X0016-001A
APOLLO CRADLES LTD
X-BEAM BOX
DESIGN CHECK CALCULATIONS

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JAN 2017

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Document Revision History

Revision	Description	Author	Revision Date	Checked
A	Initial Issue	ANW	24/01/2017	MMR

Brief

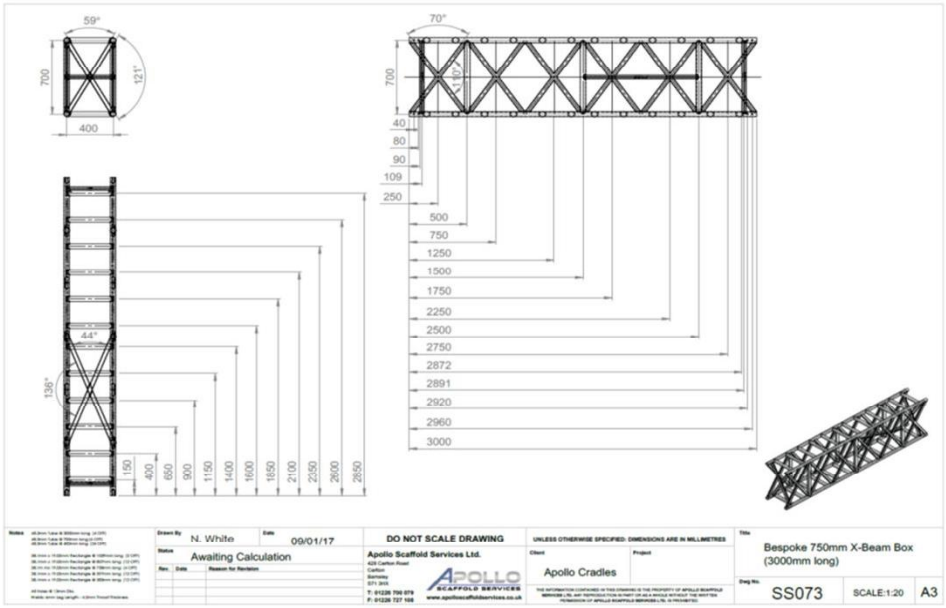
To carry out design check calculations on an Apollo X-beam box on behalf of Apollo Sales Ltd and prepare capacity tables for this configuration.

The configurations examined were 9m, 12m, 15m 18m and 21m simply supported spans. In addition a 6m cantilever span was examined.

These spans were chosen as they are the commonly used configurations for supporting a monorail over a mast climber deck.

Layout

The geometry of the beam is shown in the drawing below:



Alloy

The alloy used is 6082 T6:

For extruded profiles/tubes with thickness less than 5mm:

$P_{o,haz}$ = 0.50

$P_{u,haz}$ = 0.64

F_o = 250 N/mm^2

F_u = 290 N/mm^2

Design

Eurocode 9: Design of Aluminium structures EN 1999-1-1

Alloy used is 6082 T6 throughout

Design Assumptions

6082 T6 Aluminium is to be utilised throughout.

X-beam top and bottom booms are to be restrained at 1.00m c/c's.

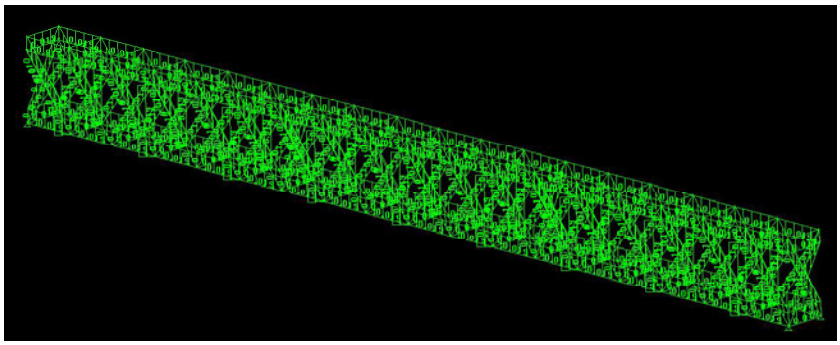
All loads are to be applied at node locations.

STRAP Analysis

The following load cases were applied to the X-beam box.

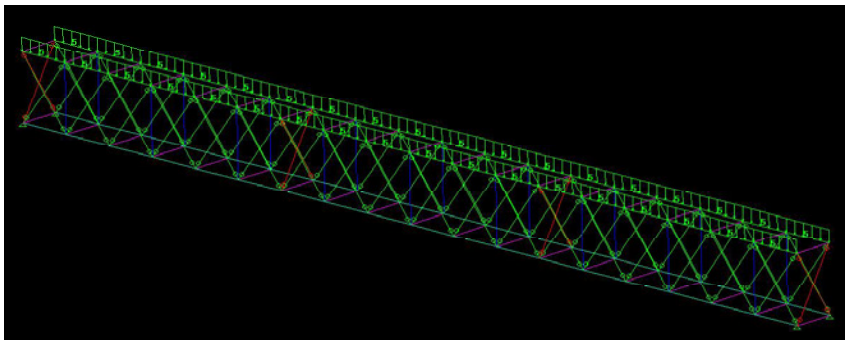
Load Case 1 **Self Weight**

Self weight of all members factored by 1.15 to account for connections



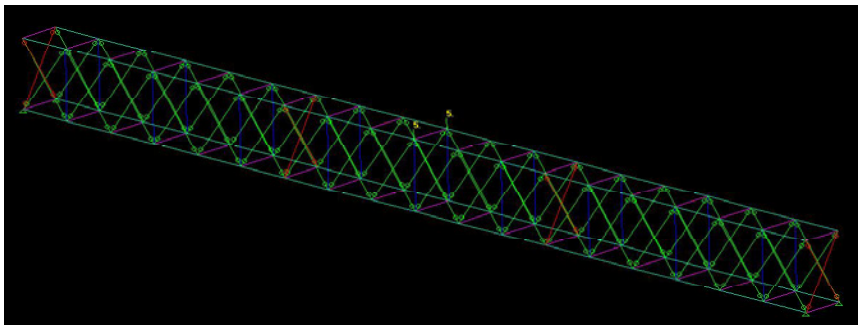
Load Case 2 **UDL**

5kN/m Load Applied to each top boom over full length of the X-Beam box at node points



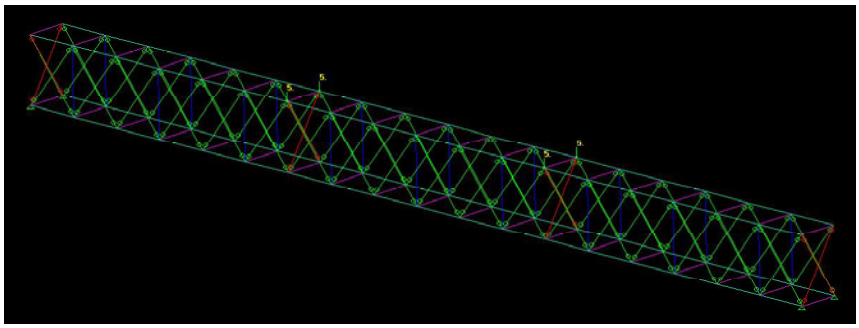
Load Case 3 **Central Point Load**

5kN Point Load Applied to Centre of each Top Boom of the X-Beam box.



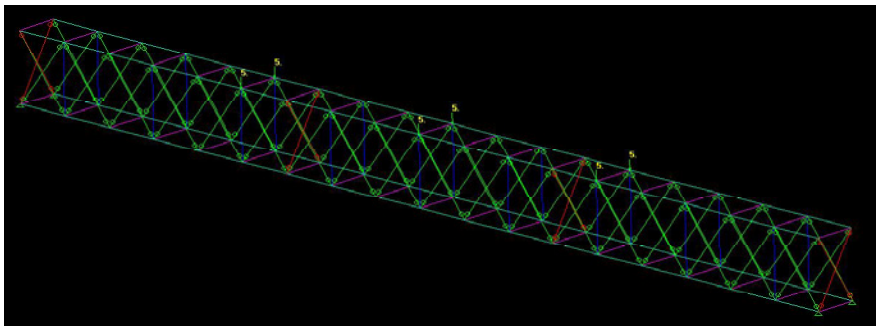
Load Case 4 **Two Point Loads**

2No 5kN point loads applied at third points along each of the top booms of the X-Beam box.



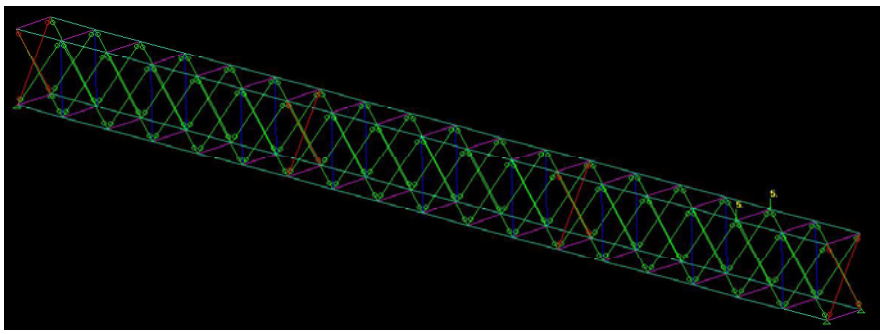
Load Case 5 **Three Point Loads**

3No 5kN Point Loads applied at quarter points along each of the top booms of the X-Beam box.



Load Case 6 **End Shear**

5kN Point Load applied 1.0m from support on each top boom of the X-Beam box.



Load Combinations

Combination Number	Combination Description	Load Cases
1	UDL	1+2
2	Central Point Load	1+3
3	Two Point Loads	1+4
4	Three Point Loads	1+5
5	End Shear	1+6

Above Combinations were checked for the following design factors:

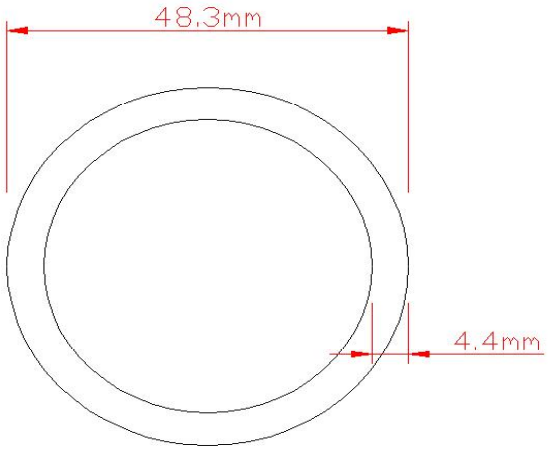
γ_D= 1.35

γ_L= 1.50

CALCULATION SHEET	Project :	Apollo X-beam Box			ALAN WHITE DESIGN
	Element :	Main Boom Capacity			
	Job Number :	X0016	By:anw	Date: Jan 17	
	Document No :	001A	Checked:mmr	Date: Jan 17	

Main Boom Capacity
ø48.3mm x 4.4mm CHS 6082-T6

Alu. 6082-T2	$P_{o,haz}$ =	0.50		(Table 3.2b)
	$P_{u,haz}$ =	0.64		
	f_o =	250	N/mm^2	
	f_u =	290	N/mm^2	



Section Properties

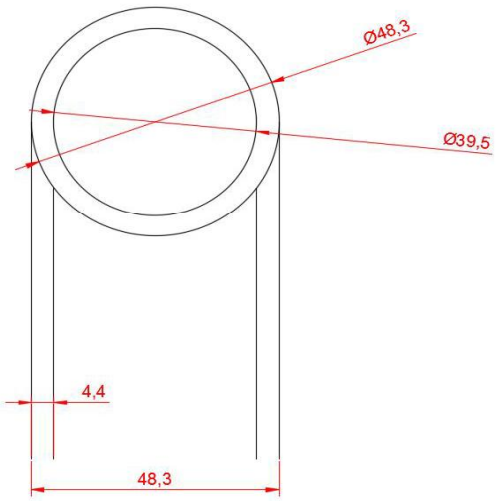
A=	607	mm^2	
I=	147654	mm^4	
W_{el}=	6114	mm^3	
W_{pl}=	8254	mm^3	
ry=	15.6	mm	

for slenderness	β=	b/t	b= 48.3
	=	10.98	t = 4.4
	ε=	sqrt(250/f_o)	f_o= 250N/mm^2
	=	1.00	
Class A, without welds, Internal parts	β_1=	11ε	
	=	11*1.0	
	=	11.00	
	>	10.98	

Section is class 1

Main Boom HAZ

There is a HAZ at welded joint to the vertical



t_{boom}= 4.40 mm

t_{vert}= 4.40 mm

$t_{average}$= 4.40 mm

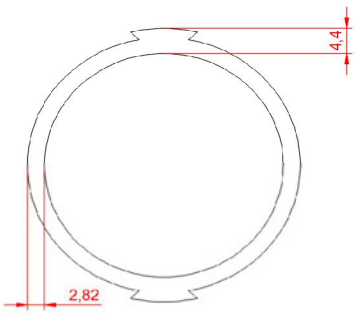
All welds are TIG.
As per EN 1999-1-1 6.1.6.3

b_{haz} = 30mm

Therefore HAZ extends 30mm from intersection of welded materials

$P_{u,haz}$ HAZ Section Layout

Take section shown as non-HAZ using p_{ohaz} of 0.50



A= 350 mm^2

I= 91819 mm^4

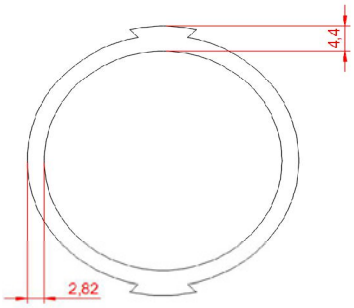
W_{el}= 4183 mm^3

W_{pl}= 5158 mm^3

ry= 13.9 mm

$P_{u,haz}$ HAZ Section Layout

Take section shown as non-HAZ using p_{uhaz} of 0.64



A=	405	mm^2
I=	100785	mm^4
W_{el}=	4592	mm^3
W_{pl}=	5765	mm^3
ry=	13.9	mm

Main Boom Moment Capacity (6.2.5.1)

Non-HAZ

$M_{o,Rd} = \alpha W_{el} f_o / \gamma_{M1}$

$\alpha_{3,u}$ =	1.00	(Table 6.4)
W_{el} =	6.11	cm^3
f_o =	250	N/mm^2
γ_{M1} =	1.1	(6.1.3)

= 1.00*6.11*250/1100

$M_{o,Rd}$ = 1.39 kNm

HAZ

$M_{u,Rd} = W_{net} f_u / \gamma_{M2}$

W_{net} =	$W_{el,PuHAZ}$	
=	4.59	cm^3
f_u =	290	N/mm^2
γ_{M2} =	1.25	(6.1.3)

= 4.59*290/1250

$M_{u,Rd}$ = 1.06 kNm

$M_{Rd,x}$ = 1.06 kNm lesser value of $M_{c,Rd}$ / $M_{u,Rd}$

CALCULATION SHEET	Project :	Apollo X-beam Box			AWD ALAN WHITE DESIGN
	Element :	Main Boom Capacity			
	Job Number :	X0016	By:anw	Date: Jan 17	
	Document No :	001A	Checked:mmr	Date: Jan 17	

Main Boom Shear Capacity (6.2.6)

$V_{Rd} = A_v f_o / \sqrt{3}\gamma_{M1}$

$A_v = 0.6A_e$

$A_v = 0.6*350$

$A_v = 210.00$ mm^2

$\gamma_{M1} = 1.1$

$f_o = 250$ N/mm^2

$= 210*250/(SQRT(3)*1100)$

$V_{Rd} = 27.56$ kN

Main Boom Axial Comp Capacity @ 400mm (effective length of beam between restraints)

Localised Weld $N_{b,Rd} = X_{haz}\omega_{x,haz} A_{u,eff} f_u / \gamma_{M2}$ (6.3.1.1 (6.49b))

$N_{cr} = \pi^2 EI / k^2 L^2$ (Appendix I.3)

$E = 70,000$ N/mm^2

$I = 147,654$ mm^4

$k = 0.50$

$L = 400$ mm

$N_{cr} = ((PI()^2)*70000*147654)/((0.5^2)*(400^2))$

$= 2,550,251.49$ N

$\lambda_{haz} = \sqrt{A_{u,eff} f_u / N_{cr}}$ (6.3.1.2)

