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STRUCTURAL CALCULATIONS FOR ROOF REPAIRS AT THE FERNS 56 TOWN STREET DUFFIELD DE56 4GG

PREPARED IN ACCORDANCE WITH THE RELEVANT PARTS OF THE FOLLOWING CODES OF PRACTICE:-

BS 6399 LOADINGS FOR BUILDINGS
BS 5950 STRUCTURAL USE OF STEELWORK
BS 5268 STRUCTURAL USE OF TIMBER
BS 5628 USE OF MASONRY

DATE: MAY 2026
REF: A10144

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GENERAL CONSTRUCTION NOTES & GUIDANCE

These notes are generic and it is possible that not all will be relevant for this project.

1. Calculations are not to be used for the purpose of ordering materials and should only be used for Building Regulations submissions. All dimensions should be checked by the contractor on site prior to ordering materials, and fabricating steelwork

2. All steelwork to be mechanically wire brushed and painted with two coats of red oxide primer. Steelwork located in the cavity or below DPC to be suitably protected with 2 coats of bituminous paint.

3. All steelwork connections to use grade 8.8 bolts unless stated otherwise. These are to be spanner tightened using the appropriate podger spanner (min length 460mm) or suitable power tools in accordance with BS2583. If a torque wrench is used the torque applied should be around 90Nm for M16 bolts, 110Nm for M20 & 130Nm for M24.

4. All steel beam-end connections to be as specified in The Green Book. All welds to be minimum 6mm fillet welds unless stated otherwise, or unless Green Book detailing requires otherwise. Hit and miss dimensions of stitch welds to be at detailer's/ fabricator's discretion.

5. All timber to be grade C24 (SC4), unless stated otherwise, and preservative-treated to Architects' specification.

6. AJS sketches, notes, and calculations are to be read in conjunction with the Architects drawings, any inconsistencies between the drawings should be reported to AJS and the Architect, and further instructions taken prior to proceeding further with the work. If any site conditions or existing details are found that may affect the structural design, AJS Structural Design should be notified immediately.
7. For details of fire protection to steelwork, see Architects' drawings.

8. The Contractor is to ensure that all existing construction is adequately supported, using needles and props as required. Where a new beam supports the existing construction, adequate pre-load is to be applied and suitable packs such as driven dry-slate introduced, then pointed up with mortar.

9. All blockwork to be 7.3 N/mm^2 in class III mortar below DPC in accordance with BS 5628:3:2005 or suitable 7.0 N/mm^2 foundation quality blocks in class II mortar in accordance with the manufacturer's instructions. All brickwork below DPC to be Engineering Bricks DPC in accordance with BS 5628:3:2005.

10. Unless noted otherwise on AJS sketches, all new blockwork is to be 7.3 N/mm^2 in class III mortar. All new brickwork is o be 20 N/mm^2 in class III mortar. Colour and surface texture of facing brickwork to be to the architect's specification.

11. All construction products should be CE marked in accordance current legislation. This includes all fabricated structural steelwork in accordance with BS EN 1090-1 and BS EN 1090-2. The consequence class is CC2 unless noted otherwise. The service class is SC1 for all buildings, SC2 for all lifting beams, sculptures & fall arrest systems. Production category will be PC1 unless noted otherwise. All site welded items, S355 steelwork & CHS lattice girders will be PC2. As such the execution class for buildings will be EXC2.

12. Consider foundation depth on shrinkable clays and to avoid future problems, increase the depth above standard requirements if there is a risk. This should be in accordance with the NHBC Standards, Chapter 4.2 Guidance on Building near Trees. If the calculations do not specifically design the depths of the foundations to take into account any local trees, then this should be checked and agreed with the Building Inspector on site.

13. If part of the work is adjacent to the boundary, the adjacent neighbour's right to support could be affected; the issues associated with Party Wall Act 1996 may need to be considered. This may include providing information to the adjoining owner, giving sufficient notice of works in compliance with the Act. If the following list applies to this project then the Party Wall Act will apply;
    - installing a new beam into the shared wall between properties,
    - demolishing, building or under-pinning an existing shared wall,
    - building a new wall at or on the boundary or junction of two properties,
    - damp-proofing all the way through a party wall, or
    - digging foundations that are within 3m of a Party Wall, where the new foundations are deeper than the existing.

14. All new foundations to be taken down into natural soil stratum with a minimum bearing capacity = 100kN/m^2 Depths of all new foundations and bearing strata to be approved by Building Control prior to placing concrete. Foundations may need to be taken deeper to account for the influence of nearby trees. Refer to note 11 above.
    New foundation concrete to be min grade C25, unless noted otherwise.
    Where new or existing pipe runs are required to pass through new foundations these are to be suitably sleeved.

15. Where new timber joists are supported off new cavity work outer walls via joist hangers, the hangers should be of the 'restraint-type' as Building Regulations Part A Clause 2C35 (b), and diagram 15(c) e.g Expamet SPH Type 'R' (or similar)
    Where new timber joists span parallel to new cavity work outer walls, the walls are to be restrained via Expamet M305 (or similar) tension straps and timber noggins as Building Regulations Part A Clause 2C35 and Diagram 15(b).
    Gable walls to be restrained at roof level via Expamet M305 (or similar) tension straps as Building Regulations Part A Clause 2C36 and Diagram 16(b)

