


APOLLO SCAFFOLD SERVICES LTD TEMPORARY ROOF GUIDELINES DESIGN CHECK CALCULATIONS

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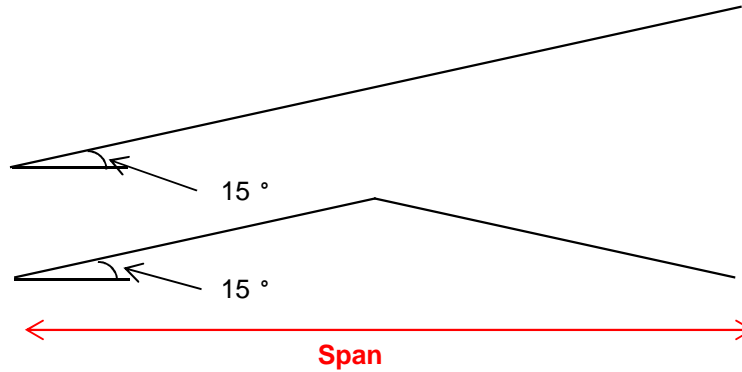
Mar 2013

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CALCULATION SHEET	Project : Apollo Temp. Roof Guidelines			 ALAN WHITE DESIGN
	Element : Brief			
	Job Number : S0005	By : eas	Date: Mar13	
	Document No : 001	Checked: anw	Date: Mar13	

Brief To prepare structural design calculations for four temporary roof structures, one duo pitch and one mono pitch using Apollo 450mm Lattice Beams and Apollo 750 X-Beams.

Layout



Roofs are to be sheeted and an independent scaffold system must be used at each gable wall.

Bays are to be 2.5m c/c using bracing system as per AWD R0182-001B.

The design is to incorporate snow loads and be standing for less than a year

The angle of pitch on both roofs - 15°

Apollo 450 Lattice Beam Capacities as per AWD F006/004

Apollo 450 Lattice Ridge Frame Capacities as per AWD G0041/001

Apollo 750 X-beam Capacities as per AWD R0076/001

Apollo 750 X-beam Ridge Frame Capacities as per AWD R0151/001

Design Actions on Structures - Snow EN 1991-1-3
Actions on Structures - Wind EN 1991-1-4
Temporay Demountable Structures

Assumptions The design is to account for snow lying on the roof

It is assumed that the roof beams will be fixed to the scaffold structure at each end to allow for simply supported design .

Roof design wind speed = 22 m/s (London only)


Max roof height above sea level is 60m

Max roof eave height above ground level is 20m

The plan brace has been designed to withstand the weight of one operative on the brace frame. Max operative and tool weight is 100kg

The plan brace is not designed for impact from falling objects

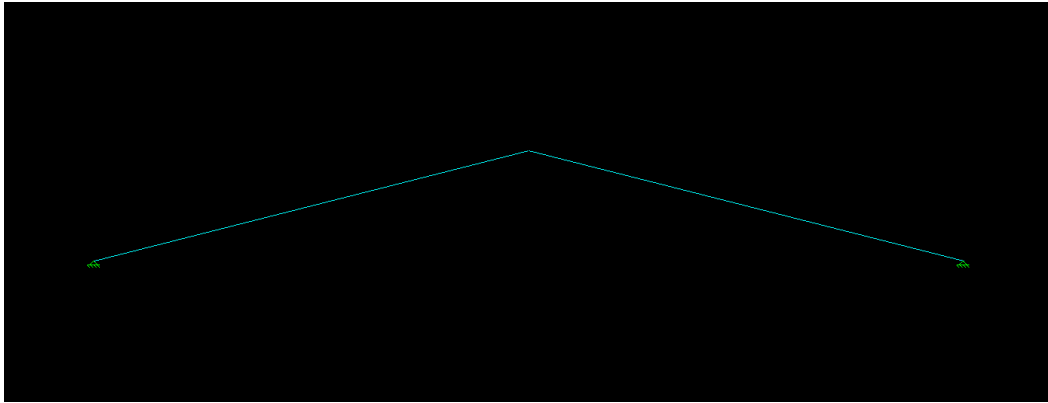
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Analysis

