

STRUCTURAL REPORT

Client Details:

Name: Mohammed Alam

Address: 8 Laburnham Terrace,
Rochdale, OL11 2ND





Prepared By: ER

Sheet No./Rev.
2

Client Name: Mohammed Alam

Address: 8 Laburnham Terrace, Rochdale, OL11 2ND

Date
19/02/2025

Document Control:

Purpose/Status	Date	Rev.	Comments	Structural Engineer
Approval Issue	20/02/2025	1	B-Regs Issue	ER

Project Information

Design Codes – Eurocodes and their respective 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 5: 'Design of timber structures'

BS EN 1996. Eurocode 6: 'Design of masonry structures' BS EN

1997. Eurocode 7: 'Geotechnical Design'

ASSUMPTIONS

THE FOLLOWING ASSUMPTIONS ARE MADE ABOUT THE SITE. THEY ARE TO BE CHECKED ON SITE BY THE CONTRACTOR AND BUILDING CONTROL OFFICER PRIOR TO THE START OF THE WORKS. ANY DIFFERENCES ARE TO BE REPORTED US IMMEDIATELY;

1. The existing masonry is assumed to be minimum 3.6N/mm^2 blockwork in a 1:2:8 mortar
2. Floor joists are assumed to span as indicated on the drawings.
3. The external walls are assumed to be cavity brickwork.

NOTES

Contractor to check all dimensions before ordering any steel.

All material and workmanship must fully comply with all relevant current British Standard and Codes of practice.



Prepared By: ER

Sheet No./Rev.
3

Client Name: Mohammed Alam

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Date
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ITEMS

LOADING DETAILS

1. WALL DESIGN

- **Cavity Wall**

Provide 300 mm thick cavity wall having, 100 mm inner leaf, 100mm cavity and 100 mm outer leaf

2. FOUNDATION DESIGN

- **Cavity Wall Foundation-1**

Provide 600 mm wide centric Cavity wall foundation, depth to be decided by building control inspector on site keeping minimum of 1000 mm below level (800+200).

- **Cavity Wall Foundation-2**

Provide 600 mm wide eccentric Cavity wall foundation, depth to be decided by building control inspector on site keeping minimum of 1000 mm below level (800+200).

3. LINTEL DESIGN

- **Lintel-1** IG L1/HD 150 (For Cavity Wall)

4. TIMBER DESIGN

- **Roof Rafter** 50 x 200 @ 400 c/c (C-24)

5. FLOOR DESIGN

- Provide Solid Ground Floor.

	Prepared By: ER	Sheet No./Rev. 4
	Client Name: Mohammed Alam Address: 8 Laburnham Terrace, Rochdale, OL11 2ND	Date 19/02/2025

LOADING DETAILS

PITCHED ROOF

Clay Tiles	=	0.65	KN/m ²
Felt and battens	=	0.05	KN/m ²
Timber rafters	=	0.1	KN/m ²
Insulations and other membranes	=	0.1	KN/m ²
Ceiling and services	=	0.2	KN/m ²
Total dead load on the slope	=	1.1	KN/m²
Live Load	=	0.6	KN/m²

FLAT ROOF

Waterproofing, Insulation	=	0.45	KN/m ²
Timber joist	=	0.2	KN/m ²
Plyboard decking	=	0.1	KN/m ²
Ceiling and services	=	0.2	KN/m ²
Total Dead Load	=	0.95	KN/m²
Live Load	=	0.6	KN/m²

LOFT FLOOR

Plywood Flooring	=	0.15	KN/m ²
Timber Joists	=	0.2	KN/m ²
Insulation	=	0.05	KN/m ²
Ceiling and services	=	0.2	KN/m ²
Partitions	=	0.5	KN/m ²
Total dead load	=	1.10	KN/m²
Live Load	=	1.5	KN/m²

FIRST FLOOR

Plywood Flooring	=	0.15	KN/m ²
Timber Joists	=	0.2	KN/m ²
Insulation	=	0.05	KN/m ²
Ceiling and services	=	0.2	KN/m ²
Partitions	=	0.5	KN/m ²
Total dead load	=	1.10	KN/m²
Live Load	=	1.5	KN/m²

WALL LOAD

Brick wall (102 mm)	=	2	KN/m ²
Block wall with plaster	=	1.9	KN/m ²
Glazing	=	0.5	KN/m ²

	Prepared By: ER	Sheet No./Rev. 5
	Client Name: Mohammed Alam Address: 8 Laburnham Terrace, Rochdale, OL11 2ND	Date 19/02/2025

LOADING DETAILS

1. WALL DESIGN

- **Cavity Wall**

Provide 300 mm thick cavity wall having, 100 mm inner leaf, 100mm cavity and 100 mm outer leaf.

MASONRY WALL PANEL DESIGN

In accordance with BS5628-1:2005

Tedds calculation version 1.2.13

Masonry panel details

Cavity Wall - Unreinforced masonry wall without openings

Panel length; $L = 4000$ mm

Panel height; $h = 2400$ mm

Panel support conditions

Outer leaf;

Simply supported on 4 no. sides

Inner leaf;

