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Project				Job Ref.	
Tes Global, 26 Red Lion Square, WC1R 4HQ				**AR0280**	
Section				Sheet no./rev.	
Balustrade with stability platform Design				**1 / C**	
Calc. by	Date	Chk'd by	Date	App'd by	Date
SS	**June 2019**	**AC**	**June 2019**		

STRUCTURAL CALCULATIONS

Balustrade with Stability Platform Design

For

TES Global

At

26 Red Lion Square

London

WC1R 4HQ

June 2019

PREAMBLE

1. The calculations that follow form part only of the overall application submitted for Building Control Approval and are based upon drawings prepared by others. Dimensions used in calculations have been scaled/obtained from such drawings.

2. The purpose of the calculations is to justify the use of identified structural members as shown on plans, or to determine minimum sizes necessary to comply with relevant Standards where sizes have either not been shown on plans or have proved to be undersized. Should sizes calculated conflict with those shown on plans the most structurally beneficial shall be adopted and it is the responsibility of the drawing originator to amend plans as appropriate.

3. The calculations are in respect only of those structural elements to which they specifically refer. No responsibility or liability is therefore accepted in respect of any other element or part of the building.

4. The contractor is to take all necessary precautions to ensure the safety of the building and its stability during all stages of the proposed works.

5. Any alterations to the drawings or any on site discrepancies or changes affected on site during construction should be notified to the Structural Engineer in writing, with specific instructions to accommodate the changes made – as such changes could materially affect the sizes of the structural members that have been designed, approved and adopted on plans.

6. In any event, all work shall be made available for inspection by, and shall be to the entire satisfaction of, the Local Authority Building Control Inspector or other Approved Inspector.

7. No work appertaining to the plans should be carried out until the plans and calculations have been examined by the appropriate Local/Statutory Authority and formal written approval obtained. Any works carried before such approval is obtained, either for the original Application or revised information, is done solely at the Contractor's/Owners own risk. No works relating to these calculations should be carried out if 'Conditional Approval Subject to Calculations' is granted by the Local Authority.

8. No site visits are to be made by the Engineer during the course of construction unless specifically requested in writing.

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GENERAL NOTES

1. For setting out dimensions and general construction details, see Architect's Drawings. Any Engineer's sketch or drawings must not be scaled.

2. Contractor to check all dimensions and levels prior to commencing any construction or fabrication.

3. Any sketch, drawing or specification is to be read in conjunction with all other sketches, drawings or specifications relating to the project.

4. Where site or adjoining building details are at variance with issued details the Engineer is to be informed immediately in writing.

5. The contractor is to ensure the stability of each element and the whole building until the construction is complete.

6. All designs, connections, workmanship and materials are to comply with current Building Regulations, relevant British Standards, Codes of Practice, Manufacturers recommendations and Engineer details.

7. No structural members are to be cut, notched or jointed unless specified.

8. Proprietary structural elements, fixings or admixtures may only be used with Engineer's approval and to manufacturers' recommendations.

9. Unless noted otherwise, all connections (including laps and anchorage of any reinforcement in concrete) shall mobilize the full structural capacity of the member.

10. All bolted connections of steelwork shall have a minimum of 2 bolts.

11. All structural connections of timber to be formed using double-sided timber connectors and bolts with large washers.

12. No holes of any size to be formed in structural members unless specified by the Engineer or approval by him in writing.

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Balustrade with stability platform Design				**4 / C**	
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Introduction & Assumptions

INTRODUCTION:

The following calculations are to justify the provision of a terrace area with decking and balustrade on the existing roof of the building at 26 Red Lion Square, WC1R 4HQ, based on the information provided by Cayford Design via email dated **03/04/19**.
No site visit or surveys have been carried out for the purposes of these calculations.
The calculations are to be read in conjunction with all the relevant structural engineering drawings/sketches and architectural drawings/sketches.
The following calculations are to justify the steelwork sizes for the new balustrades, and stability of the overall platform. The glass panels are for modelling purposes and no glass design is incorporated within these calculations (to be provided by glass specialist).

EXISTING ROOF STRUCTURE:

IMPOSED LOAD

It is assumed that the existing roof structure was designed for maintenance access & imposed loading only, translating to 1.50kN/m^2 imposed load. The terrace use would mean the imposed loading of 2.5kN/m^2 according to EC1, which would result in 1.0kN/m^2 additinoal loading.

PERMANENT LOAD

In order to provide the new stability platform for the balustrades & decking system, the existing 50mm paving slabs are to be removed, which would result in a reduction of 0.05x25 = 1.25kN/m^2 permanent load. The permanent load to be applied by the proposed decking would be 2.0kN/m^2, resulting in additional 0.75kN/m^2.

Total additional load = (1.0 + 0.75) = 1.75kN/m^2

The existing roof structure will be required to be assessed in order to confirm the adequacy against the additional applied load. This can be carried out once the information about the existing roof structure is made available either from as-built (record) drawings or intrusive investigations.

