PEARL ENGINEERS, PLANNERS & PROJECT MANAGERS

STRUCTURAL CALCULATION REPORT

Project Reference: 2024-01-SL67JX

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Document Control:

Purpose/Status	Date	Rev.	Comments	Structural Engineer
Approval Issue		00	B'Regs Issue	MM

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PROJECT INFORMATION

Design Codes – Eurocodes and their respective National Annexes:

Design Codes	Eurocodes	National Annexes
BS EN 1990	Eurocode 0	'Basis of structural design'
BS EN 1991	Eurocode 1	'Actions on structures'
BS EN 1992	Eurocode 2	'Design of concrete structures'
BS EN 1993	Eurocode 3	'Design of steel structures'
BS EN 1995	Eurocode 4	'Design of timber structures'
BS EN 1996	Eurocode 6	'Design of masonry structures'
BS EN 1997	Eurocode 7	'Geotechnical Design'

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1. LOADING DETAILS

The following loading is generally considered in the design of the structural elements.

PITCHED ROOF PERMANENT ACTIONS

Tiles w_{Gtiles} **= 0.55 kN/m²**

Rafters, Battens and Felt $w_{Grafters}$ **= 0.15 kN/m²**

Insulation w_{Ginsul} **= 0.10 kN/m²**

Plasterboard & Skim $w_{Gplaster}$ **= 0.20 kN/m²**

Total pitched roof permanent action = 1.00 kN/m²

PITCHED ROOF VARIABLE ACTIONS

Pitched roof variable action $w_{Qsnow\ pitch}$ **= 0.60 kN/m²**

FLAT ROOF PERMANENT ACTIONS

Chipping's and Bitumen w_{Gchip} **= 0.20 kN/m²**

Three Layers Felt w_{Gfelt} **= 0.10 kN/m²**

Boarding & Joists $w_{Gjoists}$ **= 0.30 kN/m²**

Insulation w_{Ginsul} **= 0.10 kN/m²**

Plasterboard & Skim $w_{Gplaster}$ **= 0.20 kN/m²**

Total flat roof permanent action $w_{Gflatroof} = (w_{Gchip} + w_{Gfelt} + w_{Gjoists} + w_{Ginsul} + w_{Gplaster}) =$ **0.90 kN/m²**

FLAT ROOF VARIABLE ACTIONS

Flat roof variable action $w_{Qsnow\ flat}$ **= 0.75 kN/m²**

CEILING PERMANENT ACTIONS

Boarding & Joists $w_{Gjoists}$ **= 0.30 kN/m²**

Insulation w_{Ginsul} **= 0.10 kN/m²**

Plasterboard & Skim $w_{Gplaster}$ **= 0.20 kN/m²**

CEILING VARIABLE ACTIONS

Ceiling variable action $w_{Qceiling} = 0.25\ kN/m^2$

FLOORS PERMANENT ACTIONS

Boarding & Joists $w_{Gjoists} = 0.30\ kN/m^2$

Plasterboard & Skim $w_{Gplaster} = 0.20\ kN/m^2$

Total floor permanent action $w_{Gfloor} = (w_{Gjoists} + w_{Gplaster} + w) =$ 0.7[illegible] kN/m²