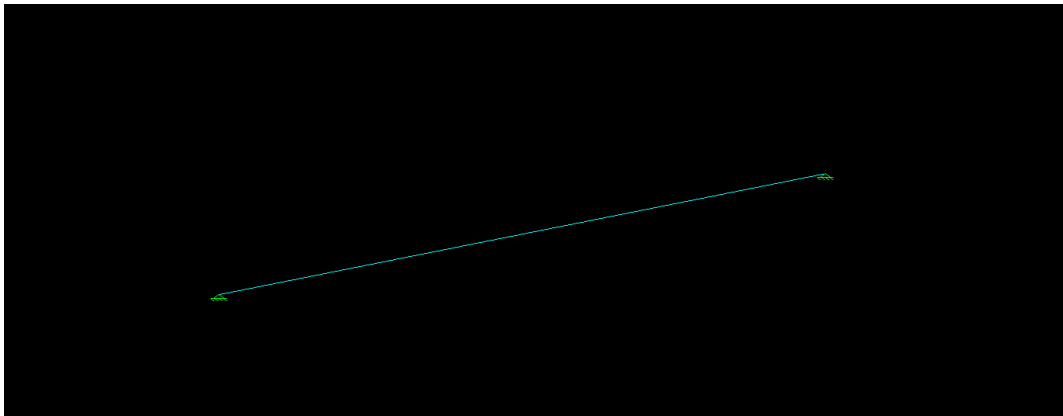
Truss 1


Duo Pitch



Truss 2

Mono Pitch



CALCULATION SHEET	Project : Apollo Temp. Roof Guidelines			 ALAN WHITE DESIGN
	Element : Wind Loading			
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Wind Loading

Wind calculation procedures are taken from the European standards
 EN 1991-1-4 Eurocode 1 Actions on structures - Wind
 EN 13782 Temporary Structures -safety

Basic Wind Speed	$V_b = 22$ m/s	Greater London
Site Altitude	$A = 60.00$ m	
Site Altitude Factor	$C_{alt} = 1 + 0.001A * (10/z)^{0.2}$	N.A.2.5
	$C_{alt} = 1.06$	
Directional Factor	$C_{dir} = 1.00$	Tab N.A.1
Seasonal Factor	$C_s = 1.00$	Table N.A.2
Probability Factor	$C_p = 0.85$	Temp Works

Wind Speed

$$V_e = V_b * C_{alt} * C_d * C_s * C_p$$

$$= 19.82 \text{ m/s}$$

Dynamic Wind Pressure

$$q_b = k * V_e^2$$

$$= 0.24 \text{ kN/m}^2$$

$k = 0.613$

Effective Height	$z - h_{dis} = 10.00$ m	Assumes 15m h_{dis}
Distance to the sea from site location	80.00 km	
Site Location	Town	(Town or Country)
Distance to the edge of town	10.00	
Exposure Factor	$C_e(z) = 2.32$	Fig N.A.7
Exposure Correction	$C_e(t) = 0.79$	Fig N.A.8 (in town only)
Size Effect Factor	$C_s = 0.94$	Table N.A.3
Temporary Works	$C_{pe} = 1.00$	

Dynamic Wind Pressure

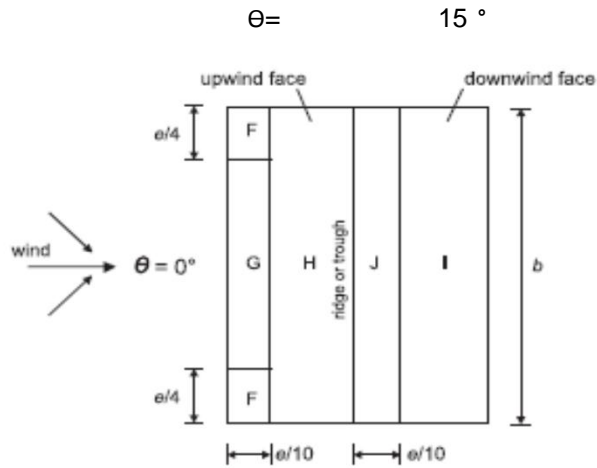
$$q_s = C_e(t) * C_e(z) * C_s * C_{pe} * q_b$$

$$= 0.41 \text{ kN/m}^2$$

Project :	Apollo Temp. Roof Guidelines		
Element :	Duo Pitch Roof Loading		
Job Number :	S0005	By : eas	Date:Mar13
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Roof Pressures - Duo Pitch



h= 26 m
 b= dependant on site
 e= b or 2h (smaller of the two)
 = 52 m
 e/10= 5.2 m

Linear model of roof section therefore areas F & G to be averaged (conservatively).

