Christmas at Kenwood

Planning Application

06 Presents -Structural Detail Document

Prepared by Cubit Design

3rd August 2021

ENGLISH HERITAGE

KILIMANJARO

ELLIOT BOND

Calculation Sheet

Job ref	: EBC00904 – Kenwood Hse for Walk the Plank
Sheet	:
Made By	: PD
Date	: JULY 2021
Checked	: PD

Kenwood House – Giant Christmas Presents Installation – Christmas 2021

STRUCTURAL CALCULATIONS

for

Stability of Giant Outdoor Christmas Presents

Date: 26 July 2021

Elliot Bond Consulting Limited – 2nd Floor The Annexe – 13 Hope Street – Liverpool - L1 9BQ

ELLIOT BOND Calculation Sheet	Job ref : EBC00904 – Kenwood Hse for Walk the Plank Sheet : Made By : PD Date : JULY 2021 Checked : PD

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APPENDIX

ELLIOT BOND Calculation Sheet	Job ref : EBC00904 – Kenwood Hse for Walk the Plank Sheet : Made By : PD Date : JULY 2021 Checked : PD

INTRODUCTION & DESCRIPTION

Walk the Plank are providing a number of Giant Christmas Presents for an outdoor installation at Kenwood House, Hampstead, North London. There are 10 presents in total, and they are constructed as lightweight wooden cubes.

The sizes and quantities are as follows:

2 no x 4.8m x 4.8m x 4.8m
2 no x 3.6m x 3,6m x 3.6m
2 no x 2.4m x 2.4m x 2.4m
2 no x 2m x 2m x 2m
2 no x 1m x 1m x 1m

The timber framing is 75 x 25 softwood on edge, clad with 6mm Q plywood. The SW frames are bolted together. Plywood is glued and stapled to the frames. The lid is made in the same style and bolted all around. Decorative bows on top are made from 3mm flat bar steel formers with 5mm bendy ply riveted to the steel. These are bolted to the roof frame. The roof frame is supported by vertical 75 x 25 timbers to the ground.

The presents will be installed outside Kenwood House (on the front lawn) in November 2021, and will be in-situ for approximately 2 months.

These calculations relate to the stability of the cubes under wind loading

WIND LOADS

Wind loads are calculated using BS6399 using 'Tedds' software. The results of the wind analysis on the largest of the cubes is included in the Appendix to these calculations (refer to pages App-1 to App-6).

Two cases are considered:

1 Wind load at 90 degrees to a vertical surface with an internal pressure coefficient of -0.3, and

2 Wind load at 90 degrees to a vertical surface with an internal pressure coefficient of +0.2.

Due to the limited period of exposure (c. 8 weeks), a probability factor of 0.95 is used.

The worst case for overturning is found to be when there is a positive internal pressure (i.e coefficient = +0.2).

STABILITY CALCULATIONS (CHECK LARGEST 4.8m x 4.8m x 4.8m CUBE FIRST):

Destabilising Forces:

A vertical upward force (suction) on the lid of 6.03kN. This is considered to act above the centre of the lid for simplicity.

A horizontal force on the sides of the cube of 9.90kN. This is considered to act at the mid-point of the side wall of the cube (i.e 2.4m above ground level).

Stabilising Force:

The self weight of the cube, based on 5 sides of 6mm ply and softwood framing, is c. 5 kN; acting downwards at the centre of the cube. The weight of the bows etc on top of the lid are ignored (i.e conservative)

The worst case overturning moment is therefore:

M = 2.4m x (9.90 + (6.03kN – 5.0kN)) = 26.2kNm.

Assuming the centre of the ballast (used to hold down the cube) corresponds to the centre of the cube, then the ballast force required is 26.2kN / 2.4m = c. 11kN (i.e circa 1122 kg). A factor of safety of 1.5 is required, hence ballast weight will be 16.5kN / 1682 kg. There are two alternative methods that can be used to stabilise the cube: Either ballast, or ground anchors (subject to client approval):

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Option 1: HOLDING-DOWN USING GROUND ANCHORS:

The 4.8m cubes can be held down using screw-in ground anchors rather than ballast:

i.e Leach's BIG BEN Heavy Duty Hurricane Ground Anchor - 500mm

Extract from manufacturers Technical info:

'The BIG BEN Hurricane is manufactured in three different lengths, 500mm, 650mm and 900mm, offering a range of holding capabilities, from 5.60kn to 12.60kn.

