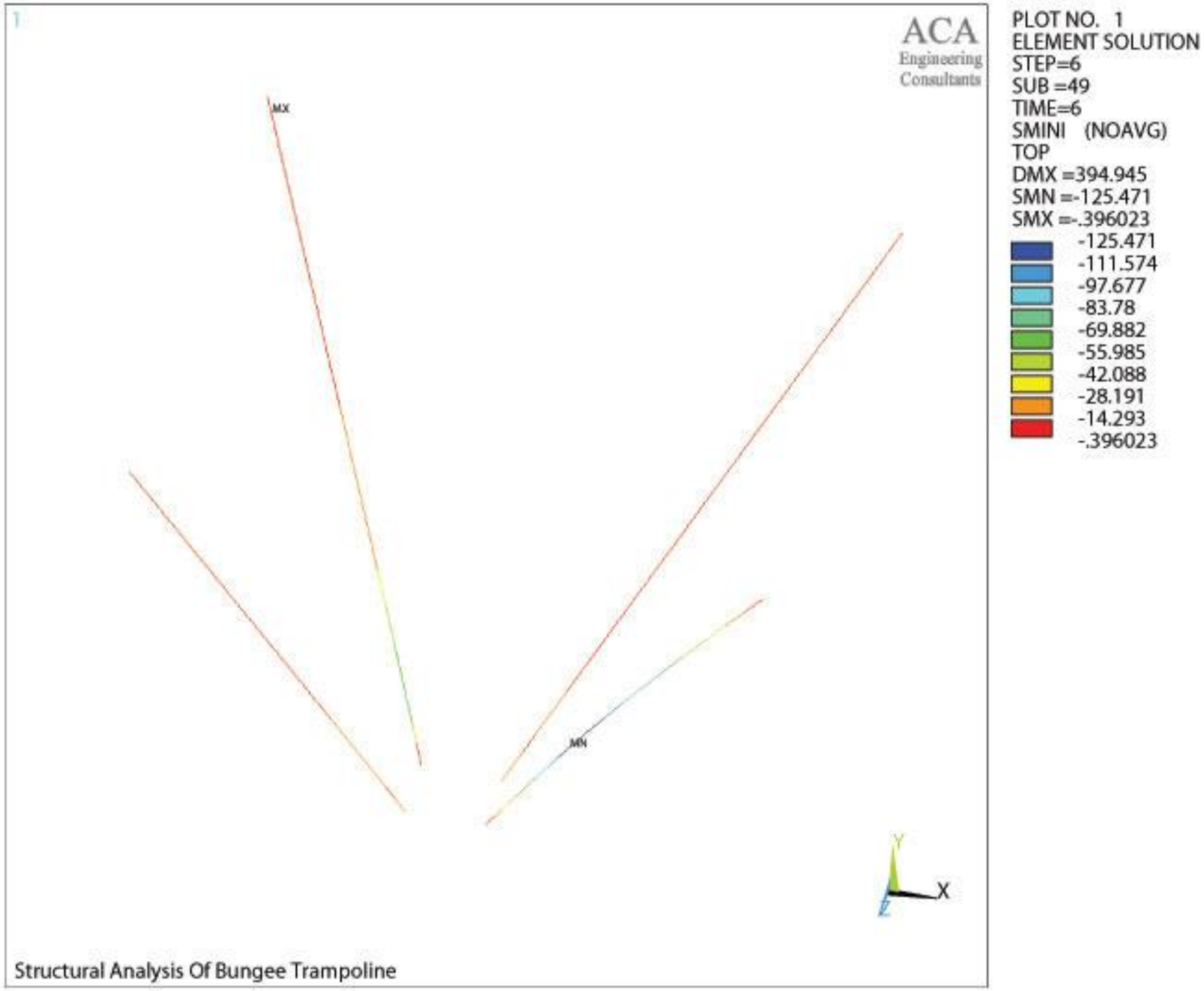


Figure 2.12 – Stresses In Aluminium Beam Structure, Due To Load Case 6

Maximum Stress = -125.5 N/mm^2

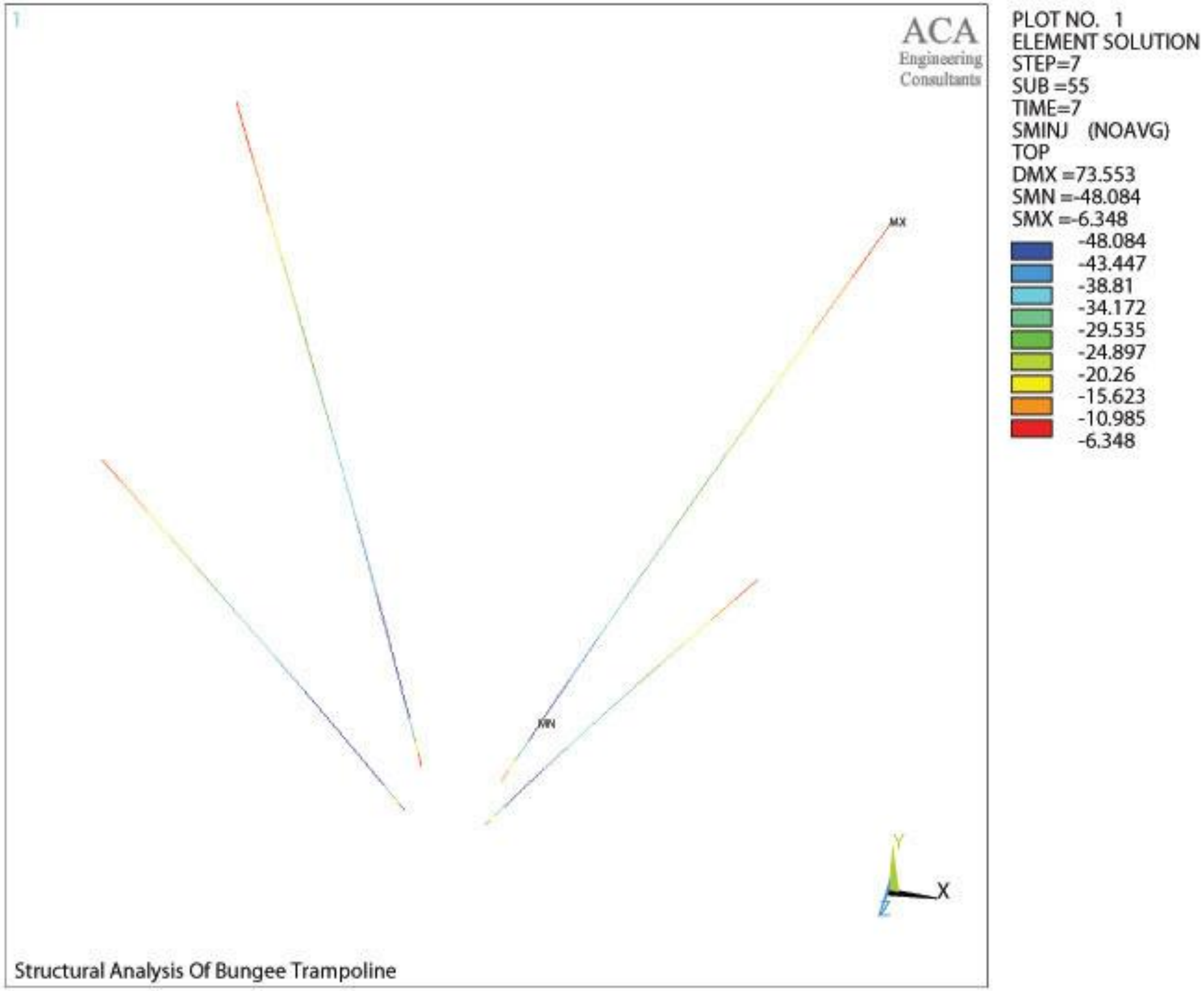


Figure 2.13 – Stresses In Aluminium Beam Structure, Due To Load Case 7

Maximum Stress = -48.1 N/mm^2

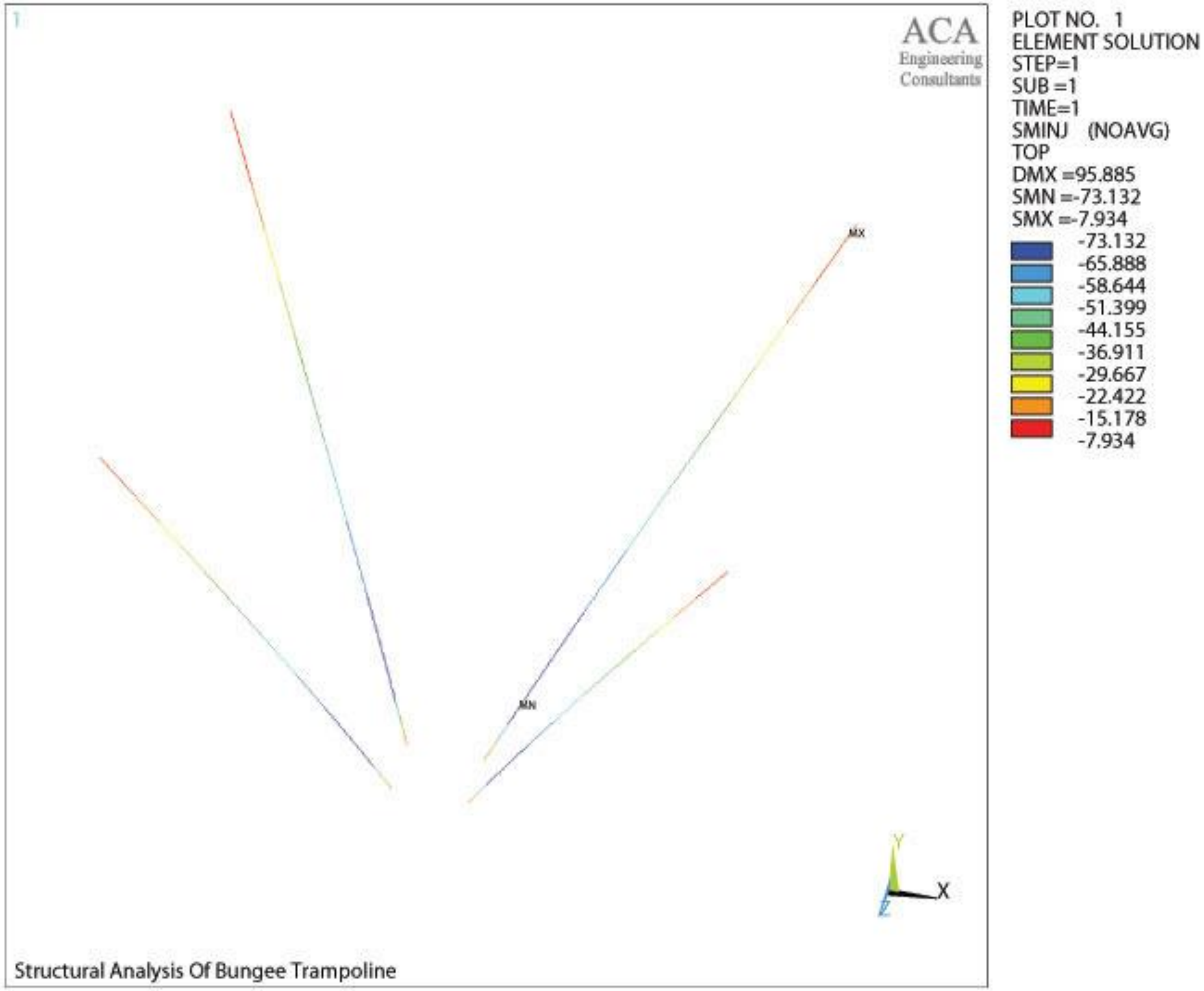


Figure 2.14 – Stresses In Aluminium Beam Structure, Due To Load Case 8

Maximum Stress = -73.1 N/mm^2

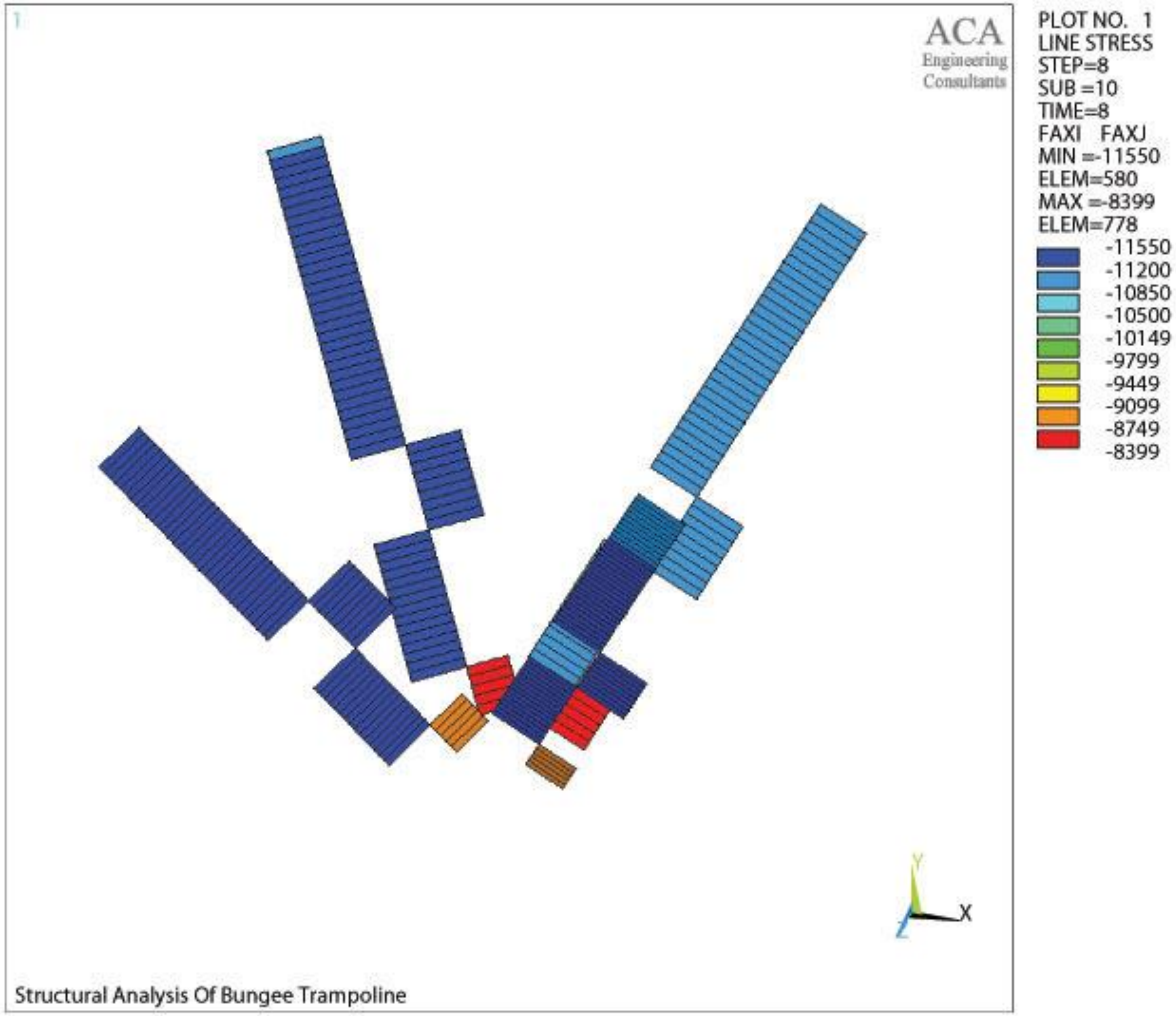


Figure 3.1 – Axial Forces In Aluminium Beam Structure, Due To Load Case 8

Maximum Axial Force = 11.6 kN

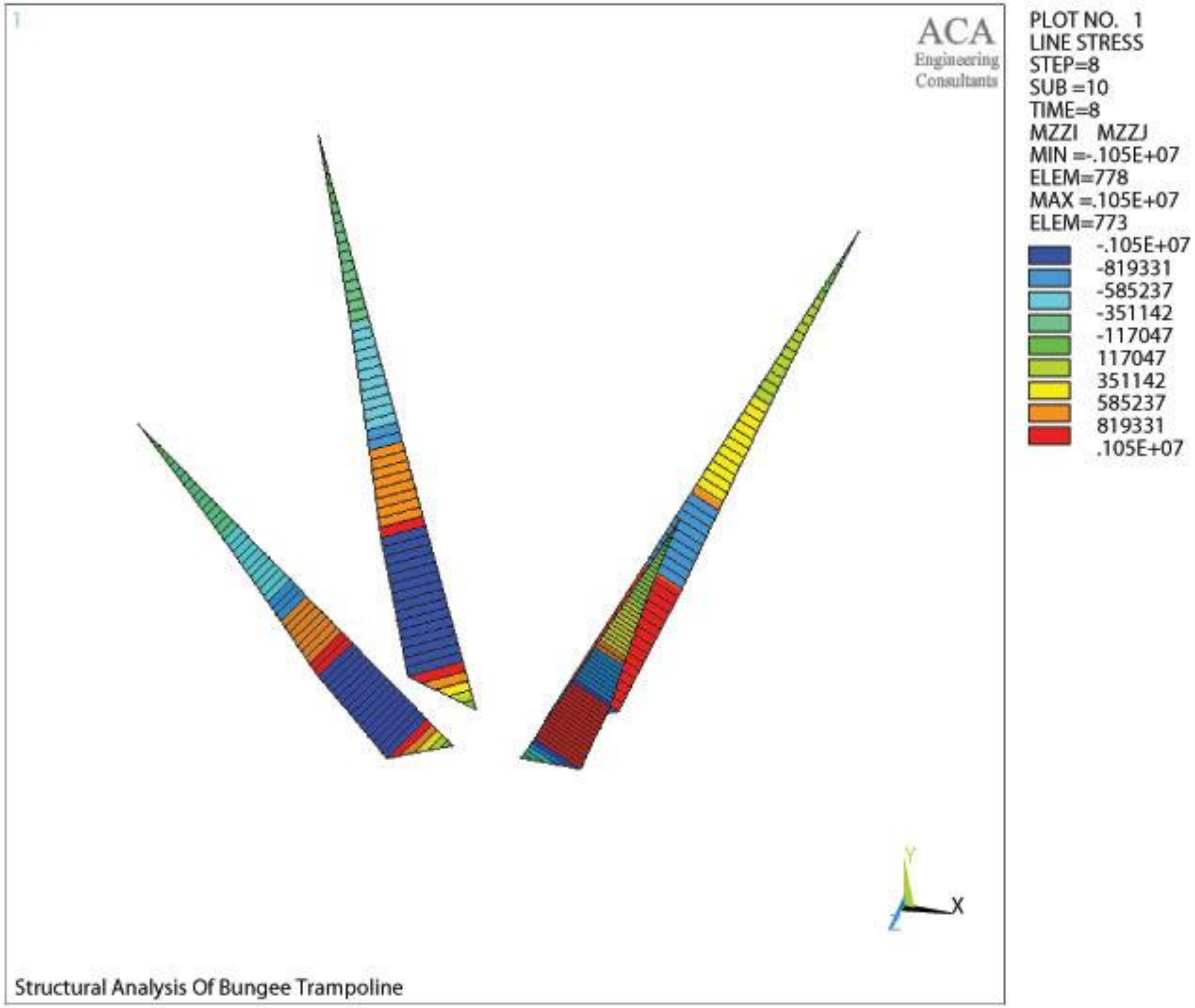


Figure 3.2 – Bending Moments About Major Axis In Aluminium Beam Structure, Due To Load Case 8

