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Independent Property Survey Specialists

Sample Report

No image available

Structural Calculations

Another Client
Another Property, Another Road, Another Town
Date: **/**/**

Structural Engineer

E Duka

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1 Introduction

This structural calculation report has been prepared on behalf of **Another Client** for the support of solid wall to the kitchen ceiling. This structural design includes the following element

1. Design existing timber beam supporting solid wall (Failed)
2. Design Trimmer beam supporting solid wall (Failed)
3. Proposed Steel beam supporting solid wall.

2 Codes of practice

BS 6399-Loading

BS 5268-Timber

BS 5950-Steel

BS 5628-Masonry

3 Loads

Dead Loads

Description	Units
Finishes	0.3 KN/m ²
Single Brick wall	2.1 KN/m ² (102mm thick)

Load Calculations

Dead Loads

Finishes (Wall height 2.5m)

$$= 0.3 \frac{KN}{m^2} * 2.5m = 0.75 \frac{KN}{m}$$

Brick Wall (Wall height 2.5m)

$$= 2.1 \frac{KN}{m^2} * 2.5m = 5.25 \frac{KN}{m}$$

Floor (width 0.4m)

$$= 0.3 \frac{KN}{m^2} * 0.4m = 0.12 \frac{KN}{m}$$

Total Dead Loads	$= 6.12 \frac{KN}{m}$
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Imposed Loads

Domestic

$$= 1.5 \frac{KN}{m^2} * 0.4m = 0.6 \frac{KN}{m}$$

Total Imposed Loads	$= 0.6 \frac{KN}{m}$
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4 Summary

We have calculated three different scenarios to verify and apply the correct member to support the sold wall above. Initially, we have applied the loads to the existing timber beam (200x50mm) which failed in lateral support, exceed bending stress, exceed shear stress, and failed in deflection. In addition to this, we have tested if a trimmer beam could resist such loads but was still failing. Finally, we tested a steel beam that is acceptable to resist such loads.

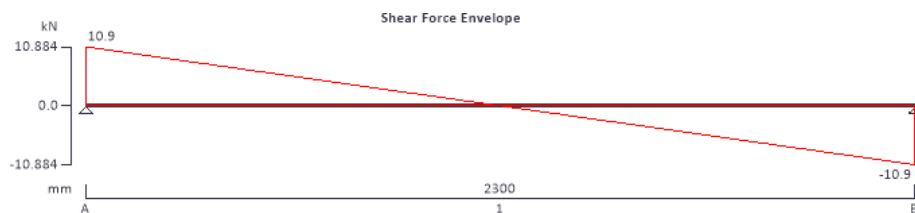
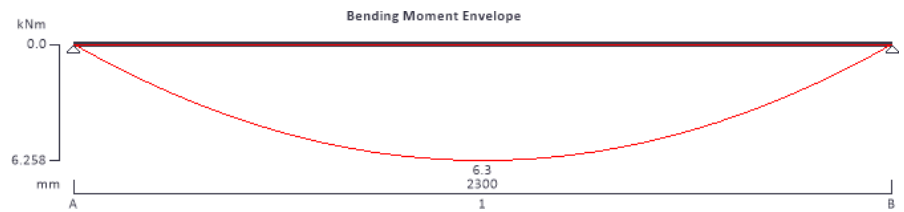
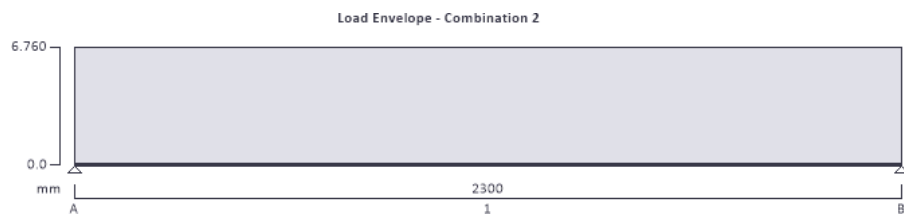
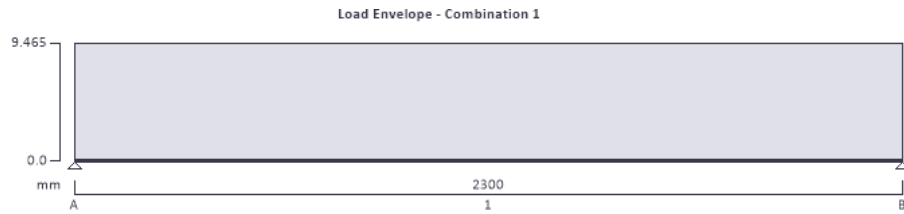
We have recommended using steel beam UC 152x152x30with Steel grade; S275. The steel beam is to be supported in engineering brick.

