Brief

The brief is to prepare calculated values for the capacity of a ladder 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 F0021/009

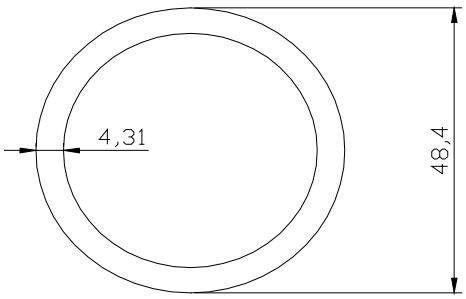
The beams have been tested and the results are compared in the summary

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

Classification

Slenderness

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= 950.00 m**

r= 15.66 mm

λ= KL/r **K= 0.7**

0.7*950/15.66

42.46

Fig 4.10b gives **ps= 180.00 N/mm2**

A= 597mm2

γm= 1.2

Pr= 180*597/1200

= 89.55 kN

Classification

Slenderness

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

L= 260.00 m
r= 15.66 mm
λ= KL/r **K= 0.85**
0.85*260/15.66
14.11

Fig 4.10b gives **ps= 250.00 N/mm2**
A= 597mm2
γm= 1.2

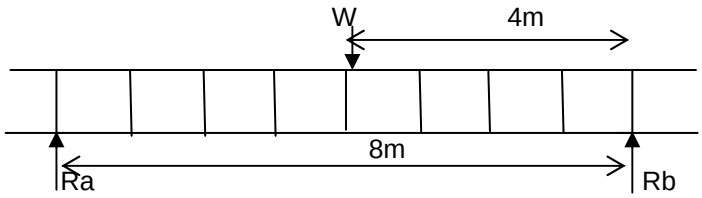
Pr= 250*597/1200
= 124.38 kN

Load Case 2 Load at middle (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	0.78	2.23
	Shear	Vrs	46.27	3.4	13.61
	Tension	Prs	117.10	81.2	1.44
	Compression	Pry	89.55	81.2	1.10
		coexist M		0.8	
	Combined	P/Prs+M/Mrs<1		1.37	0.73
Vertical	Moment	Mrs	1.74	1.01	1.72
	Shear	Vrs	46.27	6.6	7.01
	Tension	Prs	117.10	0.03	3903.46
	Compression	Pry	124.38	6.6	18.85
		coexist M		0	
	Combined	P/Prs+M/Mrs<1		0.05	18.85

Factor = 0.73



Max Moment= ML/4

so for ultimate condition

W= **1.33*10**

13.30 kN

apply factor from above

Wf= 13.3*0.73

9.71

so maximum moment is as above

Ultimate Mu= Wf*8/4

9.71*8/4

19.42 kN

and for allowable value

allowable max moment= 19.42/1.33

= **14.60** **kN**

Moment values	**Ultimate**	**19.42 kN**
	Allowable	**14.60 kN**

CALCULATION SHEET	Project :	Apollo aluminium ladder beam		
	Element :	Load Case 4- 1m bracing		
	Job Number :	F0006	By : anw	Date:Feb 02
	Document No :	007B	Checked : jjg	Date:Feb 02

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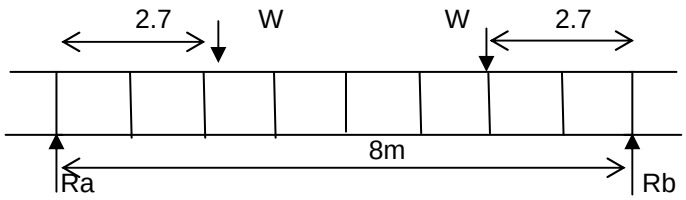
Load Case 4 Load at third points