Maximum Bending Moment = 1.05 kNm

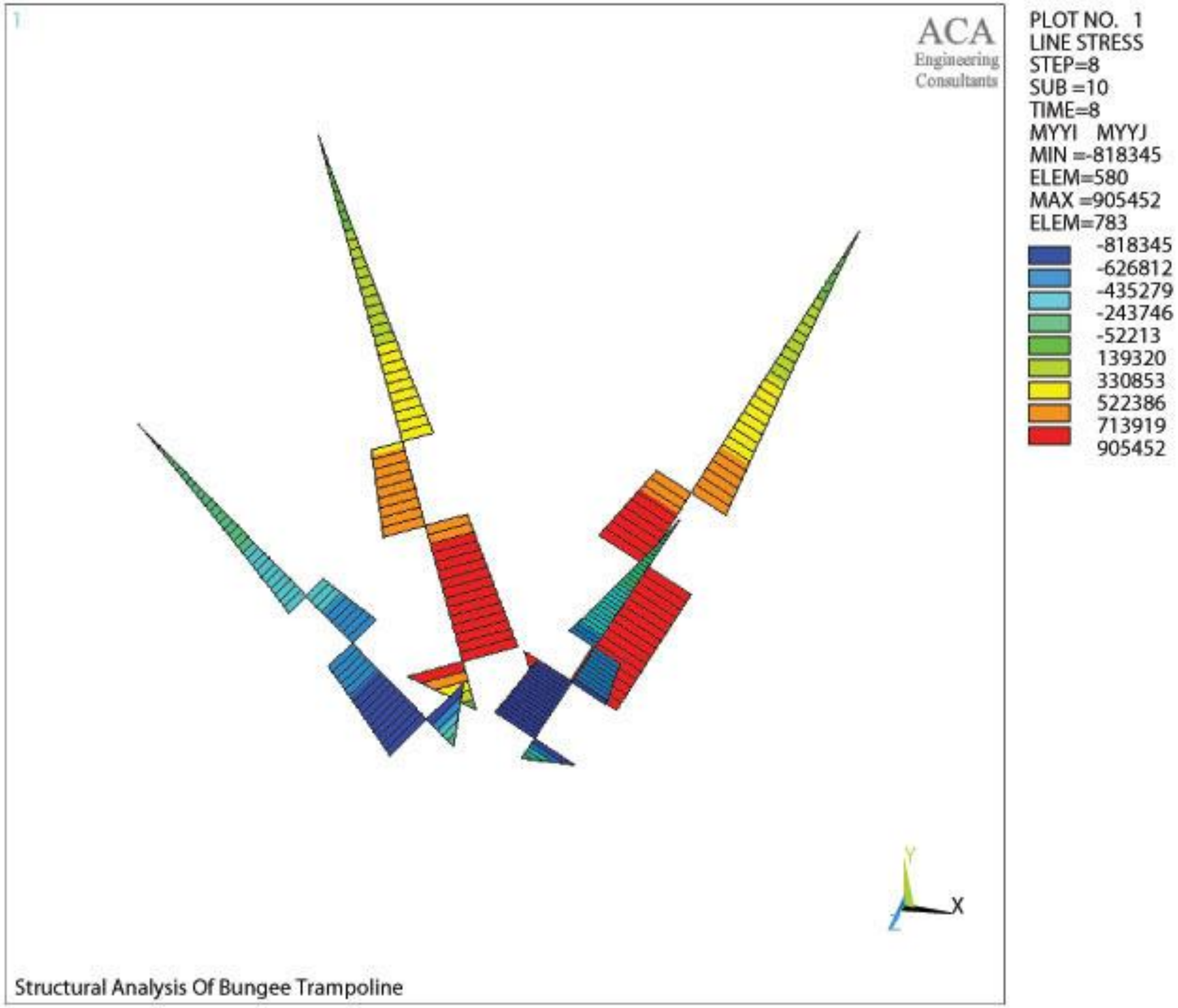


Figure 3.3 – Bending Moments About Major Axis In Aluminium Beam Structure, Due To Load Case 8

