BRETT DESIGN PARTNERSHIP
Consulting Engineers

4 Maiden Way, Hadleigh, Suffolk IP7 5EH
01473 822047 / 822227
e: info@brettdesignpartnership.co.uk
www.brettdesignpartnership.co.uk

1st August 2023

Mrs L Howie
Widgeham Barn
Poplar Farm
Laxfield Road
Fressingfield
EYE
IP21 5PY

Our Ref: BS/11352
Your Ref: N/A

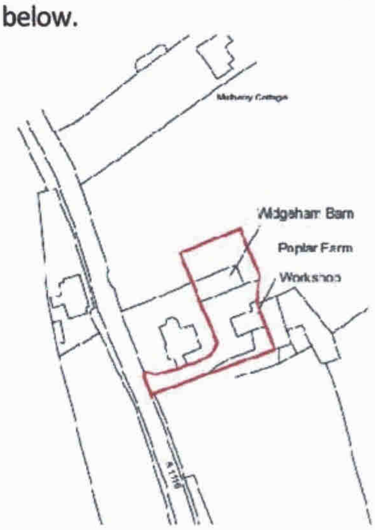
Dear Mrs Howie,

Re: Structural Appraisal Report, Proposed Conversion of Existing Workshop, Widgeham Barn, Poplar Fram, Fressingfield.

As requested, we visited the above property on the 20th of July 2023. The purpose of the visit was to undertake a visual inspection of the structure to the existing workshop to enable an assessment to be made regarding its suitability for the proposed conversion to an annex/holiday let. Following our visit, we report as follows:

Scope and limitations

Our inspection and the contents of this report are confined to the existing workshop as indicated on the plan below.



We have not inspected those parts of the structure that were inaccessible, covered or unexposed and as such we are unable to confirm these areas are free from defect. We have not inspected the foundations, which as such are beyond the scope of this report.

The discussions and recommendations contained within this report are based upon the proposals as indicated on Hollins Architects drawing 23 64 – 02, dated May 2023.

Observations and comments

The existing single storey workshop is principally of timber frame construction and measures approximately 9m in length, 5.5mm in width. External walls support a mono-pitch roof supporting clay pantiles. The height to eaves of the south elevation is approximately 3.0m. The height to eaves of the north elevation is approximately 4.5m.

External walls comprise 50mm wide, 150mm deep timber studs at 600mm centres, supported on a 0.75m high, 228mm wide brickwork plinth, rendered internally. Above the plinth wall, externally the timber frame is clad in black weatherboard. Locally to the west elevation there is no overlap to the cladding, and at this location ply sheathing is evident beneath. External ply sheathing is also evident to the north elevation where locally there is no internal finish. More generally the external walls are clad internally with OSB, with the exception of the west elevation.

No significant deflection or racking was evident to the timber frame external walls. Also, no significant cracking or lateral movement was evident to the plinth brickwork.

The existing roof comprises 50mm wide, 225mm deep timber rafters, supporting clay pantiles. Throughout the workshop the underside of the rafters has been sheathed in OSB or Plywood. Nail spacings indicate the rafters to be at 450mm centres,

No significant deflection or sagging is evident to the existing roof.

The internal wall comprises 100m thick blockwork, with a single 615mm long, 110mm wide pier at approximately mid-length of the wall. No significant cracking is evident to the internal wall.

Discussions and recommendations

From the limits of our visual inspection the existing workshop appears to be in good condition, without significant cracking to masonry walls, and without significant movement or deflection to the external timber frame and roof.

We have also completed structural calculations considering the existing timber studs forming the external walls, and the timber rafters forming the roof. These calculations also indicate these members to be adequate (see attached).

We would comment that it is likely the existing internal masonry wall does not have a foundation, and as such independent would be required to the proposed mezzanine, as opposed to the beam bearing onto the internal wall as currently indicated on the architectural drawings. This should include supporting posts and new concrete pad foundations. We would comment also that whilst there is no evidence of significant movement or cracking within the existing internal masonry wall, the wall would benefit from buttressing to reduce its slenderness. This could be provided by the new partitions abutting the wall, or the adjacent post supporting the mezzanine.

We would also comment that at present there is no clear connection between the top of the west wall and the roof structure. Whilst there is no evidence of movement between the roof and wall, we would consider it prudent to provide timber noggins between the end rafter and the studwork forming the west wall, and to extend the ply sheathing to the underside of the timber rafters as this currently stops short of the wall.

To the sides of the existing double doors the timber studs are discontinuous. We would recommend that a full height stud is provided to the ends of the existing timber lintel, replacing the short length of stud, with a further two studs beneath the bearing of the timber lintel. These multi-studs are to be bolted together at 500mm centres using M10 diameter grade 4.6 bolts.