Simply supported on 4 no. sides

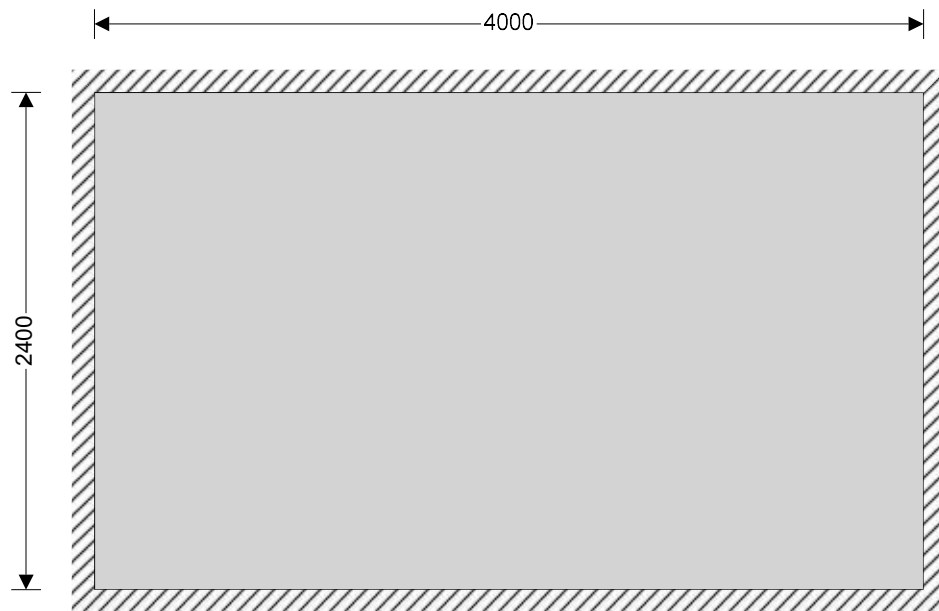
Effective panel length;

$L_{ef} = 1.0 \times L = 4000$ mm

Effective panel height;

$h_{ef} = 1.0 \times h = 2400$ mm

	Prepared By: ER	Sheet No./Rev. 6
	Client Name: Mohammed Alam Address: 8 Laburnham Terrace, Rochdale, OL11 2ND	Date 19/02/2025



Cavity wall construction details

Outer leaf thickness;

$t_1 = 100 \text{ mm}$

Cavity thickness;

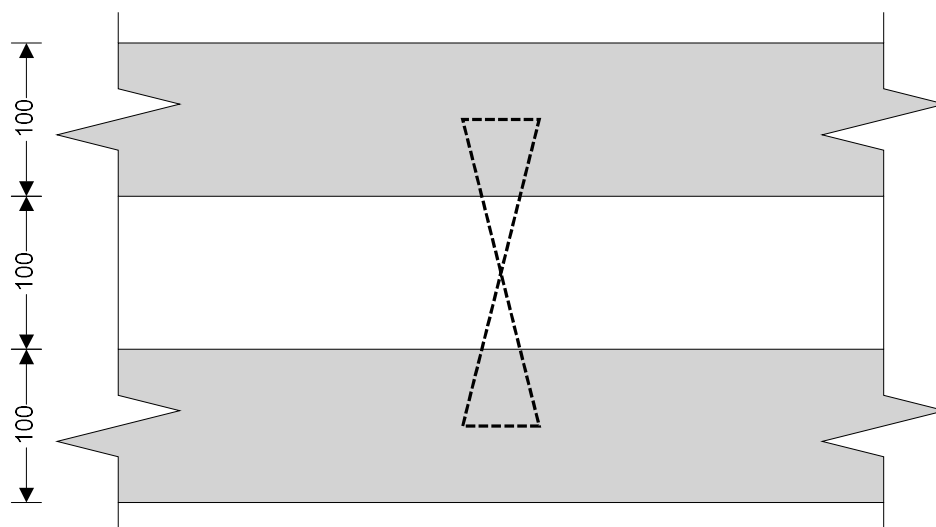
$t_c = 100 \text{ mm}$

Inner leaf thickness;

$t_2 = 100 \text{ mm}$

Effective wall thickness;

$t_{ef} = \max(2 \times (t_1 + t_2) / 3, t_1, t_2) = 133 \text{ mm}$



	Prepared By: ER	Sheet No./Rev. 7
	Client Name: Mohammed Alam Address: 8 Laburnham Terrace, Rochdale, OL11 2ND	Date 19/02/2025

Masonry outer leaf details

Masonry type;

Clay bricks having a water absorption between 7%

and 12%

Compressive strength of unit;

$p_{unit1} = 10.0 \text{ N/mm}^2$

Mortar strength Class/Designation;

M6 / (ii);

Height of masonry units;

$h_{b1} = 65 \text{ mm}$

Density of masonry;

$\gamma_1 = 18.0 \text{ kN/m}^3$

From BS5628-1 Table 2a - Characteristic compressive strength of masonry

Characteristic compressive strength;

$f_{k1} = 3.80 \text{ N/mm}^2$

From BS5628-1 Table 3 - Characteristic flexural strength of masonry

Plane of failure parallel to bed joints;

$f_{kx_para1} = 0.40 \text{ N/mm}^2$

Plane of failure perpendicular to bed joints;

$f_{kx_perp1} = 1.10 \text{ N/mm}^2$

Masonry inner leaf details

Masonry type;

Aggregate concrete blocks with no voids

Compressive strength of unit;

$p_{unit2} = 7.3 \text{ N/mm}^2$

Mortar strength Class/Designation;

M6 / (ii);

Height of masonry units;

$h_{b2} = 215 \text{ mm}$

Density of masonry;

$\gamma_2 = 18.0 \text{ kN/m}^3$

Least horizontal dimension of masonry units;

$t_{min2} = 100 \text{ mm}$

Ratio of height to least horizontal dimension;

$h_{b2} / t_{min2} = 2.15$

From BS5628-1 Table 2d - Characteristic compressive strength of masonry

Characteristic compressive strength;

