Alpine Surveys
Independent Property Survey Specialists

Sample Report

No image available

Structural Calculations

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

Structural Engineer

E Duka

Alpine Surveys Ltd

Riverside House, 47 The Lynch, Uxbridge, Middlesex, UB8 2TQ

TEL: 0845 319 9 319 or 0330 333 9238

www.alpinesurveys.co.uk

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/m2
Single Brick wall	2.1 KN/m2 (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	$= \mathbf{6.12}\ \frac{\boldsymbol{KN}}{\boldsymbol{m}}$

Imposed Loads

Domestic

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

Total Imposed Loads	$= \mathbf{0.6}\ \frac{\boldsymbol{KN}}{\boldsymbol{m}}$

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

Alpine Surveys	Project: Another Client, Another Address, Another Postcode				Job no.: 1	
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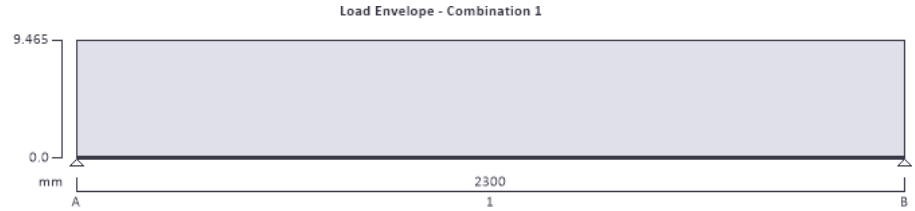
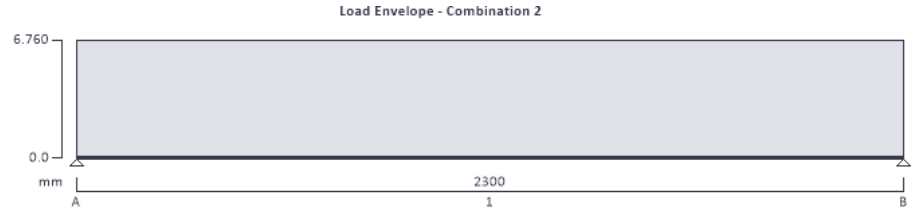
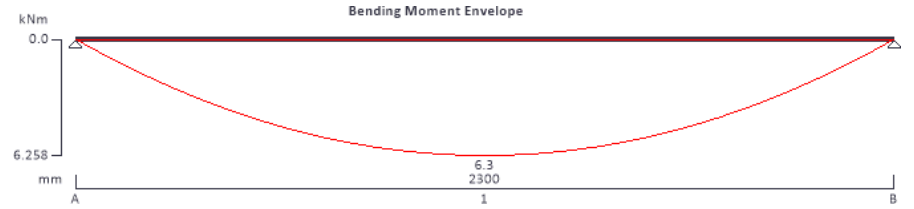
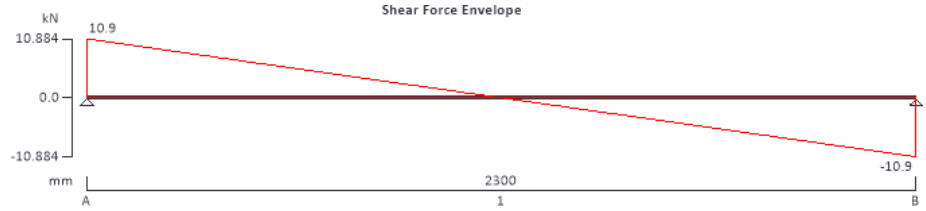
TIMBER BEAM ANALYSIS & DESIGN TO BS5268-2:2002