Maximum Bending Moment = 0.91 kNm

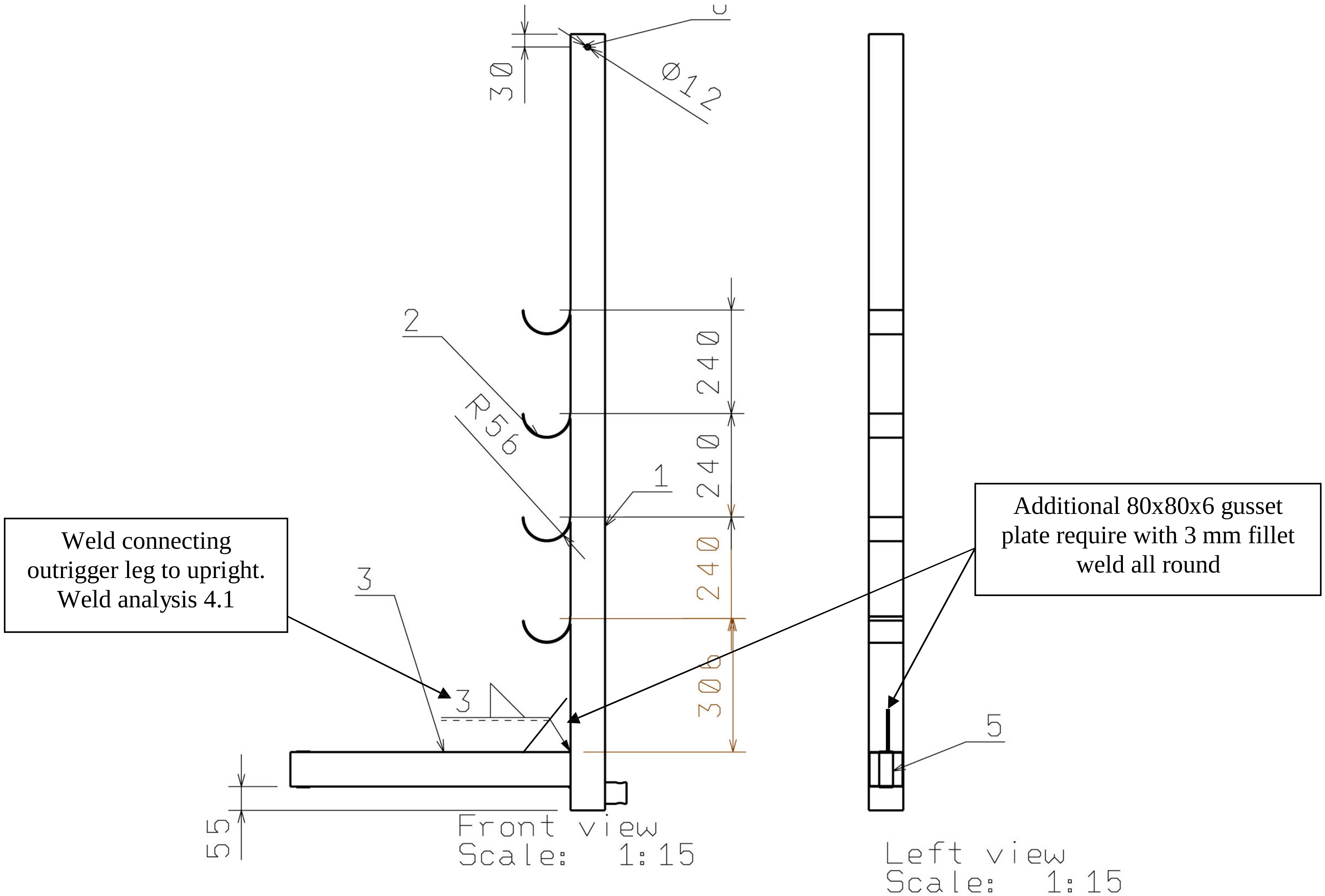


Figure 4.1 – Critical Welds

Figure 4.2 – Critical Welds

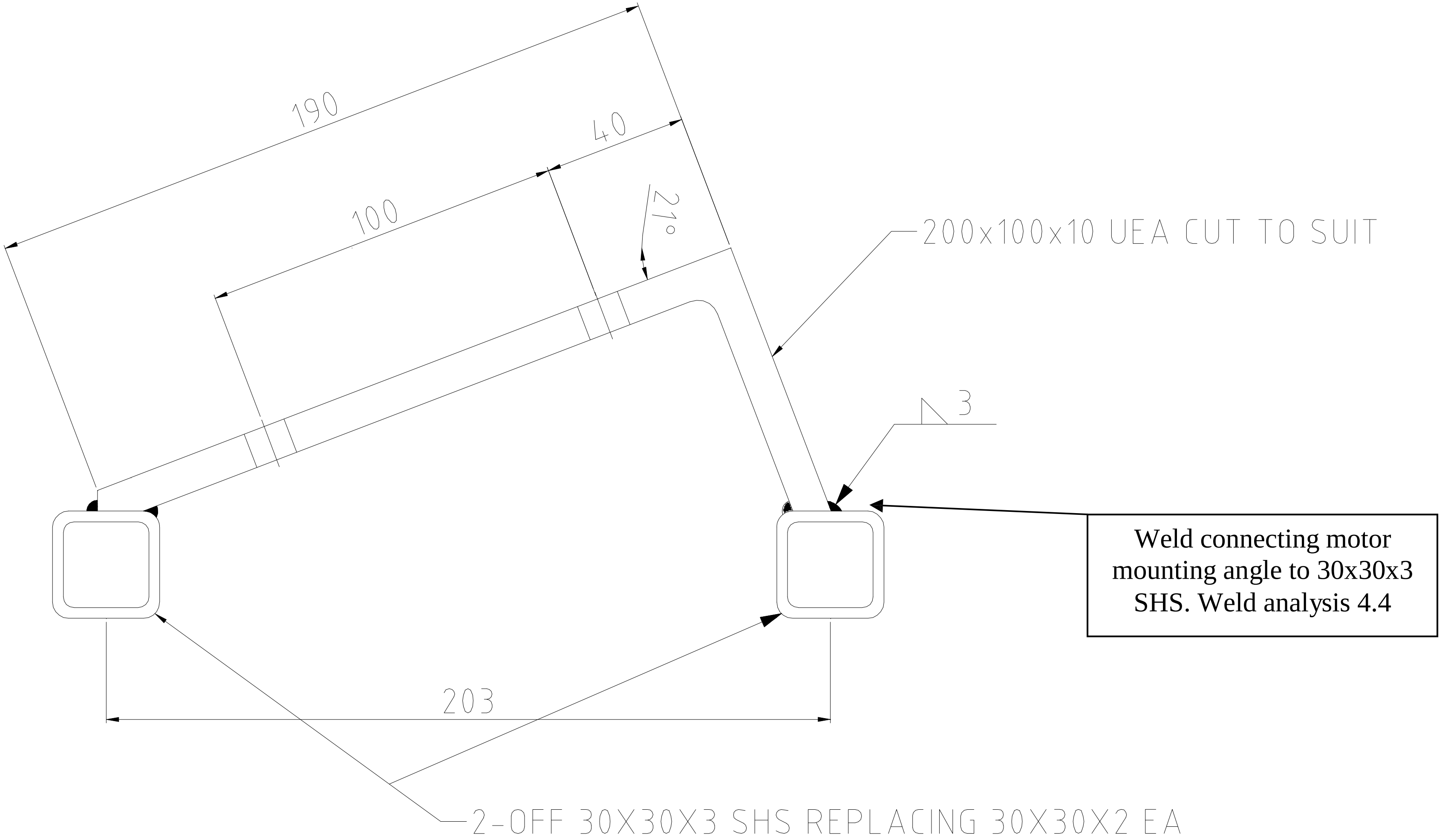


Figure 4.3 – Critical Welds

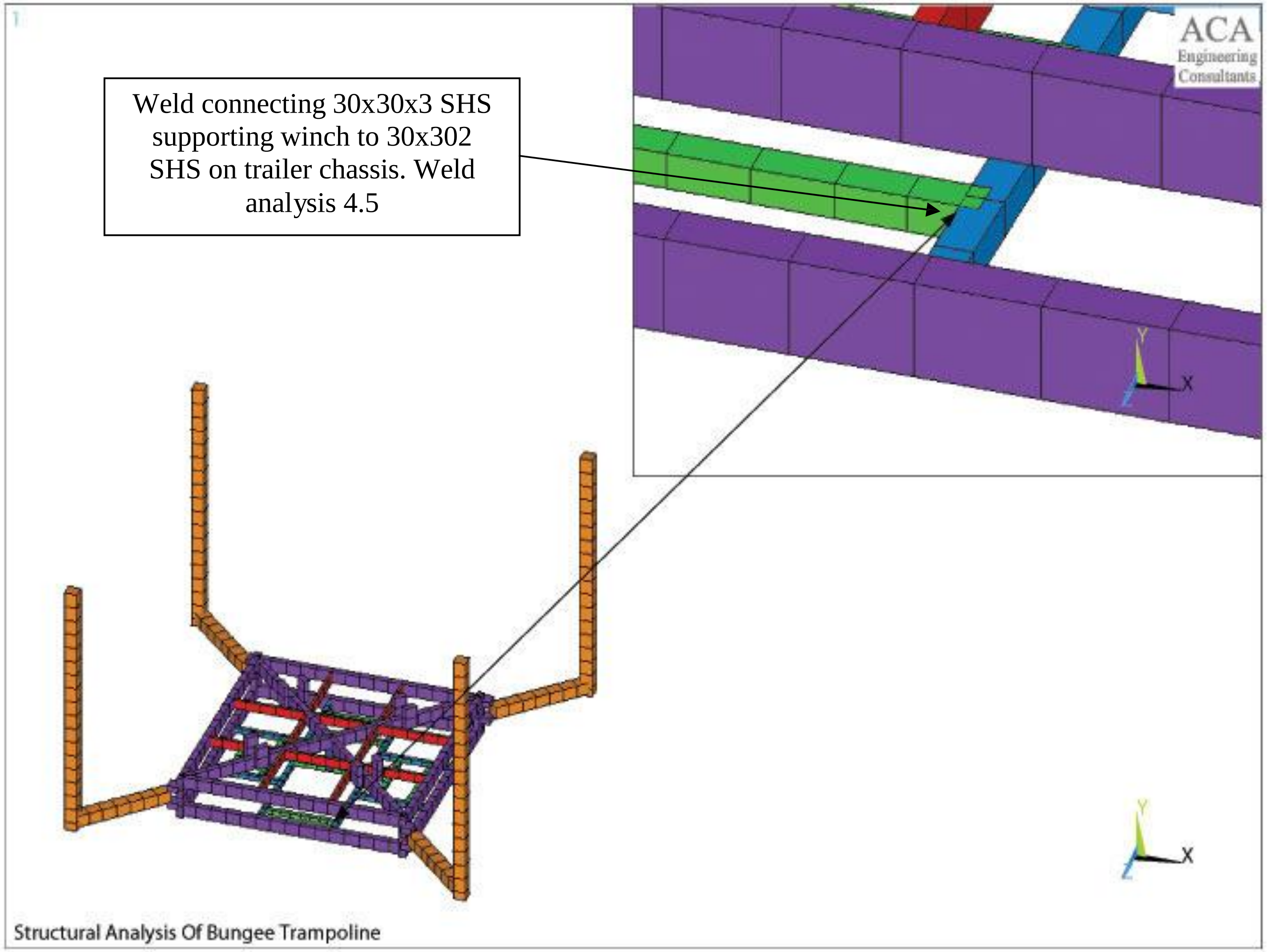


Figure 4.4 – Critical Welds

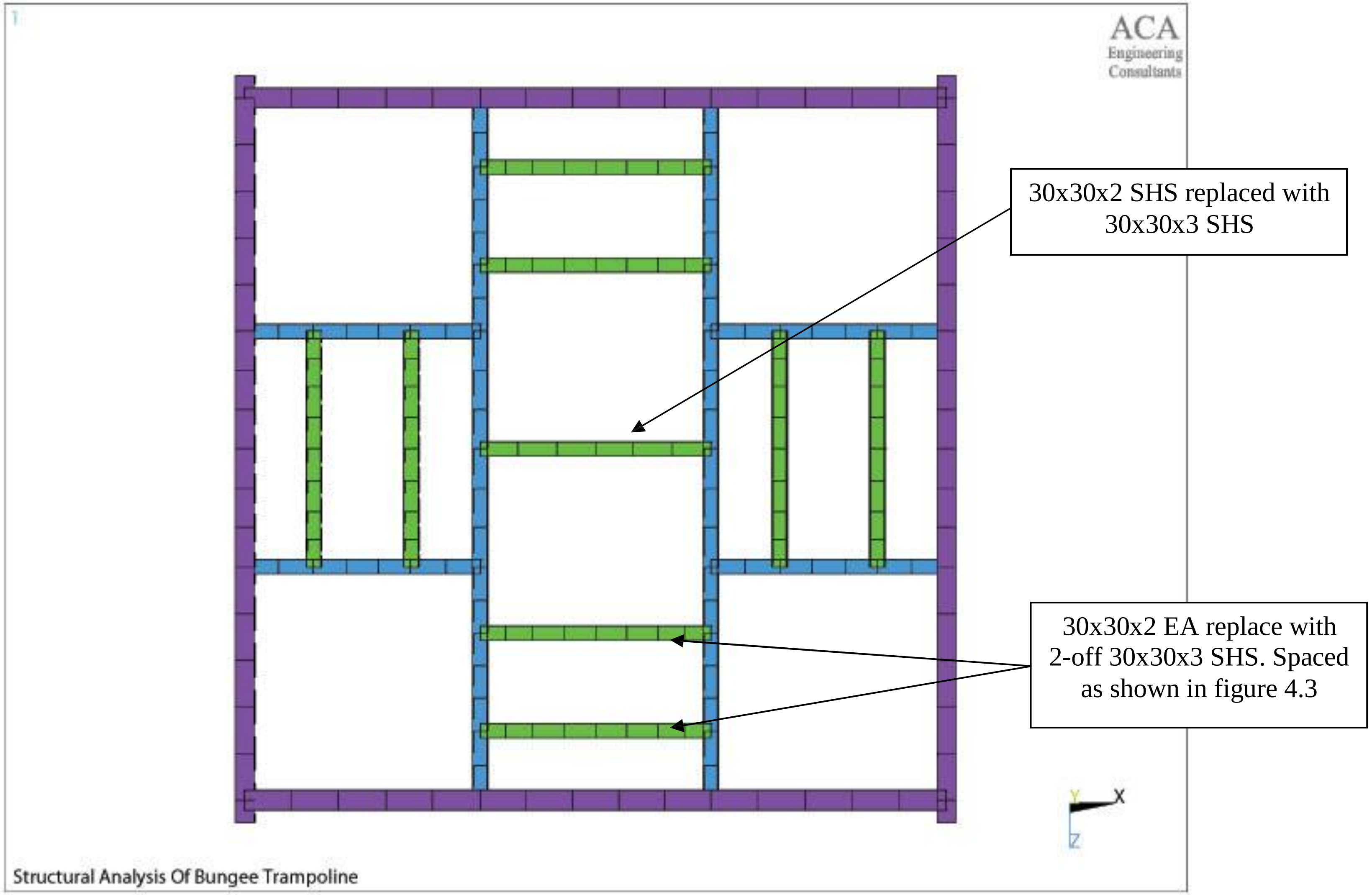


Figure 5.1 – Modifications To Chassis Structure

Plan View

Appendix A - Certificate Of Conformity For Aluminium Support Poles

Ф 824.01-09	ФОРМУЛЯР ОТ ИНТЕГРИРАНАТА СИСТЕМА	ALCOMET
Ревизия - 01	**QUALITY CERTIFICATE**	EN ISO 9001 / BS OHSAS 18001 / EN ISO 1

Page 1

Producer
ALCOMET AD
Second Industrial Zone
BG-9700 Shoumen
BULGARIA

QUALITY CERTIFICATE
№ C0017461/16.03.12
EN: 10204.3.1

Customer order: ZZ12/00494

Contract (Order):DP0002450
Ref. No.

Buyer
INVESTA Sp. z o.o
ULZASTAWNA 27
PRUSZCZ GDANSKI
POLAND

Standard
EN 755-1
L +10 mm

Size [mm]	Profile №	L[mm]	Product	Alloy / standard		Temper / standard		Qty. [MT]
20x2	500-2553	6 000.00	Al. round tube	6060	EN573-3	T66	EN 755-2	0.535
100x5	500-2388	6 000.00	Al. round tube	6060	EN573-3	T66	EN 755-2	0.522

Chemical Composition And Mechanical Properties

Actual Chemical Results

Size [mm]	Melt №	Si	Fe	Cu	Mn	Mg	Zn	Ti	Cr	Ni	Pb	As	Na	Al
20x2	91202	0.44	0.20	0.00	0.01	0.48	0.00	0.01	0.00		0.00			98.81
100x5	7120176	0.50	0.29	0.00	0.04	0.58	0.01	0.01	0.00		0.00			98.55

Actual Mechanical Results

Size [mm]	Profile №	Rm/MPa	Rp/MPa	A %		HB	
Standard		MIN 215	MIN 160	MIN 6			
20x2	500-2553	225.00	198.00	A50	13.00		
100x5	500-2388	218.00	189.00	A50	14.00		

The products comply with the European directives and regulations (2002/95/EC RoHS, 2000/53/EC ELV) and correspond to the specification.

Quality Control Department

Figure A1 – Conformity Certificate For Aluminium Grade 6005A T5 Support Poles

Appendix B - Certificate Of Conformity For Steel Sections.

A01

Stalprodukt S.A.

A02

ATEST 2.2
TEST REPORT 2.2
WERKSZEUGNIS 2.2
EN 10204

A03

Nr: 11118952

Dn. 2011-08-16

A06
Zamawiający:
Customer:
Besteller:

Stalprodukt Centrostal - Kraków Sp. z o.o.
ul. Płk. Dąbka 9 30-732 Kraków

A10
Nr wagonu - Wagoon no:
Wagon no:
KBCH 599

A08
Nr zamówienia
Manufacturer's works order number
Werksauftragsnummer

A07
Nr zamówienia klienta
Purchase order number
Kundenbestellnummer

B01 Wyrób, Product, Erzeugnis

B02 Gatunek, Steel Grade, Marke

B07.2 Numer KP Lot No - Los no	B07.1 Wytop Heat - Abstrich	Norma przedmiotowa According Nach	B03 Norma klasyfikacyjna Classification standards Materialnorm	Norma wymiarowa Dimensional standards Massnorm	B08 Sztuki wiązek No of bundles Bundanzahl	B13 Masa rzecz. Actual mass Ist-Masse
P47295	ZAMKN. KWADR. 60X60X4.0. KSZT. Z/GIĘTY Z BEDN. G/WALC. ;GAT. S235JRH KL. I					
6384 / 6	OC152303	EN 10219-1	EN 10219-1	EN 10219-2	1	2,53
P47529	ZAMKN. PROST. 80X40X3.0. KSZT. Z/GIĘTY Z BEDN. G/WALC. ;GAT. S235JRH KL. I					
6561 / 5	113621	EN 10219-1	EN 10219-1	EN 10219-2	2	3,71
P47529	ZAMKN. PROST. 80X40X4.0. KSZT. Z/GIĘTY Z BEDN. G/WALC. ;GAT. S235JRH KL. I					
6609 / 6	132048	EN 10219-1	EN 10219-1	EN 10219-2	3	6,05
P47529	ZAMKN. OKRĄGŁY 26.9X2 KSZT. Z/GIĘTY Z BEDN. G/WALC. ;GAT. S235JRH KL. I					
6807 / 4	OC152551	EN 10219-1	EN 10219-1	EN 10219-2	5	5,71
P47529	ZAMKN. OKRĄGŁY 26.9X2.6. KSZT. Z/GIĘTY Z BEDN. G/WALC. ;GAT. S235JRH KL. I					
6271 / 4	E123895	EN 10219-1	EN 10219-1	EN 10219-2	1	0,73
P47529	ZAMKN. OKRĄGŁY 26.9X2.6. KSZT. Z/GIĘTY Z BEDN. G/WALC. ;GAT. S235JRH KL. I					
6729 / 4	110506	EN 10219-1	EN 10219-1	EN 10219-2	2	2,84

C71-C92 Skład chemiczny - Chemical composition - Chemische Zusammensetzung

	B07.1 Wytop - Heat - Abstrich	C [%]	Mn [%]	Si [%]	P [%]	S [%]	Cr [%]	Ni [%]	Cu [%]	Al [%]	N2 [%]	Nb [%]	Ti [%]	Mo [%]	V [%]	C_{EV} [%]
	110506	0,14	0,48	0,02	0,014	0,011	0,01	0,01	0,01	0,049	0,006	0,002	0,002	0,002	0,003	0,22
	113621	0,16	0,49	0,010	0,006	0,021	0,01	0,01	0,01		0,005	0,002	0,002	0,001	0,003	0,25
E	123895	0,07	0,53	0,012	0,010	0,007	0,03	0,02	0,04	0,034	0,0036	0,0010	0,0010	0,004	0,0010	0,1693
	132048	0,07	0,58	0,021	0,008	0,010	0,03	0,02	0,03	0,040	0,0067	0,0010	0,0010	0,003	0,0013	0,1769
OC	152303	0,07	0,57	0,010	0,014	0,016	0,02	0,02	0,05	0,036	0,0059	0,0010	0,0010	0,003	0,0020	0,1747
OC	152551	0,07	0,55	0,010	0,010	0,010	0,02	0,02	0,04	0,045	0,0052	0,0010	0,0010	0,002	0,0010	0,1703

Własności mechaniczne - Mechanical properties - Mechanische Eigenschaften

B07.2 Numer KP - Lot No - Los no	C11 Re [MPa]	C12 Rm [MPa]	C13.1 A5 [%]	C13.2 A50 [%]	C13.3 A80 [%]	D51 Ra [µm]	D52 KV [J]	C69 Rp 0,2 [MPa]
6271 / 4	308	397			34,1			
6384 / 6	313	431	34,4					
6561 / 5	315	405			29,0			
6609 / 6	313	431	34,4					
6729 / 4	335	410			28,0			
6807 / 4	315	415			32.5			

Atest nr 11118952

Strona 1

Figure B1 – Conformity Certificate For 80x40x3 RHS

A01

Stalprodukt S.A.

A02

ATEST 2.2
TEST REPORT 2.2
WERKSZEUGNIS 2.2
EN 10204

A03

Nr: 11125270

Dn. 2011-10-24

A06
Zamawiający:
Customer:
Besteller:

Stalprodukt Centrostal - Kraków Sp. z o.o.
ul. Płk. Dąbka 9 30-732 Kraków

A10
Nr wagonu - Wagoon no:
Wagon no:
SL63571

A08
Nr zamówienia
Manufacturer's works order number
Werksauftragsnummer

A07
Nr zamówienia klienta
Purchase order number
Kundenbestellnummer

B01 Wyrób, Product, Erzeugnis

B02 Gatunek, Steel Grade, Marke

B07.2 Numer KP Lot No - Los no	B07.1 Wytop Heat - Abstrich	Norma przedmiotowa According Nach	B03 Norma klasyfikacyjna Classification standards Materialnorm	Norma wymiarowa Dimensional standards Massnorm	B08 Sztuki wiązek No of bundles Bundanzahl	B13 Masa rzecz. Actual mass Ist-Masse
P48116	CEOWNIK RÓWNOR. 40X60X40X3.0. Z/GIĘTY Z BEDN. G/WALC. ;GAT. S235JR. KL. I					
1759 / 3	58704	EN 10025-1/ EN 10162	EN 10025-2	EN 10162	1	1,96
P48116	CEOWNIK RÓWNOR. 40X60X40X3.0. Z/GIĘTY Z BEDN. G/WALC. ;GAT. S235JR. KL. I					
1760 / 3	58702	EN 10025-1/ EN 10162	EN 10025-2	EN 10162	2	4,09
P48116	ZAMKN. KWADR. 30X30X2.0. KSZT. Z/GIĘTY Z BEDN. G/WALC. ;GAT. S235JRH KL. I					
1766 / 2	OC153092	EN 10219-1	EN 10219-1	EN 10219-2	3	5,38
P48116	ZAMKN. KWADR. 30X30X2.0. KSZT. Z/GIĘTY Z BEDN. G/WALC. ;GAT. S235JRH KL. I					
1768 / 2	OC153092	EN 10219-1	EN 10219-1	EN 10219-2	1	0,3
P48116	KSZTAŁTOWNIK KWADRATOWY 40X40X1,8 Z/GIĘTY Z BEDN. G/WALC. W GAT. S235JRH, KL. I					
1737 / 1	37899	EN 10219-1	EN 10219-1	EN 10219-2	1	1,03
P48116	ZAMKN. KWADR. 40X40X2.0. KSZT. Z/GIĘTY Z BEDN. G/WALC. ;GAT. S235JRH KL. I					
1679 / 1	OC272231	EN 10219-1	EN 10219-1	EN 10219-2	1	1,07
P48116	ZAMKN. KWADR. 40X40X2.0. KSZT. Z/GIĘTY Z BEDN. G/WALC. ;GAT. S235JRH KL. I					
1704 / 1	132634	EN 10219-1	EN 10219-1	EN 10219-2	4	7,1
P48116	KSZTAŁTOWNIK PROSTOKĄTNY 50X30X1,8 Z/GIĘTY Z BEDN. G/WALC. W GAT. S235JRH, KL.I					
1691 / 1	OC272162	EN 10219-1	EN 10219-1	EN 10219-2	2	3,17
P48373	ZAMKN. PROST. 40X27X1,8 KSZT. Z/GIĘTY Z BEDN. G/WALC. ;GAT. S235JRH KL. I					
1197 / 2	OC271549	EN 10219-1	EN 10219-1	EN 10219-2	1	0,5

C71-C92 Skład chemiczny - Chemical composition - Chemische Zusammensetzung

B07.1 Wytop - Heat - Abstrich		C [%]	Mn [%]	Si [%]	P [%]	S [%]	Cr [%]	Ni [%]	Cu [%]	Al [%]	N2 [%]	Nb [%]	Ti [%]	Mo [%]	V [%]	C_{EV} [%]
	132634	0,07	0,54	0,024	0,008	0,010	0,03	0,03	0,07	0,033	0,0059	0,0007	0,0003	0,003	0,0010	0,1735
OC	153092	0,10	0,36	0,007	0,018	0,012	0,03	0,03	0,07	0,039	0,0056	0,0010	0,0010	0,003	0,0010	0,1735
OC	271549	0,07	0,53	0,011	0,012	0,009	0,02	0,02	0,02	0,035	0,0049	0,0010	0,0010	0,003	0,0010	0,1658
OC	272162	0,07	0,53	0,008	0,013	0,009	0,02	0,02	0,05	0,045	0,0043	0,0010	0,0010	0,003	0,0010	0,1678
OC	272231	0,06	0,53	0,010	0,012	0,012	0,02	0,02	0,06	0,044	0,0063	0,0010	0,0010	0,002	0,0010	0,1583
	37899	0,11	0,31	0,010	0,011	0,009	0,02	0,01	0,03	0,035	0,004			0,002	0,001	0,165
	58702	0,09	0,35	0,010	0,009	0,008	0,03	0,01	0,05	0,032	0,002			0,002	0,001	0,157
	58704	0,09	0,34	0,020	0,015	0,012	0,02	0,01	0,03	0,041	0,002			0,002	0,001	0,158

Własności mechaniczne - Mechanical properties - Mechanische Eigenschaften

B07.2 Numer KP - Lot No - Los no	C11 Rc [MPa]	C12 Rm [MPa]	C13.1 A5 [%]	C13.2 A50 [%]	C13.3 A80 [%]	D51 Ra [μm]	D52 KV [J]	C69 Rp 0,2 [MPa]
1197 / 2	308	397			32,7			
1679 / 1	315	415			32,5			

Atest nr 11125270

Strona 1

Figure B2 – Conformity Certificate For 30x30x2 SHS

Appendix C - Conformity Certificate For Steel Cables

MARCOPOL

marka która łączy

Marcopol Sp. z o.o. Producent Śrub
ul. Oliwska 100, 80-209 Chwaszczyno k. Gdyni,
tel.: +48 (058) 55 40 555,
fax: + 48 (058) 55 40 565:
e-mail: marcopol.th@marcopol.com.pl
www.marcopol.com.pl

BankPKO S.A. O/Gdynia 12401239-5009823-2700-401112-001

NIP 589-000-85-28

DEKLARACJA ZGODNOŚCI Nr 002/3/03

wg PN-EN 45014

Chwaszczyno, dnia 2004-08-02

Wyrób.

1.	Lina stalowa ϕ1,0	8.	Lina stalowa ϕ6,0	15.	Lina stalowa ϕ20,0
2.	Lina stalowa ϕ1,5	9.	Lina stalowa ϕ8,0		
3.	Lina stalowa ϕ2,0	10.	Lina stalowa ϕ10,0		
4.	Lina stalowa ϕ2,5	11.	Lina stalowa ϕ12,0		
5.	Lina stalowa ϕ3,0	12.	Lina stalowa ϕ13,0		
6.	Lina stalowa ϕ4,0	13.	Lina stalowa ϕ14,0		
7.	Lina stalowa ϕ5,0	14.	Lina stalowa ϕ16,0		

Deklaracja zgodności

Marcopol Sp. z o.o. Producent Śrub niniejszym deklaruje, że wyrób do którego odnosi się niniejsza deklaracja jest zgodny z przedstawionymi poniżej normami, innymi dokumentami normatywnymi, lub spełnia (jeśli dotyczy) zamieszczone poniżej przepisy.

Normy, dokumenty normatywne, przepisy.

I Kształt i wymiary:

1.	1x7 wg PN-69/M-80202	8.	6x19+FE wg DIN 3060	15.	6x37+FE wg DIN 3066
2.	1x7 wg PN-69/M-80202	9.	6x19+FE wg DIN 3060		
3.	6x7+FE wg DIN 3055	10.	6x19+FE wg DIN 3060		
4.	6x7+FE wg DIN 3055	11.	6x37+FE wg DIN 3066		
5.	6x7+FE wg DIN 3055	12.	6x37+FE wg DIN 3066		
6.	6x19+FE wg DIN 3055	13.	6x37+FE wg DIN 3066		
7.	6x19+FE wg DIN 3055	14.	6x37+FE wg DIN 3066		

II Minimalna siła zrywającą:

1.	1,08 kN	8.	22,8 kN	15.	218 kN
2.	2,00 kN	9.	34,8 kN		
3.	2,40 kN	10.	54,4 kN		
4.	3,70 kN	11.	75,1 kN		
5.	5,29 kN	12.	88,2 kN		
6.	9,41 kN	13.	102 kN		
7.	14,7 kN	14.	134 kN		

Uwagi i wnioski.