16. **Construction (Design and Management) Regulation 2015**
    Although private domestic projects do not require notification under the Construction (Design and Management) Regulation 2015 the designer(s) and the contractor are still required to assess risks to health and safety, and to design and construct the works accordingly.
    Heavy structural elements
    The contractor is to give due consideration to the placement of heavy structural elements such as steel beams and/or concrete lintels to ensure a safe method of lifting and placement. Suitable mechanical lifting equipment is to be utilised wherever possible. Responsibility for the safe execution of this work lies with the Contractor.
    Splice details for long-span beams can often be provided upon request.
    Temporary support works
    The existing construction will require temporary propping of walls, floors, roofs etc. to facilitate installation of some of the lintels, and beams. The adequacy of the design, installation, (including sequence), maintenance, and removal (including sequence) of all temporary support works remains the sole responsibility of the contractor. Temporary support works must not be removed before the installation of the new structure has been completed, and has gained adequate strength.
    Demolition
    The contractor is to give due consideration to the stability of residual existing construction during and following demolition works, and temporary support works are to be installed as necessary. The adequacy of the design, installation, (including sequence), maintenance, and removal (including sequence) of all temporary support works remains the sole responsibility of the contractor. Temporary support works must not be removed before the installation of the new structure has been completed, and has gained adequate strength.
    Where walls assumed to be non-loadbearing are to be removed the contractor is nonetheless to carefully check that no structural element is taking support off the wall. If necessary further advice is to be sought from AJS prior to proceeding with demolition.
    Excavation
    The sides of excavations in which operatives are required to work are to be adequately supported. The adequacy of the design, installation, (including sequence), maintenance, and removal (including sequence) of all temporary support works remain the sole responsibility of the contractor. Temporary support works must not be removed before the installation of the new structure has been completed, and has gained adequate strength.
    The contractor is to check that no excavation will undermine adjacent structures. If it is found that an adjacent structure will be undermined by excavation works, then excavation is to cease immediately. The matter is to be reported to AJS, and the architect, and further advice is to be taken prior to proceeding further.
    Buried services
    The locations of buried services are shown on the architect's/AJS drawings where known. The completeness and accuracy of this information MUST NOT be assumed. The contractor is to carefully locate, and protect ALL services prior to the commencement of the site works. Where services are to be removed, the contractor is to ensure that these have been safely isolated prior to commencing removal.
    Asbestos
    The discovery of asbestos is to be reported to the architect immediately upon discovery. The contractor MUST NOT attempt to remove this material. The material must only be removed by a licensed specialist contractor.

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GENERAL LOADINGS

PITCHED ROOF		SUPER	= 0.6 x (60-40)/30 = **0.40 kN/m², 0.75 kN/m²** in valley
		DEAD	= 0.9kN/m² / cos 40 = **1.18 kN/m²**
FLAT ROOF		SUPER	= **0.75 kN/m²**
		DEAD	= **0.9 kN/m²**
CEILINGS		SUPER	= **0.25 kN/m²** + **0.9kN** point load
		DEAD	= **0.75 kN/m²**
WALLS	DEAD:	TIMBER STUD	0.2 kN/m²
		100 BRW	2.2 kN/m²
		100 BLW	1.4 kN/m²
		140 BLW	1.96 kN/m²
		PLASTER/RENDER	0.2 kN/m²

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RAFTERS (GENERAL)

TIMBER RAFTER DESIGN (BS5268-2:2002)

Rafter details

Breadth of timber sections	b = **50** mm
Depth of timber sections	h = **75** mm
Rafter spacing	s = **420** mm
Rafter slope	α = **40.0** deg
Clear span of rafter on horizontal	L_{clh} = **1100** mm
Clear span of rafter on slope	$L_{cl} = L_{clh} / \cos(\alpha)$ = **1436** mm
Rafter span	**Single span**
Timber strength class	**C24**

Section properties

Cross sectional area of rafter	$A = b \times h$ = **3750** mm^2
Section modulus	$Z = b \times h^2 / 6$ = **46875** mm^3
Second moment of area	$I = b \times h^3 / 12$ = **1757812** mm^4
Radius of gyration	$r = \sqrt{(I / A)}$ = **21.7** mm

Loading details

Rafter self weight	$F_j = b \times h \times \rho_{char} \times g_{acc}$ = **0.01** kN/m
Dead load on slope	F_d = **0.90** kN/m^2
Imposed load on plan	F_u = **0.60** kN/m^2
Imposed point load	F_p = **0.90** kN

Modification factors

Section depth factor	$K_7 = (300 \text{ mm} / h)^{0.11}$ = **1.16**
Load sharing factor	K_8 = **1.10**

Consider long term load condition

Load duration factor	K_3 = **1.00**
Total UDL perpendicular to rafter	$F = F_d \times \cos(\alpha) \times s + F_j \times \cos(\alpha)$ = **0.299** kN/m
Notional bearing length	$L_b = F \times L_{cl} / [2 \times (b \times \sigma_{cp1} \times K_8 - F)]$ = **2** mm
Effective span	$L_{eff} = L_{cl} + L_b$ = **1438** mm

Check bending stress

Bending stress parallel to grain	σ_m = **7.500** N/mm^2
Permissible bending stress	$\sigma_{m_adm} = \sigma_m \times K_3 \times K_7 \times K_8$ = **9.609** N/mm^2
Applied bending stress	$\sigma_{m_max} = F \times L_{eff}^2 / (8 \times Z)$ = **1.650** N/mm^2

PASS - Applied bending stress within permissible limits

Check compressive stress parallel to grain

Compression stress parallel to grain	σ_c = **7.900** N/mm^2
Minimum modulus of elasticity	E_{min} = **7200** N/mm^2
Compression member factor	K_{12} = **0.62**
Permissible compressive stress	$\sigma_{c_adm} = \sigma_c \times K_3 \times K_8 \times K_{12}$ = **5.395** N/mm^2
Applied compressive stress	$\sigma_{c_max} = F \times L_{eff} \times (\cot(\alpha) + 3 \times \tan(\alpha)) / (2 \times A)$ = **0.213** N/mm^2

PASS - Applied compressive stress within permissible limits

Check combined bending and compressive stress parallel to grain

Euler stress	$\sigma_e = \pi^2 \times E_{min} / \lambda^2$ = **16.118** N/mm^2
Euler coefficient	$K_{eu} = 1 - (1.5 \times \sigma_{c_max} \times K_{12} / \sigma_e)$ = **0.988**
Combined axial compression and bending check	$\sigma_{m_max} / (\sigma_{m_adm} \times K_{eu}) + \sigma_{c_max} / \sigma_{c_adm}$ = **0.213** **< 1**

PASS - Combined compressive and bending stresses are within permissible limits

Check shear stress

Shear stress parallel to grain — τ = **0.710** N/mm²

Permissible shear stress — $\tau_{adm} = \tau \times K_3 \times K_8$ = **0.781** N/mm²

Applied shear stress — $\tau_{max} = 3 \times F \times L_{eff} / (4 \times A)$ = **0.086** N/mm²

