ALPINE SURVEYS
Independent Property Surveyors

Structural Survey
Final Report

Cenergist Limited

Streatham Ice and Leisure, 390 Streatham High Road,

London, SW16 6HX

Alpine Surveys
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1 Introduction

Alpine Surveys were requested by the client to carry out a structural survey for PV panel installaion on the roofs of the above property.

As this is a non-disruptive survey, the inspection method is based on a visual investigation; therefore, the covered and rendered zones are evaluated using engineering judgement and analysis.

The report will concentrate on the structural elements of the property, and any maintenance issues will be only highlighted if considered relevant.

This inspection is limited to the client's requirements, requests, desires, and the provided information.

The inspection procedure adheres to standard building surveying regulations and operating procedures and comments are based on visual inspection only as no opening works are included.

The below-ground drainage was not part of this investigation as well as the drainage survey.

The Building Survey aims to:
• Help you make a reasoned and informed decision when purchasing the property, or when planning for repairs, maintenance or upgrading of the property.
• Provide detailed advice on the condition.
• Describe the identifiable risk of potential or hidden defects.
• Where practicable and agreed, provide an estimate of costs for identified repairs.
• Make recommendations as to any further actions or advice which need to be obtained before committing to purchase.

Building setting out and measuring for the procurement of surveys and measurement services are based on the BS 5964-3:1996 code of practice.

Survey Overview Description

We conducted a thorough and detailed investigation to determine the overall structural condition of the property, followed by a thorough examination of the exterior and evaluated the necessary rooms.

The first section of the report will provide specific details about your property, such as its style, construction type, and general condition, followed by an in-depth external assessment.

In each section of the report, the identified flaws, problems, flaws, deteriorations, potential threats, and structural issues are detailed. Wherever the terms "Attention is required" or "Needs to be addressed" appear in the report, the "Recommendation" section of the report contains the corresponding suggestions, tips, and solutions.

As a result, we assessed the causes of the issues in the interior rooms, with relevant photos taken and attached to the report. Finally, based on our findings, you will find detailed recommendations to correct and rectify.

No liability is accepted by any third party. No formal enquiries have been made of the Statutory Authorities or investigations made to verify information as to the tenure and existence of rights or easements.

Where work has been carried out on the property in the past, the surveyor cannot warrant that this has been done in accordance with manufacturers' recommendations, British and European Standards and Codes of Practice, Agreement Certificates, and Statutory Regulations.

This report's findings and conclusions are based on a combination of structure formation analysis, evaluation of layouts and drawings, scanning procedure, as well as engineering judgments and analysis.

We also reserve the right to amend our opinions in the event of additional information being made available at some future date. The Contracts (Rights of Third Parties) Act 1999 shall not apply to this agreement.

This report is a considered professional opinion and is not a warranty or guarantee of the property, and no liability shall attach to us except to the extent that we have failed to exercise reasonable skill, care, and diligence in the provision of our services under the terms of appointment. This report does not increase our liability beyond that agreed upon under the terms and appointment. This report is not a "design and construction certificate" as defined in The Building Act 1984 and The Building (Approved Inspectors, etc.) Regulations.

Where works address repairs that are not covered by the insurance policy we recommend that you seek professional advice on the repair methodology and whether the works will involve the Construction (Design & Management) Regulations 2015. Compliance with these Regulations is compulsory.

Alpine Surveys strives to provide its valued clients with the most optimised technical and feasible recommendations that we believe will safeguard the clients' financial interests as well as the safety and security of the property and its inhabitants.

2 Property Details

Client	Cenergist Limited	Survey Date	31 August 2023
Address	Streatham Ice and Leisure, 390 Streatham High Road, London, SW16 6HX		
Consulting Engineer	Abbas Ladonni BSc, MSc, PhD, Civil Eng. GMIce.		
Instruction	Structural Survey for PV Panel Installation		

Property Details

Use of Property	Mixed Use	Property Style	Sport & Leisure Complex
Occupants	10+	Number of Floors	3+1
Listed Building	No	Conservation Area	No
Approximate Year of Construction	2013		
Wall Construction and Covering	Concrete Blocks		
Roof Construction inc Visual Condition	Low-Pitched Cladded Roof		

Historical Information

Originally opened on in 1931 and was used as a food storage during the WWII. Reopend in 1962 and refurbished in 1980. Converted to a new ice rink and swimming pool in 2001. Demolished in 2011, and replaced by the existing mixed-use complex in 2013.

Plans Provided	Yes	Full Access Provided	Yes
Comments	PV panels installation on roofs.		

External Details

External Condition Summary

No critical structural defects were observed.

DPC in Place	Yes	DPC Type and Cond.	DPC assumed but not visible
Vent Brick Details	Not Visible	Guttering Condition	Acceptable Condition

External Fixtures Fittings

N/A

Windows & Doors	uPVC	Pathways & Gardens	Slabs
Chimney Stacks	No	Condition	No Chimney Stacks
Water Supply Checked	N/A	Drainage	N/A

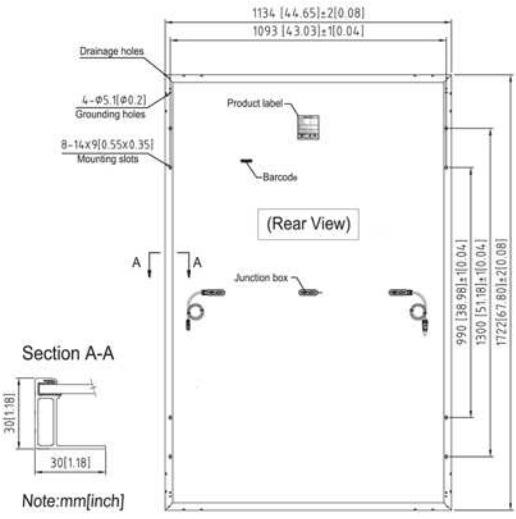
Technical Specifications

SUNTECH

Ultra V STPXXXS - C54/Umhm 395-415W

Mechanical Characteristics

Solar Cell	Monocrystalline silicon 182 mm
No. of Cells	108 (6 × 18)
Dimensions	1722 × 1134 × 30 mm (67.8 × 44.6 × 1.2 inches)
Weight	21.0 kgs (46.3 lbs.)
Front Glass	3.2 mm (0.126 inches) fully tempered glass
Output Cables	4.0 mm², (-) 350 mm (+) 160 mm in length or customized length
Junction Box	IP68 rated (3 bypass diodes)
Operating Module Temperature	-40 °C to +85 °C
Maximum System Voltage	1500 V DC (IEC)
Connectors	MC4-EVO2
Maximum Series Fuse Rating	25 A
Power Tolerance	0/+5 W
Frame	Anodized aluminum alloy frame
Packing Configuration	36 Pieces per pallet 936 Pieces per container /40'HC 1755×1120×1255 794kg