FLOOR VARIABLE ACTIONS

Floor variable action $w_{Qfloor} = 1.50\ kN/m^2$

STUDWORK PARTITIONS

Studs and Noggins $w_{Gstud} = 0.10\ kN/m^2$

Insulation $w_{Ginsul} =$ 0.[illegible]0 kN/m²

Plasterboard & Skim $w_{Gplaster} = 0.20\ kN/m^2$

Total $w_{Gpartitions} = (w_{Gstud} + w_{Ginsul} + w_{Gplaster}) = 0.40\ kN/m^2$

BLOCKWORK PARTITIONS

100mm blockwork $w_{Gblock} = 2.20\ kN/m^2$

Plasterboard & Skim $w_{Gplaster} = 0.20\ kN/m^2$

100mm BRICK WALL

100 Bricks $w_{Gbrick100} = 2.15\ kN/m^2$

Plasterboard & Skim $w_{Gplaster} = 0.20\ kN/m^2$

215mm BRICK WALL

215 Bricks $w_{Gbrick215} = 4.30\ kN/m^2$

Render & Skim $w_{Grender} = 0.70\ kN/m^2$

CAVITY WALL

102 Brick + 140 Block	$\mathbf{w_{Gblock} + w_{Gbrick100} = 4.35\ kN/m^2}$
Insulation	$\mathbf{w_{Ginsul} = 0.10\ kN/m^2}$
Plasterboard & Skim	$\mathbf{w_{Gplaster} = 0.20\ kN/m^2}$

GLASS

15mm thick toughened laminated	$\mathbf{w_{Gglass} = 0.38\ kN/m^2}$

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2. STEEL DESIGN

2.1 Beam B1 (UC 152x152x30 S355)

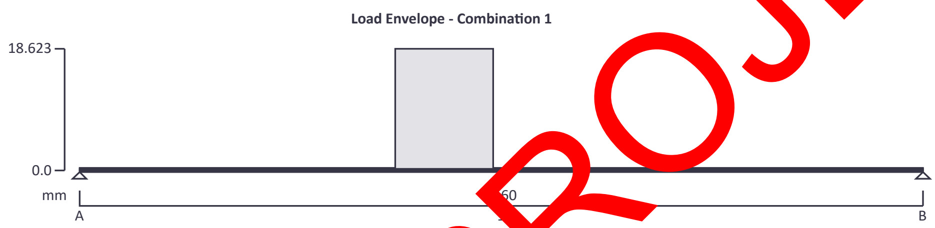
Permanent

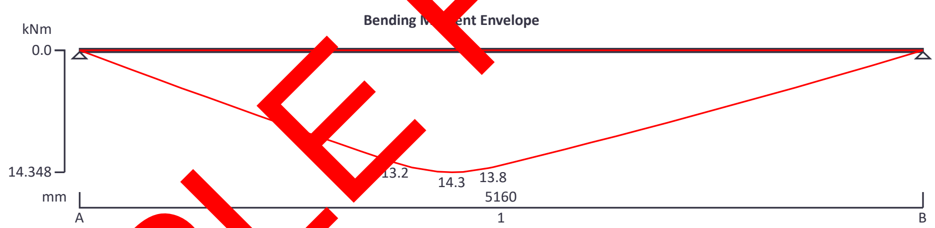
Chimney load 600mm wide @ 1931m =5kN/m² x 2.7m = ***13.5kN/m***

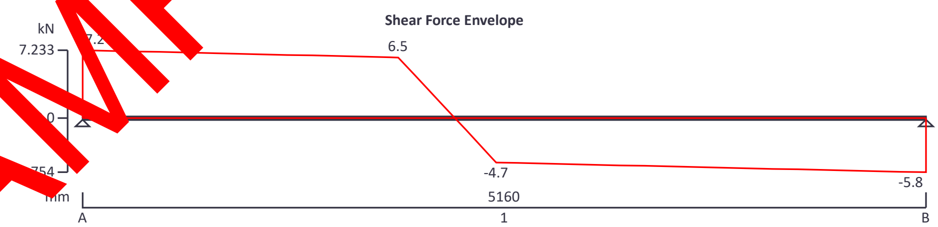
STEEL BEAM ANALYSIS & DESIGN (EN1993-1-1:2005)

In accordance with EN1993-1-1:2005 incorporating Corrigenda February 2006 and April 2009 and the UK national annex

TEDDS calculation version 3.0.13







Support conditions

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

Applied loading

Beam loads	Permanent self weight of beam × 1 Permanent partial UDL 13.5 kN/m from 1931 mm to 2531 mm

