

Project 887/887A Manchester Road, Rochdale				Job Ref. HC-25253	
Section Rear Extension				Sheet no./rev. 1	
Calc. by JTB	Date 07.05.25	Chk'd by PMH	Date 07.05.25	App'd by	Date

1 – INTRODUCTION

The following document is associated with the construction work to take place at the above mentioned address and contains design calculations for structural elements, as well as approximate schematic arrangements of those elements.

2 - DEFINITIONS

The "Engineer" is HEALEY CONSULTING

The "Client" is the individual or organisation that has instructed the engineer to carry out structural engineering consultancy work.

The "Architect" is the individual or organisation that has provided the information upon which these calculations are based.

The "Builder" is the contractor who has been engaged to undertake the construction work to which this document relates.

DUTY HOLDERS – SEE ABCA DOCUMENT ATTACHED

3 - IMPORTANT GUIDANCE ON THE USE OF THIS DOCUMENT **(TO BE READ BY ALL PARTIES)**

This document is intended to be accompanied by all relevant architects' and engineer's drawings, and all relevant documentation should be considered prior to commencement of the work.

Engineer's drawings relating to this document will be explicitly outlined herein.

This document should be reviewed in its entirety (along with any other relevant documentation) by the builder, architect (if applicable) and client, prior to commencement of the work.

Any layouts, instructions or recommendations should be considered. Any deviations from the proposals outlined herein are to be approved by the Engineer prior to the work being undertaken. Any deviations from the proposals made

without the Engineer's consent are beyond the scope of this document and the Engineer cannot be held liable for any adverse consequences of such deviations.

The calculations within this document have been carried out in good faith based on the data provided by the client and/or builder/architect.

Where applicable extracts of the information provided will be included within this document for reference.

It is the responsibility of the architect (where applicable) or client to notify the engineer when changes are made to the information. This will enable the design to be reviewed and, where necessary, changes made.

Approval of these calculations and drawings by the Local Authority Building Control or similar approved body should be obtained prior to any ordering of material or fabrication. No liability is accepted for any changes that may be required as a result of work having commenced prior to such an approval.

Where information about the existing arrangements of buildings is not available (e.g. floor / roof span orientations or load-bearing wall arrangements) the Engineer will use their judgement to make assumptions. These (generally conservative) assumptions will be clearly outlined within the document, and should be confirmed by a suitably qualified individual on site. The engineer is then to be notified of any discrepancies prior to commencement of the work as design changes may be necessary.

IF IN DOUBT: ASK!!

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It should be noted that until the existing structure has been exposed it is not always possible to foresee what the existing structural arrangement will be. This may include floor and roof span directions, construction materials and existing beam locations among other aspects. It is therefore advised to remove finishes from areas being modified as early as possible to avoid any delays on site that the untimely discovery of such (previously unknown) information can lead to.

In addition, it is advised to carry out some form of ground investigation as early as possible to avoid any unexpected below ground construction requirements which may cause delays on site e.g. piled foundations, raft foundations etc.

Wherever there is any uncertainty we will make every effort to highlight where this lies, however suitable project planning / management by the contractor / client are essential to the smooth execution of any construction project.

4 - HEALTH & SAFETY

It should be noted that structural work, particularly where this involves the transit and installation of large, heavy structural elements, has the potential to be hazardous. Where possible any specific risks are identified either within these calculations or drawings related to this document.

IF IN DOUBT: ASK!!

5 - PARTY WALL AGREEMENTS

If the building work involves:

- work on an existing wall which is shared with another property, or
- building on the boundary with a neighbouring property, or
- excavating near a neighbouring building,

then the client must find out whether the work falls under the Party Wall Act. If it does, the Act requires the client to notify all affected neighbours of proposed works. Refer to your architect for guidance, or see this website for guidance:- <https://www.gov.uk/guidance/partywall-etc-act-1996-guidance>.

6 - CONSTRUCTION NOTES

GENERAL NOTES

Where design GA drawings are issued alongside calculations, the design GA drawings TAKE PRECEDENCE over the calculations.

- Any SPAN / HEIGHT DIMENSIONS shown in this document are for CALCULATION PURPOSES ONLY and are not to be used as a final dimension for the fabrication / machining of structural elements.
- All dimensions are to be checked on site by the builder / contractor / fabricator prior to commencement of fabrication / machining / construction.

Any discrepancies between the information outlined herein and the dimensions on site are to be reported to the engineer.

- Temporary works are the sole responsibility of the builder / contractor. Temporary works method statements are to be provided to the Engineer by the builder / contractor prior to commencement of the work.

- All parties are assumed to be aware of their responsibilities under the Construction Design and Management (CDM) Regulations 2015.

If you are unsure of this please contact the Engineer.

- HEALEY CONSULTING take no responsibility for any elements outside of the scope of these calculations. For structural elements not covered by this document it is assumed that a design is being prepared / provided by

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others, if additional calculations / drawings / specifications are required then please contact HEALEY CONSULTING and we can provide a fee for their design.

- All structural work has to be carried out by a competent builder in accordance with the requirements of The Building Regulations Part A and the recommendations set out in BS8103 Parts 1-3.

SIMPLY SUPPORTED BEAM EXAMPLE

- This document is to be read in conjunction with the architectural drawings / details, and any discrepancies reported to the engineer immediately. Final steel levels and dimensions are to be confirmed by the architectural consultant.
- If HEALEY CONSULTING are not contracted to visit site we take no responsibility for the quality of construction nor its compliance with this document. It is the contractor's responsibility to ensure that all works comply with the drawings, notes and assumptions made within these calculations.
- The client / contractor should be aware of beam, frame and column deflections and their impact on existing or adjacent elements, for example beam deflection on bi-fold doors. Typical beam deflections will be span/200 total (Dead+Live) for beams and height/300 (Wind) for columns.

The following calculations provide anticipated deflections within the relevant sections.

- The client should be aware that where beams are installed within existing masonry structures it is likely that minor cracking will occur within the masonry above due to the load redistribution. It is recommended that the contractor allows to make suitable repairs within their contract.
- All proprietary (i.e. off-the-shelf) items specified within this document are to be installed in strict accordance with the manufacturer's recommendations. This includes, but is not limited to restraint straps, lintels, chemical / resin anchors and fixing brackets.
- For structural elements not considered within the scope of this document it is assumed that a suitable specification is to be made by others. If additional calculations, specifications or drawings are required then please contact HEALEY CONSULTING and we can provide a fee for their design.
- At locations where beam bearing information is provided on the layout this will be in a position where load-bearing masonry (with foundations / support) has been assumed. It should be confirmed by a suitably qualified individual that these walls are load-bearing, and the masonry is to be inspected for suitability prior to commencement of the work.