Please refer to Appendix A for structural calculation details.

Appendix A

Project Another Client, Another Address, Another Postcode				Job no. 1	
Calcs for Another Client				Start page no./Revision 1	
Calcs by ED	Calcs date 08/08/2021	Checked by ED	Checked date 08/08/2021	Approved by ED	Approved date 08/08/2021

TIMBER BEAM ANALYSIS & DESIGN TO BS5268-2:2002



Applied loading

Beam loads

Timber Dead self weight of beam \times 1
 Dead Loads Dead full UDL 6.120 kN/m
 Live Load Dead full UDL 0.600 kN/m

Load combinations

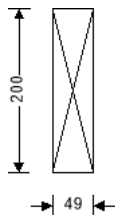
Load combination 1	Support A	Dead \times 1.40 Imposed \times 1.60
	Span 1	Dead \times 1.40 Imposed \times 1.60
	Support B	Dead \times 1.40

Project Another Client, Another Address, Another Postcode				Job no. 1	
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Load combination 2	Support A	Imposed × 1.60 Dead × 1.00
	Span 1	Imposed × 1.00 Dead × 1.00
	Support B	Imposed × 1.00 Dead × 1.00

Analysis results

Maximum moment	$M_{max} = 6.258$ kNm	$M_{min} = 0.000$ kNm
Design moment	$M = \max(\text{abs}(M_{max}), \text{abs}(M_{min})) = 6.258$ kNm	
Maximum shear	$F_{max} = 10.884$ kN	$F_{min} = -10.884$ kN
Design shear	$F = \max(\text{abs}(F_{max}), \text{abs}(F_{min})) = 10.884$ kN	
Total load on beam	$W_{tot} = 21.768$ kN	
Reactions at support A	$R_{A_{max}} = 10.884$ kN	$R_{A_{min}} = 7.774$ kN
Unfactored dead load reaction at support A	$R_{A_{Dead}} = 7.774$ kN	
Reactions at support B	$R_{B_{max}} = 10.884$ kN	$R_{B_{min}} = 7.774$ kN
Unfactored dead load reaction at support B	$R_{B_{Dead}} = 7.774$ kN	



Timber section details

Breadth of sections	$b = 49$ mm
Depth of sections	$h = 200$ mm
Number of sections in member	$N = 1$
Overall breadth of member	$b_b = N \times b = 49$ mm
Timber strength class	C24

Member details

Service class of timber	1
Load duration	Long term
Length of span	$L_{s1} = 2300$ mm
Length of bearing	$L_b = 100$ mm

Section properties

Cross sectional area of member	$A = N \times b \times h = 9800$ mm ²
Section modulus	$Z_x = N \times b \times h^2 / 6 = 326667$ mm ³
	$Z_y = h \times (N \times b)^2 / 6 = 80033$ mm ³
Second moment of area	$I_x = N \times b \times h^3 / 12 = 32666667$ mm ⁴
	$I_y = h \times (N \times b)^3 / 12 = 1960817$ mm ⁴
Radius of gyration	$i_x = \sqrt{I_x / A} = 57.7$ mm
	$i_y = \sqrt{I_y / A} = 14.1$ mm

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Modification factors

Duration of loading - Table 17	$K_3 = 1.00$
Bearing stress - Table 18	$K_4 = 1.00$
Total depth of member - cl.2.10.6	$K_7 = (300 \text{ mm} / h)^{0.11} = 1.05$
Load sharing - cl.2.9	$K_8 = 1.00$

Lateral support - cl.2.10.8

No lateral support	
Permissible depth-to-breadth ratio - Table 19	2.00
Actual depth-to-breadth ratio	$h / (N \times b) = 4.08$

FAIL - Lateral support is inadequate

Compression perpendicular to grain

Permissible bearing stress (no wane)	$\sigma_{c_adm} = \sigma_{cp1} \times K_3 \times K_4 \times K_8 = 2.400 \text{ N/mm}^2$
Applied bearing stress	$\sigma_{c_a} = R_{A_max} / (N \times b \times L_b) = 2.221 \text{ N/mm}^2$
	$\sigma_{c_a} / \sigma_{c_adm} = 0.926$