PASS - Applied shear stress within permissible limits

Check deflection

Permissible deflection — $\delta_{adm} = 0.003 \times L_{eff}$ = **4.313** mm

Bending deflection — $\delta_b = 5 \times F \times L_{eff}^4 / (384 \times E_{mean} \times I)$ = **0.877** mm

Shear deflection — $\delta_s = 12 \times F \times L_{eff}^2 / (5 \times E_{mean} \times A)$ = **0.037** mm

Total deflection — $\delta_{max} = \delta_b + \delta_s$ = **0.914** mm

PASS - Total deflection within permissible limits

Consider medium term load condition

Load duration factor — K_3 = **1.25**

Total UDL perpendicular to rafter — $F = [F_u \times \cos(\alpha)^2 + F_d \times \cos(\alpha)] \times s + F_j \times \cos(\alpha)$ = **0.447** kN/m

Notional bearing length — $L_b = F \times L_{cl} / [2 \times (b \times \sigma_{cp1} \times K_8 - F)]$ = **2** mm

Effective span — $L_{eff} = L_{cl} + L_b$ = **1438** mm

Check bending stress

Bending stress parallel to grain — σ_m = **7.500** N/mm²

Permissible bending stress — $\sigma_{m_adm} = \sigma_m \times K_3 \times K_7 \times K_8$ = **12.011** N/mm²

Applied bending stress — $\sigma_{m_max} = F \times L_{eff}^2 / (8 \times Z)$ = **2.468** N/mm²

PASS - Applied bending stress within permissible limits

Check compressive stress parallel to grain

Compression stress parallel to grain — σ_c = **7.900** N/mm²

Minimum modulus of elasticity — E_{min} = **7200** N/mm²

Compression member factor — K_{12} = **0.58**

Permissible compressive stress — $\sigma_{c_adm} = \sigma_c \times K_3 \times K_8 \times K_{12}$ = **6.330** N/mm²

Applied compressive stress — $\sigma_{c_max} = F \times L_{eff} \times (\cot(\alpha) + 3 \times \tan(\alpha)) / (2 \times A)$ = **0.318** N/mm²

PASS - Applied compressive stress within permissible limits

Check combined bending and compressive stress parallel to grain

Euler stress — $\sigma_e = \pi^2 \times E_{min} / \lambda^2$ = **16.100** N/mm²

Euler coefficient — $K_{eu} = 1 - (1.5 \times \sigma_{c_max} \times K_{12} / \sigma_e)$ = **0.983**

Combined axial compression and bending check — $\sigma_{m_max} / (\sigma_{m_adm} \times K_{eu}) + \sigma_{c_max} / \sigma_{c_adm}$ = **0.259** **< 1**

PASS - Combined compressive and bending stresses are within permissible limits

Check shear stress

Shear stress parallel to grain — τ = **0.710** N/mm²

Permissible shear stress — $\tau_{adm} = \tau \times K_3 \times K_8$ = **0.976** N/mm²

Applied shear stress — $\tau_{max} = 3 \times F \times L_{eff} / (4 \times A)$ = **0.129** N/mm²

PASS - Applied shear stress within permissible limits

Check deflection

Permissible deflection — $\delta_{adm} = 0.003 \times L_{eff}$ = **4.315** mm

Bending deflection — $\delta_b = 5 \times F \times L_{eff}^4 / (384 \times E_{mean} \times I)$ = **1.313** mm

Shear deflection — $\delta_s = 12 \times F \times L_{eff}^2 / (5 \times E_{mean} \times A)$ = **0.055** mm

Total deflection — $\delta_{max} = \delta_b + \delta_s$ = **1.368** mm

PASS - Total deflection within permissible limits

Consider short term load condition

Load duration factor — K_3 = **1.50**

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Total UDL perpendicular to rafter	$F = F_d \times \cos(\alpha) \times s + F_j \times \cos(\alpha)$ = **0.299** kN/m
Notional bearing length	$L_b = [F \times L_{cl} + F_p \times \cos(\alpha)] / [2 \times (b \times \sigma_{cp1} \times K_8 - F)]$ = **4** mm
Effective span	$L_{eff} = L_{cl} + L_b$ = **1440** mm

Check bending stress

Bending stress parallel to grain	σ_m = **7.500** N/mm^2
Permissible bending stress	$\sigma_{m_adm} = \sigma_m \times K_3 \times K_7 \times K_8$ = **14.414** N/mm^2
Applied bending stress	$\sigma_{m_max} = F \times L_{eff}^2/(8 \times Z) + F_p \times \cos(\alpha) \times L_{eff}/(4 \times Z)$ = **6.952** N/mm^2

PASS - Applied bending stress within permissible limits

Check compressive stress parallel to grain

Compression stress parallel to grain	σ_c = **7.900** N/mm^2
Minimum modulus of elasticity	E_{min} = **7200** N/mm^2
Compression member factor	K_{12} = **0.54**
Permissible compressive stress	$\sigma_{c_adm} = \sigma_c \times K_3 \times K_8 \times K_{12}$ = **7.096** N/mm^2
Applied compressive stress	$\sigma_{c_max} = F \times L_{eff} \times (\cot(\alpha) + 3 \times \tan(\alpha))/(2 \times A) + F_p \times \sin(\alpha)/A$ = **0.368** N/mm^2

PASS - Applied compressive stress within permissible limits

Check combined bending and compressive stress parallel to grain

Euler stress	$\sigma_e = \pi^2 \times E_{min} / \lambda^2$ = **16.059** 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	$\sigma_{m_max} / (\sigma_{m_adm} \times K_{eu}) + \sigma_{c_max} / \sigma_{c_adm}$ = **0.543 < 1**

PASS - Combined compressive and bending stresses are within permissible limits

Check shear stress

Shear stress parallel to grain	τ = **0.710** N/mm^2
Permissible shear stress	$\tau_{adm} = \tau \times K_3 \times K_8$ = **1.172** N/mm^2
Applied shear stress	$\tau_{max} = 3 \times F \times L_{eff} / (4 \times A) + 3 \times F_p \times \cos(\alpha) / (2 \times A)$ = **0.362** N/mm^2

PASS - Applied shear stress within permissible limits

Check deflection

Permissible deflection	$\delta_{adm} = 0.003 \times L_{eff}$ = **4.321** mm
Bending deflection	$\delta_b = L_{eff}^3 \times (5 \times F \times L_{eff} / 384 + F_p \times \cos(\alpha)/ 48) / (E_{mean} \times I)$ = **3.144** mm
Shear deflection	$\delta_s = 12 \times L_{eff} \times (F \times L_{eff} + 2 \times F_p \times \cos(\alpha))/(5 \times E_{mean} \times A)$ = **0.154** mm
Total deflection	$\delta_{max} = \delta_b + \delta_s$ = **3.298** mm

PASS - Total deflection within permissible limits

USE MIN 75mm x 50mm C24 RAFTERS AT ~420mm CENTRES.