Upwind Face(-ve)

F/G= -0.85 (Averaged)
 H= -0.30
 I= -0.4
 J= -1

Therefore applied loads for a 2.5m bay are:


F/G= -0.88 kN/m
 H= -0.31 kN/m
 I= -0.41 kN/m
 J= -1.04 kN/m

Upwind Face(+ve)

F/G= 0.20
 H= 0.20
 I= 0.00
 J= 0.00

Therefore applied loads for a 2.5m bay are:

F/G= 0.21 kN/m
 H= 0.21 kN/m
 I= 0.00 kN/m
 J= 0.00 kN/m

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	Element : Duo Pitch Roof Loading			
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Internal Pressure Walls

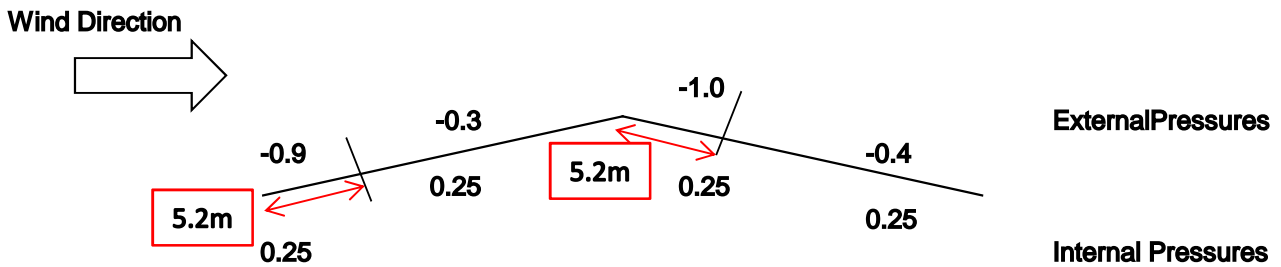
As per BS EN 1991-1-4- 7.2.9 note 5
Internal pressure coefficient is 75% of the windward face pressure due to the open face.

$$\begin{aligned} \text{Internal Pressure, } C_{pi} &= 0.75 \times C_{pe} && \text{(Vertical Wall)} \\ &= 0.25 \text{ kN/m}^2 && C_{pe}=0.8 * q_s \end{aligned}$$

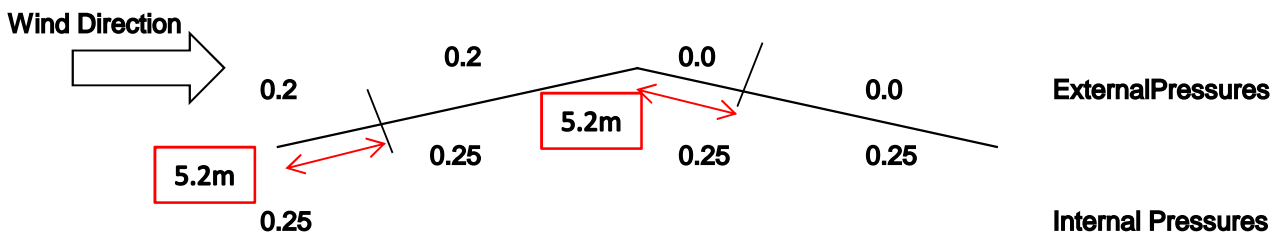
Wind Pressures


Negative External Values Indicate Uplift
All Values are in kN/m

Upwind Negative



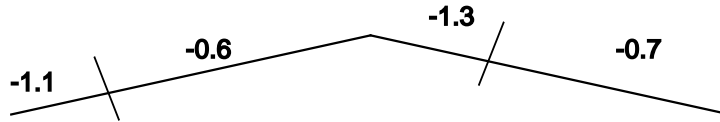
Upwind Positive



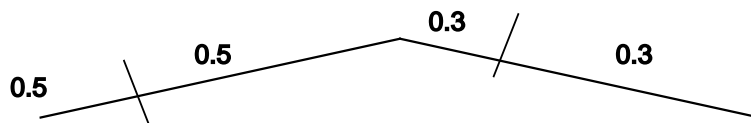
CALCULATION SHEET	Project : Apollo Temp. Roof Guidelines			 ALAN WHITE DESIGN
	Element : Duo Pitch Roof Loading			
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Applied Roof Load Cases **Negative Values Indicate Uplift**
All Values are in kN/m

