



AXIOM
Structural Design Ltd

STRUCTURAL DESIGN CALCULATIONS

Project: **EXTENSION AT 141 HEOLGERRIG ROAD, MERTHYR TYDFIL**
Job reference: **AX427**
Date: **June 2022**

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*The Institution
of Structural
Engineers*



BUILDING LOADS FOR DESIGN CALCULATIONS

 Contract No.: **AX427**

Date: June 2022

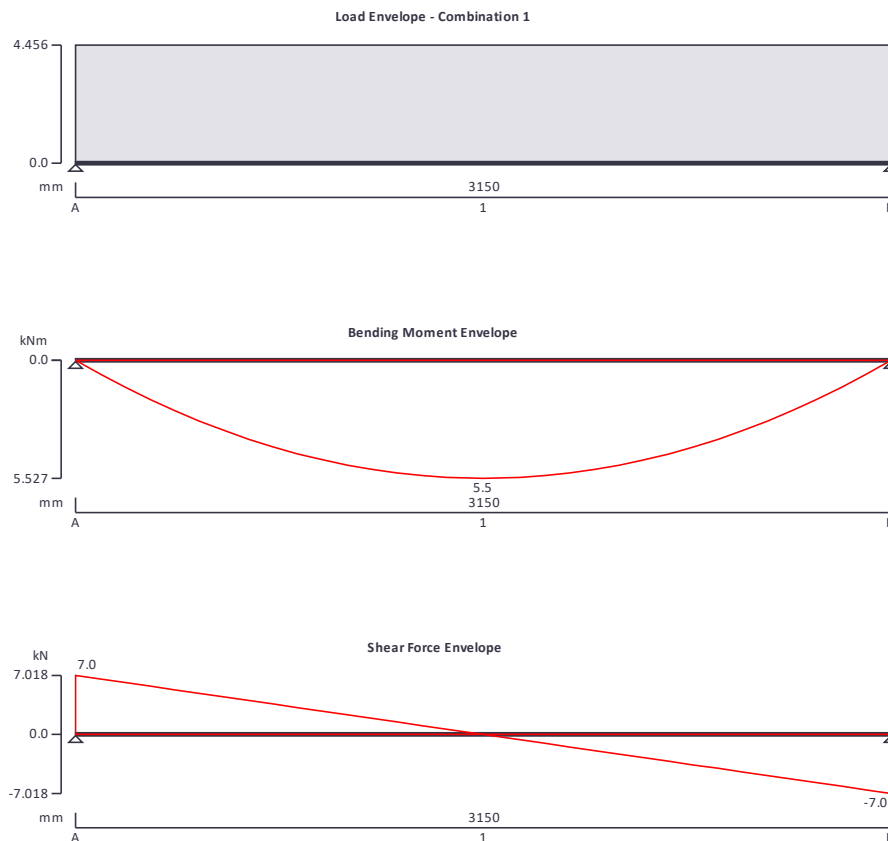
Project: 141 Heolgerrig

<u>Dead Loads:</u> -		kN/m ²
<u>Roof:</u>	Single ply membrane	0.10
	Joists & 18mm deck	0.40
	Ins felt	0.05
	<u>Plasterboard & skim</u>	<u>0.15</u>
	Total	0.70 kN/m ²
<u>First Floor:</u>	Joists & decking	0.40
	<u>Plasterboard & skim</u>	<u>0.20</u>
	Total	0.60 kN/m ²
<u>Imposed Loads:</u> -		
<u>Roof:</u>	Snow (pitch)	0.75 kN/m ²
<u>First Floor:</u>	Residential	1.50 kN/m ²

Imposed loads are in accordance with BS 6399: Part 1: 1996 - Code of practice for dead and Imposed loads and BS 6399: Part 3: 1988 - Code of practice for imposed roof loads.

