APOLLO SALES LTD
ALLOY LATTICE BEAM CALCULATIONS

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Woodside House
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F0006/004

Brief

The brief is to prepare calculated values for the capacity of a lattice beam to BS 8118.

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

The geometry of the beam is as shown on drawing No F0021/006

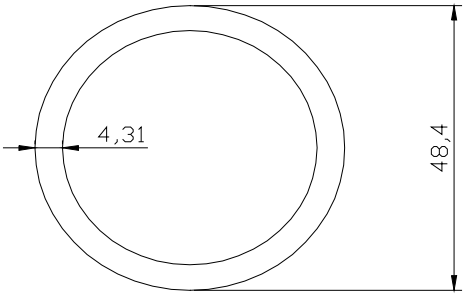
The beams have been tested and the results are compared in the summary

Material

The alloy 6082T6 has the following properties

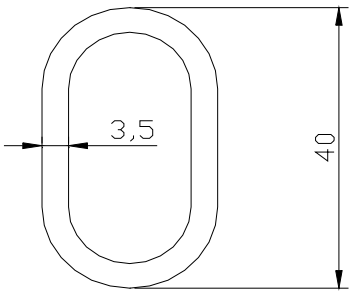
p_0=	255	N/mm2
p_a=	280	N/mm2
p_v=	155	N/mm2

Main boom and verticals



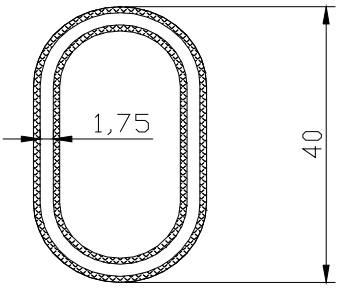
Area:		596.99	mm2
Bounding box:	X:	-24.2 -- 24.2	mm
	Y:	-24.2 -- 24.2	mm
Moments of inertia:	X:	146449.49	mm4
	Y:	146449.49	mm4
Radii of gyration:	X:	15.66	mm
	Y:	15.66	mm
Elastic Modulus	X:	6051.63	mm3
	Y:	6051.63	mm3
Plastic Modulus	X:	8169.70	mm3
	Y:	8169.70	mm3

Diagonals



Area:		333.81	mm2
Bounding box:	X:	-10.5 -- 10.5	mm
	Y:	-20.00 -- 20.00	mm
Moments of inertia:	X:	51847.37	mm4
	Y:	22161.25	mm4
Radii of gyration:	X:	12.46	mm
	Y:	8.15	mm
Elastic Modulus	X:	2592.37	mm3
	Y:	1918.72	mm3
Plastic Modulus	X:	3240.46	mm3
	Y:	2398.40	mm3

Diagonals HAZ



Area:		166.91	mm2
Bounding box:	X:	-10.675-10.675	mm
	Y:	-19.125-19.125	mm
Moments of inertia:	X:	25709.36	mm4
	Y:	10911.59	mm4
Radii of gyration:	X:	12.46	mm
	Y:	8.15	mm
Elastic Modulus	X:	1285.47	mm3
	Y:	944.73	mm3
Plastic Modulus	X:	1606.84	mm3
	Y:	1180.91	mm3