Load combinations

Load combination 1	Support A	Permanent × 1.35
		Variable × 1.50
		Permanent × 1.35
		Variable × 1.50
	Support B	Permanent × 1.35
		Variable × 1.50

Analysis results

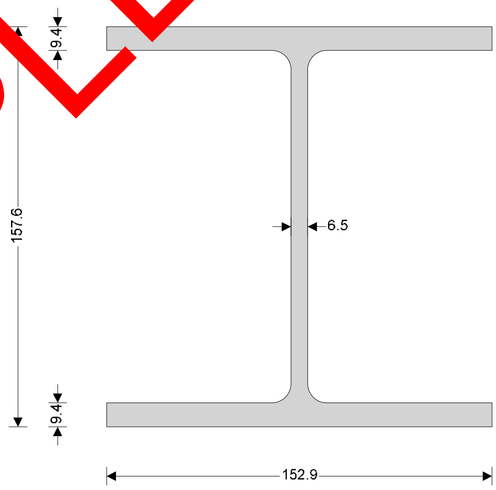
Maximum moment;	M_{max} = **14.3** kNm;	M_{min} = **0** kNm
Maximum shear;	V_{max} = **7.2** kN;	V_{min} = **-5.8** kN
Deflection;	δ_{max} = **6.9** mm;	δ_{min} = **0** mm
Maximum reaction at support A;	R_{A_max} = **7.2** kN;	R_{A_min} = **7.2** kN
Unfactored permanent load reaction at support A;	$R_{A\_Permanent}$ = **5.4** kN	
Maximum reaction at support B;	R_{B_max} = **5.8** kN;	R_{B_min} = **5.8** kN
Unfactored permanent load reaction at support B;	$R_{B\_Permanent}$ = **4.[illegible]** kN	

Section details

Section type;	**UC 152x152x30 (BS4-1)**
Steel grade;	**S355**

EN 10025-2:2004 - Hot rolled products of structural steels

Nominal thickness of element;	$t = \max(t_f, t_w)$ = **9.4** mm
Nominal yield strength;	f_y = **355** N/mm^2
Nominal ultimate tensile strength;	f_u = **470** N/mm^2
Modulus of elasticity;	E = **210000** N/mm^2



Partial factors - Section 6.1

Resistance of cross-sections;	γ_{M0} = **1.00**
Resistance of members to instability;	γ_{M1} = **1.00**
Resistance of tensile members to fracture;	γ_{M2} = **1.10**

Lateral restraint

Span 1 has lateral restraint at supports only

Effective length factors

Effective length factor in major axis; K_y = **1.000**

Effective length factor in minor axis; K_z = **1.000**

Effective length factor for torsion; $K_{LT.A}$ = **1.000**;

$K_{LT.B}$ = **1.000**;

Classification of cross sections - Section 5.5

$\varepsilon = \sqrt{[235 \text{ N/mm}^2 / f_y]}$ = **0.81**

Internal compression parts subject to bending - Table 5.2 (sheet 1 of 3)

Width of section; c = d = **123.6** mm

$c / t_w = 23.4 \times \varepsilon <= 72 \times \varepsilon$; Class 1

Outstand flanges - Table 5.2 (sheet 2 of 3)

Width of section; $c = (b - t_w - 2 \times r) / 2$ = **65.6** mm

$c / t_f = 8.6 \times \varepsilon <= 9 \times \varepsilon$; Class 1

Section is class 1

Check shear - Section 6.2.6

Height of web; $h_w = h - 2 \times t_f$ = **[illegible]8.8** mm

Shear area factor; η = **1.000**

$h_w / t_w < 72 \times \varepsilon / \eta$

Shear buckling resistance can be ignored

Design shear force; $V_{Ed} = \max(\text{abs}(V_{max}), \text{abs}(V_{min}))$ = **7.2** kN

Shear area - cl 6.2.6(3); $A_v = \max(A - 2 \times b \times t_f + (t_w + 2 \times r) \times t_f, \eta \times h_w \times t_w)$ = **1156** mm^2