Conclusion

In our considered opinion the existing workshop would be suitable for conversion to an annex/holiday let.

As part of a conversion, we would recommend the following:

- Provide independent support to the proposed mezzanine floor.
- Provide buttressing to the existing internal wall, utilising either the new partitions or the new post supporting the mezzanine floor.
- Provide additional connection between the top of the west wall and the roof.
- Provide multi-studs each side of the existing double doors.

All works should be designed and detailed by a Structural Engineer.

We trust that the above report meets with your current requirements, however, should you have any queries, or require any further assistance, please do not hesitate to contact us.

Yours sincerely,

[redacted]

Barney Simmons
On behalf of Brett Design Partnership Limited

Enc.

DESIGN CALCULATIONS

JOB TITLE: WIDGEHAM BARN.

JOB REF: 11352 DATE: JULY 23.

ENGINEER: B.J. PAGE NO. 1. REV:

BRETT DESIGN PARTNERSHIP
Consulting Engineers
4 Maiden Way, Hadleigh, Suffolk IP7 5EH
01473 822047 / 822227
info@brettdesignpartnership.co.uk
brettdesignpartnership.co.uk

REMARKS

CONSIDER EXISTING TIMBER FRAME TO WORKSHOP.

DESIGN LOADING DATA.	kN/m2
ROOF - 20° PITCH.	
DL - ALLOWING CLAY PANTILES -	0.89.
IL - SNOW LOADING -	0.75.
EXTERNAL WALL	
DL - BLK/STUD/PLY/CLADDING -	0.5.

ALLOW 1.0kN/m2 WIND LOAD.

LOADING TO WALL SUPPORTING ROOF.	DLkN/m	ILkN/m
ROOF - DL = 0.89 kN/m2 x 6.0m / 2 =	2.67	
IL = 0.75kN/m2 x 6.0m / 2 =		2.25
WALL - DL = 0.5kN/m2 x 3.8m =	1.9.	
	4.57.	2.25

GRID REF: TM271765

REVISION DETAILS:

Registered User: Brett Design Partnership
59 High Street, Hadleigh, Ipswich, Suffolk IP7 5DY

Wind Code Suite

Job No.

