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DESKTOP ROOF LOADING APPRAISAL

STONYHURST

CANTEEN
STONYHURST CLITHEROE BB7 9PT

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Checked By	BMcG				
Revisions:					

CALCULATIONS CARRIED OUT IN ACCORDANCE WITH MCS SOLAR PV STANDARDS

TABLE OF CONTENTS

NOTE: This report has been carried out in accordance with BS EN 1991-1, BRE Digest 489 (2015) and (Where required) Section 5.9 of MIS 3002 The Solar PV Standard.

1.0 APPLIED LOADINGS

In considering the applied loading, we have assessed as noted below:

- Dead loads are based on the actual specified make up for the existing roof.
- Imposed floor loads are based on the loadings within BS 6399 & Eurocode- 1 (BS EN 1991-1) in line with the date of design/construction.
- Wind & Snow loadings are calculated on a site-specific basis in line with European Codes of Practice.
- The property has been built in accordance with relevant building codes.

Applied loads are as follows:

EXISTING ROOF MAKE UP:

DEAD LOAD	Existing Trapezoidal Sheets	= 0.18kN/m2
	Existing Insulation	= 0.12kN/m2
	Existing Purlins	= 0.15kN/m2
	Total DL	**= 0.45kN/m**
IMPOSED LOADS		
BS 6399:PT3:4.2 & Eurocode- 1 (BS EN 1991-1)	**General Roof Load**	**= 0.60kN/m2**

EXISTING ROOF WIND LOADINGS:

Calculated using TEDDS design software for both positive and negative internal pressure and for wind acting both perpendicular and parallel to the front elevation of the building.

The positive pressures on the building have already been considered at design stage and installing Solar PV does not increase or reduce these loadings, therefore positive wind pressures do not need to be considered in this loading assessment.

Negative wind pressures are used to calculate the wind uploads and determine the fixing resistance for any mounting frame designs.

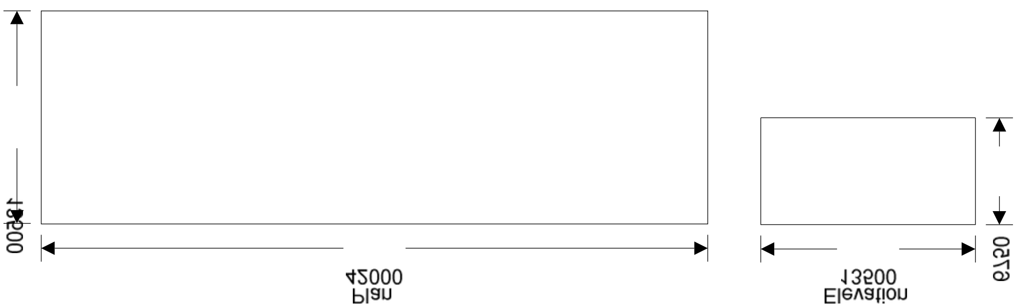
EXISTING ROOF SNOW LOADINGS:

Calculated using TEDDS design software for both basic and where appropriate complex snow loadings.

WIND LOADING

In accordance with EN1991-1-4:2005+A1:2010 and the UK national annex

Tedds calculation version 3.0.29



Building data

Type of roof; Flat

Length of building; L = **42000** mm
Width of building; W = **13500** mm
Height to eaves; H = **6750** mm
Eaves type; Sharp
Total height; h = **6750** mm