$f_{k2} = 6.40 \text{ N/mm}^2$

From BS5628-1 Table 3 - Characteristic flexural strength of masonry

Plane of failure parallel to bed joints;

$f_{kx_para2} = 0.25 \text{ N/mm}^2$

Plane of failure perpendicular to bed joints;

$f_{kx_perp2} = 0.60 \text{ N/mm}^2$

Lateral loading details

Characteristic wind load on panel;

$W_k = 0.700 \text{ kN/m}^2$

Vertical loading details

Dead load on top of outer leaf;

$G_{k1} = 5 \text{ kN/m};$

Imposed load on top of outer leaf;

$Q_{k1} = 2 \text{ kN/m};$

Partial safety factors for material strength

Category of manufacturing control;

Category II

Category of construction control;

Normal

Partial safety factor for masonry in compression;

$\gamma_{mc} = 3.50$

Partial safety factor for masonry in flexure;

$\gamma_{mf} = 3.00$

Partial safety factor for masonry in shear;

$\gamma_{mv} = 2.50$

	Prepared By: ER	Sheet No./Rev. 8
	Client Name: Mohammed Alam Address: 8 Laburnham Terrace, Rochdale, OL11 2ND	Date 19/02/2025

Slenderness ratio (cl 24.1)

Allowable slenderness ratio;

$$SR_{all} = 27$$

Slenderness ratio;

$$SR = \min(h_{ef}, L_{ef}) / t_{ef} = 18.0$$

PASS - Slenderness ratio is less than maximum allowable

Vertical loading (cl 28)

Partial safety factors for design loads

Partial safety factor for design dead load;

$$\gamma_{FG} = 1.40$$

Partial safety factor for design imposed load;

$$\gamma_{FQ} = 1.60$$

Considering outer leaf at top of wall

Design vertical load on wall;

$$F_{V1} = G_{k1} \times \gamma_{FG} + Q_{k1} \times \gamma_{FQ} = 10.2 \text{ kN/m}$$

Design vertical load stress on wall;

$$f_{V1} = F_{V1} / t_1 = 0.102 \text{ N/mm}^2$$

Design bending moment;

$$M_{V1} = G_{k1} \times \gamma_{FG} \times e_{G1} + Q_{k1} \times \gamma_{FQ} \times e_{Q1} = 0.0 \text{ kNm/m}$$

Resultant eccentricity at the top of the wall;

$$e_{x1} = M_{V1} / F_{V1} = 0 \text{ mm}$$

From BS5628-1 Table 7 - Capacity reduction factor

Capacity reduction factor;

$$\beta_1 = 0.84$$

Allowable stress capacity;

$$f_{cap1} = \beta_1 \times f_{k1} / \gamma_{mc} = 0.908 \text{ N/mm}^2$$

PASS - Allowable stress capacity exceeds design vertical load stress on wall

Horizontal loading (cl 32)

Limiting dimensions (cl 32.3)

Area of panel;

$$A_p = h \times L = 9.6 \text{ m}^2$$

Limiting area of panel;

$$A_{max} = 2025 \times t_{ef}^2 = 36.0 \text{ m}^2$$

PASS - Area of panel does not exceed limiting area of panel

Limiting panel dimension;

$$L_{max} = 50 \times t_{ef} = 6667 \text{ mm}$$

PASS - Limiting panel dimension is not exceeded

Partial safety factors for design loads

Partial safety factor for design wind load;

$$\gamma_{FW} = 1.40$$

Partial safety factor for design dead load;

$$\gamma_{FG} = 0.90$$

Design moments of resistance in panels (cl 32.4.2)

Considering outer leaf

Design vertical compressive stress;

$$g_{d1} = \gamma_{FG} \times G_{k1} / t_1 = 0.05 \text{ N/mm}^2$$

Enhanced flexural strength of masonry;

$$f_{ka_para1} = f_{kx_para1} + \gamma_{mf} \times g_{d1} = 0.54 \text{ N/mm}^2$$

Section modulus of wall;

$$Z_1 = t_1^2 / 6 = 1666667 \text{ mm}^3/\text{m}$$

Elastic design moment of resistance;

$$M_{d1} = f_{kx_perp1} \times Z_1 / \gamma_{mf} = 0.611 \text{ kNm/m}$$

Considering inner leaf

Design vertical compressive stress;

$$g_{d2} = \gamma_{FG} \times G_{k2} / t_2 = 0.00 \text{ N/mm}^2$$

Enhanced flexural strength of masonry;

$$f_{ka_para2} = f_{kx_para2} + \gamma_{mf} \times g_{d2} = 0.25 \text{ N/mm}^2$$

Section modulus of wall;

$$Z_2 = t_2^2 / 6 = 1666667 \text{ mm}^3/\text{m}$$

	Prepared By: ER	Sheet No./Rev. 9
	Client Name: Mohammed Alam Address: 8 Laburnham Terrace, Rochdale, OL11 2ND	Date 19/02/2025

Elastic design moment of resistance;

$$M_{d2} = f_{kx_perp2} \times Z_2 / \gamma_{mf} = \mathbf{0.333 \text{ kNm/m}}$$

Calculate design wind load acting on each leaf

Outer leaf design wind load;

$$W_{k1} = M_{d1} \times W_k / (M_{d1} + M_{d2}) = \mathbf{0.453 \text{ kN/m}^2}$$

Inner leaf design wind load;

$$W_{k2} = M_{d2} \times W_k / (M_{d1} + M_{d2}) = \mathbf{0.247 \text{ kN/m}^2}$$

Design moment in panels (cl 32.4.2)