Applied loading

Beam loads

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

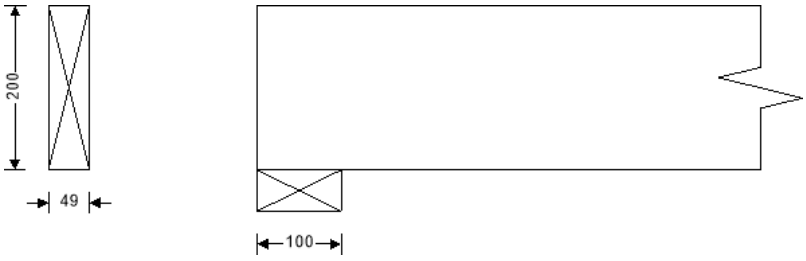
Load combinations

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

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

Analysis results

Maximum moment	M_{max} = **6.258** kNm	M_{min} = **0.000** kNm
Design moment	M = max(abs(M_{max}),abs(M_{min})) = **6.258** kNm	
Maximum shear	F_{max} = **10.884** kN	F_{min} = **-10.884** kN
Design shear	F = max(abs(F_{max}),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 × 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 × b × h = **9800** mm^2
Section modulus	Z_x = N × b × h^2 / 6 = **326667** mm^3
	Z_y = h × (N × b)^2 / 6 = **80033** mm^3
Second moment of area	I_x = N × b × h^3 / 12 = **32666667** mm^4
	I_y = h × (N × b)^3 / 12 = **1960817** mm^4
Radius of gyration	i_x = √(I_x / A) = **57.7** mm
	i_y = √(I_y / A) = **14.1** mm

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	$K_7 = (300\ mm / h)^{0.11}$ = **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** N/mm²
Applied bearing stress	$\sigma_{c\_a} = R_{A\_max} / (N \times b \times L_b)$ = **2.221** N/mm²
	$\sigma_{c\_a} / \sigma_{c\_adm}$ = **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** N/mm²
Applied bending stress	$\sigma_{m\_a} = M / Z_x$ = **19.158** N/mm²
	$\sigma_{m\_a} / \sigma_{m\_adm}$ = **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** N/mm²
Applied shear stress	$\tau_a = 3 \times F / (2 \times A)$ = **1.666** N/mm²
	τ_a / τ_{adm} = **2.346**

FAIL - Applied shear stress exceeds permissible shear stress

Deflection

Modulus of elasticity for deflection	$E = E_{min}$ = **7200** N/mm²
Permissible deflection	$\delta_{adm} = \min(0.551\ in, 0.003 \times L_{s1})$ = **6.900** mm
Bending deflection	δ_{b_s1} = **10.473** mm
Shear deflection	δ_{v_s1} = **1.216** mm
Total deflection	$\delta_a = \delta_{b\_s1} + \delta_{v\_s1}$ = **11.690** mm
	δ_a / δ_{adm} = **1.694**

FAIL - Total deflection exceeds permissible deflection

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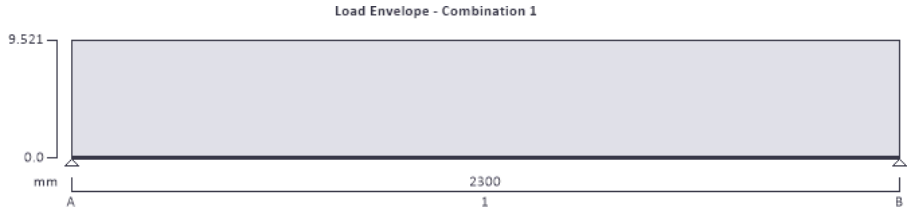
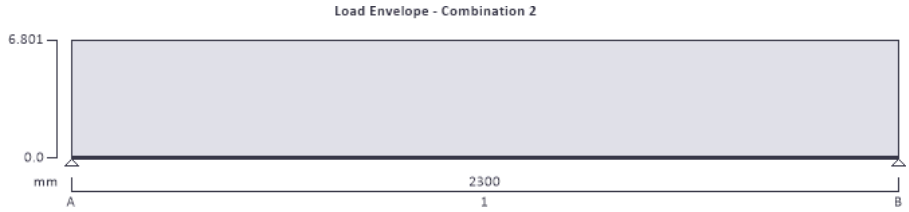
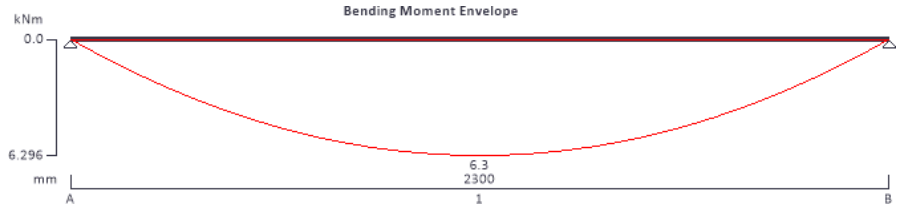
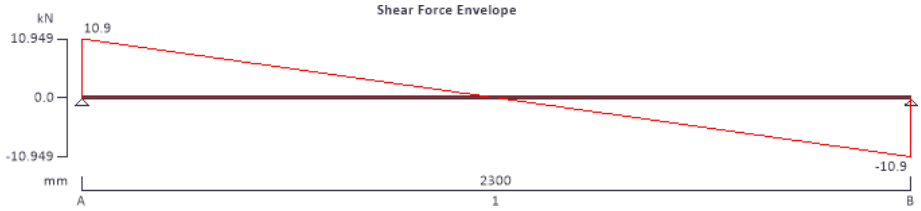
TIMBER BEAM ANALYSIS & DESIGN TO BS5268-2:2002