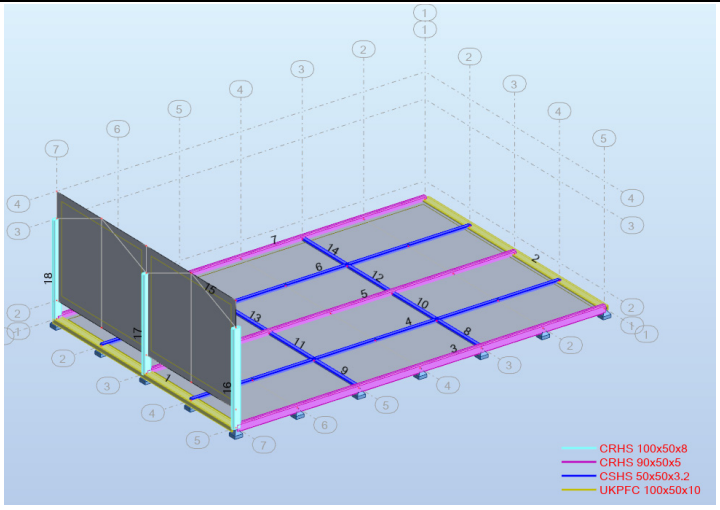
Alternatively, in order for the existing roof structure for not being overstressed, it is proposed to limit the number of people or total imposed load to no more than 0.60kN/m^2.

For the purposes of these calculations, based on 80m^2 area to be used as a terrace, 0.60kN/m^2 x 80m^2 = 48kN or 4800kgs. Assuming average weight of 90kg/person, 4800/90 = 53 persons, say a limitation to be applied is a maximum of 50 persons or 4800kgs at any one time for the terrace area.

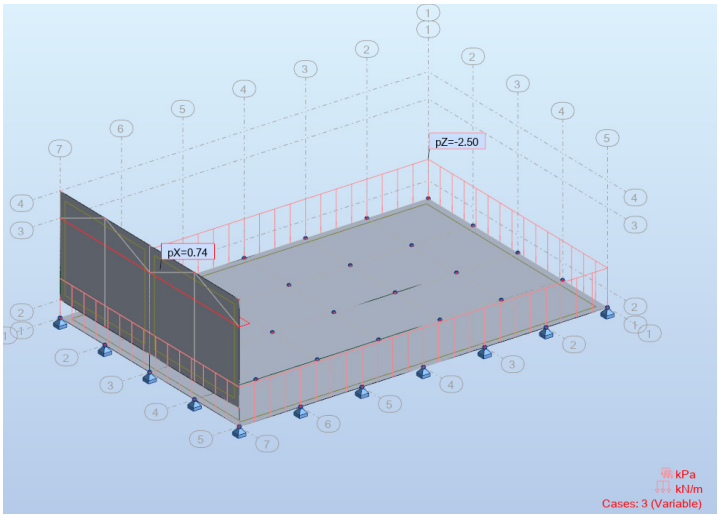
Loading for Balustrade

For the purposes of this calculation, a 3-meter long typical section of the proposed stability platform has been modelled.

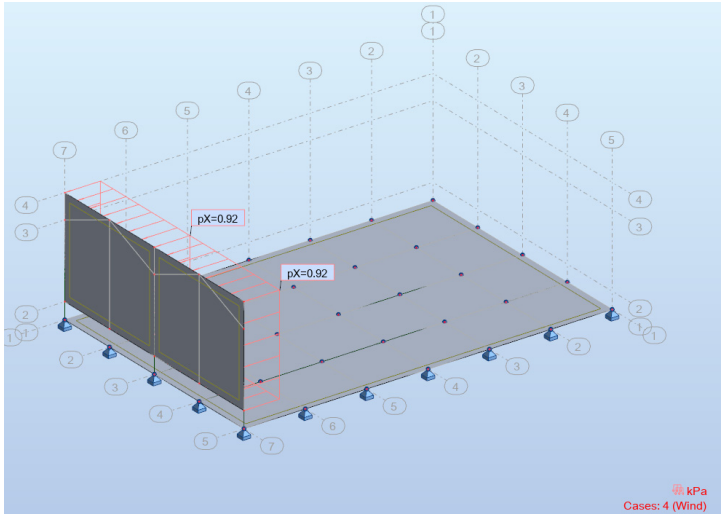
Variable Horizontal line load = 0.74kN/m
Area Wind Load (horizontal on walls) = 0.70kN/m^2 (refer to wind load calculations pages 12-17)
Area Wind Load (vertical suction on roof) = 0.94kN/m^2 (refer to wind load calculations pages 12-17)
Variable terrace load = 2.50kN/m^2
Resultant Self Weight of platform = 2.04kN/m^2



