

Roof Loading Assessment for PV Installation

at

The Met

Undertaken on behalf of

Warden Construction Ltd

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Revision Status / History

Rev	Date	Issue / Purpose/ Comment	Prepared	Checked
01	26/01/2022	First Issue	AS	MS
02	24/02/2022	Revised to include detailed calculations	AL	AJL

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1.0 INTRODUCTION

- 1.1 WML Consulting Ltd have been appointed to undertake a structural assessment of roof loadings for the installation of new Photovoltaic (PV) panels on a Decarbonisation scheme for Bury Council. The scheme involves installation of new PV panels on refurbished roofs for a number of sites.
- 1.2 This document refers to a roof assessment of The Met, located at Market Street, Bury, BL9 0BW.

2.0 PROPOSED WORKS

- 2.1 The part of the building under consideration is a two/three storey structure with a multispan duo pitch roof. The existing roof is finished with slates, supported by a traditional timber roof structure; timber rafters and purlins.
- 2.2 The proposed works involve installation of PV panels on the existing slate roof. The new PV panels will be installed on the existing roof on proprietary support brackets.
- 2.3 The proposed details are shown on Halliday Meecham drawing 5449-HMA-TM-00-DR-00003 rev P2 - Proposed Roof Plan.
- 2.4 The proposed solar panels are Longi LR4-60HPH 350~380M; a data sheet has been provided. The solar panels will be mounted using the Solar Limpet system.

3.0 WIND LOADINGS

- 3.1 The site is located in Bury, and for the purpose of calculating the roof wind loading, town terrain has been assumed. The closest distance to shore has been measured from the west direction, which will generate the most onerous wind loading. Wind pressure calculations are presented in appendix A.



- 3.2 The site is located at approximately 98m AOD.
- 3.3 The building height measured on the east elevation from the ground level to the ridge is 13.5m.
- 3.4 The design calculations of the roof wind loading have been partially undertaken using Tekla Tedds analysis software and by hand. The calculations include both external and internal pressures combinations, resulting in net wind pressures/suction on the roof panels. The calculations assume worst case wind direction from the west.

4.0 SNOW LOADINGS

- 4.1 The design calculation of snow loading has been undertaken using Tekla Tedds analysis software. Both basic and, where appropriate, complex snow loading combinations have been considered.

5.0 EXISTING AND PROPOSED ROOF LOADING SUMMARY AND COMPARISON

- 5.1 Due to the high snow heaping loads it is not possible to justify by comparison that the addition of the PV panels is acceptable. As such a more detailed survey of the roof structure has been carried out to allow calculations of the timber capacity to be undertaken.
- 5.2 The roof is formed by timber rafters, supported on braced timber purlins, which are in turn supported by timber trusses. The ceiling is supported from the bottom chord of the truss and as such there is no requirement to consider the ceiling weight in the rafter and purlin assessment.
- 5.3 It is only considered necessary to carry out checks on the rafters and purlins. The increase in overall load on the timber trusses is a small percentage and the effect of snow load is shared over the length of the truss.

Design Codes		
BS EN 1990 & National Annex – Basis of Structural Design BS EN 1991 & National Annex – Actions on Structures		
Roof Loading		
Existing Roof		SLS
Self-weight of roof	Slates:	0.40 kN/m ²
	Felt & Battens:	0.04 kN/m ²
	Timber structure:	0.13 kN/m ²
	Total Dead load on roof:	0.57 kN/m ²
Imposed Load Allowance		0.75 kN/m ² (accordance with CP3 chapter V)
Total		<u>0.75 kN/m²</u>
Proposed Roof		SLS
Proposed dead loads added to existing roof	PV Panels (19.5kg / (1.755m x 1.038m))	0.11 kN/m ²
	PV panel supporting frame, assumed	0.02 kN/m ²
Imposed loads	Assuming no access is possible, where the PV panes are installed	0.00kN/m ²
Wind Load	Maximum downwards pressure (refer to Appendix 4 for Hand wind pressure calculations)	0.00 kN/m ²
	Maximum uplift pressure (refer to Appendix 4 for Hand wind pressure calculations)	-0.79 kN/m ²
Snow Load	(refer to Appendix B for basic snow load calculations)	
	Basic snow load	0.50kN/m ²
	Drifted snow load (max)	1.30kN/m ²

- 5.4 Existing rafters were measured as 60 x 120mm at average 375mm centres with a span of approximately 1.65m. The timber grade is unknown, but is likely to be high given the age of the building.