Electrical Characteristics

Module Type	STP415S-C54/Umhm		STP410S-C54/Umhm		STP405S-C54/Umhm		STP400S-C54/Umhm		STP395S-C54/Umhm	
Testing Condition	STC	NMOT	STC	NMOT	STC	NMOT	STC	NMOT	STC	NMOT
Maximum Power (Pmax/W)	415	314.9	410	311.2	405	307.6	400	303.7	395	300.0
Optimum Operating Voltage (Vmp/V)	31.81	29.4	31.59	29.2	31.38	29.0	31.18	28.8	30.98	28.7
Optimum Operating Current (Imp/A)	13.05	10.70	12.98	10.65	12.91	10.60	12.83	10.53	12.76	10.47
Open Circuit Voltage (Voc/V)	37.67	35.5	37.45	35.3	37.24	35.1	37.04	34.9	36.84	34.7
Short Circuit Current (Isc/A)	13.95	11.25	13.88	11.20	13.81	11.14	13.73	11.08	13.66	11.02
Module Efficiency (%)	21.3%		21.0%		20.7%		20.5%		20.2%	

STC: Irradiance 1000 W/m², module temperature 25 °C, AM=1.5; NMOT: Irradiance 800 W/m², ambient temperature 20 °C, AM=1.5, wind speed 1 m/s; Tolerance of Pmax is within +/- 3%;

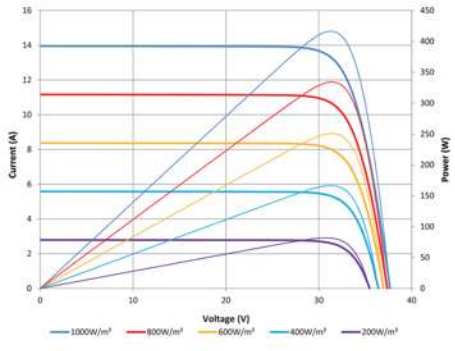
Temperature Characteristics

Nominal Module Operating Temperature (NMOT)	42 ± 2 °C
Temperature Coefficient of Pmax	-0.34%/°C
Temperature Coefficient of Voc	-0.26%/°C
Temperature Coefficient of Isc	0.050%/°C

Information on how to install and operate this product is available in the installation instruction. All values indicated in this data sheet are subject to change without prior announcement. The specifications may vary slightly . All specifications are in accordance with standard EN 50380. Color differences of the modules relative to the figures as well as discolorations of/in the modules which do not impair their proper functioning are possible and do not constitute a deviation from the specification.

Graphs

Current-Voltage & Power-Voltage Curve (415S)



Information bar

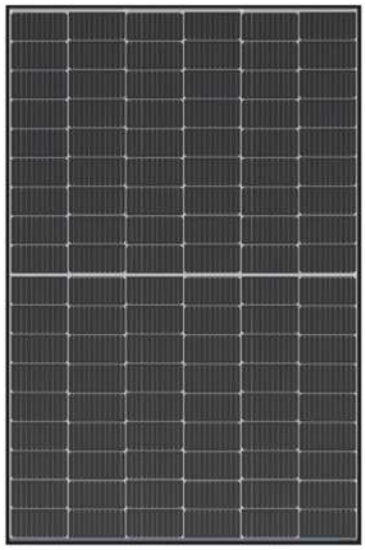
Technical Specifications

SUNTECH

Ultra V mini

HALF-CELL MONOFACIAL MODULE

TYPE: STPXXXS - C54/Umhm



395-415W POWER OUTPUT

21.3% MAX EFFICIENCY

Flexible Module Design
Small panel design, light in weight, flexible in transportation and loading

Lower operating temperature
Lower operating temperature and temperature coefficient increase the power output

Withstanding harsh environment
reliable quality leads to a better sustainability even in harsh environment like desert, farm and coastline

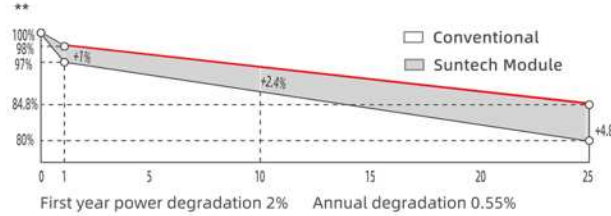
Extended wind and snow load tests
Module certified to withstand extreme wind (**3800** Pascal) and snow loads (**6000** Pascal)*

ISO 14001 Environment Management System
ISO 45001 Occupational Health and Safety
ISO 9001 Quality Management System
SA 8000 Social Responsibility Standards
IEC TS 62941 Guideline for Module Design

IEC 61701 Salt-mist certification
IEC 62716 ammonia certification
IEC 60068-2-68 Dust and Sand
IEC 61730-2 (UL790) fire class C

25 years of linear warranty

15 years of product warranty



First year power degradation 2% Annual degradation 0.55%

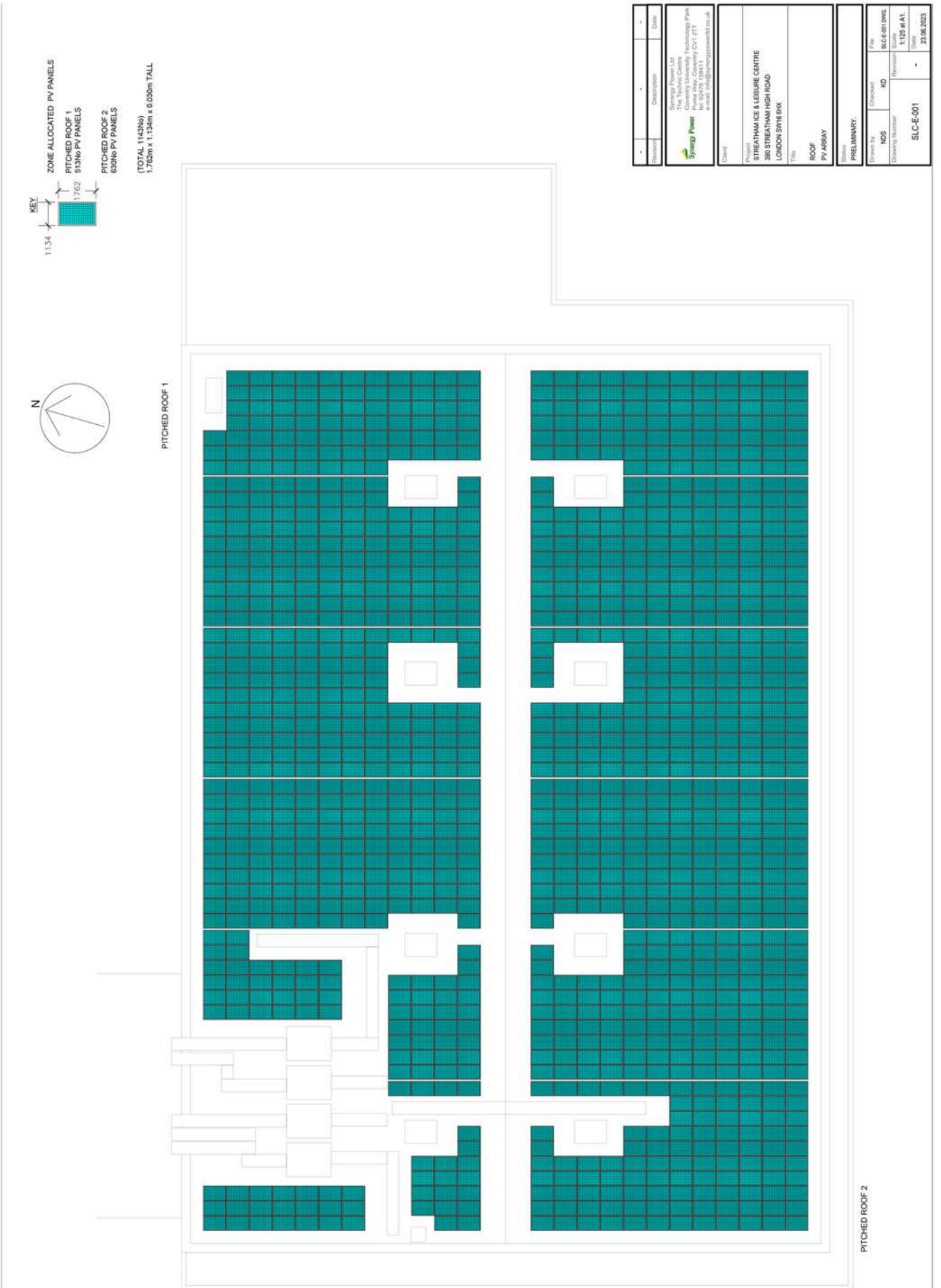
* Please refer to Suntech Standard Module Installation Manual for details.