Classification

4.3.1

β= 3*((D/t)^0.5)
= 3*(((48.4-4.31)/4.31)^0.5)
= 9.595169899

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

$\beta 1$= 15ε
15*0.99
14.85
> 9.6

Section is compact

Bending capacity 4.5.2.2

Mrs= poSn/γm

po= 255N/mm2
Sn= 8.17cm3
γm= 1.2

= 255*8.17/1200
= **1.74 kNm**

Shear 4.5.3.2

Vrs= pvAv/γm

pv= 155N/mm2
Av= 0.6A
= 0.6*597
= 358.2mm2
γm= 1.2

=155*358.2/1200
= **46.27 kN**

Lateral Torsional Buckling

No check required for CHS

Tension 4.6

for General Tension

Prs= poA/γm

po= 255N/mm2
A= 597mm2
γm= 1.3

= 255*597/1300
= 117.10 kN

For local at splice

Prs paAn/γm

pa= 280N.mm2
An= A-2dt
597-2*14*4.31
476.32mm2
γm= 1.3

= 280*476.3/1300
= **102.59 kN**

Compression

4.7

Pr= psA/γm

for 1m bracing

L= 1000.00 m
r= 15.66 mm
λ= KL/r K= 0.85
0.85*1000/15.66
54.28
Fig 4.10b gives ps= 126.00 N/mm2
A= 597mm2
γm= 1.2
Pr= 126*597/1200
= **62.69 kN**

for 2m bracing

L= 2000.00 m
r= 15.66 mm
λ= KL/r K= 0.7
0.7*2000/15.66
89.40
Fig 4.10b gives ps= 68.00 N/mm2
A= 597mm2
γm= 1.2
Pr= 68*597/1200
= **33.83 kN**

Classification

4.3.1

β= 3*((D/t)^0.5)
= 3*(((40-3.5)/3.5)^0.5)
= 9.69

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

β1= 15ε
15*0.99
14.85
> 9.7

Section is compact

Bending capacity 4.5.2.2

Mrs= poSn/γm

po= 255N/mm2
Sn= 3.24cm3
γm= 1.3

= 255*3.24/1300
= **0.64 kNm**

Shear 4.5.3.2

Vrs= pvAv/γm

pv= 155N/mm2
Av= 0.6A
= 0.6*333.8
= 200mm2
γm= 1.3

= 155*200/1300
= **23.85 kN**

Lateral Torsional Buckling

No check required for CHS

Tension 4.6

for General Tension only (no local holes)

Prs= poA/γm

po= 255N/mm2
A= 333.8mm2
γm= 1.2

= 255*333.8/1200
= **70.93 kN**

Compression

4.7

Pr= psA/γm

L= 0.57 m
r= 8.15 mm
λ= KL/r K= 0.7
= 0.7*570/8.15
= 48.96

Fig 4.10b gives ps= 140.00 N/mm2

A= 283.6mm2
γm= 1.2

Pr= 140*283.6/1200
= **33.09 kN**

for local squashing Prs= paAe/γm pa= 280N/mm2
Ae= 141.8
γm= 1.2

= 280*141.8/1200
= **33.09 kN**

Use local squashing value

Classification

4.3.1

β= 3*((D/t)^0.5)
= 3*(((40-3.5)/3.5)^0.5)
= 9.69

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

β1= 15ε
15*0.99
14.85
> 9.7

Section is compact

Bending capacity 4.5.2.2
HAZ Mrs= poSn/γm po= 255N/mm2
Sn= 1.61cm
γm= 1.3
= 255*1.61/1300
= **0.32 kNm**

Shear 4.5.3.2
HAZ Vrs= pvAv/γm pv= 90N/mm2
Av= 0.6Ae
= 0.6*166.9
= 100mm2
γm= 1.3
= 90*100/1300
= **6.92 kN**

Lateral Torsional Buckling

No check required for CHS

Tension 4.6

for General Tension only (no local holes)
Prs= poA/γm po= 255N/mm2
A= 333.8mm2
γm= 1.3
= 255*333.8/1300
= **65.48 kN**

for local softening Prs= paAe/γm pa= 280N/mm2
Ae= 141.6mm2
γm= 1.2
= 280*141.6/1200
= **33.04 kN**

Compression

4.7

Pr= psA/γm

L= 0.57 m

r= 8.15 mm

λ= KL/r K= 0.85

= 0.85*570/8.15

= 59.45

Fig 4.10b gives ps= 109.00 N/mm2

A= 283.6mm2

γm= 1.2

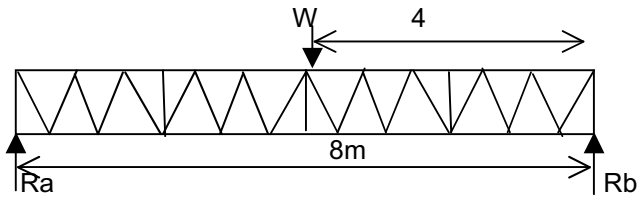
Pr= 109*283.63.8/1200

= **25.76 kN**

Load Case 2 Load at centre (note Load case 1 was not used for analyisis - self weight only)