PASS - Applied compressive stress is less than permissible compressive stress at bearing

Bending parallel to grain

Permissible bending stress	$\sigma_{m_adm} = \sigma_m \times K_3 \times K_7 \times K_8 = 7.842 \text{ N/mm}^2$
Applied bending stress	$\sigma_{m_a} = M / Z_x = 19.158 \text{ N/mm}^2$
	$\sigma_{m_a} / \sigma_{m_adm} = 2.443$

FAIL - Applied bending stress exceeds permissible bending stress

Shear parallel to grain

Permissible shear stress	$\tau_{adm} = \tau \times K_3 \times K_8 = 0.710 \text{ N/mm}^2$
Applied shear stress	$\tau_a = 3 \times F / (2 \times A) = 1.666 \text{ N/mm}^2$
	$\tau_a / \tau_{adm} = 2.346$

FAIL - Applied shear stress exceeds permissible shear stress

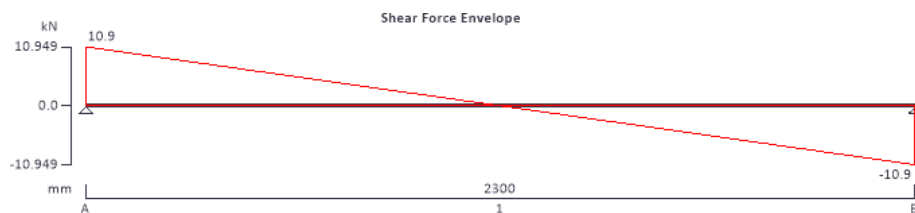
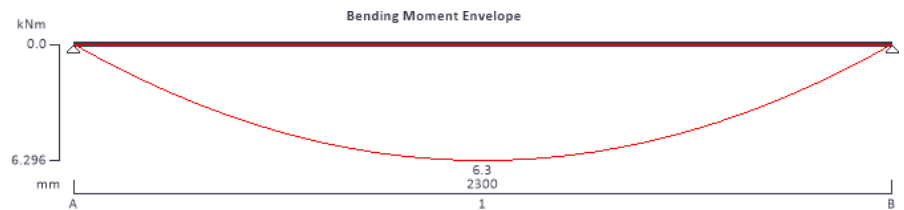
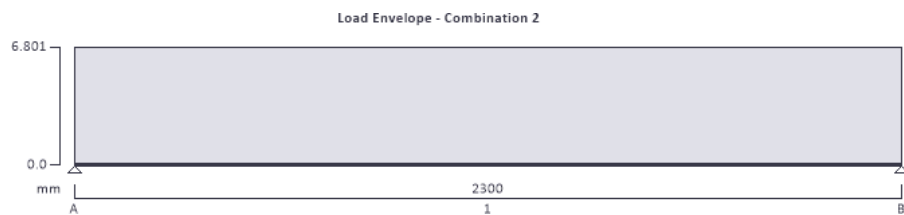
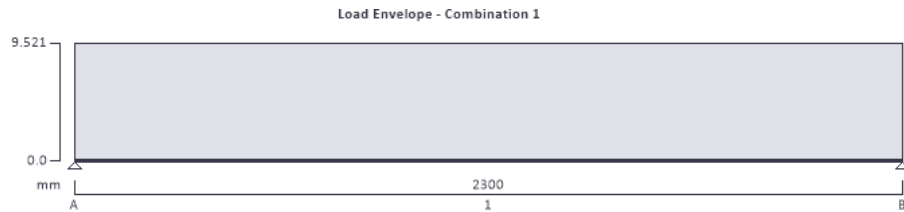
Deflection

Modulus of elasticity for deflection	$E = E_{min} = 7200 \text{ N/mm}^2$
Permissible deflection	$\delta_{adm} = \min(0.551 \text{ in}, 0.003 \times L_{s1}) = 6.900 \text{ mm}$
Bending deflection	$\delta_{b_s1} = 10.473 \text{ mm}$
Shear deflection	$\delta_{v_s1} = 1.216 \text{ mm}$
Total deflection	$\delta_a = \delta_{b_s1} + \delta_{v_s1} = 11.690 \text{ mm}$
	$\delta_a / \delta_{adm} = 1.694$