A calculation has been carried out for the rafter with the proposed dead loading and the snow drift load (short term), using C16 timber (expected to be very conservative) and the section is adequate.

- 5.5 The existing purlins span between the trusses (approx. 3.2m), but have a raking prop/brace to each end, thus reducing the span to 1.15m. The section size was measured at 97 x 235mm over the central portion, reducing to 97 x 150mm from the brace to the truss. Again the timber grade is unknown.

The purlin has been checked based on a 3.2m span using the full section size as C16 timber. This is considered to be very conservative, and the section is adequate.

6.0 CONCLUSIONS

- 6.1 It is assumed that the existing roof was designed for an imposed load allowance of at least 0.75kN/m^2 , given the age of the building in accordance with CP3 Chapter V.

- 6.2 The proposed PV panels will be mounted on the existing roof on proprietary support brackets.

- 6.3 No access is possible in areas where the new PV panels are being installed and therefore no imposed load allowance is required at those locations. However, snow loading has been considered and snow drift within the roof valley will be significant.

- 6.4 The load from the PV panels plus the basic snow load ($0.50 + 0.127 = 0.627\text{kN/m}^2$) is below the 0.75kN/m^2 assumed imposed load allowance, as a result, this is considered adequate.

Therefore the Solar Panels can be installed in areas where basic snow loading occurs without further consideration.

- 6.5 To areas where there may be drifted snow heaping the addition of the PV panels could not be justified in the same way and as such a detailed survey of the timber sizes was carried out to allow checks on the timber section sizes for the increased load.

Checks have shown that the existing timber roof structure is capable of supporting the additional load from the PV panels.

- 6.6 There will be no change to the wind loading on the roof due to the addition of the PV panels.

- 6.7 On the basis of the assessment carried out, the existing roof structure is capable of supporting the proposed PV Panel installation.

APPENDIX 02

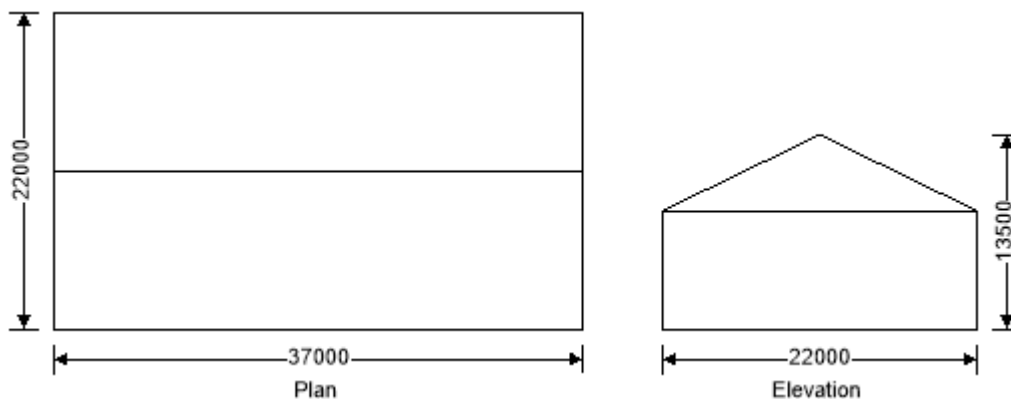
Snow Loading Calculations

WMLCONSULTING Civil, Structural and Geotechnical Engineers WML Consulting Ltd No. 8 Oak Green, Earl Road Stanley Business Park, Cheadle Hulme Cheshire, SK8 6QL	Project Bury Decarbonation, PV installation				Job no. 1024R	
	Calcs for The Met				Start page no./Revision 1	
	Calcs by A.S	Calcs date 26/01/2022	Checked by M.S	Checked date 27/01/2022	Approved by A.L	Approved date 27/01/2022

WIND LOADING

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

Tedds calculation version 3.0.28



Building data

Type of roof	Duopitch
Length of building	L = 37000 mm
Width of building	W = 22000 mm
Height to eaves	H = 8211 mm
Pitch of roof	$\alpha_0 = 25.7$ deg
Total height	h = 13500 mm