10kN applied at centre

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	Moment	Mrs	1.74	0.232	7.48
	Shear	Vrs	46.27	7.04	6.57
	Tension	Prs	117.10	65.3	1.79
	Compression	Pry	62.69	65.3	0.96
		coexist M		0.232	
	Combined	P/Prs+M/Mrs<1		1.18	0.85
Vertical	Moment	Mrs	1.74	0.12	14.47
	Shear	Vrs	46.27	0.45	102.82
	Tension	Prs	117.10	0.26	450.40
	Compression	Pry	62.69	6.9	9.09
		coexist M		0.08	
	Combined	P/Prs+M/Mrs<1		0.16	6.40
Diagonal	Tension	Prs	33.09	9.85	3.36
	Compression	Pry	25.76	9.73	2.65
				Factor	**0.85**



Max Moment= ML/4

so for ultimate condition

W= **1.33*10**

13.30 kN

apply factor from above

Wf= 13.3*0.85

11.33

so maximum moment is as above

Ultimate Mu= Wf*8/4

11.33*8/4

22.66 kN

and for allowable value

allowable max moment= 22.66/1.33

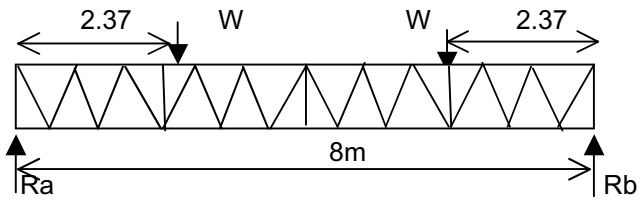
= **17.04** **kN**

Moment values	**Ultimate**	**23.20 kN**
	Allowable	**17.04 kN**

Load Case 3 Load at middle

10kN applied at centre

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	Moment	Mrs	1.74	0.42	4.13
	Shear	Vrs	46.27	13.88	3.33
	Tension	Prs	117.10	79.4	1.47
	Compression	Pry	62.69	79.44	0.79
		coexist M		0.42	
	Combined	P/Prs+M/Mrs<1		1.51	0.66
Vertical	Moment	Mrs	1.74	0.25	6.94
	Shear	Vrs	46.27	0.64	72.30
	Tension	Prs	117.10	0.01	11710.38
	Compression	Pry	62.69	13.6	4.61
		coexist M		0.16	
	Combined	P/Prs+M/Mrs<1		0.31	3.24
Diagonal	Tension	Prs	33.09	19.5	1.70
	Compression	Pry	25.76	19.2	1.34
				Factor	**0.66**