TIMBER BEAM ANALYSIS & DESIGN TO BS5268-2:2002

TEDDS calculation version 1.7.02



Applied loading

Beam loads

3m roof

3m snow

Dead self weight of beam * 1

Dead full UDL 2.100 kN/m

Imposed full UDL 2.250 kN/m

Load combinations

Load combination 1

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

 $M_{\max} = 5.527 \text{ kNm}$
 $M_{\min} = 0.000 \text{ kNm}$

Design moment

 $M = \max(\text{abs}(M_{\max}), \text{abs}(M_{\min})) = 5.527 \text{ kNm}$

Maximum shear

 $F_{\max} = 7.018 \text{ kN}$
 $F_{\min} = -7.018 \text{ kN}$

Design shear

 $F = \max(\text{abs}(F_{\max}), \text{abs}(F_{\min})) = 7.018 \text{ kN}$

Total load on beam

 $W_{\text{tot}} = 14.036 \text{ kN}$

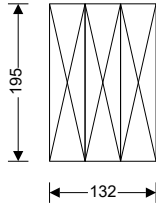
Reactions at support A

 $R_{A_{\max}} = 7.018 \text{ kN}$
 $R_{A_{\min}} = 7.018 \text{ kN}$

 AXIOM Structural Design Ltd info@axiomsdl.co.uk	Project 141 Heolgerrig				Job no. AX427	
	Calcs for Timber Roof Beam				Start page no./Revision 3	
	Calcs by LB	Calcs date 30/05/2022	Checked by LB	Checked date 18/06/2022	Approved by	Approved date

Unfactored dead load reaction at support A
Unfactored imposed load reaction at support A
Reactions at support B
Unfactored dead load reaction at support B
Unfactored imposed load reaction at support B

$R_{A_Dead} = 3.474 \text{ kN}$
 $R_{A_Imposed} = 3.544 \text{ kN}$
 $R_{B_max} = 7.018 \text{ kN}$
 $R_{B_Dead} = 3.474 \text{ kN}$
 $R_{B_Imposed} = 3.544 \text{ kN}$
 $R_{B_min} = 7.018 \text{ kN}$



Timber section details

Breadth of sections $b = 44 \text{ mm}$
Depth of sections $h = 195 \text{ mm}$
Number of sections in member $N = 3$
Overall breadth of member $b_b = N \times b = 132 \text{ mm}$
Timber strength class **C24**

Member details

Service class of timber **1**
Load duration **Long term**
Length of span $L_{s1} = 3150 \text{ mm}$
Length of bearing $L_b = 50 \text{ mm}$

Section properties

Cross sectional area of member $A = N \times b \times h = 25740 \text{ mm}^2$
Section modulus $Z_x = N \times b \times h^2 / 6 = 836550 \text{ mm}^3$
 $Z_y = h \times (N \times b)^2 / 6 = 566280 \text{ mm}^3$
Second moment of area $I_x = N \times b \times h^3 / 12 = 81563625 \text{ mm}^4$
 $I_y = h \times (N \times b)^3 / 12 = 37374480 \text{ mm}^4$
Radius of gyration $i_x = \sqrt{I_x / A} = 56.3 \text{ mm}$
 $i_y = \sqrt{I_y / A} = 38.1 \text{ mm}$

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 $K_7 = (300 \text{ mm} / h)^{0.11} = 1.05$
Load sharing - cl.2.10.11 $K_8 = 1.10$
Minimum modulus of elasticity - Table 20 $K_9 = 1.21$

Lateral support - cl.2.10.8

Ends held in position
Permissible depth-to-breadth ratio - Table 19 **3.00**
Actual depth-to-breadth ratio $h / (N \times b) = 1.48$

PASS - Lateral support is adequate

Compression perpendicular to grain

Permissible bearing stress (no wane) $\sigma_{c_adm} = \sigma_{cp1} * K_3 * K_4 * K_8 = 2.640 \text{ N/mm}^2$

 AXIOM Structural Design Ltd info@axiomsdl.co.uk	Project 141 Heolgerrig				Job no. AX427	
	Calcs for Timber Roof Beam				Start page no./Revision 4	
	Calcs by LB	Calcs date 30/05/2022	Checked by LB	Checked date 18/06/2022	Approved by	Approved date

