BMG Surveys Limited.
Renewable Energy Consulting Engineering Services
info@bmgsurveysltd.co.uk
Tel: 0141 530 2322

bmg SURVEYS LTD.

DESKTOP ROOF LOADING APPRAISAL

STONYHURST

MAIN
STONYHURST CLITHEROE BB7 9PT

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Prepared By:	JMC				
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Revisions:					

CALCULATIONS CARRIED OUT IN ACCORDANCE WITH MCS SOLAR PV STANDARDS

NATIONAL MEMBER EEA Energy Efficiency Association CIC. SCOTLAND

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.

Disclaimer:
The Desk Top Appraisal Report has been produced from information supplied by client. BMG Surveys Ltd. cannot be held responsible for any damage caused from the supply of limited information or damage caused due to inaccuracies within the information supplied.

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 LOADS

Existing Membrane = 0.15kN/m2
Existing Insulation = 0.30kN/m2
Existing Concrete Slab = 3.50kN/m2

Total DL = 3.95kN/m

IMPOSED LOADS

BS 6399:PT3:4.2 & Eurocode- 1 (BS EN 1991-1)

General Roof Load = 1.50kN/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.

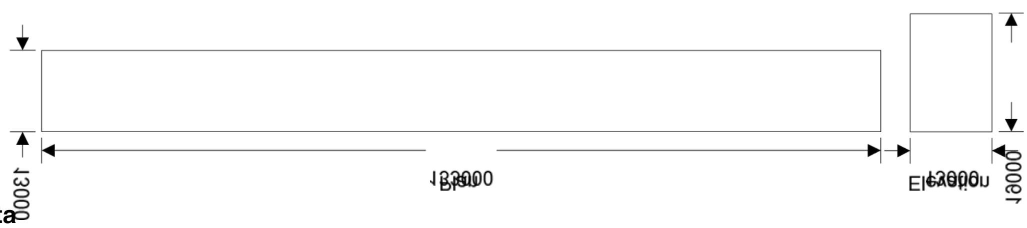
EXISTING ROOF SNOW LOADINGS:

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 = **133000** mm
Width of building;	W = **13000** mm

Height to eaves;	H = **19000** mm
Eaves type;	Sharp
Total height;	h = **19000** 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 2 parts as the height h is greater than b but less than 2b (cl.7.2.2)

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

Reference height (at which q is sought); z = **19000**mm

Displacement height (sheltering effects excluded); h_{dis} = **0** mm

Exposure factor (Figure NA.7);	c_e = **2.84**
Peak velocity pressure;	$q_p = c_e \times q_b =$ **1.15** kN/m^2

Structural factor

Structural damping;	δ_s = **0.050**
Height of element;	h_{part} = **19000** mm
Size factor (Table NA.3);	c_s = **0.833**
Dynamic factor (Figure NA.9);	c_d = **1.006**
Structural factor;	$c_sC_d = c_s \times c_d =$ **0.838**

Peak velocity pressure - windward wall (lower part) - Wind 90 deg

Reference height (at which q is sought); z = **13000**mm

Displacement height (sheltering effects excluded); h_{dis} = **0** mm

Exposure factor (Figure NA.7);	c_e = **2.58**
Peak velocity pressure;	$q_p = c_e \times q_b =$ **1.05** kN/m^2

Structural factor

Structural damping; δs = **0.050** hpart =
Height of element; **13000** mm cs = **0.917**
Size factor (Table NA.3); cd = **1.064**
Dynamic factor (Figure NA.9); csCd = cs × cd =
Structural factor; **0.976**

Peak velocity pressure - windward wall (upper part) - Wind 90 deg and roof

Reference height (at which q is sought); z = **19000**mm
Displacement height (sheltering effects excluded); hdis = **0** mm
Exposure factor (Figure NA.7); ce = **2.84**
Peak velocity pressure; qp = ce × qb = **1.15** kN/m²

Structural factor

Structural damping; δs = **0.050**
Height of element; hpart = **6000** mm
Size factor (Table NA.3); cs = **0.932**
Dynamic factor (Figure NA.9); cd = **1.064**
Structural factor; csCd = cs × cd = **0.991**

Structural factor

Structural damping; δs = **0.050**
Height of element; hpart = **19000** mm
Size factor (Table NA.3); cs = **0.915**
Dynamic factor (Figure NA.9); cd = **1.064**
Structural factor; csCd = cs × cd = **0.974**