Max Moment= 2.7W

so for ultimate condition

W= **1.33*10**

13.30 kN

apply factor from above

Wf= 13.3*0.66

8.80

so maximum moment is as above

Ultimate Mu= Wf*2.37

2.37*8.8

20.86 kN

and for allowable value

allowable max moment= 20.86/1.33

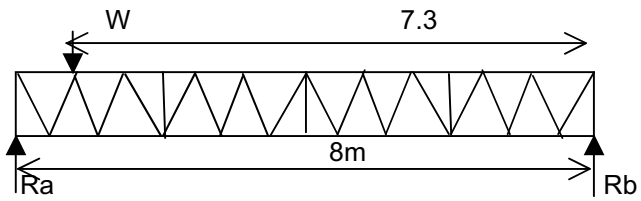
= **15.68** **kN**

Moment values	**Ultimate**	**20.86 kN**
	Allowable	**15.70 kN**

Load Case 4 Load at third points

10kN applied at each of the two third points

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	Moment	Mrs	1.74	0.24	7.23
	Shear	Vrs	46.27	12.27	3.77
	Tension	Prs	117.10	23.4	5.00
	Compression	Pry	64.68	23.4	2.76
		coexist M		0.11	
	Combined	P/Prs+M/Mrs<1		0.43	2.35
Vertical	Moment	Mrs	1.74	0.15	11.57
	Shear	Vrs	46.27	1.1	42.06
	Tension	Prs	117.10	0.14	836.46
	Compression	Pry	64.68	12.2	5.30
		coexist M		0.15	
	Combined	P/Prs+M/Mrs<1		0.28	3.64
Diagonal	Tension	Prs	33.09	16.8	1.97
	Compression	Pry	25.76	16.9	1.52
				Factor	**1.52**



Max shear Ra= W*7.3/8

so for ultimate condition

W= **1.33*10**

13.30 kN

apply factor from above

Wf= 13.3*1.52

20.26

so reaction at A is max shear

Ultimate Ra= Wf*7.3/8

Ultimate shear= **18.49 kN**

and for allowable value

allowable Shear= 18.49/1.33

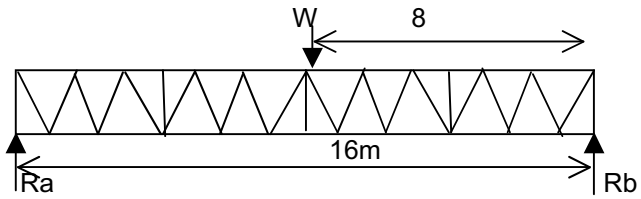
= **13.90** **kN**

Shear values	**Ultimate**	**18.49 kN**
	Allowable	**13.90 kN**

Load Case 2 Load at centre (note Load case 1 was not used for analyisis - self weight only)

10kN applied at centre

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	Moment	Mrs	1.74	0.32	5.43
	Shear	Vrs	46.27	7.3	6.34
	Tension	Prs	117.10	133.95	0.87
	Compression	Pry	62.69	133.95	0.47
		coexist M		0.22	
	Combined	P/Prs+M/Mrs<1		2.26	0.44
Vertical	Moment	Mrs	1.74	0.12	14.47
	Shear	Vrs	46.27	0.47	98.45
	Tension	Prs	117.10	0.1	1171.04
	Compression	Pry	62.69	7.15	8.77
		coexist M		0.09	
	Combined	P/Prs+M/Mrs<1		0.17	6.03
Diagonal	Tension	Prs	33.09	10.2	3.24
	Compression	Pry	25.76	10.1	2.55
				Factor	**0.44**



Max Moment= ML/4

so for ultimate condition

W= **1.33*10**

13.30 kN

apply factor from above

Wf= 13.3*0.44

5.87

so maximum moment is as above

Ultimate Mu= Wf*16/4

5.87*4

23.48 kN

and for allowable value

allowable max moment= 23.47/1.33

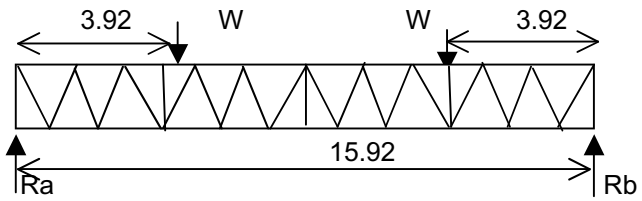
= **17.65** **kN**

Moment values	**Ultimate**	**23.48 kN**
	Allowable	**17.65 kN**

Load Case 3 Load at middle

10kN applied at centre

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	Moment	Mrs	1.74	0.45	3.86
	Shear	Vrs	46.27	14.16	3.27
	Tension	Prs	117.10	134.07	0.87
	Compression	Pry	62.69	134.07	0.47
		coexist M		0.19	
	Combined	P/Prs+M/Mrs<1		2.25	0.44
Vertical	Moment	Mrs	1.74	0.24	7.23
	Shear	Vrs	46.27	0.92	50.29
	Tension	Prs	117.10	0.24	487.93
	Compression	Pry	62.69	13.85	4.53
		coexist M		0.17	
	Combined	P/Prs+M/Mrs<1		0.32	3.14
Diagonal	Tension	Prs	33.09	18.95	1.75
	Compression	Pry	25.76	19.5	1.32
				Factor	**0.44**