Design shear resistance - cl 6.2.6(2); $V_{c,Rd} = V_{pl,Rd} = A_v \times (f_y / \sqrt{[3]}) / \gamma_{M0}$ = **236.9** kN

PASS - Design shear resistance exceeds design shear force

Check bending moment major (y-y) axis - Section 6.2.5

Design bending moment; $M_{Ed} = \max(\text{abs}(M_{s1\_max}), \text{abs}(M_{s1\_min}))$ = **14.3** kNm

Design bending resistance moment - eq 6.13; $M_{c,Rd} = M_{pl,Rd} = W_{pl.y} \times f_y / \gamma_{M0}$ = **87.9** kNm

Slenderness ratio for lateral torsional buckling

Correction factor - Table 6.6; k_c = **0.94**

$C_1 = 1 / k_c^2$ = **1.132**

Curvature factor; $g = \sqrt{[1 - (I_z / I_y)]}$ = **0.824**

Poisson's ratio; ν = **0.3**

Shear modulus; $G = E / [2 \times (1 + \nu)]$ = **80769** N/mm^2

Unrestrained length; $L = 1.0 \times L_{s1}$ = **5160** mm

Elastic critical buckling moment; $M_{cr} = C_1 \times \pi^2 \times E \times I_z / (L^2 \times g) \times \sqrt{[I_w / I_z + L^2 \times G \times I_t / (\pi^2 \times E \times I_z)]}$ = **94.6** kNm

Slenderness ratio for lateral torsional buckling; $\bar{\lambda}_{LT} = \sqrt{(W_{pl.y} \times f_y / M_{cr})}$ = **0.964**

Limiting slenderness ratio; $\bar{\lambda}_{LT,0}$ = **0.4**

$\bar{\lambda}_{LT} > \bar{\lambda}_{LT,0}$ - Lateral torsional buckling cannot be ignored

Design resistance for buckling - Section 6.3.2.1

Buckling curve - Table 6.5; b

Imperfection factor - Table 6.3; α_{LT} = **0.34**

Correction factor for rolled sections; β = **0.75**

LTB reduction determination factor; $\phi_{LT} = 0.5 \times [1 + \alpha_{LT} \times (\bar{\lambda}_{LT} - \bar{\lambda}_{LT,0}) + \beta \times \bar{\lambda}_{LT}^2]$ = **0.944**

LTB reduction factor - eq 6.57; $\chi_{LT} = \min(1 / [\phi_{LT} + \sqrt{(\phi_{LT}^2 - \beta \times \bar{\lambda}_{LT}^2)}], 1, 1 / \bar{\lambda}_{LT}^2)$ = **0.722**

Modification factor; $f = \min(1 - 0.5 \times (1 - k_c)\times [1 - 2 \times (\bar{\lambda}_{LT} - 0.8)^2], 1)$ = **0.972**

Modified LTB reduction factor - eq 6.58; $\chi_{LT,mod} = \min(\chi_{LT} / f, 1)$ = **0.743**

Design buckling resistance moment - eq 6.55; $M_{b,Rd} = \chi_{LT,mod} \times W_{pl.y} \times f_y / \gamma_{M1}$ = **6[illegible].3** kNm

PASS - Design buckling resistance moment exceeds design bending moment

Check vertical deflection - Section 7.2.1

Consider deflection due to permanent loads

Limiting deflection; $\delta_{lim} = L_{s1} / 250$ = **20.6** mm

Maximum deflection span 1; $\delta = \max(abs(\delta_{max}), abs(\delta_{min}))$ = **[illegible].866** mm