$= 0.20$

$A_{u,eff} = 405$ mm^2

$A = 607$ mm^2

$X = 1/ \Phi+\sqrt{\Phi^2-\lambda^2}$

$\Phi = 0.5(1+\acute{\alpha}(\lambda-\lambda_o)+\lambda^2)$

$\acute{\alpha} = 0.20$ Table 6.6

$\lambda_o = 0.10$ Table 6.6

$\Phi = 0.53$

$X = 0.95$

$\omega_{x,haz} = 1/(X_{haz}+(1-X_{haz})\sin(PI()x_{s,haz}/lcr))$

$= 1.05$

$N_{b,Rd} = 0.95*1.05*405*290/1250$

$= 93.73$ kN

CALCULATION SHEET	Project :	Apollo X-beam Box		
	Element :	Main Boom Capacity		
	Job Number :	X0016	By:anw	Date: Jan 17
	Document No :	001A	Checked:mmr	Date: Jan 17

ALAN WHITE DESIGN

Main Boom Axial Tension Capacity (6.2.3)

1. General yielding

$N_{o,Rd} = A_g f_o / \gamma_{M1}$

$f_o =$ 250 N/mm^2

$A_g =$ A

$=$ 607 mm^2

$\gamma_{M1} =$ 1.1

$=$ 607*250/1100

$=$ 137.95 kN

2. Local failure

$N_{u,Rd} = A_{u,eff} f_u / \gamma_{M2}$

$f_u =$ 290 N/mm^2

$A_{u,eff} =$ 405 mm^2

$\gamma_{M1} =$ 1.25

$=$ 405*290/1250

$=$ 93.96 kN

Lesser Value= 93.96 kN

RHS diagonal Layout

38x19x3.5mm Oval 6082-T6

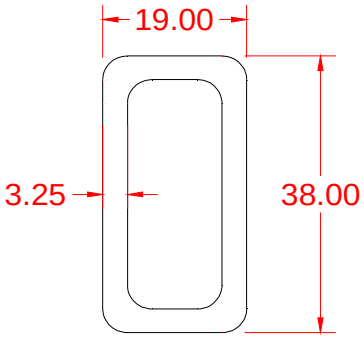
Alu. 6082-T2

$P_{o,haz}$ = 0.50 (Table 3.2b)

$P_{u,haz}$ = 0.64

f_o = 250 N/mm^2

f_u = 290 N/mm^2



Section Properties

A= 328 mm^2

I= 53341 mm^4

W_{el}= 2807 mm^3

W_{pl}= 3729 mm^3

ry= 7.0 mm

for slenderness β= b/t b= 38-2*3.25 = 31.50

= 9.69 t = 3.25

ε= sqrt(250/f_o) f_o= 250N/mm^2

= 1.00

Class A, without welds, Internal parts β_1= 11ε

= 11*1.0

= 11.00

> 9.69

Section is class 1

Diagonal HAZ Length

Full perimeter weld at the joint, therefore the entire section is affected by HAZ.

As per BS EN 1999-1-1, for HAZ wall thickness factored by 0.50 (For $P_{o,haz}$)

As per BS EN 1999-1-1, for HAZ wall thickness factored by 0.64 (For $P_{u,haz}$)

applying ρ_{uhaz}=0.64

A_{eff}= 0.64*328

= 209.92 mm^2

Diagonal Axial Comp Capacity @ 400mm (effective length of beam)

Localised Weld

$N_{b,Rd} = X_{haz}\omega_{x,haz} A_{u,eff} f_u / \gamma_{M2}$ (6.3.1.1 (6.49b))

$N_{cr} = \pi^2 EI / k^2 L^2$ (Appendix I.3)

$E =$ 70,000 N/mm^2

$I =$ 53,341 mm^4

$k =$ 0.50

$L =$ 400 mm

$N_{cr} =$ ((PI()^2)*70000*53341)/((0.5^2)*(400^2))

$=$ 921,295.49 N

$\lambda_{haz} = \sqrt{A_{u,eff} f_u / N_{cr}}$ (6.3.1.2)

$=$ 0.24

$A_{u,eff} =$ 210 mm^2

$A =$ 328 mm^2

$X = 1/ \Phi+\sqrt{\Phi^2-\lambda^2}$

$\Phi = 0.5(1+\acute{\alpha}(\lambda-\lambda_o)+\lambda^2)$

$\acute{\alpha} =$ 0.20 Table 6.6

$\lambda_o =$ 0.10 Table 6.6

$\Phi =$ 0.54

$X =$ 0.93

$\omega_{x,haz} = 1/(X_{haz}+(1-X_{haz})\sin(PI()x_{s,haz}/lcr))$

$=$ 1.07

$N_{b,Rd} =$ 0.93*1.07*210*290/1250

$=$ 48.48 kN

Diagonal Axial Tension Capacity (6.2.3)

1. General yielding

$N_{o,Rd} = A_g f_o / \gamma_{M1}$

$f_o =$ 250 N/mm^2

$A_g =$ 350 mm^2

$\gamma_{M1} =$ 1.1

$=$ 350*250/1100

$=$ 79.55 kN

2. Local failure

$N_{u,Rd} = A_{eff} f_u / \gamma_{M2}$

$f_u =$ 290 N/mm^2

$A_g =$ 210 mm^2

$\gamma_{M2} =$ 1.25

$=$ 290*210/1250

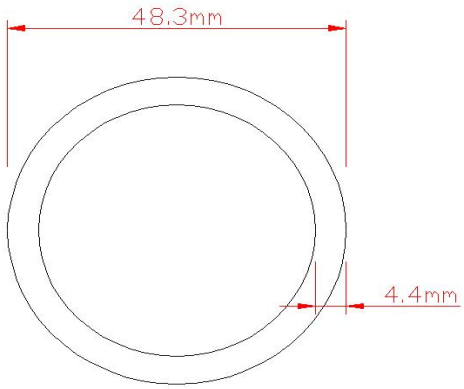
$=$ 48.72 kN

Lesser Value= 48.72 kN

CALCULATION SHEET	Project :	Apollo X-beam Box			ALAN WHITE DESIGN
	Element :	Vertical CHS Member Capacity			
	Job Number :	X0016	By:anw	Date: Jan 17	
	Document No :	001A	Checked:mmr	Date: Jan 17	

Vertical CHS Member Capacity
ø48.3mm x 4.4mm CHS 6082-T6

Alu. 6082-T2	$P_{o,haz}$ =	0.50		(Table 3.2b)
	$P_{u,haz}$ =	0.64		
	f_o =	250	N/mm^2	
	f_u =	290	N/mm^2	



Section Properties

		A=	607	mm^2	
		I=	147654	mm^4	
		W_{el}=	6114	mm^3	
		W_{pl}=	8254	mm^3	
		ry=	15.6	mm	
for slenderness	β=	b/t	b=	48.3	mm
	=	10.98	t =	4.4	mm
	ε=	sqrt(250/f_o)	f_o=	250	N/mm^2
	=	1.00			
Class A, without welds, Internal parts		β_1=	11ε		
		=	11*1.0		
		=	11.00		
		>	10.98		

Section is class 1

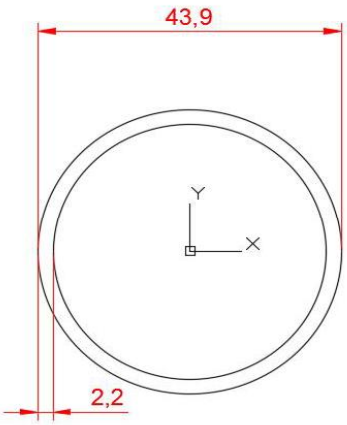
Vertical CHS HAZ Length

Full perimeter weld at the joint, therefore the entire section is affected by HAZ.

As per BS EN 1999-1-1, for HAZ wall thickness factored by 0.50 (For $P_{o,haz}$)

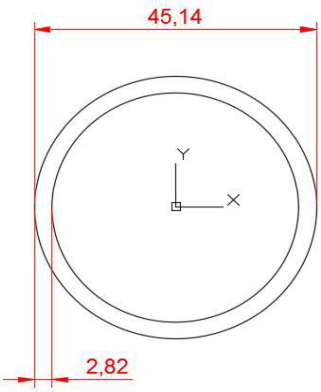
As per BS EN 1999-1-1, for HAZ wall thickness factored by 0.64 (For $P_{u,haz}$)

Vertical CHS $P_{o,haz}$ HAZ Section Layout



A_{haz}=	288	mm^2
I=	62820	mm^4
I_z=	62820	mm^4
$W_{el,PoHAZ}$=	2,862	mm^3
$W_{pl,PoHAZ}$=	3,864	mm^3

Vertical CHS $P_{u,haz}$ HAZ Section Layout



A_{haz}=	374	mm^2
I=	84308	mm^4
I_z=	84308	mm^4
$W_{el,PuHAZ}$=	3,735	mm^3
$W_{pl,PuHAZ}$=	5,043	mm^3

CALCULATION SHEET	Project :	Apollo X-beam Box		
	Element :	Vertical CHS Member Capacity		
	Job Number :	X0016	By:anw	Date: Jan 17
	Document No :	001A	Checked:mmr	Date: Jan 17

ALAN WHITE DESIGN

Vertical CHS Moment Capacity (6.2.5.1)

Non-HAZ

$M_{o,Rd} = \alpha W_{el} f_o / \gamma_{M1}$

$\alpha = W_{pl}/W_{el}$ (Table 6.4)

$= 1.35$

$W_{el} = 6.11\ cm^3$

$f_o = 250\ N/mm^2$

$\gamma_{M1} = 1.1$ (6.1.3)

$= 1.35*6.11*250/1100$

$M_{o,Rd} = 1.87\ kNm$

HAZ

$M_{u,Rd} = W_{net} f_u / \gamma_{M2}$

$W_{net} = W_{el,PuHAZ}$

$= 3.74\ cm^3$

$f_u = 290\ N/mm^2$

$\gamma_{M2} = 1.25$ (6.1.3)

$= 3.74*290/1250$

$M_{u,Rd} = 0.87\ kNm$

$M_{Rd,x} = 0.87\ kNm$ lesser value of $M_{c,Rd}$ / $M_{u,Rd}$

Vertical CHS Shear Capacity (6.2.6)

$V_{Rd} = A_v f_o / \sqrt{3}\gamma_{M1}$

$A_v = 0.6A_e$

$A_v = 0.6*288$

$A_v = 172.80\ mm^2$

$\gamma_{M1} = 1.1$

$f_o = 250\ N/mm^2$

$= 172.80*250/(SQRT(3)*1100)$

$V_{Rd} = 22.67\ kN$

CALCULATION SHEET	Project :	Apollo X-beam Box			AWD ALAN WHITE DESIGN
	Element :	Vertical CHS Member Capacity			
	Job Number :	X0016	By:anw	Date: Jan 17	
	Document No :	001A	Checked:mmr	Date: Jan 17	

Vertical CHS Axial Comp Capacity @ 650mm (effective length of beam)

Localised Weld

$N_{b,Rd} = X_{haz}\omega_{x,haz} A_{u,eff} f_u / \gamma_{M2}$ (6.3.1.1 (6.49b))

$N_{cr} = \pi^2 EI / k^2 L^2$ (Appendix I.3)

$E =$ 70,000 N/mm^2
$I =$ 147,654 mm^4
$k =$ 0.50
$L =$ 650 mm

$N_{cr} =$ ((PI()^2)*70000*147654)/((0.5^2)*(650^2))
$=$ 965,775.71 N

$\lambda_{haz} = \sqrt{A_{u,eff} f_u / N_{cr}}$ (6.3.1.2)
$=$ 0.31

$A_{u,eff} =$ 374 mm^2
$A =$ 607 mm^2

$X = 1/ \Phi+\sqrt{\Phi^2-\lambda^2}$

$\Phi = 0.5(1+\acute{\alpha}(\lambda-\lambda_o)+\lambda^2)$
$\acute{\alpha} =$ 0.20 Table 6.6
$\lambda_o =$ 0.10 Table 6.6
$\Phi =$ 0.57

$X =$ 0.88

$\omega_{x,haz} = 1/(X_{haz}+(1-X_{haz})\sin(PI()x_{s,haz}/lcr))$

$=$ 1.12

$N_{b,Rd} =$ 0.88*1.12*374*290/1250
$=$ 85.52 kN

CALCULATION SHEET	Project :	Apollo X-beam Box		
	Element :	Vertical CHS Member Capacity		
	Job Number :	X0016	By:anw	Date: Jan 17
	Document No :	001A	Checked:mmr	Date: Jan 17

ALAN WHITE DESIGN

Vertical CHS Axial Tension Capacity (6.2.3)

1. General yielding

$N_{o,Rd} = A_g f_o / \gamma_{M1}$

$f_o =$ 250 N/mm^2

$A_g =$ A

$=$ 607 mm^2

$\gamma_{M1} =$ 1.1

$=$ 607*250/1100

$=$ 137.95 kN

2. Local failure

$N_{u,Rd} = A_{u,eff} f_u / \gamma_{M2}$

$f_u =$ 290 N/mm^2

$A_{u,eff} =$ 374 mm^2

$\gamma_{M1} =$ 1.25

$=$ 374*290/1250

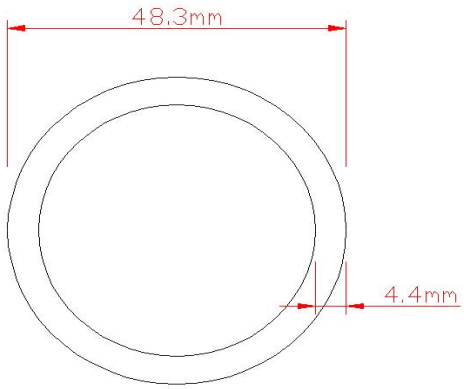
$=$ 86.77 kN

Lesser Value= 86.77 kN

CALCULATION SHEET	Project :	Apollo X-beam Box			ALAN WHITE DESIGN
	Element :	Horizontal CHS Member Capacity			
	Job Number :	X0016	By:anw	Date: Jan 17	
	Document No :	001A	Checked:mmr	Date: Jan 17	

Horizontal CHS Member Capacity
ø48.3mm x 4.4mm CHS 6082-T6

Alu. 6082-T2	$P_{o,haz}$ =	0.50		(Table 3.2b)
	$P_{u,haz}$ =	0.64		
	f_o =	250	N/mm^2	
	f_u =	290	N/mm^2	



Section Properties

	A=	607	mm^2	
	I=	147654	mm^4	
	W_{el}=	6114	mm^3	
	W_{pl}=	8254	mm^3	
	ry=	15.6	mm	

for slenderness	β=	b/t	b=	48.3	mm
	=	10.98	t =	4.4	mm
	ε=	sqrt(250/f_o)	f_o=	250	N/mm^2
	=	1.00			
Class A, without welds, Internal parts		β_1=	11ε		
		=	11*1.0		
		=	11.00		
		>	10.98		

Section is class 1

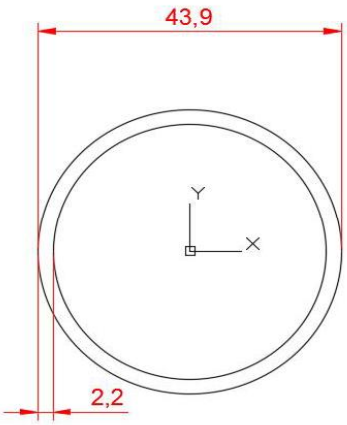
Horizontal CHS HAZ Length

Full perimeter weld at the joint, therefore the entire section is affected by HAZ.

