APOLLO
X-BEAM RIDGE PIECES
DESIGN CALCULATIONS

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Brief

The brief is to prepare calculated values for the capacity of the Apollo X-BEAM ridge connection to BS 8118.

The beams are fabricated from tube extrusions in aluminium alloy 6082 T6

Design resistance

The design resistance of the apollo lattice beam is

Based on BS8118

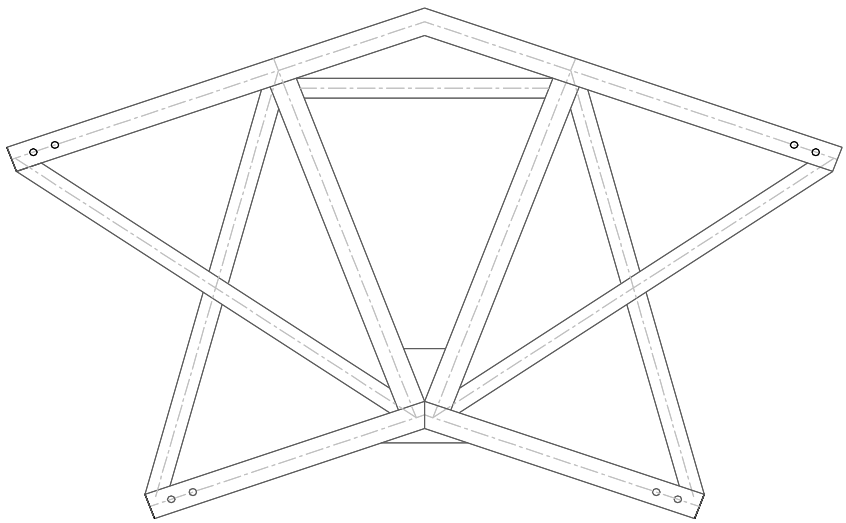
Max moment on the beam is

Allowable moment	**42.9 kNm**
Ultimate moment	**57.0 kNm**

and Maximum Shear is

Allowable shear	**45.4 kN**
Ultimate shear	**60.4 kN**

Geometry

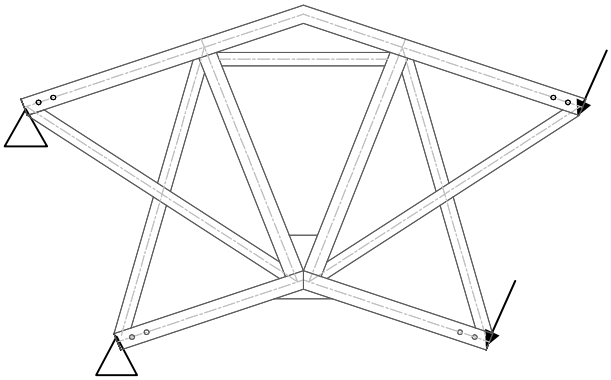


Loading

For the shear load case the applied forces are

V= 45.4/2
= **22.7 kN**

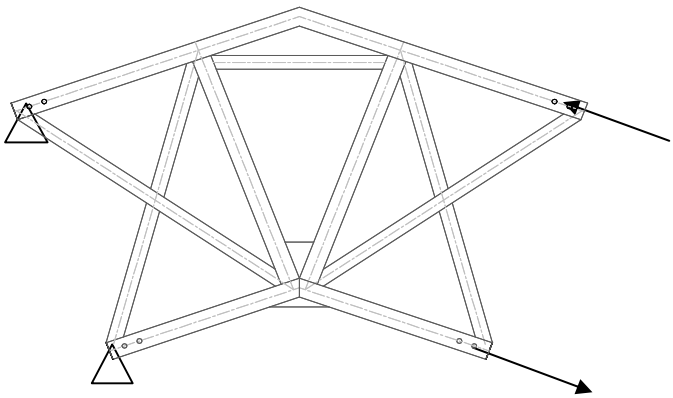
These are applied at the top and bottom booms as below



The model has the ridge piece supported as shown on the top and bottom booms by pins

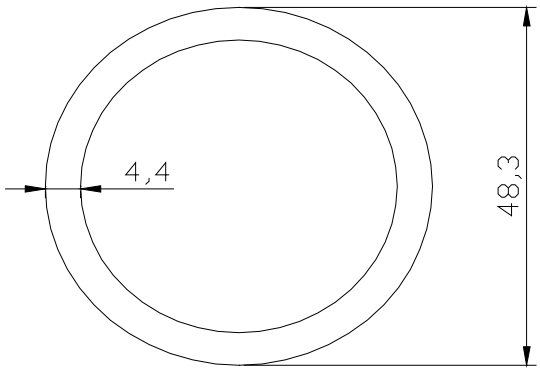
For the moment load case

P= 42.9/0.7
= **61.29 kN**



The direction of the forces are interchangeable and can produce either tension or compression in the members.