Basic values

Location	Manchester
Wind speed velocity (Figure NA.1)	$V_{b,map} = 23.0$ m/s
Distance to shore	$L_{shore} = 51.70$ km
Altitude above sea level	$A_{alt} = 98.0$ m
Altitude factor	$C_{alt} = A_{alt}/1m \times 0.001 + 1 = 1.098$
Fundamental basic wind velocity	$V_{b,0} = V_{b,map} \times C_{alt} = 25.3$ 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	$\rho = 1.226$ kg/m ³
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)	$V_b = C_{dir} \times C_{season} \times V_{b,0} \times C_{prob} = 25.3$ m/s
Reference mean velocity pressure	$q_b = 0.5 \times \rho \times V_b^2 = 0.391$ kN/m ²

Orography

Orography factor not significant	$C_o = 1.0$
Terrain category	Town
Displacement height (sheltering effect excluded)	$h_{dis} = 0$ mm

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

Project Bury Decarbonation, PV installation				Job no. 1024R	
Calcs for The Met				Start page no./Revision 2	
Calcs by A.S	Calcs date 26/01/2022	Checked by M.S	Checked date 27/01/2022	Approved by A.L	Approved date 27/01/2022

Reference height (at which q is sought) $z = 8211\text{mm}$
Displacement height (sheltering effects excluded) $h_{dis} = 0\text{ mm}$
Exposure factor (Figure NA.7) $C_e = 2.24$
Exposure correction factor (Figure NA.8) $C_{e,T} = 0.90$
Peak velocity pressure $q_p = C_e \times C_{e,T} \times q_b = 0.79\text{ kN/m}^2$

Structural factor

Structural damping $\delta_s = 0.100$
Height of element $h_{part} = 8211\text{ mm}$
Size factor (Table NA.3) $C_s = 0.796$
Dynamic factor (Figure NA.9) $C_d = 1.008$
Structural factor $C_s C_d = C_s \times C_d = 0.803$

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

Reference height (at which q is sought) $z = 13500\text{mm}$
Displacement height (sheltering effects excluded) $h_{dis} = 0\text{ mm}$
Exposure factor (Figure NA.7) $C_e = 2.56$
Exposure correction factor (Figure NA.8) $C_{e,T} = 0.95$
Peak velocity pressure $q_p = C_e \times C_{e,T} \times q_b = 0.96\text{ kN/m}^2$

Structural factor

Structural damping $\delta_s = 0.100$
Height of element $h_{part} = 13500\text{ mm}$
Size factor (Table NA.3) $C_s = 0.836$
Dynamic factor (Figure NA.9) $C_d = 1.018$
Structural factor $C_s C_d = C_s \times C_d = 0.851$

Structural factor - roof 0 deg

Structural damping $\delta_s = 0.100$
Height of element $h_{part} = 13500\text{ mm}$
Size factor (Table NA.3) $C_s = 0.808$
Dynamic factor (Figure NA.9) $C_d = 1.008$
Structural factor $C_s C_d = C_s \times C_d = 0.815$

Peak velocity pressure for internal pressure

Peak velocity pressure – internal (as roof press.) $q_{p,i} = 0.96\text{ kN/m}^2$

Pressures and forces

Net pressure $p = C_s C_d \times q_p \times C_{pe} - q_{p,i} \times C_{pi}$
Net force $F_w = p_w \times A_{ref}$

Roof load case 1 - Wind 0, $C_{pi} 0.20$, $-C_{pe}$

Zone	Ext pressure coefficient C_{pe}	Peak velocity pressure q_p , (kN/m ²)	Net pressure p (kN/m ²)	Area A_{ref} (m ²)	Net force F_w (kN)
F (-ve)	-0.67	0.96	-0.72	40.45	-28.97
G (-ve)	-0.59	0.96	-0.65	70.40	-45.69
H (-ve)	-0.26	0.96	-0.39	340.76	-133.73
I (-ve)	-0.50	0.96	-0.58	340.76	-198.16
J (-ve)	-1.02	0.96	-0.98	110.85	-109.01

Total vertical net force $F_{w,v} = -464.64\text{ kN}$

Total horizontal net force $F_{w,h} = 42.81\text{ kN}$

Project Bury Decarbonation, PV installation				Job no. 1024R	
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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 1.0.13