Customer

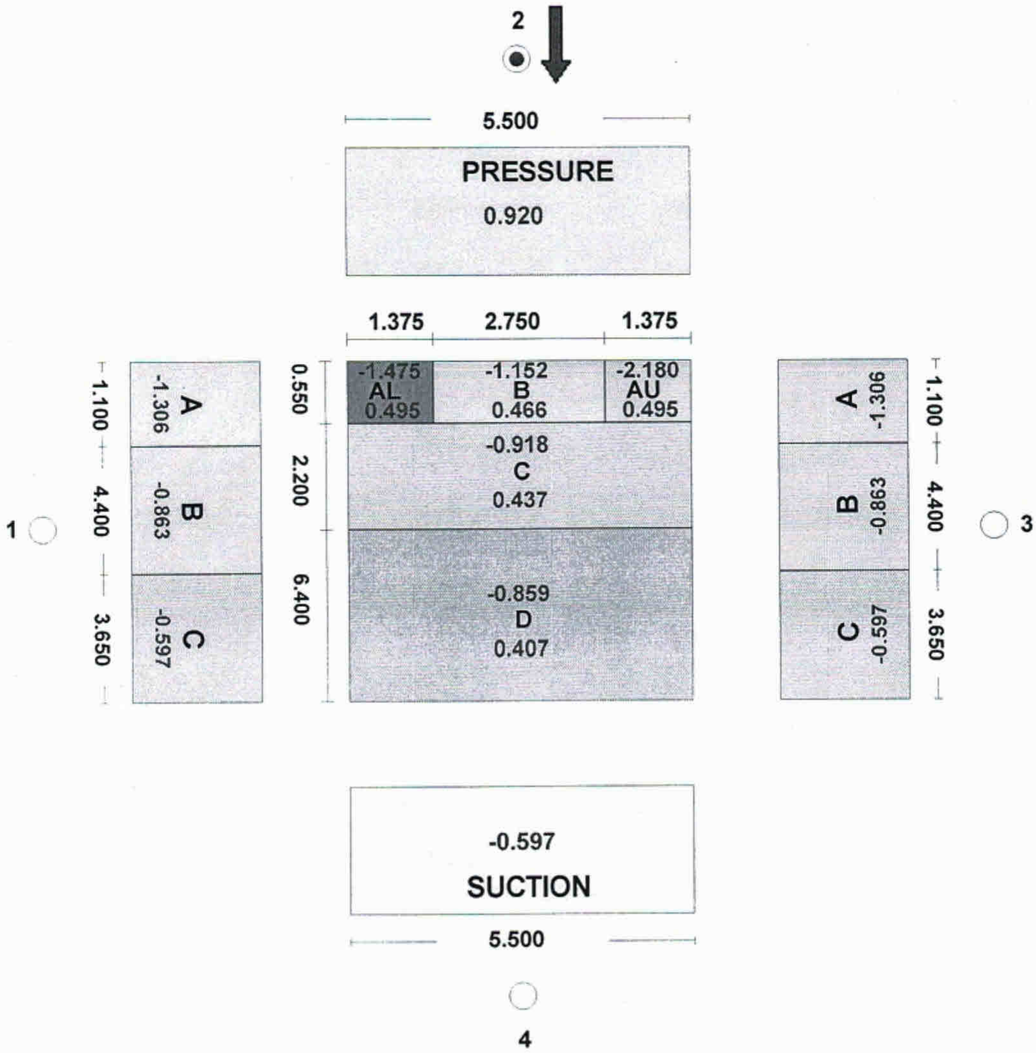
Project/Site

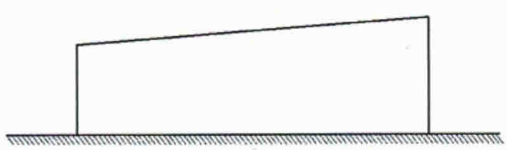
Designer

Project Date 31/07/2023

INPUT DATA			
OS Reference	**TM271765**	**Basic Wind Speed Vb**	**24.1 m/s**
Site Altitude	**52**	**Pitch**	**20°**
Sa calculated using	**Topography**	**Obstructions**	**Included**

MAX DYNAMIC PRESSURE q (kN/m²)												
Direction (N)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
Roof	0.604	0.534	0.551	0.573	0.557	0.664	0.716	0.811	0.938	0.919	0.777	0.631
Sides	0.510	0.451	0.465	0.484	0.470	0.561	0.605	0.685	0.792	0.776	0.656	0.532
Gable	0.604	0.534	0.551	0.573	0.557	0.664	0.716	0.811	0.938	0.919	0.777	0.631





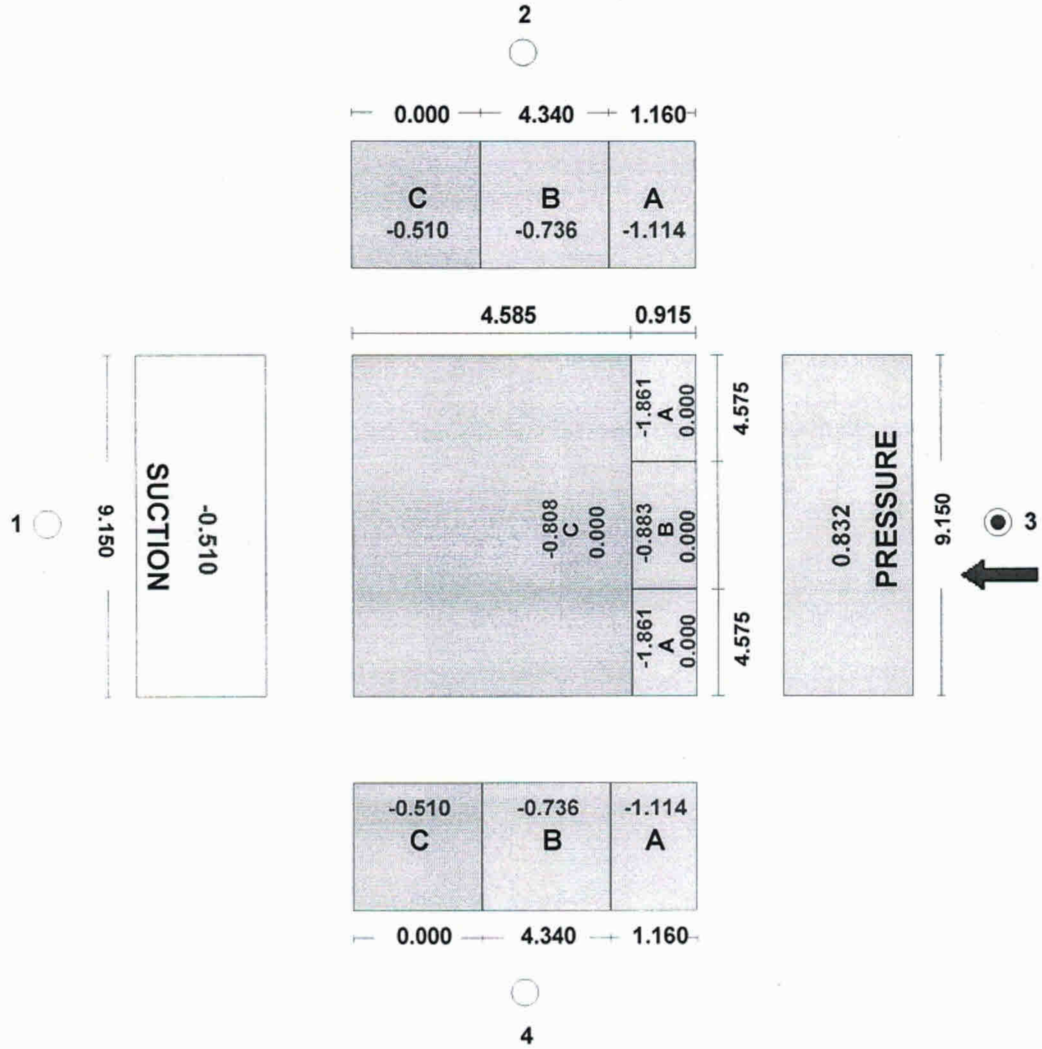
Registered User: Brett Design Partnership
59 High Street, Hadleigh, Ipswich, Suffolk IP7 5DY