As per BS EN 1999-1-1, for HAZ wall thickness factored by 0.50 (For $P_{o,haz}$)

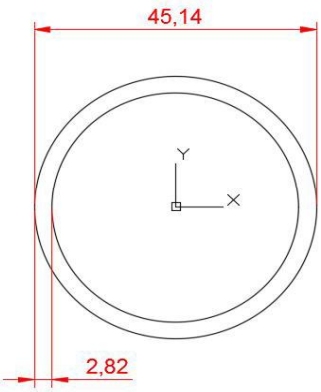
As per BS EN 1999-1-1, for HAZ wall thickness factored by 0.64 (For $P_{u,haz}$)

Horizontal CHS $P_{o,haz}$ HAZ Section Layout



A_{haz}=	288	mm^2
I=	62820	mm^4
I_z=	62820	mm^4
$W_{el,PoHAZ}$=	2,862	mm^3
$W_{pl,PoHAZ}$=	3,864	mm^3

Horizontal CHS $P_{u,haz}$ HAZ Section Layout



A_{haz}=	374	mm^2
I=	84308	mm^4
I_z=	84308	mm^4
$W_{el,PuHAZ}$=	3,735	mm^3
$W_{pl,PuHAZ}$=	5,043	mm^3

CALCULATION SHEET	Project :	Apollo X-beam Box			AWD ALAN WHITE DESIGN
	Element :	Horizontal CHS Member Capacity			
	Job Number :	X0016	By:anw	Date: Jan 17	
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Horizontal CHS Moment Capacity (6.2.5.1)

Non-HAZ

$M_{o,Rd} = \alpha W_{el} f_o / \gamma_{M1}$

$\alpha = W_{pl}/W_{el}$ (Table 6.4)

$= 1.35$

$W_{el} = 6.11\ cm^3$

$f_o = 250\ N/mm^2$

$\gamma_{M1} = 1.1$ (6.1.3)

$= 1.35*6.11*250/1100$

$M_{o,Rd} = 1.87\ kNm$

HAZ

$M_{u,Rd} = W_{net} f_u / \gamma_{M2}$

$W_{net} = W_{el,PuHAZ}$

$= 3.74\ cm^3$

$f_u = 290\ N/mm^2$

$\gamma_{M2} = 1.25$ (6.1.3)

$= 3.74*290/1250$

$M_{u,Rd} = 0.87\ kNm$

$M_{Rd,x} = 0.87\ kNm$ lesser value of $M_{c,Rd}$ / $M_{u,Rd}$

Horizontal CHS Shear Capacity (6.2.6)

$V_{Rd} = A_v f_o / \sqrt{3}\gamma_{M1}$

$A_v = 0.6A_e$

$A_v = 0.6*288$

$A_v = 172.80\ mm^2$

$\gamma_{M1} = 1.1$

$f_o = 250\ N/mm^2$

$= 172.80*250/(SQRT(3)*1100)$

$V_{Rd} = 22.67\ kN$

CALCULATION SHEET	Project :	Apollo X-beam Box			AWD ALAN WHITE DESIGN
	Element :	Horizontal CHS Member Capacity			
	Job Number :	X0016	By:anw	Date: Jan 17	
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Horizontal CHS Axial Comp Capacity @ 350mm (effective length of beam)

Localised Weld

$N_{b,Rd} = X_{haz}\omega_{x,haz} A_{u,eff} f_u / \gamma_{M2}$ (6.3.1.1 (6.49b))

$N_{cr} = \pi^2 EI / k^2 L^2$ (Appendix I.3)

$E =$ 70,000 N/mm^2

$I =$ 147,654 mm^4

$k =$ 0.50

$L =$ 350 mm

$N_{cr} =$ ((PI()^2)*70000*147654)/((0.5^2)*(350^2))

$=$ 3,330,940.73 N

$\lambda_{haz} = \sqrt{A_{u,eff} f_u / N_{cr}}$ (6.3.1.2)

$=$ 0.17

$A_{u,eff} =$ 374 mm^2

$A =$ 607 mm^2

$X = 1/ \Phi+\sqrt{\Phi^2-\lambda^2}$

$\Phi = 0.5(1+\acute{\alpha}(\lambda-\lambda_o)+\lambda^2)$

$\acute{\alpha} =$ 0.20 Table 6.6

$\lambda_o =$ 0.10 Table 6.6

$\Phi =$ 0.52

$X =$ 0.97

$\omega_{x,haz} = 1/(X_{haz}+(1-X_{haz})\sin(PI()x_{s,haz}/lcr))$

$=$ 1.03

$N_{b,Rd} =$ 0.97*1.03*374*290/1250

$=$ 86.69 kN

CALCULATION SHEET	Project :	Apollo X-beam Box		
	Element :	Horizontal CHS Member Capacity		
	Job Number :	X0016	By:anw	Date: Jan 17
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ALAN WHITE DESIGN

Horizontal CHS Axial Tension Capacity (6.2.3)

1. General yielding

$N_{o,Rd} = A_g f_o / \gamma_{M1}$

$f_o =$ 250 N/mm^2

$A_g =$ A

$=$ 607 mm^2

$\gamma_{M1} =$ 1.1

$=$ 607*250/1100

$=$ 137.95 kN

2. Local failure

$N_{u,Rd} = A_{u,eff} f_u / \gamma_{M2}$

$f_u =$ 290 N/mm^2

$A_{u,eff} =$ 374 mm^2

$\gamma_{M1} =$ 1.25

$=$ 374*290/1250

$=$ 86.77 kN

Lesser Value= 86.77 kN

RHS Brace Layout

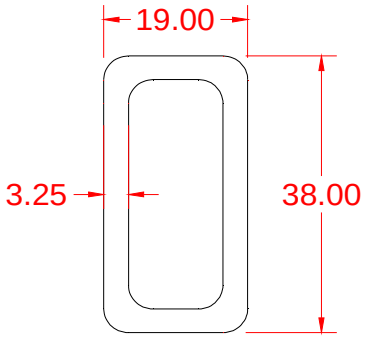
38x19x3.5mm Oval 6082-T6

Alu. 6082-T2 $P_{o,haz}$ = 0.50 (Table 3.2b)

$P_{u,haz}$ = 0.64

f_o = 250 N/mm^2

f_u = 290 N/mm^2



Section Properties

A= 328 mm^2

I= 53341 mm^4

W_{el}= 2807 mm^3

W_{pl}= 3729 mm^3

ry= 7.0 mm

for slenderness β= b/t b= 38-2*3.25

= 31.50

= 9.69 t = 3.25

ε= sqrt(250/f_o) f_o= 250N/mm^2

= 1.00

Class A, without welds, Internal parts β_1= 11ε

= 11*1.0

= 11.00

> 9.69

Section is class 1

Brace HAZ Length

Full perimeter weld at the joint, therefore the entire section is affected by HAZ.

As per BS EN 1999-1-1, for HAZ wall thickness factored by 0.50 (For $P_{o,haz}$)

As per BS EN 1999-1-1, for HAZ wall thickness factored by 0.64 (For $P_{u,haz}$)

applying ρ_{uhaz}=0.64

A_{eff}= 0.64*328

= 209.92 mm^2

Brace Axial Comp Capacity @ 375mm (effective length of beam)

Localised Weld

$N_{b,Rd} = X_{haz}\omega_{x,haz} A_{u,eff} f_u / \gamma_{M2}$ (6.3.1.1 (6.49b))

$N_{cr} = \pi^2 EI / k^2 L^2$ (Appendix I.3)

$E =$ 70,000 N/mm^2

$I =$ 53,341 mm^4

$k =$ 0.50

$L =$ 375 mm

$N_{cr} =$ ((PI()^2)*70000*53341)/((0.5^2)*(375^2))

$=$ 1,048,229.54 N

$\lambda_{haz} = \sqrt{A_{u,eff} f_u / N_{cr}}$ (6.3.1.2)

$=$ 0.23

$A_{u,eff} =$ 210 mm^2

$A =$ 328 mm^2

$X = 1/ \Phi+\sqrt{\Phi^2-\lambda^2}$

$\Phi = 0.5(1+\acute{\alpha}(\lambda-\lambda_o)+\lambda^2)$

$\acute{\alpha} =$ 0.20 Table 6.6

$\lambda_o =$ 0.10 Table 6.6

$\Phi =$ 0.54

$X =$ 0.94

$\omega_{x,haz} = 1/(X_{haz}+(1-X_{haz})\sin(PI()x_{s,haz}/lcr))$

$=$ 1.06

$N_{b,Rd} =$ 0.94*1.06*210*290/1250

$=$ 48.54 kN

Brace Axial Tension Capacity (6.2.3)

1. General yielding

$N_{o,Rd} = A_g f_o / \gamma_{M1}$

$f_o =$ 250 N/mm^2

$A_g =$ 350 mm^2

$\gamma_{M1} =$ 1.1

$=$ 350*250/1100

$=$ 79.55 kN

2. Local failure

$N_{u,Rd} = A_{eff} f_u / \gamma_{M2}$

$f_u =$ 290 N/mm^2

$A_g =$ 210 mm^2

$\gamma_{M2} =$ 1.25

$=$ 290*210/1250

$=$ 48.72 kN

Lesser Value= 48.72 kN

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9m X-Beam Box Results

CALCULATION SHEET	Project :	Apollo X-beam Box		
	Element :	9m X-Beam Box Results		
	Job Number :	X0016	By:anw	Date: Jan 17
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ALAN WHITE DESIGN

Load Comb. 1 UDL load 10kN/m applied along beam

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	**Moment**	$M_{c,Rd}$	1.06	0.23	4.65
	Co-exist Axial	$N_{b,Rd}$	93.73	33.08	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	1.94
	Shear	V_{Rd}	27.56	2.25	12.25
	Tension	$N_{o,Rd}$	93.96	35.42	2.65
	Co-exist Moment	$M_{c,Rd}$	1.06	0.10	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	2.23
	Compression	$N_{b,Rd}$	93.73	108.56	0.86
	Co-exist Moment	$M_{c,Rd}$	1.06	0.15	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	0.79
	Deflection	d	90.00	24.00	3.75
Vertical	Moment	$M_{c,Rd}$	0.87	0.09	9.97
	Shear	V_{Rd}	22.67	0.19	120.61
	Tension	$N_{o,Rd}$	86.77	6.60	13.15
	Compression	$N_{b,Rd}$	85.52	0.01	8,551.85
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	9.97
Diagonal	Tension	$N_{o,Rd}$	48.72	29.97	1.63
	Compression	$N_{b,Rd}$	48.48	29.97	1.62
Cross member	Moment	$M_{c,Rd}$	0.87	0.01	86.77
	Shear	V_{Rd}	22.67	0.01	2,267.41
	Tension	$N_{o,Rd}$	86.77	5.63	15.40
	Compression	$N_{b,Rd}$	86.69	2.27	38.19
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	28.39
Brace	Tension	$N_{o,Rd}$	48.72	4.61	10.57
	Compression	$N_{b,Rd}$	48.54	11.40	4.26
				Factor	**0.79**

CALCULATION SHEET	Project :	Apollo X-beam Box		
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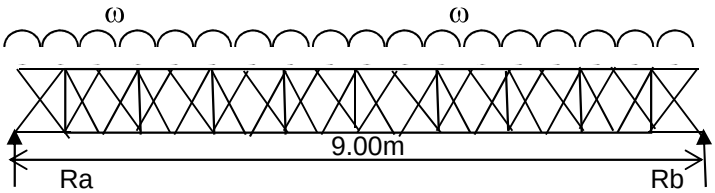
ALAN WHITE DESIGN



Max Moment= $WL^2/8$

so for ultimate condition

W= 1.5*10

15.00 kN/m

apply factor from above

Wf= 15*0.79

= 11.85 kN/m

so maximum moment is as above

Ultimate Mu= Wf*9^2/8

= (11.85*9^2)/8

= 119.98 kNm

and for allowable value

allowable max moment= 119.98/1.50

= 79.99 kNm

Moment values	**Ultimate**	**119.98 kNm**
	Allowable	**79.99 kNm**

CALCULATION SHEET	Project :	Apollo X-beam Box		
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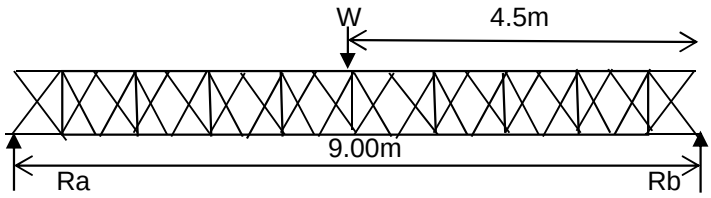
ALAN WHITE DESIGN

Load Comb. 2 Point load 10kN load applied at midspan of beam

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	**Moment**	$M_{c,Rd}$	1.06	0.04	24.20
	Co-exist Axial	$N_{b,Rd}$	93.96	24.42	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	3.54
	Shear	V_{Rd}	27.56	0.11	252.80
	Tension	$N_{o,Rd}$	93.96	11.32	8.30
	Co-exist Moment	$M_{c,Rd}$	1.06	0.02	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	7.43
	Compression	$N_{b,Rd}$	93.73	24.42	3.84
	Co-exist Moment	$M_{c,Rd}$	1.06	0.04	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	3.43
	Deflection	d	90.00	4.60	19.57
Vertical	Moment	$M_{c,Rd}$	0.87	0.01	66.74
	Shear	V_{Rd}	22.67	0.03	708.57
	Tension	$N_{o,Rd}$	86.77	1.17	74.16
	Compression	$N_{b,Rd}$	85.52	2.98	28.67
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	21.45
Diagonal	Tension	$N_{o,Rd}$	48.72	4.10	11.89
	Compression	$N_{b,Rd}$	48.48	4.10	11.83
Cross member	Moment	$M_{c,Rd}$	0.87	0.01	86.77
	Shear	V_{Rd}	22.67	0.01	2,267.41
	Tension	$N_{o,Rd}$	86.77	0.59	146.82
	Compression	$N_{b,Rd}$	86.69	0.59	146.68
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	60.04
Brace	Tension	$N_{o,Rd}$	48.72	1.20	40.57
	Compression	$N_{b,Rd}$	48.54	1.20	40.57
				Factor	**3.43**



Max Moment= WL/4

so for ultimate condition

W= 1.50*10
= 15.00 kN

apply factor from above

Wf= 15*3.43
= 51.45 kN

so maximum moment is as above

Ultimate Mu= Wf*9/4
= 51.45*9/4
= 115.76 kNm

and for allowable value

allowable max moment= 115.76/1.50
= 77.17 kNm

Moment values	**Ultimate**	**115.76**	**kNm**
	Allowable	**77.17**	**kNm**

CALCULATION SHEET	Project :	Apollo X-beam Box			AWD ALAN WHITE DESIGN
	Element :	9m X-Beam Box Results			
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Load Comb. 3 PL at third points
10kN load applied at each of the two third points

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	**Moment**	$M_{c,Rd}$	1.06	0.03	31.32
	Co-exist Axial	$N_{b,Rd}$	93.73	29.91	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	3.00
	Shear	V_{Rd}	27.56	0.10	272.83
	Tension	$N_{o,Rd}$	93.96	11.83	7.94
	Co-exist Moment	$M_{c,Rd}$	1.06	0.03	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	6.75
	Compression	$N_{b,Rd}$	93.73	33.94	2.76
	Co-exist Moment	$M_{c,Rd}$	1.06	0.02	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	2.66
	Deflection	d	90.00	7.00	12.86
Vertical	Moment	$M_{c,Rd}$	0.87	0.03	30.99
	Shear	V_{Rd}	22.67	0.07	323.92
	Tension	$N_{o,Rd}$	86.77	2.04	42.53
	Compression	$N_{b,Rd}$	85.52	0.01	8,551.85
	Combined Axial	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	30.97
Diagonal	Tension	$N_{o,Rd}$	48.72	4.93	9.88
	Compression	$N_{b,Rd}$	48.48	7.50	6.46
Cross member	Moment	$M_{c,Rd}$	0.87	0.01	86.77
	Shear	V_{Rd}	22.67	0.01	2,267.41
	Tension	$N_{o,Rd}$	86.77	1.14	75.85
	Compression	$N_{b,Rd}$	86.69	0.01	8,668.99
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	44.27
Brace	Tension	$N_{o,Rd}$	48.72	0.01	4,872.00
	Compression	$N_{b,Rd}$	48.54	2.32	20.92
				Factor	**2.66**

CALCULATION SHEET	Project :	Apollo X-beam Box		
	Element :	9m X-Beam Box Results		
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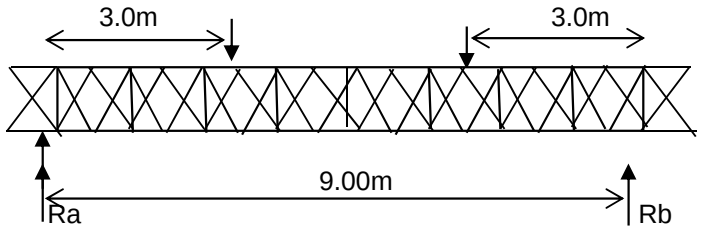
ALAN WHITE DESIGN



Max Moment= WL/3

so for ultimate condition

W= 1.50*10
15.00 kN

apply factor from above

Wf= 15.00*2.66
= 39.90 kN

so maximum moment is as above

Ultimate Mu= Wf*9/3
= (39.90*9)/3
= 119.70 kNm

and for allowable value

allowable max moment= 119.70/1.50
= 79.80 kNm

Moment values	**Ultimate**	**119.70 kNm**
	Allowable	**79.80 kNm**

CALCULATION SHEET	Project :	Apollo X-beam Box		
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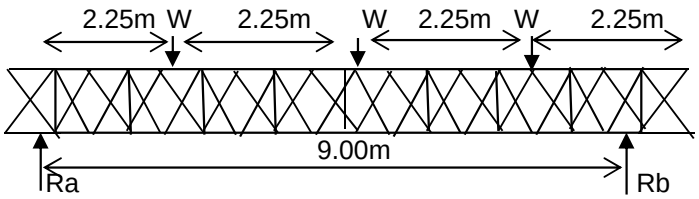
ALAN WHITE DESIGN