The internal measurement of the metal loop at the top of the anchor is 60mm wide x 75mm high.

For exact holding power, it is strongly recommended that anchors are proof tested after installation to determine the anchor capacity, to ensure holding power and correct number of anchors can be specified.

The Hurricane 500mm length tested to 560kg/5.60kN.
The Hurricane 650mm length tested to 960kg/9.60kN.
The Hurricane 900mm length tested to 1,260kg/12.60kN.

The Hurricane ground anchor is perfect for scaffolding, marquees, tents and other light free standing buildings'.

Hence 4 no 500mm anchors would be required at each corner of the 4.8m cubes. i.e 4 x 5.60kN = 22.4 kN resistance against uplift giving a Factor of Safety of 2 (i.e 100% spare capacity).

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Option 2: HOLDING-DOWN USING BALLAST:

As before, the total holding load required, for a F.o.S. of 1.5, is 16.5kN / 1682 kg. This means 4.13kN / 420kg is required in each corner. If sealed containers full of water are used, each of these four containers would need to contain a minimum of 420 litres (1 litre = 1 kg). If dense 100mm x 215mm x 440mm concrete blocks are used, each of these blocks weighs c. 18.5kg, so 23 blocks would be required in each corner (i.e a total of 92 concrete blocks).

SUMMARY OF HOLDING DOWN REQUIREMENTS FOR ALL PRESENTS:

4.8m PRESENTS:
4 no 500mm ground anchors (1 in each corner), or 420kg ballast in each corner (420litres of water, or 23 dense concrete building blocks, in each corner)

3.6m PRESENTS:
4 no 500mm ground anchors (1 in each corner), or 240kg ballast in each corner (240litres of water, or 13 dense concrete building blocks, in each corner)

2.4m PRESENTS:
105kg ballast in each corner (105 litres of water, or 6 dense concrete building blocks, in each corner)

2m PRESENTS:
73kg ballast in each corner (73 litres of water, or 4 dense concrete building blocks, in each corner)

1m PRESENTS:
73kg ballast in the centre of each cube (73 litres of water, or 4 dense concrete building blocks, total)

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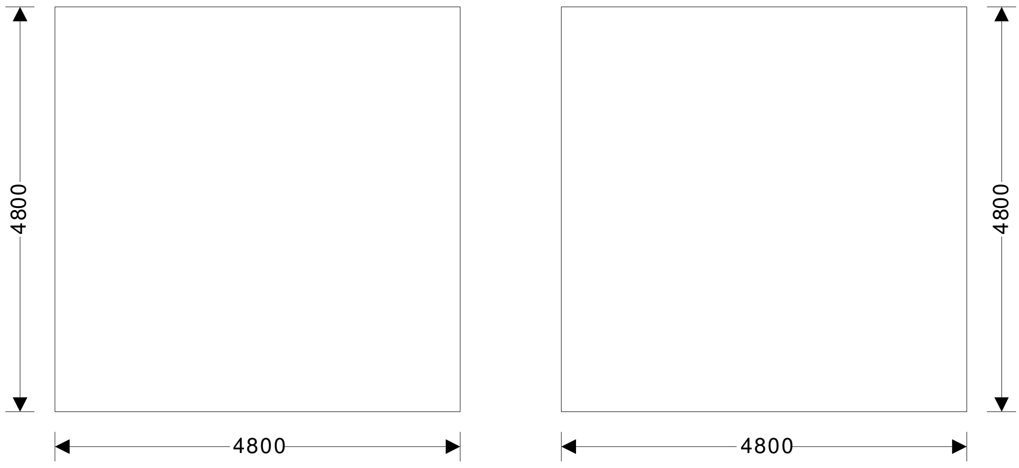
Appendix A – Tedds Analysis / Design Output (Wind Analysis)

(see overleaf)

WIND LOADING (BS6399)

In accordance with BS6399

Tedds calculation version 3.0.18



Plan   Elevation

Building data

Type of roof   Flat

Length of building $L = \mathbf{4800}$ mm

Width of building $W = \mathbf{4800}$ mm

Height to eaves $H = \mathbf{4800}$ mm

Eaves type   Sharp

Reference height $H_r = \mathbf{4800}$ mm

Dynamic classification

Building type factor (Table 1) $K_b = \mathbf{2.0}$

Dynamic augmentation factor (1.6.1) $C_r = [K_b \times (H_r / (0.1\ m))^{0.75}] / (800 \times \log(H_r / (0.1\ m))) = \mathbf{0.03}$