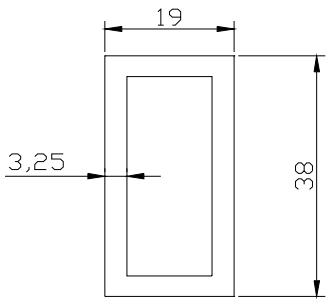
Main boom and verticals



Area:		606.83	mm2
Bounding box:	X:	-24.15 - 24.15	mm
	Y:	-24.15 - 24.15	mm
Moments of inertia:	X:	147654.64	mm4
	Y:	147654.64	mm4
Radii of gyration:	X:	15.60	mm
	Y:	15.60	mm
Elastic Modulus	X:	6114.06	mm3
	Y:	6114.06	mm3
Plastic Modulus	X:	8253.99	mm3
	Y:	8253.99	mm3

Diagonals

Loads in



Area:		328.25	mm2
Bounding box:	X:	-9.5 -- 9.5	mm
	Y:	-19.00 -- 19.00	mm
Moments of inertia:	X:	54322.46	mm4
	Y:	16593.21	mm4
Radii of gyration:	X:	12.86	mm
	Y:	7.11	mm
Elastic Modulus	X:	2859.08	mm3
	Y:	1746.65	mm3
Plastic Modulus	X:	3758.22	mm3
	Y:	2199.03	mm3

Material

The alloy 6082T6 has the following properties

p_0=	255	N/mm2
p_a=	280	N/mm2
p_v=	155	N/mm2

Classification

4.3.1

β= 3*((D/t)^0.5)
= 3*(((48.3-4.4)/4.4)^0.5)
= 9.48

ε= (250/p0)^0.5
= (250/255)^0.5
= 0.99

$\beta 1$= 15ε
15*0.99
14.85
> 9.48

Section is compact

Bending capacity 4.5.2.2

Mrs= poSn/γm

po= 255N/mm2
Sn= 8.25cm3
γm= 1.2

= 255*8.25/1200
= **1.74 kNm**

Shear 4.5.3.2

Vrs= pvAv/γm

pv= 155N/mm2
Av= 0.6A
= 0.6*606.83
= 364.1mm2
γm= 1.2

=155*364.1/1200
= **47.03 kN**

Loads indicated in italics and shaded are limited by shear.

Lateral Torsional Buckling

No check required for CHS

Tension 4.6

for General Tension

Prs= poA/γm

po= 255N/mm2
A= 606.83mm2
γm= 1.3

= 255*606.83/1300
= **119.03** kN

For local at splice

Prs paAn/γm

pa= 280N.mm2
An= A-2dt
606.83-2*14*4.4
483.63mm2
γm= 1.3

= 280*483.63/1300
= **104.17 kN**

Compression

4.7

Pr= psA/γm

for 1m bracing

L= 950.00 m
r= 15.6 mm
λ= KL/r K= 0.7
0.7*950/15.6
42.63
Fig 4.10b gives ps= 184.00 N/mm2
A= 606.83mm2
γm= 1.3
Pr= 184*606.83/1300
= **85.89 kN**

for 0.5m bracing

L= 450.00 m
r= 15.6 mm
λ= KL/r K= 0.7
0.7*450/15.6
20.19
ps= 205.00 N/mm2
A= 606.83mm2
γm= 1.3
Pr= 205*606.83/1300
= **95.69 kN**

Classification

4.3.1

β= 3*((D/t)^0.5)
= 3*(((38-3.25)/3.25)^0.5)
= 9.81

ε= (250/p0)^0.5
= (250/255)^0.5
= 0.99

β1= 15ε
15*0.99
14.85
> 9.81

Section is compact

Bending capacity 4.5.2.2

Mrs= poSn/γm

po= 255N/mm2
Sn= 3.76cm3
γm= 1.3

= 255*3.76/1300
= **0.74 kNm**

Shear 4.5.3.2

Vrs= pvAv/γm

pv= 155N/mm2
Av= 0.8NDt
= 0.8*2*38*3.25
= 197.6mm2
γm= 1.3

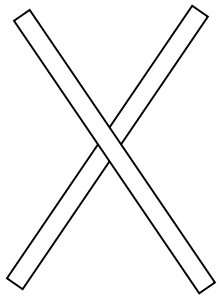
=155*197.6/1300
= **23.56 kN**

Loads indicated in italics and shaded are limited by shear.