Characteristic ground snow load

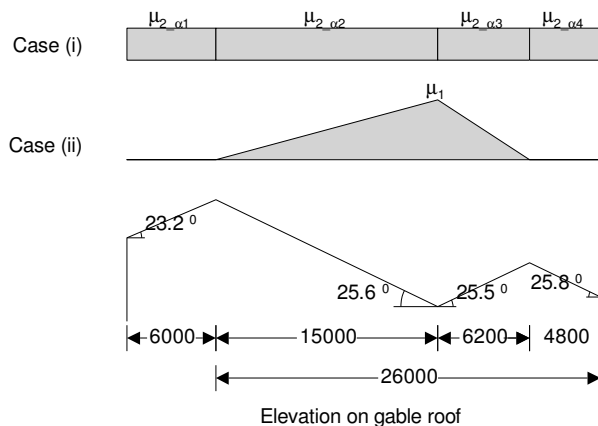
Location	Manchester
Site altitude above sea level (user modified value)	A = 98 m
Zone number	Z = 3.0
Density of snow	$\gamma = 2.00 \text{ kN/m}^3$
Characteristic ground snow load	$s_k = ((0.15 + (0.1 \times Z + 0.05)) + ((A - 100\text{m}) / 525\text{m})) \times 1\text{kN/m}^2 = 0.50 \text{ kN/m}^2$
Exposure coefficient (Normal)	$C_e = 1.0$
Thermal coefficient	$C_t = 1.0$
Snow fence	Not present

Building details

Roof type	Multispan
Width of roof 1 (LHS on left building)	$b_1 = 6.00 \text{ m}$
Width of roof 2 (RHS on left building)	$b_2 = 15.00 \text{ m}$
Width of roof 3 (LHS on right building)	$b_3 = 6.20 \text{ m}$
Width of roof 4 (RHS on right building)	$b_4 = 4.80 \text{ m}$
Average roof height at valley	$h_{\text{avg}} = 4.20 \text{ m}$
Slope of roof 1 (LHS of left building)	$\alpha_1 = 23.18 \text{ deg}$
Slope of roof (RHS of left building)	$\alpha_2 = 25.63 \text{ deg}$
Slope of roof 3 (LHS of right building)	$\alpha_3 = 25.53 \text{ deg}$
Slope of roof 4 (RHS of right building)	$\alpha_4 = 25.83 \text{ deg}$

Shape coefficients

Shape coefficient roof (Table 5.2)	$\mu_{2_a1} = 0.80$
Shape coefficient roof (Table 5.2)	$\mu_{2_a2} = 0.80$
Shape coefficient roof (Table 5.2)	$\mu_{2_a3} = 0.80$
Shape coefficient roof (Table 5.2)	$\mu_{2_a4} = 0.80$
Shape coefficient roof (Annex B2)	$\mu_1 = \min(2\text{kN/m}^3 \times h_{\text{avg}} / s_k, 2 \times (b_2 + b_3 + \max(b_1, b_4)) / (b_2 + b_3), 5) = 2.57$



Shape coef	Coef	Loading (kN/m²)
μ_{2_a1}	0.800	0.40
μ_{2_a2}	0.800	0.40
μ_{2_a3}	0.800	0.40
μ_{2_a4}	0.800	0.40
μ_1	2.566	1.27

Project Bury Decarbonation, PV installation				Job no. 1024R	
Calcs for The Met				Start page no./Revision 2	
Calcs by A.S	Calcs date 27/01/2022	Checked by M.S	Checked date 27/01/2022	Approved by A.L	Approved date 27/01/2022

Loadcase1 Table 5.2

Loading to roof 1	$S_{1_1} = \mu_{2_a1} \times C_e \times C_t \times S_k = \mathbf{0.40 \text{ kN/m}^2}$
Loading to roof 2	$S_{2_1} = \mu_{2_a2} \times C_e \times C_t \times S_k = \mathbf{0.40 \text{ kN/m}^2}$
Loading to roof 3	$S_{3_1} = \mu_{2_a3} \times C_e \times C_t \times S_k = \mathbf{0.40 \text{ kN/m}^2}$
Loading to roof 4	$S_{4_1} = \mu_{2_a4} \times C_e \times C_t \times S_k = \mathbf{0.40 \text{ kN/m}^2}$

Loadcase 2 Annex B2

Loading to roof 1	$S_{1_2} = 0 \times S_k = \mathbf{0.00 \text{ kN/m}^2}$
Loading to avg roof 2 & 3	$S_{2_2} = \mu_1 \times S_k = \mathbf{1.27 \text{ kN/m}^2}$
Loading to roof 4	$S_{3_2} = 0 \times S_k = \mathbf{0.00 \text{ kN/m}^2}$