Considering outer leaf

Orthogonal strength ratio;

$$\mu_1 = f_{ka_para1} / f_{kx_perp1} = \mathbf{0.49}$$

Using yield line analysis to calculate bending moment coefficient

Bending moment coefficient;

$$\alpha_1 = \mathbf{0.036}$$

Design moment in wall;

$$M_1 = \alpha_1 \times W_{k1} \times \gamma_{fW} \times L^2 = \mathbf{0.361 \text{ kNm/m}}$$

PASS - Resistance moment exceeds design moment

Considering inner leaf

Orthogonal strength ratio;

$$\mu_2 = f_{ka_para2} / f_{kx_perp2} = \mathbf{0.42}$$

Using yield line analysis to calculate bending moment coefficient

Bending moment coefficient;

$$\alpha_2 = \mathbf{0.039}$$

Design moment in wall;

$$M_2 = \alpha_2 \times W_{k2} \times \gamma_{fW} \times L^2 = \mathbf{0.214 \text{ kNm/m}}$$

PASS - Resistance moment exceeds design moment

	Prepared By: ER	Sheet No./Rev. 10
	Client Name: Mohammed Alam Address: 8 Laburnham Terrace, Rochdale, OL11 2ND	Date 19/02/2025

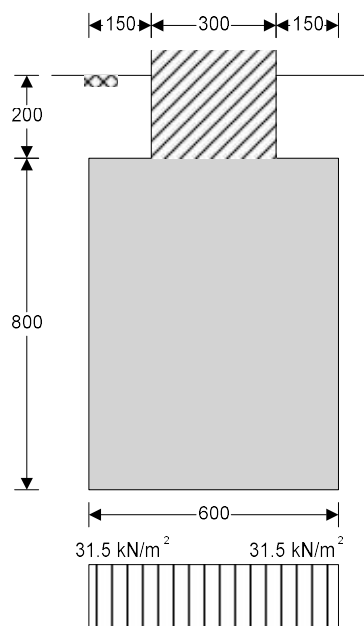
2. FOUNDATION DESIGN

- Cavity Wall Foundation-1**

Provide 600 mm wide centric Cavity wall foundation, depth to be decided by building control inspector on site keeping minimum of 1000 mm below level (800+200).

STRIP FOOTING ANALYSIS AND DESIGN (BS8110-1:1997)

Tedds calculation version 2.0.07



Strip footing details

Width of strip footing;

Depth of strip footing;

Depth of soil over strip footing;

Density of concrete;

$B = 600$ mm

$h = 800$ mm

$h_{soil} = 200$ mm

$\rho_{conc} = 23.6$ kN/m³

Load details

Load width;

Load eccentricity;

$b = 300$ mm

$e_P = 0$ mm

	Prepared By: ER	Sheet No./Rev. 11
	Client Name: Mohammed Alam Address: 8 Laburnham Terrace, Rochdale, OL11 2ND	Date 19/02/2025

Soil details

Dense, moderately graded, sub-angular, gravel

Mobilisation factor;

$$m = 1.5;$$

Density of soil;

$$\rho_{\text{soil}} = 20.0 \text{ kN/m}^3$$

Design shear strength;

$$\phi' = 25.0 \text{ deg}$$

Design base friction;

$$\delta = 19.3 \text{ deg}$$

Allowable bearing pressure;

$$P_{\text{bearing}} = 105 \text{ kN/m}^2$$

Axial loading on strip footing

Dead axial load;

$$P_G = 4.0 \text{ kN/m}$$

Imposed axial load;

$$P_Q = 0.0 \text{ kN/m}$$

Wind axial load;

$$P_W = 0.0 \text{ kN/m}$$

Total axial load;

$$P = 4.0 \text{ kN/m}$$

Foundation loads

Dead surcharge load;

$$F_{G_{\text{sur}}} = 2.000 \text{ kN/m}^2$$

Imposed surcharge load;

$$F_{Q_{\text{sur}}} = 0.000 \text{ kN/m}^2$$

Strip footing self weight;

$$F_{\text{swt}} = h \times \rho_{\text{conc}} = 18.880 \text{ kN/m}^2$$

Soil self weight;

$$F_{\text{soil}} = h_{\text{soil}} \times \rho_{\text{soil}} = 4.000 \text{ kN/m}^2$$

Total foundation load;

$$F = B \times (F_{G_{\text{sur}}} + F_{Q_{\text{sur}}} + F_{\text{swt}} + F_{\text{soil}}) = 14.9 \text{ kN/m}$$

Calculate base reaction

Total base reaction;

$$T = F + P = 18.9 \text{ kN/m}$$

Eccentricity of base reaction in x;

$$e_T = (P \times e_P + M + H \times h) / T = 0 \text{ mm}$$

Base reaction acts within middle third of base

Calculate base pressures

$$q_1 = (T / B) \times (1 - 6 \times e_T / B) = 31.547 \text{ kN/m}^2$$

$$q_2 = (T / B) \times (1 + 6 \times e_T / B) = 31.547 \text{ kN/m}^2$$

Minimum base pressure;

$$q_{\text{min}} = \min(q_1, q_2) = 31.547 \text{ kN/m}^2$$

Maximum base pressure;

$$q_{\text{max}} = \max(q_1, q_2) = 31.547 \text{ kN/m}^2$$

PASS - Maximum base pressure is less than allowable bearing pressure

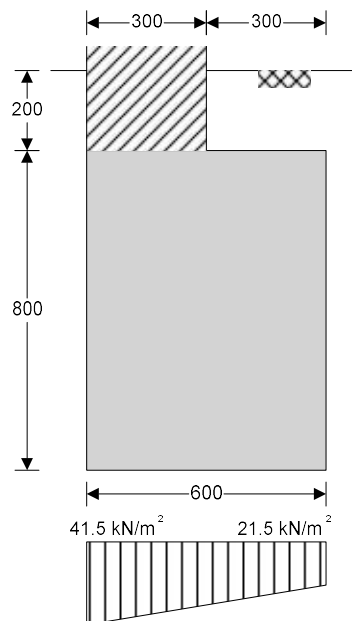
	Prepared By: ER	Sheet No./Rev. 12
	Client Name: Mohammed Alam Address: 8 Laburnham Terrace, Rochdale, OL11 2ND	Date 19/02/2025