Load Comb. 4 PL at quarter points
10kN load applied at each of the three quarter points

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	**Moment**	$M_{c,Rd}$	1.06	0.07	14.79
	Co-exist Axial	$N_{b,Rd}$	93.73	50.99	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	1.68
	Shear	V_{Rd}	27.56	0.18	150.58
	Tension	$N_{o,Rd}$	93.96	18.49	5.08
	Co-exist Moment	$M_{c,Rd}$	1.06	0.05	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	4.30
	Compression	$N_{b,Rd}$	93.73	50.99	1.84
	Co-exist Moment	$M_{c,Rd}$	1.06	0.07	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	1.68
	Deflection	d	90.00	11.00	8.18
Vertical	Moment	$M_{c,Rd}$	0.87	0.04	23.45
	Shear	V_{Rd}	22.67	0.09	251.93
	Tension	$N_{o,Rd}$	86.77	2.95	29.41
	Compression	$N_{b,Rd}$	85.52	2.63	32.52
	Combined Axial	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	15.01
Diagonal	Tension	$N_{o,Rd}$	48.72	7.24	6.73
	Compression	$N_{b,Rd}$	48.48	10.93	4.44
Cross member	Moment	$M_{c,Rd}$	0.87	0.01	86.77
	Shear	V_{Rd}	22.67	0.01	2,267.41
	Tension	$N_{o,Rd}$	86.77	1.69	51.34
	Compression	$N_{b,Rd}$	86.69	1.36	63.74
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	40.01
Brace	Tension	$N_{o,Rd}$	48.72	2.76	17.65
	Compression	$N_{b,Rd}$	48.54	3.42	14.19
				Factor	**1.68**



Max Moment= WL/2

so for ultimate condition

W= 1.50*10
15.00 kN

apply factor from above

Wf= 15.00*1.68
= 25.20 kN

so maximum moment is as above

Ultimate Mu= Wf*9/2
= (25.20*9)/2
= 113.40 kNm

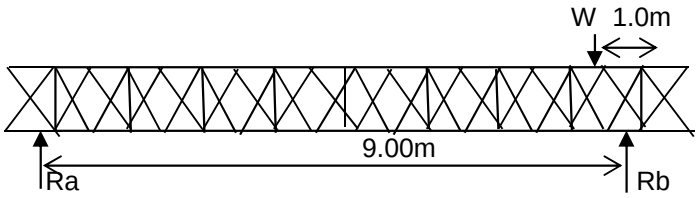
and for allowable value

allowable max moment= 113.40/1.50
= 75.60 kNm

Moment values	**Ultimate**	**113.40 kNm**
	Allowable	**75.60 kNm**

Load Comb. 5 End Shear 10kN load applied at 1.0m distance from the support

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	Moment	$M_{c,Rd}$	1.06	0.05	23.66
	Co-exist Axial	$N_{b,Rd}$	93.73	6.51	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	9.70
	Shear	V_{Rd}	27.56	0.17	167.00
	Tension	$N_{o,Rd}$	93.96	5.10	18.42
	Co-exist Moment	$M_{c,Rd}$	1.06	0.01	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	15.73
	Compression	$N_{b,Rd}$	93.73	9.91	9.46
	Co-exist Moment	$M_{c,Rd}$	1.06	0.01	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	8.88
	Deflection	d	90.00	1.00	90.00
Vertical	Moment	$M_{c,Rd}$	0.87	0.03	33.37
	Shear	V_{Rd}	22.67	0.06	354.28
	Tension	$N_{o,Rd}$	86.77	2.59	33.50
	Compression	$N_{b,Rd}$	85.52	0.01	8,551.85
	Combined Axial	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	33.37
Diagonal	Tension	$N_{o,Rd}$	48.72	3.15	15.47
	Compression	$N_{b,Rd}$	48.48	6.43	7.54
Cross member	Moment	$M_{c,Rd}$	0.87	0.01	86.77
	Shear	V_{Rd}	22.67	0.01	2,267.41
	Tension	$N_{o,Rd}$	86.77	1.45	59.84
	Compression	$N_{b,Rd}$	86.69	0.24	361.21
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	75.61
Brace	Tension	$N_{o,Rd}$	48.72	0.48	101.50
	Compression	$N_{b,Rd}$	48.54	2.93	16.57
				Factor	**7.54**



Max Shear Rb= W*2/3

so for ultimate condition

W= 1.50*10
15.00 kN

apply factor from above

Wf= 15*7.54
= 113.10 kN

so maximum shear is as above

Ultimate Qu= Wf*8.0/9
= 113.10*8.0/9
= 100.53 kN

and for allowable value

allowable max shear= 100.53/1.50
= 67.02 kN

Shear values	**Ultimate**	**100.53 kN**
	Allowable	**67.02 kN**

CALCULATION SHEET	Project :	Apollo X-beam Box		
	Element :	9m X-Beam Box Results		
	Job Number :	X0016	By:anw	Date: Jan 17
	Document No :	001A	Checked:mmr	Date: Jan 17

ALAN WHITE DESIGN

9.0m X-BEAM BOX

Loadcase No.		Ultimate Moment	Allowable Moment
1	UDL	119.98	79.99
2	Point	115.76	77.17
3	Third	119.70	79.80
4	Quarter	113.40	75.60

Loadcase No.		Ultimate Shear	Allowable Shear
5	End Shear	100.53	67.02

Max Allowable Moment = 75.60 kNm

Max Allowable Shear = 67.02 kN

CALCULATION SHEET	Project :	Apollo X-beam Box		
	Element :	12m X-Beam Results		
	Job Number :	X0016	By: anw	Date: Jan 17
	Document No :	001A	Checked:mmr	Date: Jan 17

AWD
ALAN WHITE DESIGN

12m X-Beam Box Results

CALCULATION SHEET	Project :	Apollo X-beam Box		
	Element :	12m X-Beam Results		
	Job Number :	X0016	By: anw	Date: Jan 17
	Document No :	001A	Checked:mmr	Date: Jan 17

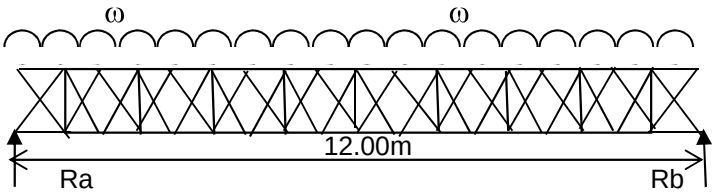
ALAN WHITE DESIGN

Load Comb. 1 UDL load 10kN/m applied along beam

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	**Moment**	$M_{c,Rd}$	1.06	0.24	4.40
	Co-exist Axial	$N_{b,Rd}$	93.73	45.38	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	1.51
	Shear	V_{Rd}	27.56	2.30	11.97
	Tension	$N_{o,Rd}$	93.96	66.03	1.42
	Co-exist Moment	$M_{c,Rd}$	1.06	0.15	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	1.24
	Compression	$N_{b,Rd}$	93.73	191.39	0.49
	Co-exist Moment	$M_{c,Rd}$	1.06	0.15	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	0.47
	Deflection	d	120.00	72.00	1.67
Vertical	Moment	$M_{c,Rd}$	0.87	0.12	7.00
	Shear	V_{Rd}	22.67	0.27	84.92
	Tension	$N_{o,Rd}$	86.77	10.70	8.11
	Compression	$N_{b,Rd}$	85.52	0.01	8,551.85
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	4.13
Diagonal	Tension	$N_{o,Rd}$	48.72	23.51	2.07
	Compression	$N_{b,Rd}$	48.48	41.95	1.16
Cross member	Moment	$M_{c,Rd}$	0.87	0.01	86.77
	Shear	V_{Rd}	22.67	0.01	2,267.41
	Tension	$N_{o,Rd}$	86.77	6.63	13.09
	Compression	$N_{b,Rd}$	86.69	4.41	19.66
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	16.76
Brace	Tension	$N_{o,Rd}$	48.72	8.98	5.43
	Compression	$N_{b,Rd}$	48.54	13.42	3.62
				Factor	**0.47**

CALCULATION SHEET	Project :	Apollo X-beam Box		
	Element :	12m X-Beam Results		
	Job Number :	X0016	By: anw	Date: Jan 17
	Document No :	001A	Checked:mmr	Date: Jan 17

ALAN WHITE DESIGN



Max Moment= $WL^2/8$

so for ultimate condition

W= 1.5*10
15.00 kN

apply factor from above

Wf= 15*0.47
= 7.05 kN

so maximum moment is as above

Ultimate Mu= Wf*12^2/8
= (7.05*12^2)/8
= 126.90 kNm

and for allowable value

allowable max moment= 126.90/1.50
= 84.60 kNm

Moment values	**Ultimate**	**126.90 kNm**
	Allowable	**84.60 kNm**

CALCULATION SHEET	Project :	Apollo X-beam Box		
	Element :	12m X-Beam Results		
	Job Number :	X0016	By: anw	Date: Jan 17
	Document No :	001A	Checked:mmr	Date: Jan 17

ALAN WHITE DESIGN

Load Comb. 2 Point load 10kN load applied at midspan of beam

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	**Moment**	$M_{c,Rd}$	1.06	0.04	27.30
	Co-exist Axial	$N_{b,Rd}$	93.73	33.21	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	2.62
	Shear	V_{Rd}	27.56	0.08	344.44
	Tension	$N_{o,Rd}$	93.96	16.56	5.67
	Co-exist Moment	$M_{c,Rd}$	1.06	0.03	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	5.06
	Compression	$N_{b,Rd}$	93.73	33.21	2.82
	Co-exist Moment	$M_{c,Rd}$	1.06	0.04	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	2.62
	Deflection	d	120.00	10.20	11.76
Vertical	Moment	$M_{c,Rd}$	0.87	0.02	43.38
	Shear	V_{Rd}	22.67	0.04	566.85
	Tension	$N_{o,Rd}$	86.77	1.42	61.10
	Compression	$N_{b,Rd}$	85.52	0.01	8,551.85
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	27.94
Diagonal	Tension	$N_{o,Rd}$	48.72	2.74	17.78
	Compression	$N_{b,Rd}$	48.48	4.54	10.68
				Factor	**2.62**
Cross member	Moment	$M_{c,Rd}$	0.87	0.01	86.77
	Shear	V_{Rd}	22.67	0.01	2,267.41
	Tension	$N_{o,Rd}$	86.77	0.51	170.13
	Compression	$N_{b,Rd}$	86.69	0.70	123.84
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	56.19
Brace	Tension	$N_{o,Rd}$	48.72	1.42	34.31
	Compression	$N_{b,Rd}$	48.54	1.04	46.85
				Factor	**2.62**

CALCULATION SHEET	Project :	Apollo X-beam Box		
	Element :	12m X-Beam Results		
	Job Number :	X0016	By: anw	Date: Jan 17
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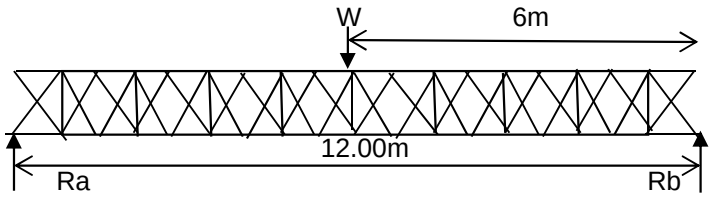
ALAN WHITE DESIGN



Max Moment= WL/4

so for ultimate condition

W= 1.50*10
= 15.00 kN

apply factor from above

Wf= 15*2.62
= 39.30 kN

so maximum moment is as above

Ultimate Mu= Wf*9/4
= 39.30*12/4
= 117.90 kNm

and for allowable value

allowable max moment= 117.90/1.50
= 78.60 kNm

Moment values	**Ultimate**	**117.90**	**kNm**
	Allowable	**78.60**	**kNm**

CALCULATION SHEET	Project :	Apollo X-beam Box		
	Element :	12m X-Beam Results		
	Job Number :	X0016	By: anw	Date: Jan 17
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ALAN WHITE DESIGN

Load Comb. 3 PL at third points
10kN load applied at each of the two third points

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	**Moment**	$M_{c,Rd}$	1.06	0.04	26.62
	Co-exist Axial	$N_{b,Rd}$	93.96	14.85	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	5.36
	Shear	V_{Rd}	27.56	0.13	208.75
	Tension	$N_{o,Rd}$	93.96	15.85	5.93
	Co-exist Moment	$M_{c,Rd}$	1.06	0.04	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	5.15
	Compression	$N_{b,Rd}$	93.73	46.06	2.03
	Co-exist Moment	$M_{c,Rd}$	1.06	0.04	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	1.93
	Deflection	d	120.00	17.00	7.06
Vertical	Moment	$M_{c,Rd}$	0.87	0.03	32.14
	Shear	V_{Rd}	22.67	0.07	323.92
	Tension	$N_{o,Rd}$	86.77	2.77	31.32
	Compression	$N_{b,Rd}$	85.52	0.01	8,551.85
	Combined Axial	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	17.40
Diagonal	Tension	$N_{o,Rd}$	48.72	5.04	9.67
	Compression	$N_{b,Rd}$	48.48	8.12	5.97
Cross member	Moment	$M_{c,Rd}$	0.87	0.01	86.77
	Shear	V_{Rd}	22.67	0.01	2,267.41
	Tension	$N_{o,Rd}$	86.77	0.99	87.64
	Compression	$N_{b,Rd}$	86.69	1.17	74.09
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	47.80
Brace	Tension	$N_{o,Rd}$	48.72	2.38	20.47
	Compression	$N_{b,Rd}$	48.54	2.00	24.27
				Factor	**1.93**

CALCULATION SHEET	Project :	Apollo X-beam Box		
	Element :	12m X-Beam Results		
	Job Number :	X0016	By: anw	Date: Jan 17
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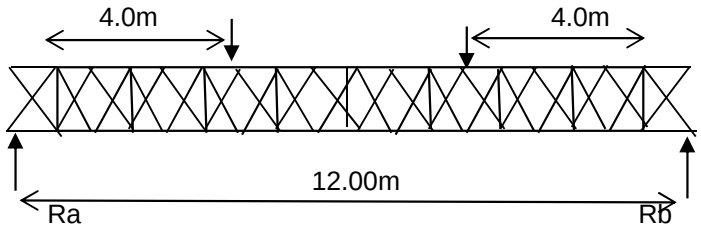
ALAN WHITE DESIGN



Max Moment= WL/3

so for ultimate condition

W= 1.50*10
15.00 kN

apply factor from above

Wf= 15.00*1.93
= 28.95 kN

so maximum moment is as above

Ultimate Mu= Wf*9/3
= (28.95*12)/3
= 115.80 kNm

and for allowable value

allowable max moment= 115.80/1.50
= 77.20 kNm

Moment values	**Ultimate**	**115.80 kNm**
	Allowable	**77.20 kNm**

Load Comb. 4 PL at quarter points
10kN load applied at each of the three quarter points

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	**Moment**	$M_{c,Rd}$	1.06	0.06	16.64
	Co-exist Axial	$N_{b,Rd}$	93.96	57.71	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	1.52
	Shear	V_{Rd}	27.56	0.18	155.68
	Tension	$N_{o,Rd}$	93.96	24.75	3.80
	Co-exist Moment	$M_{c,Rd}$	1.06	0.06	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	3.31
	Compression	$N_{b,Rd}$	93.73	64.57	1.45
	Co-exist Moment	$M_{c,Rd}$	1.06	0.04	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	1.39
	Deflection	d	120.00	11.00	10.91
Vertical	Moment	$M_{c,Rd}$	0.87	0.04	21.16
	Shear	V_{Rd}	22.67	0.10	224.50
	Tension	$N_{o,Rd}$	86.77	3.47	25.01
	Compression	$N_{b,Rd}$	85.52	0.01	8,551.85
	Combined Axial	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	12.62
Diagonal	Tension	$N_{o,Rd}$	48.72	7.35	6.63
	Compression	$N_{b,Rd}$	48.48	11.64	4.17
Cross member	Moment	$M_{c,Rd}$	0.87	0.01	86.77
	Shear	V_{Rd}	22.67	0.01	2,267.41
	Tension	$N_{o,Rd}$	86.77	1.49	58.23
	Compression	$N_{b,Rd}$	86.69	0.01	8,668.99
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	37.85
Brace	Tension	$N_{o,Rd}$	48.72	0.82	59.41
	Compression	$N_{b,Rd}$	48.54	3.02	16.07
				Factor	**1.39**