Basic values

Location; Preston
Wind speed velocity (FigureNA.1); $v_{b,map}$ = **23.2** m/s
Distance to shore; L_{shore} = **28.40** km
Altitude above sea level; A_{alt} = **108.0**m
Altitude factor; $c_{alt} = A_{alt}/1m \times 0.001 + 1$ = **1.108**
Fundamental basic wind velocity; $v_{b,0} = v_{b,map} \times c_{alt}$ = **25.7** m/s
Direction factor; c_{dir} = **1.00**
Season factor; c_{season} = **1.00**
Shape parameter K; K = **0.2**
Exponent n; n = **0.5**
Air density; ρ = **1.226** kg/m3
Probability factor; $c_{prob} = [(1 - K \times \ln(-\ln(1-p)))/(1 - K \times \ln(-\ln(0.98)))]^n$ = **1.00**
Basic wind velocity (Exp. 4.1); $v_b = c_{dir} \times c_{season} \times v_{b,0} \times c_{prob}$ = **25.7** m/s
Reference mean velocity pressure; $q_b = 0.5 \times \rho \times v_b^2$ = **0.405** kN/m^2

Orography

Orography factor not significant; c_o = 1.0
Terrain category; Country
Displacement height (sheltering effect excluded); h_{dis} = 0mm

The velocity pressure for the windward face of the building with a 0 degree wind is to be considered as 1 part as the height h is less than b (cl.7.2.2)

The velocity pressure for the windward face of the building with a 90 degree wind is to be considered as 1 part as the height h is less than b (cl.7.2.2)

Peak velocity pressure - windward wall - Wind 0 deg and roof

Reference height (at which q is sought); z = **6750**mm
Displacement height (sheltering effects excluded); h_{dis} = **0** mm
Exposure factor (Figure NA.7); c_e = **2.16**
Peak velocity pressure; $q_p = c_e \times q_b$ = **0.87** kN/m^2

Structural factor

Structural damping; δ_s = **0.050**
Height of element; h_{part} = **6750** mm
Size factor (Table NA.3); c_s = **0.866**
Dynamic factor (Figure NA.9); c_d = **1.015**
Structural factor; $c_sC_d = c_s \times c_d$ = **0.879**

Peak velocity pressure - windward wall - Wind 90 deg and roof

Reference height (at which q is sought); z = **6750**mm
Displacement height (sheltering effects excluded); h_{dis} = **0** mm
Exposure factor (Figure NA.7); c_e = **2.16**
Peak velocity pressure; $q_p = c_e \times q_b$ = **0.87** kN/m^2

Structural factor

Structural damping; δs = **0.050** hpart =

Height of element; **6750** mm cs = **0.911**

Size factor (Table NA.3); cd = **1.035**

Dynamic factor (Figure NA.9); csCd = cs × cd =

Structural factor; **0.943**

Peak velocity pressure for internal pressure

Peak velocity pressure – internal (as roof press.); qp,i = **0.87** kN/m²

Pressures and forces

Net pressure; p = csCd × qp × cpe - qp,i × cpi;

Net force; Fw = pw × Aref;

Roof load case 1 - Wind 0, cpi 0.20, -cpe

Zone	Ext pressure coefficient c_{pe}	Peak velocity pressure qp, (kN/m²)	Net pressure p (kN/m²)	Area Aref (m²)	Net force Fw (kN)
F (-ve)	-2.00	0.87	-1.71	9.11	-15.59
G (-ve)	-1.40	0.87	-1.25	47.59	-59.48
H (-ve)	-0.70	0.87	-0.71	226.80	-161.55
I (-ve)	-0.20	0.87	-0.33	283.50	-93.08

Total vertical net force; Fw,v = **-329.69** kN

Total horizontal net force; Fw,h = **0.00** kN

Walls load case 1 - Wind 0, cpi 0.20, -cpe

Zone	Ext pressure coefficient c_{pe}	Peak velocity pressure qp, (kN/m²)	Net pressure p (kN/m²)	Area Aref (m²)	Net force Fw (kN)
A	-1.20	0.87	-1.10	18.23	-19.98
B	-0.80	0.87	-0.79	72.90	-57.52
D	0.73	0.87	0.39	283.50	110.12
E	-0.37	0.87	-0.46	283.50	-129.36