Site wind speed

Location   London

Basic wind speed (Figure 6 BS6399:Pt 2) $V_b = \mathbf{20.7}$ m/s

Site altitude $\Delta_S = \mathbf{20}$ m

Upwind distance from sea to site $d_{sea} = \mathbf{66}$ km

Direction factor $S_d = \mathbf{1.00}$

Seasonal factor $S_s = \mathbf{0.75}$

Probability factor $S_p = \mathbf{0.95}$

Critical gap between buildings $g = \mathbf{30000}$ mm

Topography

Type of feature   Hills and ridges

Actual length of upwind slope in wind direction $L_u = \mathbf{50000}$ mm

Actual length downwind slope in wind direction $L_d = \mathbf{50000}$ mm

Effective height of feature $Z = \mathbf{2500}$ mm

Upwind slope in upwind direction $\psi_U = Z / L_u = \mathbf{0.05}$

Effective slope of topographic feature $\psi_e = \psi_U = \mathbf{0.05}$

Effective length of upwind slope (cl 2.2.2.2.4) $L_e = L_u = \mathbf{50000}$ mm

Horiz distance of the site from the top of the crest $x = \mathbf{0}$ mm

Altitude of upwind base of topographic feature Δ_T = **17.500** m

Site altitude Δ_S = **20.000** m

Topographic location factor (Figure 9a) s = **0.84**

Topographic increment (Table 25) $S_h = 2 \times \psi_U \times s$ = **0.08**

Altitude factor $S_a = \max(1 + 0.001 \times \Delta_S/1m, 1 + 0.001 \times \Delta_T/1m + 1.2 \times \psi_e \times s)$ = **1.07**

Site wind speed $V_s = V_b \times S_a \times S_d \times S_s \times S_p$ = **15.8** m/s

Terrain category Country

Displacement height (sheltering effect excluded) H_d = 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.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} = **4800**mm

Effective height $H_e = \max(H_{ref} - H_d, 0.4 \times H_{ref})$ = **4800**mm

Fetch factor (Table 22) S_c = **0.893**

Turbulence factor (Table 22) S_t = **0.194**

Gust peak factor g_t = **3.44**

Terrain and building factor $S_b = S_c \times (1 + (g_t \times S_t) + S_h)$ = **1.56**

Effective wind speed $V_e = V_s \times S_b$ = **24.6** m/s

Dynamic pressure $q_s = 0.613 \text{ kg/m}^3 \times V_e^2$ = **0.372** kN/m²

Dynamic pressure - windward wall - Wind 90 deg and roof

Reference height (at which q is sought) H_{ref} = **4800**mm

Effective height $H_e = \max(H_{ref} - H_d, 0.4 \times H_{ref})$ = **4800**mm

Fetch factor (Table 22) S_c = **0.893**

Turbulence factor (Table 22) S_t = **0.194**

Gust peak factor g_t = **3.44**

Terrain and building factor $S_b = S_c \times (1 + (g_t \times S_t) + S_h)$ = **1.56**

Effective wind speed $V_e = V_s \times S_b$ = **24.6** m/s

Dynamic pressure $q_s = 0.613 \text{ kg/m}^3 \times V_e^2$ = **0.372** kN/m²

Size effect factors

Diagonal dimension for gablewall a_{eg} = **6.8** m

External size effect factor gablewall C_{aeg} = **0.977**

Diagonal dimension for side wall a_{es} = **6.8** m

External size effect factor side wall C_{aes} = **0.977**

Diagonal dimension for roof a_{er} = **6.8** m

External size effect factor roof C_{aer} = **0.977**

Room/storey volume for internal size effect factor V_i = **110.600** m³

Diagonal dimension for internal size effect factors $a_i = 10 \times (V_i)^{1/3}$ = **48.001** m

Internal size effect factor C_{ai} = **0.829**

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 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 (-ve)	-2.00	0.37	0.977	-0.79	1.15	-0.91
B (-ve)	-1.40	0.37	0.977	-0.57	1.15	-0.66
C (-ve)	-0.70	0.37	0.977	-0.32	9.22	-2.91
D (-ve)	-0.20	0.37	0.977	-0.13	11.52	-1.55

Total vertical net force $F_{w,v}$ = **-6.03** kN

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

Walls load case 1 - 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	0.37	0.977	-0.53	4.61	-2.46
B	-0.80	0.37	0.977	-0.35	18.43	-6.50
w	0.85	0.37	0.977	0.25	23.04	5.70
l	-0.50	0.37	0.977	-0.24	23.04	-5.61