Peak velocity pressure for internal pressure

Peak velocity pressure – internal (as roof press.); qp,i = **1.15** 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 cpe	Peak velocity pressure qp, (kN/m²)	Net pressure p (kN/m2)	Area Aref (m²)	Net force Fw (kN)
			-2.16		
F (-ve)	-2.00	1.15	-1.58	72.20	-155.86
G (-ve)	-1.40	1.15	-0.91	433.20	-684.52
H (-ve)	-0.70	1.15		1223.60	-1107.57

Total vertical net force; Fw,v = **-1947.95** kN
Total horizontal net force; Fw,h = **0.00** kN

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

Zone	Ext pressure coefficient cpe	Peak velocity pressure qp, (kN/m²)	Net pressure p (kN/m2)	Area Aref (m²)	Net force Fw (kN)
			-1.39		
A	-1.20	1.15		144.40	-200.33

B	-0.80	1.15	-1.00	102.60	-102.76
D	0.80	1.15	0.54	2527.00	1367.55
E	-0.52	1.15	-0.73	2527.00	-1856.28

Overall loading

Equiv leeward net force for overall section; Fl = Fw,wE = **-1856.3** kN

Net windward force for overall section; Fw = Fw,wD = **1367.6** kN

Lack of correlation (cl.7.2.2(3) – Note); fcorr = **0.87**; as h/W is 1.462

Overall loading overall section; Fw,D = fcorr × (Fw - Fl + Fw,h) = **2796.1** 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	1.15	-1.58	72.20	-114.30
G (+ve)	-1.40	1.15	-1.00	433.20	-435.20
H (+ve)	-0.70	1.15	-0.33	1223.60	-403.36

Total vertical net force; Fw,v = **-952.86** 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	1.15	-0.81	144.40	-117.22
B	-0.80	1.15	-0.43	102.60	-43.71
D	0.80	1.15	1.12	2527.00	2821.91
E	-0.52	1.15	-0.16	2527.00	-401.93

Overall loading

Equiv leeward net force for overall section; Fl = Fw,wE = **-401.9** kN

Net windward force for overall section; Fw = Fw,wD = **2821.9** kN

Lack of correlation (cl.7.2.2(3) – Note); fcorr = **0.87**; as h/W is 1.462

Overall loading overall section; Fw,D = fcorr × (Fw - Fl + Fw,h) = **2796.1** 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	1.15	-2.47	8.45	-20.89
G (-ve)	-1.40	1.15	-1.80	8.45	-15.20
H (-ve)	-0.70	1.15	-1.01	67.60	-68.60
I (-ve)	-0.20	1.15	-0.45	1644.50	-747.19

Total vertical net force; Fw,v = **-851.88** 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	1.15	-1.58	49.40	-77.81
B	-0.80	1.15	-1.13	197.60	-222.66
C	-0.50	1.15	-0.79	2280.00	-1802.53
Db	0.70	1.05	0.48	169.00	81.90
Du	0.70	1.15	0.57	78.00	44.34
E	-0.30	1.15	-0.57	247.00	-139.91

Overall loading

Equiv leeward net force for upper section; Fl = Fw,wE / Aref,wE × Aref,wu = **-44.2** kN

Net windward force for upper section; Fw = Fw,wu = **44.3** kN

Lack of correlation (cl.7.2.2(3) – Note); fcorr = **0.85**; as h/L is 0.143

Overall loading upper section; Fw,u = fcorr × (Fw - Fl + Fw,h) = **75.2** kN

Equiv leeward net force for bottom section; Fl = Fw,wE / Aref,wE × Aref,wb = **-95.7** kN

Net windward force for bottom section; Fw = Fw,wb = **81.9** kN

Lack of correlation (cl.7.2.2(3) – Note); fcorr = **0.85**; as h/L is 0.143

Overall loading bottom section; Fw,b = fcorr × (Fw - Fl) = **151.0** 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	1.15	-1.90	8.45	-16.02
G (+ve)	-1.40	1.15	-1.22	8.45	-10.34
H (+ve)	-0.70	1.15	-0.44	67.60	-29.69
I (+ve)	0.20	1.15	0.57	1644.50	936.49