Overall loading

Equiv leeward net force for overall section; Fl = Fw,wE = **-129.4** kN

Net windward force for overall section; Fw = Fw,wD = **110.1** kN

Lack of correlation (cl.7.2.2(3) – Note); fcorr = **0.85**; as h/W is 0.500

Overall loading overall section; Fw,D = fcorr × (Fw - Fl + Fw,h) = **203.6** kN

Roof load case 2 - Wind 0, cpi -0.3, +cpe

Zone	Ext pressure coefficient c_{pe}	Peak velocity pressure qp, (kN/m²)	Net pressure p (kN/m²)	Area Aref (m²)	Net force Fw (kN)
F (+ve)	-2.00	0.87	-1.27	9.11	-11.61
G (+ve)	-1.40	0.87	-0.81	47.59	-38.69
H (+ve)	-0.70	0.87	-0.28	226.80	-62.47

I (+ve)	0.20	0.87	0.42	283.50	117.85

Total vertical net force; Fw,v = **5.07** kN

Total horizontal net force; Fw,h = **0.00** kN

Walls load case 2 - Wind 0, cpi -0.3, +cpe

Zone	Ext pressure coefficient c_{pe}	Peak velocity pressure qp, (kN/m²)	Net pressure p (kN/m²)	Area Aref (m²)	Net force Fw (kN)
A	-1.20	0.87	-0.66	18.23	-12.02
B	-0.80	0.87	-0.35	72.90	-25.68
D	0.73	0.87	0.83	283.50	233.96
E	-0.37	0.87	-0.02	283.50	-5.52

Overall loading

Equiv leeward net force for overall section; Fl = Fw,wE = **-5.5** kN

Net windward force for overall section; Fw = Fw,wD = **234.0** kN

Lack of correlation (cl.7.2.2(3) – Note); fcorr = **0.85**; as h/W is 0.500

Overall loading overall section; Fw,D = fcorr × (Fw - Fl + Fw,h) = **203.6** kN

Roof load case 3 - Wind 90, cpi 0.20, -cpe

Zone	Ext pressure coefficient c_{pe}	Peak velocity pressure qp, (kN/m²)	Net pressure p (kN/m²)	Area Aref (m²)	Net force Fw (kN)
F (-ve)	-2.00	0.87	-1.82	9.11	-16.61
G (-ve)	-1.40	0.87	-1.33	9.11	-12.11
H (-ve)	-0.70	0.87	-0.75	72.90	-54.79
I (-ve)	-0.20	0.87	-0.34	475.88	-161.58

Total vertical net force; Fw,v = **-245.10** kN

Total horizontal net force; Fw,h = **0.00** kN

Walls load case 3 - Wind 90, cpi 0.20, -cpe

Zone	Ext pressure coefficient c_{pe}	Peak velocity pressure qp, (kN/m²)	Net pressure p (kN/m²)	Area Aref (m²)	Net force Fw (kN)
A	-1.20	0.87	-1.16	18.23	-21.21
B	-0.80	0.87	-0.83	72.90	-60.80
C	-0.50	0.87	-0.59	192.38	-112.88
D	0.70	0.87	0.40	91.13	36.65
E	-0.30	0.87	-0.42	91.13	-38.45

Overall loading

Equiv leeward net force for overall section; Fl = Fw,wE = **-38.5** kN

Net windward force for overall section; Fw = Fw,wD = **36.6** kN

Lack of correlation (cl.7.2.2(3) – Note); fcorr = **0.85**; as h/L is 0.161 Fw,D =

Overall loading overall section; fcorr × (Fw - Fl + Fw,h) = **63.8** kN

Roof load case 4 - Wind 90, cpi -0.3, +cpe

Zone	Ext pressure coefficient c_{pe}	Peak velocity pressure qp, (kN/m²)	Net pressure p (kN/m²)	Area Aref (m²)	Net force Fw (kN)
F (+ve)	-2.00	0.87	-1.39	9.11	-12.63
G (+ve)	-1.40	0.87	-0.89	9.11	-8.13
H (+ve)	-0.70	0.87	-0.31	72.90	-22.95
I (+ve)	0.20	0.87	0.43	475.88	203.16