Applied bearing stress

$$\sigma_{c_a} = R_{A_{max}} / (N * b * L_b) = 1.063 \text{ N/mm}^2$$

$$\sigma_{c_a} / \sigma_{c_{adm}} = 0.403$$

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

Bending parallel to grain

Permissible bending stress

$$\sigma_{m_{adm}} = \sigma_m * K_3 * K_7 * K_8 = 8.650 \text{ N/mm}^2$$

Applied bending stress

$$\sigma_{m_a} = M / Z_x = 6.607 \text{ N/mm}^2$$

$$\sigma_{m_a} / \sigma_{m_{adm}} = 0.764$$

PASS - Applied bending stress is less than permissible bending stress

Shear parallel to grain

Permissible shear stress

$$\tau_{adm} = \tau * K_3 * K_8 = 0.781 \text{ N/mm}^2$$

Applied shear stress

$$\tau_a = 3 * F / (2 * A) = 0.409 \text{ N/mm}^2$$

$$\tau_a / \tau_{adm} = 0.524$$

PASS - Applied shear stress is less than permissible shear stress

Deflection

Modulus of elasticity for deflection

$$E = E_{min} * K_9 = 8712 \text{ N/mm}^2$$

Permissible deflection

$$\delta_{adm} = \min(0.551 \text{ in}, 0.003 * L_{s1}) = 9.450 \text{ mm}$$

Bending deflection

$$\delta_{b_{s1}} = 8.039 \text{ mm}$$

Shear deflection

$$\delta_{v_{s1}} = 0.473 \text{ mm}$$

Total deflection

$$\delta_a = \delta_{b_{s1}} + \delta_{v_{s1}} = 8.512 \text{ mm}$$

$$\delta_a / \delta_{adm} = 0.901$$

PASS - Total deflection is less than permissible deflection

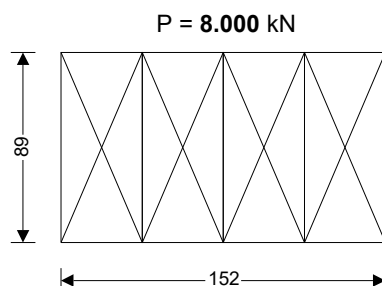
 AXIOM Structural Design Ltd info@axiomsdl.co.uk	Project 141 Heolgerrig				Job no. AX427	
	Calcs for Cripple Studs Supporting Roof Beam				Start page no./Revision 5	
	Calcs by LB	Calcs date 30/05/2022	Checked by LB	Checked date 18/06/2022	Approved by	Approved date

TIMBER MEMBER DESIGN TO BS5268-2:2002

TEDDS calculation version 1.7.02

Analysis results

Design axial compression



Timber section details

Breadth of sections

b = 38 mm

Depth of sections

h = 89 mm

Number of sections in member

N = 4

Overall breadth of member

b_b = N × b = 152 mm

Timber strength class

C16

Member details

Service class of timber

1

Load duration

Medium term

Effective length - cl.2.11.3

Unbraced length in x-axis

L_x = 2100 mm

Effective length factor in x-axis - Table 21

K_x = 1

Effective length in x-axis

L_{ex} = L_x × K_x = 2100 mm

Unbraced length in y-axis

L_y = 2100 mm

Effective length factor in y-axis - Table 21

K_y = 1

Effective length in y-axis

L_{ey} = L_y × K_y = 2100 mm

Section properties

Cross sectional area of member

A = N × b × h = 13528 mm²

Section modulus

Z_x = N × b × h² / 6 = 200665 mm³

Z_y = h × (N × b)² / 6 = 342709 mm³

Second moment of area

I_x = N × b × h³ / 12 = 8929607 mm⁴

I_y = h × (N × b)³ / 12 = 26045909 mm⁴

Radius of gyration

i_x = √(I_x / A) = 25.7 mm

i_y = √(I_y / A) = 43.9 mm

Modification factors

Duration of loading - Table 17

K₃ = 1.25

Total depth of member - cl.2.10.6

K₇ = (300 mm / h)^{0.11} = 1.14

Load sharing - cl.2.10.11

K₈ = 1.10

Minimum modulus of elasticity - Table 20

K₉ = 1.24

Members subject to axial compression - Table 22

K₁₂ = 0.50

Slenderness ratio - cl.2.11.4

Permissible slenderness ratio

λ_{max} = 180

Slenderness ratio

λ = max(L_{ex} / i_x, L_{ey} / i_y) = 81.737

 AXIOM Structural Design Ltd info@axiomsdl.co.uk	Project				Job no.	
	141 Heolgerrig				AX427	
	Calcs for				Start page no./Revision	
	Cripple Studs Supporting Roof Beam				6	
	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
	LB	30/05/2022	LB	18/06/2022		

PASS - Slenderness ratio is less than permissible slenderness ratio

Compression parallel to grain

Permissible compressive stress

$$\sigma_{c_adm} = \sigma_c * K_3 * K_8 * K_{12} = \mathbf{4.646 \text{ N/mm}^2}$$