7. DESIGN PHILOSOPHY

All structural members are designed to be capable of withstanding applied loads during construction, operation and maintenance of the building without any distress, failure, loss of function, damage or durability problems. They are to support the most onerous combinations of dead, imposed and (where applicable) wind loads tending to produce either maximum ultimate stresses or deflection.

8. STABILITY STATEMENT

For this project the stability is to be provided by the following structural systems or a combination thereof:

Global Lateral Stability: moment-transmitting frames / masonry piers or shear walls with dead load restoring moment / floors or ceilings to provide diaphragm (boarded & strapped where critical)

Wall Panel Local Lateral Stability: steel or timber posts / masonry piers or walls / floors, ceilings or rafters (boarded & strapped where critical) / timber stud walls.

Vertical Loads: masonry walls, piers or columns with padstones for concentrated loads where necessary / steel posts / strip footings / pad foundations

Internal walls are to be removed. If required sway frames will be introduced

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DESIGN PHILOSOPHY

These calculations should be read in conjunction with the relevant drawing HC-25253-(60)-001.

STABILITY STATEMENT

As part of the extension works, a substantial opening is to be made to the existing rear elevation. This compromises the stability of the existing rear elevation. For this purpose, the steel beams to support the structure over the new opening will make up part of a sway frame structure to resist lateral loading.

GROUND BEARING PRESSURES

Not Applicable

Notes:

Timber designs carried out in accordance with BS 5268: Part 2:1996
Masonry designs carried out in accordance with BS 5628: Part 1:1992
Steel beams designed in accordance with BS 5950: Part 1 2000
All beam-ends are to be bolted down to concrete pad stones using
M12 – RAWL R-HPT THROUGH BOLTS 100mm Long

LOADING

LOADINGS

	kN/m ²	kN/m ²
<u>ROOF</u>		
Dead + Services + Pbrd Ceiling	1.00	
Live		0.75

TIMBER FLOOR

Dead	
Finishes + Boards	0.15
Insulation	0.05
Timber Joists	0.20
Single boarded ceiling + Plaster	0.15
	<u>0.55</u>

Live

Domestic	1.50
Partitions	0.50
	<u>2.00</u>

WALL

DL	103 brickwork	2.20
	100 blockwork	2.00
	Plaster per face	0.20

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SIDE WALL PANEL CHECK

MASONRY WALL PANEL DESIGN (BS5628)

MASONRY WALL PANEL DESIGN

In accordance with BS5628-1:2005

Tedds calculation version 1.2.16

Masonry panel details

Side Gable - Unreinforced masonry wall without openings

Panel length $L = 2850$ mm

Panel height $h = 3000$ mm

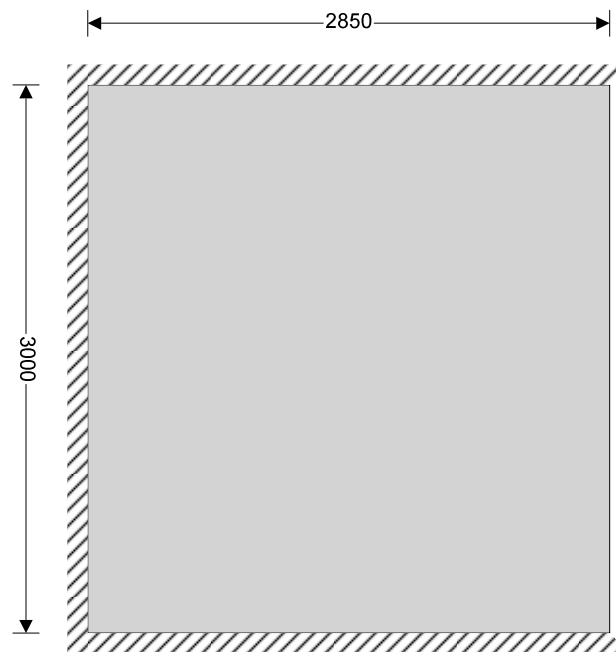
Panel support conditions

Outer leaf **Top, bottom and left supported, left continuous**

Inner leaf **Top, bottom and left supported, left continuous**

Effective panel length $L_{ef} = 2.5 \times L = 7125$ mm

Effective panel height $h_{ef} = 1.0 \times h = 3000$ mm



Cavity wall construction details

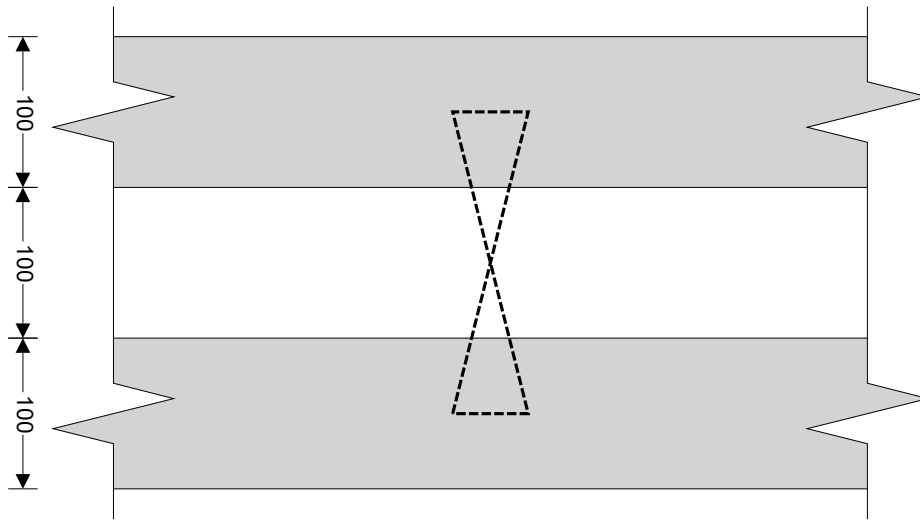
Outer leaf thickness $t_1 = 100$ mm

Cavity thickness $t_c = 100$ mm

Inner leaf thickness $t_2 = 100$ mm

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

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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	$f_{k1} = 3.80 \text{ N/mm}^2$
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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	$f_{k2} = 6.40 \text{ N/mm}^2$
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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	$W_k = 0.700 \text{ kN/m}^2$
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Partial safety factors for material strength

Category of manufacturing control	Category II
Category of construction control	Normal

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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 $\gamma_{mv} = 2.50$