** Please refer to Suntech Limited Warranty for details.

*** WEEE only for EU market.

**** Suntech reserves the right to the final.

Maps & Layouts



Bird's Eye View

Conclusions:

We accessed the roof and inspected all accessible areas as well as the internal places, structural elements and etc. Based on the information, evidence, and specifications we obtained during the survey and the relevant structural analysis, the following table contains our findings and conclusions:

ID.	ITEM	SEVERITY		
		Acceptable	Pro-Active Modifications (Risk)	Immediate Repairs (High)
1.	Erosion	✔		
2.	Corrosion / rust	✔		
3.	Decay / rot	✔		
4.	Deflection / Sagging	✔		
5.	Twisting / Bowing	✔		
6.	Damp & Moisture	✔		
7.	Roof Structural Condition	✔		
8.	Cracks & Defects & Deterioration	✔		
9.	Deformations & Structural Issues	✔		
10.	Capacity to bear the additional load of the PV Panels	✔		

Final Conclusion:

The proposed panels can be installed on the roof adhering to standards, and building regulations, and H&S. No modification, repairs, or amendments are required prior to panel installation.

Signed: *Abbas Ladonni BSc, MSc, PhD, Civil Eng.*

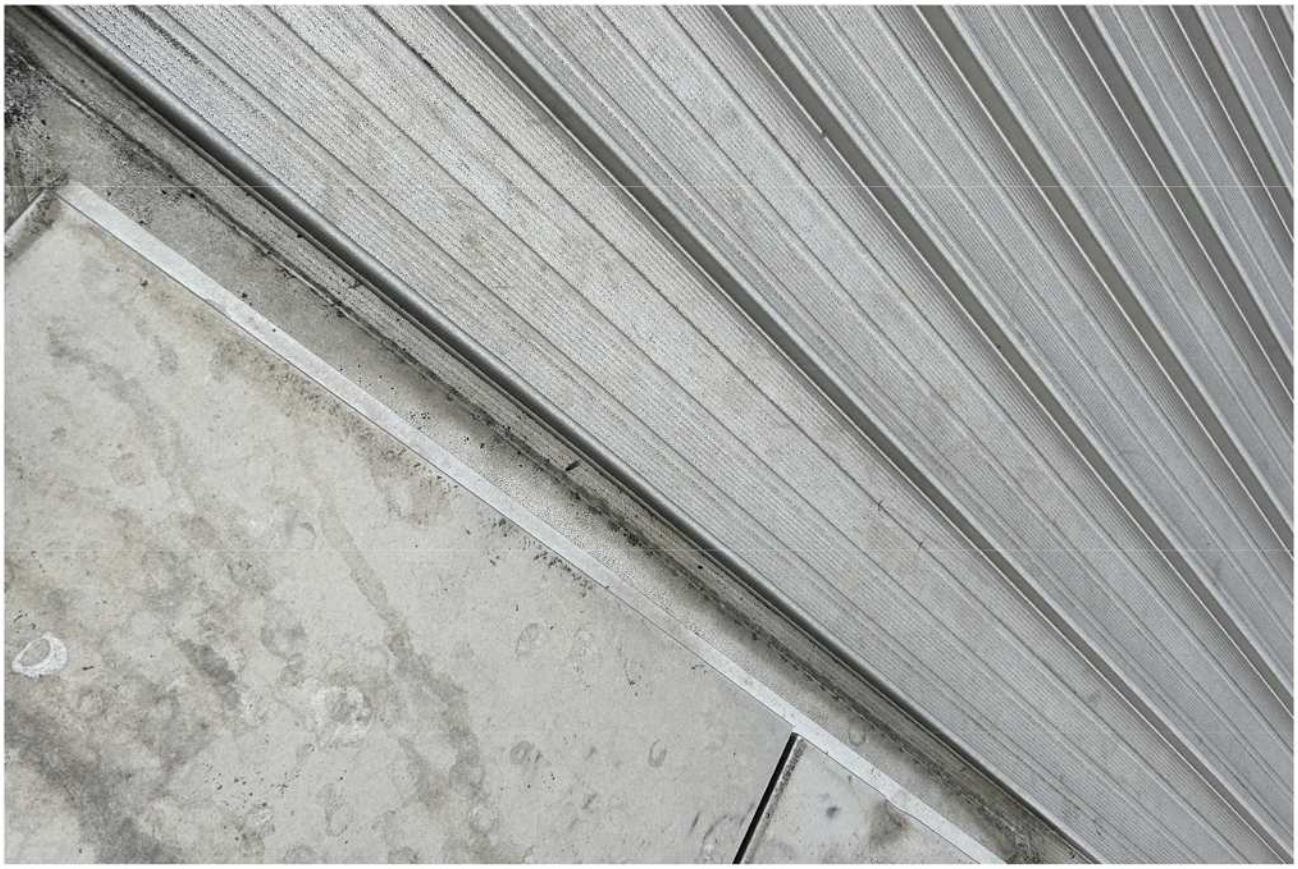
Date: 31 August 2023

Exterior Photos

Exterior Photos

Exterior Photos

Exterior Photos



Interior Photos

Interior Photos

Interior Photos

Interior Photos

Interior Photos

Panel Installation Details

Unit Dimensions:

1722mm x 1134mm x 30mm (Area: 1.923cm^2)

67.8" x 44.6" x 1.2" (21 ft^2)

Unit Weight:

1 unit = 21.0 Kg (46.3 lbs)

Unified Load = 21.0 kg / 1.923cm^2 = 10.92 kg/cm^2

Installation Pattern:

Pitched Roof No.1:

Block 1-A:

3 + (7 x 11) – 4 = 76 Panels

76 Panels x 21 kg = 1596 kg

Block 1-B:

(10 x 9) + (8 x3) = 114 Panels

114 Panels x 21 kg = 2394 kg

Block 1-C:

(10 x 12) - 13 = 107 Panels

107 Panels x 21 = 2247 kg

Block 1-D:

(10 x 12) – 3 = 117 Panels

117 Panels x 21kg = 2457 kg

Panel Installation Details

Block 1-E:

4 + (4 x 6) = 28 Panels

28 Panels x 21 kg = 588 kg

Block 1-F:

3 x 7 = 21 Panels

21 Panels x 21 kg = 441 kg

Block 1-G:

2 + (8 x 4) = 34 Panels

34 Panels x 21 kg = 714 kg

Block 1-H:

12 + 4 = 14 Panels

14 Panels x 21 kg = 294 kg

Total Number of Panels on Pitched Roof No.1: 513 Panels

Total Weight of Panels on Pitched Roof No.1: 10773 kg

Pitched Roof No.2:

Block 2-A:

(7 x 12) – 4 = 80 Panels

Block 2-B:

(10 x 12) -6 = 114 Panels

Block 2-C:

(10 x 12) – 6 = 114 Panels

114 Panels x 21 kg = 2394 kg

Block 2-D:

(10 x 12) – 13 = 107 Panels

107 Panels x 21 kg = 2247 kg

Block 2-E:

(10 x 12) – 3 = 117 Panels

Panel Installation Details

117 Panels x 21 kg = 2457 kg

Block 2-F:

(10 x 12) – 10 = 110 Panels

110 Panels x 21 kg = 2310 kg

Block 2-G:

(10 x 12) – 18 = 102 Panels

102 Panels x 21 kg = 2142 kg

Total Number of Panels on Pitched Roof No.2: 630 Panels

Total Weight of Panels on Pitched Roof No.2: 13230 kg

Total Number Panels on the roof: 1143 Panels

Total Weight of Panels on the roof: 24003 kg

Average Weight of Panels on Roofs: 7.53 kg/m^2

Beams: 1320 mm x 450 mm x 8 @ 7800 mm

24003 kg / 8 = 3000.375 kg per beam

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Project				Job no.	
Streatham Ice & Leisure Centre				1739	
Client				Page No./ / Revision	
Cenergist				1 / Rev 1.0	
Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
A. Ladonni	31/08/2023	J. Dobson	10/09/2023	M. Dobson	10/09/2023

SNOW LOADING TO BS6399:PART 3:1988

TEDDS calculation version 1.0.03

Site location

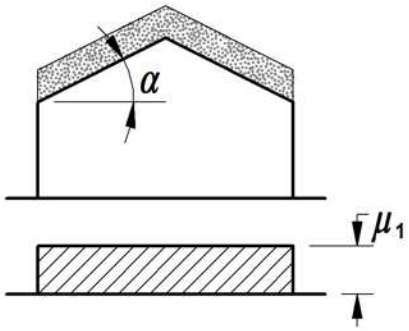
Location of site	**London**
Site altitude	A = **20** m

Calculate site snow load

From BS6399:Part 3: 1988 - Figure 1. Basic snow load on the ground

Basic snow load	s_b = **0.40** kN/m^2
	$s_{alt} = 0.1 \times s_b + (0.09\ kN/m^2)$ = **0.13** kN/m^2
Site snow load	$s_0 = \max(s_b, s_b + s_{alt} \times (A - (100\ m)) / 100\ m)$ = **0.40** kN/m^2

BS6399:Part3:1988 Cl.6.2



Uniform loading

Roof geometry

Roof type	**Pitched**
Distance on plan from gutter to ridge	b = **25.000** m
Angle of pitch of roof	α = **5.0** deg

Calculate uniform snow load

From BS6399:Part 3: 1988 - Figure 3. Snow load shape coefficients for pitched roofs

Snow load shape coefficient	**μ_1 = 0.80**
Uniform roof snow load	$s_{d1} = \mu_1 \times s_0$ = **0.32** kN/m^2

BS6399:Part3:1988 Cl.5

Roof pitch α is not greater than 15 degrees so there is no asymmetric loadcase

Snow sliding down roof

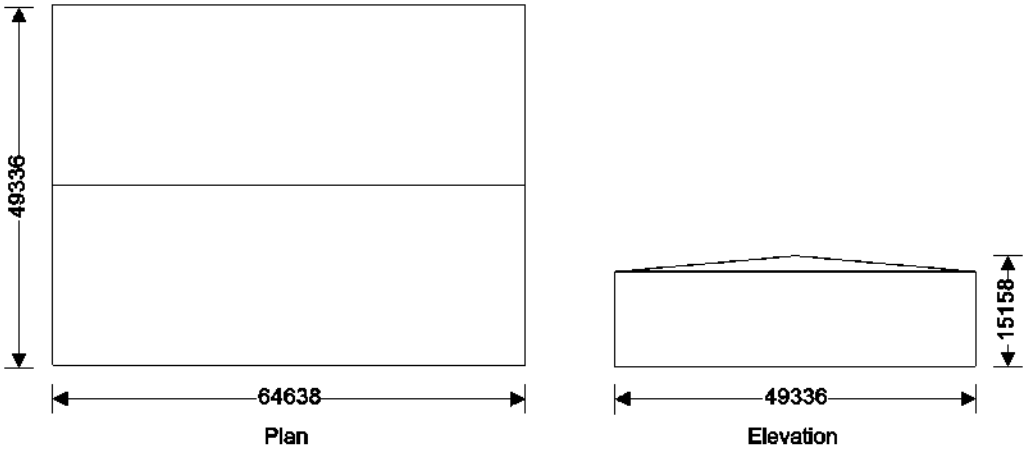
Maximum uniform snow load on roof	s_{d_max} = **0.32** kN/m^2
Force from sliding snow load	$F_s = s_{d\_max} \times b \times \sin(\alpha)$ = **0.70** kN/m

BS6399:Part3:1988 Cl.8

WIND LOADING (BS6399)

In accordance with BS6399

Tedds calculation version 3.0.17



Building data

Type of roof	Duopitch
Length of building	L = **64638** mm
Width of building	W = **49336** mm
Height to eaves	H = **13000** mm
Pitch of roof	α_0 = **5.0** deg
Reference height	H_r = **15158** mm

Dynamic classification

Building type factor (Table 1)	K_b = **8.0**
Dynamic augmentation factor (1.6.1)	$C_r = [K_b \times (H_r / (0.1\ m))^{0.75}] / (800 \times \log(H_r / (0.1\ m))) =$ **0.20**

Site wind speed

Location	London
Basic wind speed (Figure 6 BS6399:Pt 2)	V_b = **20.7** m/s
Site altitude	Δ_S = **20** m
Upwind distance from sea to site	d_{sea} = **66** km
Direction factor	S_d =**1.00**
Seasonal factor	S_s = **1.00**
Probability factor	S_p = **1.00**
Critical gap between buildings	g = **5000** mm

Topography

Type of feature	Hills and ridges
Actual length of upwind slope in wind direction	L_u = **50000** mm
Actual length downwind slope in wind direction	L_d = **50000** mm
Effective height of feature	Z = **20000** mm
Upwind slope in upwind direction	$\psi_U = Z / L_u =$ **0.40**
Effective slope of topographic feature	ψ_e = **0.30**
Effective length of upwind slope (cl 2.2.2.2.4)	$L_e = Z / 0.3 =$ **66667** mm
Horiz distance of the site from the top of the crest	x = **-5000** mm
Altitude of upwind base of topographic feature	Δ_T = **2.000** m
Site altitude	Δ_S = **20.000** m