CALCULATION SHEET	Project :	Apollo X-beam Box		
	Element :	12m X-Beam Box Results		
	Job Number :	X0016	By:anw	Date: Jan 17
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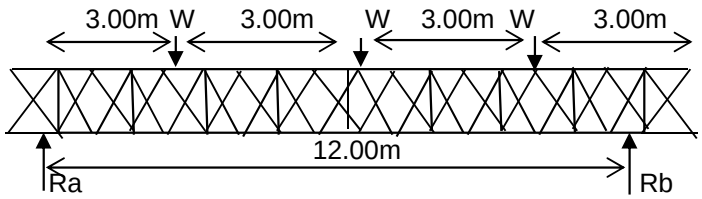
ALAN WHITE DESIGN



Max Moment= WL/2

so for ultimate condition

W= 1.50*10
15.00 kN

apply factor from above

Wf= 15.00*1.39
= 20.85 kN

so maximum moment is as above

Ultimate Mu= Wf*12/2
= (20.85*12)/2
= 125.10 kNm

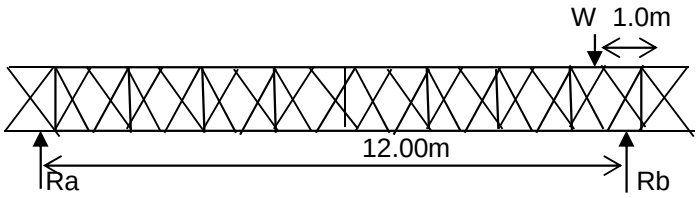
and for allowable value

allowable max moment= 125.10/1.50
= 83.40 kNm

Moment values	**Ultimate**	**125.10 kNm**
	Allowable	**83.40 kNm**

Load Comb. 5 End Shear 10kN load applied at 1.0m distance from the support

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	Moment	$M_{c,Rd}$	1.06	0.04	24.20
	Co-exist Axial	$N_{b,Rd}$	93.73	6.96	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	9.34
	Shear	V_{Rd}	27.56	0.17	167.00
	Tension	$N_{o,Rd}$	93.96	4.68	20.08
	Co-exist Moment	$M_{c,Rd}$	1.06	0.01	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	16.91
	Compression	$N_{b,Rd}$	93.73	10.95	8.56
	Co-exist Moment	$M_{c,Rd}$	1.06	0.01	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	8.08
	Deflection	d	120.00	1.00	120.00
Vertical	Moment	$M_{c,Rd}$	1.06	0.03	39.44
	Shear	V_{Rd}	27.56	0.07	405.23
	Tension	$N_{o,Rd}$	86.77	2.70	32.14
	Compression	$N_{b,Rd}$	85.52	0.01	8,551.85
	Combined Axial	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	19.34
Diagonal	Tension	$N_{o,Rd}$	48.72	6.28	7.76
	Compression	$N_{b,Rd}$	48.48	6.69	7.25
Cross member	Moment	$M_{c,Rd}$	0.87	0.01	86.77
	Shear	V_{Rd}	22.67	0.01	2,267.41
	Tension	$N_{o,Rd}$	86.77	1.51	57.46
	Compression	$N_{b,Rd}$	86.69	0.28	309.61
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	73.60
Brace	Tension	$N_{o,Rd}$	48.72	0.57	85.47
	Compression	$N_{b,Rd}$	48.54	3.05	15.92
				Factor	**7.25**



Max Shear Rb= W*11/12

so for ultimate condition

W= 1.50*10
15.00 kN

apply factor from above

Wf= 15*7.25
= 108.75 kN

so maximum shear is as above

Ultimate Qu= Wf*11/12
= 108.75*11/12
= 99.69 kN

and for allowable value

allowable max shear= 99.69/1.50
= 66.46 kN

Shear values	**Ultimate**	**99.69 kN**
	Allowable	**66.46 kN**

CALCULATION SHEET	Project :	Apollo X-beam Box		
	Element :	12m X-Beam Box Results		
	Job Number :	X0016	By: anw	Date: Jan 17
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ALAN WHITE DESIGN

12.0m X-BEAM BOX

Loadcase No.		Ultimate Moment	Allowable Moment
1	UDL	126.90	84.60
2	Point	117.90	78.60
3	Third	115.80	77.20
4	Quarter	125.10	83.40

Loadcase No.		Ultimate Shear	Allowable Shear
5	End Shear	99.69	66.46

Max Allowable Moment = 77.20 kNm

Max Allowable Shear = 66.46 kN

CALCULATION SHEET	Project :	Apollo X-beam Box			AWD ALAN WHITE DESIGN
	Element :	15m X-Beam Box Results			
	Job Number :	X0016	By: anw	Date: Jan 17	
	Document No :	001A	Checked:mmr	Date: Jan 17	

15m X-Beam Box Results

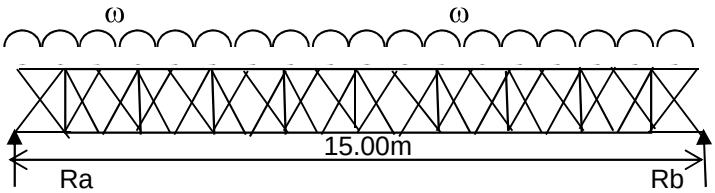
CALCULATION SHEET	Project :	Apollo X-beam Box			AWD ALAN WHITE DESIGN
	Element :	15m X-Beam Box Results			
	Job Number :	X0016	By: anw	Date: Jan 17	
	Document No :	001A	Checked:mmr	Date: Jan 17	

Load Comb. 1 UDL load 10kN/m applied along beam

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	**Moment**	$M_{c,Rd}$	1.06	0.29	3.63
	Co-exist Axial	$N_{b,Rd}$	93.96	96.51	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		0.39	0.38
	Shear	V_{Rd}	27.56	2.56	10.76
	Tension	$N_{o,Rd}$	93.96	99.65	0.94
	Co-exist Moment	$M_{c,Rd}$	1.06	0.29	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	0.79
	Compression	$N_{b,Rd}$	93.73	303.75	0.31
	Co-exist Moment	$M_{c,Rd}$	1.06	0.16	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	0.30
	Deflection	d	150.00	284.00	0.53
Vertical	Moment	$M_{c,Rd}$	0.87	0.62	1.40
	Shear	V_{Rd}	22.67	0.36	63.87
	Tension	$N_{o,Rd}$	86.77	15.62	5.55
	Compression	$N_{b,Rd}$	85.52	0.01	8,551.85
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	1.21
Diagonal	Tension	$N_{o,Rd}$	48.72	30.47	1.60
	Compression	$N_{b,Rd}$	48.48	54.83	0.88
Cross member	Moment	$M_{c,Rd}$	0.87	0.01	86.77
	Shear	V_{Rd}	22.67	0.01	2,267.41
	Tension	$N_{o,Rd}$	86.77	7.23	12.00
	Compression	$N_{b,Rd}$	86.69	7.17	12.09
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	10.95
Brace	Tension	$N_{o,Rd}$	48.72	14.58	3.34
	Compression	$N_{b,Rd}$	48.54	14.63	3.32
				Factor	**0.30**

CALCULATION SHEET	Project :	Apollo X-beam Box		
	Element :	15m X-Beam Box Results		
	Job Number :	X0016	By: anw	Date: Jan 17
	Document No :	001A	Checked:mmr	Date: Jan 17

ALAN WHITE DESIGN



Max Moment= $WL^2/8$

so for ultimate condition

W= 1.5*10
15.00 kN

apply factor from above

Wf= 15*0.30
= 4.50 kN

so maximum moment is as above

Ultimate Mu= Wf*15^2/8
= (4.50*15^2)/8
= 126.56 kNm

and for allowable value

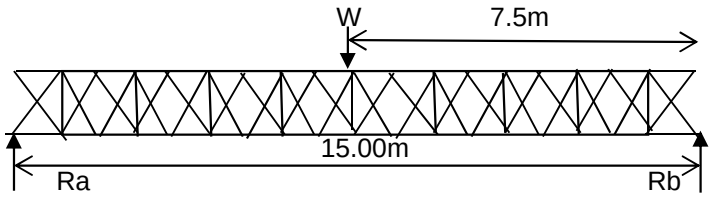
allowable max moment= 126.56/1.50
= 84.37 kNm

Moment values	**Ultimate**	**126.56 kNm**
	Allowable	**84.37 kNm**

CALCULATION SHEET	Project :	Apollo X-beam Box			AWD ALAN WHITE DESIGN
	Element :	15m X-Beam Box Results			
	Job Number :	X0016	By: anw	Date: Jan 17	
	Document No :	001A	Checked:mmr	Date: Jan 17	

Load Comb. 2 Point load 10kN load applied at midspan of beam

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	**Moment**	$M_{c,Rd}$	1.06	0.06	16.90
	Co-exist Axial	$N_{b,Rd}$	93.73	43.95	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	1.95
	Shear	V_{Rd}	27.56	0.14	194.05
	Tension	$N_{o,Rd}$	93.96	20.45	4.59
	Co-exist Moment	$M_{c,Rd}$	1.06	0.04	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	4.03
	Compression	$N_{b,Rd}$	93.73	43.95	2.13
	Co-exist Moment	$M_{c,Rd}$	1.06	0.06	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	1.95
	Deflection	d	150.00	19.00	7.89
Vertical	Moment	$M_{c,Rd}$	0.87	0.02	57.85
	Shear	V_{Rd}	22.67	0.04	629.84
	Tension	$N_{o,Rd}$	86.77	1.71	50.74
	Compression	$N_{b,Rd}$	85.52	2.79	30.65
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	21.59
Diagonal	Tension	$N_{o,Rd}$	48.72	2.86	17.03
	Compression	$N_{b,Rd}$	48.48	5.00	9.70
Cross member	Moment	$M_{c,Rd}$	0.87	0.01	86.77
	Shear	V_{Rd}	22.67	0.01	2,267.41
	Tension	$N_{o,Rd}$	86.77	0.42	206.59
	Compression	$N_{b,Rd}$	86.69	0.90	96.32
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	50.13
Brace	Tension	$N_{o,Rd}$	48.72	1.83	26.62
	Compression	$N_{b,Rd}$	48.54	0.86	56.65
				Factor	**1.95**



Max Moment= WL/4

so for ultimate condition

W= 1.50*10
= 15.00 kN

apply factor from above

Wf= 15*1.95
= 29.25 kN

so maximum moment is as above

Ultimate Mu= Wf*15/4
= 29.25*15/4
= 109.69 kNm

and for allowable value

allowable max moment= 109.69/1.50
= 73.13 kNm

Moment values	**Ultimate**	**109.69 kNm**
	Allowable	**73.13 kNm**

CALCULATION SHEET	Project :	Apollo X-beam Box			AWD ALAN WHITE DESIGN
	Element :	15m X-Beam Box Results			
	Job Number :	X0016	By: anw	Date: Jan 17	
	Document No :	001A	Checked:mmr	Date: Jan 17	

Load Comb. 3 PL at third points
10kN load applied at each of the two third points

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	**Moment**	$M_{c,Rd}$	1.06	0.06	18.36
	Co-exist Axial	$N_{b,Rd}$	93.73	53.73	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	1.63
	Shear	V_{Rd}	27.56	0.16	173.30
	Tension	$N_{o,Rd}$	93.96	19.85	4.73
	Co-exist Moment	$M_{c,Rd}$	1.06	0.04	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	4.19
	Compression	$N_{b,Rd}$	93.73	58.78	1.59
	Co-exist Moment	$M_{c,Rd}$	1.06	0.05	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	1.51
	Deflection	d	150.00	31.60	4.75
Vertical	Moment	$M_{c,Rd}$	0.87	0.03	28.92
	Shear	V_{Rd}	22.67	0.07	319.35
	Tension	$N_{o,Rd}$	86.77	3.13	27.72
	Compression	$N_{b,Rd}$	85.52	0.01	8,551.85
	Combined Axial	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	15.51
Diagonal	Tension	$N_{o,Rd}$	48.72	5.16	9.44
	Compression	$N_{b,Rd}$	48.48	8.76	5.53
Cross member	Moment	$M_{c,Rd}$	0.87	0.01	86.77
	Shear	V_{Rd}	22.67	0.01	2,267.41
	Tension	$N_{o,Rd}$	86.77	0.82	105.81
	Compression	$N_{b,Rd}$	86.69	1.49	58.18
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	37.82
Brace	Tension	$N_{o,Rd}$	48.72	3.02	16.13
	Compression	$N_{b,Rd}$	48.54	1.67	29.07
				Factor	**1.51**

CALCULATION SHEET	Project :	Apollo X-beam Box		
	Element :	15m X-Beam Box Results		
	Job Number :	X0016	By: anw	Date: Jan 17
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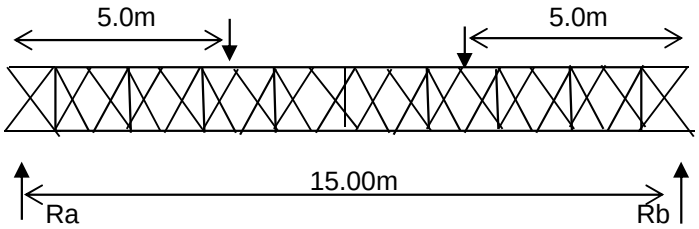
ALAN WHITE DESIGN



Max Moment= WL/3

so for ultimate condition

W= 1.50*10
15.00 kN

apply factor from above

Wf= 15.00*1.51
= 22.65 kN

so maximum moment is as above

Ultimate Mu= Wf*15/3
= (22.65*15)/3
= 113.25 kNm

and for allowable value

allowable max moment= 113.25/1.50
= 75.50 kNm

Moment values	**Ultimate**	**113.25 kNm**
	Allowable	**75.50 kNm**

CALCULATION SHEET	Project :	Apollo X-beam Box			AWD ALAN WHITE DESIGN
	Element :	15m X-Beam Box Results			
	Job Number :	X0016	By: anw	Date: Jan 17	
	Document No :	001A	Checked:mmr	Date: Jan 17	

Load Comb. 4 PL at quarter points
10kN load applied at each of the three quarter points

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	Moment	$M_{c,Rd}$	1.06	0.11	9.95
	Co-exist Axial	$N_{b,Rd}$	93.73	86.47	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	1.00
	Shear	V_{Rd}	27.56	0.24	114.34
	Tension	$N_{o,Rd}$	93.96	31.40	2.99
	Co-exist Moment	$M_{c,Rd}$	1.06	0.09	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	2.53
	Compression	$N_{b,Rd}$	93.73	86.47	1.08
	Co-exist Moment	$M_{c,Rd}$	1.06	0.11	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	1.00
	Deflection	d	150.00	45.50	3.30
Vertical	Moment	$M_{c,Rd}$	0.87	0.04	22.25
	Shear	V_{Rd}	22.67	0.10	224.50
	Tension	$N_{o,Rd}$	86.77	4.12	21.06
	Compression	$N_{b,Rd}$	85.52	2.21	38.70
	Combined Axial	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	15.56
Diagonal	Tension	$N_{o,Rd}$	48.72	7.45	6.54
	Compression	$N_{b,Rd}$	48.48	12.51	3.88
Cross member	Moment	$M_{c,Rd}$	0.87	0.01	86.77
	Shear	V_{Rd}	22.67	0.01	2,267.41
	Tension	$N_{o,Rd}$	86.77	1.22	71.12
	Compression	$N_{b,Rd}$	86.69	2.08	41.68
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	30.23
Brace	Tension	$N_{o,Rd}$	48.72	4.24	11.49
	Compression	$N_{b,Rd}$	48.54	2.48	19.57
				Factor	**1.00**

CALCULATION SHEET	Project :	Apollo X-beam Box		
	Element :	15m X-Beam Box Results		
	Job Number :	X0016	By: anw	Date: Jan 17
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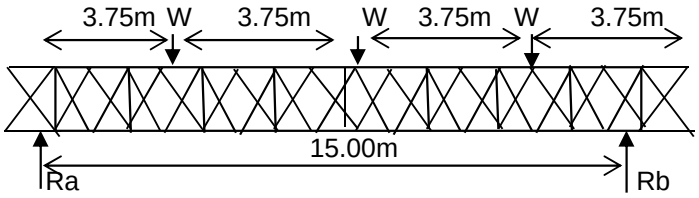
ALAN WHITE DESIGN