• Cavity Wall Foundation-2

Provide 600 mm wide Eccentric Cavity Wall Foundation, depth to be decided by building control inspector on site keeping minimum of 1000 mm below level (800+200).

STRIP FOOTING ANALYSIS AND DESIGN (BS8110-1:1997)

Tedds calculation version 2.0.07



Strip footing details

Width of strip footing;

Depth of strip footing;

Depth of soil over strip footing;

Density of concrete;

$B = 600$ mm

$h = 800$ mm

$h_{\text{soil}} = 200$ mm

$\rho_{\text{conc}} = 23.6$ kN/m³

Load details

Load width;

Load eccentricity;

$b = 300$ mm

$e_P = -150$ mm

	Prepared By: ER	Sheet No./Rev. 13
	Client Name: Mohammed Alam Address: 8 Laburnham Terrace, Rochdale, OL11 2ND	Date 19/02/2025

Soil details

Dense, moderately graded, sub-angular, gravel

Mobilisation factor;

$$m = 1.5;$$

Density of soil;

$$\rho_{\text{soil}} = 20.0 \text{ kN/m}^3$$

Design shear strength;

$$\phi' = 25.0 \text{ deg}$$

Design base friction;

$$\delta = 19.3 \text{ deg}$$

Allowable bearing pressure;

$$P_{\text{bearing}} = 105 \text{ kN/m}^2$$

Axial loading on strip footing

Dead axial load;

$$P_G = 4.0 \text{ kN/m}$$

Imposed axial load;

$$P_Q = 0.0 \text{ kN/m}$$

Wind axial load;

$$P_W = 0.0 \text{ kN/m}$$

Total axial load;

$$P = 4.0 \text{ kN/m}$$

Foundation loads

Dead surcharge load;

$$F_{G_{\text{sur}}} = 2.000 \text{ kN/m}^2$$

Imposed surcharge load;

$$F_{Q_{\text{sur}}} = 0.000 \text{ kN/m}^2$$

Strip footing self weight;

$$F_{\text{swt}} = h \times \rho_{\text{conc}} = 18.880 \text{ kN/m}^2$$

Soil self weight;

$$F_{\text{soil}} = h_{\text{soil}} \times \rho_{\text{soil}} = 4.000 \text{ kN/m}^2$$

Total foundation load;

$$F = B \times (F_{G_{\text{sur}}} + F_{Q_{\text{sur}}} + F_{\text{swt}} + F_{\text{soil}}) = 14.9 \text{ kN/m}$$

Calculate base reaction

Total base reaction;

$$T = F + P = 18.9 \text{ kN/m}$$

Eccentricity of base reaction in x;

$$e_T = (P \times e_P + M + H \times h) / T = -32 \text{ mm}$$

Base reaction acts within middle third of base

Calculate base pressures

$$q_1 = (T / B) \times (1 - 6 \times e_T / B) = 41.547 \text{ kN/m}^2$$

$$q_2 = (T / B) \times (1 + 6 \times e_T / B) = 21.547 \text{ kN/m}^2$$

Minimum base pressure;

$$q_{\text{min}} = \min(q_1, q_2) = 21.547 \text{ kN/m}^2$$

Maximum base pressure;

$$q_{\text{max}} = \max(q_1, q_2) = 41.547 \text{ kN/m}^2$$

PASS - Maximum base pressure is less than allowable bearing pressure

	Prepared By: ER	Sheet No./Rev. 14
	Client Name: Mohammed Alam Address: 8 Laburnham Terrace, Rochdale, OL11 2ND	Date 19/02/2025