Max Moment= 2.7W

so for ultimate condition

W= **1.33*10**

13.30 kN

apply factor from above

Wf= 13.3*0.44

5.87

so maximum moment is as above

Ultimate Mu= Wf*3.92

= 5.87*3.92

= **23.01 kN**

and for allowable value

allowable max moment= 23.01/1.33

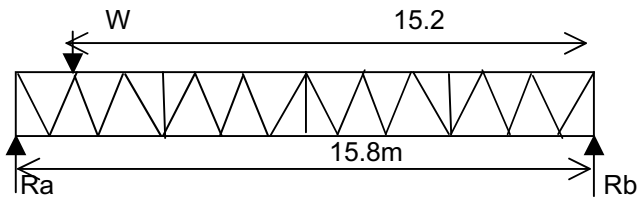
= **17.30** **kN**

Moment values	**Ultimate**	**23.01 kN**
	Allowable	**17.30 kN**

Load Case 4 Load at third points

10kN applied at each of the two third points

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	Moment	Mrs	1.74	0.29	5.99
	Shear	Vrs	46.27	13.09	3.53
	Tension	Prs	117.10	25.02	4.68
	Compression	Pry	64.68	25.2	2.57
		coexist M		0.14	
	Combined	P/Prs+M/Mrs<1		0.47	2.13
Vertical	Moment	Mrs	1.74	0.18	9.65
	Shear	Vrs	46.27	0.68	68.04
	Tension	Prs	117.10	0.4	292.76
	Compression	Pry	64.68	13.2	4.90
		coexist M		0.18	
	Combined	P/Prs+M/Mrs<1		0.31	3.25
Diagonal	Tension	Prs	33.09	17.9	1.85
	Compression	Pry	25.76	18	1.43
				Factor	**1.43**



Max shear Ra= W*7.3/8

so for ultimate condition

W= **1.33*10**

13.30 kN

apply factor from above

Wf= 13.3*1.43

19.06

so reaction at A is max shear

Ultimate Ra= Wf*15.3/16

Ultimate shear= **18.46 kN**

and for allowable value

allowable Shear= 18.46/1.33

= **13.88** **kN**

Shear values	**Ultimate**	**18.49 kN**
	Allowable	**13.88 kN**

Test Results

The test results for mid point and third point moments agree closely with the calculated values

Allowable moment	**15.7 kNm**
Ultimate moment	**20.9 kNm**

Selected results

From calculated values confirmed by test results for bracing at 1m intervals

Max moment on the beam is

Allowable moment	**15.7 kNm**
Ultimate moment	**20.9 kNm**

and Maximum Shear is

Allowable shear	**13.90 kN**
Ultimate shear	**18.50 kN**

ALAN WHITE DESIGN

For simply supported lattice beam with a compression chord restraint at 1m intervals

Allowable Bending Moment	15.7kNm
Allowable Shear	13.9kN

Allowable loads for load distributions

Type of Load		Clear span (m)									
		3	4	5	6	7	8	9	10	11	12
Uniformly Distributed load	kN/m	*9.3*	*7.0*	5.0	3.5	2.6	2.0	1.6	1.3	1.0	0.9
Total UDL	kN	*27.8*	*27.8*	25.1	20.9	17.9	15.7	14.0	12.6	11.4	10.5
Single point load (mid Point)	kN	20.9	15.7	12.6	10.5	9.0	7.9	7.0	6.3	5.7	5.2
Two point loads (third points)	Each kN	*13.9*	11.8	9.4	7.9	6.7	5.9	5.2	4.7	4.3	3.9
Three point loads (quarter points)	Each kN	*9.3*	7.9	6.3	5.2	4.5	3.9	3.5	3.1	2.9	2.6