Applied loading

Beam loads

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

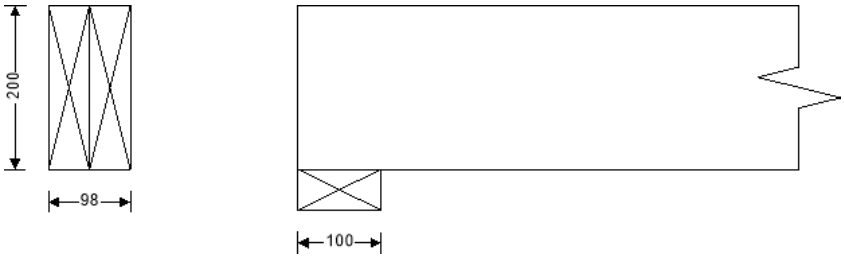
Load combinations

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

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

Analysis results

Maximum moment	M_{max} = **6.296** kNm	M_{min} = **0.000** kNm
Design moment	M = max(abs(M_{max}),abs(M_{min})) = **6.296** kNm	
Maximum shear	F_{max} = **10.949** kN	F_{min} = **-10.949** kN
Design shear	F = max(abs(F_{max}),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 × 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 × b × h = **19600** mm^2
Section modulus	Z_x = N × b × h^2 / 6 = **653333** mm^3
	Z_y = h × (N × b)^2 / 6 = **320133** mm^3
Second moment of area	I_x = N × b × h^3 / 12 = **65333333** mm^4
	I_y = h × (N × b)^3 / 12 = **15686533** mm^4
Radius of gyration	i_x = √(I_x / A) = **57.7** mm
	i_y = √(I_y / A) = **28.3** mm

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	$K_7 = (300\ mm / h)^{0.11}$ = **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** N/mm²
Applied bearing stress	$\sigma_{c\_a} = R_{A\_max} / (N \times b \times L_b)$ = **1.117** N/mm²
	$\sigma_{c\_a} / \sigma_{c\_adm}$ = **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** N/mm²
Applied bending stress	$\sigma_{m\_a} = M / Z_x$ = **9.636** N/mm²
	$\sigma_{m\_a} / \sigma_{m\_adm}$ = **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** N/mm²
Applied shear stress	$\tau_a = 3 \times F / (2 \times A)$ = **0.838** N/mm²
	τ_a / τ_{adm} = **1.180**

FAIL - Applied shear stress exceeds permissible shear stress

Deflection

Modulus of elasticity for deflection	$E = E_{min}$ = **7200** N/mm²
Permissible deflection	$\delta_{adm} = \min(0.551\ in, 0.003 \times L_{s1})$ = **6.900** mm
Bending deflection	δ_{b_s1} = **5.268** mm
Shear deflection	δ_{v_s1} = **0.612** mm
Total deflection	$\delta_a = \delta_{b\_s1} + \delta_{v\_s1}$ = **5.880** mm
	δ_a / δ_{adm} = **0.852**