Applied compressive stress

$$\sigma_{c_a} = P / A = \mathbf{0.591 \text{ N/mm}^2}$$

$$\sigma_{c_a} / \sigma_{c_adm} = \mathbf{0.127}$$

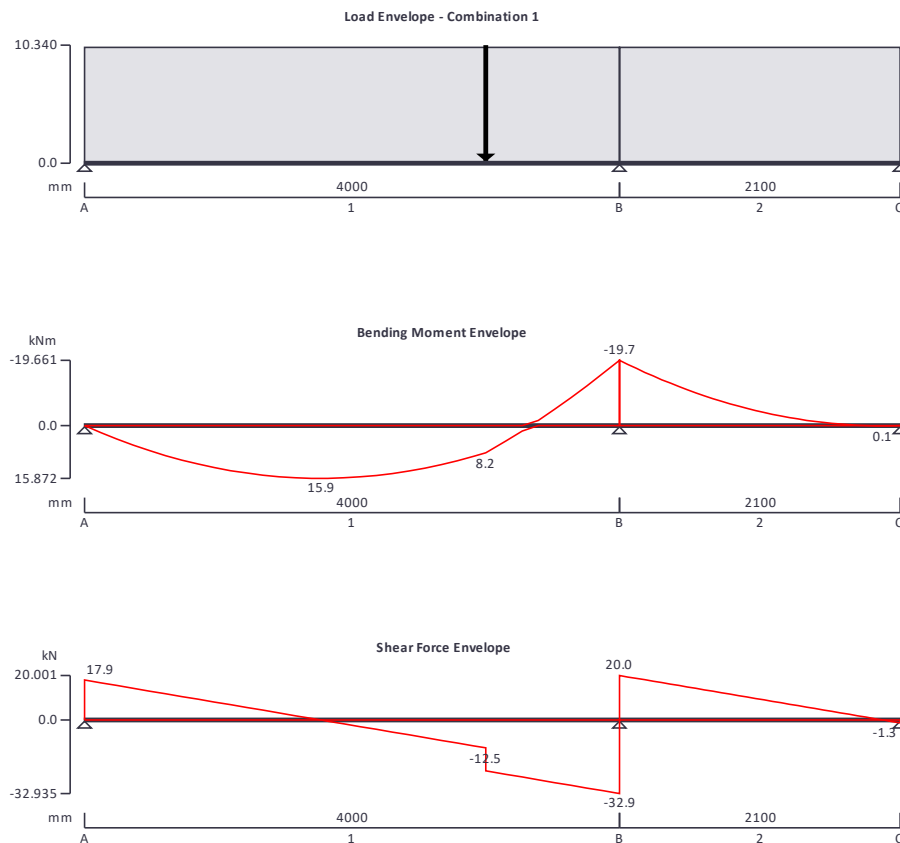
PASS - Applied compressive stress is less than permissible compressive stress

 AXIOM Structural Design Ltd info@axiomsdl.co.uk	Project 141 Heolgerrig				Job no. AX427	
	Calcs for 152x152x30 UC				Start page no./Revision 7	
	Calcs by LB	Calcs date 30/05/2022	Checked by LB	Checked date 18/06/2022	Approved by	Approved date

STEEL BEAM ANALYSIS & DESIGN (BS5950)

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

TEDDS calculation version 3.0.07



Support conditions

Support A

Vertically restrained
Rotationally free

Support B

Vertically restrained
Rotationally free

Support C

Vertically restrained
Rotationally free

Applied loading

Beam loads

Dead self weight of beam * 1
3m floor - Dead full UDL 1.8 kN/m
3m floor - Imposed full UDL 4.5 kN/m
roof beam - Dead point load 3.5 kN at 3000 mm
roof beam - Imposed point load 3.4 kN at 3000 mm