Total vertical net force; Fw,v = **159.45** kN

Total horizontal net force; Fw,h = **0.00** kN

Walls load case 4 - Wind 90, cpi -0.3, +cpe

Zone	Ext pressure coefficient c_{pe}	Peak velocity pressure qp, (kN/m²)	Net pressure p (kN/m²)	Area Aref (m²)	Net force Fw (kN)
A	-1.20	0.87	-0.73	18.23	-13.25
B	-0.80	0.87	-0.40	72.90	-28.96
C	-0.50	0.87	-0.15	192.38	-28.85
D	0.70	0.87	0.84	91.13	76.45
E	-0.30	0.87	0.01	91.13	1.35

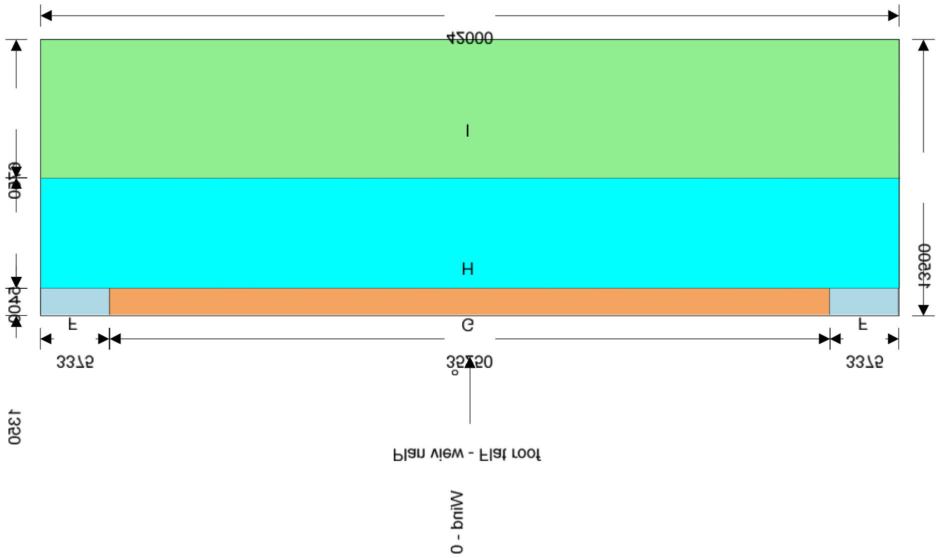
Overall loading