Horizontal loading (cl 32)

Limiting dimensions (cl 32.3)

Area of panel $A_p = h \times L = 8.6 \text{ m}^2$

Limiting area of panel $A_{max} = 1350 \times t_{ef}^2 = 24.0 \text{ m}^2$

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 $g_{d1} = \gamma_{fG} \times G_{k1} / t_1 = 0.00 \text{ N/mm}^2$

Enhanced flexural strength of masonry $f_{ka_para1} = f_{kx_para1} + \gamma_{mf} \times g_{d1} = 0.40 \text{ N/mm}^2$

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

Elastic design moment of resistance $M_{d1} = f_{ka_para1} \times Z_1 / \gamma_{mf} = 0.222 \text{ kNm/m}$

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

Elastic design moment of resistance $M_{d2} = f_{ka_para2} \times Z_2 / \gamma_{mf} = 0.139 \text{ kNm/m}$

Calculate design wind load acting on each leaf

Outer leaf design wind load $W_{k1} = M_{d1} \times W_k / (M_{d1} + M_{d2}) = 0.431 \text{ kN/m}^2$

Inner leaf design wind load $W_{k2} = M_{d2} \times W_k / (M_{d1} + M_{d2}) = 0.269 \text{ kN/m}^2$

Design moment in panels (cl 32.4.2)

Considering outer leaf

Orthogonal strength ratio $\mu_1 = f_{ka_para1} / f_{kx_perp1} = 0.36$

Using yield line analysis to calculate bending moment coefficient

Bending moment coefficient $\alpha_1 = 0.107$

Design moment in wall $M_1 = \mu_1 \times \alpha_1 \times W_{k1} \times \gamma_{fW} \times L^2 = 0.191 \text{ kNm/m}$

PASS - Resistance moment exceeds design moment

Considering inner leaf

Orthogonal strength ratio $\mu_2 = f_{ka_para2} / f_{kx_perp2} = 0.42$

Using yield line analysis to calculate bending moment coefficient

Bending moment coefficient $\alpha_2 = 0.100$

Design moment in wall $M_2 = \mu_2 \times \alpha_2 \times W_{k2} \times \gamma_{fW} \times L^2 = 0.127 \text{ kNm/m}$

PASS - Resistance moment exceeds design moment

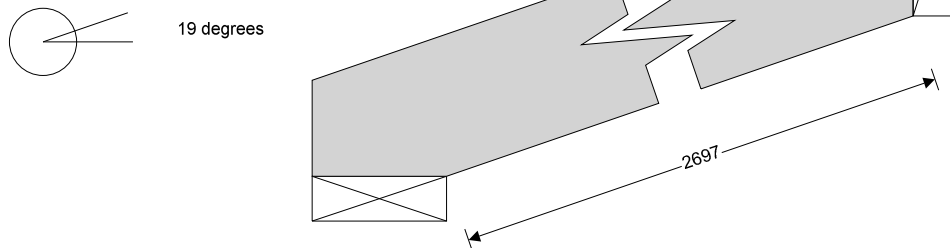
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TIMBER RAFTER

TIMBER RAFTER DESIGN (BS5268)

TIMBER RAFTER DESIGN (BS5268-2:2002)

TEDDS calculation version 1.0.03



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

$b = 50 \text{ mm}$
 $h = 150 \text{ mm}$
 $s = 400 \text{ mm}$
 $\alpha = 19.0 \text{ deg}$
 $L_{clh} = 2550 \text{ mm}$
 $L_{cl} = L_{clh} / \cos(\alpha) = 2697 \text{ mm}$
Single span
C16

Section properties

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

$A = b \times h = 7500 \text{ mm}^2$
 $Z = b \times h^2 / 6 = 187500 \text{ mm}^3$
 $I = b \times h^3 / 12 = 14062500 \text{ mm}^4$
 $r = \sqrt{I / A} = 43.3 \text{ mm}$

Loading details

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

$F_j = b \times h \times \rho_{char} \times g_{acc} = 0.02 \text{ kN/m}$
 $F_d = 1.00 \text{ kN/m}^2$
 $F_u = 0.75 \text{ kN/m}^2$
 $F_p = 0.90 \text{ kN}$

Modification factors

Section depth factor
Load sharing factor

$K_7 = (300 \text{ mm} / h)^{0.11} = 1.08$
 $K_8 = 1.10$

Consider long term load condition

Load duration factor
Total UDL perpendicular to rafter
Notional bearing length

$K_3 = 1.00$
 $F = F_d \times \cos(\alpha) \times s + F_j \times \cos(\alpha) = 0.400 \text{ kN/m}$
 $L_b = F \times L_{cl} / [2 \times (b \times \sigma_{cp1} \times K_8 - F)] = 4 \text{ mm}$

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Effective span

$$L_{eff} = L_{cl} + L_b = 2701 \text{ mm}$$

Check bending stress

Bending stress parallel to grain

$$\sigma_m = 5.300 \text{ N/mm}^2$$

Permissible bending stress

$$\sigma_{m_adm} = \sigma_m \times K_3 \times K_7 \times K_8 = 6.292 \text{ N/mm}^2$$

Applied bending stress

$$\sigma_{m_max} = F \times L_{eff}^2 / (8 \times Z) = 1.945 \text{ N/mm}^2$$

PASS - Applied bending stress within permissible limits

Check compressive stress parallel to grain

Compression stress parallel to grain

$$\sigma_c = 6.800 \text{ N/mm}^2$$

Minimum modulus of elasticity

$$E_{min} = 5800 \text{ N/mm}^2$$

Compression member factor

$$K_{12} = 0.64$$

Permissible compressive stress

$$\sigma_{c_adm} = \sigma_c \times K_3 \times K_8 \times K_{12} = 4.791 \text{ N/mm}^2$$

Applied compressive stress

$$\sigma_{c_max} = F \times L_{eff} / (\cot(\alpha) + 3 \times \tan(\alpha)) / (2 \times A) = 0.283 \text{ N/mm}^2$$

PASS - Applied compressive stress within permissible limits

Check combined bending and compressive stress parallel to grain

Euler stress

$$\sigma_e = \pi^2 \times E_{min} / \lambda^2 = 14.708 \text{ N/mm}^2$$

Euler coefficient

$$K_{eu} = 1 - (1.5 \times \sigma_{c_max} \times K_{12} / \sigma_e) = 0.981$$

Combined axial compression and bending check

$$\sigma_{m_max} / (\sigma_{m_adm} \times K_{eu}) + \sigma_{c_max} / \sigma_{c_adm} = 0.374 < 1$$