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CEILING JOISTS (GENERAL)

TIMBER JOIST DESIGN (BS5268-2:2002)

Joist details

Joist breadth	b = **50** mm
Joist depth	h = **100** mm
Joist spacing	s = **420** mm
Timber strength class	**C24**
Service class of timber	**1**

Span details

Number of spans	N_{span} = **1**
Length of bearing	L_b = **100** mm
Effective length of span	L_{s1} = **2100** mm

Section properties

Second moment of area	$I = b \times h^3 / 12$ = **4166667** mm^4
Section modulus	$Z = b \times h^2 / 6$ = **83333** mm^3

Loading details

Joist self weight	$F_{swt} = b \times h \times \rho_{char} \times g_{acc}$ = **0.02** kN/m
Dead load	F_{d_udl} = **0.75** kN/m^2
Imposed UDL(Long term)	F_{i_udl} = **0.25** kN/m^2
Imposed point load (Medium term)	F_{i_pt} = **0.90** 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 = **1.13**
Load sharing factor	K_8 = **1.10**

Consider long term loads

Load duration factor	K_3 = **1.00**
Maximum bending moment	M = **0.241** kNm
Maximum shear force	V = **0.459** kN
Maximum support reaction	R = **0.459** kN
Maximum deflection	δ = **2.546** mm

Check bending stress

Bending stress	σ_m = **7.500** N/mm^2
Permissible bending stress	$\sigma_{m_adm} = \sigma_m \times K_{2m} \times K_3 \times K_7 \times K_8$ = **9.310** N/mm^2
Applied bending stress	$\sigma_{m_max} = M / Z$ = **2.892** N/mm^2

PASS - Applied bending stress within permissible limits

Check shear stress

Shear stress	τ = **0.710** N/mm^2
Permissible shear stress	$\tau_{adm} = \tau \times K_{2s} \times K_3 \times K_8$ = **0.781** N/mm^2
Applied shear stress	$\tau_{max} = 3 \times V / (2 \times b \times h)$ = **0.138** N/mm^2

PASS - Applied shear stress within permissible limits

Check bearing stress

Compression perpendicular to grain (no wane)	σ_{cp1} = **2.400** N/mm^2
Permissible bearing stress	$\sigma_{c_adm} = \sigma_{cp1} \times K_{2c} \times K_3 \times K_8$ = **2.640** N/mm^2

Applied bearing stress	$\sigma_{c_max} = R / (b \times L_b) =$ **0.092** N/mm²

PASS - Applied bearing stress within permissible limits

Check deflection

Permissible deflection	$\delta_{adm} = \min(L_{s1} \times 0.003, 14\ mm) =$ **6.300** mm
Bending deflection (based on E_{mean})	$\delta_{bending} =$ **2.460** mm
Shear deflection	$\delta_{shear} =$ **0.086** mm
Total deflection	$\delta = \delta_{bending} + \delta_{shear} =$ **2.546** mm

PASS - Actual deflection within permissible limits

Consider medium term loads

Load duration factor	$K_3 =$ **1.25**
Maximum bending moment	M = **0.656** kNm
Maximum shear force	V = **1.249** kN
Maximum support reaction	R = **1.249** kN
Maximum deflection	$\delta =$ **5.961** mm

Check bending stress

Bending stress	$\sigma_m =$ **7.500** N/mm²
Permissible bending stress	$\sigma_{m_adm} = \sigma_m \times K_{2m} \times K_3 \times K_7 \times K_8 =$ **11.637** N/mm²
Applied bending stress	$\sigma_{m_max} = M / Z =$ **7.867** N/mm²

PASS - Applied bending stress within permissible limits

Check shear stress

Shear stress	$\tau =$ **0.710** N/mm²
Permissible shear stress	$\tau_{adm} = \tau \times K_{2s} \times K_3 \times K_8 =$ **0.976** N/mm²
Applied shear stress	$\tau_{max} = 3 \times V / (2 \times b \times h) =$ **0.375** N/mm²

PASS - Applied shear stress within permissible limits

Check bearing stress

Compression perpendicular to grain (no wane)	$\sigma_{cp1} =$ **2.400** N/mm²
Permissible bearing stress	$\sigma_{c_adm} = \sigma_{cp1} \times K_{2c} \times K_3 \times K_8 =$ **3.300** N/mm²
Applied bearing stress	$\sigma_{c_max} = R / (b \times L_b) =$ **0.250** N/mm²

PASS - Applied bearing stress within permissible limits

Check deflection

Permissible deflection	$\delta_{adm} = \min(L_{s1} \times 0.003, 14\ mm) =$ **6.300** mm
Bending deflection (based on E_{mean})	$\delta_{bending} =$ **5.728** mm
Shear deflection	$\delta_{shear} =$ **0.233** mm
Total deflection	$\delta = \delta_{bending} + \delta_{shear} =$ **5.961** mm

PASS - Actual deflection within permissible limits

USE MIN 100mm x 50mm C24 CEILING JOISTS AT ~420mm CENTRES.