Overall loading

Equiv leeward net force for overall section $F_l = F_{w,wl}$ = **-5.6** kN

Net windward force for overall section $F_w = F_{w,ww}$ = **5.7** kN

Overall loading overall section $F_{w,w} = 0.85 \times (1 + C_r) \times (F_w - F_l + F_{w,h})$ = **9.9** kN

Roof load case 2 - Wind 0, c_{pi} -0.3, $+c_{pe}$

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	0.37	0.977	-0.63	1.15	-0.73
B (+ve)	-1.40	0.37	0.977	-0.42	1.15	-0.48
C (+ve)	-0.70	0.37	0.977	-0.16	9.22	-1.49
D (+ve)	0.20	0.37	0.977	0.17	11.52	1.90

Total vertical net force $F_{w,v}$ = **-0.80** kN

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

Walls load case 2 - Wind 0, c_{pi} -0.3, $+c_{pe}$

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	0.37	0.977	-0.38	4.61	-1.75
B	-0.80	0.37	0.977	-0.20	18.43	-3.65
w	0.85	0.37	0.977	0.40	23.04	9.25
l	-0.50	0.37	0.977	-0.09	23.04	-2.05

Overall loading

Equiv leeward net force for overall section $F_l = F_{w,wl}$ = **-2.1** kN

Net windward force for overall section $F_w = F_{w,ww}$ = **9.3** kN

Overall loading overall section $F_{w,w} = 0.85 \times (1 + C_r) \times (F_w - F_l + F_{w,h})$ = **9.9** kN

Roof load case 3 - Wind 90, 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 (-ve)	-2.00	0.37	0.977	-0.79	1.15	-0.91
B (-ve)	-1.40	0.37	0.977	-0.57	1.15	-0.66
C (-ve)	-0.70	0.37	0.977	-0.32	9.22	-2.91
D (-ve)	-0.20	0.37	0.977	-0.13	11.52	-1.55

Total vertical net force $F_{w,v}$ = **-6.03** kN

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

Walls load case 3 - Wind 90, 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	0.37	0.977	-0.53	4.61	-2.46
B	-0.80	0.37	0.977	-0.35	18.43	-6.50
w	0.85	0.37	0.977	0.25	23.04	5.70
l	-0.50	0.37	0.977	-0.24	23.04	-5.61

Overall loading

Equiv leeward net force for overall section $F_l = F_{w,wl}$ = **-5.6** kN

Net windward force for overall section $F_w = F_{w,ww}$ = **5.7** kN

Overall loading overall section $F_{w,w} = 0.85 \times (1 + C_r) \times (F_w - F_l + F_{w,h})$ = **9.9** kN

Roof load case 4 - Wind 90, c_{pi} -0.3, $+c_{pe}$

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	0.37	0.977	-0.63	1.15	-0.73
B (+ve)	-1.40	0.37	0.977	-0.42	1.15	-0.48
C (+ve)	-0.70	0.37	0.977	-0.16	9.22	-1.49
D (+ve)	0.20	0.37	0.977	0.17	11.52	1.90

Total vertical net force $F_{w,v}$ = **-0.80** kN

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

Walls load case 4 - Wind 90, c_{pi} -0.3, $+c_{pe}$

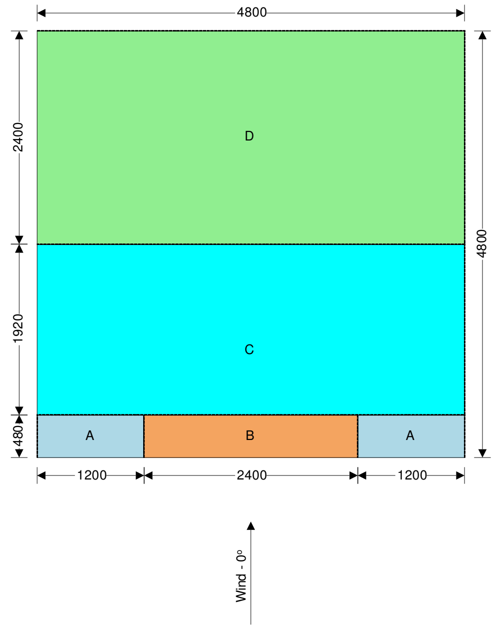
Zone	Ext pressure coefficient, c_{pe}	Dynamic pressure, q_s (kN/m^2)	External size factor, C_{ae}	Net Pressure, p (kN/m^2)	Area, A_{ref} (m^2)	Net force, F_w (kN)
A	-1.30	0.37	0.977	-0.38	4.61	-1.75
B	-0.80	0.37	0.977	-0.20	18.43	-3.65
w	0.85	0.37	0.977	0.40	23.04	9.25
l	-0.50	0.37	0.977	-0.09	23.04	-2.05