FAIL - Total deflection exceeds permissible deflection

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TIMBER BEAM ANALYSIS & DESIGN TO BS5268-2:2002



Applied loading

Beam loads

Timber Dead self weight of beam \times 1
 Dead Loads Dead full UDL 6.120 kN/m
 Live Load Dead full UDL 0.600 kN/m

Load combinations

Load combination 1

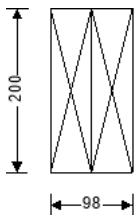
Support A	Dead \times 1.40
	Imposed \times 1.60
Span 1	Dead \times 1.40
	Imposed \times 1.60
Support B	Dead \times 1.40

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Load combination 2	Support A	Imposed × 1.60 Dead × 1.00
	Span 1	Imposed × 1.00 Dead × 1.00
	Support B	Imposed × 1.00 Dead × 1.00

Analysis results

Maximum moment	$M_{max} = 6.296$ kNm	$M_{min} = 0.000$ kNm
Design moment	$M = \max(\text{abs}(M_{max}), \text{abs}(M_{min})) = 6.296$ kNm	
Maximum shear	$F_{max} = 10.949$ kN	$F_{min} = -10.949$ kN
Design shear	$F = \max(\text{abs}(F_{max}), \text{abs}(F_{min})) = 10.949$ kN	
Total load on beam	$W_{tot} = 21.898$ kN	
Reactions at support A	$R_{A_{max}} = 10.949$ kN	$R_{A_{min}} = 7.821$ kN
Unfactored dead load reaction at support A	$R_{A_{Dead}} = 7.821$ kN	
Reactions at support B	$R_{B_{max}} = 10.949$ kN	$R_{B_{min}} = 7.821$ kN
Unfactored dead load reaction at support B	$R_{B_{Dead}} = 7.821$ kN	



Timber section details

Breadth of sections	$b = 49$ mm
Depth of sections	$h = 200$ mm
Number of sections in member	$N = 2$
Overall breadth of member	$b_b = N \times b = 98$ mm
Timber strength class	C24

Member details

Service class of timber	1
Load duration	Long term
Length of span	$L_{s1} = 2300$ mm
Length of bearing	$L_b = 100$ mm

Section properties

Cross sectional area of member	$A = N \times b \times h = 19600$ mm ²
Section modulus	$Z_x = N \times b \times h^2 / 6 = 653333$ mm ³
	$Z_y = h \times (N \times b)^2 / 6 = 320133$ mm ³
Second moment of area	$I_x = N \times b \times h^3 / 12 = 65333333$ mm ⁴
	$I_y = h \times (N \times b)^3 / 12 = 15686533$ mm ⁴
Radius of gyration	$i_x = \sqrt{I_x / A} = 57.7$ mm
	$i_y = \sqrt{I_y / A} = 28.3$ mm

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Modification factors

Duration of loading - Table 17	$K_3 = 1.00$
Bearing stress - Table 18	$K_4 = 1.00$
Total depth of member - cl.2.10.6	$K_7 = (300 \text{ mm} / h)^{0.11} = 1.05$
Load sharing - cl.2.9	$K_8 = 1.00$

Lateral support - cl.2.10.8

No lateral support	
Permissible depth-to-breadth ratio - Table 19	2.00
Actual depth-to-breadth ratio	$h / (N \times b) = 2.04$

FAIL - Lateral support is inadequate

Compression perpendicular to grain

Permissible bearing stress (no wane)	$\sigma_{c_adm} = \sigma_{cp1} \times K_3 \times K_4 \times K_8 = 2.400 \text{ N/mm}^2$
Applied bearing stress	$\sigma_{c_a} = R_{A_max} / (N \times b \times L_b) = 1.117 \text{ N/mm}^2$
	$\sigma_{c_a} / \sigma_{c_adm} = 0.466$

PASS - Applied compressive stress is less than permissible compressive stress at bearing

Bending parallel to grain

Permissible bending stress	$\sigma_{m_adm} = \sigma_m \times K_3 \times K_7 \times K_8 = 7.842 \text{ N/mm}^2$
Applied bending stress	$\sigma_{m_a} = M / Z_x = 9.636 \text{ N/mm}^2$
	$\sigma_{m_a} / \sigma_{m_adm} = 1.229$