Total vertical net force; Fw,v = **880.43** kN

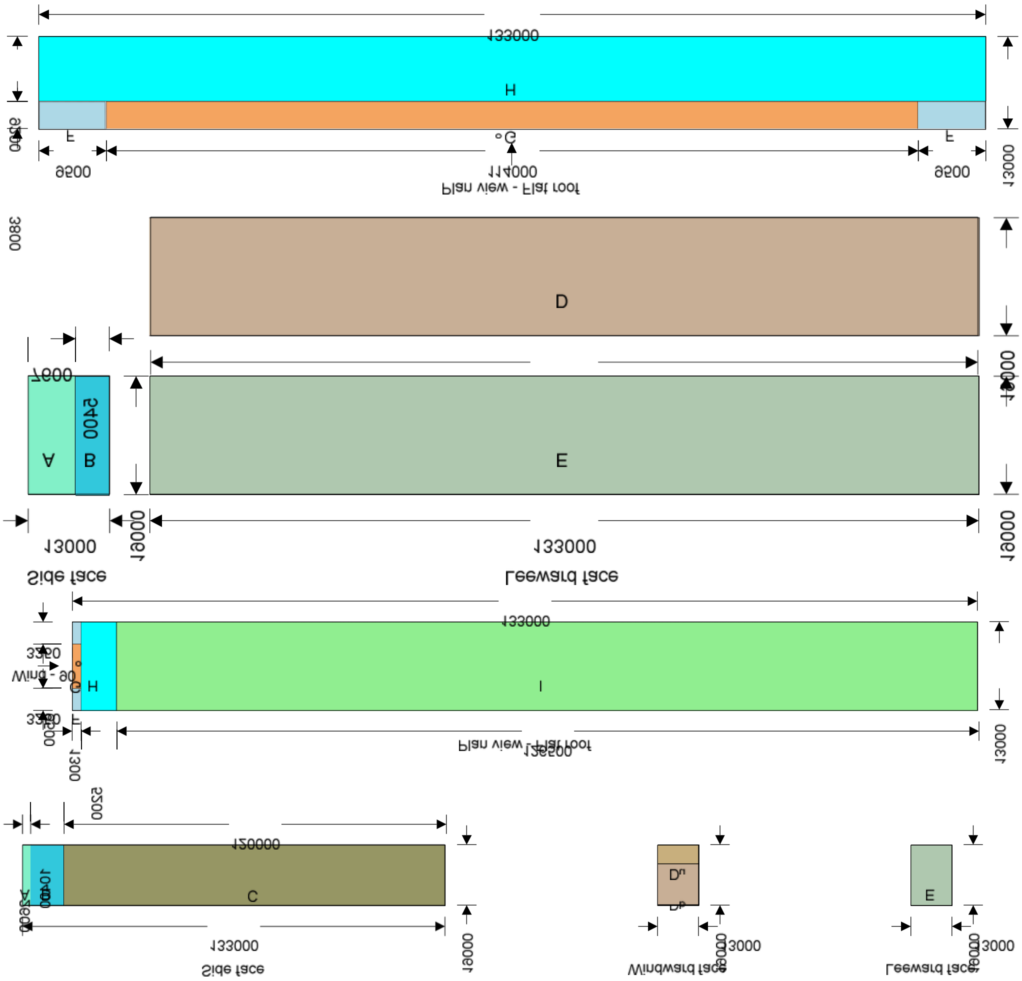
Total horizontal net force; Fw,h = **0.00** kN

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	1.15	-1.00	49.40	-49.38
B	-0.80	1.15	-0.55	197.60	-108.93
C	-0.50	1.15	-0.22	2280.00	-490.32
Db	0.70	1.05	1.06	169.00	179.17
Du	0.70	1.15	1.14	78.00	89.23
E	-0.30	1.15	0.01	247.00	2.25

Overall loading Equiv leeward net force for upper section; Net windward force for upper section; Lack of correlation (cl.7.2.2(3) – Note); Overall loading upper section; Equiv leeward net force for bottom section; Net windward force for bottom section; Lack of correlation (cl.7.2.2(3) – Note); Overall loading bottom section;

Fl = Fw,wE / Aref,wE × Aref,wu = **0.7** kN
Fw = Fw,wu = **89.2** kN
fcorr = **0.85**; as h/L is 0.143
Fw,u = fcorr × (Fw - Fl + Fw,h) = **75.2** kN
Fl = Fw,wE / Aref,wE × Aref,wb = **1.5** kN
Fw = Fw,wb = **179.2** kN
fcorr = **0.85**; as h/L is 0.143
Fw,b = fcorr × (Fw - Fl) = **151.0** kN



2.0 JUSTIFICATION OF PANELS FOR GRAVITY LOADINGS

2.1 Proposed PV Loadings

The client has supplied the Enstall calculations, and the system max loading is 37.56kg/m2 or 0.38kN/m2.