Load Case 1- Upwind Negative (combined external & internal pressure)



Load Case 2- Upwind Positive (combined external & internal pressure)



Snow Loads

From BS EN 1991-1-3 Snow loads

The max characterisitic ground snow load to be applied anywhere in the UK

fig NA1 $s_k = 0.70 \text{ kN/m}^2$

the snow load on the roof is

$$s = \mu \cdot C_e \cdot C_t \cdot s_k$$

$\mu =$ shape factor
 $C_e = 1.0 \text{ Cl NA.2.15}$
 $C_t = 1.0 \text{ Cl Na 2.16}$
 $s_k = 0.7 \text{ kN/m}^2$

From Table 5.2 $\mu = 0.80$

so

$$s = 0.8 * 1 * 1 * 0.7$$

$$= 0.56 \text{ kN/m}^2$$

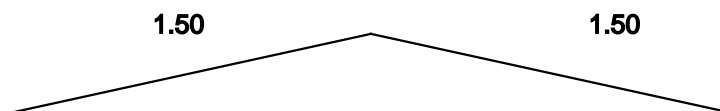
But BS EN 1991-1-1 General actions gives that the minimum imposed load for roofs is to be

Table NA7 $q_k = 0.60 \text{ kN/m}^2$

Applied Load = 1.50 kN/m for a 2.5m bay

Applied Roof Loads **Negative Values Indicate Uplift**
All Values are in kN/m

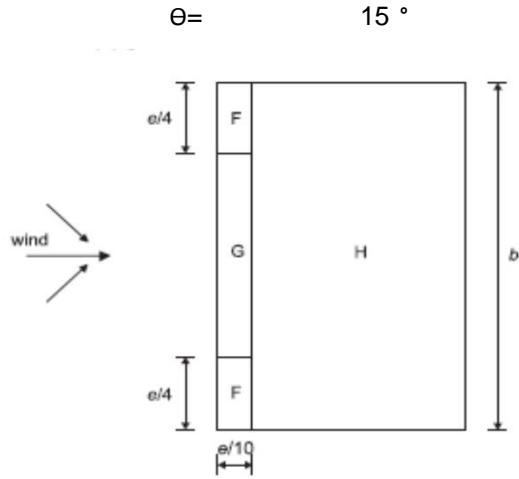
Load Case 3- Snow Loads



Load Case 2: Wind Down Force not analysed as Snow Load more onerous.

Project :	Apollo Temp. Roof Guidelines		
Element :	Mono Pitch Roof Loading		
Job Number :	S0005	By : eas	Date:Mar13
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Roof Pressures - Mono Pitch 0°



$\theta = 15^\circ$

$h = 26 \text{ m}$
 $b = \text{dependant on site}$

$e = b \text{ or } 2h \text{ (smaller of the two)}$
 $= 52 \text{ m}$

$e/10 = 5.2 \text{ m}$

Linear model of roof section therefore areas F & G to be averaged (conservatively).

Upwind Face(-ve)

$F/G = -0.85$ (Averaged)
 $H = -0.30$

Therefore applied loads for a 2.5m bay are:


$F/G = -0.88 \text{ kN/m}$
 $H = -0.31 \text{ kN/m}$

Upwind Face(+ve)

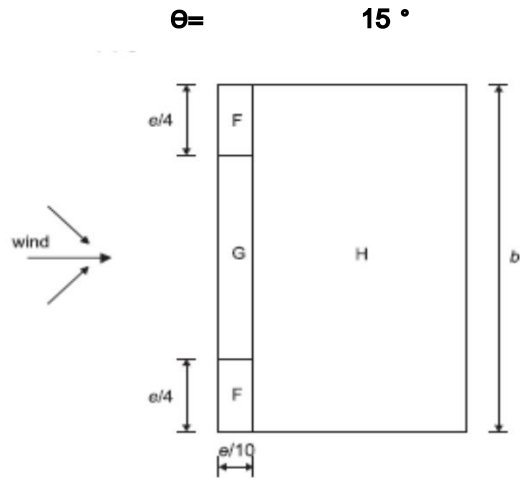
$F/G = 0.20$
 $H = 0.20$

Therefore applied loads for a 2.5m bay are:

$F/G = 0.21 \text{ kN/m}$
 $H = 0.21 \text{ kN/m}$

CALCULATION SHEET	Project : Apollo Temp. Roof Guidelines			 ALAN WHITE DESIGN
	Element : Mono Pitch Roof Loading			
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Roof Pressures - Mono Pitch 180°



$h = 26 \text{ m}$
 $b = \text{dependant on site}$

$e = b \text{ or } 2h \text{ (smaller of the two)}$
 $= 52 \text{ m}$

$e/10 = 5.2 \text{ m}$


Linear model of roof section therefore areas F & G to be averaged (conservatively).

Upwind Face(-ve)

$F/G = -1.90$ (Averaged)
 $H = -0.90$

Therefore applied loads for a 2.5m bay are:

$F/G = -1.97 \text{ kN/m}$
 $H = -0.93 \text{ kN/m}$

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	Element : Mono Pitch Roof Loading			
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Internal Pressure Walls

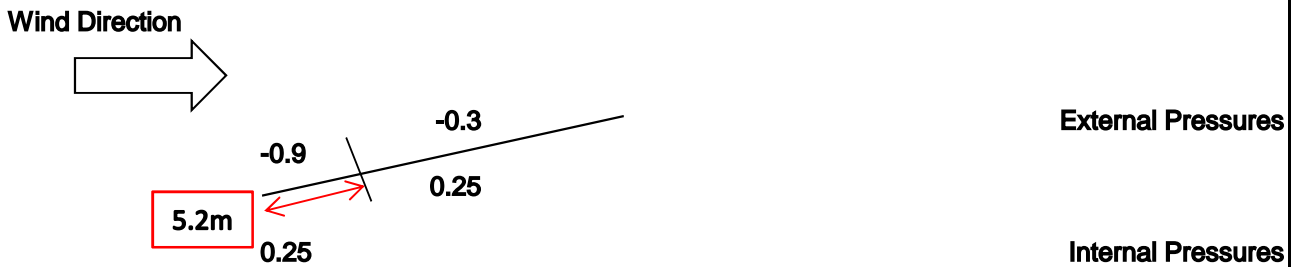
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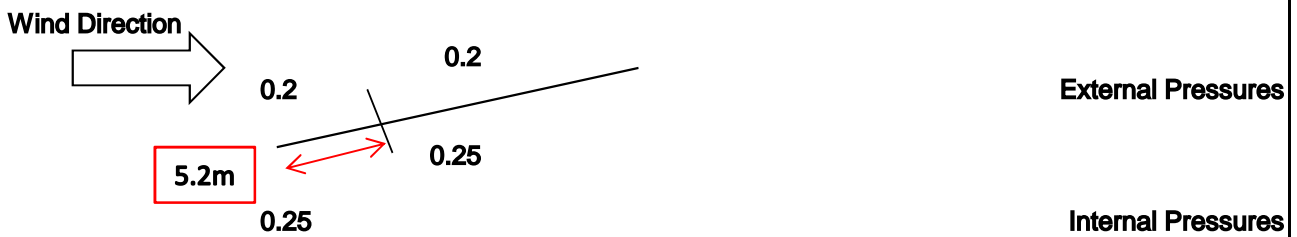
Wind Pressures

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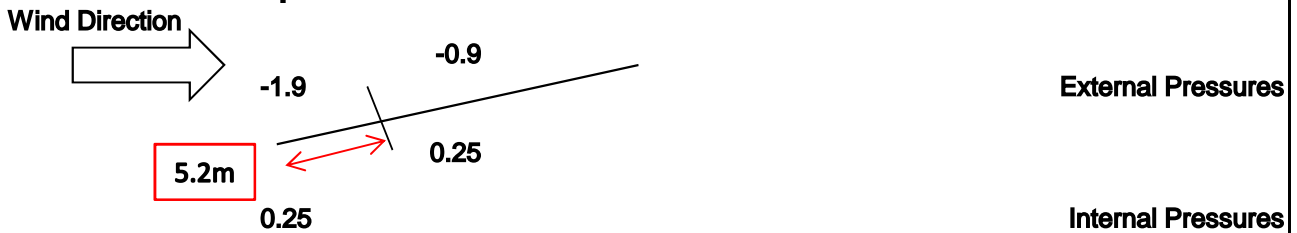
Upwind Negative 0°