PASS - Combined compressive and bending stresses are within permissible limits

Check shear stress

Shear stress parallel to grain

$$\tau = 0.670 \text{ N/mm}^2$$

Permissible shear stress

$$\tau_{adm} = \tau \times K_3 \times K_8 = 0.737 \text{ N/mm}^2$$

Applied shear stress

$$\tau_{max} = 3 \times F \times L_{eff} / (4 \times A) = 0.108 \text{ N/mm}^2$$

PASS - Applied shear stress within permissible limits

Check deflection

Permissible deflection

$$\delta_{adm} = 0.003 \times L_{eff} = 8.104 \text{ mm}$$

Bending deflection

$$\delta_b = 5 \times F \times L_{eff}^4 / (384 \times E_{mean} \times I) = 2.240 \text{ mm}$$

Shear deflection

$$\delta_s = 12 \times F \times L_{eff}^2 / (5 \times E_{mean} \times A) = 0.106 \text{ mm}$$

Total deflection

$$\delta_{max} = \delta_b + \delta_s = 2.346 \text{ mm}$$

PASS - Total deflection within permissible limits

Consider medium term load condition

Load duration factor

$$K_3 = 1.25$$

Total UDL perpendicular to rafter

$$F = [F_u \times \cos(\alpha)^2 + F_d \times \cos(\alpha)] \times s + F_j \times \cos(\alpha) = 0.668 \text{ kN/m}$$

Notional bearing length

$$L_b = F \times L_{cl} / [2 \times (b \times \sigma_{cp1} \times K_8 - F)] = 7 \text{ mm}$$

Effective span

$$L_{eff} = L_{cl} + L_b = 2704 \text{ mm}$$

Check bending stress

Bending stress parallel to grain

$$\sigma_m = 5.300 \text{ N/mm}^2$$

Permissible bending stress

$$\sigma_{m_adm} = \sigma_m \times K_3 \times K_7 \times K_8 = 7.865 \text{ N/mm}^2$$

Applied bending stress

$$\sigma_{m_max} = F \times L_{eff}^2 / (8 \times Z) = 3.257 \text{ N/mm}^2$$

PASS - Applied bending stress within permissible limits

Check compressive stress parallel to grain

Compression stress parallel to grain

$$\sigma_c = 6.800 \text{ N/mm}^2$$

Minimum modulus of elasticity

$$E_{min} = 5800 \text{ N/mm}^2$$

Compression member factor

$$K_{12} = 0.60$$

Permissible compressive stress

$$\sigma_{c_adm} = \sigma_c \times K_3 \times K_8 \times K_{12} = 5.644 \text{ N/mm}^2$$

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Applied compressive stress

$$\sigma_{c_max} = F \times L_{eff} \times (\cot(\alpha) + 3 \times \tan(\alpha)) / (2 \times A) = \mathbf{0.474 \text{ N/mm}^2}$$

PASS - Applied compressive stress within permissible limits

Check combined bending and compressive stress parallel to grain

Euler stress $\sigma_e = \pi^2 \times E_{min} / \lambda^2 = \mathbf{14.675 \text{ N/mm}^2}$

Euler coefficient $K_{eu} = 1 - (1.5 \times \sigma_{c_max} \times K_{12} / \sigma_e) = \mathbf{0.971}$

Combined axial compression and bending check $\sigma_{m_max} / (\sigma_{m_adm} \times K_{eu}) + \sigma_{c_max} / \sigma_{c_adm} = \mathbf{0.511 < 1}$

PASS - Combined compressive and bending stresses are within permissible limits

Check shear stress

Shear stress parallel to grain $\tau = \mathbf{0.670 \text{ N/mm}^2}$

Permissible shear stress $\tau_{adm} = \tau \times K_3 \times K_8 = \mathbf{0.921 \text{ N/mm}^2}$

Applied shear stress $\tau_{max} = 3 \times F \times L_{eff} / (4 \times A) = \mathbf{0.181 \text{ N/mm}^2}$

PASS - Applied shear stress within permissible limits

Check deflection

Permissible deflection $\delta_{adm} = 0.003 \times L_{eff} = \mathbf{8.113 \text{ mm}}$

Bending deflection $\delta_b = 5 \times F \times L_{eff}^4 / (384 \times E_{mean} \times I) = \mathbf{3.760 \text{ mm}}$

Shear deflection $\delta_s = 12 \times F \times L_{eff}^2 / (5 \times E_{mean} \times A) = \mathbf{0.178 \text{ mm}}$

Total deflection $\delta_{max} = \delta_b + \delta_s = \mathbf{3.937 \text{ mm}}$

PASS - Total deflection within permissible limits

Consider short term load condition

Load duration factor

$$K_3 = \mathbf{1.50}$$

Total UDL perpendicular to rafter

$$F = F_d \times \cos(\alpha) \times s + F_j \times \cos(\alpha) = \mathbf{0.400 \text{ kN/m}}$$

Notional bearing length

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

Effective span

$$L_{eff} = L_{cl} + L_b = \mathbf{2705 \text{ mm}}$$

Check bending stress

Bending stress parallel to grain $\sigma_m = \mathbf{5.300 \text{ N/mm}^2}$

Permissible bending stress $\sigma_{m_adm} = \sigma_m \times K_3 \times K_7 \times K_8 = \mathbf{9.438 \text{ N/mm}^2}$

Applied bending stress $\sigma_{m_max} = F \times L_{eff}^2 / (8 \times Z) + F_p \times \cos(\alpha) \times L_{eff} / (4 \times Z) = \mathbf{5.019 \text{ N/mm}^2}$

PASS - Applied bending stress within permissible limits

Check compressive stress parallel to grain

Compression stress parallel to grain $\sigma_c = \mathbf{6.800 \text{ N/mm}^2}$

Minimum modulus of elasticity $E_{min} = \mathbf{5800 \text{ N/mm}^2}$

Compression member factor $K_{12} = \mathbf{0.57}$

Permissible compressive stress $\sigma_{c_adm} = \sigma_c \times K_3 \times K_8 \times K_{12} = \mathbf{6.360 \text{ N/mm}^2}$

Applied compressive stress $\sigma_{c_max} = F \times L_{eff} \times (\cot(\alpha) + 3 \times \tan(\alpha)) / (2 \times A) + F_p \times \sin(\alpha) / A = \mathbf{0.323 \text{ N/mm}^2}$

PASS - Applied compressive stress within permissible limits

Check combined bending and compressive stress parallel to grain

Euler stress $\sigma_e = \pi^2 \times E_{min} / \lambda^2 = \mathbf{14.670 \text{ N/mm}^2}$