3. LINTEL DESIGN

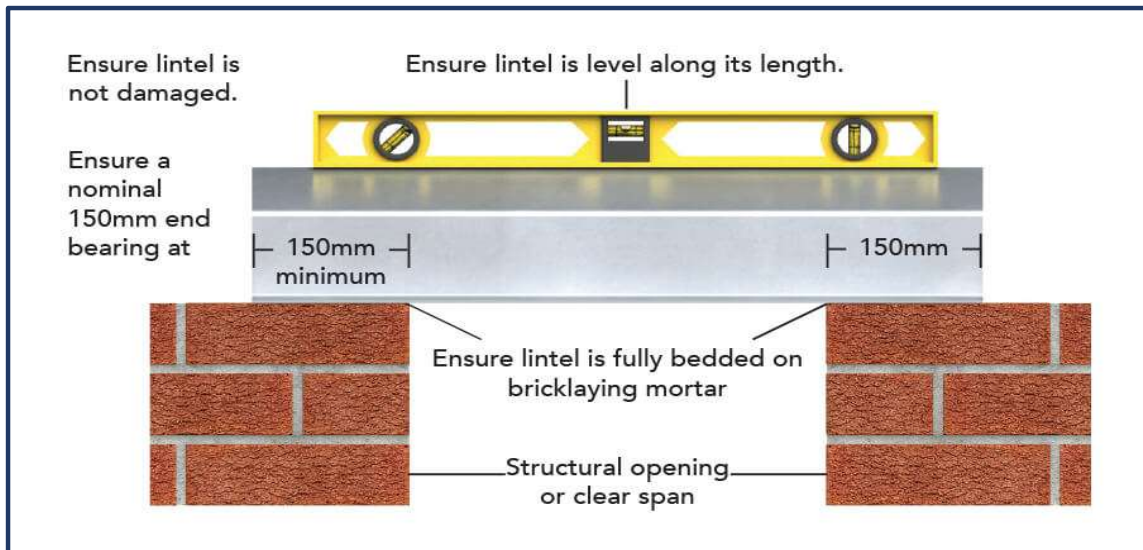
- **Lintel-1** IG L1/HD 150

Select a suitable lintel according to the span

Length	Height	Thickness	Total UDL KN 3:1	Total UDL KN 19:1
600	125	2.9	30	20
1500				
1650	160	2.9	30	22
2100				
2250	180	3.2	35	30
3000				
3150	180	3.2	30	25
3600				
3750	200	3.2	30	26
4050				

Installation

Provide a minimum bearing of 150 mm on both sides

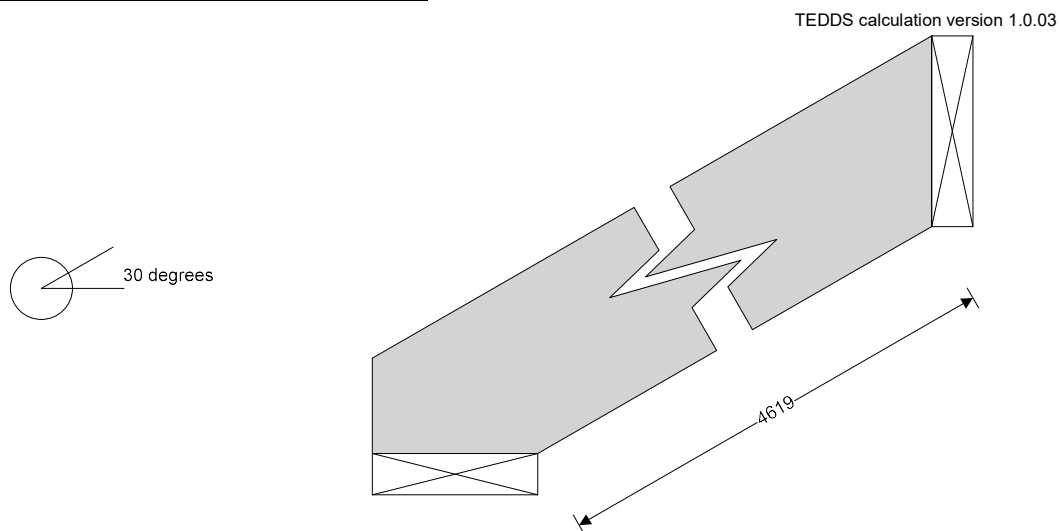


	Prepared By: ER	Sheet No./Rev. 15
	Client Name: Mohammed Alam Address: 8 Laburnham Terrace, Rochdale, OL11 2ND	Date 19/02/2025

4. TIMBER DESIGN

- Roof Rafter 50 x 200 @ 400 c/c (C-24)

TIMBER RAFTER DESIGN (BS5268-2:2002)



Rafter details

Breadth of timber sections;
 Depth of timber sections;
 Rafter spacing;
 Rafter slope;
 Clear span of rafter on horizontal;
 Clear span of rafter on slope;
 Rafter span;
 Timber strength class;

b = 50 mm
h = 200 mm
s = 400 mm
 $\alpha = 30.0 \text{ deg}$
 $L_{clh} = 4000 \text{ mm}$
 $L_{cl} = L_{clh} / \cos(\alpha) = 4619 \text{ mm}$
Single span
C24

Section properties

Cross sectional area of rafter;
 Section modulus;
 Second moment of area;
 Radius of gyration;

$A = b \times h = 10000 \text{ mm}^2$
 $Z = b \times h^2 / 6 = 333333 \text{ mm}^3$
 $I = b \times h^3 / 12 = 33333333 \text{ mm}^4$
 $r = \sqrt{I / A} = 57.7 \text{ mm}$

Loading details

Rafter self weight;
 Dead load on slope;
 Imposed load on plan;

$F_j = b \times h \times \rho_{char} \times g_{acc} = 0.03 \text{ kN/m}$
 $F_d = 0.75 \text{ kN/m}^2$
 $F_u = 0.75 \text{ kN/m}^2$

	Prepared By: ER	Sheet No./Rev. 16
	Client Name: Mohammed Alam Address: 8 Laburnham Terrace, Rochdale, OL11 2ND	Date 19/02/2025

Imposed point load;

$$F_p = 0.90 \text{ kN}$$

Modification factors

Section depth factor;

$$K_7 = (300 \text{ mm} / h)^{0.11} = 1.05$$

Load sharing factor;

$$K_8 = 1.10$$

Consider long term load condition

Load duration factor;

$$K_3 = 1.00$$

Total UDL perpendicular to rafter;

$$F = F_d \cdot \cos(\alpha) \cdot s + F_j \cdot \cos(\alpha) = 0.290 \text{ kN/m}$$

Notional bearing length;

$$L_b = F \times L_{cl} / [2 \times (b \times \sigma_{cp1} \times K_8 - F)] = 5 \text{ mm}$$