Max Moment= WL/2

so for ultimate condition

W= 1.50*10
15.00 kN

apply factor from above

Wf= 15.00*1.00
= 15.00 kN

so maximum moment is as above

Ultimate Mu= Wf*15/2
= (15.0*15)/2
= 112.50 kNm

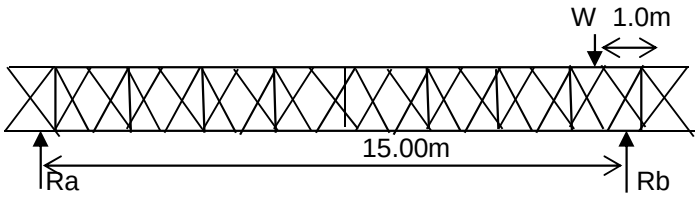
and for allowable value

allowable max moment= 112.50/1.50
= 75.00 kNm

Moment values	**Ultimate**	**112.50 kNm**
	Allowable	**75.00 kNm**

Load Comb. 5 End Shear 10kN load applied at 1.0m distance from the support

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	Moment	$M_{c,Rd}$	1.06	0.04	24.76
	Co-exist Axial	$N_{b,Rd}$	93.73	7.32	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	9.10
	Shear	V_{Rd}	27.56	0.16	168.02
	Tension	$N_{o,Rd}$	93.96	3.86	24.34
	Co-exist Moment	$M_{c,Rd}$	1.06	0.12	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	7.12
	Compression	$N_{b,Rd}$	93.73	12.18	7.69
	Co-exist Moment	$M_{c,Rd}$	1.06	0.01	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	7.30
	Deflection	d	150.00	3.00	50.00
Vertical	Moment	$M_{c,Rd}$	0.87	0.03	32.14
	Shear	V_{Rd}	22.67	0.07	323.92
	Tension	$N_{o,Rd}$	86.77	2.81	30.88
	Compression	$N_{b,Rd}$	85.52	0.01	8,551.85
	Combined Axial	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	17.26
Diagonal	Tension	$N_{o,Rd}$	48.72	3.36	14.50
	Compression	$N_{b,Rd}$	48.48	6.89	7.04
Cross member	Moment	$M_{c,Rd}$	0.87	0.01	86.77
	Shear	V_{Rd}	22.67	0.01	2,267.41
	Tension	$N_{o,Rd}$	86.77	1.54	56.34
	Compression	$N_{b,Rd}$	86.69	0.33	262.70
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	37.05
Brace	Tension	$N_{o,Rd}$	48.72	0.68	71.65
	Compression	$N_{b,Rd}$	48.54	3.13	15.51
				Factor	**7.04**



Max Shear Rb= W*14/15

so for ultimate condition

W= 1.50*10
15.00 kN

apply factor from above

Wf= 15*7.04
= 105.60 kN

so maximum shear is as above

Ultimate Qu= Wf*14/15
= 105.60*14/15
= 98.56 kN

and for allowable value

allowable max shear= 98.56/1.50
= 65.71 kN

Shear values	**Ultimate**	**98.56 kN**
	Allowable	**65.71 kN**

CALCULATION SHEET	Project :	Apollo X-beam Box		
	Element :	15m X-Beam Box Results		
	Job Number :	X0016	By: anw	Date: Jan 17
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ALAN WHITE DESIGN

15.0m X-BEAM BOX		
Loadcase No.	**Ultimate Moment**	**Allowable Moment**
1 UDL	126.56	84.37
2 Point	109.69	73.13
3 Third	113.25	75.50
4 Quarter	112.50	75.00

Loadcase No.	**Ultimate Shear**	**Allowable Shear**
5 End Shear	98.56	65.71

Max Allowable Moment = 73.13 kNm

Max Allowable Shear = 65.71 kN

CALCULATION SHEET	Project :	Apollo X-beam Box		
	Element :	18m X-Beam Box Results		
	Job Number :	X0016	By: anw	Date: Jan 17
	Document No :	001A	Checked:mmr	Date: Jan 17

AWD
ALAN WHITE DESIGN

18m X-Beam Box Results

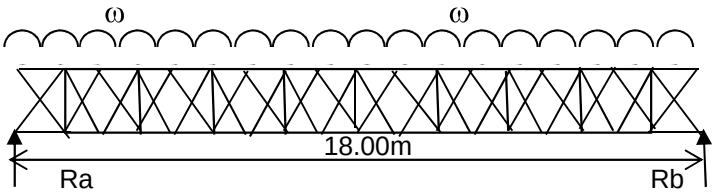
CALCULATION SHEET	Project :	Apollo X-beam Box		
	Element :	18m X-Beam Box Results		
	Job Number :	X0016	By: anw	Date: Jan 17
	Document No :	001A	Checked:mmr	Date: Jan 17

ALAN WHITE DESIGN

Load Comb. 1 UDL load 10kN/m applied along beam

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	**Moment**	$M_{c,Rd}$	1.06	0.42	2.53
	Co-exist Axial	$N_{b,Rd}$	93.96	135.70	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	0.57
	Shear	V_{Rd}	27.56	2.89	9.55
	Tension	$N_{o,Rd}$	93.96	149.80	0.63
	Co-exist Moment	$M_{c,Rd}$	1.06	0.33	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	0.55
	Compression	$N_{b,Rd}$	93.73	435.41	0.22
	Co-exist Moment	$M_{c,Rd}$	1.06	0.22	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	0.21
	Deflection	d	180.00	351.00	0.51
Vertical	Moment	$M_{c,Rd}$	0.87	0.22	3.96
	Shear	V_{Rd}	22.67	0.47	48.76
	Tension	$N_{o,Rd}$	86.77	21.35	4.06
	Compression	$N_{b,Rd}$	85.52	0.01	8,551.85
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	2.20
Diagonal	Tension	$N_{o,Rd}$	48.72	37.45	1.30
	Compression	$N_{b,Rd}$	48.48	68.76	0.71
Cross member	Moment	$M_{c,Rd}$	0.87	0.01	86.77
	Shear	V_{Rd}	22.67	0.01	2,267.41
	Tension	$N_{o,Rd}$	86.77	7.42	11.69
	Compression	$N_{b,Rd}$	86.69	10.54	8.22
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	7.68
Brace	Tension	$N_{o,Rd}$	48.72	21.43	2.27
	Compression	$N_{b,Rd}$	48.54	15.02	3.23
				Factor	**0.21**

CALCULATION SHEET	Project :	Apollo X-beam Box			AWD ALAN WHITE DESIGN
	Element :	18m X-Beam Box Results			
	Job Number :	X0016	By: anw	Date: Jan 17	
	Document No :	001A	Checked:mmr	Date: Jan 17	



Max Moment= $WL^2/8$

so for ultimate condition

W= 1.5*10

15.00 kN

apply factor from above

Wf= 15*0.21

= 3.15 kN

so maximum moment is as above

Ultimate Mu= Wf*18^2/8

= (3.15*18^2)/8

= 127.58 kNm

and for allowable value

allowable max moment= 127.58/1.50

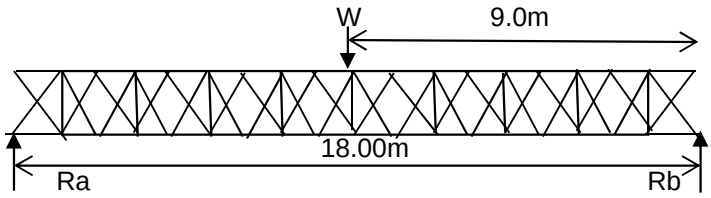
= 85.05 kNm

Moment values	**Ultimate**	**127.58 kNm**
	Allowable	**85.05 kNm**

CALCULATION SHEET	Project :	Apollo X-beam Box			AWD ALAN WHITE DESIGN
	Element :	18m X-Beam Box Results			
	Job Number :	X0016	By: anw	Date: Jan 17	
	Document No :	001A	Checked:mmr	Date: Jan 17	

Load Comb. 2 Point load 10kN load applied at midspan of beam

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	**Moment**	$M_{c,Rd}$	1.06	0.05	20.88
	Co-exist Axial	$N_{b,Rd}$	93.73	46.28	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	1.89
	Shear	V_{Rd}	27.56	0.12	239.61
	Tension	$N_{o,Rd}$	93.96	26.23	3.58
	Co-exist Moment	$M_{c,Rd}$	1.06	0.05	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	3.20
	Compression	$N_{b,Rd}$	93.73	53.40	1.76
	Co-exist Moment	$M_{c,Rd}$	1.06	0.05	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	1.66
	Deflection	d	180.00	33.00	5.45
Vertical	Moment	$M_{c,Rd}$	0.87	0.02	48.20
	Shear	V_{Rd}	22.67	0.04	581.39
	Tension	$N_{o,Rd}$	86.77	2.02	42.95
	Compression	$N_{b,Rd}$	85.52	0.01	8,551.85
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	24.86
Diagonal	Tension	$N_{o,Rd}$	48.72	2.99	16.29
	Compression	$N_{b,Rd}$	48.48	5.49	8.83
Cross member	Moment	$M_{c,Rd}$	0.87	0.01	86.77
	Shear	V_{Rd}	22.67	0.01	2,267.41
	Tension	$N_{o,Rd}$	86.77	0.33	262.93
	Compression	$N_{b,Rd}$	86.69	1.11	78.10
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	44.99
Brace	Tension	$N_{o,Rd}$	48.72	2.26	21.56
	Compression	$N_{b,Rd}$	48.54	0.67	72.72
				Factor	**1.66**



Max Moment= WL/4

so for ultimate condition

W= 1.50*10
= 15.00 kN

apply factor from above

Wf= 15*1.66
= 24.90 kN

so maximum moment is as above

Ultimate Mu= Wf*18/4
= 24.90*18/4
= 112.05 kNm

and for allowable value

allowable max moment= 112.50/1.50
= 75.00 kNm

Moment values	**Ultimate**	**112.05**	**kNm**
	Allowable	**75.00**	**kNm**

CALCULATION SHEET	Project :	Apollo X-beam Box			AWD ALAN WHITE DESIGN
	Element :	18m X-Beam Box Results			
	Job Number :	X0016	By: anw	Date: Jan 17	
	Document No :	001A	Checked:mmr	Date: Jan 17	

Load Comb. 3 PL at third points
10kN load applied at each of the two third points

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	**Moment**	$M_{c,Rd}$	1.06	0.07	15.00
	Co-exist Axial	$N_{b,Rd}$	93.73	71.51	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	1.23
	Shear	V_{Rd}	27.56	0.19	147.35
	Tension	$N_{o,Rd}$	93.96	24.59	3.82
	Co-exist Moment	$M_{c,Rd}$	1.06	0.05	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	3.34
	Compression	$N_{b,Rd}$	93.73	71.89	1.30
	Co-exist Moment	$M_{c,Rd}$	1.06	0.06	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	1.24
	Deflection	d	180.00	54.00	3.33
Vertical	Moment	$M_{c,Rd}$	0.87	0.03	27.99
	Shear	V_{Rd}	22.67	0.07	314.92
	Tension	$N_{o,Rd}$	86.77	3.36	25.82
	Compression	$N_{b,Rd}$	85.52	0.01	8,551.85
	Combined Axial	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	14.71
Diagonal	Tension	$N_{o,Rd}$	48.72	5.28	9.23
	Compression	$N_{b,Rd}$	48.48	9.42	5.15
Cross member	Moment	$M_{c,Rd}$	0.87	0.01	86.77
	Shear	V_{Rd}	22.67	0.01	2,267.41
	Tension	$N_{o,Rd}$	86.77	0.65	133.49
	Compression	$N_{b,Rd}$	86.77	1.81	47.94
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	33.30
Brace	Tension	$N_{o,Rd}$	48.72	3.69	13.20
	Compression	$N_{b,Rd}$	48.54	1.32	36.78
				Factor	**1.23**

CALCULATION SHEET	Project :	Apollo X-beam Box		
	Element :	18m X-Beam Box Results		
	Job Number :	X0016	By: anw	Date: Jan 17
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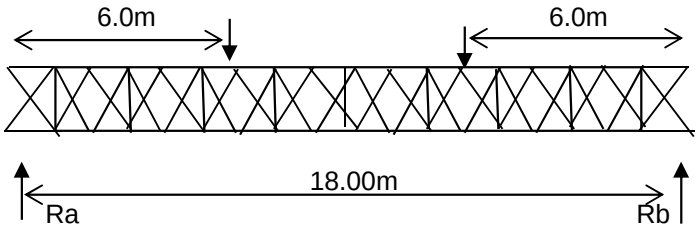
ALAN WHITE DESIGN



Max Moment= WL/3

so for ultimate condition

W= 1.50*10
15.00 kN

apply factor from above

Wf= 15.00*1.23
= 18.45 kN

so maximum moment is as above

Ultimate Mu= Wf*18/3
= (18.45*18)/3
= 110.70 kNm

and for allowable value

allowable max moment= 110.70/1.50
= 73.80 kNm

Moment values	**Ultimate**	**110.70 kNm**
	Allowable	**73.80 kNm**

CALCULATION SHEET	Project :	Apollo X-beam Box			AWD ALAN WHITE DESIGN
	Element :	18m X-Beam Box Results			
	Job Number :	X0016	By: anw	Date: Jan 17	
	Document No :	001A	Checked:mmr	Date: Jan 17	

Load Comb. 4 PL at quarter points
10kN load applied at each of the three quarter points

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	Moment	$M_{c,Rd}$	1.06	0.12	9.18
	Co-exist Axial	$N_{b,Rd}$	93.96	73.34	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	1.16
	Shear	V_{Rd}	27.56	0.30	90.94
	Tension	$N_{o,Rd}$	93.96	38.69	2.43
	Co-exist Moment	$M_{c,Rd}$	1.06	0.08	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	2.13
	Compression	$N_{b,Rd}$	93.73	100.46	0.93
	Co-exist Moment	$M_{c,Rd}$	1.06	0.06	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	0.90
	Deflection	d	180.00	75.00	2.40
Vertical	Moment	$M_{c,Rd}$	0.87	0.04	19.72
	Shear	V_{Rd}	22.67	0.10	236.19
	Tension	$N_{o,Rd}$	86.77	4.65	18.66
	Compression	$N_{b,Rd}$	85.52	2.03	42.13
	Combined Axial	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	14.76
Diagonal	Tension	$N_{o,Rd}$	48.72	7.57	6.44
	Compression	$N_{b,Rd}$	48.48	13.27	3.65
Cross member	Moment	$M_{c,Rd}$	0.87	0.01	86.77
	Shear	V_{Rd}	22.67	0.01	2,267.41
	Tension	$N_{o,Rd}$	86.77	1.01	85.91
	Compression	$N_{b,Rd}$	86.69	2.47	35.10
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	26.67
Brace	Tension	$N_{o,Rd}$	48.72	5.02	9.71
	Compression	$N_{b,Rd}$	48.54	2.05	23.68
				Factor	**0.90**

CALCULATION SHEET	Project :	Apollo X-beam Box		
	Element :	18m X-Beam Box Results		
	Job Number :	X0016	By: anw	Date: Jan 17
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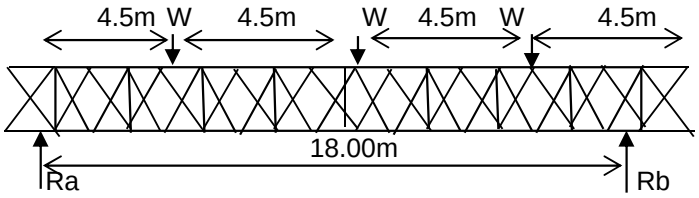
ALAN WHITE DESIGN