Euler coefficient $K_{eu} = 1 - (1.5 \times \sigma_{c_max} \times K_{12} / \sigma_e) = \mathbf{0.981}$

Combined axial compression and bending check $\sigma_{m_max} / (\sigma_{m_adm} \times K_{eu}) + \sigma_{c_max} / \sigma_{c_adm} = \mathbf{0.593 < 1}$

PASS - Combined compressive and bending stresses are within permissible limits

Check shear stress

Shear stress parallel to grain $\tau = \mathbf{0.670 \text{ N/mm}^2}$

Permissible shear stress $\tau_{adm} = \tau \times K_3 \times K_8 = \mathbf{1.106 \text{ N/mm}^2}$

Applied shear stress $\tau_{max} = 3 \times F \times L_{eff} / (4 \times A) + 3 \times F_p \times \cos(\alpha) / (2 \times A) = \mathbf{0.278 \text{ N/mm}^2}$

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PASS - Applied shear stress within permissible limits

Check deflection

Permissible deflection

$$\delta_{adm} = 0.003 \times L_{eff} = \mathbf{8.115 \text{ mm}}$$

Bending deflection

$$\delta_b = L_{eff}^3 \times (5 \times F \times L_{eff} / 384 + F_p \times \cos(\alpha) / 48) / (E_{mean} \times I) = \mathbf{5.087 \text{ mm}}$$

Shear deflection

$$\delta_s = 12 \times L_{eff} \times (F \times L_{eff} + 2 \times F_p \times \cos(\alpha)) / (5 \times E_{mean} \times A) = \mathbf{0.274 \text{ mm}}$$

Total deflection

$$\delta_{max} = \delta_b + \delta_s = \mathbf{5.361 \text{ mm}}$$

PASS - Total deflection within permissible limits

TIMBER CEILING JOISTS (IF REQUIRED)

TIMBER JOIST DESIGN (BS5268)

TIMBER JOIST DESIGN (BS5268-2:2002)

Tedds calculation version 1.1.04

Joist details

Joist breadth

$$b = \mathbf{50 \text{ mm}}$$

Joist depth

$$h = \mathbf{150 \text{ mm}}$$

Joist spacing

$$s = \mathbf{400 \text{ mm}}$$

Timber strength class

$$\mathbf{C16}$$

Service class of timber

$$\mathbf{1}$$



Span details

Number of spans

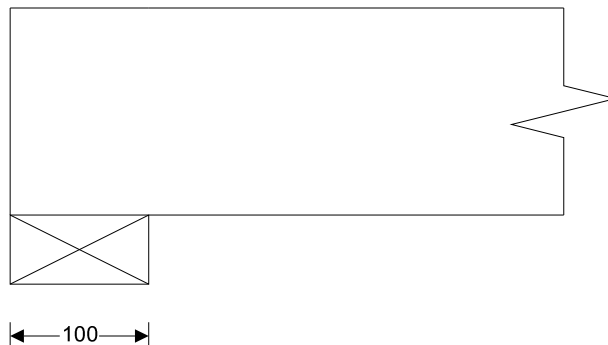
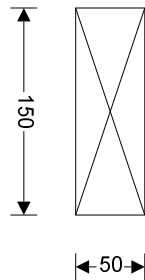
$$N_{span} = \mathbf{1}$$

Length of bearing

$$L_b = \mathbf{100 \text{ mm}}$$

Effective length of span

$$L_{s1} = \mathbf{2550 \text{ mm}}$$



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Section properties

Second moment of area $I = b \times h^3 / 12 = 14062500 \text{ mm}^4$
 Section modulus $Z = b \times h^2 / 6 = 187500 \text{ mm}^3$

Loading details

Joist self weight $F_{\text{swt}} = b \times h \times \rho_{\text{char}} \times g_{\text{acc}} = 0.02 \text{ kN/m}$
 Dead load $F_{\text{d_udl}} = 0.35 \text{ kN/m}^2$
 Imposed UDL(Long term) $F_{\text{i_udl}} = 0.50 \text{ kN/m}^2$
 Imposed point load (Medium term) $F_{\text{i_pt}} = 1.40 \text{ kN}$

Modification factors

Service class for bending parallel to grain $K_{2m} = 1.00$
 Service class for compression $K_{2c} = 1.00$
 Service class for shear parallel to grain $K_{2s} = 1.00$
 Service class for modulus of elasticity $K_{2e} = 1.00$
 Section depth factor $K_7 = 1.08$
 Load sharing factor $K_8 = 1.10$

Consider long term loads

Load duration factor $K_3 = 1.00$
 Maximum bending moment $M = 0.295 \text{ kNm}$
 Maximum shear force $V = 0.463 \text{ kN}$
 Maximum support reaction $R = 0.463 \text{ kN}$
 Maximum deflection $\delta = 1.700 \text{ mm}$

Check bending stress

Bending stress $\sigma_m = 5.300 \text{ N/mm}^2$
 Permissible bending stress $\sigma_{m_adm} = \sigma_m \times K_{2m} \times K_3 \times K_7 \times K_8 = 6.292 \text{ N/mm}^2$
 Applied bending stress $\sigma_{m_max} = M / Z = 1.573 \text{ N/mm}^2$
PASS - Applied bending stress within permissible limits

Check shear stress

Shear stress $\tau = 0.670 \text{ N/mm}^2$
 Permissible shear stress $\tau_{adm} = \tau \times K_{2s} \times K_3 \times K_8 = 0.737 \text{ N/mm}^2$
 Applied shear stress $\tau_{max} = 3 \times V / (2 \times b \times h) = 0.093 \text{ N/mm}^2$
PASS - Applied shear stress within permissible limits

Check bearing stress

Compression perpendicular to grain (no wane) $\sigma_{cp1} = 2.200 \text{ N/mm}^2$
 Permissible bearing stress $\sigma_{c_adm} = \sigma_{cp1} \times K_{2c} \times K_3 \times K_8 = 2.420 \text{ N/mm}^2$
 Applied bearing stress $\sigma_{c_max} = R / (b \times L_b) = 0.093 \text{ N/mm}^2$
PASS - Applied bearing stress within permissible limits

Check deflection

Permissible deflection $\delta_{adm} = \min(L_{s1} \times 0.003, 14 \text{ mm}) = 7.650 \text{ mm}$
 Bending deflection (based on E_{mean}) $\delta_{bending} = 1.614 \text{ mm}$
 Shear deflection $\delta_{shear} = 0.086 \text{ mm}$
 Total deflection $\delta = \delta_{bending} + \delta_{shear} = 1.700 \text{ mm}$
PASS - Actual deflection within permissible limits