Upwind Positive 0°



Upwind Positive 180°

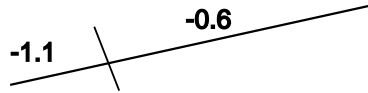


CALCULATION SHEET	Project : Apollo Temp. Roof Guidelines			 ALAN WHITE DESIGN
	Element : Mono Pitch Roof Loading			
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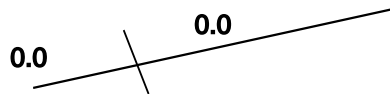
Applied Roof Loads Cases

Negative Values Indicate Uplift
All Values are in kN/m

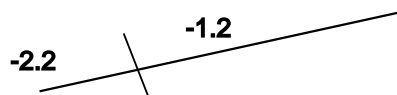
Load Case 1- Upwind Negative 0° (combined external & internal pressure)



Load Case 2- Upwind Positive 0° (combined external & internal pressure)



Load Case 3- Upwind Negative 180° (combined external & internal pressure)



Snow Loads

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 $s_k = 0.7 \text{ kN/m}^2$

From Table 5.2 $\mu = 0.80$

$$\begin{aligned} \text{so } s &= 0.8 * 1 * 1 * 0.7 \\ &= 0.56 \text{ kN/m}^2 \end{aligned}$$

But BS EN 1991-1-1 General actions gives that the minimum imposed load for roofs is to be

Table NA7 $q_k = 0.60 \text{ kN/m}^2$

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	Element : Mono Pitch Roof Loading			
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Applied Roof Loads

All Values are in kN/m


Load Case 4- Snow Loads

0.60



Load Case 1: Wind Uplift 0° not analysed as Wind Uplift 180° more onerous.

Load Case 2: Wind Down Force not analysed as Snow Load more onerous.

CALCULATION SHEET	Project : Apollo Temp. Roof Guidelines			 ALAN WHITE DESIGN
	Element : X-Beam Check			
	Job Number : S0005	By : eas	Date: Mar13	
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X-Beam Check Duo Pitch

Apollo 750 X-beam Capacities as per AWD R0076/001

30m Span (2No 15m Spans):

Moment= 48.00 kNm
Shear= 39.00 kN

From STRAP analysis:

Load Case 1: Wind

Applied Moment= 19.68 kNm
Applied Shear= 7.11 kN

Load Case 2: Snow

Applied Moment= 37.93 kNm
Applied Shear= 12.71 kN

Factor of Safety on Max Value

Max Moment= 1.27 <1 Ok
Max Shear= 3.07 <1 Ok

X-Beam Check Mono Pitch

Apollo 750 X-beam Capacities as per AWD R0076/001

15m Span:

Moment= 48.00 kNm
Shear= 39.00 kN

From STRAP analysis:

Load Case 1: Wind


Applied Moment= 31.11 kNm
Applied Shear= 13.55 kN

Load Case 2: Snow

Applied Moment= 30.36 kNm
Applied Shear= 11.73 kN

Factor of Safety on Max Value

Max Moment= 1.54 <1 Ok
Max Shear= 2.88 <1 Ok

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	Element : X-Beam Check			
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Lattice Beam Check Duo Pitch

Apollo Lattice Beam Capacities as per AWD R0076/001

18m Span (2No 9m Spans):

Moment= 15.70 kNm
Shear= 13.90 kN

From STRAP analysis:

Load Case 1: Wind

Applied Moment= 8.55 kNm
Applied Shear= 4.90 kN

Load Case 2: Snow

Applied Moment= 13.45 kNm
Applied Shear= 7.58 kN

Factor of Safety on Max Value

Max Moment= 1.17 <1 Ok
Max Shear= 1.83 <1 Ok

Lattice Beam Check Mono Pitch

Apollo Lattice beam Capacities as per AWD R0076/001

9m Span:

Moment= 15.70 kNm
Shear= 13.90 kN

From STRAP analysis:

Load Case 1: Wind


Applied Moment= 13.59 kNm
Applied Shear= 9.25 kN

Load Case 2: Snow

Applied Moment= 10.93 kNm
Applied Shear= 7.039 kN

Factor of Safety on Max Value

Max Moment= 1.16 <1 Ok
Max Shear= 1.50 <1 Ok

CALCULATION SHEET	Project : Apollo Temp. Roof Guidelines			 ALAN WHITE DESIGN
	Element : Deflections			
	Job Number : S0005	By : eas	Date:Mar13	
	Document No : 001	Checked: anw	Date:Mar13	

X-Beam Check Duo Pitch

Allowable Deflection= L/250
L= 30000
Allowable Deflection= 120 mm

Span Deflection= 19.74 mm from STRAP analysis
Ridge Deflection= 27.33 mm from STRAP analysis

X-Beam Check Mono Pitch

Allowable Deflection= L/250
L= 15000
Allowable Deflection= 60 mm

Calculated Deflection= 17.26 mm from STRAP analysis

Lattice Beam Check Duo Pitch


Allowable Deflection= L/250
L= 18000
Allowable Deflection= 72 mm

Span Deflection= 7.75 mm from STRAP analysis
Ridge Deflection= 9.91 mm from STRAP analysis

Lattice Beam Check Mono Pitch

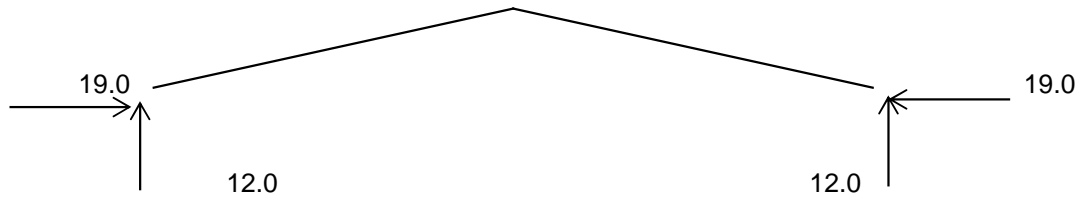
Allowable Deflection= L/250
L= 9000
Allowable Deflection= 36 mm

Calculated Deflection= 8.69 mm from STRAP analysis

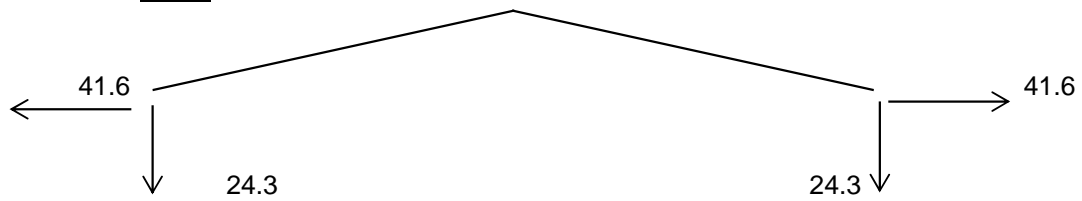
CALCULATION SHEET	Project : Apollo Temp. Roof Guidelines			 ALAN WHITE DESIGN
	Element : Reactions			
	Job Number : S0005	By : eas	Date: Mar13	
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X-Beam Check Duo Pitch (all values in kN)

Wind Uplift

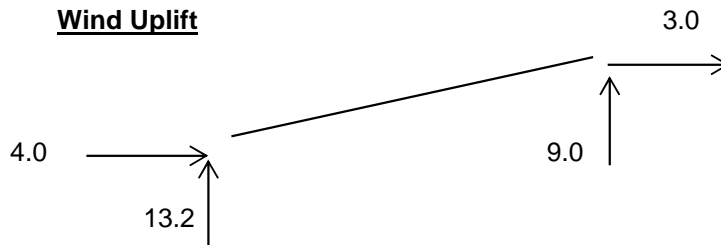


Snow

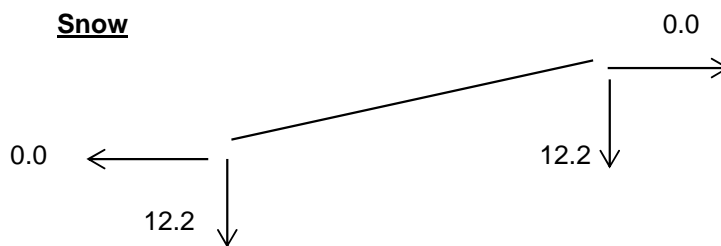



X-Beam Check Mono Pitch (all values in kN)