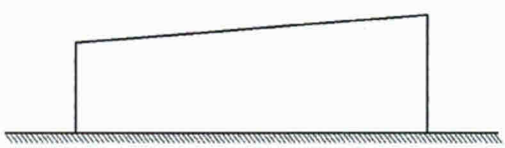
Wind Code Suite

Job No.
Customer
Project/Site
Designer
Project Date 31/07/2023

INPUT DATA			
OS Reference	**TM271765**	**Basic Wind Speed Vb**	**24.1 m/s**
Site Altitude	**52**	**Pitch**	**20°**
Sa calculated using	**Topography**	**Obstructions**	**Included**

MAX DYNAMIC PRESSURE q (kN/m²)												
Direction (N)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
Roof	0.604	0.534	0.551	0.573	0.557	0.664	0.716	0.811	0.938	0.919	0.777	0.631
Sides	0.510	0.451	0.465	0.484	0.470	0.561	0.605	0.685	0.792	0.776	0.656	0.532
Gable	0.604	0.534	0.551	0.573	0.557	0.664	0.716	0.811	0.938	0.919	0.777	0.631

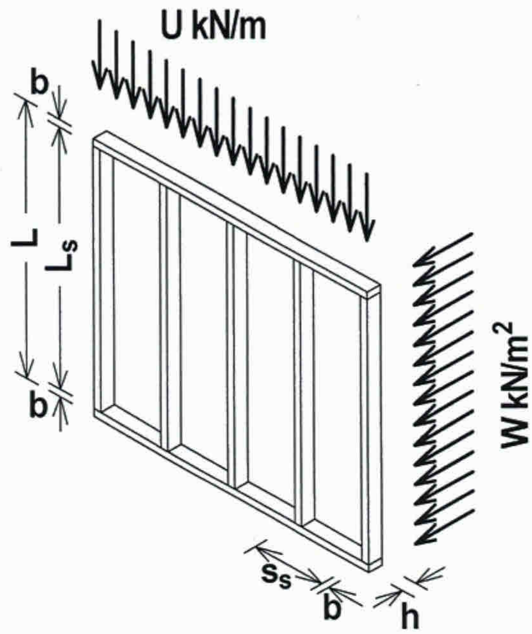




Brett Design Partnership 4 Maiden Way Hadleigh, Ipswich Suffolk IP7 5EH	Project Widgeham Barn				Job Ref. 11352	
	Section Studwork				Sheet no./rev. 4	
	Calc. by B. Simmons	Date 31/07/2023	Chk'd by	Date	App'd by	Date

TIMBER STUD DESIGN (BS5268-2:2002)

TEDDS calculation version 1.0.01



Stud details

Stud breadth b = **50** mm

Stud depth h = **150** mm

Number of studs N_s = **1**

Strength class C16 timber (Table 8 BS5268:Pt 2:2002)

Section properties

Cross sectional area $A = N_s \times b \times h$ = **7500** mm^2

Section modulus $Z = N_s \times b \times h^2 / 6$ = **187500** mm^3

Moment of inertia in the major axis $I_x = N_s \times b \times h^3 / 12$ = **14062500** mm^4

Moment of inertia in the minor axis $I_y = N_s \times h \times b^3 / 12$ = **1562500** mm^4