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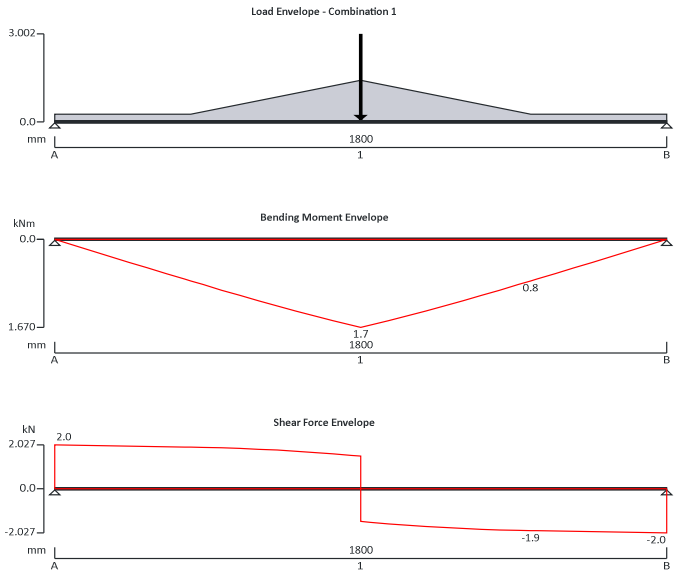
① BEAM SUPPORTING PURLIN OVER STAIRS

Clear span ~ 1.8m
Loaded area of purlin ~ ¼ x 3.5m x ½ x 3.0m = 1.31m^2

Dead roof UDL ~ 1.31m^2 x 1.18kNm^2 = 1.55kN
Imposed roof UDL ~ 1.31m^2 x 0.4kN/m^2 = 0.52kN
Height of brickwork over ~5no courses = 375mm
VDL$_{max}$ ~ 0.375m x 0.1m x 22kN/m^3 = 0.83kN/m

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	Dead self weight of beam × 1
	Dead point load 1.55 kN at 900 mm
	Imposed point load 0.52 kN at 900 mm
	Dead partial VDL 0 kN/m at 400 mm to 0.83 kN/m at 900 mm
	Dead partial VDL 0.83 kN/m at 900 mm to 0 kN/m at 1400 mm

Load combinations

Load combination 1	Dead × 1.40	Imposed × 1.60

Analysis results

Maximum moment	M_{max} = **1.7** kNm	M_{min} = **0** kNm
Maximum shear	V_{max} = **2** kN	V_{min} = **-2** kN
Deflection	δ_{max} = **0.1** mm	δ_{min} = **0** mm
Maximum reaction at support A	R_{A_max} = **2** kN	R_{A_min} = **2** kN

Unfactored dead load reaction at support A	R_{A_Dead} = **1.2** kN	
Unfactored imposed load reaction at support A	$R_{A_Imposed}$ = **0.3** kN	
Maximum reaction at support B	R_{B_max} = **2** kN	R_{B_min} = **2** kN
Unfactored dead load reaction at support B	R_{B_Dead} = **1.2** kN	
Unfactored imposed load reaction at support B	$R_{B_Imposed}$ = **0.3** kN	

Section details

Section type **UB 178x102x19 (British Steel Section Range 2022 (BS4-1))** Steel grade **S355**

Classification of cross sections - Section 3.5

Tensile strain coefficient ε = **0.88** Section classification **Plastic**

Shear capacity - Section 4.2.3

Design shear force F_v = **2** kN Design shear resistance P_v = **181.8** kN

PASS - Design shear resistance exceeds design shear force

Moment capacity - Section 4.2.5

Design bending moment M = **1.7** kNm Moment capacity low shear M_c = **60.8** kNm

Buckling resistance moment - Section 4.3.6.4

Buckling resistance moment M_b = **43.8** kNm M_b / m_{LT} = **51** 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 δ_{lim} = **5** mm Maximum deflection δ = **0.117** mm

PASS - Maximum deflection does not exceed deflection limit

USE MIN UB178x102x19 (S355).

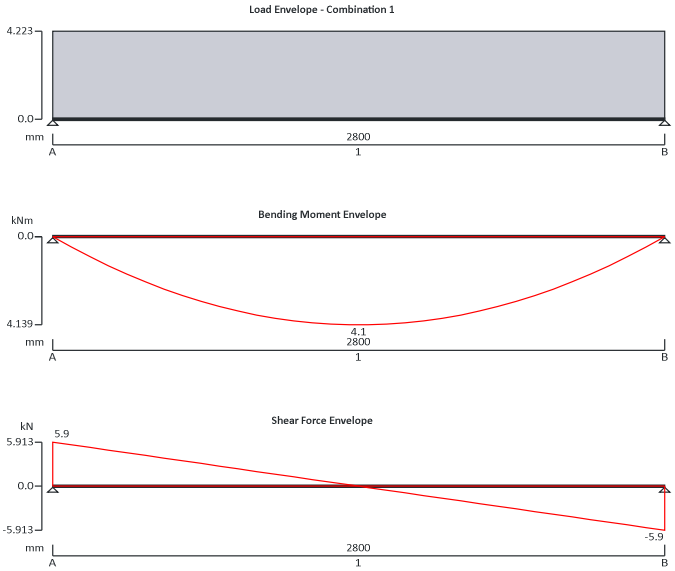
② SUPPORT TO VALLEY BEAM

Clear span ~ 2.8m
Loaded width of valley beam ~ ¼ x 3.5m = 0.75m

Dead pitched roof UDL ~ 0.75m x 1.18kNm^2 = 0.89kN/m
Imposed pitched roof UDL ~ 0.75m x 0.75kN/m^2 = 0.56kN/m
Build up ~ 0.5m packing masonry ~ 0.5m x (2.2+ 0.4)kN/m^2 = 1.3kN/m

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	Dead self weight of beam × 1
	Dead full UDL 0.89 kN/m
	Imposed full UDL 0.56 kN/m
	Dead full UDL 1.3 kN/m

Load combinations

Load combination 1	Dead × 1.40	Imposed × 1.60

Analysis results

Maximum moment	M_{max} = **4.1** kNm	M_{min} = **0** kNm
Maximum shear	V_{max} = **5.9** kN	V_{min} = **-5.9** kN
Deflection	δ_{max} = **0.8** mm	δ_{min} = **0** mm
Maximum reaction at support A	R_{A_max} = **5.9** kN	R_{A_min} = **5.9** kN
Unfactored dead load reaction at support A	R_{A_Dead} = **3.3** kN	
Unfactored imposed load reaction at support A	$R_{A_Imposed}$ = **0.8** kN	

Maximum reaction at support B — R_{B_max} = **5.9** kN — R_{B_min} = **5.9** kN
Unfactored dead load reaction at support B — R_{B_Dead} = **3.3** kN
Unfactored imposed load reaction at support B — $R_{B_Imposed}$ = **0.8** kN