W przypadku wbudowania wyrobu w urządzenia, zestawy lub elementy bezpieczeństwa podlegające osobnemu dopuszczeniu, wyrób należy przebadać we współpracy z połączonymi elementami oraz zgodnie z wymaganiami wynikającymi z przeznaczenia i zakresu stosowania wyrobu finalnego.

Marcopol Sp. z o.o. Producent Śrub promuje politykę nieustannego rozwoju. Marcopol Sp. z o.o. Producent Śrub zastrzega sobie prawo do wprowadzania zmian we wszelkich produktach opisanych w tym dokumencie bez uprzedniego powiadomienia.

Opracował:
Technolog
M. Stacharski
Mariusz Stacharski

Zatwierdził:
Dział Kontroli Jakości
Michał Łopa
Michał Łopa

Biura Handlowe

BIAŁYSTOK
15-070 Białystok
ul. Starokościelska 10/1u
tel./fax: (085) 741 36 38
e-mail: bialystok@marcopol.com.pl

BYDGOSZCZ
85-330 Bydgoszcz
ul. Hetmańska 28 B
tel./fax: (052) 328 77 69
e-mail: bydgoszcz@marcopol.com.pl

CHOJNICE
89-606 Charzykowy
Chojnicka ul. Żwirowa
tel./fax: (052) 397 76 73
e-mail: chojnice@marcopol.com.pl

KATOWICE
40-850 Katowice
ul. Kościuszki 227
tel./fax: (032) 202 40 46
e-mail: katowice@marcopol.com.pl

KRAKÓW
30-614 Kraków
ul. Cechowa 51
tel./fax: (012) 654 06 95
e-mail: krakow@marcopol.com.pl

LUBLIN
20-445 Lublin
ul. Zemborzycka 57
tel./fax: (081) 441 86 23
e-mail: lublin@marcopol.com.pl

OLSZTYN
10-419 Olsztyn
ul. Żelazna 1
tel./fax: (089) 533 85 83
e-mail: olsztyn@marcopol.com.pl

SUWAŁKI
16-400 Suwałki
ul. Sejneńska 41
tel./fax: (087) 565 38 97
e-mail: suwalki@marcopol.com.pl

SZCZECIN
71-073 Szczecin
ul. Ku słońcu 32
tel./fax: (091) 485 69 30
e-mail: szczecin@marcopol.com.pl

WROCŁAW
53-012 Wrocław
ul. Wyścigowa 56
tel./fax: (071) 780 06 16
e-mail: wroclaw@marcopol.com.pl

Figure C1 – Conformity Certificate For Steel Cables

Load Capacity = 9.41 kN

Appendix D – Conformity Certificate For Carabineer

TEST WYTRZYMAŁOŚCIOWY / RESISTANCE TEST

KARABIŃCZYK DO LIN Z ZABEZPIECZENIEM DIN 5299 D

SNAP HOOK WITH SCREW DIN 5299 D

DOSTAWCA / SUPPLIER

Przedsiębiorstwo "GÓRALMET" M. i J. Góral Sp. J.
Ul.Krakowska 68, 32-860 Czchów
Tel / fax: 014 6635260
www.goralmet.pl

TEST KONTROLNY NR TEST CONTROL NO.	**11/GM/2006**

ROZMIAR/SIZE		L [mm]	D [mm]	C [mm]		**Masa/szt** Weight/pc [kg]	**Obciąż. znamion.** Working load [kg]	**Obciąż. zrywające** Breaking load [kg]
4 mm		40	6	5		0.009	70	100
5 mm		50	8	6		0.0164	100	150
6 mm		60	9	6		0.0284	120	180
7 mm		70	10	7		0.0434	180	270
8 mm		80	11	9		0.0648	230	345
10 mm		100	16	13		0.128	350	525
11 mm		120	18	17		0.1842	400	600
12 mm		140	20	20		0.2562	450	675
13 mm		160	25	25		0.3454	530	795
14 mm		180	25	30		0.4578	580	870
15 mm		200	25	35		0.5658	700	1 050

MATERIAŁ / MATERIAL	**POKRYCIE** / COVERING
C15	*ocynk / galv.*

tolerancja pomiarów +/- 5%
measurement tolerance +/- 5%

artykuł posiada sygnaturę dostawcy - "GM"
product with supplier's signature - "GM"

badania wykonał / tested by :
Instytut Odlewnictwa
Ul. Zakopiańska 73, 30-418 Kraków
nr raportu / report no.: **54/TBM/2006**

Przedsiębiorstwo „GÓRALMET" M. i J. Góral Sp. J.
32-860 Czchów, ul. Krakowska 68

PIECZĄTKA DOSTAWCY
SUPPLIER'S STAMP

DATA/DATE

12-05-2011

Figure D1 – Conformity Certificate For 12mm Diameter Carabineer

Load Capacity = 450 kg

Appendix E – Conformity Certificate For Bungee Harness

Harnesses for bungy-trampoline

4 sizes and colors : xs orange, s yellow, m blue, L cherry

Approximate dimensions in cm

	xs	s	m	L
waist	64	72	83	93
leg	36	46	55	65

Adjust the length of the belt in cm

	xs	s	m	L
at the waist	27	36	40	41
at the leg	29	40	44	47

It can withstand 800 kg at break.

SAM PPH ul. Franki 38
+ 48 691600831
tel/fax +48 71 315 39 71
VAT UE: PL 8951087246

51-348 Wroclaw Poland
www.bungy-trampolina.com
info@bungy-trampolina.com
www.sampph.pl

Figure E1 – Conformity Certificate For Bungee Harness

Load Capacity = 800 kg

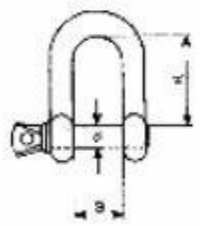
Appendix F - Certificate Of Conformity For D-Shackle

TEST WYTRZYMAŁOŚCIOWY / RESISTANCE TEST

SZEKLA ZWYKŁA
DEE SHACKLE

DOSTAWCA / SUPPLIER

Przedsiębiorstwo "GÓRALMET" M. i J. Góral Sp. J.
Ul.Krakowska 68, 32-860 Czchów
Tel / fax: 014 6635260
www.goralmet.pl



TEST KONTROLNY NR / TEST CONTROL NO.	12/GM/2006

ROZMIAR/SIZE		d [mm]	B [mm]	H [mm]		Masa/szt Weight/pc [kg]	Obciąż. znamion. Working load [kg]	Obciąż. zrywające Breaking load [kg]
3,5 mm		4	8	16		0.0082	50	150
5 mm		5	10	19		0.0146	80	240
6 mm		6	12	24		0.0248	100	300
8 mm		8	16	32		0.0510	200	600
10 mm		10	20	40		0.1086	320	960
12 mm		12	25	48		0.2056	520	1 560
14 mm		14	28	56		0.3248	650	1 950
16 mm		16	32	64		0.4874	800	2 400
18 mm		18	36	71		0.7076	1 000	3 000
20 mm		20	38	76		0.9122	1 100	3 300
22 mm		22	44	85		1.285	1 500	4 500
25 mm		25	50	95		1.8496	2 100	6 300
28 mm		28	56	106		2.5068	3 000	9 000
32 mm		32	64	120		3.1668	3 500	10 500
38 mm		41	76	145		6.2002	5 000	15 000
45 mm		45	80	155		10.810	7 000	21 000

MATERIAŁ / MATERIAL	POKRYCIE / COVERING
C15	*ocynk / galv.*

tolerancja pomiarów +/- 5%
measurement tolerance +/- 5%

artykuł posiada sygnaturę dostawcy - "GM"
product with supplier's signature - "GM"

badania wykonał / tested by :
Instytut Odlewnictwa
Ul. Zakopiańska 73, 30-418 Kraków
nr raportu / report no.: **55/TBM/2006**

Przedsiębiorstwo „GÓRALMET"
M. i J. Góral Sp. J.
32-860 Czchów, ul. Krakowska 68

PIECZĄTKA DOSTAWCY
SUPPLIER'S STAMP

DATA/DATE

12-05-2011

Figure F1 – Conformity Certificate For M12 D-Shackles

Load Capacity = 520 kg

Appendix G – Certificate Of Conformity For Eye-Nut

„OCH-MAN"
Zakład Produkcyjno-Handlowy
Joachim Ochman
Jeżowa ul. Asfaltowa 19
42-793 Ciasna
tel./fax 34 / 35-35-654
NIP 575-000-47-72

Odbiorca: "AMAR" Mark Brzenska
Sieraków Śląski
ul. Wyzwolenia 4
42-793 Ciasna
NIP: 575-111-00-22

DEKLARACJA ZGODNOŚCI DOSTAWCY
według PN-EN ISO/IEC 17050-1:2005

Nazwa wyrobu: według faktury VAT nr 827/11

Norma/materiał: według faktury VAT nr 827/11

Wykaz towarów których dotyczy zaświadczenie:

1. Błoczek do lin 50 mm pojedynczy.
2. Karabińczyk M10x100 strażacki z zabezpieczeniem.
3. Karabińczyk M12x140 strażacki z zabezpieczeniem.
4. Kausze 6 mm do lin.
5. Kausze 10 mm do lin.
6. Lina stalowa 6.0 ocynk (6*19).
7. Szekla 10 mm ocynk 320kg.
8. Śruba rzymska M16x175 hak - oko ocynk.
9. Zacisk 6.0 mm do lin.
10. Zacisk linowy kubełkowy 6,0 mm ocynk.
11. Krętlik 6,0 mm A4.
12. Krętlik 10.0 mm A4.
13. Nakrętka z uchem M12 DIN 582 ocynk.

Odbiór na podstawie warunków: według normy na FV

Wyrób spełnia warunki normy

Figure G1 – Conformity Certificate For M10 Eye-Nut

Load Capacity = 320 kg

Appendix H - Certificate Of Conformity For Rope Clip

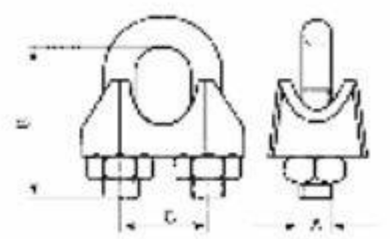
PARAMETRY TECHNICZNE / TECHNICAL PARAMETERS

ZACISK LINOWY DIN 741
WIRE ROPE CLIP DIN 741

DOSTAWCA / SUPPLIER

Przedsiębiorstwo "GÓRALMET" M. i J. Góral Sp. J.
Ul.Krakowska 68, 32-860 Czchów
Tel / fax: 014 6835260
www.goralmet.pl

TEST KONTROLNY NR / TEST CONTROL NO.	27/GM/2006



ROZMIAR/SIZE do liny/for wire	A [mm]	B [mm]	C [mm]					Masa/szt Weight/pc [kg]
3 mm	4	16	9					0.0084
5 mm	5	19	11					0.0142
6 mm	5	23	13					0.0158
8 mm	6	28	16					0.0276
10 mm	8	35	19					0.0595
11 mm	8	37	20					0.0662
12/13 mm	10	45	24					0.1120
14 mm	10	46	25					0.1234
16 mm	12	51	27					0.1838
19/20 mm	12	62	32					0.2316
22 mm	14	72	37					0.3458
26 mm	14	76	41					0.3850
30 mm	16	95	48					0.6356
34 mm	16	105	54					0.7410
40 mm	16	125	60					0.9340

MATERIAŁ / MATERIAL	POKRYCIE / COVERING
C15	*ocynk / galv.*

tolerancja pomiarów +/- 5%
measurement tolerance +/- 5%

badania wykonał / tested by :
Instytut Odlewnictwa
Ul. Zakopiańska 73, 30-418 Kraków
nr raportu / report no.: 289/TBM/2006

Przedsiębiorstwo „GÓRALMET"
M. i J. Góral Sp. J.
32-860 Czchów, ul. Krakowska 68
tel./fax 014 68 35 260, 68 35 265

PIECZĄTKA DOSTAWCY
SUPPLIER'S STAMP

DATA/DATE

12-05-2011

Figure H1 – Conformity Certificate For Wire Rope Clip

Appendix I – Certificate Of Conformity For Turnbuckle

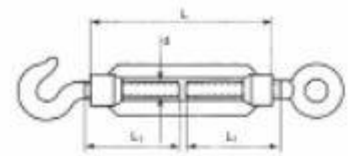
TEST WYTRZYMAŁOŚCIOWY / RESISTANCE TEST

ŚRUBA RZYMSKA UCHO + HAK DIN 1480

TURNBUCKLE WITH EYE / HOOK DIN 1480

DOSTAWCA / SUPPLIER

Przedsiębiorstwo "GÓRALMET" M. i J. Góral Sp. J.
Ul.Krakowska 68, 32-860 Czchów
Tel / fax: 014 6635260
www.goralmet.pl



TEST KONTROLNY NR / TEST CONTROL NO.	3/GM/2006

ROZMIAR/SIZE		L [mm]	L1 [mm]	d		Masa/szt Weight/pc [kg]	Obciąż. znamion. Working load [kg]	Obciąż. zrywające Breaking load [kg]
5 mm		70	35	M5		0.0496	50	125
6 mm		110	55	M6		0.0912	70	175
8 mm		110	57	M8		0.1552	140	350
10 mm		125	68	M10		0.2808	220	550
12 mm		125	70	M12		0.4222	310	770
14 mm		140	75	M14		0.603	450	1 120
16 mm		170	88	M16		0.9080	600	1 500
18 mm		200	98	M18		1.3216	750	1 875
20 mm		200	105	M20		1.6264	910	2 270
22 mm		220	118	M22		2.1972	1 100	2 750
24 mm		255	135	M24		3.0572	1 300	3 250
28 mm		255	135	M27		4.3588	1 900	4 750
32 mm		295	148	M33		5.9846	2 200	5 500

MATERIAŁ / MATERIAL	POKRYCIE / COVERING
C15	ocynk / galv.

tolerancja pomiarów +/- 5%
measurement tolerance +/- 5%

artykuł posiada sygnaturę dostawcy - "GM"
product with supplier's signature - "GM"

badania wykonał / tested by :
Instytut Odlewnictwa
Ul. Zakopiańska 73, 30-418 Kraków
nr raportu / report no.: 48/TBM/2006

Przedsiębiorstwo „GÓRALMET"
M. i J. Góral Sp. J.
32-860 Czchów, ul. Krakowska 68

PIECZĄTKA DOSTAWCY
SUPPLIER'S STAMP

DATA/DATE

12-05-2011

Figure I1 – Certificate Of Conformity For M12 Turnbuckle

Load Capacity = 310 kg

Appendix J – Test Certificate For Bungee Cords

Reference EB18
Issue Level 4
May 2010

CERTIFICATE OF CONFORMITY

ENGLISH BRAIDS LTD
Spring Lane
Malvern
Worcs WR14 1AL

Tel :- 01684 892222
Fax:- 01684 892111
Website: www.englishbraids.com
E.mail: info@englishbraids.com

Airmax Inflatables Limited
Johns Well Village
Johns Well
County Kilkenny
Eire

CERTIFICATE NO.	1369
DATE OF DESPATCH	06.11.2012
DATE OF CERTIFICATE	6/11/2012
ORDER NO.	SOR016236
CUSTOMER ORDER NO.	James Oakey

PRODUCT	ISSUE NO	DESCRIPTION	BATCH NO.	QTY	TEST NO.
39120050000		9mm Nylon Static Line Rope White/Blue Static Strength Without Terminations 9mm Type B = 26.7kn Safe Working Load 1.9K	12F0123	50	

Deviations / concession or notes

We certify that the goods listed meet the requirements of English Braids manufacturing specification. All testing is carried out in accordance to BS:EN:ISO 2307:2005 where applicable. The information and our technical advice - whether verbal, in writing or by way of trials - are given in good faith but without warranty. This also applies where proprietary rights of third parties are involved. Our advice does not release you from the obligation to check it's validity and to test products as to their suitability for the intended purposes. The application and use of our products by you on the advice given are beyond our control and therefore your responsibility. Our products are sold in accordance with our General Conditions of Sale.