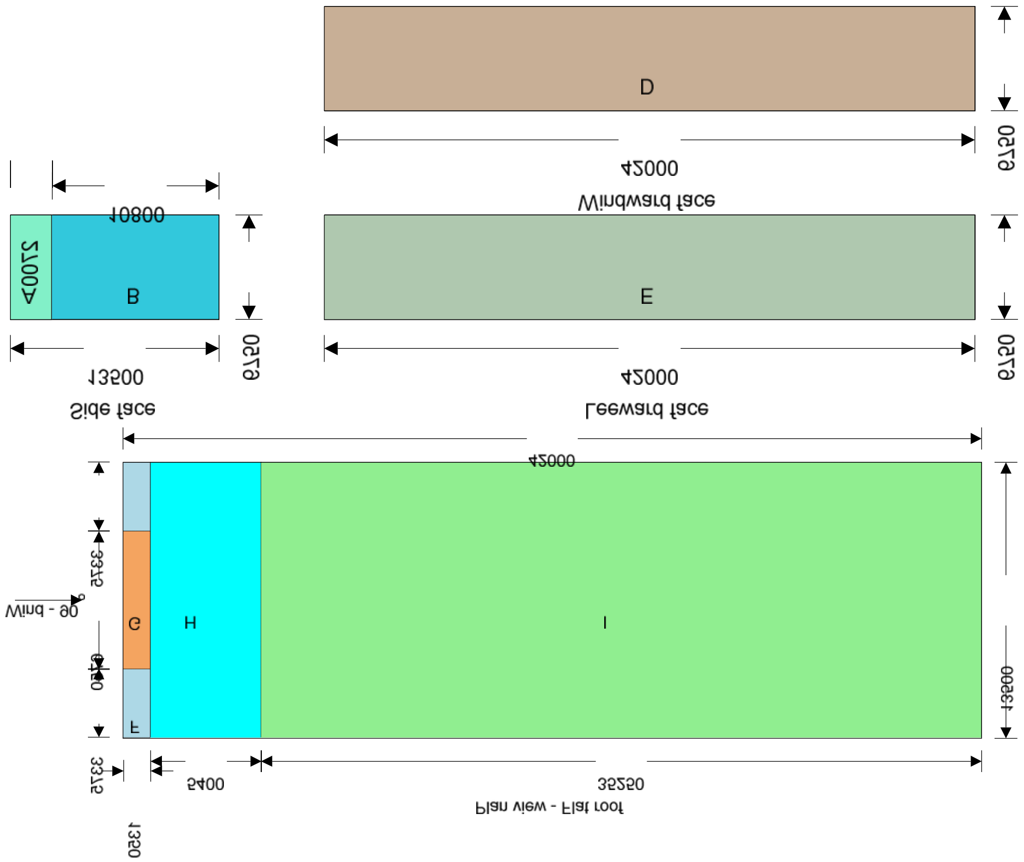
Equiv leeward net force for overall section; Fl = Fw,wE = **1.4** kN

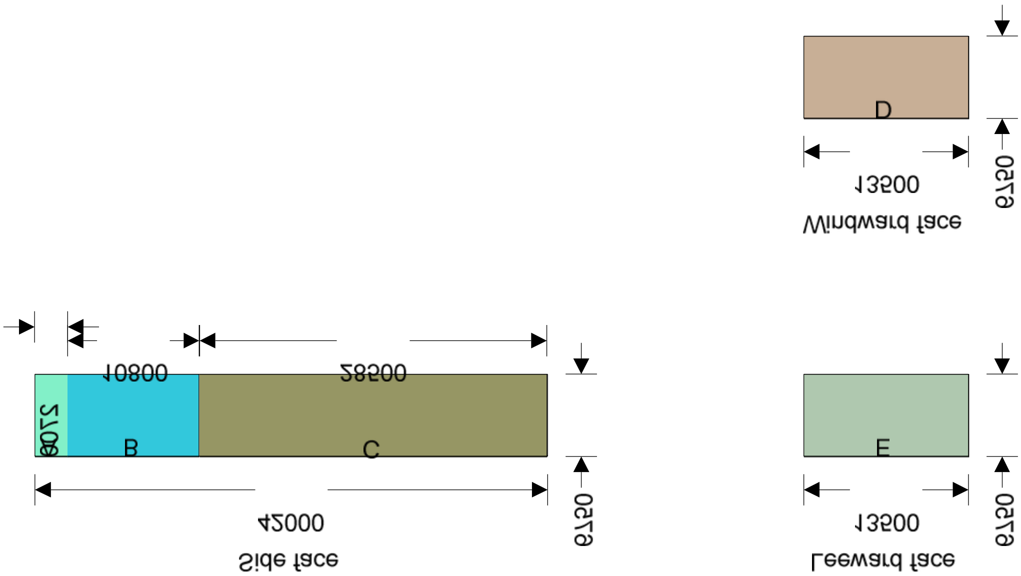
Net windward force for overall section; Fw = Fw,wD = **76.5** kN

Lack of correlation (cl.7.2.2(3) – Note); fcorr = **0.85**; as h/L is 0.161

Overall loading overall section; Fw,D = fcorr × (Fw - Fl + Fw,h) = **63.8** kN




D
42000
Windward face
10800
B
E
13500
42000
Side face
Leeward face
42000
Wind - 90
G
H
I
F
5400
35250
Plan view - Flat roof