Radius of gyration in the major axis $r_x = \sqrt{(I_x / A)}$ = **43.3** mm

Radius of gyration in the minor axis $r_y = \sqrt{(I_y / A)}$ = **14.4** mm

Panel details - Studs restrained by sheathing in the plane of the panel

Panel height L = **3800** mm

Stud length $L_s = L - (2 \times b)$ = **3700** mm

Standard stud spacing s_s = **600** mm

Panel opening O = **0** mm

Loaded panel length $s = \max(s_s, (O + s_s) / 2)$ = **600** mm

Effective length in the major axis $L_{ex} = 1.00 \times L_s$ = **3700** mm

Slenderness ratio $\lambda = L_{ex} / r_x$ = **85.45**

Vertical loading details	**Dead loads**	**Imposed loads**
Wall UDL	U_{w_d} = **1.90** kN/m	

Roof UDL — U_{r_d} = **2.67** kN/m — U_{r_i} = **1.90** kN/m

Lateral loading details

Wind loading — W = **0.92** kN/m^2

Wind load duration — **Short term**

Modification factors

Section depth factor — $K_7 = (300\text{ mm} / h)^{0.11}$ = **1.08**

Load sharing factor — K_8 = **1.10**

Consider combined axial compression and bending under short term loads

Load duration factor — K_3 = **1.50**

Vertical loading — $F = (U_{w\_d} + U_{r\_d} + U_{r\_i}) \times s$ = **3.88** kN

Check bending stress

Bending parallel to grain — σ_m = **5.300** N/mm^2

Permissible bending stress — $\sigma_{m\_adm} = \sigma_m \times K_3 \times K_7 \times K_8$ = **9.438** N/mm^2

Bending moment — $M_{max} = W \times s \times L^2 / 8$ = **0.996** kNm

Applied bending stress — $\sigma_{m\_max} = M_{max} / Z$ = **5.314** N/mm^2

PASS - Applied bending stress under short term loads is within permissible limits

Check compressive stress on stud

Compression member factor — K_{12} = **0.38**

Compression parallel to grain — σ_c = **6.800** N/mm^2

Permissible compressive stress — $\sigma_{c\_adm} = \sigma_c \times K_3 \times K_8 \times K_{12}$ = **4.251** N/mm^2

Applied compressive stress — $\sigma_{c\_max} = F / (N_s \times b \times h)$ = **0.518** N/mm^2

PASS - Applied compressive stress under short term loads is within permissible limits

Check compressive stress on rail

Bearing stress modification factor — K_4 = **1.20**

Compression perpendicular to grain (no wane) — σ_{cp1} = **2.200** N/mm^2

Permissible compressive stress — $\sigma_{cp1\_adm} = \sigma_{cp1} \times K_3 \times K_4$ = **3.960** N/mm^2

Applied compressive stress — $\sigma_{cp1\_max} = F / (N_s \times b \times h)$ = **0.518** N/mm^2

PASS - Applied compressive stress under short term loads is within permissible limits

Check combined axial compression and bending

Euler critical stress — $\sigma_e = (\pi^2 \times E_{min}) / \lambda^2$ = **7.840** N/mm^2

Euler coefficient — $K_{eu} = 1 - (1.5 \times \sigma_{c\_max} \times K_{12} / \sigma_e)$ = **0.962**

Combined axial compression and bending value — $K = \sigma_{m\_max} / (\sigma_{m\_adm} \times K_{eu}) + \sigma_{c\_max} / \sigma_{c\_adm}$ = **0.707** **< 1**

PASS - Combined compressive and bending stresses under short term loads are within permissible limits

Check stud deflection

Maximum deflection — $\delta_{adm} = \min(11.1\text{ mm}, 0.003 \times (L - 2 \times b))$ = **11.100** mm

Bending deflection — $\delta_{max} = 5 \times W \times s \times L_s^4 / (384 \times E_{mean} \times I_x)$ = **10.885** mm

PASS - Deflection due to wind loading is less than permissible limit

Consider axial compression without bending under medium term loads

Load duration factor — K_3 = **1.25**

Vertical loading — $F = (U_{w\_d} + U_{r\_d} + U_{r\_i}) \times s$ = **3.88** kN

Check compressive stress on stud

Compression member factor — K_{12} = **0.42**

Compression parallel to grain — σ_c = **6.800** N/mm^2

Permissible compressive stress — $\sigma_{c\_adm} = \sigma_c \times K_3 \times K_8 \times K_{12}$ = **3.951** N/mm^2

Applied compressive stress $\sigma_{c\_max} = F / (N_s \times b \times h) = \mathbf{0.518}$ N/mm^2

PASS - Applied compressive stress under medium term loads is within permissible limits

Check compressive stress on rail

Bearing stress modification factor $K_4 = \mathbf{1.20}$

Compression perpendicular to grain (no wane) $\sigma_{cp1} = \mathbf{2.200}$ N/mm^2

Permissible compressive stress $\sigma_{cp1\_adm} = \sigma_{cp1} \times K_3 \times K_4 = \mathbf{3.300}$ N/mm^2