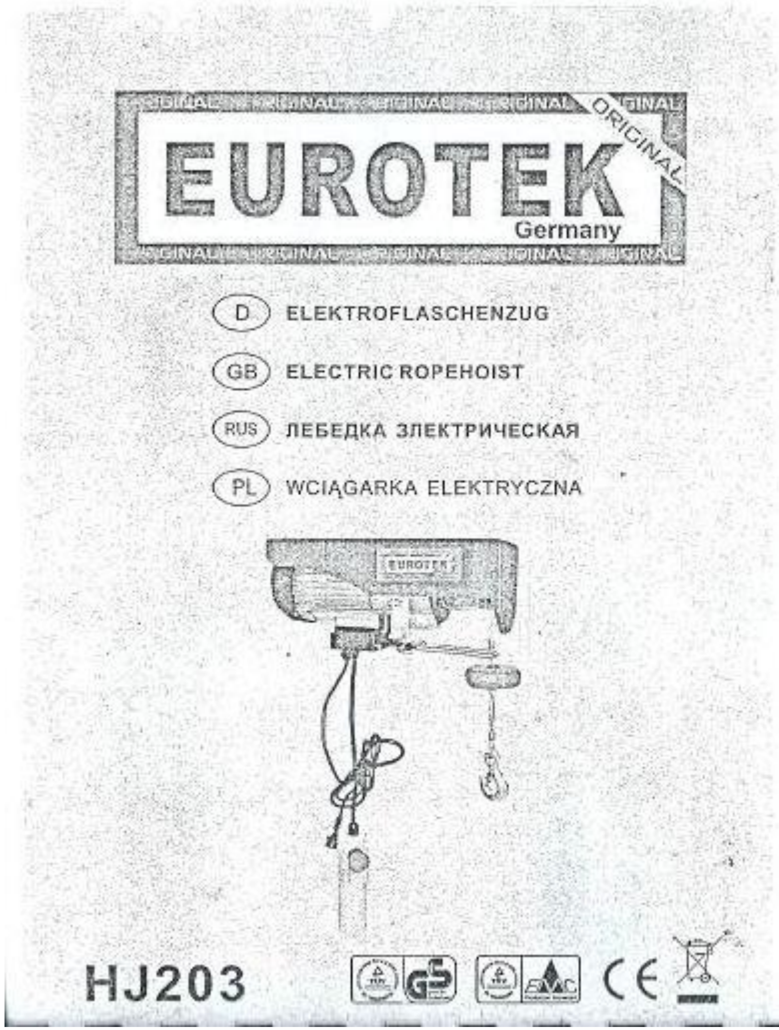
Signed for and on behalf of English Braids Ltd

Date 06/11/2012

Figure J1 – Conformity Certificate For Bungee Cords

Safe Working Load = 1.9 kN

Appendix K – Conformity Certificate For Winch Motor



Technical data		Load capacity	Lifting height	Lifting speed	Cable length	Cable diameter	Mains voltage	Motor performance
100/200	Standard Version	100kg	12m	10m/min	12m	3.0mm	230V~50Hz	P1 500W
	Version with Double load cap.	200kg	6m	5m/min				
125/250	Standard Version	125kg	12m	10m/min	12m	3.0mm	230V~50Hz	P1 550W
	Version with Double load cap.	250kg	6m	5m/min				
150/300	Standard Version	150kg	12m	10m/min	12m	3.0mm	230V~50Hz	P1 550W
	Version with Double load cap.	300kg	6m	5m/min				
200/400	Standard Version	200kg	12m	10m/min	12m	3.5mm	230V~50Hz	P1 1000W
	Version with Double load cap.	400kg	6m	5m/min				
250/500	Standard Version	250kg	12m	10m/min	12m	4.0mm	230V~50Hz	P1 1000W
	Version with Double load cap.	500kg	6m	5m/min				
300/600	Standard Version	300kg	12m	10m/min	12m	4.5mm	230V~50Hz	P1 1050W
	Version with Double load cap.	600kg	6m	5m/min				
350/700	Standard Version	350kg	12m	10m/min	12m	5.0mm	230V~50Hz	P1 1200W
	Version with Double load cap.	700kg	6m	5m/min				
400/800	Standard Version	400kg	12m	10m/min	12m	5.5mm	230V~50Hz	P1 1300W
	Version with Double load cap.	800kg	6m	5m/min				
500/1000	Standard Version	500kg	12m	10m/min	12m	6.0mm	230V~50Hz	P1 1600W
	Version with Double load cap.	1000kg	6m	5m/min				
600/1200	Standard Version	600kg	12m	10m/min	12m	6.0mm	230V~50Hz	P1 1600W
	Version with Double load cap.	1200kg	6m	5m/min				

These descriptions and illustrations are not binding the firm reserves the right to modify them without any notice.

Figure K1 = Conformity Certificate For Winch Motor, Model HJ203

Load Capacity = 500 kg

Appendix L – Conformity Certificate For Trampoline

ZERTIFIKAT ◆ CERTIFICATE ◆ 認証証書 ◆ СЕРТИФИКАТ ◆ CERTIFICADO ◆ CERTIFICAT

TÜV SÜD
Product Service

CERTIFICATE
No. [redacted]98 021

Model(s): TX-TEA-6', TX-TEA-8', TX-TEA-10', TX-TEA-12', TX-TEA-13', TX-TEA-14', TX-TEA-15', TX-TEA-16'

Parameters: Steel structure, pad, jumping sheet, safety net, home use only.

Type:	TX-TEA-6'	TX-TEA-8'
Overall dimension(mm):	Ø1829xH2000	Ø2438xH2380
Weight(kg):	36	42
Max. user weight(kg):	100	100

Type:	TX-TEA-10'	TX-TEA-10'
Overall dimension (mm):	Ø3048xH2380	Ø3048xH2380
Weight(kg):	48	55
Max. user weight(kg):	100	150

Type:	TX-TEA-10'	TX-TEA-12'
Overall dimension(mm):	Ø3048xH2460	Ø3658xH2590
Weight(kg):	57	65
Max. user weight(kg):	150	150

Type:	TX-TEA-13'	TX-TEA-14'
Overall dimension(mm):	Ø3962xH2590	Ø4267xH2590
Weight(kg):	69	73
Max. user weight(kg):	150	150

Type:	TX-TEA-15'	TX-TEA-15'
Overall dimension(mm):	Ø4572xH2590	Ø4572xH2590
Weight(kg):	86	92
Max. user weight(kg):	150	150

Type:	TX-TEA-16'
Overall dimension(mm):	Ø4877xH2590
Weight(kg):	96
Max. user weight (kg):	150

Remark: The compliance of the serial production must be guaranteed by a documented technical pre-shipment inspection conducted by TÜV SÜD.

Tested according to: PPP 62001:2008

Factory(ies): 48098

Page 2 of 2

TÜV SÜD Product Service GmbH · Zertifizierstelle · Ridlerstrasse 65 · 80339 München · Germany

Figure L1 – TUV Certificate Of Conformity For Trampoline Structure

Maximum User Weight = 100 kg

Appendix M – Risk Assessment

Likelihood						
	5	L	M	H	H	H
	4	L	M	M	H	H
	3	L	M	M	M	H
	2	L	L	M	M	M
	1	L	L	L	L	L
		1	2	3	4	5
		Severity				

Severity
1 - None or Trivial injury / illness / loss - 1 person at risk.
2 - Minor injury. Minor first aid required only - Up to 5 persons at risk.
3 - Injury (reportable). Moderate loss - Up to 10 persons at risk.
4 - Major injury / severe incapacity. Serious loss. Up to 25 persons at risk.
5 - Fatality / incapacity. Widespread loss. - 25 or more persons involved.

Likelihood
1 - Improbable
2 - Remote
3 - Possible
4 - Likely
5 - Almost Certain

When calculating the risk the number of persons exposed and the frequency of exposure to the risk must be taken into account.
Risks that calculate as high MUST have further control measures put into place that reduce the risk BEFORE the activity is carried out.
Medium risk factors should have more control measures introduced where possible to reduce the risk to the lowest possible risk.

Risk	Area							
Hazard	**Risk & Identity of Persons Affected**	**Risk Severity**			**Control Measures**	**Remaining Risk Severity**		
		S	**L**	**RR**		**S**	**L**	**RR**
Uneven ground	Ride may be unlevel. Risk of becoming unstable and overturning on packing blocks. Serious injury or death to participants, operators and nearby public	5	4	H	All work force to be trained and supervisor to have appropriate experience. Ground should be assessed prior to build up Always try to assemble on most level ground Use adequate and sufficient packing blocks Regular visual checks on packing areas by trained personnel, re-pack if and when necessary. To be assembled as per manufacturers operating manual.	5	2	L
Soft ground	Risk of ride leveling/packing points sinking into ground. Ride may become unstable and risk of overturning Serious injury or death to participants, operators and nearby public	5	3	M	All work force to be trained and supervisor to have appropriate experience. Ground should be assessed prior to build up Always try to build up on most stable ground possible Use adequate and sufficient packing blocks Regular visual checks on packing areas by trained personnel, re-pack if and when necessary To be assembled as per manufacturers operating manual.	5	2	L

Risk	Structural failure							
Hazard	**Risk & Identity of Persons Affected**	**Risk Severity**			**Control Measures**	**Remaining Risk Severity**		
		S	**L**	**RR**		**S**	**L**	**RR**
Failure of welds on base frame	Ride could become unstable and collapse Serious injury or death to participants, operators and nearby public	5	3	M	Daily and periodic checks and maintenance by adequately trained workforce Adequately trained workforce in operation and evacuation of the ride Repair as and when necessary by qualified/competent person Device not to be opened until repairs etc carried out Annual inspection and NDT by RIB **Refer to manufacturers instruction**	5	2	L
Failure of pins/brackets supporting & connecting main aluminum arms	Main arm could collapse Serious injury or death to participants, operators and nearby public	5	3	M	Daily and periodic checks and maintenance by adequately trained workforce Adequately trained workforce in operation and evacuation of the ride Repair as and when necessary by qualified/competent person Device not to be opened until repairs etc carried out Annual inspection and NDT by RIB **Refer to manufacturers instruction**	5	1	L
Failure of aluminum arms	Main arm could collapse Serious injury or death to participants, operators and nearby public	5	3	M	Daily and periodic checks and maintenance by adequately trained workforce Adequately trained workforce in operation and evacuation of the ride Repair as and when necessary by qualified/competent person Device not to be opened until repairs etc carried out Annual inspection and NDT by RIB **Refer to manufacturers instruction**	5	1	L

Risk	**Structural failure**							
Hazard	**Risk & Identity of Persons Affected**	**Risk Severity**			**Control Measures**	**Remaining Risk Severity**		
		S	**L**	**RR**		**S**	**L**	**RR**
Failure of winch rope	Participant would not be supported by bungee. Risk of falling from height/being thrown from ride. Serious injury to participants	4	3	M	Daily and periodic checks and maintenance by adequately trained workforce Adequately trained workforce in operation and evacuation of the ride Winch to meet loading requirements as specified by operating manual and this design review Replace bungee as and when necessary by qualified/competent person Device not to be opened until repairs etc carried out Annual inspection and NDT by RIB **Refer to manufacturers instruction**	4	1	L
Failure of harness	Main arm could collapse Serious injury or death to participants, operators and nearby public	5	3	M	Daily and periodic checks and maintenance by adequately trained workforce Adequately trained workforce in operation and evacuation of the ride Harness to meet loading requirements as specified by operating manual and this design review Replace as and when necessary by qualified/competent person Ensure harness is correct size for participant. Adequately trained operators to ensure harnesses are fitted correctly Device not to be opened until repairs etc carried out Annual inspection and NDT by RIB **Refer to manufacturers instruction**	5	1	L

Risk	Structural failure							
Hazard	**Risk & Identity of Persons Affected**	**Risk Severity**			**Control Measures**	**Remaining Risk Severity**		
		S	**L**	**RR**		**S**	**L**	**RR**
Failure of electric winch	Participant would not be supported by bungee. Risk of falling from height/being thrown from ride. Serious injury to participants	4	3	M	Daily and periodic checks and maintenance on electrics and power source, and generator for- water-oil-diesel, by adequately trained workforce Adequately trained workforce in operation and evacuation of the ride Repair as and when necessary by qualified/competent person Device not to be opened until repairs etc carried out Annual inspection, and Electrical test by RIB **Refer to manufacturers instruction**	4	1	L
Electric shock	Risk of major injury or death to operators, participants and nearby public	5	3	M	All required MCB's and RCD's in place Daily and periodic checks and maintenance on electrics by adequately trained workforce Adequately trained workforce in operation and evacuation of the ride Repair as and when necessary by qualified/competent person Device not to be opened until repairs etc carried out Annual Electrical test by RIB **Refer to manufacturers instruction**	5	1	L

Risk	Structural failure							
Hazard	**Risk & Identity of Persons Affected**	**Risk Severity**			**Control Measures**	**Remaining Risk Severity**		
		S	**L**	**RR**		**S**	**L**	**RR**
High winds	Risk of major injury or death from participant being blown off normal trajectory to overturn of ride	5	3	M	Adequately trained workforce in operation and evacuation of the ride Sufficient checks and maintenance throughout operation by adequately trained persons Device to be operated only in wind speeds as specified by the manufacturer and in the design review. Device to be disassembled in wind speeds greater than 8 m/s. Device to be guy roped down if excessive movement results when not in use	5	1	L
Age of passengers	This type of ride may cause distress to young participants. Young riders may lack the ability to understand the dangers associated with misbehaving on this ride	2	2	L	Adequately trained workforce in operation and evacuation of the ride Injuries etc are not always visible to operator/attendants therefore safety and instructional signage should be clearly visible Operator to give verbal instruction if necessary **Refer to manufacturers instruction**	2	1	L

This risk assessment report covers the operation of the attraction when used as an amusement device. It is based on an overview of the risks associated with the device. It does not cover detailed component failure. The assessment is based on engineering and operational aspects of the device and does not take into account personal or legislative risks. Each hazard/risk has been reviewed individually to ensure that all required actions have been taken to reduce the risk, so far as reasonably practicable and in line with the manufacturer's recommendation. As there is no statistical data available this risk assessment is based on the experience, judgement and knowledge of the device by the manufacturer and various Owner/Operators. There is a manufacturers operation manual in place for owner/controller reference.

NB;
Operation and maintenance should only be carried out by an adequately trained adult after instruction and training from the manufacturer.
When the 'Bungee Trampoline' is owned/controlled by anyone other than the manufacturer if there is any part of the assessment or operations manual that they do not understand they should consult the manufacturer as soon as possible.
All maintenance and training should be documented.
The manufacturer's instruction should be followed at all times

Appendix N – Non-Destructive Test schedule

BUNGEE TRAMPOLINE RIDE NDT SCHEDULE FOR ROUTINE TESTING OF CRITICAL PARTS

Item	Description/Location	Test Method	Frequency Of Test
Trailer chassis	Welds on trailer chassis at points where out riggers connect to chassis. Weld connecting arm support to chassis	MPI	Annually
Arm pins	All pins in the ends of the arms connecting arms to trailer chassis	UTS/MPI	Annually
Arm joints	All joint brackets	Visual	Daily By Operator Annually
Winch rope	Winch ropes	Visual	Daily By Operator Annually
Bungee cords	Bungee cords	Visual	Daily By Operator Annually
Harness	Harness	Visual/ Functional	Daily By Operator Annually
Winch motor	Winch motor and winch motor anchor bolts	Visual/ Functional/ Tightness check	Daily By Operator Annually

100% of all items listed must be visually examined unless stated.
Any and all defects found must be reported to the AIB.
Any previous weld repairs must be recorded.
Any areas outside the scope of the schedule must be examined by the NDT engineer if deemed relevant , and reported to the AIB
Eddy Current may be used as an alternative or in combination with other listed Test Methods where appropriate.

All items to be sufficiently dismantled for proper and adequate NDE

Remove any flaky paint, corrosion and de-grease. Remaining paint layers to be no more than the maximum thickness to allow proper and adequate NDE