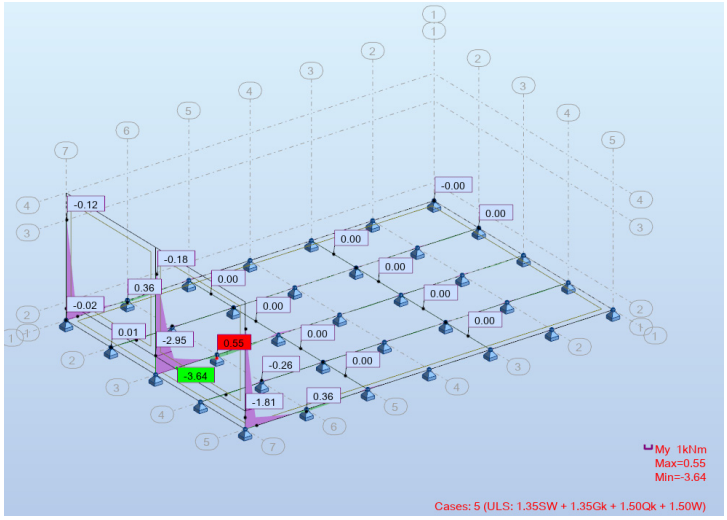
Idealised structural diagram



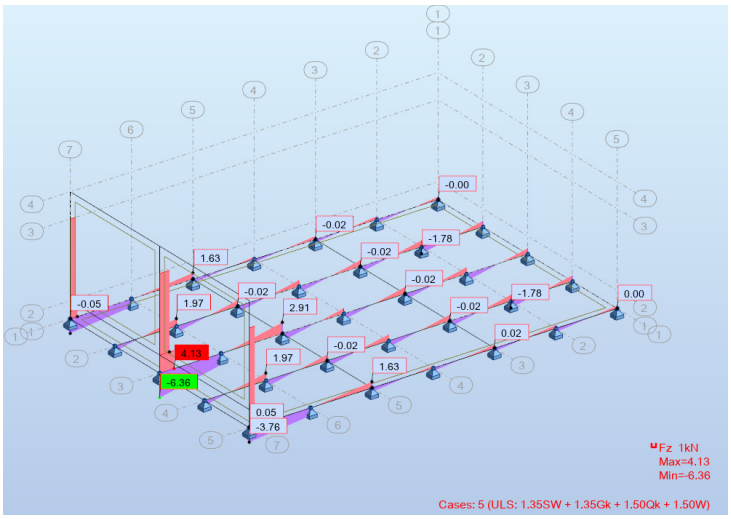
Application of variable loads



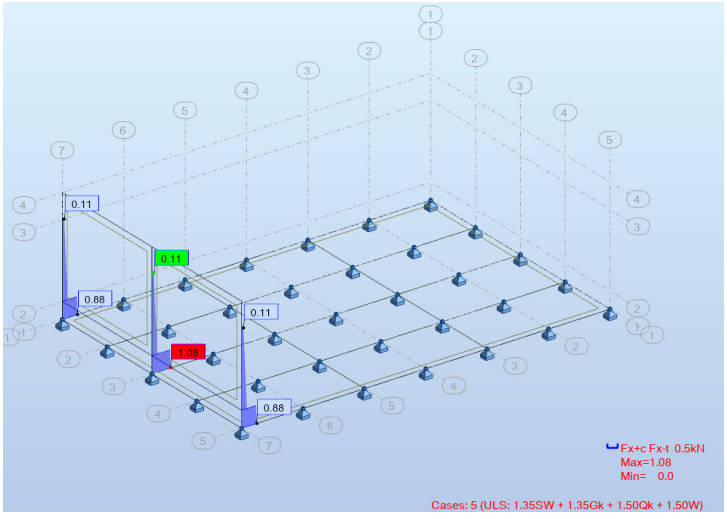
Application of wind loads



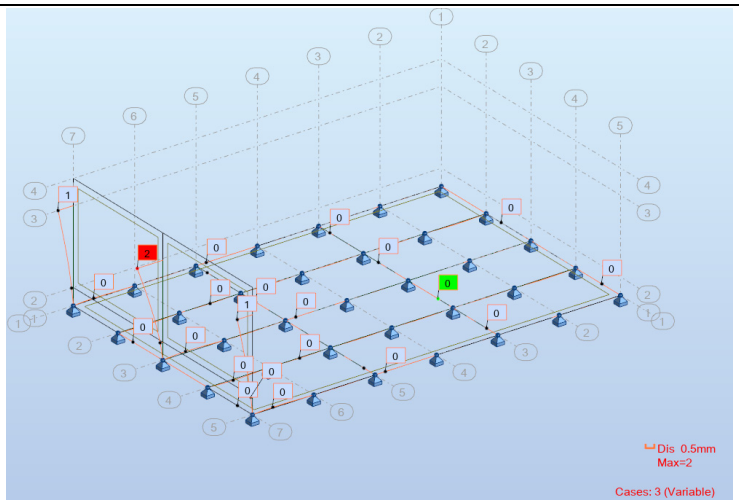
ULS Bending Moments



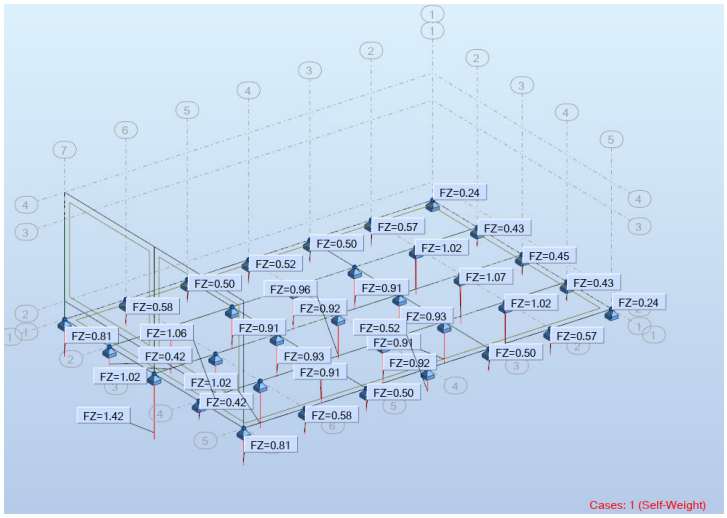
ULS Shear Force



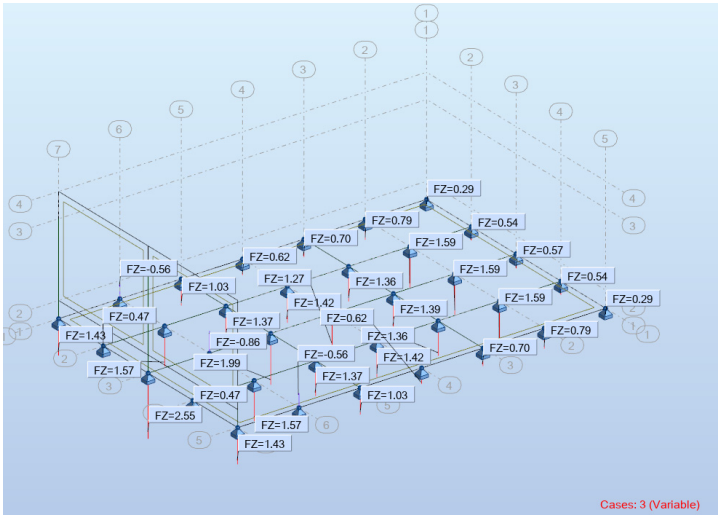
ULS Axial Forces



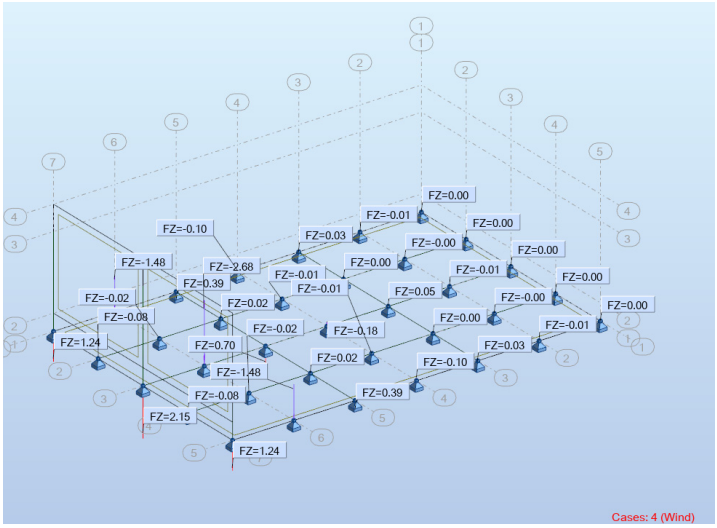
Variable load deflections



Self-weight reactions



Variable load reactions



Wind load reactions

Steel Platform Stability (by gravity only)

Total Self Weight of the steel platform = 27.60kN

Total Overturning Moment from balustrade horizontal loads = (0.74kN/m x 3m x 1.1m + 0.70kN/m^2 x 1.1^2 x 3 / 2) = 3.71kNm

Restoring moment required is to be greater than 3.71kNm, hence the stability platform required is to have a minimum of the following weight:

3.71 / 2.25m = 1.65kN, say 2.0kN or (2.0/(3x4.5) = 0.15kN/m^2)

Restoring Moment (based on the calculation model) = 27.6 x 4.5 / 2 = 62.1kNm >> 3.71kN, hence OK!

Minimum weight required to withstand suction load on the roof = 0.94x3x4.5 = 12.69kN, say 15.0kN < 27.60kN, hence OK!

Factor of Safety = 27.60/15 = 1.84

STEEL DESIGN (Critical Members Only)

CODE: *BS-EN 1993-1:2005/NA:2008/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 1 Beam_1 **POINT:** 1 **COORDINATE:** x = 0.25 L = 0.75 m