APPENDIX 03

Longi LR4-60HPH 350~380M; a data sheet

Hi-MO 4m

LR4-60HPH 350~380M

- Suitable for distributed projects
- Advanced module technology delivers superior module efficiency
 - M6 Gallium-doped Wafer
 - 9-busbar Half-cut Cell
- Excellent outdoor power generation performance
- High module quality ensures long-term reliability



12-year Warranty for
Materials and Processing



25-year Warranty for Extra
Linear Power Output

Complete System and Product Certifications

IEC 61215, IEC 61730, UL 61730

ISO 9001:2008: ISO Quality Management System

ISO 14001: 2004: ISO Environment Management System

TS62941: Guideline for module design qualification and type approval

OHSAS 18001: 2007 Occupational Health and Safety

LONGi



20.9%
MAX MODULE
EFFICIENCY

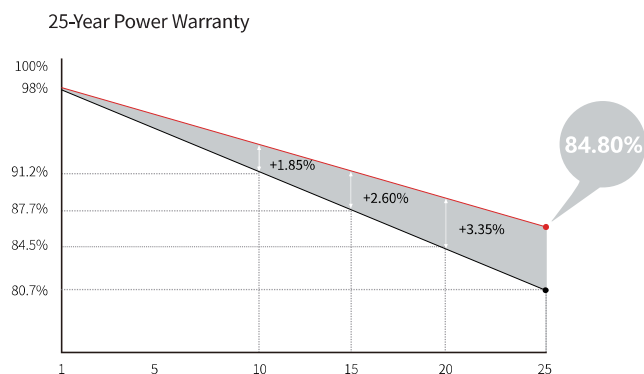
0~+5W
POWER
TOLERANCE

<2%
FIRST YEAR
POWER DEGRADATION

0.55%
YEAR 2-25
POWER DEGRADATION

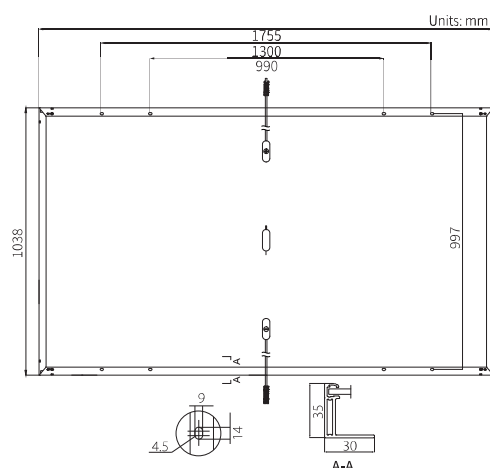
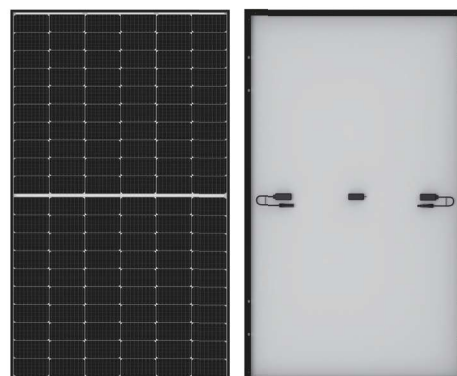
HALF-CELL
Lower operating temperature

Additional Value



Mechanical Parameters

Cell Orientation	120 (6×20)
Junction Box	IP68, three diodes
Output Cable	4mm ² , 1200mm length can be customized
Connector	EVO2
Glass	Single glass, 3.2mm coated tempered glass
Frame	Anodized aluminum alloy frame
Weight	19.5kg
Dimension	1755×1038×35mm
Packaging	30pcs per pallet / 180pcs per 20' GP / 780pcs per 40' HC



Electrical Characteristics

STC : AM1.5 1000W/m² 25°C Test uncertainty for Pmax: ±3%

Power Class	350	355	360	365	370	375	380
Maximum Power (Pmax/W)	350	355	360	365	370	375	380
Open Circuit Voltage (Voc/V)	40.1	40.3	40.5	40.7	40.9	41.1	41.3
Short Circuit Current (Isc/A)	11.15	11.25	11.35	11.43	11.52	11.60	11.69
Voltage at Maximum Power (Vmp/V)	33.6	33.8	34.0	34.2	34.4	34.6	34.8
Current at Maximum Power (Imp/A)	10.42	10.51	10.59	10.68	10.76	10.84	10.92
Module Efficiency(%)	19.2	19.5	19.8	20.0	20.3	20.6	20.9