FAIL - Applied bending stress exceeds permissible bending stress

Shear parallel to grain

Permissible shear stress	$\tau_{adm} = \tau \times K_3 \times K_8 = 0.710 \text{ N/mm}^2$
Applied shear stress	$\tau_a = 3 \times F / (2 \times A) = 0.838 \text{ N/mm}^2$
	$\tau_a / \tau_{adm} = 1.180$

FAIL - Applied shear stress exceeds permissible shear stress

Deflection

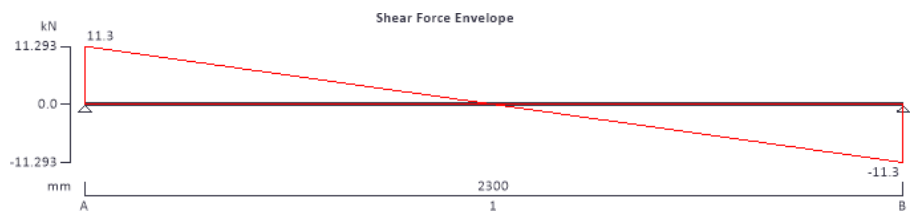
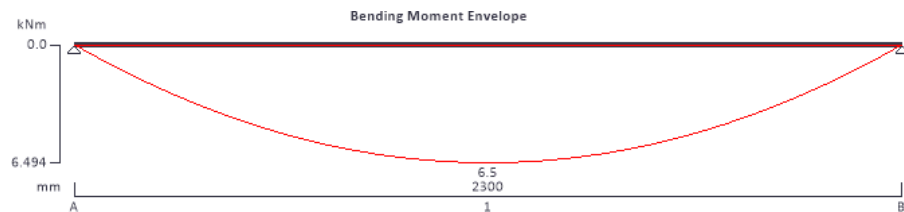
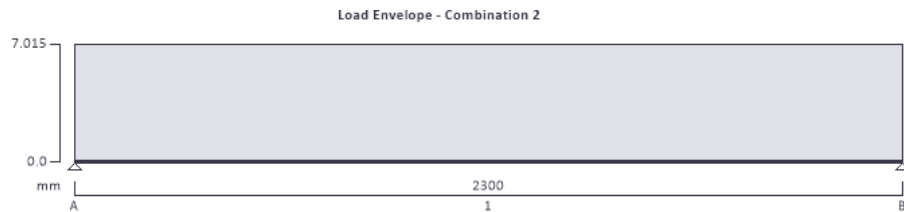
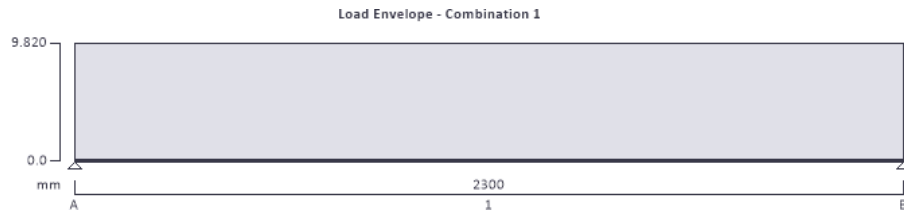
Modulus of elasticity for deflection	$E = E_{min} = 7200 \text{ N/mm}^2$
Permissible deflection	$\delta_{adm} = \min(0.551 \text{ in}, 0.003 \times L_{s1}) = 6.900 \text{ mm}$
Bending deflection	$\delta_{b_s1} = 5.268 \text{ mm}$
Shear deflection	$\delta_{v_s1} = 0.612 \text{ mm}$
Total deflection	$\delta_a = \delta_{b_s1} + \delta_{v_s1} = 5.880 \text{ mm}$
	$\delta_a / \delta_{adm} = 0.852$

PASS - Total deflection is less than permissible deflection

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STEEL BEAM ANALYSIS & DESIGN (BS5950)

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



Support conditions

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

Applied loading

Beam loads	Beam - Dead self weight of beam × 1
	Dead Load - Dead full UDL 6.12 kN/m
	Live Load - Dead full UDL 0.6 kN/m

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Load combinations

Load combination 1 - ULS	Support A	Dead × 1.40
		Imposed × 1.60
	Support B	Dead × 1.40
		Imposed × 1.60
Load combination 2 - SLS	Support A	Dead × 1.00
		Imposed × 1.00
	Support B	Dead × 1.00
		Imposed × 1.00