Effective span;

$$L_{eff} = L_{cl} + L_b = 4624 \text{ mm}$$

Check bending stress

Bending stress parallel to grain;

$$\sigma_m = 7.500 \text{ N/mm}^2$$

Permissible bending stress;

$$\sigma_{m_adm} = \sigma_m \times K_3 \times K_7 \times K_8 = 8.626 \text{ N/mm}^2$$

Applied bending stress;

$$\sigma_{m_max} = F \cdot L_{eff}^2 / (8 \cdot Z) = 2.321 \text{ N/mm}^2$$

PASS - Applied bending stress within permissible limits

Check compressive stress parallel to grain

Compression stress parallel to grain;

$$\sigma_c = 7.900 \text{ N/mm}^2$$

Minimum modulus of elasticity;

$$E_{min} = 7200 \text{ N/mm}^2$$

Compression member factor;

$$K_{12} = 0.52$$

Permissible compressive stress;

$$\sigma_{c_adm} = \sigma_c \times K_3 \times K_8 \times K_{12} = 4.550 \text{ N/mm}^2$$

Applied compressive stress;

$$\sigma_{c_max} = F \cdot L_{eff} \cdot (\cot(\alpha) + 3 \cdot \tan(\alpha)) / (2 \cdot A) =$$

$$0.232 \text{ N/mm}^2$$

PASS - Applied compressive stress within permissible limits

Check combined bending and compressive stress parallel to grain

Euler stress;

$$\sigma_e = \pi^2 \times E_{min} / \lambda^2 = 11.079 \text{ N/mm}^2$$

Euler coefficient;

$$K_{eu} = 1 - (1.5 \times \sigma_{c_max} \times K_{12} / \sigma_e) = 0.984$$

Combined axial compression and bending check;

$$\sigma_{m_max} / (\sigma_{m_adm} \times K_{eu}) + \sigma_{c_max} / \sigma_{c_adm} = 0.325; < 1$$

PASS - Combined compressive and bending stresses are within permissible limits

Check shear stress

Shear stress parallel to grain;

$$\tau = 0.710 \text{ N/mm}^2$$

Permissible shear stress;

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

Applied shear stress;

$$\tau_{max} = 3 \cdot F \cdot L_{eff} / (4 \cdot A) = 0.100 \text{ N/mm}^2$$

PASS - Applied shear stress within permissible limits

Check deflection

Permissible deflection;

$$\delta_{adm} = 0.003 \times L_{eff} = 13.872 \text{ mm}$$

Bending deflection;

$$\delta_b = 5 \cdot F \cdot L_{eff}^4 / (384 \cdot E_{mean} \cdot I) = 4.787 \text{ mm}$$

Shear deflection;

$$\delta_s = 12 \cdot F \cdot L_{eff}^2 / (5 \cdot E_{mean} \cdot A) = 0.138 \text{ mm}$$

Total deflection;

$$\delta_{max} = \delta_b + \delta_s = 4.925 \text{ mm}$$

PASS - Total deflection within permissible limits

	Prepared By: ER	Sheet No./Rev. 17
	Client Name: Mohammed Alam Address: 8 Laburnham Terrace, Rochdale, OL11 2ND	Date 19/02/2025

Consider medium term load condition

Load duration factor;

$$K_3 = 1.25$$

Total UDL perpendicular to rafter;

$$F = [F_u \cos(\alpha)^2 + F_d \cos(\alpha)] s + F_j \cos(\alpha) =$$

0.515 kN/m

Notional bearing length;

$$L_b = F \times L_{cl} / [2 \times (b \times \sigma_{cp1} \times K_8 - F)] = 9 \text{ mm}$$

Effective span;

$$L_{eff} = L_{cl} + L_b = 4628 \text{ mm}$$

Check bending stress

Bending stress parallel to grain;

$$\sigma_m = 7.500 \text{ N/mm}^2$$

Permissible bending stress;

$$\sigma_{m_adm} = \sigma_m \times K_3 \times K_7 \times K_8 = 10.783 \text{ N/mm}^2$$

Applied bending stress;

$$\sigma_{m_max} = F \times L_{eff}^2 / (8 \times Z) = 4.132 \text{ N/mm}^2$$

PASS - Applied bending stress within permissible limits

Check compressive stress parallel to grain

Compression stress parallel to grain;

$$\sigma_c = 7.900 \text{ N/mm}^2$$

Minimum modulus of elasticity;

$$E_{min} = 7200 \text{ N/mm}^2$$

Compression member factor;

$$K_{12} = 0.48$$

Permissible compressive stress;

$$\sigma_{c_adm} = \sigma_c \times K_3 \times K_8 \times K_{12} = 5.164 \text{ N/mm}^2$$

Applied compressive stress;

$$\sigma_{c_max} = F \times L_{eff} \times (\cot(\alpha) + 3 \times \tan(\alpha)) / (2 \times A) =$$

0.412 N/mm}^2

PASS - Applied compressive stress within permissible limits

Check combined bending and compressive stress parallel to grain

Euler stress;

$$\sigma_e = \pi^2 \times E_{min} / \lambda^2 = 11.060 \text{ N/mm}^2$$

Euler coefficient;

$$K_{eu} = 1 - (1.5 \times \sigma_{c_max} \times K_{12} / \sigma_e) = 0.973$$

Combined axial compression and bending check; $\sigma_{m_max} / (\sigma_{m_adm} \times K_{eu}) + \sigma_{c_max} / \sigma_{c_adm} = 0.474; < 1$