Operating Parameters

Operational Temperature	-40°C ~ +85°C
Power Output Tolerance	0 ~ +5 W
Voc and Isc Tolerance	±3%
Maximum System Voltage	DC1500V (IEC/UL)
Maximum Series Fuse Rating	20A
Nominal Operating Cell Temperature	45±2°C
Protection Class	Class II
Fire Rating	UL type 1 or 2

Mechanical Loading

Front Side Maximum Static Loading	5400Pa
Rear Side Maximum Static Loading	2400Pa
Hailstone Test	25mm Hailstone at the speed of 23m/s

Temperature Ratings (STC)

Temperature Coefficient of Isc	+0.048%/°C
Temperature Coefficient of Voc	-0.270%/°C
Temperature Coefficient of Pmax	-0.350%/°C

APPENDIX 04

Calculations

Project Title:	PV INSTALLATION, BURY DECARBONATION THE MET			Project No:	Page No:	Rev:
				10242R	01	00
Calculations	Notes	Meeting Minutes	Made by:	Checked by:	Date:	Scanned:
			A.S	M.S	JAN 22	

DESIGN CALCULATION FOR WIND PRESSURE ON ROOF

PEAK VELOCITY PRESSURE $q_b = 0.79 \text{ kN/m}^2$ (FROM TEDOS)

C_{pi} TO BE TAKEN $+0.2$ OR -0.3

$C_{pe,10} = -0.8$ (ZONE H & J) -0.6 (ZONE I)

COEFFICIENT C_{pe} FOR = C_{pe} (FIG 6.18 MANUAL DESIGN EC1)
MULTI ROOF DUAL PITCH TAKING WORSE CASE

WIND PRESSURE ON ROOF

* NET PRESSURE ACTING ON ROOF ZONE H & J

$$W_{net} = W_e - W_i$$

$$\begin{aligned} W_e &= C_{pe} \times q_b(z) \\ &= -0.8 \times 0.79 \\ &= -0.63 \end{aligned}$$

$$\begin{aligned} W_{i(min)} &= C_{pi} \times q_b(z) \\ &= 0.2 \times 0.79 \\ &= 0.16 \end{aligned}$$

$$\begin{aligned} W_{i(max)} &= C_{pi} \times q_b(z) \\ &= -0.3 \times 0.79 \\ &= -0.24 \end{aligned}$$

$$\begin{aligned} W_{net(min)} &= (-0.63) - (0.16) \\ &= \underline{-0.79} \end{aligned}$$

$$\begin{aligned} W_{net(max)} &= (-0.63) - (-0.24) \\ &= \underline{-0.39} \end{aligned}$$

* NET PRESSURE ACTING ON ROOF ZONE I

$$W_{net} = W_e - W_i$$

$$\begin{aligned} W_e &= C_{pe} \times q_b(z) \\ &= -0.6 \times 0.79 = -0.47 \end{aligned}$$

$$\begin{aligned} W_{i(min)} &= C_{pi} \times q_b(z) = 0.16 \quad (\text{calculated above for zone H}) \\ W_{i(max)} &= C_{pi} \times q_b(z) = -0.24 \quad (") \end{aligned}$$

$$\begin{aligned} W_{net(min)} &= (-0.47) - (0.16) = \underline{-0.63} \\ W_{net(max)} &= (-0.47) - (-0.24) = \underline{-0.23} \end{aligned}$$

Project Title:	PV INSTALLATION, BURY DECARBONATION THE MET	Project No:	Page No:	Rev:
		102422	01	00
Calculations	Notes	Meeting Minutes	Made by:	Checked by:
			A.S	M.S
			Date:	Scanned:
			JAN 22	

DRIFTED SNOW LOAD ARRANGEMENT OBSTRUCTION FROM THE WEST

$$S_k = 0.50 \text{ kN/m}^2$$

$$h = \text{height of obstruction} = 4\text{m}$$

$$b_2 = 15\text{m} \quad \text{and} \quad b_1 = 6.2\text{m} \quad \text{and} \quad b_3 = 27.6\text{m}$$