Lateral Torsional Buckling

overall length L= SQRT(652^2+425^2)
778.29

length to brace point is L/2



Le= 0.85*778.29/2
330.77

λ= Le/ry
= 330.77/7.11
= 47

ps= 220 N/mm2

Mrx= psS/γ_m

S= 3.76cm3
γm= 1.2

= 220*3.76/1200
= **0.69 kNm**

Tension 4.6

for General Tension only (no local holes)

Prs= poA/γm po= 255N/mm2
A= 328.3mm2
γm= 1.2

= 255*328.3/1200
= **69.76 kN**

Compression

4.7

Pr= psA/γm

L= 0.338 m
r= 7.11 mm
λ= KL/r K= 0.7
= 0.7*338/7.11
= 33.28

Fig 4.10b gives ps= 182.00 N/mm2
A= 328.3mm2
γm= 1.2

Pr= 182*328.3/1200
= **49.79 kN**

for local squashing Prs= paAe/γm pa= 280N/mm2
Ae= 164.2mm2
γm= 1.2

= 280*164.2/1200
= **38.31 kN**

Use local squashing value

Tension 4.6

for General Tension only (no local holes)

Prs= poA/γm po= 255N/mm2
A= 328.3mm2
γm= 1.3

= 255*328.3/1300
= **64.40 kN**

for local softening Prs= paAe/γm pa= 280N/mm2
Ae= 164.2mm2
γm= 1.2

= 280*164.2/1200
= **38.31 kN**

Shear load - 10 degree ridge

Restrained at 0.5m

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	Moment	Mrs	1.74	0.24	7.23
	Shear	Vrs	47.03	1.85	25.42
	Axial	Pry	95.69	78.89	1.21
		coexist M		0.08	
	Combined	P/Prs+M/Mrs<1		0.87	1.15
Vertical	Moment	Mrs	1.74	0.17	10.21
	Shear	Vrs	47.03	0.45	104.51
	Axial	Pry	95.69	32.8	2.92
		coexist M		0.17	
	Combined	P/Prs+M/Mrs<1		0.44	2.27
Diagonal	Axial	Prs	38.31	35.2	1.09
				Factor	**1.09**

CALCULATION SHEET	Project :	Apollo X-BEAM -Ridge Piece		
	Element :	Moment load - 20 degree ridge		
	Job Number :	G0041	By : anw	Date:Apr 03
	Document No :	003B	Checked :	Date:

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Moment load - 20 degree ridge

Restrained at 0.5m

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	Moment	Mrs	1.74	0.13	13.35
	Shear	Vrs	47.03	0.28	167.96
	Axial	Pry	95.69	87.39	1.09
		coexist M		0.04	
	Combined	P/Prs+M/Mrs<1		0.94	1.07
Vertical	Moment	Mrs	1.74	0.03	57.87
	Shear	Vrs	47.03	0.07	671.85
	Axial	Pry	95.69	14.6	6.55
		coexist M		0.03	
	Combined	P/Prs+M/Mrs<1		0.17	5.89
Diagonal	Axial	Prs	38.31	2.42	15.83
				Factor	**1.07**

Shear load - 20 degree ridge

Restrained at 0.5m

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	Moment	Mrs	1.74	0.28	6.20
	Shear	Vrs	47.03	2.14	21.98
	Axial	Pry	95.69	91.99	1.04
		coexist M		0.07	
	Combined	P/Prs+M/Mrs<1		1.00	1.00
Vertical	Moment	Mrs	1.74	0.18	9.65
	Shear	Vrs	47.03	0.49	95.98
	Axial	Pry	95.69	29.1	3.29
		coexist M		0.06	
	Combined	P/Prs+M/Mrs<1		0.34	2.95
Diagonal	Axial	Prs	38.31	34.6	1.11
				Factor	**1.00**

CALCULATION SHEET	Project :	Apollo X-BEAM -Ridge Piece		
	Element :	Moment load - 20 degree ridge		
	Job Number :	G0041	By : anw	Date:Apr 03
	Document No :	003B	Checked :	Date:

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Moment load - 20 degree ridge

Restrained at 0.5m

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	Moment	Mrs	1.74	0.51	3.40
	Shear	Vrs	47.03	3.64	12.92
	Axial	Pry	95.69	83.74	1.14
		coexist M		0.19	
	Combined	P/Prs+M/Mrs<1		0.98	1.02
Vertical	Moment	Mrs	1.74	0.05	34.72
	Shear	Vrs	47.03	0.08	587.87
	Axial	Pry	95.69	28.91	3.31
		coexist M		0.11	
	Combined	P/Prs+M/Mrs<1		0.36	2.78
Diagonal	Axial	Prs	38.31	4.9	7.82
				Factor	**1.02**

Sections

Both the 20 degree and the 10 degree ridge pieces have been checked.

Results

The design has been to the code BS8118 under loading that produces equivalent moments and shears to the rated values of the X-beam.

The resistance of the ridge piece is greater than required to The factor below is strength of ridge piece/ strength of X-beam

20 degree

Factor for bending	**1.00**
Factor for shear	**1.03**

10 degree

Factor for bending	**1.07**
Factor for shear	**1.09**

Conclusions

This geometry for the ridge pieces is equivalent in strength to the X-beams and suitable to form the ridge joints.