Analysis results

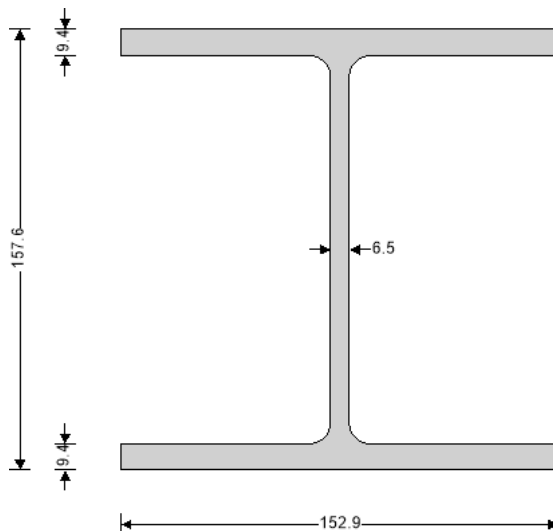
Maximum moment	$M_{max} = 6.5 \text{ kNm}$	$M_{min} = 0 \text{ kNm}$
Maximum shear	$V_{max} = 11.3 \text{ kN}$	$V_{min} = -11.3 \text{ kN}$
Deflection	$\delta_{max} = 0 \text{ mm}$	$\delta_{min} = 0 \text{ mm}$
Maximum reaction at support A	$R_{A_max} = 11.3 \text{ kN}$	$R_{A_min} = 8.1 \text{ kN}$
Unfactored dead load reaction at support A	$R_{A_Dead} = 8.1 \text{ kN}$	
Maximum reaction at support B	$R_{B_max} = 11.3 \text{ kN}$	$R_{B_min} = 8.1 \text{ kN}$
Unfactored dead load reaction at support B	$R_{B_Dead} = 8.1 \text{ kN}$	

Section details

Section type **UC 152x152x30 (BS4-1)**
 Steel grade **S275**

From table 9: Design strength p_y

Thickness of element $\max(T, t) = 9.4 \text{ mm}$
 Design strength $p_y = 275 \text{ N/mm}^2$
 Modulus of elasticity $E = 205000 \text{ N/mm}^2$



Lateral restraint

Span 1 has full lateral restraint

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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 $K_{L.T.A} = 1.00$
 $K_{L.T.B} = 1.00$

Classification of cross sections - Section 3.5

$$\varepsilon = \sqrt{[275 \text{ N/mm}^2 / p_y]} = 1.00$$

Internal compression parts - Table 11

Depth of section $d = 123.6 \text{ mm}$
 $d / t = 19.0 \times \varepsilon \leq 80 \times \varepsilon$ Class 1 plastic

Outstand flanges - Table 11

Width of section $b = B / 2 = 76.5 \text{ mm}$
 $b / T = 8.1 \times \varepsilon \leq 9 \times \varepsilon$ Class 1 plastic
Section is class 1 plastic

Shear capacity - Section 4.2.3

Design shear force $F_v = \max(\text{abs}(V_{\max}), \text{abs}(V_{\min})) = 11.3 \text{ kN}$
 $d / t < 70 \times \varepsilon$
Web does not need to be checked for shear buckling

Shear area $A_v = t \times D = 1024 \text{ mm}^2$
 Design shear resistance $P_v = 0.6 \times p_y \times A_v = 169 \text{ kN}$

PASS - Design shear resistance exceeds design shear force

Moment capacity - Section 4.2.5

Design bending moment $M = \max(\text{abs}(M_{s1_{\max}}), \text{abs}(M_{s1_{\min}})) = 6.5 \text{ kNm}$
 Moment capacity low shear - cl.4.2.5.2 $M_c = \min(p_y \times S_{xx}, 1.2 \times p_y \times Z_{xx}) = 68.1 \text{ kNm}$
PASS - Moment capacity exceeds design bending moment

Check vertical deflection - Section 2.5.2

Consider deflection due to imposed loads
 Limiting deflection $\delta_{\text{lim}} = L_{s1} / 360 = 6.389 \text{ mm}$
 Maximum deflection span 1 $\delta = \max(\text{abs}(\delta_{\max}), \text{abs}(\delta_{\min})) = 0 \text{ mm}$