Appendix O – Fabrication Drawings Of Bungee Trampoline

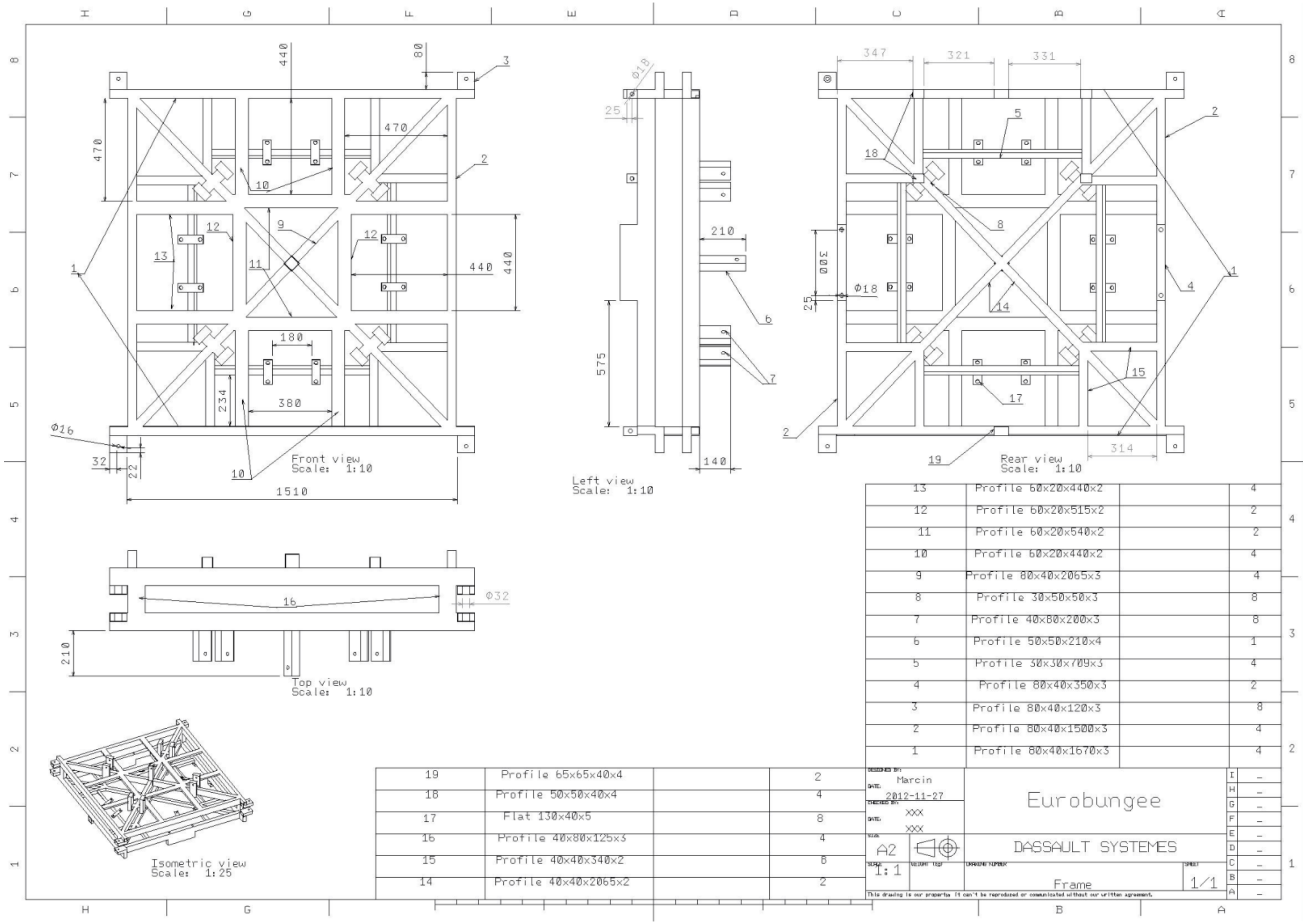


Figure O1 – Details Of Trailer Chassis

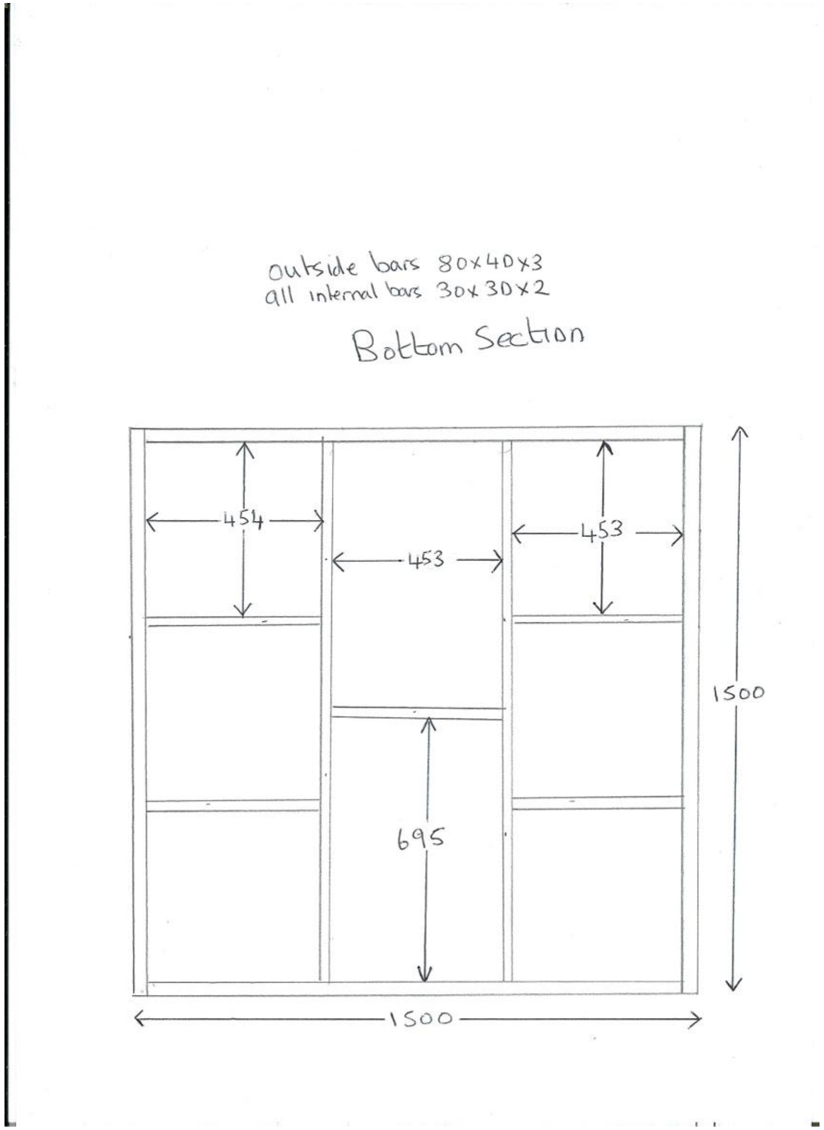


Figure O2 – Modified Details Of Trailer Chassis, Lower Section Only

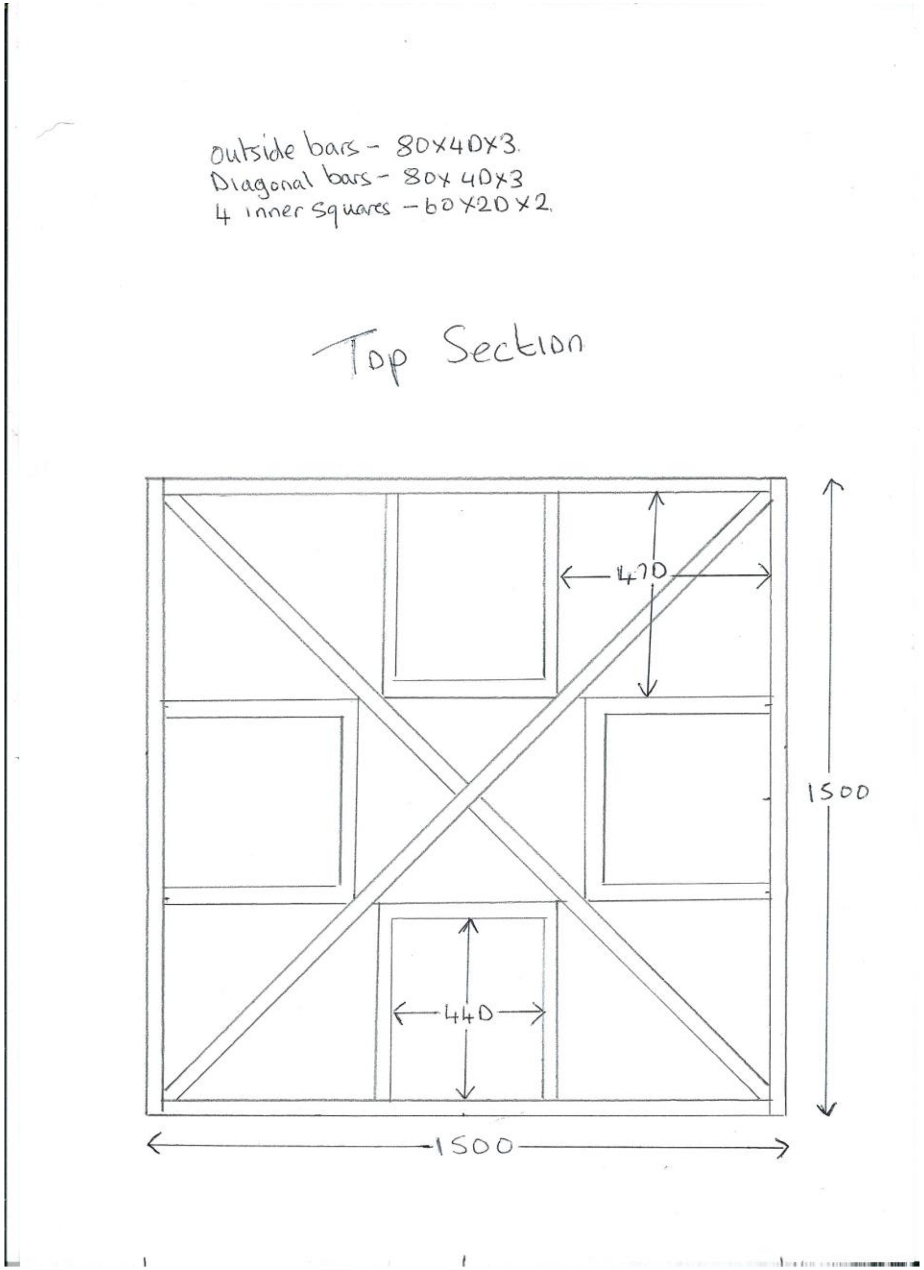


Figure O3 – Modified Details Of Trailer Chassis, Top Section Only

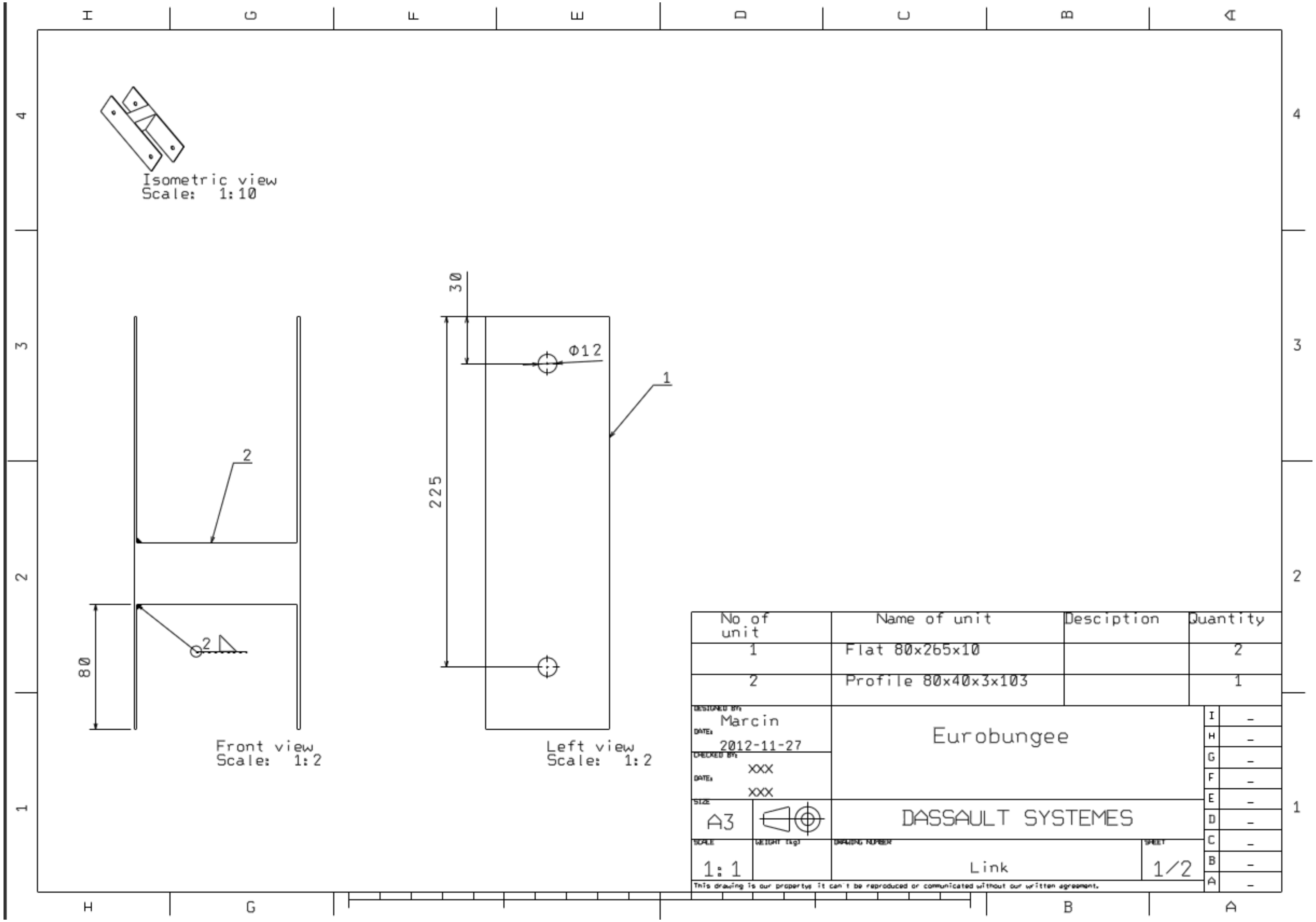
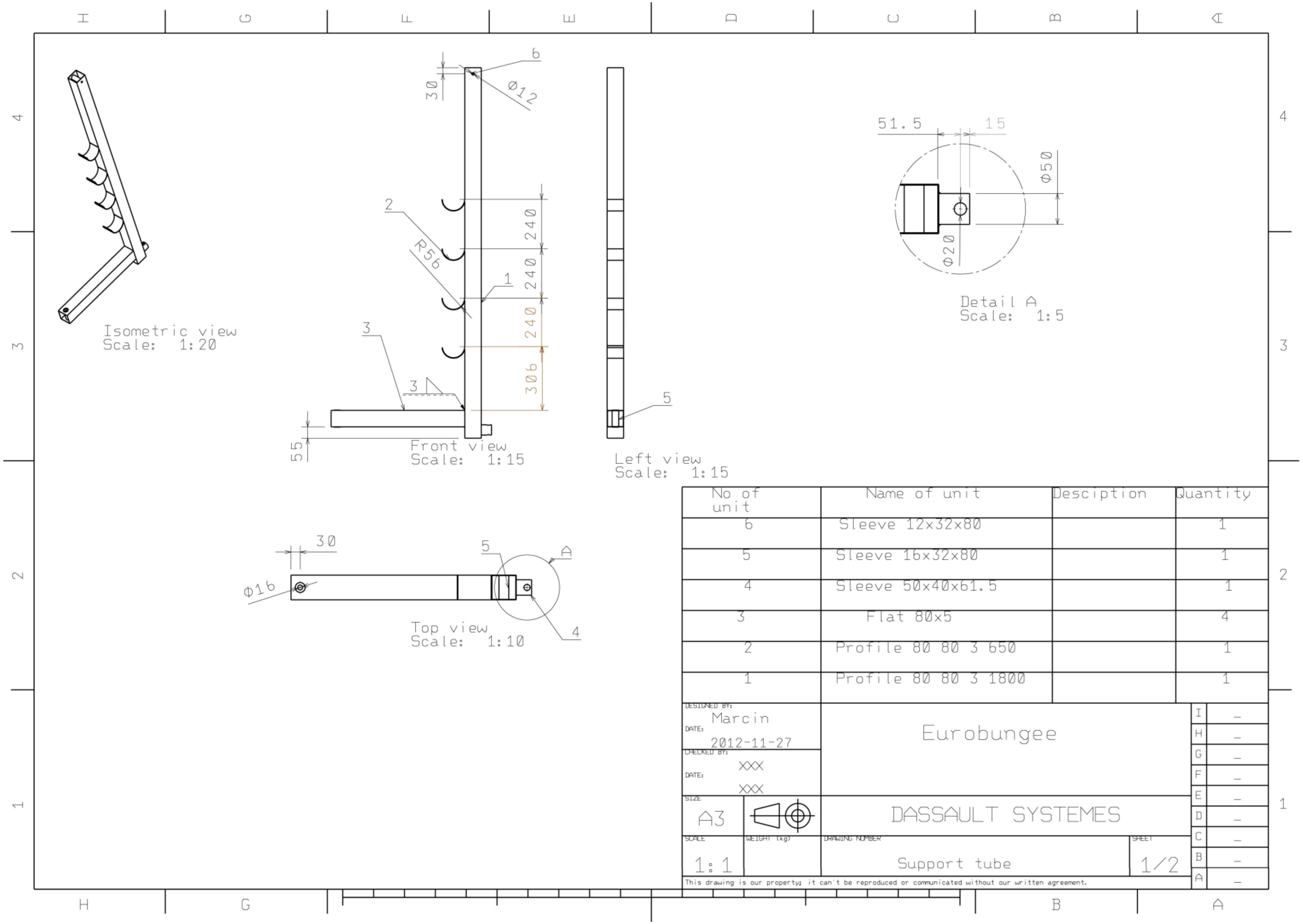


Figure O4 – Details Of Pole Support Bracket



No of unit	Name of unit	Desciption	Quantity
6	Sleeve 12x32x80		1
5	Sleeve 16x32x80		1
4	Sleeve 50x40x61.5		1
3	Flat 80x5		4
2	Profile 80 80 3 650		1
1	Profile 80 80 3 1800		1

Figure O5 – Details Of Outrigger

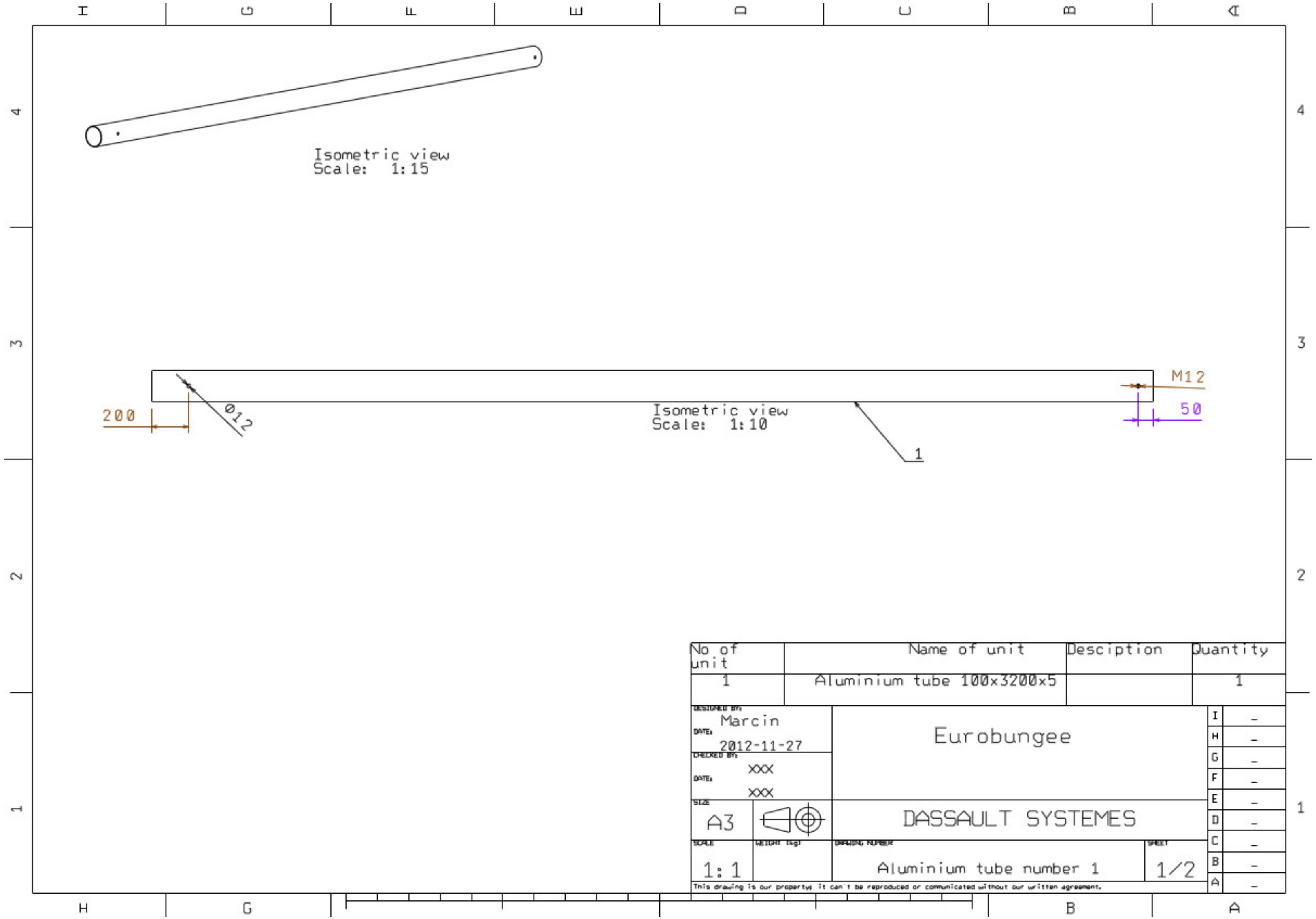


Figure O6 – Details Of Aluminium Pole, Upper Section

Overall Length Of Arm As Specified by Client = 6m

Advanced Computational Analysis
4a, Main Road, Gedling, Nottingham. NG4 3HP
Telephone 0115 9533931 e-mail:info@aca-consultants.co.uk