D
13500
Windward face
10800
28500
B
C
42000
Side face
E
13500
Leeward face

2.0 JUSTIFICATION OF PANELS FOR GRAVITY LOADINGS

2.1 Proposed PV Loadings

The main gravity loading within this assessment is the PV panel and frame loading which is details below:

Panel Size: 1950mm x 1134mm.
Panel Weight: 26.8kg
Support Frame: 2kg/m2

 26.8kg / (1.950m x 1.134m) + 2kg/m2 = 14.1kg/m2 or **0.14kN/m2.**

The allowable vertical imposed load is 0.60kN/m2 or 60kg/m2 which is far more than the weight of the panel being placed on the roof.

Once the panel is in situ this area of roof will not be trafficked and so there is no need to consider the actual weight of the panel as being an additional imposed load on the roof. Should anyone stand on the panel it will be destroyed, the owner of the property will therefore take strict steps to ensure that no one at any time stands on the panel. Therefore, this area of roof can be considered as carrying less than the design-imposed load indicated in BS EN 1991-1. Therefore, there is no requirement for strengthening as a result of combined imposed load and panel load.

2.2 Gravity Loadings During Installation

The total additional load permitted on the roof structure for the installation of the PV panels is 0.60kN/m2 or 60kg/m2. The maximum permitted point loading during construction is 0.90kN or 90kg.

In accordance with BS EN 1991-1, 0.60kN/m2 or 0.9kN point loads are permitted for non-accessble roofs except for normal maintenance and repairs. Therefore the existing roof has been desgined for these allowable loads.

During solar panel installation we recommend plywood sheets or other appropriate load spreaders are used to adequately distrubute the load to avoid comprimising the 0.60kN/m2 or 0.90kN values. If the PV panels and associated equipment are to be stored on the roof during installation these should be dispersed in a manner that the weight does not exceed 0.60kN/m2. Access to the roof is not permitted during periods of snow.

The roof structure is uniform across its entire area and does not appear to have any strong points or weakend areas, so the points listed are considered to be applicable for the whole structure.

2.3 Snow Load Assessment

When carrying out a roof loading assessment for an installation of PV Panels we need to consider the combined loadings from both the PV Panels and the loadings from snow & snow drift.

With regards snow loading we see that the snow load is 0.41kN/m2. This load will be cumulative to the weight of the panel and frame loadings which are noted within Section 2.1 of this report.

SNOW LOADING

In accordance with EN1991-1-3:2003+A1:2015 incorporating corrigenda dated December 2004 and March 2009 and the UK national annex NA+A1:2015 to BS EN 1991-1-3:2003+A1:2015 incorporating Corrigendum No.1

Tedds calculation version 1.0.14

Characteristic ground snow load

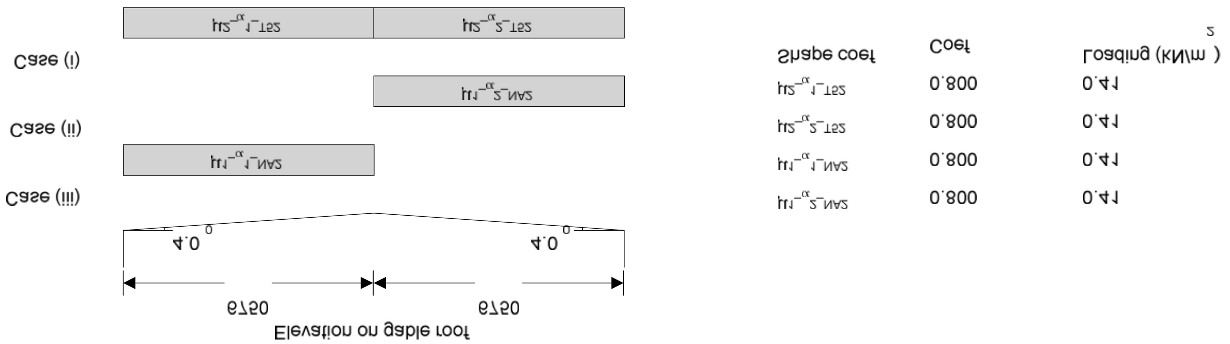
Location;	Preston
Site altitude above sea level (user modified value);	A = **108** m
Zone number;	Z = **3.0**
Density of snow;	γ = **2.00** kN/m3
Characteristic ground snow load;	s_k = ((0.15 + (0.1 × Z + 0.05)) + ((A - 100m) / 525m)) × 1kN/m² = **0.52** kN/m2
Exposure coefficient (Normal);	Ce = **1.0**
Thermal coefficient;	Ct = **1.0**
Snow fence;	Not present