Topographic location factor (Figure 9a)	s = **0.52**
Topographic increment (Table 25)	$S_h = 0.6 \times s$ = **0.31**
Altitude factor	$S_a = \max(1 + 0.001 \times \Delta s/1m, 1 + 0.001 \times \Delta T/1m + 1.2 \times \psi_e \times s)$ = **1.19**
Site wind speed	$V_s = V_b \times S_a \times S_d \times S_s \times S_p$ = **24.6** m/s
Terrain category	Town
Average height of surrounding buildings	H_o = **15000** mm
Distance to nearest building	X_o = **30000** mm
Displacement height (cl.1.7.3.3)	$H_d = 0.8 \times H_o$ = **12000** 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.2.2.3.2)

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.2.2.3.2)

Dynamic pressure - windward wall - Wind 0 deg and roof

Reference height (at which q is sought)	H_{ref} = **13000**mm
Effective height	$H_e = \max(H_{ref} - H_d, 0.4 \times H_{ref})$ = **5200**mm
Fetch factor (Table 22)	S_c = **0.909**
Turbulence factor (Table 22)	S_t = **0.191**
Fetch adjustment factor (Table 23)	T_c = **0.757**
Turbulence adjustment factor (Table 23)	T_t = **1.625**
Gust peak factor	g_t = **3.44**
Terrain and building factor	$S_b = S_c \times T_c \times (1 + (g_t \times S_t \times T_t) + S_h)$ = **1.64**
Effective wind speed	$V_e = V_s \times S_b$ = **40.3** m/s
Dynamic pressure	$q_s = 0.613$ kg/m^3 $\times V_e^2$ = **0.998** kN/m^2

Dynamic pressure - windward wall - Wind 90 deg and roof

Reference height (at which q is sought)	H_{ref} = **15158**mm
Effective height	$H_e = \max(H_{ref} - H_d, 0.4 \times H_{ref})$ = **6063**mm
Fetch factor (Table 22)	S_c = **0.931**
Turbulence factor (Table 22)	S_t = **0.189**
Fetch adjustment factor (Table 23)	T_c = **0.770**
Turbulence adjustment factor (Table 23)	T_t = **1.602**
Gust peak factor	g_t = **3.44**
Terrain and building factor	$S_b = S_c \times T_c \times (1 + (g_t \times S_t \times T_t) + S_h)$ = **1.69**
Effective wind speed	$V_e = V_s \times S_b$ = **41.5** m/s
Dynamic pressure	$q_s = 0.613$ kg/m^3 $\times V_e^2$ = **1.056** kN/m^2

Size effect factors

Diagonal dimension for gablewall	a_{eg} = **51.0** m
External size effect factor gablewall	C_{aeg} = **0.825**
Diagonal dimension for side wall	a_{es} = **65.9** m
External size effect factor side wall	C_{aes} = **0.805**
Diagonal dimension for roof	a_{er} = **69.2** m
External size effect factor roof	C_{aer} = **0.802**
Room/storey volume for internal size effect factor	V_i = **0.125** m^3
Diagonal dimension for internal size effect factors	$a_i = 10 \times (V_i)^{1/3}$ = **5.000** m
Internal size effect factor	C_{ai} = **1.000**

Pressures and forces

Net pressure	$p = q_s \times c_{pe} \times C_{ae} - q_s \times c_{pi} \times C_{ai}$

Net force $F_w = p \times A_{ref}$

Roof load case 1 - Wind 90, c_{pi} 0.20, - c_{pe}

Zone	Ext pressure coefficient, c_{pe}	Dynamic pressure, q_s (kN/m²)	External size factor, C_{ae}	Net Pressure, p (kN/m²)	Area, A_{ref} (m²)	Net force, F_w (kN)
A (-ve)	-2.00	1.06	0.802	-1.90	75.07	-142.95
B (-ve)	-1.10	1.06	0.802	-1.14	75.07	-85.76
C (-ve)	-0.60	1.06	0.802	-0.72	600.56	-431.88
D (-ve)	-0.50	1.06	0.802	-0.63	2450.46	-1554.76

Total vertical net force $F_{w,v}$ = **-2206.93** kN

Total horizontal net force $F_{w,h}$ = **0.00** kN

Walls load case 1 - Wind 90, c_{pi} 0.20, - c_{pe}

Zone	Ext pressure coefficient, c_{pe}	Dynamic pressure, q_s (kN/m²)	External size factor, C_{ae}	Net Pressure, p (kN/m²)	Area, A_{ref} (m²)	Net force, F_w (kN)
A	-1.30	1.00	0.805	-1.24	67.60	-84.12
B	-0.80	1.00	0.805	-0.84	270.40	-227.81
C	-0.50	1.00	0.805	-0.60	502.29	-302.09
w	0.60	1.06	0.825	0.31	694.61	216.23
l	-0.50	1.06	0.825	-0.65	694.61	-449.16

Overall loading

Equiv leeward net force for overall section $F_l = F_{w,wl}$ = **-449.2** kN

Net windward force for overall section $F_w = F_{w,ww}$ = **216.2** kN

Overall loading overall section $F_{w,w} = 0.85 \times (1 + C_r) \times (F_w - F_l + F_{w,h})$ = **677.6** kN

Roof load case 2 - Wind 0, c_{pi} 0.20, - c_{pe}

Zone	Ext pressure coefficient, c_{pe}	Dynamic pressure, q_s (kN/m²)	External size factor, C_{ae}	Net Pressure, p (kN/m²)	Area, A_{ref} (m²)	Net force, F_w (kN)
A (-ve)	-1.80	1.06	0.802	-1.73	92.26	-160.07
B (-ve)	-1.20	1.06	0.802	-1.23	104.45	-128.16
C (-ve)	-0.60	1.06	0.802	-0.72	1403.87	-1009.57
E (-ve)	-0.90	1.06	0.802	-0.97	92.26	-89.78
F (-ve)	-0.30	1.06	0.802	-0.47	104.45	-48.59
G (-ve)	-0.40	1.06	0.802	-0.55	1403.87	-771.88

Total vertical net force $F_{w,v}$ = **-2199.64** kN

Total horizontal net force $F_{w,h}$ = **-33.78** kN

Walls load case 2 - Wind 0, c_{pi} 0.20, - c_{pe}

Zone	Ext pressure coefficient, c_{pe}	Dynamic pressure, q_s (kN/m^2)	External size factor, C_{ae}	Net Pressure, p (kN/m^2)	Area, A_{ref} (m^2)	Net force, F_w (kN)
A	-1.30	1.06	0.825	-1.34	80.43	-108.04
B	-0.80	1.06	0.825	-0.91	351.10	-318.76
C	-0.50	1.06	0.825	-0.65	263.08	-170.12
w	0.62	1.00	0.805	0.30	840.29	248.99
l	-0.50	1.00	0.805	-0.60	840.29	-505.36