Section details

Section type **UB 178x102x19 (British Steel Section Range 2022 (BS4-1))** Steel grade **S355**

Classification of cross sections - Section 3.5

Tensile strain coefficient ε = **0.88** Section classification **Plastic**

Shear capacity - Section 4.2.3

Design shear force F_v = **5.9** kN Design shear resistance P_v = **181.8** kN

PASS - Design shear resistance exceeds design shear force

Moment capacity - Section 4.2.5

Design bending moment M = **4.1** kNm Moment capacity low shear M_c = **60.8** kNm

Buckling resistance moment - Section 4.3.6.4

Buckling resistance moment M_b = **30.3** kNm M_b / m_{LT} = **32.8** 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 δ_{lim} = **7.778** mm Maximum deflection δ = **0.846** mm

PASS - Maximum deflection does not exceed deflection limit

USE MIN UB178x102x19 (S355).

③ SUPPORT TO CEILING BINDER ON CHIMNEY BREAST

Loaded area of ceiling to binder bearing ~ ¼ x 3.5m x 3.5m = 3.06m^2

Dead ceiling reaction ~ 3.06m^2 x 0.75kNm^2 = 2.3kN, 3.2kN factored
Imposed roof UDL ~ 3.06m^2 x 0.25kN/m^2 = 0.77kN, 1.2kN factored

Input data

Design method	Design Method ETAG029
Base material	common brickwork, 5.8N/mm^2 Mortar strength M2.5 - M9, Joints visible and filled
Drilling method	Hammer drilling or rotary drilling with carbide drill bit
Installation type	Pre-positioned installation
Type of loading	Permanent-Transient/Static
Sigma D	σ_D = 1.0 N/mm²
Installation condition	dry/dry
Base plate location	Base plate flush installed on base material
Base plate geometry	200 mm x 200 mm x 10 mm
Profile type	None

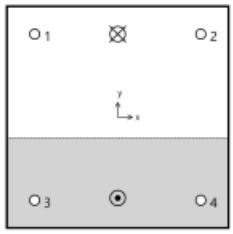
Design actions *)

#	N_{Sd} kN	$V_{Sd,x}$ kN	$V_{Sd,y}$ kN	$M_{Sd,x}$ kNm	$M_{Sd,y}$ kNm	$M_{T,Sd}$ kNm	Type of loading
1	0.00	0.00	-4.40	0.20	0.00	0.00	Permanent-Transient/Static

*) The required partial safety factors for actions are included

Resulting anchor forces

Anchor no.	Tensile action kN	Shear Action kN	Shear Action x kN	Shear Action y kN
1	0.68	1.10	0.00	-1.10
2	0.68	1.10	0.00	-1.10
3	0.00	1.10	0.00	-1.10
4	0.00	1.10	0.00	-1.10



Resulting tensile actions : 1.4 kN , X/Y position (0 / 75)
Resulting compression actions : 1.4 kN , X/Y position (0 / -73)

Resistance to tension loads

Proof	Action kN	Capacity kN	Utilisation β_N %
Steel failure [1]	0.7	30.7	2.2
Pullout failure [1]	0.7	1.8	**37.5**
Brick breakout single anchor [1]	0.7	1.8	37.5
Brick breakout anchor group	1.4	3.6	37.5
Pull-out of one brick	1.4	17.1	7.9

[1] Most unfavourable anchor

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Installation data

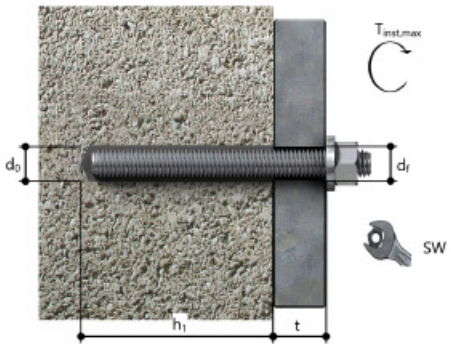
Anchor

Anchor system	**fischer Injection system FIS V Plus for masonry**	
Injection resin	FIS V Plus 360 S (other cartridge sizes available)	Art.-No. 558746
Fixing element	Threaded rod FIS A M 10 x 130 8.8, zinc plated steel, Property Class 8.8	Art.-No. 519478
Accessories	FIS MR Plus	Art.-No. 545853
	FIS DM S Pro	Art.-No. 563337
	SDS Plus-V II 12/110/160	Art.-No. 531803
Alternative cartridges	FIS VS Plus 300 T The shown cartridges are alternative to the highlighted one above with the same approval number.	Art.-No. 563280



Installation details

Thread diameter	M 10
Drill hole diameter	d_0 = 12 mm
Drill hole depth	h_1 = 50 mm
Calculated anchorage depth	h_{ef} = 50.00 mm
Drilling method	Hammer drilling or rotary drilling with carbide drill bit
Installation type	Pre-positioned installation
Installation torque	$T_{inst,max}$ = 10.0 Nm
Socket size	17 mm
Socket size	17 mm
Base plate thickness	t = 10 mm
Total fixing thickness	t_{fix} = 10 mm
Tfix,max	



USE 4no M10 8.8g RESIN-FIXED STUDS w/ FISCHER FIS V PLUS 360 S RESIN AND MIN 50mm EFFECTIVE EMBEDMENT, FIXING MIN 200mm-LONG SECTION OF UKA200x100x10 (S275) SHELF ANGLE TO BRICKWORK, TIGHT TO UNDERSIDE OF FIRM CEILING BINDER TIMBER.

DRILL EXTRA OFFSET HOLES IN SHELF ANGLE IN ORDER TO ALIGN STUDS WITH CENTRES OF BRICKS.