$$l_1 = \dots \quad l_2 = \dots$$

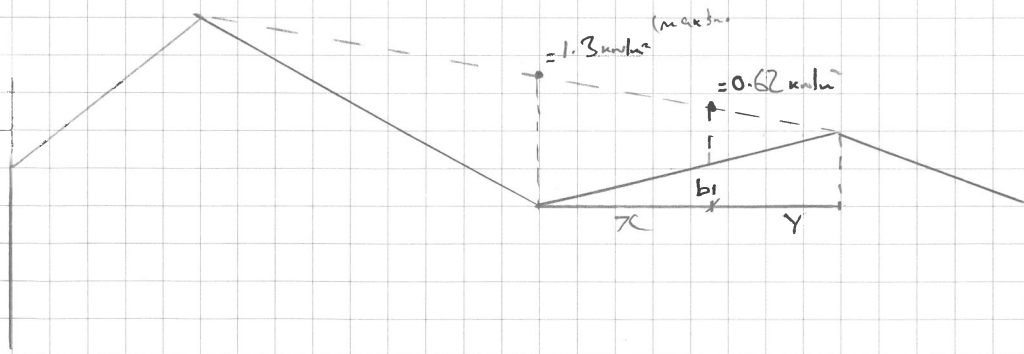
$$b = \text{LARGER OF } b_1 \text{ OR } b_2 \Rightarrow b_1 = 15\text{m} \quad l_{s1} = 6.2 \quad l_{s2} = 15$$

$$u_1 = 2h / s_k = 2 \times 4 / 0.5 = 16\text{m}$$

$$u_i = 2b_3 / (b_1 + l_{s2}) = 2.6\text{m} \quad (\text{TAKE LEAST})$$

$$u_1 = 5 \quad \therefore u_i = 2.6\text{m}$$

$$S_{\text{drift}} = 2.6 \times 0.50 = 1.30 \text{ kN/m}^2$$



$$\frac{0.62}{y} = \frac{1.3}{6.2} \Rightarrow y = \frac{6.2 \times 0.62}{1.3} = 2.98\text{m}$$

$$x = 6.2 - 2.98 = 3.24\text{m}$$

$$\text{ALLOW } 1\text{m away from RIDGE} \therefore 2.98\text{m} - 1 = 1.98\text{m}$$

$\therefore$ 2m of PV PANELS will be ALLOWED, 1m away FROM THE RIDGE.

Wright Mottershaw Lydon Consulting

Cloud e50e5

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Job Ref : Bury Decarbonisation, The Met

Sheet : 10242R /

Made by : AJL

Date : 24 February 2022 / Ver. 2020.22

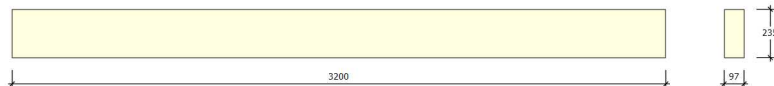
Checked :

Approved :

MasterKey : Timber Design

Joist Design to BS 5268 : Part 2

Existing Timber Joist

**Summary Design Data**

Section Size	b = 97, h = 235, 235x97 in Strength Class C16
Section Properties (cm ² , cm ⁴ , cm ³)	Area 228, I _x 10490.5, Z 892.8
Specification	2 : Covered and generally unheated, Short Term loading
	Load sharing
Joist data	Span 3.2 m, Spacing 1.65 m, Bearing length B 75, Distance to Bearing 150 mm
Joist loading	Dead load 0.7 kN/m ² , Live load 1.3 kN/m ²

Grade and Admissible Stresses (Strength Class C16)

$\sigma_{m,adm} = K_2 \cdot K_3 \cdot K_7 \cdot K_8 \cdot \sigma_m$	1.00 x 1.50 x 1.03 x 1.10 x 5.30	8.98 N/mm ²
$\sigma_{c,adm} = K_2 \cdot K_3 \cdot K_4 \cdot K_8 \cdot \sigma_c$	1.00 x 1.50 x 1.14 x 1.10 x 1.70	3.20 N/mm ²
$\tau_{adm} = K_2 \cdot K_3 \cdot K_8 \cdot \tau$	1.00 x 1.50 x 1.10 x 0.67	1.11 N/mm ²
$E = K_2 \cdot E_{mean}$	1.00 x 8800	8800.0 N/mm ²

Design Loads

Density and Selfweight	Timber Density 370 kg/m³, Fj 0.08 kN/m	
w = (Fd+Fl).s+Fj	(0.70 + 1.30) x 1.65 + 0.08	3.38 kN/m

Bending Check

$M = w \cdot L^2 / 8$	3.38 x 3.2 ² / 8	4.326 kN.m	
$\sigma_{m,a} = M / Z$	4.326 / 892.8 ≤ 8.98	4.85 N/mm ²	OK