Max Moment= WL/2

so for ultimate condition

W= 1.50*10
15.00 kN

apply factor from above

Wf= 15.00*0.90
= 13.50 kN

so maximum moment is as above

Ultimate Mu= Wf*18/2
= (13.50*18)/2
= 121.50 kNm

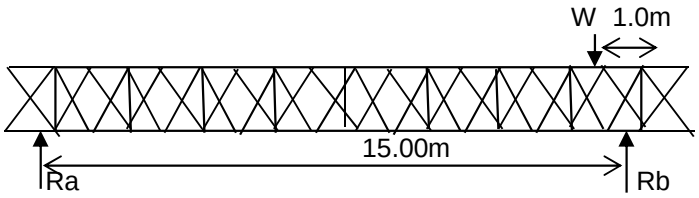
and for allowable value

allowable max moment= 121.50/1.50
= 81.00 kNm

Moment values	**Ultimate**	**121.50 kNm**
	Allowable	**81.00 kNm**

Load Comb. 5 End Shear 10kN load applied at 1.0m distance from the support

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	Moment	$M_{c,Rd}$	1.06	0.04	25.35
	Co-exist Axial	$N_{b,Rd}$	93.73	7.63	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	8.89
	Shear	V_{Rd}	27.56	0.16	170.09
	Tension	$N_{o,Rd}$	93.96	3.93	23.91
	Co-exist Moment	$M_{c,Rd}$	1.06	0.01	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	20.42
	Compression	$N_{b,Rd}$	93.73	14.22	6.59
	Co-exist Moment	$M_{c,Rd}$	1.06	0.01	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	6.31
	Deflection	d	180.00	5.00	36.00
Vertical	Moment	$M_{c,Rd}$	0.87	0.03	29.92
	Shear	V_{Rd}	22.67	0.08	298.34
	Tension	$N_{o,Rd}$	86.77	2.92	29.72
	Compression	$N_{b,Rd}$	85.52	0.01	8,551.85
	Combined Axial	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	16.33
Diagonal	Tension	$N_{o,Rd}$	48.72	3.40	14.33
	Compression	$N_{b,Rd}$	48.48	7.07	6.86
Cross member	Moment	$M_{c,Rd}$	0.87	0.01	86.77
	Shear	V_{Rd}	22.67	0.01	2,267.41
	Tension	$N_{o,Rd}$	86.77	1.56	55.62
	Compression	$N_{b,Rd}$	86.69	0.40	216.72
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	67.90
Brace	Tension	$N_{o,Rd}$	48.72	0.81	60.15
	Compression	$N_{b,Rd}$	48.54	3.16	15.36
				Factor	**6.31**



Max Shear Rb= W*17/18

so for ultimate condition

W= 1.50*10
15.00 kN

apply factor from above

Wf= 15*6.31
= 94.65 kN

so maximum shear is as above

Ultimate Qu= Wf*17/18
= 94.65*17/18
= 89.39 kN

and for allowable value

allowable max shear= 89.39/1.50
= 59.59 kN

Shear values	**Ultimate**	**89.39 kN**
	Allowable	**59.59 kN**

CALCULATION SHEET	Project :	Apollo X-beam Box		
	Element :	18m X-Beam Box Results		
	Job Number :	X0016	By: anw	Date: Jan 17
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ALAN WHITE DESIGN

18.0m X-BEAM BOX

Loadcase No.		Ultimate Moment	Allowable Moment
1	UDL	127.58	85.05
2	Point	112.05	75.00
3	Third	110.70	73.80
4	Quarter	121.50	81.00

Loadcase No.		Ultimate Shear	Allowable Shear
5	End Shear	89.39	59.59

Max Allowable Moment = 73.80 kNm

Max Allowable Shear = 59.59 kN

CALCULATION SHEET	Project :	Apollo X-beam Box			AWD ALAN WHITE DESIGN
	Element :	21m X-Beam Box Results			
	Job Number :	X0016	By: anw	Date: Jan 17	
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21m X-Beam Box Results

CALCULATION SHEET	Project :	Apollo X-beam Box		
	Element :	21m X-Beam Box Results		
	Job Number :	X0016	By: anw	Date: Jan 17
	Document No :	001A	Checked:mmr	Date: Jan 17

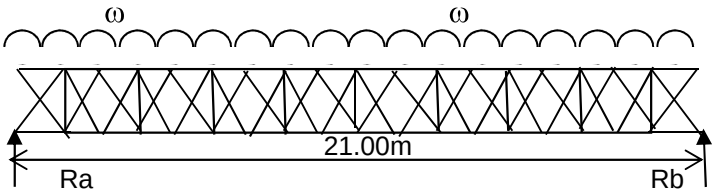
ALAN WHITE DESIGN

Load Comb. 1 UDL load 10kN/m applied along beam

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	**Moment**	$M_{c,Rd}$	1.06	0.58	1.84
	Co-exist Axial	$N_{b,Rd}$	93.96	196.02	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	0.40
	Shear	V_{Rd}	27.56	3.26	8.45
	Tension	$N_{o,Rd}$	93.96	196.09	0.48
	Co-exist Moment	$M_{c,Rd}$	1.06	0.43	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	0.42
	Compression	$N_{b,Rd}$	93.73	595.86	0.16
	Co-exist Moment	$M_{c,Rd}$	1.06	0.43	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	0.15
	Deflection	d	210.00	644.00	0.33
Vertical	Moment	$M_{c,Rd}$	0.87	0.24	3.59
	Shear	V_{Rd}	22.67	0.53	42.54
	Tension	$N_{o,Rd}$	86.77	27.89	3.11
	Compression	$N_{b,Rd}$	85.52	0.01	8,551.85
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	1.82
Diagonal	Tension	$N_{o,Rd}$	48.72	44.30	1.10
	Compression	$N_{b,Rd}$	48.48	83.35	0.58
Cross member	Moment	$M_{c,Rd}$	0.87	0.01	86.77
	Shear	V_{Rd}	22.67	0.01	2,267.41
	Tension	$N_{o,Rd}$	86.77	7.22	12.02
	Compression	$N_{b,Rd}$	86.69	14.53	5.97
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		0.04	0.47
Brace	Tension	$N_{o,Rd}$	48.72	29.53	1.65
	Compression	$N_{b,Rd}$	48.54	14.61	3.32
				Factor	**0.15**

CALCULATION SHEET	Project :	Apollo X-beam Box		
	Element :	21m X-Beam Box Results		
	Job Number :	X0016	By: anw	Date: Jan 17
	Document No :	001A	Checked:mmr	Date: Jan 17

ALAN WHITE DESIGN



Max Moment= $WL^2/8$

so for ultimate condition

W= 1.5*10
15.00 kN

apply factor from above

Wf= 15*0.15
= 2.25 kN

so maximum moment is as above

Ultimate Mu= Wf*21^2/8
= (2.25*21^2)/8
= 124.03 kNm

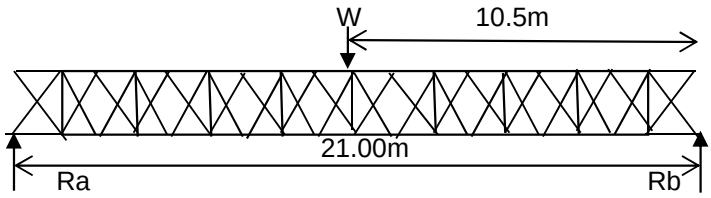
and for allowable value

allowable max moment= 124.03/1.50
= 82.69 kNm

Moment values	**Ultimate**	**124.03 kNm**
	Allowable	**82.69 kNm**

Load Comb. 2 Point load 10kN load applied at midspan of beam

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	**Moment**	$M_{c,Rd}$	1.06	0.08	12.83
	Co-exist Axial	$N_{b,Rd}$	93.73	65.28	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	1.33
	Shear	V_{Rd}	27.56	0.18	154.81
	Tension	$N_{o,Rd}$	93.96	30.17	3.11
	Co-exist Moment	$M_{c,Rd}$	1.06	0.06	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	2.73
	Compression	$N_{b,Rd}$	93.73	65.28	1.44
	Co-exist Moment	$M_{c,Rd}$	1.06	0.08	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	1.33
	Deflection	d	210.00	52.00	4.04
Vertical	Moment	$M_{c,Rd}$	0.87	0.02	51.04
	Shear	V_{Rd}	22.67	0.04	581.39
	Tension	$N_{o,Rd}$	86.77	2.33	37.24
	Compression	$N_{b,Rd}$	85.52	2.58	33.15
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	21.80
Diagonal	Tension	$N_{o,Rd}$	48.72	3.10	15.72
	Compression	$N_{b,Rd}$	48.48	5.97	8.12
Cross member	Moment	$M_{c,Rd}$	0.87	0.01	86.77
	Shear	V_{Rd}	22.67	0.01	2,267.41
	Tension	$N_{o,Rd}$	86.77	0.23	377.25
	Compression	$N_{b,Rd}$	86.69	1.33	65.18
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	40.56
Brace	Tension	$N_{o,Rd}$	48.72	2.71	17.98
	Compression	$N_{b,Rd}$	48.54	0.46	105.91
				Factor	**1.33**



Max Moment= WL/4

so for ultimate condition

W= 1.50*10
= 15.00 kN

apply factor from above

Wf= 15*1.33
= 19.95 kN

so maximum moment is as above

Ultimate Mu= Wf*21/4
= 19.95*21/4
= 104.74 kNm

and for allowable value

allowable max moment= 104.74/1.50
= 69.83 kNm

Moment values	**Ultimate**	**104.74 kNm**
	Allowable	**69.83 kNm**

CALCULATION SHEET	Project :	Apollo X-beam Box			AWD ALAN WHITE DESIGN
	Element :	21m X-Beam Box Results			
	Job Number :	X0016	By: anw	Date: Jan 17	
	Document No :	001A	Checked:mmr	Date: Jan 17	

Load Comb. 3 PL at third points
10kN load applied at each of the two third points

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	**Moment**	$M_{c,Rd}$	1.06	0.01	92.60
	Co-exist Axial	$N_{b,Rd}$	93.96	86.79	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	1.07
	Shear	V_{Rd}	27.56	0.27	102.82
	Tension	$N_{o,Rd}$	93.96	32.86	2.86
	Co-exist Moment	$M_{c,Rd}$	1.06	0.07	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	2.52
	Compression	$N_{b,Rd}$	93.73	90.78	1.03
	Co-exist Moment	$M_{c,Rd}$	1.06	0.08	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	0.98
	Deflection	d	210.00	89.00	2.36
Vertical	Moment	$M_{c,Rd}$	0.87	0.03	28.92
	Shear	V_{Rd}	22.67	0.07	333.44
	Tension	$N_{o,Rd}$	86.77	3.92	22.13
	Compression	$N_{b,Rd}$	85.52	2.15	39.78
	Combined Axial	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	13.67
Diagonal	Tension	$N_{o,Rd}$	48.72	5.38	9.06
	Compression	$N_{b,Rd}$	48.48	10.16	4.77
Cross member	Moment	$M_{c,Rd}$	0.87	0.01	86.77
	Shear	V_{Rd}	22.67	0.01	2,267.41
	Tension	$N_{o,Rd}$	86.77	0.44	197.20
	Compression	$N_{b,Rd}$	86.69	2.22	39.05
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	28.84
Brace	Tension	$N_{o,Rd}$	48.72	4.51	10.80
	Compression	$N_{b,Rd}$	48.54	0.89	54.54
				Factor	**0.98**

CALCULATION SHEET	Project :	Apollo X-beam Box		
	Element :	21m X-Beam Box Results		
	Job Number :	X0016	By: anw	Date: Jan 17
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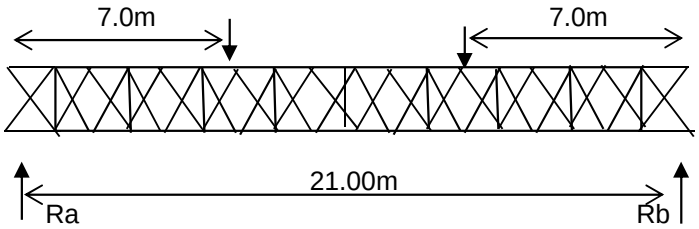
ALAN WHITE DESIGN



Max Moment= WL/3

so for ultimate condition

W= 1.50*10
15.00 kN

apply factor from above

Wf= 15.00*0.98
= 14.70 kN

so maximum moment is as above

Ultimate Mu= Wf*21/3
= (14.70*21)/3
= 102.90 kNm

and for allowable value

allowable max moment= 102.90/1.50
= 68.60 kNm

Moment values	**Ultimate**	**102.90 kNm**
	Allowable	**68.60 kNm**

CALCULATION SHEET	Project :	Apollo X-beam Box			AWD ALAN WHITE DESIGN
	Element :	21m X-Beam Box Results			
	Job Number :	X0016	By: anw	Date: Jan 17	
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Load Comb. 4 PL at quarter points
10kN load applied at each of the three quarter points

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	Moment	$M_{c,Rd}$	1.06	0.14	7.66
	Co-exist Axial	$N_{b,Rd}$	93.73	118.42	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	0.74
	Shear	V_{Rd}	27.56	0.31	90.05
	Tension	$N_{o,Rd}$	93.96	42.44	2.21
	Co-exist Moment	$M_{c,Rd}$	1.06	0.12	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	1.87
	Compression	$N_{b,Rd}$	93.73	118.42	0.79
	Co-exist Moment	$M_{c,Rd}$	1.06	0.14	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	0.74
	Deflection	d	210.00	115.00	1.83
Vertical	Moment	$M_{c,Rd}$	0.87	0.04	20.66
	Shear	V_{Rd}	22.67	0.10	218.02
	Tension	$N_{o,Rd}$	86.77	5.20	16.69
	Compression	$N_{b,Rd}$	85.52	1.83	46.73
	Combined Axial	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	15.73
Diagonal	Tension	$N_{o,Rd}$	48.72	7.67	6.35
	Compression	$N_{b,Rd}$	48.48	14.00	3.46
Cross member	Moment	$M_{c,Rd}$	0.87	0.01	86.77
	Shear	V_{Rd}	22.67	0.01	2,267.41
	Tension	$N_{o,Rd}$	86.77	0.80	108.46
	Compression	$N_{b,Rd}$	86.69	2.87	30.21
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	23.78
Brace	Tension	$N_{o,Rd}$	48.72	5.83	8.36
	Compression	$N_{b,Rd}$	48.54	1.61	30.15
				Factor	**0.74**

CALCULATION SHEET	Project :	Apollo X-beam Box		
	Element :	21m X-Beam Box Results		
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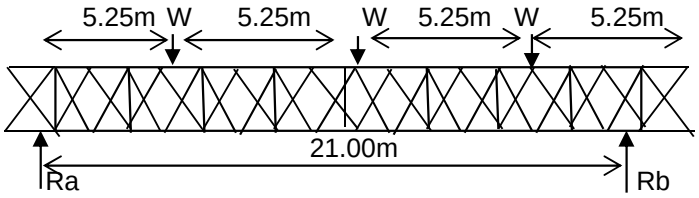


Max Moment= WL/2

so for ultimate condition

W= 1.50*10
15.00 kN

apply factor from above

Wf= 15.00*0.74
= 11.10 kN

so maximum moment is as above

Ultimate Mu= Wf*21/2
= (11.10*21)/2
= 116.55 kNm

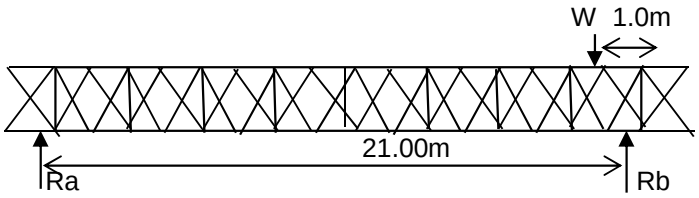
and for allowable value

allowable max moment= 116.55/1.50
= 77.70 kNm

Moment values	**Ultimate**	**116.55 kNm**
	Allowable	**77.70 kNm**

Load Comb. 5 End Shear 10kN load applied at 1.0m distance from the support

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	Moment	$M_{c,Rd}$	1.06	0.04	26.62
	Co-exist Axial	$N_{b,Rd}$	93.73	7.92	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	8.78
	Shear	V_{Rd}	27.56	0.16	173.30
	Tension	$N_{o,Rd}$	93.96	4.61	20.38
	Co-exist Moment	$M_{c,Rd}$	1.06	0.01	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	17.80
	Compression	$N_{b,Rd}$	93.73	16.94	5.53
	Co-exist Moment	$M_{c,Rd}$	1.06	0.01	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	5.33
	Deflection	d	210.00	7.00	30.00
Vertical	Moment	$M_{c,Rd}$	0.87	0.03	30.99
	Shear	V_{Rd}	22.67	0.07	306.41
	Tension	$N_{o,Rd}$	86.77	3.05	28.45
	Compression	$N_{b,Rd}$	85.52	0.01	8,551.85
	Combined Axial	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	16.24
Diagonal	Tension	$N_{o,Rd}$	48.72	3.42	14.25
	Compression	$N_{b,Rd}$	48.48	7.23	6.71
Cross member	Moment	$M_{c,Rd}$	0.87	0.01	86.77
	Shear	V_{Rd}	22.67	0.01	2,267.41
	Tension	$N_{o,Rd}$	86.77	1.57	55.27
	Compression	$N_{b,Rd}$	86.69	0.47	184.45
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	64.84
Brace	Tension	$N_{o,Rd}$	48.72	0.96	50.75
	Compression	$N_{b,Rd}$	48.54	3.18	15.27
				Factor	**5.33**



Max Shear Rb= W*20/21

so for ultimate condition

W= 1.50*10
15.00 kN

apply factor from above

Wf= 15*5.33
= 79.95 kN

so maximum shear is as above

Ultimate Qu= Wf*20/21
= 79.95*20/21
= 76.14 **kN**

and for allowable value

allowable max shear= 76.14/1.50
= 50.76 **kN**

Shear values	**Ultimate**	**76.14 kN**
	Allowable	**50.76 kN**

CALCULATION SHEET	Project :	Apollo X-beam Box		
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21.0m X-BEAM BOX

Loadcase No.		Ultimate Moment	Allowable Moment
1	UDL	124.03	82.69
2	Point	104.74	69.83
3	Third	102.90	68.60
4	Quarter	116.55	77.70

Loadcase No.		Ultimate Shear	Allowable Shear
5	End Shear	76.14	50.76

Max Allowable Moment = 68.60 kNm

Max Allowable Shear = 50.76 kN

CALCULATION SHEET	Project :	Apollo X-beam Box		
	Element :	6m X-Beam Box Cantilever Results		
	Job Number :	X0016	By: anw	Date: Jan 17
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AWD
ALAN WHITE DESIGN

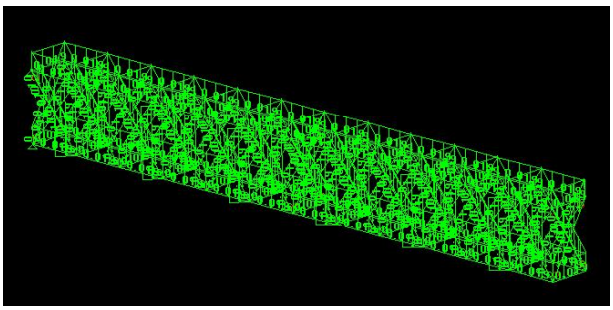
6m X-Beam Box Cantilever Results

STRAP Analysis

The following load cases were applied to the X-beam box.