Overall loading

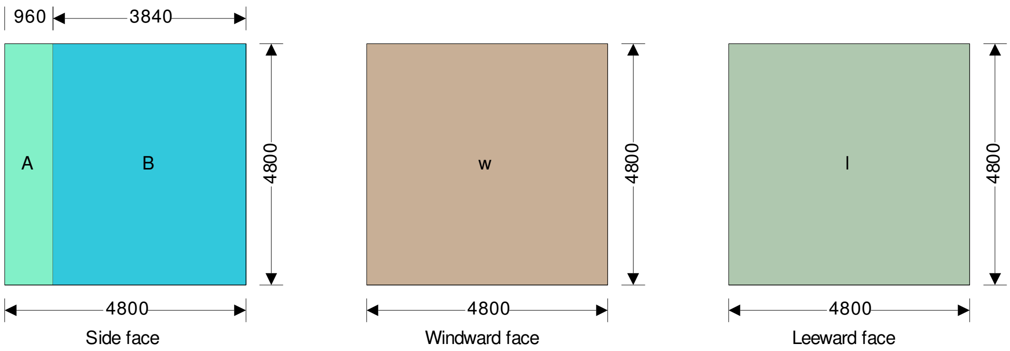
Equiv leeward net force for overall section $F_l = F_{w,wl}$ = **-2.1** kN

Net windward force for overall section $F_w = F_{w,ww}$ = **9.3** kN

Overall loading overall section $F_{w,w} = 0.85 \times (1 + C_r) \times (F_w - F_l + F_{w,h})$ = **9.9** kN



Plan view - Flat roof



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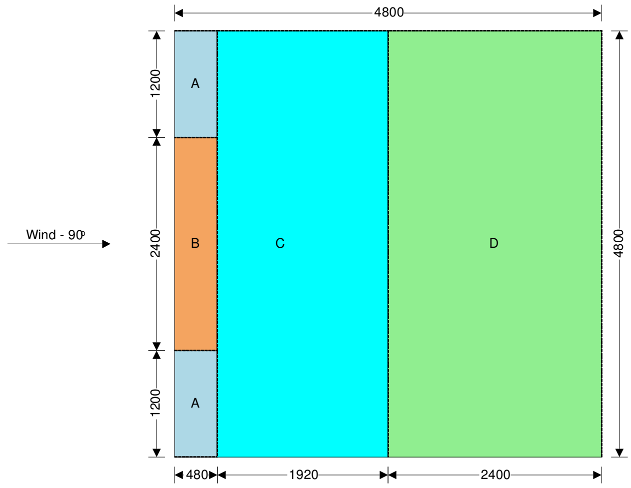
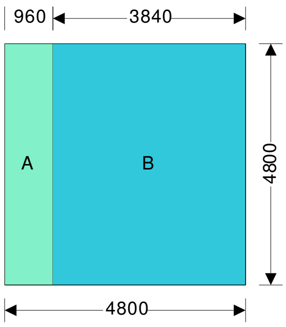
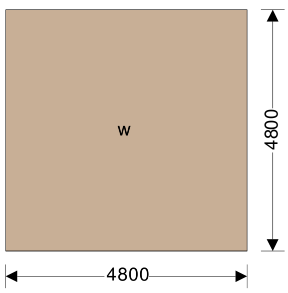
	Calcs for Wind Loads on Xmas Presents				Start page no./Revision app- 6	
	Calcs by PD	Calcs date 26/07/2021	Checked by PD	Checked date 26/07/2021	Approved by PD	Approved date 26/07/2021



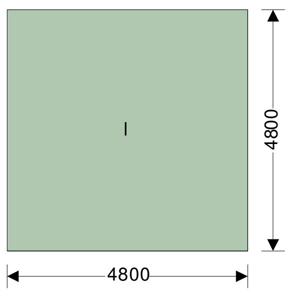
Plan view - Flat roof



Side face



Windward face



Leeward face