PASS - Total deflection is less than permissible deflection

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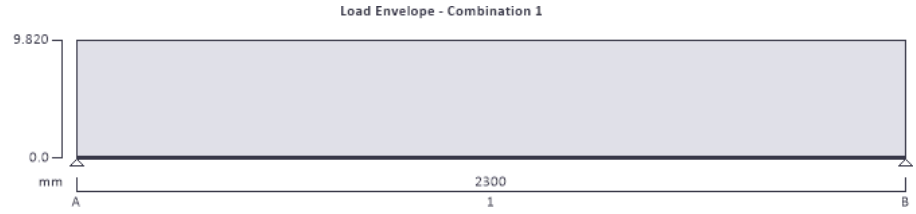
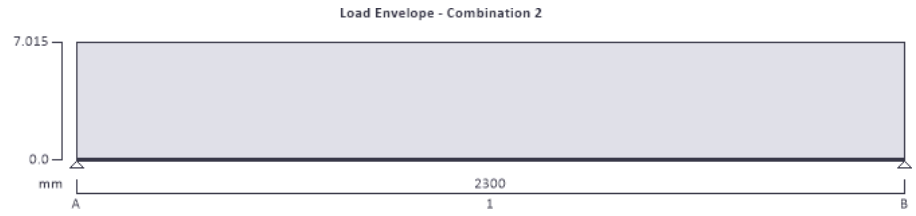
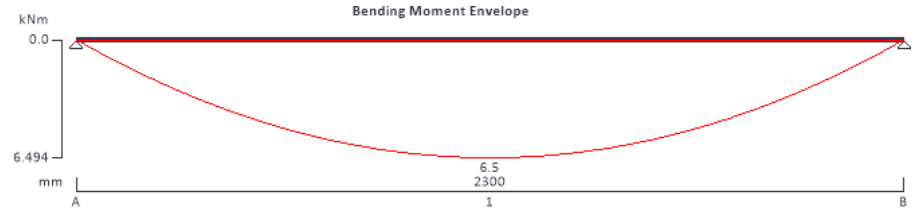
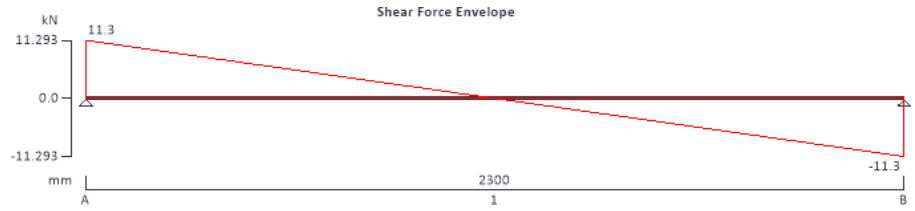
STEEL BEAM ANALYSIS & DESIGN (BS5950)

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

Load combinations

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

Analysis results

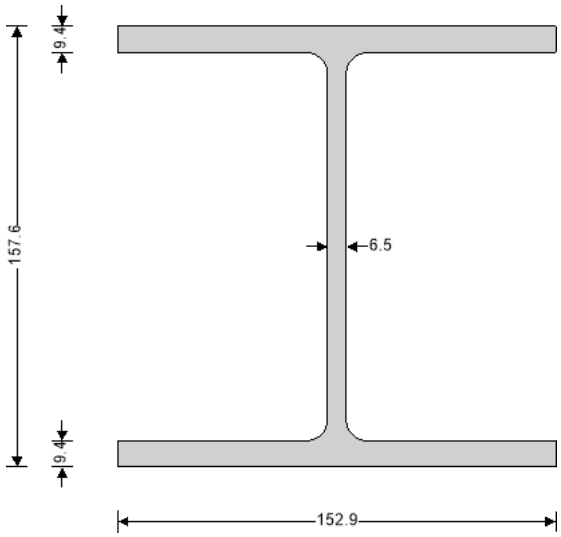
Maximum moment	M_{max} = **6.5** kNm	M_{min} = **0** kNm
Maximum shear	V_{max} = **11.3** kN	V_{min} = **-11.3** kN
Deflection	δ_{max} = **0** mm	δ_{min} = **0** mm
Maximum reaction at support A	R_{A_max} = **11.3** kN	R_{A_min} = **8.1** kN
Unfactored dead load reaction at support A	R_{A_Dead} = **8.1** kN	
Maximum reaction at support B	R_{B_max} = **11.3** kN	R_{B_min} = **8.1** kN
Unfactored dead load reaction at support B	R_{B_Dead} = **8.1** 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** mm
Design strength	p_y = **275** N/mm²
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	$K_{LT.A}$ = **1.00**
	$K_{LT.B}$ = **1.00**