Client :*Airmax Inflatable* ACA Contract No : *S2149-1*

Date : 27th February *2013*

Description : *Structural Verification Of Trailer Mounted 4-Person Bungee Trampoline*

ACA
Engineering Consultants

1.0 *Loading Verification*

1.1 *Self weight*

Self weight loading was included automatically by the FE program,
based on material densities an acceleration due to gravity of $9.81\ m/s^2$

Estimated mass of harness $= 10\ kg$

Estimated mass of winch motor $= 30\ kg$

Estimated mass of wheel and stub axle $= 40\ kg$ *each*

1.2 *Passenger loading*

Passenger mass $= 80\ kg$

Equivalent acceleration $= 2x9.81 = 19.62\ m/s^2$

Equivalent force $= 19.62x\left(80 + 10\right) = 1766\ N$

Prepared By: *R. Anderson* | Checked By: *Dr M. Lacey*

2.0 *Section Verification*

2.1 *Load Case* 1

Steel Plate Section

$\sigma_{vm} = 17.3\, N/mm^2 < 235\, N/mm^2$

$Factor\ of\ safety\ on\ yield\ strength = \frac{235}{17.3} = 13.6$ ***Satisfactory***

$Maximum\ deflexion = 139.11$

$Suggest\ permissible\ deflexion = \frac{span}{180} = \frac{6000}{180} = 33.33\, mm$

$UF = \frac{139.11}{33} = 4.22 > 1$ ***Satisfactory Based On Dynamic Deflexion***

2.2 *Load Case* 2

Steel Plate Section

$\sigma_{vm} = 21.3\, N/mm^2 < 235\, N/mm^2$

$Factor\ of\ safety\ on\ yield\ strength = \frac{235}{21.3} = 11.0$ ***Satisfactory***

$Maximum\ deflexion = 231.77$

$Suggest\ permissible\ deflexion = \frac{span}{180} = \frac{6000}{180} = 33.33\, mm$

$UF = \frac{231.77}{33.33} = 6.95 > 1$ ***Satisfactory Based On Dynamic Deflexion***

2.3 *Load Case* 3

Steel Plate Section

$\sigma_{vm} = 21.6\, N/mm^2 < 235\, N/mm^2$

$Factor\ of\ safety\ on\ yield\ strength = \frac{235}{21.6} = 10.9$ ***Satisfactory***

$Maximum\ deflexion = 139.11$

$Suggest\ permissible\ deflexion = \frac{span}{180} = \frac{6000}{180} = 33.33\, mm$

$UF = \frac{49.74}{33.33} = 1.49 > 1$ ***Satisfactory Based On Dynamic Deflexion***

Advanced Computational Analysis
4a, Main Road, Gedling, Nottingham. NG4 3HP.
Telephone 0115 9533931 e-mail:info@aca-consultants.co.uk

Contract No. *S2149*

ACA
Engineering Consultants

2.4

Load Case 4
Steel Plate Section

$\sigma_{vm} = 21.9\, N/mm^2 < 235\, N/mm^2$

$Factor\ of\ safety\ on\ yield\ strength = \frac{235}{21.9} = 10.7$ ***Satisfactory***

$Maximum\ deflexion = 231.77$

$Suggest\ permissible\ deflexion = \frac{span}{180} = \frac{6000}{180} = 33.33\, mm$

$UF = \frac{64.08}{33.33} = 1.92 > 1$ ***Satisfactory Based On Dynamic Deflexion***

Prepared By: *R. Anderson*	Checked By *Dr M. Lacey*

© *ACA 2013*	*Section: 2*	*Sheet: 3 of: 18*

3.0 *Section capacities of steel sections in accordance with BS*449 – 2:1969

permissible stresses have been reduced by $\frac{235}{275}$ *for grade S*235 *steel*

3.1 *Real constant* 2 – 80*x*40*x*3 *RHS, component AA*

$$\lambda = \frac{1460x0.85}{16.3} = 76.1$$

$$p_c = 97x674x10^{-3} = 65.4\,kN$$

$$p_t = 145x674x10^{-3} = 97.7\,kN$$

$$M_{bx} = 154x13.6x10^{-3} = 2.09\,kNm$$

$$M_{by} = 154x9x10^{-3} = 1.39\,kNm$$

3.2 *Real constant* 3 – 60*x*20*x*2 *RHS, component AB*

$$\lambda = \frac{500x0.85}{8.3} = 51$$

$$p_c = 122x304x10^{-3} = 37.1\,kN$$

$$p_t = 145x304x10^{-3} = 44.1\,kN$$

$$M_{bx} = 154x4.19x10^{-3} = 0.65\,kNm$$

$$M_{by} = 154x2.09x10^{-3} = 0.32\,kNm$$

3.3 *Real constant* 4 – 30*x*30*x*2 *SHS, component AC*

$$\lambda = \frac{1460x0.85}{11.4} = 109$$

$$p_c = 72x220x10^{-3} = 15.8\,kN$$

$$p_t = 145x220x10^{-3} = 31.9\,kN$$

$$M_b = 154x1.89x10^{-3} = 0.29\,kNm$$

3.4 *Real constant* 7 – 80*x*80*x*3 *SHS, component AD*

$$\lambda = \frac{1680x1.5}{31.3} = 80.5$$

$$p_c = 93x914x10^{-3} = 85\,kN$$

$$p_t = 145x914x10^{-3} = 132.5\,kN$$

$$M_b = 154x22.5x10^{-3} = 3.47\,kNm$$

3.5 *Real constant* 10 @ 50*x*50*x*4 *SHS* @ *component AE*

$$\lambda = \frac{200x0.85}{18.6} = 9.1$$

$$p_c = 141x719x10^{@3} = 101.4\,kN$$

$$p_t = 145x719x10^{@3} = 104.3\,kN$$

$$M_b = 154x9.99x10^{@3} = 1.54\,kNm$$

3.6 *Real constant* 17 @ 30*x*30*x*3 *SHS, component AF*

$$\lambda = \frac{480x0.85}{10.9} = 37.4$$

$$p_c = 129x314x10^{@3} = 40.5\,kN$$

$$p_t = 145x314x10^{@3} = 45.5\,kN$$

$$M_b = 154x2.5x10^{@3} = 0.385\,kNm$$

3.7.1 *Load case* 1 @ *maximum utilisation in component AA*

$$UF_{max} = \frac{3.88}{65.4} + \frac{0.69}{2.09} + \frac{0.35}{1.39} = 0.64 < 1\ \textbf{\textit{Satisfactory}}$$

3.7.2 *Load case* 2 @ *maximum utilisation in component AA*

$$UF_{max} = \frac{5.72}{65.4} + \frac{0.69}{2.09} + \frac{0.60}{1.39} = 0.85 < 1\ \textbf{\textit{Satisfactory}}$$

3.7.3 *Load case* 3 @ *maximum utilisation in component AA*

$$UF_{max} = \frac{3.95}{65.4} + \frac{0.61}{2.09} + \frac{0.28}{1.39} = 0.55 < 1\ \textbf{\textit{Satisfactory}}$$

3.7.4 *Load case* 4 @ *maximum utilisation in component AF*

$$UF_{max} = \frac{0.07}{45.5} + \frac{0.33}{0.385} + \frac{0.003}{0.385} = 0.87 < 1\ \textbf{\textit{Satisfactory}}$$

3.8

$100x5\ CHS;\ \ Real\ constant\ 5$

$For\ aluminium\ grade\ 6060\ T66$

$f_o = 150\ N/mm^2;\quad f_u = 195;\quad \rho_{o,haz} = 0.43;\quad \rho_{u,haz} = 0.56;\quad BC = A$

$\gamma_{M1} = 1.1;\quad \gamma_{M2} = 1.25;\quad \varepsilon = \sqrt{\frac{250}{150}} = 1.29$

$Classification\ of\ cross\ section$

$\beta = 3\,x\sqrt{\frac{2r}{t}} = 3\,x\sqrt{\frac{2x47.5}{5}} = 13.1$

$\beta_{1f} = 11x1.29 = 14.2 > 13.1 \Rightarrow = class\ 2$

$A_e = A;\quad \eta = 1$

$Cross\ section\ constants$

$A = 1491\ mm^2$

$W_{ely} = \frac{1680000}{50} = 33600\ mm^3;\quad W_{pl,y} = \frac{100^3 - 90^3}{6} = 45167\ mm^3$

$r = \sqrt{\frac{1680000}{1491}} = 33.6\ mm$

$\alpha_{2u} = \frac{45167}{33600} = 1.34 \Rightarrow = 1.25$

$Flexural\ buckling$

$effective\ length\ l_c = 1.5x4080 = 6120\ mm$

$\lambda = \frac{6120}{\pi x33.6}\sqrt{\frac{150}{70000}} = 2.68$

$\varphi = 0.5\left(1 + 0.2\left(2.68 - 0.1\right) + 2.68^2\right) = 4.35$

$\chi = \frac{1}{4.35 + \sqrt{4.35^2 - 2.68^2}} = 0.13$

$N_{Rd} = \frac{Af_o}{\gamma_{M1}} = \frac{1491x150}{1.1x10^3} = 203.3\ kN$

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3.8

Exponents in interaction formula

$\psi_c = 0.8$

Bending moment capacities

shape factor for class 1 section $\alpha = 1.25$

$$M_{,Rd} = \frac{\alpha W_{el} f_o}{\gamma_{M1}} = \frac{1.25x33600x150}{1.1x10^6} = 5.73\,kNm$$

Flexural buckling verification

$$UF = \left(\frac{N_{Ed}}{\chi_z \omega_x N_{Rd}}\right)^{\psi_c} + \left[\left(\frac{1}{\omega_0}\frac{M_{y,Ed}}{M_{y,Rd}}\right)^{1.7} + \left(\frac{M_{z,Ed}}{M_{z,Rd}}\right)^{1.7}\right]^{0.6} \le 1$$

Axial tension and bending verification

$$UF = \left(\frac{N_{Ed}}{\omega_x N_{Rd}}\right)^{\psi} + \left[\left(\frac{M_{y,Ed}}{\omega_0 M_{y,Rd}}\right)^{1.7} + \left(\frac{M_{z,Ed}}{\omega_0 M_{z,Rd}}\right)^{1.7}\right]^{0.6} \le 1$$

The following utilisation factor represents the most extreme combination of axial force and bending moments for all load cases analysed;

Load case 5; $N_{Ed} = -6.3\,kN$; $M_{y,Ed} = 1.08\,kNm$; $M_{z,Ed} = 0.26\,kNm$

$$\left(\frac{6.3}{0.13x203.3}\right)^{0.8} + \left[\left(\frac{1.08}{5.73}\right)^{1.7} + \left(\frac{0.26}{5.73}\right)^{1.7}\right]^{0.6} = 0.51 < 1 \textbf{ Satisfactory}$$

Load case 6; $N_{Ed} = -8.1\,kN$; $M_{y,Ed} = 2.25\,kNm$; $M_{z,Ed} = 1.78\,kNm$

$$\left(\frac{8.0}{0.13x203.3}\right)^{0.8} + \left[\left(\frac{1.72}{5.73}\right)^{1.7} + \left(\frac{1.26}{5.73}\right)^{1.7}\right]^{0.6} = 0.82 < 1 \textbf{ Satisfactory}$$

Load case 7; $N_{Ed} = -6.6\,kN$; $M_{y,Ed} = 1.30\,kNm$; $M_{z,Ed} = 0.31\,kNm$;

$$\left(\frac{6.6}{0.13x203.3}\right)^{0.8} + \left[\left(\frac{1.3}{5.73}\right)^{1.7} + \left(\frac{0.31}{5.73}\right)^{1.7}\right]^{0.6} = 0.56 < 1 \textbf{ Satisfactory}$$

Load case 8; $N_{Ed} = -11.6\,kN$ *fig* 3.1; $M_{y,Ed} = 1.06\,kNm$ *fig* 3.2; $M_{z,Ed} = 0.91\,kNm$ *fig* 3.3

$$\left(\frac{11.6}{0.13x203.3}\right)^{0.8} + \left[\left(\frac{1.06}{5.73}\right)^{1.7} + \left(\frac{0.91}{5.73}\right)^{1.7}\right]^{0.6} = 0.77 < 1 \textbf{ Satisfactory}$$

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3.9

$90x4\ CHS;$

$For\ aluminium\ grade\ 6082\ T6$

$f_o = 260\ N/mm^2;\quad f_u = 310;\quad \rho_{o,haz} = 0.48;\quad \rho_{u,haz} = 0.60;\quad BC = A$

$\gamma_{M1} = 1.1;\quad \gamma_{M2} = 1.25;\quad \varepsilon = \sqrt{\frac{250}{260}} = 0.98$

$Classification\ of\ cross\ section$

$\beta = 3x\sqrt{\frac{2r}{t}} = 3x\sqrt{\frac{2x43}{4}} = 13.9;\quad \beta_{2f} = 16x0.98 = 15.68 > 13.9 \Rightarrow = class\ 2$

$A_e = A;\quad \eta = 1$

$Cross\ section\ constants$

$A = 1080\ mm^2$

$W_{ely} = \frac{999208}{45} = 22205\ mm^3;\quad W_{pl,y} = \frac{90^3 - 82^3}{6} = 29605\ mm^3$

$r = \sqrt{\frac{999208}{1080}} = 30.4\ mm$

$\alpha_{1u} = \frac{29605}{22205} = 1.33 \Rightarrow = 1.25$

$Flexural\ buckling$

$effective\ length\ l_c = 305\ mm$

$\lambda = \frac{305}{\pi x30.4}\sqrt{\frac{260}{70000}} = 0.19$

$\varphi = 0.5\left[1 + 0.2\left(0.19 - 0.1\right) + 0.19^2\right] = 0.53$

$\chi = \frac{1}{0.53 + \sqrt{0.53^2 - 0.19^2}} = 0.98$

$N_{Rd} = \frac{Af_o}{\gamma_{M1}} = \frac{1080x260}{1.1x10^3} = 255.3\ kN$

3.10

Exponents in interaction formula

$\psi_c = 0.8$

Bending moment capacities

shape factor for class 2 section $\alpha = 1.25$

$$M_{,Rd} = \frac{\alpha W_{el} f_o}{\gamma_{M1}} = \frac{1.25x22205x260}{1.1x10^6} = 6.56\,kNm$$

Flexural buckling verification

$$UF = \left(\frac{N_{Ed}}{\chi_z \omega_x N_{Rd}}\right)^{\psi_c} + \frac{1}{\omega_0}\left[\left(\frac{M_{y,Ed}}{M_{y,Rd}}\right)^{1.7} + \left(\frac{M_{z,Ed}}{M_{z,Rd}}\right)^{1.7}\right]^{0.6} \le 1$$

Axial tension and bending verification

$$UF = \left(\frac{N_{Ed}}{\omega_x N_{Rd}}\right)^{\psi} + \left[\left(\frac{M_{y,Ed}}{\omega_0 M_{y,Rd}}\right)^{1.7} + \left(\frac{M_{z,Ed}}{\omega_0 M_{z,Rd}}\right)^{1.7}\right]^{0.6} \le 1$$

The following utilisation factor represents the most extreme combination of axial force and bending moments for all load cases analysed;

Load case 5; $N_{Ed} = -6.2\,kN$; $M_{y,Ed} = 0.34\,kNm$; $M_{z,Ed} = 0.51\,kNm$

$$\left(\frac{6.2}{0.98x255.3}\right)^{0.8} + \left[\left(\frac{0.34}{6.56}\right)^{1.7} + \left(\frac{0.51}{6.56}\right)^{1.7}\right]^{0.6} = 0.15 < 1 \textbf{ Satisfactory}$$

Load case 6; $N_{Ed} = -8.9\,kN$; $M_{y,Ed} = 0.23\,kNm$; $M_{z,Ed} = 0.23\,kNm$

$$\left(\frac{8.9}{0.98x255.3}\right)^{0.8} + \left[\left(\frac{0.23}{6.56}\right)^{1.7} + \left(\frac{0.23}{6.56}\right)^{1.7}\right]^{0.6} = 0.12 < 1 \textbf{ Satisfactory}$$

Load case 7; $N_{Ed} = -6.3\,kN$; $M_{y,Ed} = 0.58\,kNm$; $M_{z,Ed} = 0.59\,kNm$

$$\left(\frac{6.3}{0.98x255.3}\right)^{0.8} + \left[\left(\frac{0.58}{6.56}\right)^{1.7} + \left(\frac{0.59}{6.56}\right)^{1.7}\right]^{0.6} = 0.18 < 1 \textbf{ Satisfactory}$$

Load case 8; $N_{Ed} = -11.5\,kN$; $M_{y,Ed} = 0.09\,kNm$; $M_{z,Ed} = 1.03\,kNm$

$$\left(\frac{11.5}{0.98x255.3}\right)^{0.8} + \left[\left(\frac{0.09}{6.56}\right)^{1.7} + \left(\frac{1.03}{6.56}\right)^{1.7}\right]^{0.6} = 0.24 < 1 \textbf{ Satisfactory}$$