Load combinations

Load combination 1

Support A

Dead * 1.40
Imposed * 1.60
Dead * 1.40
Imposed * 1.60

Support B

Dead * 1.40

Imposed * 1.60

Dead * 1.40

Imposed * 1.60

Support C

Dead * 1.40

Imposed * 1.60

Analysis results

Maximum moment

 $M_{max} = 15.9 \text{ kNm}$
 $M_{min} = -19.7 \text{ kNm}$

Maximum moment span 1

 $M_{s1_max} = 15.9 \text{ kNm}$
 $M_{s1_min} = -19.7 \text{ kNm}$

Maximum moment span 2

 $M_{s2_max} = 0.1 \text{ kNm}$
 $M_{s2_min} = -19.7 \text{ kNm}$

Maximum shear

 $V_{max} = 20 \text{ kN}$
 $V_{min} = -32.9 \text{ kN}$

Maximum shear span 1

 $V_{s1_max} = 17.9 \text{ kN}$
 $V_{s1_min} = -32.9 \text{ kN}$

Maximum shear span 2

 $V_{s2_max} = 20 \text{ kN}$
 $V_{s2_min} = -1.3 \text{ kN}$

Deflection

 $\delta_{max} = 4.3 \text{ mm}$
 $\delta_{min} = 0.6 \text{ mm}$

Deflection span 1

 $\delta_{s1_max} = 4.3 \text{ mm}$
 $\delta_{s1_min} = 0 \text{ mm}$

Deflection span 2

 $\delta_{s2_max} = 0 \text{ mm}$
 $\delta_{s2_min} = 0.6 \text{ mm}$

Maximum reaction at support A

 $R_{A_max} = 17.9 \text{ kN}$
 $R_{A_min} = 17.9 \text{ kN}$

Unfactored dead load reaction at support A

 $R_{A_Dead} = 3.9 \text{ kN}$

Unfactored imposed load reaction at support A

 $R_{A_Imposed} = 7.8 \text{ kN}$

Maximum reaction at support B

 $R_{B_max} = 52.9 \text{ kN}$
 $R_{B_min} = 52.9 \text{ kN}$

Unfactored dead load reaction at support B

 $R_{B_Dead} = 12.4 \text{ kN}$

Unfactored imposed load reaction at support B

 $R_{B_Imposed} = 22.2 \text{ kN}$

Maximum reaction at support C

 $R_{C_max} = 1.3 \text{ kN}$
 $R_{C_min} = 1.3 \text{ kN}$

Unfactored dead load reaction at support C

 $R_{C_Dead} = 0 \text{ kN}$

Unfactored imposed load reaction at support C

 $R_{C_Imposed} = 0.8 \text{ kN}$

Section details

Section type

UC 152x152x30 (BS4-1)

Steel grade

S275
From table 9: Design strength p_y

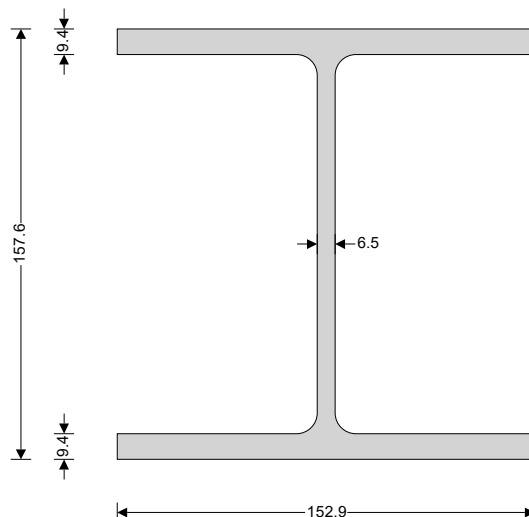
Thickness of element

 $\max(T, t) = 9.4 \text{ mm}$

Design strength

 $p_y = 275 \text{ N/mm}^2$

Modulus of elasticity

 $E = 205000 \text{ N/mm}^2$


 AXIOM Structural Design Ltd info@axiomsdl.co.uk	Project 141 Heolgerrig				Job no. AX427	
	Calcs for 152x152x30 UC				Start page no./Revision 9	
	Calcs by LB	Calcs date 30/05/2022	Checked by LB	Checked date 18/06/2022	Approved by	Approved date

Lateral restraint

Span 1 has full lateral restraint
Span 2 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 $K_{LT,A} = 1.00$
 $K_{LT,B} = 1.00$
 $K_{LT,C} = 1.00$

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 $d = 123.6 \text{ mm}$
 $d / t = 19.0 * \varepsilon \leq 80 * \varepsilon$ Class 1 plastic

Outstand flanges - Table 11

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

Shear capacity - Section 4.2.3

Design shear force $F_v = \max(\text{abs}(V_{\max}), \text{abs}(V_{\min})) = 32.9 \text{ kN}$
 $d / t < 70 * \varepsilon$
Web does not need to be checked for shear buckling
Shear area $A_v = t * D = 1024 \text{ mm}^2$
Design shear resistance $P_v = 0.6 * p_y * A_v = 169 \text{ kN}$
PASS - Design shear resistance exceeds design shear force