Applied compressive stress $\sigma_{cp1\_max} = F / (N_s \times b \times h) = \mathbf{0.518}$ N/mm^2

PASS - Applied compressive stress under medium term loads is within permissible limits

Consider axial compression without bending under long term loads

Load duration factor $K_3 = \mathbf{1.00}$

Vertical loading $F = (U_{w\_d} + U_{r\_d}) \times s = \mathbf{2.74}$ kN

Check compressive stress on stud

Compression member factor $K_{12} = \mathbf{0.47}$

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

Permissible compressive stress $\sigma_{c\_adm} = \sigma_c \times K_3 \times K_8 \times K_{12} = \mathbf{3.541}$ N/mm^2

Applied compressive stress $\sigma_{c\_max} = F / (N_s \times b \times h) = \mathbf{0.366}$ N/mm^2

PASS - Applied compressive stress under long term loads is within permissible limits

Check compressive stress on rail

Bearing stress modification factor $K_4 = \mathbf{1.20}$

Compression perpendicular to grain (no wane) $\sigma_{cp1} = \mathbf{2.200}$ N/mm^2

Permissible compressive stress $\sigma_{cp1\_adm} = \sigma_{cp1} \times K_3 \times K_4 = \mathbf{2.640}$ N/mm^2

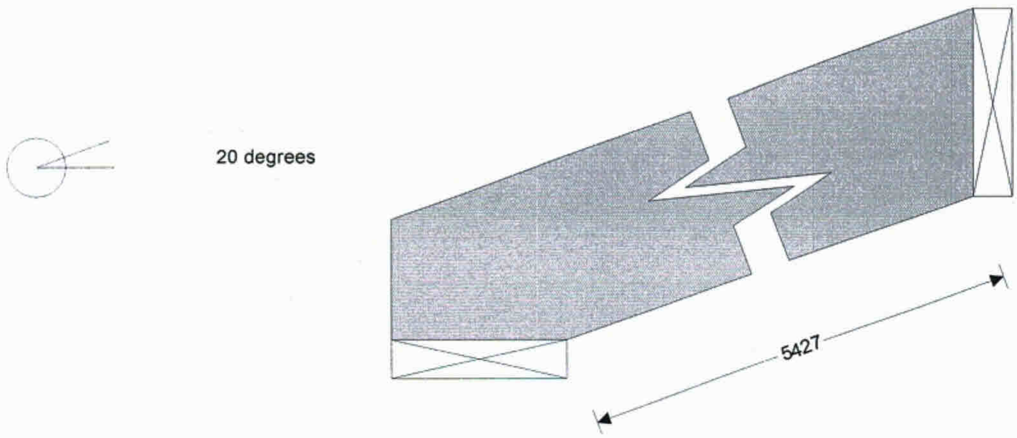
Applied compressive stress $\sigma_{cp1\_max} = F / (N_s \times b \times h) = \mathbf{0.366}$ N/mm^2

PASS - Applied compressive stress under long term loads is within permissible limits

Brett Design Partnership 4 Maiden Way Hadleigh, Ipswich Suffolk IP7 5EH	Project Widgeham Barn				Job Ref. 11352	
	Section Rafters				Sheet no./rev. 7	
	Calc. by B. Simmons	Date 31/07/2023	Chk'd by	Date	App'd by	Date

TIMBER RAFTER DESIGN (BS5268-2:2002)

TEDDS calculation version 1.0.03



Rafter details

Breadth of timber sections	b = **50** mm
Depth of timber sections	h = **225** mm
Rafter spacing	s = **450** mm
Rafter slope	α = **20.0** deg
Clear span of rafter on horizontal	L_{clh} = **5100** mm
Clear span of rafter on slope	$L_{cl} = L_{clh} / \cos(\alpha)$ = **5427** mm
Rafter span	**Single span**
Timber strength class	**C16**

Section properties

Cross sectional area of rafter	$A = b \times h$ = **11250** mm^2
Section modulus	$Z = b \times h^2 / 6$ = **421875** mm^3
Second moment of area	$I = b \times h^3 / 12$ = **47460937** mm^4
Radius of gyration	$r = \sqrt{(I / A)}$ = **65.0** mm

Loading details

Rafter self weight	$F_j = b \times h \times \rho_{char} \times g_{acc}$ = **0.03** kN/m
Dead load on slope	F_d = **0.70** kN/m^2
Imposed load on plan	F_u = **0.75** kN/m^2
Imposed point load	F_p = **0.90** kN

Modification factors

Section depth factor	$K_7 = (300 \text{ mm} / h)^{0.11}$ = **1.03**
Load sharing factor	K_8 = **1.10**