Consider medium term loads

Load duration factor $K_3 = 1.25$

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Maximum bending moment

$$M = 1.025 \text{ kNm}$$

Maximum shear force

$$V = 1.608 \text{ kN}$$

Maximum support reaction

$$R = 1.608 \text{ kN}$$

Maximum deflection

$$\delta = 4.930 \text{ mm}$$

Check bending stress

Bending stress

$$\sigma_m = 5.300 \text{ N/mm}^2$$

Permissible bending stress

$$\sigma_{m_adm} = \sigma_m \times K_{2m} \times K_3 \times K_7 \times K_8 = 7.865 \text{ N/mm}^2$$

Applied bending stress

$$\sigma_{m_max} = M / Z = 5.466 \text{ N/mm}^2$$

PASS - Applied bending stress within permissible limits

Check shear stress

Shear stress

$$\tau = 0.670 \text{ N/mm}^2$$

Permissible shear stress

$$\tau_{adm} = \tau \times K_{2s} \times K_3 \times K_8 = 0.921 \text{ N/mm}^2$$

Applied shear stress

$$\tau_{max} = 3 \times V / (2 \times b \times h) = 0.322 \text{ N/mm}^2$$

PASS - Applied shear stress within permissible limits

Check bearing stress

Compression perpendicular to grain (no wane)

$$\sigma_{cp1} = 2.200 \text{ N/mm}^2$$

Permissible bearing stress

$$\sigma_{c_adm} = \sigma_{cp1} \times K_{2c} \times K_3 \times K_8 = 3.025 \text{ N/mm}^2$$

Applied bearing stress

$$\sigma_{c_max} = R / (b \times L_b) = 0.322 \text{ N/mm}^2$$

PASS - Applied bearing stress within permissible limits

Check deflection

Permissible deflection

$$\delta_{adm} = \min(L_{s1} \times 0.003, 14 \text{ mm}) = 7.650 \text{ mm}$$

Bending deflection (based on E_{mean})

$$\delta_{bending} = 4.632 \text{ mm}$$

Shear deflection

$$\delta_{shear} = 0.298 \text{ mm}$$

Total deflection

$$\delta = \delta_{bending} + \delta_{shear} = 4.930 \text{ mm}$$

PASS - Actual deflection within permissible limits

BM01 - STAFF AREA

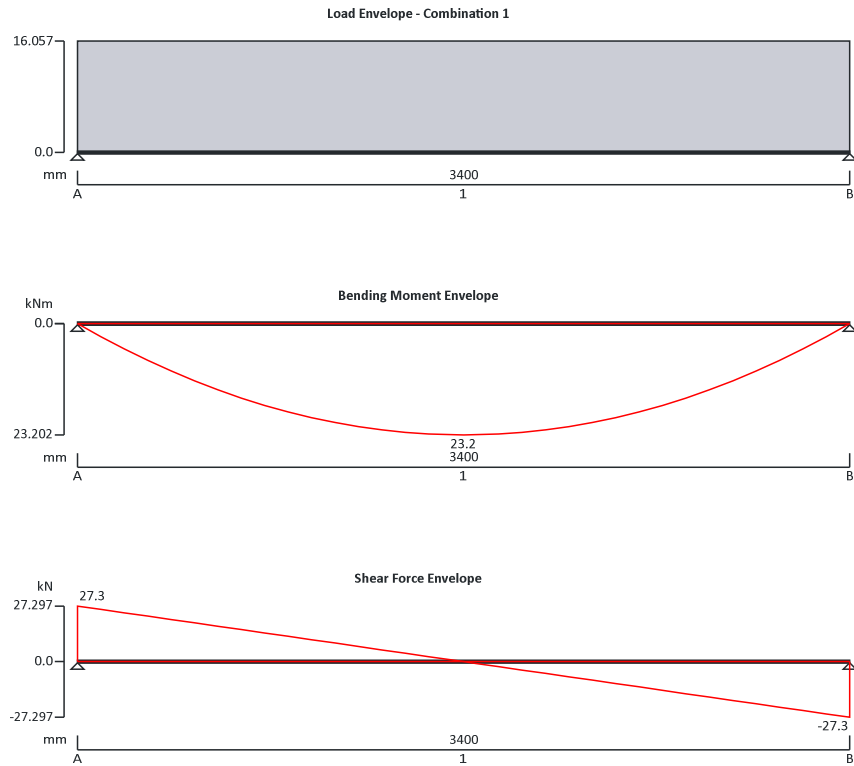
STEEL BEAM ANALYSIS & DESIGN (BS5950)

STEEL BEAM ANALYSIS & DESIGN (BS5950)

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

TEDDS calculation version 3.0.08

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Support conditions

Support A

Vertically restrained

Rotationally free

Support B

Vertically restrained

Rotationally free

Applied loading

Beam loads

Dead self weight of beam $\times 1$

Roof - Dead full UDL 1.3 kN/m

Roof - Imposed full UDL 1 kN/m

Wall - Dead full UDL 8.8 kN/m

Load combinations

Load combination 1

Support A

Dead $\times 1.40$

Imposed $\times 1.60$

Dead $\times 1.40$

Imposed $\times 1.60$

Support B

Dead $\times 1.40$

Imposed $\times 1.60$

Analysis results

Maximum moment

$M_{\max} = 23.2$ kNm

$M_{\min} = 0$ kNm

Maximum shear

$V_{\max} = 27.3$ kN

$V_{\min} = -27.3$ kN

Deflection

$\delta_{\max} = 4.6$ mm

$\delta_{\min} = 0$ mm

Maximum reaction at support A

$R_{A_{\max}} = 27.3$ kN

$R_{A_{\min}} = 27.3$ kN

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

$R_{A_Dead} = 17.6 \text{ kN}$
 $R_{A_Imposed} = 1.7 \text{ kN}$
 $R_{B_max} = 27.3 \text{ kN}$ $R_{B_min} = 27.3 \text{ kN}$
 $R_{B_Dead} = 17.6 \text{ kN}$
 $R_{B_Imposed} = 1.7 \text{ kN}$