Moment capacity at span 1 - Section 4.2.5

Design bending moment $M = \max(\text{abs}(M_{s1_max}), \text{abs}(M_{s1_min})) = 19.7 \text{ kNm}$
Moment capacity low shear - cl.4.2.5.2 $M_c = \min(p_y * S_{xx}, 1.5 * p_y * Z_{xx}) = 68.1 \text{ kNm}$
PASS - Moment capacity exceeds design bending moment

Check vertical deflection - Section 2.5.2

Consider deflection due to dead and imposed loads
Limiting deflection $\delta_{lim} = L_{s1} / 360 = 11.111 \text{ mm}$
Maximum deflection span 1 $\delta = \max(\text{abs}(\delta_{\max}), \text{abs}(\delta_{\min})) = 4.331 \text{ mm}$
PASS - Maximum deflection does not exceed deflection limit

MASONRY BEARING DESIGN TO BS5628-1:2005

TEDDS calculation version 1.0.07

Masonry details

Masonry type

Compressive strength of unit

Mortar designation

Least horizontal dimension of masonry units

Height of masonry units

Category of masonry units

Category of construction control

Partial safety factor for material strength

Thickness of load bearing leaf

Effective thickness of masonry wall

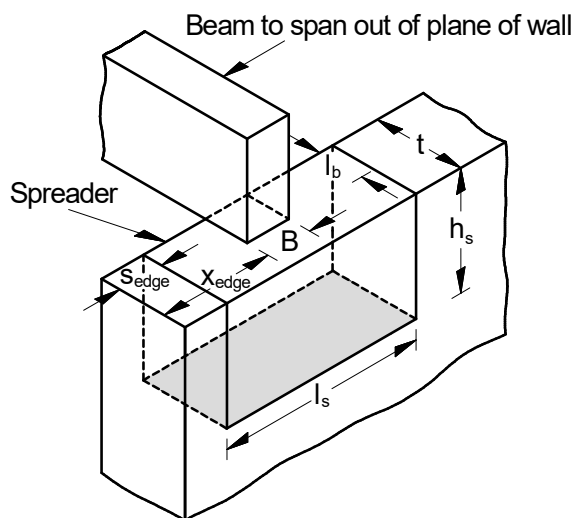
Height of masonry wall

Effective height of masonry wall

Aggregate concrete blocks (25% or less formed voids)

 $p_{unit} = 7.3 \text{ N/mm}^2$

iii

 $l_{unit} = 100 \text{ mm}$
 $h_{unit} = 215 \text{ mm}$
Category II
Normal
 $\gamma_m = 3.5$
 $t = 100 \text{ mm}$
 $t_{ef} = 100 \text{ mm}$
 $h = 2400 \text{ mm}$
 $h_{ef} = 2400 \text{ mm}$


Bearing details

Beam spanning out of plane of wall

Width of bearing

 $B = 152 \text{ mm}$

Length of bearing

 $l_b = 100 \text{ mm}$

Edge distance

 $X_{edge} = 1000 \text{ mm}$

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

Mortar designation

Mortar = "iii"

Block compressive strength

 $p_{unit} = 7.3 \text{ N/mm}^2$

Characteristic compressive strength (Table 2c)

 $f_{kc} = 3.20 \text{ N/mm}^2$

Characteristic compressive strength (Table 2d)

 $f_{kd} = 6.40 \text{ N/mm}^2$

Height of solid block

 $h_{unit} = 215.0 \text{ mm}$

Least horizontal dimension

 $l_{unit} = 100.0 \text{ mm}$

 AXIOM Structural Design Ltd info@axiomsdl.co.uk	Project 141 Heolgerrig				Job no. AX427	
	Calcs for Masonry Bearing Check				Start page no./Revision 11	
	Calcs by LB	Calcs date 30/05/2022	Checked by LB	Checked date 18/06/2022	Approved by	Approved date