Consider long term load condition

Load duration factor	K_3 = **1.00**
Total UDL perpendicular to rafter	$F = F_d \times \cos(\alpha) \times s + F_j \times \cos(\alpha)$ = **0.328** kN/m
Notional bearing length	$L_b = F \times L_{cl} / [2 \times (b \times \sigma_{cp1} \times K_8 - F)]$ = **7** mm
Effective span	$L_{eff} = L_{cl} + L_b$ = **5435** mm

Check bending stress

Bending stress parallel to grain	σ_m = **5.300** N/mm^2

Permissible bending stress	$\sigma_{m\_adm} = \sigma_m \times K_3 \times K_7 \times K_8 =$ **6.017** N/mm^2
Applied bending stress	$\sigma_{m\_max} = F \times L_{eff}^2 / (8 \times Z) =$ **2.872** 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** N/mm^2
Minimum modulus of elasticity	$E_{min} =$ **5800** N/mm^2
Compression member factor	$K_{12} =$ **0.49**
Permissible compressive stress	$\sigma_{c\_adm} = \sigma_c \times K_3 \times K_8 \times K_{12} =$ **3.630** N/mm^2
Applied compressive stress	$\sigma_{c\_max} = F \times L_{eff} \times (\cot(\alpha) + 3 \times \tan(\alpha)) / (2 \times A) =$ **0.304** N/mm^2

PASS - Applied compressive stress within permissible limits

Check combined bending and compressive stress parallel to grain

Euler stress	$\sigma_e = \pi^2 \times E_{min} / \lambda^2 =$ **8.176** 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	$\sigma_{m\_max} / (\sigma_{m\_adm} \times K_{eu}) + \sigma_{c\_max} / \sigma_{c\_adm} =$ **0.574 < 1**

PASS - Combined compressive and bending stresses are within permissible limits

Check shear stress

Shear stress parallel to grain	$\tau =$ **0.670** N/mm^2
Permissible shear stress	$\tau_{adm} = \tau \times K_3 \times K_8 =$ **0.737** N/mm^2
Applied shear stress	$\tau_{max} = 3 \times F \times L_{eff} / (4 \times A) =$ **0.119** N/mm^2

PASS - Applied shear stress within permissible limits

Check deflection

Permissible deflection	$\delta_{adm} = 0.003 \times L_{eff} =$ **16.304** mm
Bending deflection	$\delta_b = 5 \times F \times L_{eff}^4 / (384 \times E_{mean} \times I) =$ **8.924** mm
Shear deflection	$\delta_s = 12 \times F \times L_{eff}^2 / (5 \times E_{mean} \times A) =$ **0.235** mm
Total deflection	$\delta_{max} = \delta_b + \delta_s =$ **9.159** mm

PASS - Total deflection within permissible limits

Consider medium term load condition

Load duration factor	$K_3 =$ **1.25**
Total UDL perpendicular to rafter	$F = [F_u \times \cos(\alpha)^2 + F_d \times \cos(\alpha)] \times s + F_j \times \cos(\alpha) =$ **0.626** kN/m
Notional bearing length	$L_b = F \times L_{cl} / [2 \times (b \times \sigma_{cp1} \times K_8 - F)] =$ **14** mm
Effective span	$L_{eff} = L_{cl} + L_b =$ **5441** mm

Check bending stress

Bending stress parallel to grain	$\sigma_m =$ **5.300** N/mm^2
Permissible bending stress	$\sigma_{m\_adm} = \sigma_m \times K_3 \times K_7 \times K_8 =$ **7.522** N/mm^2
Applied bending stress	$\sigma_{m\_max} = F \times L_{eff}^2 / (8 \times Z) =$ **5.493** 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** N/mm^2
Minimum modulus of elasticity	$E_{min} =$ **5800** N/mm^2
Compression member factor	$K_{12} =$ **0.43**
Permissible compressive stress	$\sigma_{c\_adm} = \sigma_c \times K_3 \times K_8 \times K_{12} =$ **4.059** N/mm^2
Applied compressive stress	$\sigma_{c\_max} = F \times L_{eff} \times (\cot(\alpha) + 3 \times \tan(\alpha)) / (2 \times A) =$ **0.581** N/mm^2

PASS - Applied compressive stress within permissible limits

Check combined bending and compressive stress parallel to grain

Euler stress $\sigma_e = \pi^2 \times E_{min} / \lambda^2 = \mathbf{8.156}$ N/mm²

Euler coefficient $K_{eu} = 1 - (1.5 \times \sigma_{c\_max} \times K_{12} / \sigma_e) = \mathbf{0.954}$

Combined axial compression and bending check $\sigma_{m\_max} / (\sigma_{m\_adm} \times K_{eu}) + \sigma_{c\_max} / \sigma_{c\_adm} = \mathbf{0.909} < 1$