Section details

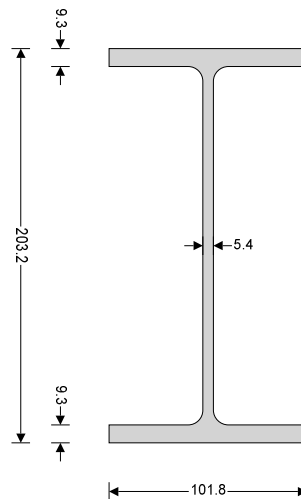
Section type
Steel grade

UB 203x102x23 (British Steel Section Range 2022 (BS4-1))
S275

From table 9: Design strength p_y

Thickness of element
Design strength
Modulus of elasticity

$\max(T, t) = 9.3 \text{ mm}$
 $p_y = 275 \text{ N/mm}^2$
 $E = 205000 \text{ N/mm}^2$



Lateral restraint

Span 1 has lateral restraint at supports only

Effective length factors

Effective length factor in major axis
Effective length factor in minor axis
Effective length factor for lateral-torsional buckling

$K_x = 1.00$
 $K_y = 1.00$
 $K_{LT,A} = 1.20 + 2 \times D$
 $K_{LT,B} = 1.20 + 2 \times D$

Classification of cross sections - Section 3.5

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

Internal compression parts - Table 11

Depth of section

$d = 169.4 \text{ mm}$
 $d / t = 31.4 \times \epsilon \leq 80 \times \epsilon$ **Class 1 plastic**

Outstand flanges - Table 11

Width of section

$b = B / 2 = 50.9 \text{ mm}$
 $b / T = 5.5 \times \epsilon \leq 9 \times \epsilon$ **Class 1 plastic**

Section is class 1 plastic

Shear capacity - Section 4.2.3

Design shear force

$F_v = \max(\text{abs}(V_{\max}), \text{abs}(V_{\min})) = 27.3 \text{ kN}$
 $d / t < 70 \times \epsilon$

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Web does not need to be checked for shear buckling

Shear area

$$A_v = t \times D = 1097 \text{ mm}^2$$

Design shear resistance

$$P_v = 0.6 \times p_y \times A_v = 181.1 \text{ kN}$$

PASS - Design shear resistance exceeds design shear force

Moment capacity - Section 4.2.5

Design bending moment

$$M = \max(\text{abs}(M_{s1_max}), \text{abs}(M_{s1_min})) = 23.2 \text{ kNm}$$

Moment capacity low shear - cl.4.2.5.2

$$M_c = \min(p_y \times S_{xx}, 1.2 \times p_y \times Z_{xx}) = 64.4 \text{ kNm}$$

Effective length for lateral-torsional buckling - Section 4.3.5

Effective length for lateral torsional buckling

$$L_E = 1.2 \times L_{s1} + 2 \times D = 4486 \text{ mm}$$

Slenderness ratio

$$\lambda = L_E / r_{yy} = 190.027$$

Equivalent slenderness - Section 4.3.6.7

Buckling parameter

$$u = 0.888$$

Torsional index

$$x = 22.460$$

Slenderness factor

$$v = 1 / [1 + 0.05 \times (\lambda / x)^{2.25}] = 0.684$$

Ratio - cl.4.3.6.9

$$\beta_w = 1.000$$

Equivalent slenderness - cl.4.3.6.7

$$\lambda_{LT} = u \times v \times \lambda \times \sqrt{\beta_w} = 115.359$$

Limiting slenderness - Annex B.2.2

$$\lambda_{L0} = 0.4 \times (\pi^2 \times E / p_y)^{0.5} = 34.310$$

$\lambda_{LT} > \lambda_{L0}$ - Allowance should be made for lateral-torsional buckling

Bending strength - Section 4.3.6.5

Robertson constant

$$\alpha_{LT} = 7.0$$

Perry factor

$$\eta_{LT} = \max(\alpha_{LT} \times (\lambda_{LT} - \lambda_{L0}) / 1000, 0) = 0.567$$

Euler stress

$$p_E = \pi^2 \times E / \lambda_{LT}^2 = 152 \text{ N/mm}^2$$

$$\phi_{LT} = (p_y + (\eta_{LT} + 1) \times p_E) / 2 = 256.6 \text{ N/mm}^2$$

Bending strength - Annex B.2.1

$$p_b = p_E \times p_y / (\phi_{LT} + (\phi_{LT}^2 - p_E \times p_y)^{0.5}) = 101.5 \text{ N/mm}^2$$

Equivalent uniform moment factor - Section 4.3.6.6

Moment at quarter point of segment

$$M_2 = 17.4 \text{ kNm}$$

Moment at centre-line of segment

$$M_3 = 23.2 \text{ kNm}$$

Moment at three quarter point of segment

$$M_4 = 17.4 \text{ kNm}$$

Maximum moment in segment

$$M_{abs} = 23.2 \text{ kNm}$$

Maximum moment governing buckling resistance

$$M_{LT} = M_{abs} = 23.2 \text{ kNm}$$

Equivalent uniform moment factor for lateral-torsional buckling

$$m_{LT} = \max(0.2 + (0.15 \times M_2 + 0.5 \times M_3 + 0.15 \times M_4) / M_{abs}, 0.44) = 0.925$$

Buckling resistance moment - Section 4.3.6.4

Buckling resistance moment

$$M_b = p_b \times S_{xx} = 23.8 \text{ kNm}$$

$$M_b / m_{LT} = 25.7 \text{ kNm}$$

PASS - Buckling resistance moment exceeds design bending moment

Check vertical deflection - Section 2.5.2

Consider deflection due to dead and imposed loads

Limiting deflection

$$\delta_{lim} = L_{s1} / 360 = 9.444 \text{ mm}$$

Maximum deflection span 1

$$\delta = \max(\text{abs}(\delta_{max}), \text{abs}(\delta_{min})) = 4.567 \text{ mm}$$

PASS - Maximum deflection does not exceed deflection limit

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BM01 MASONRY BEARING SUPPORT A

MASONRY BEARING DESIGN (BS5628)

MASONRY BEARING DESIGN TO BS5628-1:2005

TEDDS calculation version 1.0.08

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

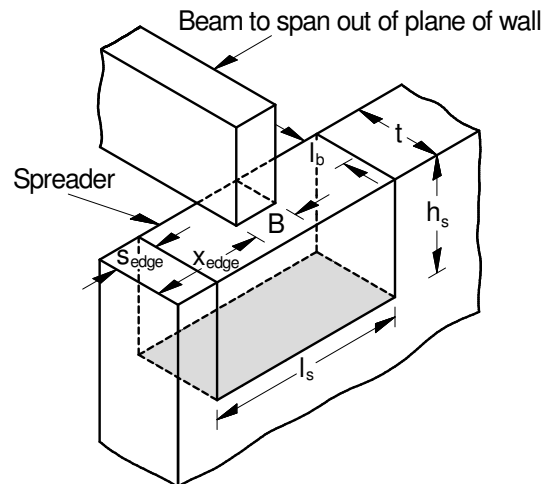
$$\gamma_m = 3.5$$

$$t = 100 \text{ mm}$$

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

$$h = 2400 \text{ mm}$$

$$h_{ef} = 2400 \text{ mm}$$



Bearing details

Beam spanning out of plane of wall
Width of bearing
Length of bearing
Edge distance

$$B = 100 \text{ mm}$$

$$l_b = 100 \text{ mm}$$

$$X_{edge} = 75 \text{ mm}$$

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)