Classification of cross sections - Section 3.5

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

Internal compression parts - Table 11

Depth of section: d = **123.6** mm

$d / t = 19.0 \times \varepsilon <= 80 \times \varepsilon$ Class 1 plastic

Outstand flanges - Table 11

Width of section: b = B / 2 = **76.5** mm

$b / T = 8.1 \times \varepsilon <= 9 \times \varepsilon$ Class 1 plastic

Section is class 1 plastic

Shear capacity - Section 4.2.3

Design shear force: $F_v = max(abs(V_{max}), abs(V_{min}))$ = **11.3** kN

$d / t < 70 \times \varepsilon$

Web does not need to be checked for shear buckling

Shear area: $A_v = t \times D$ = **1024** mm^2

Design shear resistance: $P_v = 0.6 \times p_y \times A_v$ = **169** kN

PASS - Design shear resistance exceeds design shear force

Moment capacity - Section 4.2.5

Design bending moment: $M = max(abs(M_{s1\_max}), abs(M_{s1\_min}))$ = **6.5** 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** kNm

PASS - Moment capacity exceeds design bending moment

Check vertical deflection - Section 2.5.2

Consider deflection due to imposed loads

Limiting deflection: $\delta_{lim} = L_{s1} / 360$ = **6.389** mm

Maximum deflection span 1: $\delta = max(abs(\delta_{max}), abs(\delta_{min}))$ = **0** mm

PASS - Maximum deflection does not exceed deflection limit

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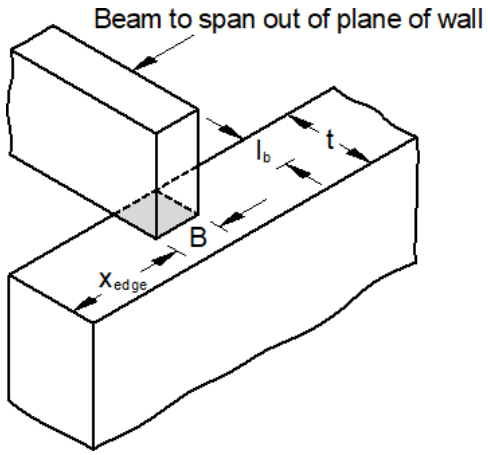
MASONRY BEARING DESIGN TO BS5628-1:2005

Masonry details

Masonry type	**Aggregate concrete blocks (25% or less formed voids)**
Compressive strength of unit	p_{unit} = **20.0** N/mm²
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/mm²
Characteristic compressive strength (Table 2c)	f_{kc} = **5.55** N/mm²
Characteristic compressive strength (Table 2d)	f_{kd} = **11.05** N/mm²
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 = **11** kN
Characteristic concentrated imposed load	Q_k = **0** kN
Design concentrated load	F = (G_k × 1.4) + (Q_k × 1.6) = **15.8** 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 × 1.4) + (q_k × 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 × l_b) + f / t = **1.582** N/mm^2
Allowable bearing stress	f_{cp} = γ_{bear} × f_k / γ_m = **4.736** N/mm^2
	PASS - Allowable bearing stress exceeds design bearing stress

Check design bearing at 0.4 × 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 × h	l_d = **1160** mm
Maximum bearing stress	f_{ca} = F / (l_d × t) + f / t = **0.136** N/mm^2
Allowable bearing stress	f_{cp} = β × f_k / γ_m = **1.910** N/mm^2
	PASS - Allowable bearing stress at 0.4 ×h below bearing level exceeds design bearing stress