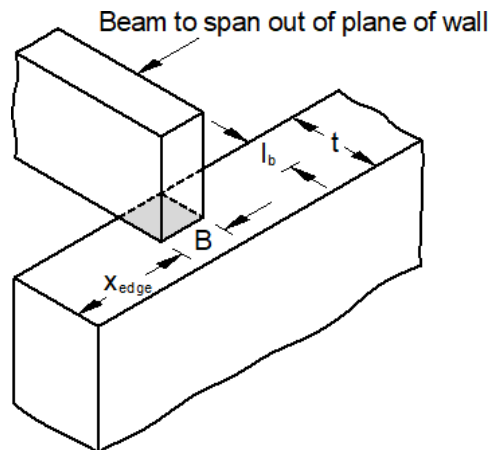
PASS - Maximum deflection does not exceed deflection limit

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MASONRY BEARING DESIGN TO BS5628-1:2005

Masonry details

Masonry type	Aggregate concrete blocks (25% or less formed voids)
Compressive strength of unit	$p_{unit} = 20.0 \text{ N/mm}^2$
Mortar designation	iii
Least horizontal dimension of masonry units	$l_{unit} = 100 \text{ mm}$
Height of masonry units	$h_{unit} = 215 \text{ mm}$
Category of masonry units	Category II
Category of construction control	Normal
Partial safety factor for material strength	$\gamma_m = 3.5$
Thickness of load bearing leaf	$t = 100 \text{ mm}$
Effective thickness of masonry wall	$t_{ef} = 100 \text{ mm}$
Height of masonry wall	$h = 2400 \text{ mm}$
Effective height of masonry wall	$h_{ef} = 2400 \text{ mm}$



Bearing details

Beam spanning out of plane of wall	
Width of bearing	$B = 100 \text{ mm}$
Length of bearing	$l_b = 100 \text{ mm}$
Edge distance	$x_{edge} = 100 \text{ mm}$

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

Mortar designation	Mortar = "iii"
Block compressive strength	$p_{unit} = 20.0 \text{ N/mm}^2$
Characteristic compressive strength (Table 2c)	$f_{kc} = 5.55 \text{ N/mm}^2$
Characteristic compressive strength (Table 2d)	$f_{kd} = 11.05 \text{ N/mm}^2$
Height of solid block	$h_{unit} = 215.0 \text{ mm}$
Least horizontal dimension	$l_{unit} = 100.0 \text{ mm}$

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Block ratio $\text{ratio} = h_{\text{unit}} / l_{\text{unit}} = \mathbf{2.2}$ **Ratio between 0.6 and 4.5 - OK**

Characteristic compressive strength $f_k = \mathbf{11.05}$ N/mm²

Loading details

Characteristic concentrated dead load $G_k = \mathbf{11}$ kN

Characteristic concentrated imposed load $Q_k = \mathbf{0}$ kN

Design concentrated load $F = (G_k \times 1.4) + (Q_k \times 1.6) = \mathbf{15.8}$ kN

Characteristic distributed dead load $g_k = \mathbf{0.0}$ kN/m

Characteristic distributed imposed load $q_k = \mathbf{0.0}$ kN/m

Design distributed load $f = (g_k \times 1.4) + (q_k \times 1.6) = \mathbf{0.0}$ kN/m

Masonry bearing type

Bearing type **Type 2**

Bearing safety factor $\gamma_{\text{bear}} = \mathbf{1.50}$

Check design bearing without a spreader

Design bearing stress $f_{ca} = F / (B \times l_b) + f / t = \mathbf{1.582}$ N/mm²

Allowable bearing stress $f_{cp} = \gamma_{\text{bear}} \times f_k / \gamma_m = \mathbf{4.736}$ N/mm²

PASS - Allowable bearing stress exceeds design bearing stress

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

Slenderness ratio $h_{\text{ef}} / t_{\text{ef}} = \mathbf{24.00}$

Eccentricity at top of wall $e_x = \mathbf{0.0}$ mm

From BS5628:1 Table 7

Capacity reduction factor $\beta = \mathbf{0.61}$

Length of bearing distributed at $0.4 \times h$ $l_d = \mathbf{1160}$ mm

Maximum bearing stress $f_{ca} = F / (l_d \times t) + f / t = \mathbf{0.136}$ N/mm²

Allowable bearing stress $f_{cp} = \beta \times f_k / \gamma_m = \mathbf{1.910}$ N/mm²

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