Overall loading

Equiv leeward net force for overall section $F_l = F_{w,wl}$ = **-505.4** kN

Net windward force for overall section $F_w = F_{w,ww}$ = **249.0** kN

Overall loading overall section $F_{w,w} = 0.85 \times (1 + C_r) \times (F_w - F_l + F_{w,h})$ = **733.8** kN

Roof load case 3 - Wind 0, c_{pi} -0.30, - c_{pe}

Zone	Ext pressure coefficient, c_{pe}	Dynamic pressure, q_s (kN/m^2)	External size factor, C_{ae}	Net Pressure, p (kN/m^2)	Area, A_{ref} (m^2)	Net force, F_w (kN)
A (-ve)	-1.80	1.06	0.802	-1.21	92.26	-111.35
B (-ve)	-1.20	1.06	0.802	-0.70	104.45	-73.01
C (-ve)	-0.60	1.06	0.802	-0.19	1403.87	-268.29
E (-ve)	-0.90	1.06	0.802	-0.45	92.26	-41.06
F (-ve)	-0.30	1.06	0.802	0.06	104.45	6.56
G (-ve)	-0.40	1.06	0.802	-0.02	1403.87	-30.61

Total vertical net force $F_{w,v}$ = **-515.79** kN

Total horizontal net force $F_{w,h}$ = **-33.78** kN

Walls load case 3 - Wind 0, c_{pi} -0.30, - c_{pe}

Zone	Ext pressure coefficient, c_{pe}	Dynamic pressure, q_s (kN/m^2)	External size factor, C_{ae}	Net Pressure, p (kN/m^2)	Area, A_{ref} (m^2)	Net force, F_w (kN)
A	-1.30	1.06	0.825	-0.82	80.43	-65.58
B	-0.80	1.06	0.825	-0.38	351.10	-133.37
C	-0.50	1.06	0.825	-0.12	263.08	-31.21
w	0.62	1.00	0.805	0.80	840.29	668.28
l	-0.50	1.00	0.805	-0.10	840.29	-86.07

Overall loading

Equiv leeward net force for overall section $F_l = F_{w,wl}$ = **-86.1** kN

Net windward force for overall section $F_w = F_{w,ww}$ = **668.3** kN

Overall loading overall section $F_{w,w} = 0.85 \times (1 + C_r) \times (F_w - F_l + F_{w,h})$ = **733.8** kN

Roof load case 4 - Wind 0, c_{pi} 0.00, - c_{pe}

Zone	Ext pressure coefficient, c_{pe}	Dynamic pressure, q_s (kN/m^2)	External size factor, C_{ae}	Net Pressure, p (kN/m^2)	Area, A_{ref} (m^2)	Net force, F_w (kN)
A (-ve)	-1.80	1.06	0.802	-1.52	92.26	-140.58
B (-ve)	-1.20	1.06	0.802	-1.02	104.45	-106.10
C (-ve)	-0.60	1.06	0.802	-0.51	1403.87	-713.06
E (-ve)	-0.90	1.06	0.802	-0.76	92.26	-70.29
F (-ve)	-0.30	1.06	0.802	-0.25	104.45	-26.53
G (-ve)	-0.40	1.06	0.802	-0.34	1403.87	-475.37

Total vertical net force $F_{w,v}$ = **-1526.10** kN

Total horizontal net force $F_{w,h}$ = **-33.78** kN

Walls load case 4 - Wind 0, c_{pi} 0.00, - c_{pe}

Zone	Ext pressure coefficient, c_{pe}	Dynamic pressure, q_s (kN/m^2)	External size factor, C_{ae}	Net Pressure, p (kN/m^2)	Area, A_{ref} (m^2)	Net force, F_w (kN)
A	-1.30	1.06	0.825	-1.13	80.43	-91.06
B	-0.80	1.06	0.825	-0.70	351.10	-244.60
C	-0.50	1.06	0.825	-0.44	263.08	-114.55
w	0.62	1.00	0.805	0.50	840.29	416.71
l	-0.50	1.00	0.805	-0.40	840.29	-337.65

Overall loading

Equiv leeward net force for overall section $F_l = F_{w,wl}$ = **-337.6** kN

Net windward force for overall section $F_w = F_{w,ww}$ = **416.7** kN

Overall loading overall section $F_{w,w} = 0.85 \times (1 + C_r) \times (F_w - F_l + F_{w,h})$ = **733.8** kN

Roof load case 5 - Wind 90, c_{pi} -0.30, - c_{pe}

Zone	Ext pressure coefficient, c_{pe}	Dynamic pressure, q_s (kN/m^2)	External size factor, C_{ae}	Net Pressure, p (kN/m^2)	Area, A_{ref} (m^2)	Net force, F_w (kN)
A (-ve)	-2.00	1.06	0.802	-1.38	75.07	-103.32
B (-ve)	-1.10	1.06	0.802	-0.61	75.07	-46.12
C (-ve)	-0.60	1.06	0.802	-0.19	600.56	-114.77
D (-ve)	-0.50	1.06	0.802	-0.11	2450.46	-260.86

Total vertical net force $F_{w,v}$ = **-523.07** kN

Total horizontal net force $F_{w,h}$ = **0.00** kN

Walls load case 5 - Wind 90, c_{pi} -0.30, - c_{pe}

Zone	Ext pressure coefficient, c_{pe}	Dynamic pressure, q_s (kN/m²)	External size factor, C_{ae}	Net Pressure, p (kN/m²)	Area, A_{ref} (m²)	Net force, F_w (kN)
A	-1.30	1.00	0.805	-0.75	67.60	-50.39
B	-0.80	1.00	0.805	-0.34	270.40	-92.89
C	-0.50	1.00	0.805	-0.10	502.29	-51.45
w	0.60	1.06	0.825	0.84	694.61	583.00
l	-0.50	1.06	0.825	-0.12	694.61	-82.39

Overall loading

Equiv leeward net force for overall section $F_l = F_{w,wl}$ = **-82.4** kN

Net windward force for overall section $F_w = F_{w,ww}$ = **583.0** kN

Overall loading overall section $F_{w,w} = 0.85 \times (1 + C_r) \times (F_w - F_l + F_{w,h})$ = **677.6** kN

Roof load case 6 - Wind 90, c_{pi} -0.30, - c_{pe}

Zone	Ext pressure coefficient, c_{pe}	Dynamic pressure, q_s (kN/m²)	External size factor, C_{ae}	Net Pressure, p (kN/m²)	Area, A_{ref} (m²)	Net force, F_w (kN)
A (-ve)	-2.00	1.06	0.802	-1.38	75.07	-103.32
B (-ve)	-1.10	1.06	0.802	-0.61	75.07	-46.12
C (-ve)	-0.60	1.06	0.802	-0.19	600.56	-114.77
D (-ve)	-0.50	1.06	0.802	-0.11	2450.46	-260.86