PASS - Combined compressive and bending stresses are within permissible limits

Check shear stress

Shear stress parallel to grain;

$$\tau = 0.710 \text{ N/mm}^2$$

Permissible shear stress;

$$\tau_{adm} = \tau \times K_3 \times K_8 = 0.976 \text{ N/mm}^2$$

Applied shear stress;

$$\tau_{max} = 3 \times F \times L_{eff} / (4 \times A) = 0.179 \text{ N/mm}^2$$

PASS - Applied shear stress within permissible limits

Check deflection

Permissible deflection;

$$\delta_{adm} = 0.003 \times L_{eff} = 13.884 \text{ mm}$$

Bending deflection;

$$\delta_b = 5 \times F \times L_{eff}^4 / (384 \times E_{mean} \times I) = 8.536 \text{ mm}$$

Shear deflection;

$$\delta_s = 12 \times F \times L_{eff}^2 / (5 \times E_{mean} \times A) = 0.245 \text{ mm}$$

Total deflection;

$$\delta_{max} = \delta_b + \delta_s = 8.781 \text{ mm}$$

PASS - Total deflection within permissible limits

Consider short term load condition

Load duration factor;

$$K_3 = 1.50$$

	Prepared By: ER	Sheet No./Rev. 18
	Client Name: Mohammed Alam Address: 8 Laburnham Terrace, Rochdale, OL11 2ND	Date 19/02/2025

Total UDL perpendicular to rafter;

$$F = F_d \cos(\alpha) + F_j \cos(\alpha) = \mathbf{0.290 \text{ kN/m}}$$

Notional bearing length;

$$L_b = [F \times L_{cl} + F_p \times \cos(\alpha)] / [2 \times (b \times \sigma_{cp1} \times K_8 - F)] = \mathbf{8}$$

mm

Effective span;

$$L_{eff} = L_{cl} + L_b = \mathbf{4627 \text{ mm}}$$

Check bending stress

Bending stress parallel to grain;

$$\sigma_m = \mathbf{7.500 \text{ N/mm}^2}$$

Permissible bending stress;

$$\sigma_{m_adm} = \sigma_m \times K_3 \times K_7 \times K_8 = \mathbf{12.939 \text{ N/mm}^2}$$

Applied bending stress;

$$\sigma_{m_max} = F \times L_{eff}^2 / (8 \times Z) + F_p \cos(\alpha) \times L_{eff} / (4 \times Z) = \mathbf{5.029}$$

N/mm²

PASS - Applied bending stress within permissible limits

Check compressive stress parallel to grain

Compression stress parallel to grain;

$$\sigma_c = \mathbf{7.900 \text{ N/mm}^2}$$

Minimum modulus of elasticity;

$$E_{min} = \mathbf{7200 \text{ N/mm}^2}$$

Compression member factor;

$$K_{12} = \mathbf{0.43}$$

Permissible compressive stress;

$$\sigma_{c_adm} = \sigma_c \times K_3 \times K_8 \times K_{12} = \mathbf{5.637 \text{ N/mm}^2}$$

Applied compressive stress;

$$\sigma_{c_max} = F \times L_{eff} \times (\cot(\alpha) + 3 \times \tan(\alpha)) / (2 \times A) + F_p \cos(\alpha) = \mathbf{0.277 \text{ N/mm}^2}$$

sin(α)/A = 0.277 N/mm²

PASS - Applied compressive stress within permissible limits

Check combined bending and compressive stress parallel to grain

Euler stress;

$$\sigma_e = \pi^2 \times E_{min} / \lambda^2 = \mathbf{11.065 \text{ N/mm}^2}$$

Euler coefficient;

$$K_{eu} = 1 - (1.5 \times \sigma_{c_max} \times K_{12} / \sigma_e) = \mathbf{0.984}$$

Combined axial compression and bending check;

$$\sigma_{m_max} / (\sigma_{m_adm} \times K_{eu}) + \sigma_{c_max} / \sigma_{c_adm} = \mathbf{0.444; < 1}$$

PASS - Combined compressive and bending stresses are within permissible limits

Check shear stress

Shear stress parallel to grain;

$$\tau = \mathbf{0.710 \text{ N/mm}^2}$$

Permissible shear stress;

$$\tau_{adm} = \tau \times K_3 \times K_8 = \mathbf{1.172 \text{ N/mm}^2}$$

Applied shear stress;

$$\tau_{max} = 3 \times F \times L_{eff} / (4 \times A) + 3 \times F_p \cos(\alpha) / (2 \times A) = \mathbf{0.217 \text{ N/mm}^2}$$

A) = 0.217 N/mm²

PASS - Applied shear stress within permissible limits

Check deflection

Permissible deflection;

$$\delta_{adm} = 0.003 \times L_{eff} = \mathbf{13.881 \text{ mm}}$$

Bending deflection;

$$\delta_b = L_{eff}^3 \times (5 \times F \times L_{eff} / 384 + F_p \cos(\alpha) / 48) / (E_{mean} \times I) = \mathbf{9.267 \text{ mm}}$$

Shear deflection;

$$\delta_s = 12 \times L_{eff} \times (F \times L_{eff} + 2 \times F_p \cos(\alpha)) / (5 \times E_{mean} \times A) = \mathbf{0.298 \text{ mm}}$$

A) = 0.298 mm

Total deflection;

$$\delta_{max} = \delta_b + \delta_s = \mathbf{9.565 \text{ mm}}$$

PASS - Total deflection within permissible limits

	Prepared By: ER	Sheet No./Rev. 19
	Client Name: Mohammed Alam Address: 8 Laburnham Terrace, Rochdale, OL11 2ND	Date 19/02/2025

5. FLOOR DESIGN

- Provide Solid Ground Floor.