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LOADS:
Governing Load Case: 5 ULS: 1.35SW + 1.35Gk + 1.50Qk + 1.50W (1+2)*1.35+(3+4)*1.50

MATERIAL:
S275 (S275) fy = 275.00 MPa

SECTION PARAMETERS: UKPFC 100x50x10

h=100 mm	gM0=1.00	gM1=1.00	
b=50 mm	Ay=975 mm2	Az=569 mm2	Ax=1300 mm2
tw=5 mm	Iy=2080000 mm4	Iz=323000 mm4	Ix=25300 mm4
tf=9 mm	Wply=48900 mm3	Wplz=17500 mm3	

INTERNAL FORCES AND CAPACITIES:

My,Ed = -0.01 kN*m	Mz,Ed = -0.01 kN*m	Vy,Ed = -0.05 kN
My,pl,Rd = 13.45 kN*m	Mz,pl,Rd = 4.81 kN*m	Vy,T,Rd = 153.71 kN
My,c,Rd = 13.45 kN*m	Mz,c,Rd = 4.81 kN*m	Vz,Ed = 0.01 kN
		Vz,T,Rd = 89.97 kN
Mb,Rd = 7.35 kN*m		Tt,Ed = 0.01 kN*m
		Class of section = 1


LATERAL BUCKLING PARAMETERS:

z = 1.00	Mcr = 12.25 kN*m	Curve,LT - d	XLT = 0.53
Lcr,low=3.00 m	Lam_LT = 1.05	fi,LT = 1.16	XLT,mod = 0.55

BUCKLING PARAMETERS:

 About y axis:

 About z axis:

VERIFICATION FORMULAS:
Section strength check:
(My,Ed/MN,y,Rd)^ 1.00 + (Mz,Ed/MN,z,Rd)^1.00 = 0.00 < 1.00 (6.2.9.1.(6))
Vy,Ed/Vy,T,Rd = 0.00 < 1.00 (6.2.6-7)
Vz,Ed/Vz,T,Rd = 0.00 < 1.00 (6.2.6-7)
Tau,ty,Ed/(fy/(sqrt(3)*gM0)) = 0.02 < 1.00 (6.2.6)
Tau,tz,Ed/(fy/(sqrt(3)*gM0)) = 0.01 < 1.00 (6.2.6)
Global stability check of member:
My,Ed/(XLT*My,Rk/gM1) + Mz,Ed/(Mz,Rk/gM1) = 0.00 < 1.00 (6.3.3.(4))