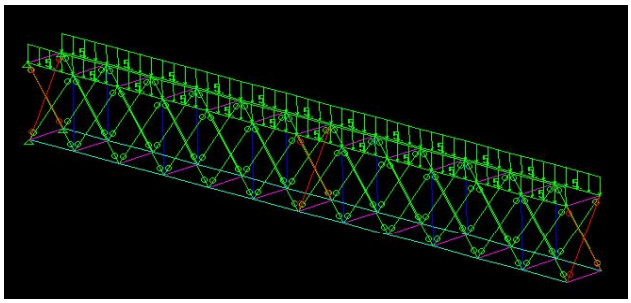
Load Case 1 **Self Weight**

Self weight of all members factored by 1.15 to account for connections



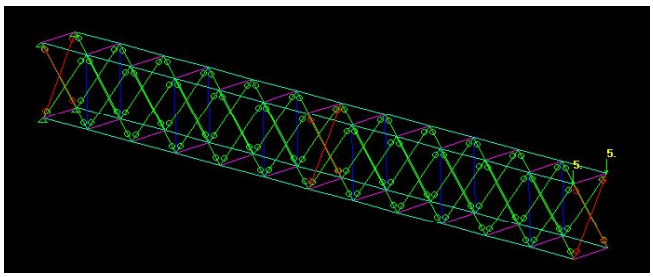
Load Case 2 **UDL**

5kN/m Load Applied to each top boom over full length of the X-Beam box at node points



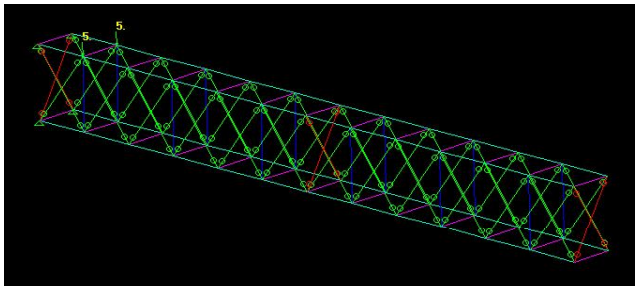
Load Case 3 **End Point**

5kN Point Load applied at end of cantilever on each top boom of the X-Beam box.



Load Case 4 **End Shear**

5kN Point Load applied 0.50m from support on each top boom of the X-Beam box.



Load Combinations

Combination Number	Combination Description	Load Cases
1	UDL	1+2
2	End Point	1+3
5	End Shear	1+4

Above Combinations were checked for the following design factors:

γ_D= 1.35

γ_L= 1.50

CALCULATION SHEET	Project :	Apollo X-beam Box		
	Element :	6m X-Beam Box Cantilever Results		
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Load Comb. 1 UDL load 10kN/m applied along beam

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	**Moment**	$M_{c,Rd}$	1.06	0.38	2.82
	Co-exist Axial	$N_{b,Rd}$	93.96	150.26	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	0.54
	Shear	V_{Rd}	27.56	2.49	11.07
	Tension	$N_{o,Rd}$	93.96	179.94	0.52
	Co-exist Moment	$M_{c,Rd}$	1.06	0.31	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	0.47
	Compression	$N_{b,Rd}$	93.73	179.74	0.52
	Co-exist Moment	$M_{c,Rd}$	1.06	0.10	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	0.50
	Deflection	d	60.00	73.00	0.82
Vertical	Moment	$M_{c,Rd}$	0.87	0.09	9.33
	Shear	V_{Rd}	22.67	0.27	85.56
	Tension	$N_{o,Rd}$	86.77	0.01	8,676.80
	Compression	$N_{b,Rd}$	85.52	1.10	77.74
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	8.79
Diagonal	Tension	$N_{o,Rd}$	48.72	27.43	1.78
	Compression	$N_{b,Rd}$	48.48	27.77	1.75
Cross member	Moment	$M_{c,Rd}$	0.87	0.01	86.77
	Shear	V_{Rd}	22.67	0.01	2,267.41
	Tension	$N_{o,Rd}$	86.77	0.52	166.86
	Compression	$N_{b,Rd}$	86.69	0.01	8,668.99
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	62.81
Brace	Tension	$N_{o,Rd}$	48.72	0.01	4,872.00
	Compression	$N_{b,Rd}$	48.54	1.07	45.37
				Factor	**0.47**

CALCULATION SHEET	Project :	Apollo X-beam Box		
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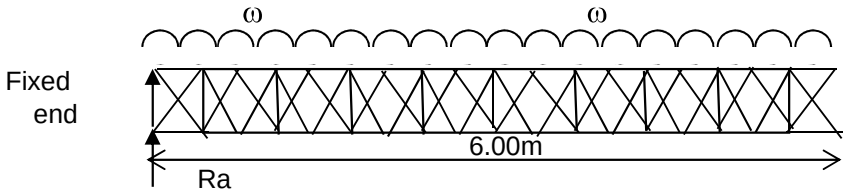

Max Moment= $WL^2/2$

so for ultimate condition

W= 1.5*10

15.00 kN/m

apply factor from above

Wf= 15*0.47

= 7.05 kN/m

so maximum moment is as above

Ultimate Mu= Wf*6^2/2

= (7.05*6^2)/2

= 126.90 kNm

and for allowable value

allowable max moment= 126.90/1.50

= 84.60 kNm

Moment values	**Ultimate**	**126.90 kNm**
	Allowable	**84.60 kNm**

CALCULATION SHEET	Project :	Apollo X-beam Box		
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ALAN WHITE DESIGN

Load Comb. 2 Point load 10kN load applied at midspan of beam

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	**Moment**	$M_{c,Rd}$	1.06	0.06	17.18
	Co-exist Axial	$N_{b,Rd}$	93.73	58.72	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	1.49
	Shear	V_{Rd}	27.56	0.10	270.15
	Tension	$N_{o,Rd}$	93.96	64.68	1.45
	Co-exist Moment	$M_{c,Rd}$	1.06	0.05	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	1.39
	Compression	$N_{b,Rd}$	93.73	64.68	1.45
	Co-exist Moment	$M_{c,Rd}$	1.06	0.05	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	1.38
	Deflection	d	60.00	32.00	1.88
Vertical	Moment	$M_{c,Rd}$	0.87	0.02	39.44
	Shear	V_{Rd}	22.67	0.06	359.91
	Tension	$N_{o,Rd}$	86.77	0.86	100.89
	Compression	$N_{b,Rd}$	85.52	0.01	8,551.85
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	31.06
Diagonal	Tension	$N_{o,Rd}$	48.72	5.28	9.23
	Compression	$N_{b,Rd}$	48.48	5.80	8.36
Cross member	Moment	$M_{c,Rd}$	0.87	0.01	86.77
	Shear	V_{Rd}	22.67	0.01	2,267.41
	Tension	$N_{o,Rd}$	86.77	1.56	55.62
	Compression	$N_{b,Rd}$	86.69	0.01	8,668.99
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	86.55
Brace	Tension	$N_{o,Rd}$	48.72	0.01	4,872.00
	Compression	$N_{b,Rd}$	48.54	3.16	15.42
				Factor	**1.38**

CALCULATION SHEET	Project :	Apollo X-beam Box		
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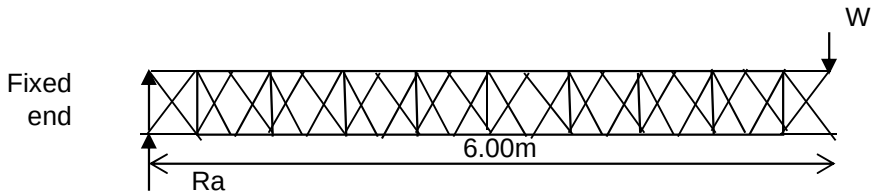


Max Moment= WL

so for ultimate condition

W= 1.50*10
= 15.00 kN

apply factor from above

Wf= 15*1.38
= 20.70 kN

so maximum moment is as above

Ultimate Mu= Wf*6
= 20.70*6
= 124.20 kNm

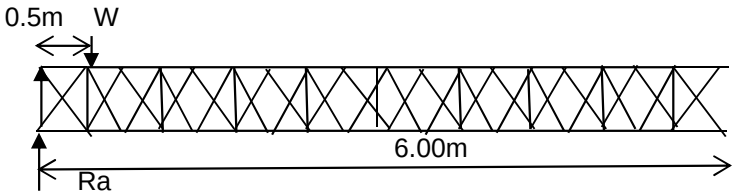
and for allowable value

allowable max moment= 124.20/1.50
= 82.80 kNm

Moment values	**Ultimate**	**124.20 kNm**
	Allowable	**82.80 kNm**

Load Comb. 3 End Shear 10kN load applied at a 0.5m distance from the support

Element	Action	Formula	Ultimate	Calculated	Factor
Boom	Moment	$M_{c,Rd}$	1.06	0.02	56.05
	Co-exist Axial	$N_{b,Rd}$	93.96	6.37	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	12.27
	Shear	V_{Rd}	27.56	0.04	626.26
	Tension	$N_{o,Rd}$	93.96	6.73	13.96
	Co-exist Moment	$M_{c,Rd}$	1.06	0.02	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	11.73
	Compression	$N_{b,Rd}$	93.73	5.79	16.19
	Co-exist Moment	$M_{c,Rd}$	1.06	0.01	
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	14.53
	Deflection	d	60.00	0.50	120.00
Vertical	Moment	$M_{c,Rd}$	0.87	0.01	72.31
	Shear	V_{Rd}	22.67	0.03	731.42
	Tension	$N_{o,Rd}$	86.77	0.01	8,676.80
	Compression	$N_{b,Rd}$	85.52	3.09	27.68
	Combined Axial	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	21.32
Diagonal	Tension	$N_{o,Rd}$	48.72	4.59	10.61
	Compression	$N_{b,Rd}$	48.48	5.57	8.70
Cross member	Moment	$M_{c,Rd}$	0.87	0.01	86.77
	Shear	V_{Rd}	22.67	0.01	2,267.41
	Tension	$N_{o,Rd}$	86.77	0.01	8,676.80
	Compression	$N_{b,Rd}$	86.69	0.01	8,668.99
	Combined	$(N_{ed}/N_{Rd})^{1.3} + [(M_{ed,x}/M_{rd,x})^{1.7}]^{0.6} < 1.0$		1.00	86.55
Brace	Tension	$N_{o,Rd}$	48.72	0.01	4,872.00
	Compression	$N_{b,Rd}$	48.54	0.01	4,854.46
				Factor	**8.70**



Max Shear Rb= W

so for ultimate condition

W= 1.50*10
= 15.00 kN

apply factor from above

Wf= 15*8.70
= 130.50 kN

so maximum shear is as above

Ultimate Qu= Wf
= 130.50 kN

and for allowable value

allowable max shear= 130.50/1.50
= 87.00 kN

Shear values	**Ultimate**	**130.50 kN**
	Allowable	**87.00 kN**

CALCULATION SHEET	Project :	Apollo X-beam Box		
	Element :	6m X-Beam Box Cantilever Results		
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ALAN WHITE DESIGN

6.00m CANTILEVER X-BEAM BOX			
Loadcase		**Ultimate**	**Allowable**
No.		**Moment**	**Moment**
1	UDL	126.90	84.60
2	Point	124.20	82.80

Loadcase		**Ultimate**	**Allowable**
No.		**Shear**	**Shear**
3	End Shear	130.50	87.00

Max Allowable Moment = 82.80 kNm

Max Allowable Shear = 87.00 kN

Overall X-Beam Results

Load case 1 : UDL

X-BEAM BOX	
Loadcase 1 Length (m)	**Ultimate Moment**
9	119.98
12	126.90
15	126.56
18	127.58
21	124.03

Minimum 119.98 kNm

Load case 2 : Central Point Load

X-BEAM BOX	
Loadcase 2 Length (m)	**Ultimate Moment**
9	115.76
12	117.90
15	109.69
18	112.05
21	104.74

Minimum 104.74 kNm

Load case 3 : Two Point Loads at Third Points

X-BEAM BOX	
Loadcase 3 Length (m)	**Ultimate Moment**
9	119.70
12	115.80
15	113.25
18	110.70
21	102.90

Minimum 102.90 kNm

Load case 4 : Three Point Loads at Quarter Points

X-BEAM BOX	
Loadcase 4 Length (m)	**Ultimate Moment**
9	113.40
12	125.10
15	112.50
18	121.50
21	116.55

Minimum 112.50 kNm

Load case 5 : Shear

X-BEAM BOX	
Loadcase 5 Length (m)	**Ultimate Shear**
9	100.53
12	99.69
15	98.56
18	89.39
21	76.14

Minimum 76.14 kN

Overall Graded Results for Allowable Working Loads on a X-Beam Box

For simply supported Apollo X-BEAM Box

Test Results

	Span (m)				
	9	12	15	18	21
Allowable Moment	75.6	77.2	73.1	73.8	68.60
Allowable Shear (Load on Vertical)	67.0	66.5	65.7	59.6	50.76

Allowable loads for load distributions from results

Type of Load	Clear span (m)					
		9	12	15	18	21
Uniformly Distributed load	kN/m	7.5	4.3	2.6	1.8	1.2
Total UDL	kN	67.2	51.5	39.0	32.8	26.1
Single point load (mid Point)	kN	33.6	25.7	19.5	16.4	13.1
Two point loads (third points)	Each kN	25.2	19.3	14.6	12.3	9.8
Three point loads (quarter points)	Each kN	16.8	12.9	9.8	8.2	6.5

Extrapolated Allowable loads for load distributions

Type of Load	Clear span (m)												
		9	10	11	12	13	14	15	16	17	18	19	20	21
Uniformly Distributed load	kN/m	7.5	6.0	5.0	4.3	3.5	3.0	2.6	2.3	3.0	1.8	1.5	1.4	1.2
Total UDL	kN	67.2	60.5	55.0	51.5	45.0	41.8	39.0	36.6	34.4	32.8	28.9	27.4	26.1
Single point load (mid Point)	kN	33.6	30.2	27.5	25.7	22.5	20.9	19.5	18.3	17.2	16.4	14.4	13.7	13.1
Two point loads (third points)	Each kN	25.2	22.7	20.6	19.3	16.9	15.7	14.6	13.7	12.9	12.3	10.8	10.3	9.8
Three point loads (quarter points)	Each kN	16.8	15.1	13.7	12.9	11.3	10.4	9.8	9.1	8.6	8.2	7.2	6.9	6.5

Notes:

1. This table is provided as a guide only and assume all loads are applied at nodes. All scaffolds and structures should be checked by a qualified structural engineer.
2. 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 nodes. Compression chord restraint required at 1.0m c/c
3. Factor of Safety = 1.65 (= 1.5*1.1 (material factor))
4. Calculations as per BS EN 1999-1-1
5. For design purposes the allowable bending moment is 68.60kNm and the allowable shear is 50.76kN.

Graph Summary of Allowable Working Loads for a X-Beam Box to BS EN 1999-1-1

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