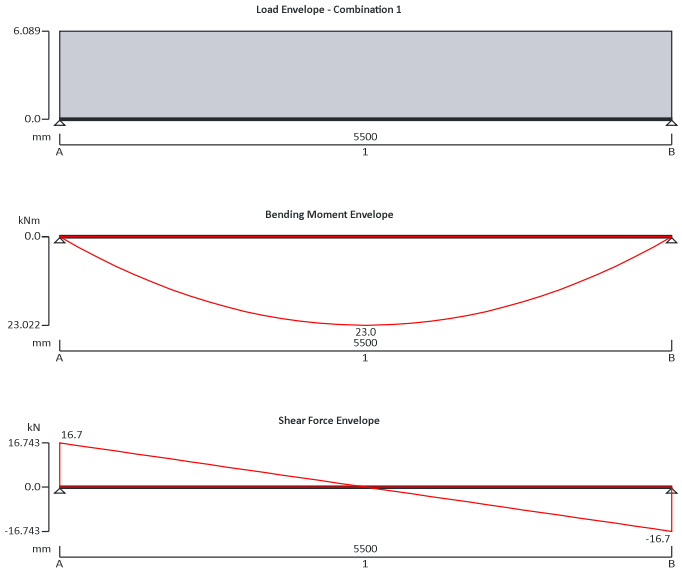
⑤ RIDGE BEAM IN ANNEXE

Clear span ~ 5.5m
Loaded width of valley beam ~ ½ x 5m = 2.5m

Dead pitched roof UDL ~ 2.5m x 1.18kNm^2 = 3.96kN/m
Imposed pitched roof UDL ~ 2.5m x 0.4kN/m^2 = 1.0kN/m

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	Dead self weight of beam × 1
	Dead full UDL 2.96 kN/m
	Imposed full UDL 1 kN/m

Load combinations

Load combination 1	Dead × 1.40	× 1.60

Analysis results

Maximum moment	M_{max} = **23** kNm	M_{min} = **0** kNm
Maximum shear	V_{max} = **16.7** kN	V_{min} = **-16.7** kN
Deflection	δ_{max} = **2.5** mm	δ_{min} = **0** mm
Maximum reaction at support A	R_{A_max} = **16.7** kN	R_{A_min} = **16.7** kN
Unfactored dead load reaction at support A	R_{A_Dead} = **8.8** kN	
Unfactored imposed load reaction at support A	$R_{A_Imposed}$ = **2.7** kN	
Maximum reaction at support B	R_{B_max} = **16.7** kN	R_{B_min} = **16.7** kN

Unfactored dead load reaction at support B R_{B_Dead} = **8.8** kN
Unfactored imposed load reaction at support B $R_{B_Imposed}$ = **2.8** kN

Section details

Section type **UB 203x133x25 (British Steel Section Range 2022 (BS4-1))** Steel grade **S355**

Classification of cross sections - Section 3.5

Tensile strain coefficient ε = **0.88** Section classification **Compact**

Shear capacity - Section 4.2.3

Design shear force F_v = **16.7** kN Design shear resistance P_v = **246.7** kN

PASS - Design shear resistance exceeds design shear force

Moment capacity - Section 4.2.5

Design bending moment M = **23** kNm Moment capacity low shear M_c = **91.5** kNm

Buckling resistance moment - Section 4.3.6.4

Buckling resistance moment M_b = **28.9** kNm M_b / m_{LT} = **31.3** kNm

PASS - Buckling resistance moment exceeds design bending moment

Check vertical deflection - Section 2.5.2

Consider deflection due to imposed loads

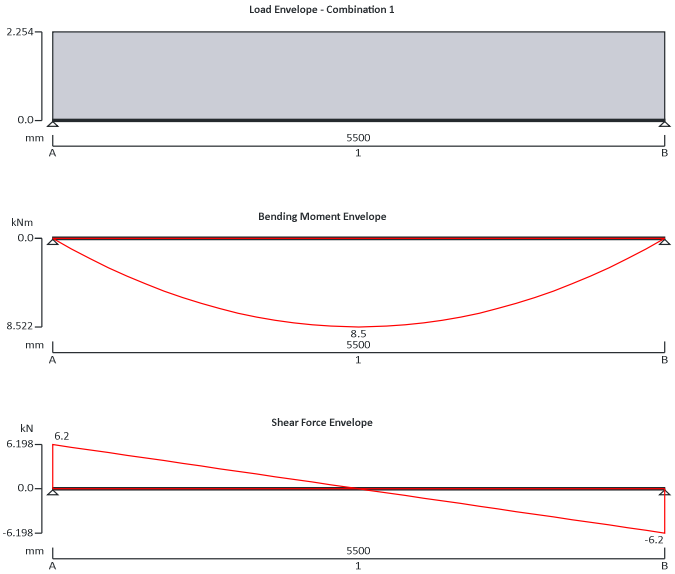
Limiting deflection δ_{lim} = **15.278** mm Maximum deflection δ = **2.484** mm

PASS - Maximum deflection does not exceed deflection limit

USE MIN UB203x133x25 (S355).

⑥ SUPPLEMENTARY PURLIN IN ANNEXE

FLITCH BEAM ANALYSIS & DESIGN TO BS5268-2:2002



Applied loading

Beam loads

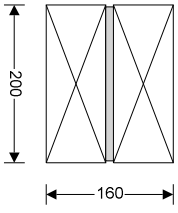
Dead self weight of beam × 1
Dead full UDL 1.480 kN/m
Imposed full UDL 0.500 kN/m

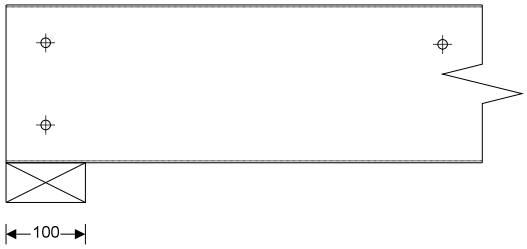
Load combinations

Load combination 1	Dead × 1.00	Imposed × 1.00

Analysis results

Maximum moment	M_{max} = **8.522** kNm	M_{min} = **0.000** kNm
Design moment	M = max(abs(M_{max}),abs(M_{min})) = **8.522** kNm	
Maximum shear	F_{max} = **6.198** kN	F_{min} = **-6.198** kN
Design shear	F = max(abs(F_{max}),abs(F_{min})) = **6.198** kN	
Total load on beam	W_{tot} = **12.395** kN	
Reactions at support A	R_{A_max} = **6.198** kN	R_{A_min} = **6.198** kN
Unfactored dead load reaction at support A	R_{A_Dead} = **4.823** kN	
Unfactored imposed load reaction at support A	$R_{A_Imposed}$ = **1.375** kN	
Reactions at support B	R_{B_max} = **6.198** kN	R_{B_min} = **6.198** kN
Unfactored dead load reaction at support B	R_{B_Dead} = **4.823** kN	
Unfactored imposed load reaction at support B	$R_{B_Imposed}$ = **1.375** kN	