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM):
uy = 0 mm < uy max = L/200.00 = 15 mm Verified
Governing Load Case: 6 SLS: 1.00SW + 1.00Gk + 1.00Qk + 1.00W (1+2+3+4)*1.00
uz = 0 mm < uz max = L/200.00 = 15 mm Verified
Governing Load Case: 6 SLS: 1.00SW + 1.00Gk + 1.00Qk + 1.00W (1+2+3+4)*1.00

Displacements (GLOBAL SYSTEM): *Not analyzed*

Section OK !!!

MEMBER: 5 Beam_5 **POINT:** 3 **COORDINATE:** x = 1.00 L = 4.50 m

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LOADS:

Governing Load Case: 5 ULS: 1.35SW + 1.35Gk + 1.50Qk + 1.50W (1+2)*1.35+(3+4)*1.50

MATERIAL:

S275 (S275) fy = 275.00 MPa

SECTION PARAMETERS: CRHS 90x50x5

h=90 mm	gM0=1.00	gM1=1.00	
b=50 mm	Ay=454 mm2	Az=816 mm2	Ax=1270 mm2
tw=5 mm	Iy=1270000 mm4	Iz=492000 mm4	Ix=1160000 mm4
tf=5 mm	Wply=36000 mm3	Wplz=23500 mm3	

INTERNAL FORCES AND CAPACITIES:

My,Ed = -2.95 kN*m
My,pl,Rd = 9.90 kN*m
My,c,Rd = 9.90 kN*m
Vz,Ed = -6.36 kN
Vz,c,Rd = 129.63 kN
Mb,Rd = 9.90 kN*m
Class of section = 1

LATERAL BUCKLING PARAMETERS:

z = 1.00	Mcr = 73.67 kN*m	Curve,LT - d	XLT = 1.00
Lcr,low=4.50 m	Lam_LT = 0.37	fi,LT = 0.54	XLT,mod = 1.00

BUCKLING PARAMETERS:

About y axis: About z axis:

VERIFICATION FORMULAS:

Section strength check:
My,Ed/My,c,Rd = 0.30 < 1.00 (6.2.5.(1))
Vz,Ed/Vz,c,Rd = 0.05 < 1.00 (6.2.6.(1))
Global stability check of member:
My,Ed/Mb,Rd = 0.30 < 1.00 (6.3.2.1.(1))

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM):
uy = 0 mm < uy max = L/200.00 = 23 mm Verified
Governing Load Case: 1 Self-Weight
uz = 0 mm < uz max = L/200.00 = 23 mm Verified
Governing Load Case: 6 SLS: 1.00SW + 1.00Gk + 1.00Qk + 1.00W (1+2+3+4)*1.00

Displacements (GLOBAL SYSTEM): *Not analyzed*

Section OK !!!

MEMBER: 17 Column_17 **POINT:** 1 **COORDINATE:** x = 0.00 L = 0.00 m

---

LOADS:

Governing Load Case: 5 ULS: 1.35SW + 1.35Gk + 1.50Qk + 1.50W (1+2)*1.35+(3+4)*1.50

MATERIAL:

S275 (S275) fy = 275.00 MPa

SECTION PARAMETERS: CRHS 100x50x8

h=100 mm	gM0=1.00	gM1=1.00	
b=50 mm	Ay=693 mm2	Az=1387 mm2	Ax=2080 mm2
tw=8 mm	Iy=2300000 mm4	Iz=717000 mm4	Ix=1860000 mm4
tf=8 mm	Wply=61400 mm3	Wplz=36300 mm3	

INTERNAL FORCES AND CAPACITIES:

N,Ed = 1.08 kN	My,Ed = -3.64 kN*m	
Nc,Rd = 572.00 kN	My,Ed,max = -3.64 kN*m	
Nb,Rd = 487.37 kN	My,c,Rd = 16.89 kN*m	Vz,Ed = 4.13 kN
	MN,y,Rd = 16.89 kN*m	Vz,c,Rd = 220.16 kN
		Class of section = 1

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:

About y axis:

About z axis:

Ly = 1.10 m	Lam_y = 0.39	Lz = 1.10 m	Lam_z = 0.69
Lcr,y = 1.10 m	Xy = 0.96	Lcr,z = 1.10 m	Xz = 0.85
Lamy = 33.08	kyy = 0.80	Lamz = 59.25	kzy = 0.49

VERIFICATION FORMULAS:

Section strength check:

N,Ed/Nc,Rd = 0.00 < 1.00 (6.2.4.(1))

My,Ed/My,c,Rd = 0.22 < 1.00 (6.2.5.(1))

Vz,Ed/Vz,c,Rd = 0.02 < 1.00 (6.2.6.(1))

Global stability check of member:

Lambda,y = 33.08 < Lambda,max = 210.00 Lambda,z = 59.25 < Lambda,max = 210.00 STABLE

N,Ed/(Xy*N,Rk/gM1) + kyy*My,Ed,max/(XLT*My,Rk/gM1) = 0.17 < 1.00 (6.3.3.(4))