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

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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

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

Block ratio

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

Ratio between 0.6 and 4.5 - OK

Characteristic compressive strength

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

Loading details

Characteristic concentrated dead load

$$G_k = 18 \text{ kN}$$

Characteristic concentrated imposed load

$$Q_k = 2 \text{ kN}$$

Design concentrated load

$$F = (G_k \times 1.4) + (Q_k \times 1.6) = 27.4 \text{ kN}$$

Characteristic distributed dead load

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

Characteristic distributed imposed load

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

Design distributed load

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

Masonry bearing type

Bearing type

Type 1

Bearing safety factor

$$\gamma_{bear} = 1.25$$

Check design bearing without a spreader

Design bearing stress

$$f_{ca} = F / (B \times l_b) + f / t = 2.736 \text{ N/mm}^2$$

Allowable bearing stress

$$f_{cp} = \gamma_{bear} \times f_k / \gamma_m = 2.286 \text{ N/mm}^2$$

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

Spreader details

Length of spreader

$$l_s = 215 \text{ mm}$$

Depth of spreader

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

Edge distance

$$s_{edge} = \max(0 \text{ mm}, x_{edge} - (l_s - B) / 2) = 18 \text{ mm}$$

Spreader bearing type

Bearing type

Type 1

Bearing safety factor

$$\gamma_{bear} = 1.25$$

Check design bearing with a spreader

Loading acts at midpoint of spreader

Design bearing stress

$$f_{ca} = F / (l_s \times t) + f / t = 1.273 \text{ N/mm}^2$$

Allowable bearing stress

$$f_{cp} = \gamma_{bear} \times f_k / \gamma_m = 2.286 \text{ N/mm}^2$$

PASS - Allowable bearing stress exceeds design bearing stress

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

Slenderness ratio

$$h_{ef} / t_{ef} = 24.00$$

Eccentricity at top of wall

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

From BS5628:1 Table 7

Capacity reduction factor

$$\beta = 0.61$$

Length of bearing distributed at $0.4 \times h$

$$l_d = 1135 \text{ mm}$$

Maximum bearing stress

$$f_{ca} = F / (l_d \times t) + f / t = 0.241 \text{ N/mm}^2$$

Allowable bearing stress

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

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

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BM01 MASONRY BEARING SUPPORT B

MASONRY BEARING DESIGN (BS5628)

MASONRY BEARING DESIGN TO BS5628-1:2005

TEDDS calculation version 1.0.08

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

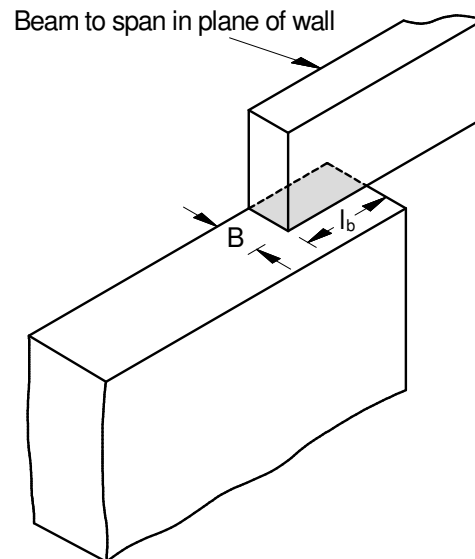
$$\gamma_m = 3.5$$

$$t = 100 \text{ mm}$$

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

$$h = 2400 \text{ mm}$$

$$h_{ef} = 2400 \text{ mm}$$



Bearing details

Beam spanning in plane of wall
Width of bearing
Length of bearing

$$B = 100 \text{ mm}$$

$$l_b = 215 \text{ mm}$$

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)

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

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Height of solid block	$h_{unit} = 215.0 \text{ mm}$	
Least horizontal dimension	$l_{unit} = 100.0 \text{ mm}$	
Block ratio	$ratio = h_{unit} / l_{unit} = 2.2$	Ratio between 0.6 and 4.5 - OK
Characteristic compressive strength	$f_k = 6.40 \text{ N/mm}^2$	
Loading details		
Characteristic concentrated dead load	$G_k = 18 \text{ kN}$	
Characteristic concentrated imposed load	$Q_k = 2 \text{ kN}$	
Design concentrated load	$F = (G_k \times 1.4) + (Q_k \times 1.6) = 27.4 \text{ kN}$	
Characteristic distributed dead load	$g_k = 0.0 \text{ kN/m}$	
Characteristic distributed imposed load	$q_k = 0.0 \text{ kN/m}$	
Design distributed load	$f = (g_k \times 1.4) + (q_k \times 1.6) = 0.0 \text{ kN/m}$	
Masonry bearing type		
Bearing type	Type 1	
Bearing safety factor	$\gamma_{bear} = 1.25$	
Check design bearing without a spreader		
Design bearing stress	$f_{ca} = F / (B \times l_b) + f / t = 1.273 \text{ N/mm}^2$	
Allowable bearing stress	$f_{cp} = \gamma_{bear} \times f_k / \gamma_m = 2.286 \text{ N/mm}^2$	PASS - Allowable bearing stress exceeds design bearing stress
Check design bearing at $0.4 \times h$ below the bearing level		
Slenderness ratio	$h_{ef} / t_{ef} = 24.00$	
Eccentricity at top of wall	$e_x = 0.0 \text{ mm}$	
From BS5628:1 Table 7		
Capacity reduction factor	$\beta = 0.61$	
Length of bearing distributed at $0.4 \times h$	$l_d = 1175 \text{ mm}$	
Maximum bearing stress	$f_{ca} = F / (l_d \times t) + f / t = 0.233 \text{ N/mm}^2$	
Allowable bearing stress	$f_{cp} = \beta \times f_k / \gamma_m = 1.106 \text{ N/mm}^2$	PASS - Allowable bearing stress at $0.4 \times h$ below bearing level exceeds design bearing stress