Block ratio

$$\text{ratio} = h_{\text{unit}} / l_{\text{unit}} = \mathbf{2.2}$$

Ratio between 0.6 and 4.5 - OK

Characteristic compressive strength

$$f_k = \mathbf{6.40 \text{ N/mm}^2}$$

Loading details

Characteristic concentrated dead load

$$G_k = \mathbf{12 \text{ kN}}$$

Characteristic concentrated imposed load

$$Q_k = \mathbf{22 \text{ kN}}$$

Design concentrated load

$$F = (G_k \times 1.4) + (Q_k \times 1.6) = \mathbf{52.9 \text{ kN}}$$

Characteristic distributed dead load

$$g_k = \mathbf{0.0 \text{ kN/m}}$$

Characteristic distributed imposed load

$$q_k = \mathbf{0.0 \text{ kN/m}}$$

Design distributed load

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

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

$$f_{ca} = F / (B \times l_b) + f / t = \mathbf{3.479 \text{ N/mm}^2}$$

Allowable bearing stress

$$f_{cp} = \gamma_{\text{bear}} \times f_k / \gamma_m = \mathbf{2.743 \text{ N/mm}^2}$$

FAIL - Design bearing stress exceeds allowable bearing stress, use a spreader

Spreader details

Length of spreader

$$l_s = \mathbf{250 \text{ mm}}$$

Depth of spreader

$$h_s = \mathbf{215 \text{ mm}}$$

Edge distance

$$s_{\text{edge}} = \max(0 \text{ mm}, x_{\text{edge}} - (l_s - B) / 2) = \mathbf{951 \text{ mm}}$$

Spreader bearing type

Bearing type

Type 2

Bearing safety factor

$$\gamma_{\text{bear}} = \mathbf{1.50}$$

Check design bearing with a spreader

Loading acts at midpoint of spreader

Design bearing stress

$$f_{ca} = F / (l_s \times t) + f / t = \mathbf{2.115 \text{ N/mm}^2}$$

Allowable bearing stress

$$f_{cp} = \gamma_{\text{bear}} \times f_k / \gamma_m = \mathbf{2.743 \text{ N/mm}^2}$$

PASS - Allowable bearing stress exceeds design bearing stress

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

Slenderness ratio

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

Eccentricity at top of wall

$$e_x = \mathbf{0.0 \text{ mm}}$$

From BS5628:1 Table 7

Capacity reduction factor

$$\beta = \mathbf{0.61}$$

Length of bearing distributed at $0.4 \times h$

$$l_d = \mathbf{2072 \text{ mm}}$$

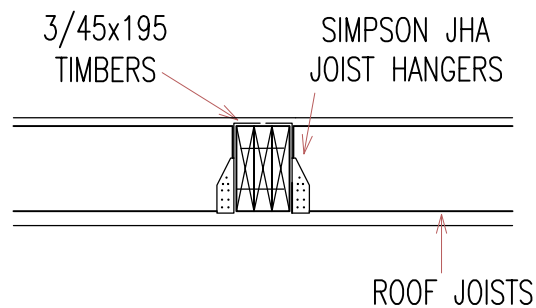
Maximum bearing stress

$$f_{ca} = F / (l_d \times t) + f / t = \mathbf{0.255 \text{ N/mm}^2}$$

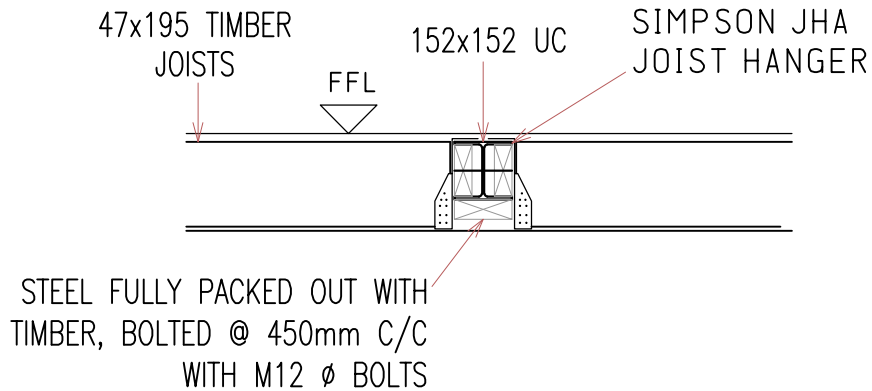
Allowable bearing stress

$$f_{cp} = \beta \times f_k / \gamma_m = \mathbf{1.106 \text{ N/mm}^2}$$

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



SECTION - TIMBER BEAM SUPPORTING ROOF JOISTS



SECTION - STEEL SUPPORTING FLOOR JOISTS