N,Ed/(Xz*N,Rk/gM1) + kzy*My,Ed,max/(XLT*My,Rk/gM1) = 0.11 < 1.00 (6.3.3.(4))

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM): *Not analyzed*

Displacements (GLOBAL SYSTEM):

vx = 4 mm < vx max = L/300.00 = 4 mm Verified

Governing Load Case: 6 SLS: 1.00SW + 1.00Gk + 1.00Qk + 1.00W (1+2+3+4)*1.00

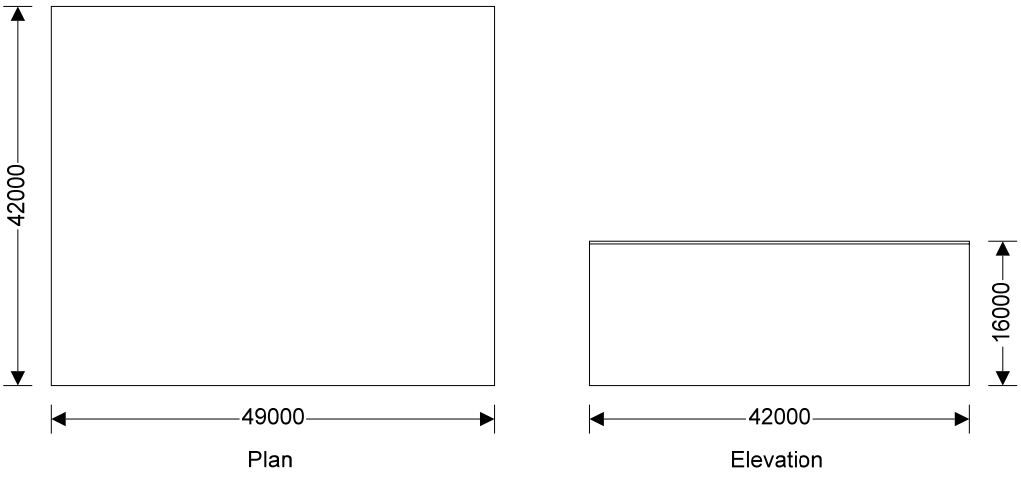
vy = 0 mm < vy max = L/300.00 = 4 mm Verified

Governing Load Case: 1 Self-Weight

Section OK !!!

WIND LOADING (BS6399)

In accordance with BS6399



Building data

Type of roof;	Flat
Length of building;	L = **49000** mm
Width of building;	W = **42000** mm
Height to eaves;	H = **15700** mm
Eaves type;	Parapet
Height of parapet;	h_p = **300** mm
Reference height;	H_r = **16000** mm

Dynamic classification

Building type factor (Table 1);	K_b = **1.0**
Dynamic augmentation factor (1.6.1);	$C_r = [K_b \times (H_r / (0.1\ m))^{0.75}] / (800 \times \log(H_r / (0.1\ m))) =$ **0.03**

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 not significant	
Altitude factor;	$S_a = 1 + 0.001 \times \Delta_S / 1m =$ **1.02**
Site wind speed	$V_s = V_b \times S_a \times S_d \times S_s \times S_p =$ **21.1** m/s
Terrain category;	Town
Average height of surrounding buildings;	H_o = **15000** mm
Distance to nearest building;	X_o = **15000** 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} = **16000**mm

Effective height; $H_e = \max(H_{ref} - H_d, 0.4 \times H_{ref})$ = **6400**mm

Fetch factor (Table 22); S_c = **0.939**

Turbulence factor (Table 22); S_t = **0.188**

Fetch adjustment factor (Table 23); T_c = **0.738**

Turbulence adjustment factor (Table 23); T_t = **1.599**

Gust peak factor; g_t = **3.44**

Terrain and building factor; $S_b = S_c \times T_c \times (1 + (g_t \times S_t \times T_t) + S_h)$ = **1.41**

Effective wind speed; $V_e = V_s \times S_b$ = **29.8** m/s

Dynamic pressure; q_s = 0.613 kg/m^3 $\times$ V_e^2 = **0.543** kN/m^2

Dynamic pressure - windward wall - Wind 90 deg and roof

Reference height (at which q is sought); H_{ref} = **16000**mm

Effective height; $H_e = \max(H_{ref} - H_d, 0.4 \times H_{ref})$ = **6400**mm

Fetch factor (Table 22); S_c = **0.939**

Turbulence factor (Table 22); S_t = **0.188**

Fetch adjustment factor (Table 23); T_c = **0.738**

Turbulence adjustment factor (Table 23); T_t = **1.599**

Gust peak factor; g_t = **3.44**

Terrain and building factor; $S_b = S_c \times T_c \times (1 + (g_t \times S_t \times T_t) + S_h)$ = **1.41**

Effective wind speed; $V_e = V_s \times S_b$ = **29.8** m/s

Dynamic pressure; q_s = 0.613 kg/m^3 $\times$ V_e^2 = **0.543** kN/m^2

Size effect factors

Diagonal dimension for gablewall; a_{eg} = **44.8** m

External size effect factor gablewall; C_{aeg} = **0.834**

Diagonal dimension for side wall; a_{es} = **51.5** m

External size effect factor side wall; C_{aes} = **0.824**

Diagonal dimension for roof; a_{er} = **64.5** m

External size effect factor roof; C_{aer} = **0.807**

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 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)	-1.90	0.54	0.807	-0.94	51.20	-48.22
B (-ve)	-1.30	0.54	0.807	-0.68	105.60	-71.67
C (-ve)	-0.70	0.54	0.807	-0.42	627.20	-260.68
D (-ve)	-0.20	0.54	0.807	-0.20	1274.00	-250.19