PASS - Combined compressive and bending stresses are within permissible limits

Check shear stress

Shear stress parallel to grain $\tau = \mathbf{0.670}$ N/mm²

Permissible shear stress $\tau_{adm} = \tau \times K_3 \times K_8 = \mathbf{0.921}$ N/mm²

Applied shear stress $\tau_{max} = 3 \times F \times L_{eff} / (4 \times A) = \mathbf{0.227}$ N/mm²

PASS - Applied shear stress within permissible limits

Check deflection

Permissible deflection $\delta_{adm} = 0.003 \times L_{eff} = \mathbf{16.324}$ mm

Bending deflection $\delta_b = 5 \times F \times L_{eff}^4 / (384 \times E_{mean} \times I) = \mathbf{17.114}$ mm

Shear deflection $\delta_s = 12 \times F \times L_{eff}^2 / (5 \times E_{mean} \times A) = \mathbf{0.449}$ mm

Total deflection $\delta_{max} = \delta_b + \delta_s = \mathbf{17.564}$ mm

FAIL - Total deflection exceeds permissible limits

<u>Consider short term load condition</u>

Load duration factor $K_3 = \mathbf{1.50}$

Total UDL perpendicular to rafter $F = F_d \times \cos(\alpha) \times s + F_j \times \cos(\alpha) = \mathbf{0.328}$ kN/m

Notional bearing length $L_b = [F \times L_{cl} + F_p \times \cos(\alpha)] / [2 \times (b \times \sigma_{cp1} \times K_8 - F)] = \mathbf{11}$ mm

Effective span $L_{eff} = L_{cl} + L_b = \mathbf{5438}$ mm

Check bending stress

Bending stress parallel to grain $\sigma_m = \mathbf{5.300}$ N/mm²

Permissible bending stress $\sigma_{m\_adm} = \sigma_m \times K_3 \times K_7 \times K_8 = \mathbf{9.026}$ N/mm²

Applied bending stress $\sigma_{m\_max} = F \times L_{eff}^2/(8 \times Z) + F_p \times \cos(\alpha) \times L_{eff}/(4 \times Z) = \mathbf{5.601}$ N/mm²

PASS - Applied bending stress within permissible limits

Check compressive stress parallel to grain

Compression stress parallel to grain $\sigma_c = \mathbf{6.800}$ N/mm²

Minimum modulus of elasticity $E_{min} = \mathbf{5800}$ N/mm²

Compression member factor $K_{12} = \mathbf{0.39}$

Permissible compressive stress $\sigma_{c\_adm} = \sigma_c \times K_3 \times K_8 \times K_{12} = \mathbf{4.382}$ N/mm²

Applied compressive stress $\sigma_{c\_max} = F \times L_{eff} \times (\cot(\alpha) + 3 \times \tan(\alpha))/(2 \times A) + F_p \times \sin(\alpha)/A = \mathbf{0.332}$ N/mm²

PASS - Applied compressive stress within permissible limits

Check combined bending and compressive stress parallel to grain

Euler stress $\sigma_e = \pi^2 \times E_{min} / \lambda^2 = \mathbf{8.166}$ N/mm²

Euler coefficient $K_{eu} = 1 - (1.5 \times \sigma_{c\_max} \times K_{12} / \sigma_e) = \mathbf{0.976}$

Combined axial compression and bending check $\sigma_{m\_max} / (\sigma_{m\_adm} \times K_{eu}) + \sigma_{c\_max} / \sigma_{c\_adm} = \mathbf{0.711} < 1$

PASS - Combined compressive and bending stresses are within permissible limits

Check shear stress

Shear stress parallel to grain $\tau = \mathbf{0.670}$ N/mm²

Permissible shear stress $\tau_{adm} = \tau \times K_3 \times K_8 = \mathbf{1.106}$ N/mm²

Applied shear stress $\tau_{max} = 3 \times F \times L_{eff} / (4 \times A) + 3 \times F_p \times \cos(\alpha) / (2 \times A) = \mathbf{0.232}$ N/mm²

PASS - Applied shear stress within permissible limits

Check deflection

Permissible deflection $\delta_{adm} = 0.003 \times L_{eff}$ = **16.315** mm

Bending deflection $\delta_b = L_{eff}^3 \times (5\times F\times L_{eff} / 384 + F_p \times\cos(\alpha)/ 48) / (E_{mean} \times I)$ = **15.732** mm

Shear deflection $\delta_s = 12 \times L_{eff} \times (F\times L_{eff} + 2\times F_p \times\cos(\alpha))/(5 \times E_{mean} \times A)$ = **0.458** mm

Total deflection $\delta_{max} = \delta_b + \delta_s$ = **16.190** mm

PASS - Total deflection within permissible limits