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Timber section details

Breadth of timber sections	b = **75** mm
Depth of timber sections	h = **200** mm
Number of timber sections in member	N = **2**
Timber strength class	**C24**

Steel section details

Breadth of steel plate	b_s = **10** mm
Depth of steel plate	h_s = **195** mm
Number of steel plates in beam	N_s = **1**
Steel stress	p_y = **165** N/mm^2
Bolt diameter	ϕ_b = **12** mm

Member details

Service class of timber	**1**
Load duration	**Long term**
Length of span	L_{s1} = **5500** mm
Length of bearing	L_b = **100** mm

Section properties

Cross sectional area of beam	$A = N \times b \times h$ = **30000** mm^2
Timber section modulus	$Z_{xt} = N \times b \times h^2 / 6$ = **1000000** mm^3
Steel section modulus	$Z_{xs} = N_s \times b_s \times h_s^2 / 6$ = **63375** mm^3
Second moment of area of timber	$I_{xt} = N \times b \times h^3 / 12$ = **100000000** mm^4
Second moment of area of steel	$I_{xs} = N_s \times b_s \times h_s^3 / 12$ = **6179062** mm^4

Load proportions

Instant deflection under permanent actions	u_{instG} = **8.904** mm
Instant deflection under principal variable action	u_{instQ1} = **2.539** mm
	k_{def} = **0.6**
	ψ_2 = **0.3**

Final minimum modulus of elasticity

$$E_{min,fin} = E_{min} \times (u_{instG} + u_{instQ1}) / (u_{instG} + u_{instQ1} + k_{def} \times (u_{instG} + \psi_2 \times u_{instQ1})) = \mathbf{4778}\ \text{N/mm}^2$$

Proportion of applied load in timber	$k_t = E_{mean} \times I_{xt} / (E_{mean} \times I_{xt} + E_{S5950} \times I_{xs})$ = **0.460**
Proportion of applied load in steel	$k_s = 1.1 \times E_{S5950} \times I_{xs} / (E_{min,fin} \times I_{xt} + E_{S5950} \times I_{xs})$ = **0.799**

Modification factors

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

Lateral support - cl.2.10.8

No lateral support	
Permissible depth-to-breadth ratio - Table 19	**2.00**
Actual depth-to-breadth ratio	$h / (N \times b + N_s \times b_s)$ = **1.25**

PASS - Lateral support is adequate

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/mm^2
Applied bearing stress	$\sigma_{c_a} = R_{B_max} / (N \times b \times L_b)$ = **0.413** N/mm^2
	$\sigma_{c_a} / \sigma_{c_adm}$ = **0.172**

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 timber bending stress $\sigma_{m_a} = k_t \times M / Z_{xt} =$ **3.922** N/mm²

$\sigma_{m_a} / \sigma_{m_adm} =$ **0.500**

PASS - Timber bending stress is less than permissible timber bending stress

Applied steel bending stress $\sigma_{m_a_s} = k_s \times M / Z_{xs} =$ **107.399** N/mm²

$\sigma_{m_a_s} / p_y =$ **0.651**

PASS - Steel bending stress is less than permissible steel bending stress

Check beam in shear

Permissible shear stress $\tau_{adm} = \tau \times K_{2s} \times K_3 \times K_8 =$ **0.710** N/mm²

Applied shear stress $\tau_a = 3 \times k_t \times F / (2 \times A) =$ **0.143** N/mm²

$\tau_a / \tau_{adm} =$ **0.201**

PASS - Shear stress within permissible limits

Deflection

Modulus of elasticity for deflection $E = E_{mean} =$ **10800** N/mm²

Permissible deflection $\delta_{adm} = \min(0.551 \text{ in}, 0.003 \times L_{s1}) =$ **13.995** mm

Bending deflection $\delta_{b_s1} =$ **11.443** mm

Shear deflection $\delta_{v_s1} =$ **0.505** mm

Total deflection $\delta_a = \delta_{b_s1} + \delta_{v_s1} =$ **11.948** mm

$\delta_a / \delta_{adm} =$ **0.854**

PASS - Total deflection is less than permissible deflection

Flitch plate bolting requirements

Total load on beam $W_{tot} =$ **12.395** kN

Total load taken by steel $W_s = k_s \times W_{tot} =$ **9.900** kN

Basic bolt shear load - Table 71 $v_{90} =$ **2.692** kN

Number of interfaces $N_{int} = (N + N_s) - 1 =$ **2**

Number of bolts required at supports $N_{be} = \max(k_s \times R_{B_max} / (N_{int} \times v_{90}), 2) =$ **2**

Limiting bolt spacing $S_{limit} = \min(2.5 \times h, 600 \text{ mm}) =$ **500** mm

Maximum bolt spacing $S_{max} =$ **500** mm

Minimum number of bolts along length of beam $N_{bl} = W_s / (N_{int} \times v_{90}) =$ **1.839**

- Provide a minimum of 2 No.12 mm diameter bolts at each support
- Provide 12 mm diameter bolts at maximum 500 mm centres staggered 50 mm alternately above and below the centre line

Minimum bolt spacings

Minimum end spacing $S_{end} = 4 \times \phi_b =$ **48** mm

Minimum edge spacing $S_{edge} = 4 \times \phi_b =$ **48** mm

Minimum bolt spacing $S_{bolt} = 4 \times \phi_b =$ **48** mm

Minimum washer diameter $\phi_w = 3 \times \phi_b =$ **36** mm

Minimum washer thickness $t_w = 0.25 \times \phi_b =$ **3** mm

USE FLITCH BEAM CONSISTING OF 2no 200mm x 75mm C24 TIMBERS SANDWICHING 10mm-THICK S275 STEEL PLATE, ADJACENT TO EXISTING OVERSTRESSED PURLIN, WITH TIMBER WEDGE PACKERS TO UNDERSIDE OF RAFTERS.