Shear and Bearing Check

$F_v = w \cdot L / 2$	3.38 x 3.2 / 2	5.408 kN	
$\tau_a = 1.5 F_v / \text{Area}$	1.5 x 5.408 / 227.95 ≤ 1.11	0.36 N/mm ²	OK
$\sigma_{ca} = F_v / (b \cdot B)$	5.408 / (97 x 75) ≤ 3.20	0.74 N/mm ²	OK

Deflection Check

$\delta_m = 5 \cdot w \cdot L^4 / (384 \cdot E \cdot I_x)$	5 x 3.38 x 3.2 ⁴ / (384 x 8800 x 10490.5)	5.00 mm	
$\delta_s = 12 \cdot w \cdot L^2 / (5 \cdot E \cdot \text{Area})$	12 x 3.38 x 3.2 ² / (5 x 8800 x 228)	0.41 mm	
$\delta = \delta_m + \delta_s$	5.00 + 0.41 ≤ L/333 or 14mm	5.41 mm	OK

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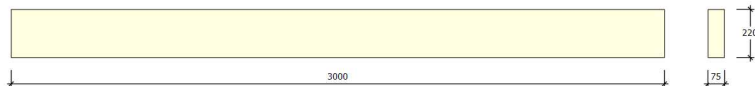
Tel: (0161) 482 0600

Job Ref : Bury Decarbonisation, The Met
 Sheet : 10242R /
 Made by : AJL
 Date : 24 February 2022 / Ver. 2020.22
 Checked :
 Approved :

MasterKey : Timber Design

Beam Design to BS 5268 : Part 2

Existing Timber Purlin

**Summary Design Data**

Section Size	b = 75, h = 220, 220x75 in Strength Class C16
Section Properties (cm ² , cm ⁴ , cm ³)	Area 165, I _x 6655, Z 605
Specification	1 : Internal use in continuously heated building
	Long Term loading, Use minimum modulus
Beam data	Span 3.0 m, Spacing 2.0 m, Bearing length B 75, Distance to Bearing 150 mm
Beam loading	Dead load 0.5 kN/m ² , Live load 1.5 kN/m ²

Grade and Admissible Stresses (Strength Class C16)

$\sigma_{m,adm} = K_2 \cdot K_3 \cdot K_7 \cdot K_8 \cdot \sigma_m$	$1.00 \times 1.00 \times 1.03 \times 1.00 \times 5.30$	5.48 N/mm ²
$\sigma_{c,adm} = K_2 \cdot K_3 \cdot K_4 \cdot K_8 \cdot \sigma_c$	$1.00 \times 1.00 \times 1.14 \times 1.00 \times 1.70$	1.94 N/mm ²
$\tau_{adm} = K_2 \cdot K_3 \cdot K_8 \cdot \tau$	$1.00 \times 1.00 \times 1.00 \times 0.67$	0.67 N/mm ²
$E = K_2 \cdot K_9 \cdot E_{min}$	$1.00 \times 1.00 \times 5800$	5800.0 N/mm ²

Design Loads

Density and Selfweight	Timber Density 370 kg/m³, Fj 0.06 kN/m	
w = (Fd+F _l).s+F _j	(0.50 + 1.50) x 2.0 + 0.06	4.06 kN/m

Bending Check

$M = w \cdot L^2 / 8$	$4.06 \times 3.0^2 / 8$	4.568 kN.m	
$\sigma_{m,a} = M / Z$	$4.568 / 605 \leq 5.48$	7.55 N/mm ²	Warning

Shear and Bearing Check

$F_v = w \cdot L / 2$	$4.06 \times 3.0 / 2$	6.090 kN	
$\tau_a = 1.5 F_v / \text{Area}$	$1.5 \times 6.09 / 165 \leq 0.67$	0.55 N/mm ²	OK
$\sigma_{ca} = F_v / (b \cdot B)$	$6.09 / (75 \times 75) \leq 1.94$	1.08 N/mm ²	OK

Deflection Check

$\delta_m = 5 \cdot w \cdot L^4 / (384 \cdot E \cdot I_x)$	$5 \times 4.06 \times 3.0^4 / (384 \times 5800 \times 6655)$	11.09 mm	
$\delta_s = 12 \cdot w \cdot L^2 / (5 \cdot E \cdot \text{Area})$	$12 \times 4.06 \times 3.0^2 / (5 \times 5800 \times 165)$	0.92 mm	
$\delta = \delta_m + \delta_s$	$11.09 + 0.92 \leq L / 333$	12.01 mm	Warning