PASS - Maximum deflection does not exceed deflection limit

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3. PADSTONE DESIGN

3.1 Padstone PD1 (440(lg)x100(w)x215(dp) C40)

Permanent

*Beam end reaction = **7.2kN***

MASONRY BEARING DESIGN TO BS5628-1:2005

TEDDS calculation version 1.0.06

Masonry details

Masonry type; **Aggregate concrete blocks (25% or less formed voids)**

Compressive strength of unit; p_{unit} = **20.0** N/mm^2

Mortar designation; **iii**

Least horizontal dimension of masonry units; l_{unit} = **100** mm

Height of masonry units; h_{unit} = **215** mm

Category of masonry units; **Category II**

Category of construction control ; **Normal**

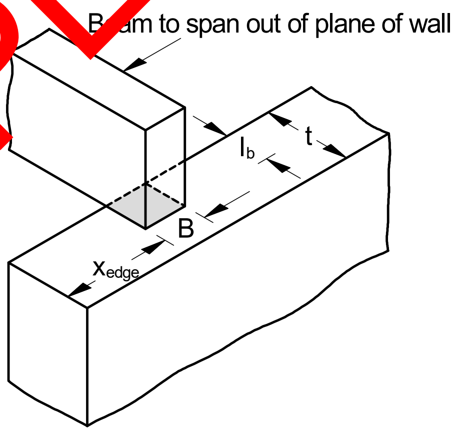
Partial safety factor for material strength; γ_m = **3.5**

Thickness of load bearing leaf; t = **100** mm

Effective thickness of masonry wall; t_{ef} = **100** mm

Height of masonry wall; h = **2400** mm

Effective height of masonry wall; h_{ef} = **2400** mm



Bearing details

Beam spanning out of plane of wall

Width of bearing; B = **100** mm

Length of bearing; l_b = **100** mm

Edge distance; x_{edge} = **100** mm

Compressive strength from Table 2 BS5628:Part 1 - aggregate concrete blocks (25% or less formed voids)

Mortar designation; Mortar = **"iii"**

Block compressive strength; p_{unit} = **20.0** N/mm^2

Characteristic compressive strength (Table 2c); f_{kc} = **5.55** N/mm^2

Characteristic compressive strength (Table 2d); f_{kd} = **11.05** N/mm^2

Height of solid block; h_{unit} = **215.0** mm ;

Least horizontal dimension; l_{unit} = **100.0** mm

Block ratio; ratio = h_{unit} / l_{unit} = **2.2**

Ratio between 0.6 and 4.5 - OK

Characteristic compressive strength; f_k = **11.05** N/mm^2

Loading details

Characteristic concentrated dead load; G_k = **7** kN

Characteristic concentrated imposed load; Q_k = **1** kN

Design concentrated load; F = ($G_k \times$ 1.4) + ($Q_k \times$ 1.6) = **11.7** kN

Characteristic distributed dead load; g_k = **0.0** kN/m

Characteristic distributed imposed load; q_k = **0.0** kN/m

Design distributed load; f = ($g_k \times$ 1.4) + ($q_k \times$ 1.6) = **0.0** kN/m

Masonry bearing type

Bearing type; **Type 2**

Bearing safety factor; γ_{bear} = **1.50**

Check design bearing without a spreader

Design bearing stress; f_{ca} = F / (B $\times$ l_b) + f / t = **1.168** N/mm^2

Allowable bearing stress; f_{cp} = $\gamma_{bear} \times f_k / \gamma_m$ = **4.736** N/mm^2

PASS - Allowable bearing stress exceeds design bearing stress

Check design bearing at 0.4 $\times$ h below the bearing level

Slenderness ratio; h_{ef} / t_{ef} = **24.00**

Eccentricity at top of wall; e_x = **0.0** mm

From BS5628:1 Table 7

Capacity reduction factor; β = **0.61**

Length of bearing distributed at 0.4 $\times$ h; l_d = **1160** mm

Maximum bearing stress; f_{ca} = F / ($l_d \times$ t) + f / t = **0.101** N/mm^2

Allowable bearing stress; f_{cp} = $\beta \times f_k / \gamma_m$ = **1.910** N/mm^2

PASS - Allowable bearing stress at 0.4 $\times$ h below bearing level exceeds design bearing stress