Total vertical net force; $F_{w,v}$ = **-630.77** 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	0.54	0.834	-0.70	102.40	-71.49
B	-0.80	0.54	0.834	-0.47	409.60	-193.10
C	-0.50	0.54	0.834	-0.34	160.00	-53.66
w	0.71	0.54	0.824	0.21	784.00	164.19
l	-0.50	0.54	0.824	-0.33	769.30	-255.85

Overall loading

Equiv leeward net force for overall section; $F_l = F_{w,wl}$ = **-255.9** kN

Net windward force for overall section; $F_w = F_{w,ww}$ = **164.2** kN

Overall loading overall section; $F_{w,w} = 0.85 \times (1 + C_r) \times (F_w - F_l + F_{w,h})$ = **366.1** 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)	-1.90	0.54	0.807	-0.67	51.20	-34.31
B (+ve)	-1.30	0.54	0.807	-0.41	105.60	-42.98
C (+ve)	-0.70	0.54	0.807	-0.14	627.20	-90.26
D (+ve)	0.20	0.54	0.807	0.25	1274.00	319.42

Total vertical net force; $F_{w,v}$ = **151.87** 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	0.54	0.834	-0.43	102.40	-43.67
B	-0.80	0.54	0.834	-0.20	409.60	-81.80
C	-0.50	0.54	0.834	-0.06	160.00	-10.19
w	0.71	0.54	0.824	0.48	784.00	377.21
l	-0.50	0.54	0.824	-0.06	769.30	-46.82

Overall loading

Equiv leeward net force for overall section; $F_l = F_{w,wl}$ = **-46.8** kN

Net windward force for overall section; $F_w = F_{w,ww}$ = **377.2** kN

Overall loading overall section; $F_{w,w} = 0.85 \times (1 + C_r) \times (F_w - F_l + F_{w,h})$ = **369.6** 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)	-1.90	0.54	0.807	-0.94	51.20	-48.22
B (-ve)	-1.30	0.54	0.807	-0.68	83.20	-56.47
C (-ve)	-0.70	0.54	0.807	-0.42	537.60	-223.44
D (-ve)	-0.20	0.54	0.807	-0.20	1386.00	-272.19

Total vertical net force; $F_{w,v}$ = **-600.32** 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	0.54	0.824	-0.69	102.40	-70.74
B	-0.80	0.54	0.824	-0.47	409.60	-191.25
C	-0.50	0.54	0.824	-0.33	272.00	-90.46
w	0.67	0.54	0.834	0.20	672.00	132.11
l	-0.50	0.54	0.834	-0.34	659.40	-221.16

Overall loading

Equiv leeward net force for overall section; $F_l = F_{w,wl}$ = **-221.2** kN

Net windward force for overall section; $F_w = F_{w,ww}$ = **132.1** kN

Overall loading overall section; $F_{w,w} = 0.85 \times (1 + C_r) \times (F_w - F_l + F_{w,h})$ = **307.9** 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)	-1.90	0.54	0.807	-0.67	51.20	-34.31
B (+ve)	-1.30	0.54	0.807	-0.41	83.20	-33.86
C (+ve)	-0.70	0.54	0.807	-0.14	537.60	-77.37
D (+ve)	0.20	0.54	0.807	0.25	1386.00	347.50

Total vertical net force; $F_{w,v}$ = **201.96** kN

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

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

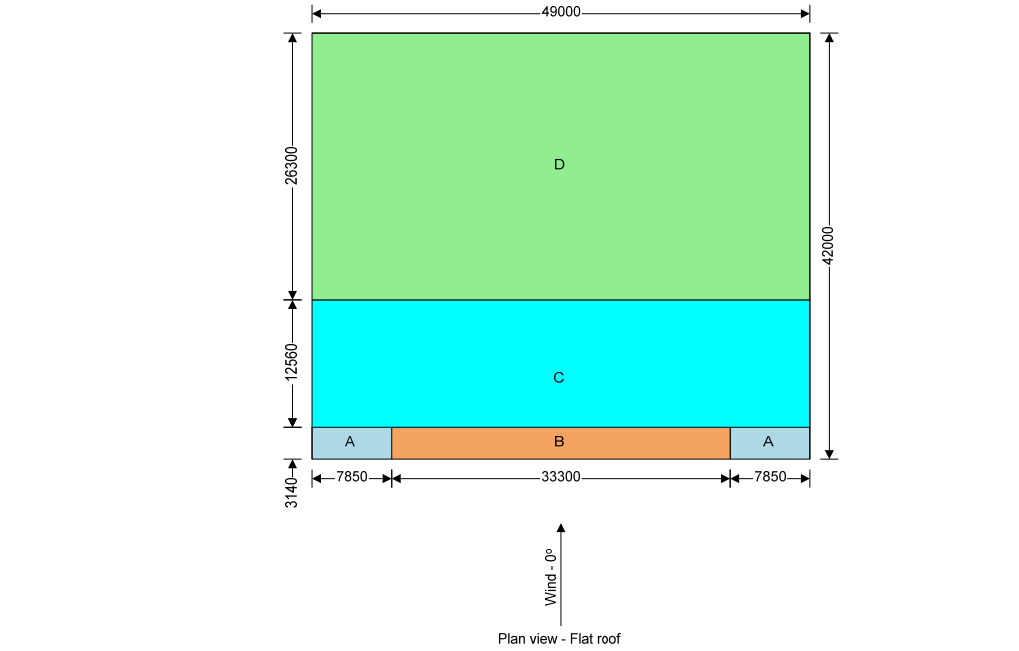
Zone	Ext pressure coefficient, c_{pe}	Dynamic pressure, q_s (kN/m^2)	External size factor, C_{ae}	Net Pressure, p (kN/m^2)	Area, A_{ref} (m^2)	Net force, F_w (kN)
A	-1.30	0.54	0.824	-0.42	102.40	-42.91
B	-0.80	0.54	0.824	-0.20	409.60	-79.95
C	-0.50	0.54	0.824	-0.06	272.00	-16.55
w	0.67	0.54	0.834	0.47	672.00	314.70
l	-0.50	0.54	0.834	-0.06	659.40	-42.00