4.0 *Connection Verification*

4.1 *Weld at base of* 80*x*80*x*3 *SHS outrigger, detailed in figure* 4.1

Assuming 80*x*160*x*3 *mm continuous fillet weld, Load Case* 2

$F_x = 108\,N; \quad SF_y = 2791\,N, \quad SF_z = 0\,N$

$SM_{xx} = 12065\,Nmm, \quad M_{yy} = 49\,Nmm; \quad M_{zz} = 1779400\,Nmm$

Tensile forces on weld per mm

$$Force\ due\ to\ M_{yy} = \left(\frac{M_{yy}}{bd + \frac{b^2}{3}}\right) = \left(\frac{49}{80x80 + \frac{80^2}{3}}\right) = 5.7x10^{-3}\,N/mm$$ **Negligible**

$$Force\ due\ to\ M_{zz} = \left(\frac{M_{zz}}{bd + \frac{d^2}{3}}\right) = \left(\frac{1779400}{80x80 + \frac{160^2}{3}}\right) = 119\,N/mm$$

$$Force\ due\ to\ F_x = \left(\frac{F_x}{2(b+d)}\right) = \left(\frac{108}{2(80+80)}\right) = 0.3\,N/mm$$ **Negligible**

$F_T = 119\,N/mm$

Shear forces on weld per mm

$$Force\ due\ to\ F_y = \left(\frac{F_y}{2(b+d)}\right) = \left(\frac{2791}{2(80+80)}\right) = 9\,N/mm$$

$$Force\ due\ to\ F_z = \left(\frac{F_z}{2(b+d)}\right) = 0\,N/mm$$

$$Force\ due\ to\ M_{xx} = \left(\frac{M_{xx}\,x\,n}{bd(b+d) + \left(\frac{d^3 + b^3}{3}\right)}\right)$$

$$= \left(\frac{12065\,x\,57}{80x80(80+80) + \left(\frac{80^3 + 80^3}{3}\right)}\right) = 0.5\,N/mm$$ **Negligible**

Resultant shear force $SF_r = 9\,N/mm$

Resultant force on weld

$$F_R = \sqrt{119^2 + 9^2} = 119\,N/mm$$

$$Resultant\ stress\ on\ weld = \left(\frac{119}{3}\right)x\sqrt{2} = 56\,N/mm^2$$

$$Permissible\ stress = 125x\left(\frac{235}{275}\right) = 107\,N/mm^2$$

$$Utilisation\ factor = \left(\frac{56}{107}\right) = 0.52 < 1$$ **Satisfactory**

4.2

Weld connecting $80x40x3$ *RHS out rigger connection on trailer chassis, detailed in figure* 4.2
Assuming $80x40x3$ *mm continuous fillet weld, Load Case* 2

$SF_x = 5920\,N; \quad F_y = 1046\,N, \quad SF_z = 5952\,N$

$M_{xx} = 114980\,Nmm, \quad SM_{yy} = 415000\,Nmm; \quad M_{zz} = 188730\,Nmm$

Tensile forces on weld per mm

$$Force\ due\ to\ M_{xx} = \left(\frac{M_{xx}}{bd + \frac{d^2}{3}}\right) = \left(\frac{114980}{40x80 + \frac{80^2}{3}}\right) = 22\,N/mm$$

$$Force\ due\ to\ M_{zz} = \left(\frac{M_{zz}}{bd + \frac{b^2}{3}}\right) = \left(\frac{188730}{40x80 + \frac{40^2}{3}}\right) = 51\,N/mm$$

$$Force\ due\ to\ F_y = \left(\frac{F_y}{2(b+d)}\right) = \left(\frac{1046}{2(40+80)}\right) = 4\,N/mm$$

$F_T = 22 + 51 + 4 = 77\,N/mm$

Shear forces on weld per mm

$$Force\ due\ to\ F_x = \left(\frac{F_x}{2(b+d)}\right) = \left(\frac{5920}{2(40+80)}\right) = 25\,N/mm$$

$$Force\ due\ to\ F_z = \left(\frac{F_z}{2(b+d)}\right) = \left(\frac{5952}{2(40+80)}\right) = 25\,N/mm$$

$$Force\ due\ to\ M_{yy} = \left(\frac{M_{yy}\,x\,r}{bd(b+d) + \left(\frac{d^3 + b^3}{3}\right)}\right)$$

$$= \left(\frac{415000\,x\,45}{40x80(40+80) + \left(\frac{80^3 + 40^3}{3}\right)}\right) = 32\,N/mm^2$$

$$Resultant\ shear\ force\ SF_r = \sqrt{\left(F_x + M_{yy}\sin 63.4\right)^2 + \left(F_z + M_{yy}\cos 63.4\right)^2}$$

$$= \sqrt{(25 + 32\sin 63.4)^2 + (25 + 32\cos 63.4)^2} = 66\,N/mm$$

Resultant force on weld

$$F_R = \sqrt{77^2 + 66^2} = 101\,N/mm$$

$$Resultant\ stress\ on\ weld = \left(\frac{101}{3}\right)x\sqrt{2} = 48\,N/mm^2$$

$$Utilisation\ factor = \left(\frac{48}{107}\right) = 0.45 < 1\ \textbf{Satisfactory}$$

4.3

Weld connecting 80*x*40*x*3 *RHS to trailer chassis, detailed in figure* 4.2

Assuming 80*x*40*x*3 *mm continuous fillet weld, Load Case* 2

$F_x = 1538\,N; \quad SF_y = 2562\,N, \quad SF_z = -1884\,N$

$SM_{xx} = 385190\,Nmm, \quad M_{yy} = 230970\,Nmm; \quad M_{zz} = 404\,Nmm$

Tensile forces on weld per mm

$$Force\ due\ to\ M_{yy} = \frac{M_{yy}}{bd + \frac{b^2}{3}} = \frac{230970}{40x80 + \frac{40^2}{3}} = 62\,N/mm$$

$$Force\ due\ to\ M_{zz} = \frac{M_{zz}}{bd + \frac{d^2}{3}} = \frac{404}{40x80 + \frac{80^2}{3}} = 0.08\,N/mm\ \textbf{Negligible}$$

$$Force\ due\ to\ F_x = \frac{F_x}{2(b+d)} = \frac{1538}{2(40+80)} = 6\,N/mm$$

$F_T = 62 + 6 = 68\,N/mm$

Shear forces on weld per mm

$$Force\ due\ to\ F_y = \frac{F_y}{2(b+d)} = \frac{2562}{2(40+80)} = 11\,N/mm$$

$$Force\ due\ to\ F_z = \frac{F_z}{2(b+d)} = \frac{1884}{2(40+80)} = 8\,N/mm$$

$$Force\ due\ to\ M_{xx} = \frac{M_{xx}\,x\,r}{bd(b+d) + \frac{d^3 + b^3}{3}}$$

$$= \frac{385190\,x\,45}{40x80(40+80) + \frac{80^3 + 40^3}{3}} = 30\,N/mm$$

$$Resultant\ shear\ force\ SF_r = \sqrt{\left(F_y + M_{xx}\sin 26.6\right)^2 + \left(F_z + M_{xx}\cos 26.6\right)^2}$$

$$= \sqrt{(11 + 30\sin 63.4)^2 + (8 + 30\cos 63.4)^2} = 43\,N/mm$$

Resultant force on weld

$F_R = \sqrt{68^2 + 43^2} = 80\,N/mm$

$$Resultant\ stress\ on\ weld = \frac{80}{3}\,x\,\sqrt{2} = 38\,N/mm^2$$

$$Permissible\ stress = 125x\,\frac{235}{275} = 107\,N/mm^2$$

$$Utilisation\ factor = \frac{38}{107} = 0.36 < 1\ \textbf{Satisfactory}$$

4.4

Weld connecting winch motor angle to $30x30x3$ *SHS, detailed in figure* 4.3
Assuming $260x203x3$ *mm continuous fillet weld, Load Case* 2

$SF_x = 10\,N; \quad F_y = 1140\,N, \quad SF_z = 707\,N$

$M_{xx} = 6788\,Nmm, \quad SM_{yy} = 130\,Nmm; \quad M_{zz} = 339\,Nmm$

Tensile forces on weld per mm

$$Force\ due\ to\ M_{xx} = \left(\frac{M_{xx}}{bd}\right) = \left(\frac{6788}{203x260}\right) = 0.12\,N/mm\ \textbf{Negligible}$$

$$Force\ due\ to\ M_{zz} = \left(\frac{M_{zz}}{\frac{d^2}{3}}\right) = \left(\frac{339}{\frac{260^2}{3}}\right) = 0.02\,N/mm\ \textbf{Negligible}$$

$$Force\ due\ to\ F_y = \left(\frac{F_y}{2\ d}\right) = \left(\frac{1140}{2x260}\right) = 2\,N/mm$$

$F_T = 2\,N/mm$

Shear forces on weld per mm

$$Force\ due\ to\ F_x = \left(\frac{F_x}{2\ d}\right) = \left(\frac{10}{2x260}\right) = 0.02\,N/mm$$

$$Force\ due\ to\ F_z = \left(\frac{F_z}{2\ d}\right) = \left(\frac{707}{2x260}\right) = 1\,N/mm$$

$$Force\ due\ to\ M_{yy} = \left(\frac{M_{yy}}{bd}\right) = \left(\frac{130}{203x260}\right) = 2x10^{-3}\,N/mm\ \textbf{Negligible}$$

Resultant shear force $SF_r = 1\,N/mm$

Resultant force on weld

$$F_R = \sqrt{2^2 + 1^2} = 2\,N/mm$$

$$Resultant\ stress\ on\ weld = \left(\frac{2}{3}x\sqrt{2}\right) = 1\,N/mm^2$$

$$Utilisation\ factor = \left(\frac{1}{107}\right) = 0.01 < 1\ \textbf{Satisfactory}$$

4.5

Weld at connecting 30*x*30*x*3 *SHS on trailer chassis, detailed in figure* 4.4

Assuming 30*x*30*x*2 *mm continuous fillet weld, Load Case* 2

$F_x = 1036\,N; \quad SF_y = 479\,N, \quad SF_z = 781\,N$

$SM_{xx} = 2590\,Nmm, \quad M_{yy} = 78444\,Nmm; \quad M_{zz} = 29191\,Nmm$

Tensile forces on weld per mm

$$Force\ due\ to\ M_{yy} = \left(\frac{M_{yy}}{bd + \frac{b^2}{3}}\right) = \left(\frac{78444}{30x30 + \frac{30^2}{3}}\right) = 65\,N/mm$$

$$Force\ due\ to\ M_{zz} = \left(\frac{M_{zz}}{bd + \frac{d^2}{3}}\right) = \left(\frac{29191}{30x30 + \frac{30^2}{3}}\right) = 24\,N/mm$$

$$Force\ due\ to\ F_x = \left(\frac{F_x}{2(b+d)}\right) = \left(\frac{1036}{2(30+30)}\right) = 9\,N/mm$$

$F_T = 65 + 24 + 9 = 98\,N/mm$

Shear forces on weld per mm

$$Force\ due\ to\ F_y = \left(\frac{F_y}{2(b+d)}\right) = \left(\frac{479}{2(30+30)}\right) = 4\,N/mm$$

$$Force\ due\ to\ F_z = \left(\frac{F_z}{2(b+d)}\right) = \left(\frac{781}{2(30+30)}\right) = 7\,N/mm$$

$$Force\ due\ to\ M_{xx} = \left(\frac{M_{xx}\,x\,r}{bd(b+d) + \left(\frac{d^3+b^3}{3}\right)}\right)$$

$$= \left(\frac{2590\,x\,21}{30x30(30+30) + \left(\frac{30^3+30^3}{3}\right)}\right) = 0.8\,N/mm\ \textbf{Negligible}$$

$$Resultant\ shear\ force\ SF_r = \sqrt{(F_y)^2 + (F_z)^2} = \sqrt{(4)^2 + (7)^2} = 8\,N/mm$$

Resultant force on weld

$$F_R = \sqrt{98^2 + 8^2} = 98\,N/mm$$

$$Resultant\ stress\ on\ weld = \left(\frac{98}{2}\right)x\sqrt{2} = 69\,N/mm^2$$

$$Permissible\ stress = 125x\left(\frac{235}{275}\right) = 107\,N/mm^2$$

$$Utilisation\ factor = \left(\frac{69}{107}\right) = 0.64 < 1\ \textbf{Satisfactory}$$

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4.6

$12\,mm\ diameter\ pin\ connecting\ 100x5\ CHS\ alluminium\ arm\ to\ trailer\ chassis$

$Forces\ and\ moments\ due\ ro\ ANSYS\ load\ case\ 2$

$F_x = 5755\,N$

$F_y = 901\,N$

$M_{xx} = 75\,Nmm$

$M_{yy} = 14645\,Nmm$

$F_y\ due\ to\ M_{xx} = \frac{75}{100} = 0.75\,N$ ***Negligible***

$F_x\ due\ to\ M_{yy} = \frac{14645}{100} = 146\,N$

$F_{xT} = \frac{5755}{2} + 146 = 3024\,N$

$F_y = \frac{901}{2} = 451\,N$

$Co@existant\ shear\ force = \sqrt{3024^2 + 451^2} = 3057\,N$

$Maximum\ shear\ stress\ \tau_{max} = \frac{3057}{113}x\frac{4}{3} = 36\,N/mm^2$

$Permissible\ shear\ stress\ \tau_p = 125x\frac{235}{275} = 107\,N/mm^2$

$UF = \frac{36}{107} < 1$ ***Satisfactory***

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Sheet: 15 of: 18

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4.7 *Verification of alluminium CHS for bearing, forces and moments from ANSYS load case* 6

$F_x = 8090\,N$

$F_y = 1491\,N$

$M_{xx} = 204\,Nmm$

$M_{yy} = 18668\,Nmm$

$F_y\ due\ to\ M_{xx} = \frac{204}{100} = 2\,N$

$F_x\ due\ to\ M_{yy} = \frac{18668}{100} = 187\,N$

$F_{xT} = \frac{8092}{2} + 187 = 4233\,N$

$F_{yT} = \frac{1491}{2} + 2 = 748\,N$

$Co - existant\ shear\ force = \sqrt{4233^2 + 748^2}\,x10^{-3} = 4.3\,N$

$Permissible\ bearing\ stress\ F_{b,Rd} = \frac{0.6x5x12x260}{1.1}x10^{-3} = 8.5\,kN$

$UF = \frac{4.3}{8.8} = 0.5 < 1$ ***Satisfactory***

4.8 *Verification of spigot connection in aluminium arm*

Forces and moments ANSYS due to load case 6

$F_x = 7955\,N$

$M_{yy} = 225670\,Nmm$

$M_{zz} = 2347400\,Nmm$

Force verification of 90*x*4 *CHS see calculation* 3.10

*Verification of M*10 *grade* 4.8 *bolt ofe shear forces*

$Shear\ force\ on\ bolt = \frac{8.0}{2} = 4\,kN$

$Permissble\ shear\ force = \frac{0.5x400x58}{1.25x10^3} = 9.3\,kN$

$UF = \frac{4}{9.3} = 0.43 < 1$ ***Satisfactory***

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5.0 *Fatigue analysis*

5.1 *Maximum change in weld resultant stresses*

Weld identified in 4.1

$\sigma_{R_1} = 56\, N/mm^2$

5.2 *Assuming stress falls to* 0 *N when participant is at top of bounce*

$\Delta\sigma_p = 56\, N/mm^2$

Weld identified in 4.2

$\sigma_{R_1} = 48\, N/mm^2$

5.3 *Assuming stress falls to* 0 *N when participant is at top of bounce*

$\Delta\sigma_p = 48\, N/mm^2$

Weld identified in 4.3

$\sigma_{R_1} = 38\, N/mm^2$

5.4 *Assuming stress falls to* 0 *N when participant is at top of bounce*

$\Delta\sigma_p = 38\, N/mm^2$

Weld identified in 4.4

$\sigma_{R_1} = 1\, N/mm^2$

5.5 *Assuming stress falls to* 0 *N when participant is at top of bounce*

$\Delta\sigma_p = 1\, N/mm^2$

Weld identified in 4.5

$\sigma_{R_1} = 69\, N/mm^2$

Assuming stress falls to 0 *N when participant is at top of bounce*

$\Delta\sigma_p = 69\, N/mm^2$

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5.6 *Fatigue analysis*

$\Delta\sigma_p = 69\, N/mm^2$ *for* 80 *kg passenger load*

$\Delta\sigma_p = 69x0.75 = 52\, N/mm^2$ *for* 60 *kg passenger load*

$\Delta\sigma_p = 69x0.5 = 34\, N/mm^2$ *for* 40 *kg passenger load*

For weld class W

with $\Delta\sigma = 69\, N/mm^2$, *predicted fatigue life* $= 4.79\, x10^5$ *cycles*

with $\Delta\sigma = 52\, N/mm^2$, *predicted fatigue life* $= 1.12\, x10^6$ *cycles*

with $\Delta\sigma = 34\, N/mm^2$, *predicted fatigue life* $= 4.00\, x10^6$ *cycles*

number of cycles per year with 80 *kg passenger loading* = 0.1*x*864000 = 86400

number of cycles per year with 60 *kg passenger loading* = 0.20*x*864000 = 172800

number of cycles per year with 40 *kg passenger loading* = 0.7*x*864000 = 604800

$$from\ Miner.\ s\ summation\ \Sigma = \frac{0.086}{0.48} + \frac{0.17}{1.1} + \frac{0.60}{4.0} = 0.48$$

$$predicted\ weld\ fatigue\ life = \frac{1}{0.48} = 2.1\ years$$ ***Satisfactory***

Note:

i) *Above analysis based on an operational life of* 30 *cycles* / min,2*mins* / *ride*, 12 *rides* / *hour*,5 *hours* / *day*, 240 *days* / *year* = 864000 *cycles*

ii) *Assumed loading spectrum is* 70% *of life half loaded* (40*kg participant*), 20% *of life with* 60 *kg particpant load*
10% *of life with* 80 *kg particpant*. *Hence analysis based on Miner*. *s summation using BS*7608:1993

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 Section: 5 *Sheet:* 18 *of:* 18