Notes

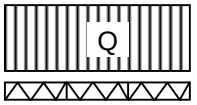
1. Above allowable loads may be increased by 1.11 for **wind loading only**
2. This table is provided as a guide only and assume all loads are applied at restrained nodes. All scaffolds and structures should be checked by a qualified structural engineer.
3. Maximum capacity of a point load mid way between nodes is 7.5kN but overall buckling of the top chord should be checked if loads are placed other than at restrained loads.
4. Loads indicated in italics are limited by shear.

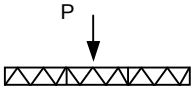
F0021/005

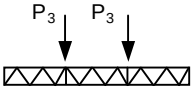
Apollo Sales Alloy truss beam

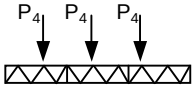
Restrained at 0.5m centres on top chord

Allowable Moment 24.5kNm — Allowable Shear 13.9kN





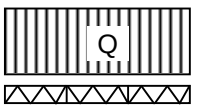


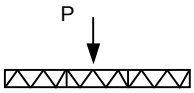


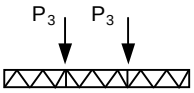
L m	Q kN	P kN	P_3 kN	P_4 kN
3	27.8	27.8	13.9	9.3
4	27.8	24.5	13.9	9.3
5	27.8	19.6	13.9	9.3
6	27.8	16.3	12.3	8.2
7	27.8	14.0	10.5	7.0
8	24.5	12.3	9.2	6.1
9	21.8	10.9	8.2	5.4
10	19.6	9.8	7.4	4.9
11	17.8	8.9	6.7	4.5
12	16.3	8.2	6.1	4.1

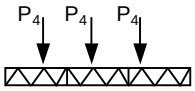
Restrained at 1.0m centres on top chord

Allowable Moment 15.7kNm — Allowable Shear 13.9kN





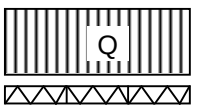


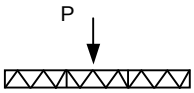


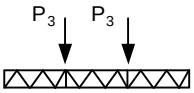
L m	Q kN	P kN	P_3 kN	P_4 kN
3	27.8	20.9	13.9	9.3
4	27.8	15.7	11.8	7.9
5	25.1	12.6	9.4	6.3
6	20.9	10.5	7.9	5.2
7	17.9	9.0	6.7	4.5
8	15.7	7.9	5.9	3.9
9	14.0	7.0	5.2	3.5
10	12.6	6.3	4.7	3.1
11	11.4	5.7	4.3	2.9
12	10.5	5.2	3.9	2.6

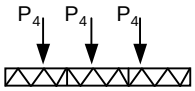
Restrained at 2.0m centres on top chord

Allowable Moment 9.3kNm — Allowable Shear 12.7kN









L m	Q kN	P kN	P_3 kN	P_4 kN
3	24.8	12.4	9.3	6.2
4	18.6	9.3	7.0	4.7
5	14.9	7.4	5.6	3.7
6	12.4	6.2	4.7	3.1
7	10.6	5.3	4.0	2.7
8	9.3	4.7	3.5	2.3
9	8.3	4.1	3.1	2.1
10	7.4	3.7	2.8	1.9
11	6.8	3.4	2.5	1.7
12	6.2	3.1	2.3	1.6

Notes:
1. Above allowable loads may be increased by 1.11 for wind loading only
2. This table is provided as a guide only and assume all loads are applied at restrained nodes. All scaffolds and structures should be checked by a qualified structural engineer.
3. Maximum capacity of a point load mid way between nodes is 15kN but overall buckling of the top chord should be checked if loads are placed other than at restrained joints.