Wind Uplift



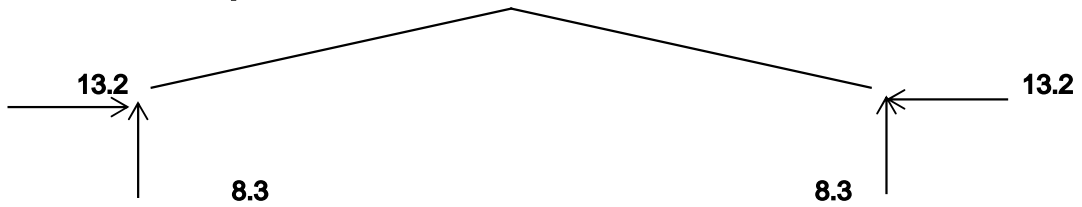
Snow



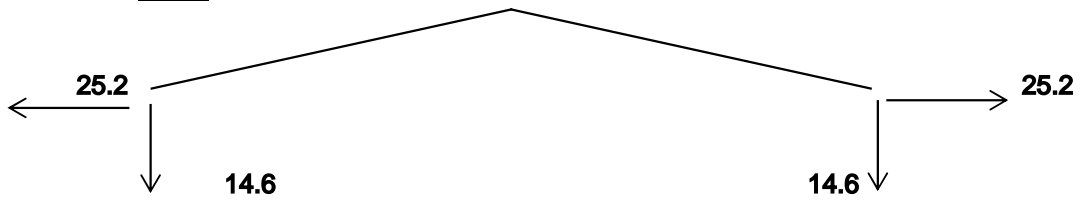
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Lattice Beam Check Duo Pitch (all values in kN)

Wind Uplift

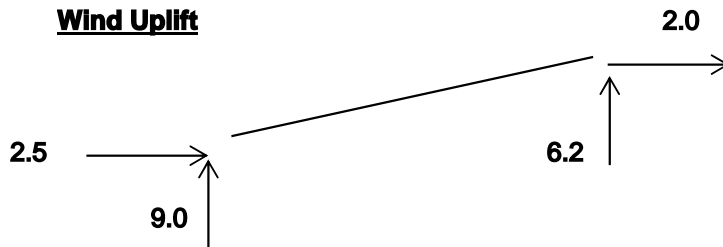


Snow

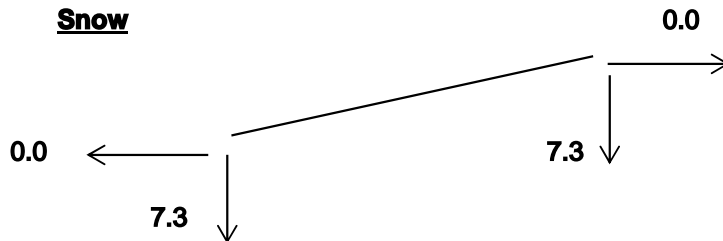



Lattice Beam Check Mono Pitch (all values in kN)

Wind Uplift



Snow



CALCULATION SHEET	Project : Apollo Temp. Roof Guidelines			 ALAN WHITE DESIGN
	Element : Summary			
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Summary

The roof beam passes design checks for specified loading.

Roof Type	Max Span(m)
X-Beam Mono Pitch	15.0
X-Beam Duo Pitch	30.0
Lattice Beam Mono Pitch	9.0
Lattice Beam Duo Pitch	18.0

This document is for guidance only, all temporary roof designs should be completed by a component engineer.

Guidelines Based On:

- Structure located in London, United Kingdom
- Maximum Wind Speed - 22m/s
- Maximum roof height above sea level - 60m
- Max eave height above ground level - 20m