10kN applied at each of the two third points

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	Moment	Mrs	1.74	3.32	0.52
	Shear	Vrs	46.27	0.19	243.53
	Tension	Prs	117.10	260.6	0.45
	Compression	Pry	89.55	260.6	0.34
		coexist M		0.45	
	Combined	P/Prs+M/Mrs<1		3.17	0.32
Vertical	Moment	Mrs	1.74	4.96	0.35
	Shear	Vrs	46.27	32.7	1.41
	Tension	Prs	117.10	0.06	1951.73
	Compression	Pry	124.38	16.3	7.63
		coexist M		0.021	
	Combined	P/Prs+M/Mrs<1		0.14	6.99
				Factor =	0.32



Max Moment= 2.7W

so for ultimate condition

W= **1.33*10**

13.30 kN

apply factor from above

Wf= 13.3*0.32

4.21

so maximum moment is as above

Ultimate Mu= Wf*2.7

2.7*4.21

11.36 kNm

and for allowable value

allowable max moment= 11.36/1.33

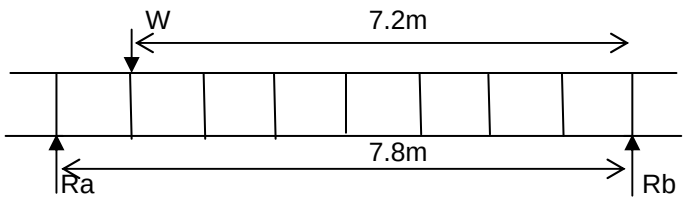
= 8.54 **kNm**

Moment values	**Ultimate**	**11.36 kN**
	Allowable	**8.54 kN**

Load Case 4 Shear

10kN applied 0.6m from end

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	Moment	Mrs	1.74	1.05	1.65
	Shear	Vrs	46.27	6.3	7.34
	Tension	Prs	117.10	22.9	5.11
	Compression	Pry	89.55	22.9	3.91
		coexist M		0.27	
	Combined	P/Prs+M/Mrs<1		0.41	2.43
Vertical	Moment	Mrs	1.74	1.6	1.09
	Shear	Vrs	46.27	10.5	4.41
	Tension	Prs	117.10	0.01	11710.38
	Compression	Pry	124.38	6.5	19.14
		coexist M		0.85	
	Combined	P/Prs+M/Mrs<1		0.54	1.85
				Factor =	1.09



Max shear Ra= W*7.2/7.8

so for ultimate condition

W= **1.33*10**

13.30 kN

apply factor from above

Wf= 13.3*1.09

14.43 kN

so reaction at A is max shear

Ultimate Ra= Wf*7.2/7.8

Ultimate shear= **13.32 kN**

and for allowable value

allowable Shear= 13.35/1.33

= **10.02** **kN**

Shear values	**Ultimate**	**13.32 kN**
	Allowable	**10.02 kN**

Test Results

The test results for mid point and third point moments are as shown
These are based on the failure and yield values.

Ultimate moment	**14.9**	**kNm**
Allowable moment	**11.2**	**kNm**

Based on the deflection criteria of the Code then the values reduce to

Ultimate moment	**12.4**	**kNm**
Allowable moment	**9.3**	**kNm**

Selected results

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

Max moment on the beam is

Ultimate moment	**11.36**	**kNm**
Allowable moment	**8.54**	**kNm**

and Maximum Shear is

Ultimate shear	**13.32**	**kN**
Allowable shear	**10.02**	**kN**

The calculated values are less than the tested values in this case due to the failure being related to the moments at the joints.

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

Allowable Bending Moment	8.54 kNm
Allowable Shear	10.02 kN

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	*6.7*	4.3	2.7	1.9	1.4	1.1	0.8	0.7	0.6	0.5
Total UDL	kN	*20.0*	17.1	13.7	11.4	9.8	8.5	7.6	6.8	6.2	5.7
Single point load (mid Point)	kN	11.4	8.5	6.8	5.7	4.9	4.3	3.8	3.4	3.1	2.8
Two point loads (third points)	Each kN	8.5	6.4	5.1	4.3	3.7	3.2	2.8	2.6	2.3	2.1
Three point loads (quarter points)	Each kN	5.7	4.3	3.4	2.8	2.4	2.1	1.9	1.7	1.6	1.4

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 loads.
4. Loads indicated in italics are limited by shear.