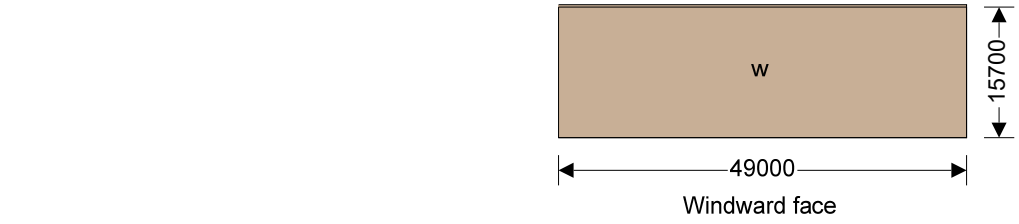
Overall loading

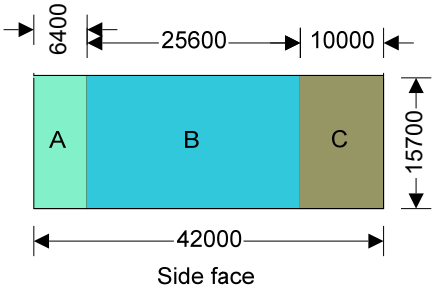
Equiv leeward net force for overall section; $F_l = F_{w,wl}$ = **-42.0** kN

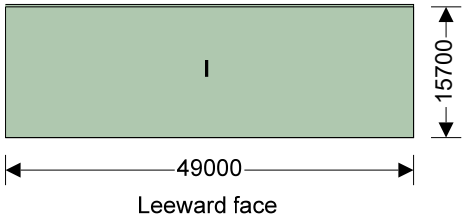
Net windward force for overall section; $F_w = F_{w,ww}$ = **314.7** kN

Overall loading overall section; $F_{w,w} = 0.85 \times (1 + C_r) \times (F_w - F_l + F_{w,h})$ = **310.9** kN









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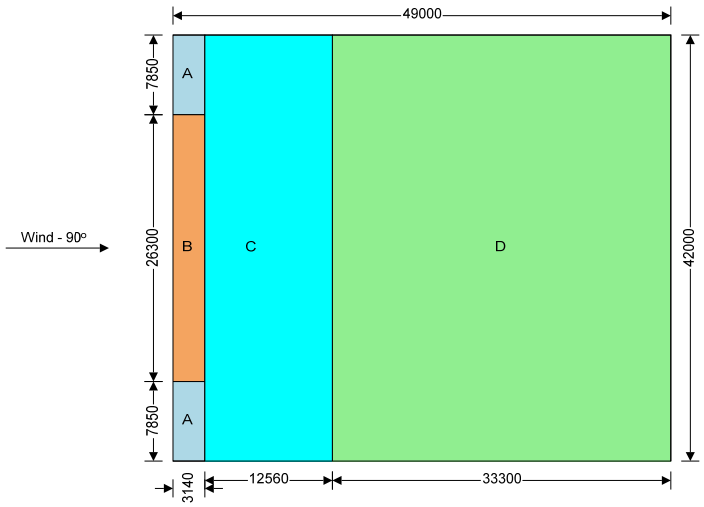
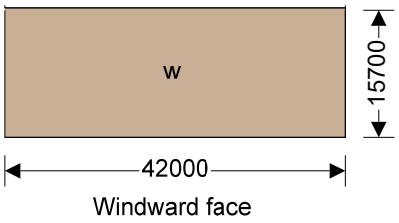
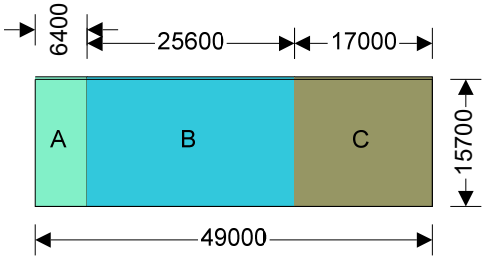
Project				Job Ref.	
Tes Global, 26 Red Lion Square, WC1R 4HQ				**AR0280**	
Section				Sheet no./rev.	
Balustrade with stability platform Design				**17 / C**	
Calc. by	Date	Chk'd by	Date	App'd by	Date
SS	**June 2019**	**AC**	**June 2019**		



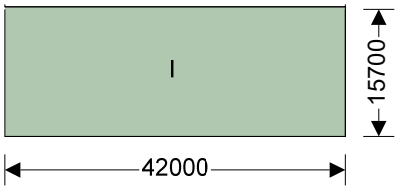
Plan view - Flat roof



Windward face



Side face



Leeward face