Roof loads

Total weight	22,881.83 kg
Total ballast weight	11,982.0 kg
Total system weight	2,139.83 kg
Total panel weight	8,760.0 kg
Number of ballast units (User defined brick)	3994*
Roof area (gross)	9,072.01 m²
System area (projected area)	928.47 m²
Average load over roof area	2.52 kg/m²
Average load over system area	24.64 kg/m²
Max load over panel area	37.56 kg/m²
Max dynamic point load (at base plate)	72.53 kPa**, 130.659 kg/base plate
Max static point load (at base plate)	16.96 kPa**

Please note that ballast loads have been supplied by Enstall.

The allowable vertical imposed load is 1.50kN/m2 or 150kg/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 1.50kN/m2 or 150kg/m2. The maximum permitted point loading during construction is 0.90kN or 90kg.

In accordance with BS EN 1991-1, 1.50kN/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 1.50kN/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 1.50kN/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 0.52kN/m2. This load will be cumulative to the weight of the panel, frame and ballast loadings which are discussed within Section 2.1 of this report.

Snow Load Calculations

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; Flat

Width of roof; b = **13.00** m

Shape coefficients

Shape coefficient roof (Table UK NA.1); μ1_NA1 = **1.00**

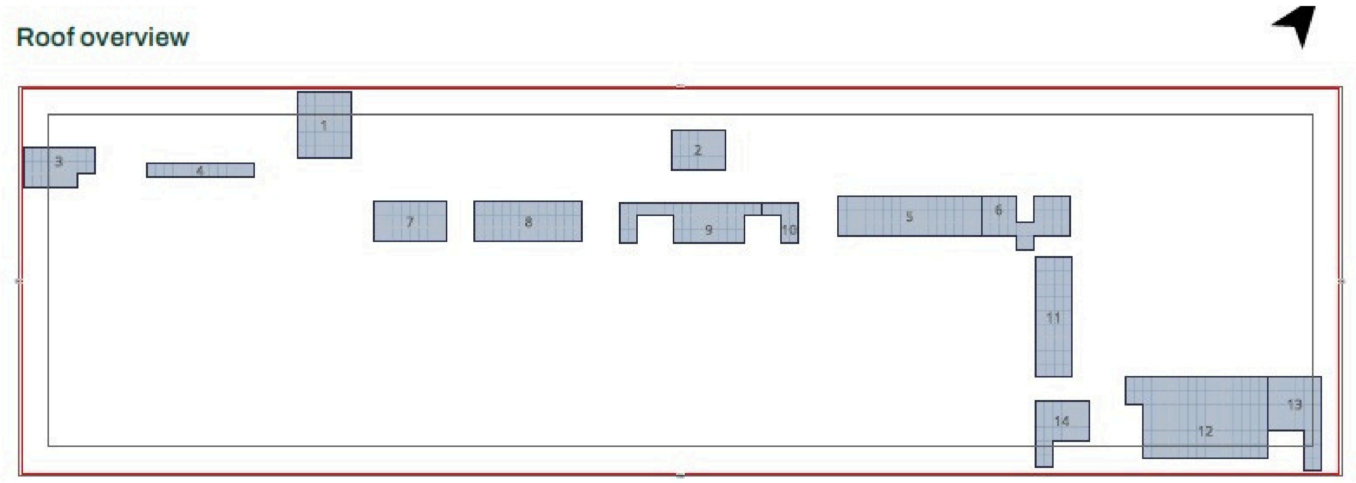
Shape coef	Coef	Loading (kN/m2)
μ1_NA1	1.000	0.52

Loadcase 1 Table 5.2

Loading to roof 1; s1_1 = μ1_NA1 × Ce × Ct × s_k = **0.52** kN/m2

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.



3.0 CONCLUSIONS

PV System Loadings

From the calculations, we see that the combined system & ballast (0.38kN/m2) + snow load (0.52kN/m2) = (0.90kN/m2) is less than or equal to the design-imposed load of 1.50kN/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.