Building details

Roof type;	Duopitch
Width of roof (left on elevation);	b1 = **6.75** m
Width of roof (right on elevation);	b2 = **6.75** m
Slope of roof (left on elevation);	α1 = **4.00** deg
Slope of roof (right on elevation);	α2 = **4.00** deg

Shape coefficients

Shape coefficient roof (Table 5.2);	µ2_α1_T52 = **0.80**
Shape coefficient roof (Table 5.2);	µ2_α2_T52 = **0.80**
Shape coefficient roof (Table UK NA.2);	µ1_α1_NA2 = **0.80**
Shape coefficient roof (Table UK NA.2);	µ1_α2_NA2 = **0.80**



Loadcase 1 Table 5.2

Loading to roof 1 (LHS); s1_1 = µ2_α1_T52 × Ce × Ct × s_k = **0.41** kN/m2

Loading to roof 2 (RHS); $s_{2\_1} = \mu_{2\_\alpha2\_T52} \times C_e \times C_t \times s_k =$ **0.41** kN/m2

Loadcase 2 UK NA.2

Loading to roof 1 (LHS); $s_{1\_2} = 0 \times C_e \times C_t \times s_k =$ **0.00** kN/m^2

Loading to roof 2 (RHS); $s_{2\_2} = \mu_{1\_\alpha2\_NA2} \times C_e \times C_t \times s_k =$ **0.41** kN/m^2

Loadcase 3 UK NA.2

Loading to roof 1 (LHS); $s_{1\_3} = \mu_{1\_\alpha1\_NA2} \times C_e \times C_t \times s_k =$ **0.41** kN/m^2

Loading to roof 2 (RHS); $s_{2\_3} = 0 \times C_e \times C_t \times s_k =$ **0.00** kN/m^2

2.4 Snow Drift

The proposed Solar PV panels are not located next to or near any areas where snow drift is likely to occur therefore snow drift is not considered a potential issue on this project.

2.5 Solar PV System Loadings to Resist Wind Uplift

To calculate the actual wind uplift on the PV Array we refer to BRE Digest 489 (2015).

From our calculations above we know that the negative wind loading, q = 0.87kN/m2 and where a module is less than 0.3m from the roof surface the Wind Uplift Net Pressure Coefficients for the panels in the centre of the roof is -1.50

 -0.87 x -1.50 = -1.31kN/m2 (All roof fixings have to be able to withstand this wind uplift load.)

Given that the panel fixings will transfer the load into the existing roof and the roof was originally designed for the positive & negative wind loadings, no strengthening works will be required to the roof structure.

3.0 CONCLUSIONS

PV System Loadings

From the calculations, we see that the combined system (0.14kN/m2) + snow load (0.41kN/m2) = (0.55kN/m2) is less than or equal to the design-imposed load of 0.60kN/m2.
We are able to confirm these loadings to be acceptable, therefore the proposed solar panels can safely be installed onto the existing roof structure with no strengthening works being required.