Total vertical net force $F_{w,v}$ = **-523.07** kN

Total horizontal net force $F_{w,h}$ = **0.00** kN

Walls load case 6 - Wind 90, c_{pi} -0.30, - c_{pe}

Zone	Ext pressure coefficient, c_{pe}	Dynamic pressure, q_s (kN/m²)	External size factor, C_{ae}	Net Pressure, p (kN/m²)	Area, A_{ref} (m²)	Net force, F_w (kN)
A	-1.30	1.00	0.805	-0.75	67.60	-50.39
B	-0.80	1.00	0.805	-0.34	270.40	-92.89
C	-0.50	1.00	0.805	-0.10	502.29	-51.45
w	0.60	1.06	0.825	0.84	694.61	583.00
l	-0.50	1.06	0.825	-0.12	694.61	-82.39

Overall loading

Equiv leeward net force for overall section $F_l = F_{w,wl}$ = **-82.4** kN

Net windward force for overall section $F_w = F_{w,ww}$ = **583.0** kN

Overall loading overall section $F_{w,w} = 0.85 \times (1 + C_r) \times (F_w - F_l + F_{w,h})$ = **677.6** kN

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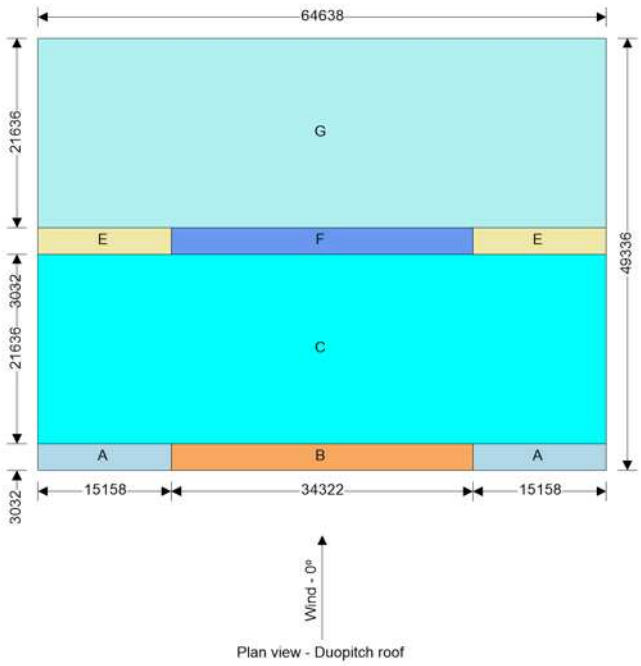
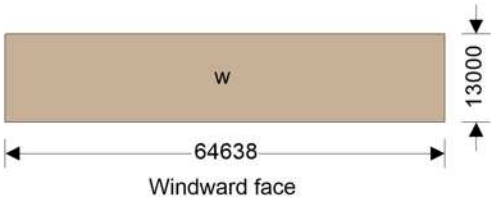
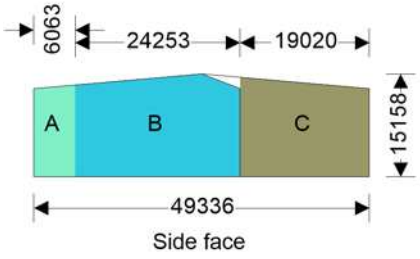
	Client: Cenergist Limited				Page No. / / Revision: 7 / Rev.1.0	
	Calcs by: A. Ladonni	Calcs date: 31/08/2023	Checked by: J. Dobson	Checked date: 11/09/2023	Approved by: M. Dobson	Approved date: 11/09/2023



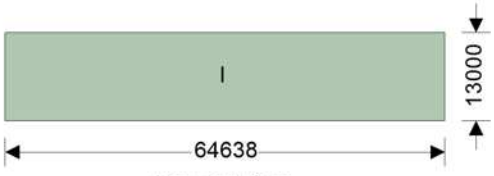
Plan view - Duopitch roof



Windward face



Side face



Leeward face

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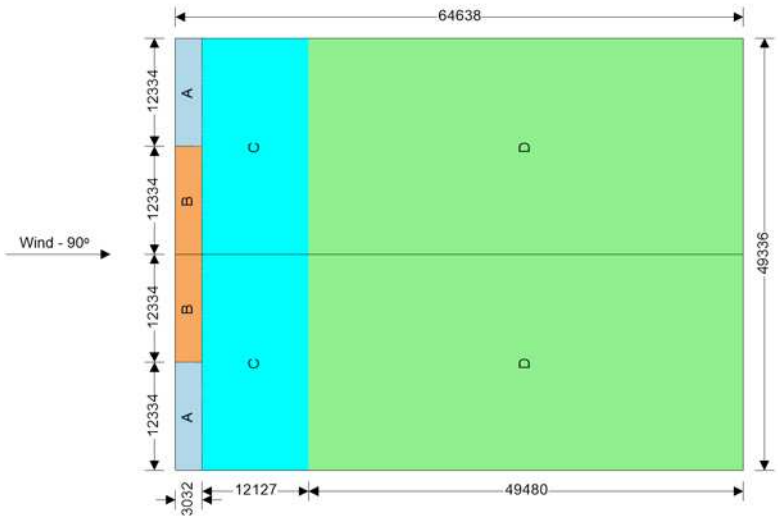
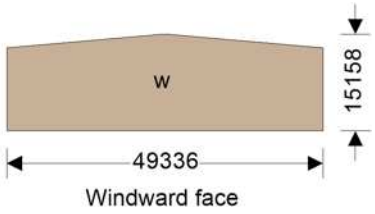
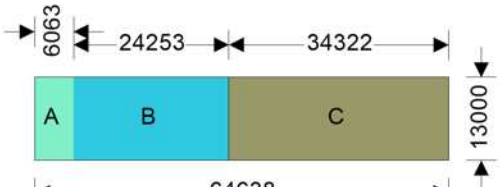
	Calcs by: A. Ladonni	Calcs date: 31/08/2023	Checked by: J. Dobson	Checked date: 11/09/2023	Approved by: M. Dobson	Approved date: 11/09/2023



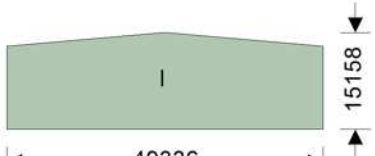
Plan view - Duopitch roof



Windward face



Side face



Leeward face

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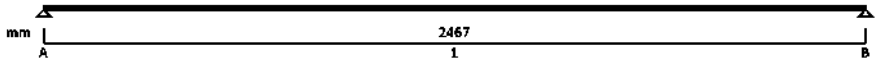
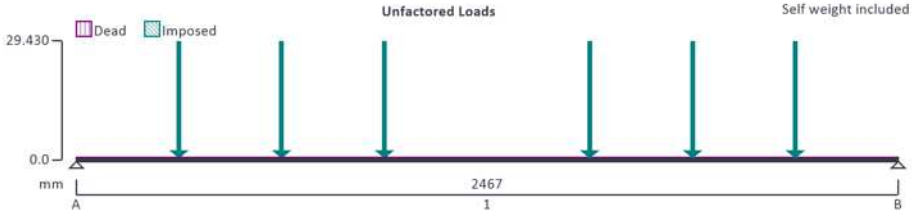
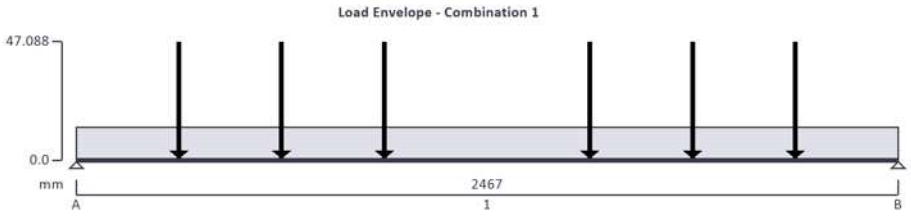
STEEL BEAM ANALYSIS & DESIGN (BS5950)

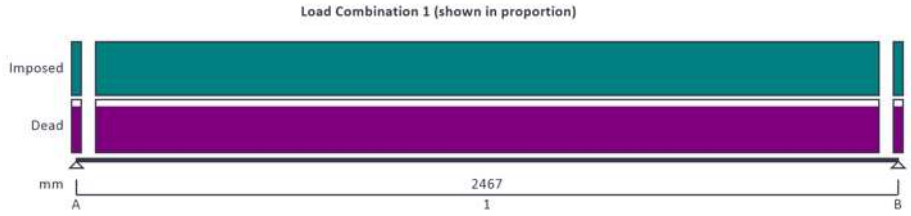
In accordance with BS5950-1:2000 incorporating Corrigendum No.1

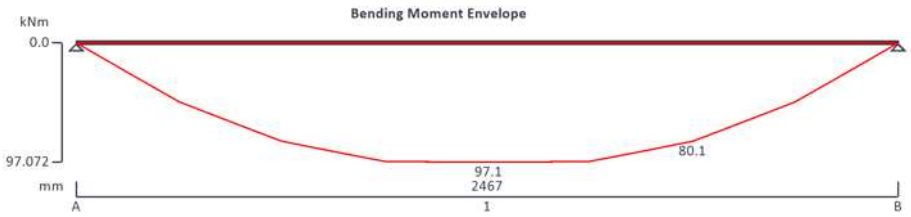
TEDDS calculation version 3.0.07

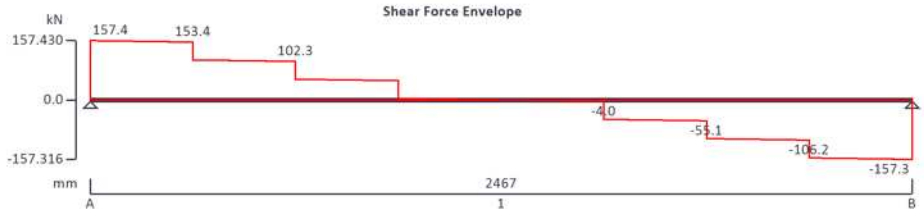












Support conditions

Support A	Vertically restrained
	Rotationally free
Support B	Vertically restrained
	Rotationally free

Applied loading

Beam loads	Self Weight - Dead self weight of beam × 2
	PV Panels - Imposed point load 29.43 kN at 308 mm
	Pv Panels - Imposed point load 29.43 kN at 616 mm
	Pv Panels - Imposed point load 29.43 kN at 925 mm
	Roof - Dead full UDL 0.65 kN/m
	PV Panels - Imposed point load 29.43 kN at 1541 mm
	PV Panels - Imposed point load 29.43 kN at 1850 mm
	PV Panels - Imposed point load 29.43 kN at 2158 mm

Load combinations

Load combination 1	Support A	Dead × 1.40
		Imposed × 1.60
		Dead × 1.40
		Imposed × 1.60
	Support B	Dead × 1.40
		Imposed × 1.60

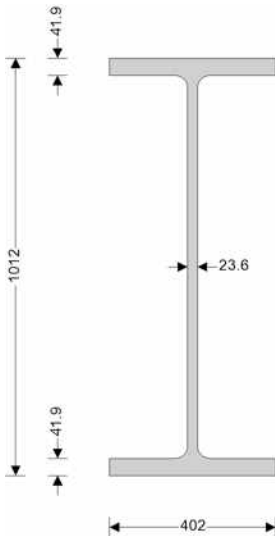
Analysis results

Maximum moment	M_{max} = **97.1** kNm	M_{min} = **0** kNm
Maximum shear	V_{max} = **157.4** kN	V_{min} = **-157.3** kN
Deflection	δ_{max} = **0** mm	δ_{min} = **0** mm
Maximum reaction at support A	R_{A_max} = **157.4** kN	R_{A_min} = **157.4** kN
Unfactored dead load reaction at support A	R_{A_Dead} = **11.5** kN	
Unfactored imposed load reaction at support A	$R_{A\_Imposed}$ = **88.3** kN	
Maximum reaction at support B	R_{B_max} = **157.3** kN	R_{B_min} = **157.3** kN
Unfactored dead load reaction at support B	R_{B_Dead} = **11.5** kN	
Unfactored imposed load reaction at support B	$R_{B\_Imposed}$ = **88.3** kN	

Section details

Section type	**HL 1000 x 443 (Arcelor)**
Steel grade	**S355**
From table 9: Design strength p_y	
Thickness of element	max(T, t) = **41.9** mm
Design strength	p_y = **335** N/mm^2

Modulus of elasticity E = **205000** N/mm²



Lateral restraint

Span 1 has full lateral restraint

Effective length factors

Effective length factor in major axis K_x = **1.00**

Effective length factor in minor axis K_y = **1.00**

Effective length factor for lateral-torsional buckling $K_{LT.A}$ = **1.20**

$K_{LT.B}$ = **1.00**

Classification of cross sections - Section 3.5

$\varepsilon = \sqrt{[275\ N/mm^2 / p_y]}$ = **0.91**

Internal compression parts - Table 11

Depth of section d = **868.2** mm

$d / t = 40.6 \times \varepsilon <= 80 \times \varepsilon$ Class 1 plastic

Outstand flanges - Table 11

Width of section $b = B / 2$ = **201** mm

$b / T = 5.3 \times \varepsilon <= 9 \times \varepsilon$ Class 1 plastic

Section is class 1 plastic

Shear capacity - Section 4.2.3

Design shear force $F_v = \max(\text{abs}(V_{max}), \text{abs}(V_{min}))$ = **157.4** kN

$d / t < 70 \times \varepsilon$

Web does not need to be checked for shear buckling

Shear area $A_v = t \times D$ = **23883** mm²

Design shear resistance $P_v = 0.6 \times p_y \times A_v$ = **4800.5** kN

PASS - Design shear resistance exceeds design shear force

Moment capacity - Section 4.2.5

Design bending moment $M = \max(\text{abs}(M_{s1\_max}), \text{abs}(M_{s1\_min}))$ = **97.1** kNm

Moment capacity low shear - cl.4.2.5.2 $M_c = \min(p_y \times S_{xx}, 1.2 \times p_y \times Z_{xx})$ = **7295.2** kNm

PASS - Moment capacity exceeds design bending moment

Check vertical deflection - Section 2.5.2

Consider deflection due to dead and imposed loads

Limiting deflection $\delta_{lim} = L_{s1} / 360 =$ **6.853** mm

Maximum deflection span 1 $\delta = \max(\text{abs}(\delta_{max}), \text{abs}(\delta_{min})) =$ **0.021** mm

PASS - Maximum deflection does not exceed deflection limit