

MW Consult Ltd

Civil & Structural Engineering Consultancy

Structural Calculations

Project: Proposed Attic Conversion at
73 Mill Race, Neath

Project Ref: 20/095 **Revision:** –

Client: Mr & Mrs Morgan

Element: Attic Conversion

Design Codes: BS 648: Weight of Materials
BS 6399: Loadings for Buildings
BS 5268: Structural use of Timber
BS 5950: Structural use of Steelwork
BS 5628: Structural use of Masonry
BS 8110: Structural use of Concrete

Prepared by:	Issue Date:
Mike Wyatt BEng (Hons) CEng MStructE	28/05/2020

Revision:	Amendment:	Issue Date:

Location: Gravity Loads

Unit loads for elements of structure

Sloping roofs with angle of 35 degrees

Serviceability loads

Dead load on plan for sloping member = Load / Cos roof angle

Rafters 75 mm x 195 mm at 400 mm c/c

Loads	Loads in kN/m ²	
	On horizontal	On slope
Rafters	0.2145	0.1757
Felt load	0.0179	0.0147
Counterbatten load	0.0106	0.0087
Batten load	0.0407	0.0333
Tile/slate load	0.6104	0.5
Sub total for dead load (Gk)	0.8941 kN/m ²	
Live load on horizontal (Qk)	0.6 kN/m ²	
Total load (Gk+Qk)	1.494 kN/m ²	
Ultimate dead load (Factor 1.4)	1.252 kN/m ²	
Ultimate live load (Factor 1.6)	0.96 kN/m ²	

Loading with plaster/plasterboard for roofs with angle of 35 degrees

Serviceability loads

Loads	On horizontal	On slope
Dead load from above	0.8941 kN/m ²	
Plaster/board load	0.2155 kN/m ²	0.1765 kN/m ²
Allowance for insulation etc.	0.1221 kN/m ²	0.1 kN/m ²
Sub total for dead load (Gk)	1.232 kN/m ²	
Live load on horizontal (Qk)	0.6 kN/m ²	
Total Gk+Qk with plaster/board	1.832 kN/m ²	
Ultimate dead load (Factor 1.4)	1.724 kN/m ²	
Ultimate live load (Factor 1.6)	0.96 kN/m ²	

Ceilings to roof spaces

Serviceability loads

Load for 47 mm x 195 mm ceiling joists at 400 mm c/c

Ceiling joists	0.1101
Plasterboard load	0.1765
Allowance for insulation etc.	0.1 kN/m ²

Sub total for dead load (Gk)	0.3866 kN/m ²
Live load (Qk)	0.25 kN/m ²

Total load (Gk+Qk)	0.6366 kN/m ²
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Loadings for water tanks must be included separately in their actual locations

Ultimate dead load (Factor 1.4)	0.5413 kN/m ²
Ultimate live load (Factor 1.6)	0.4 kN/m ²

New floors with live load of 1.5 and plasterboard

Serviceability loads

47 mm x 195 mm joists at 400 mm c/c

Joist load	0.1101 kN/m ²
Boarding load	0.17 kN/m ²
Plaster/plasterboard load	0.1765 kN/m ²
Allowance for insulation etc.	0.1 kN/m ²

Sub total for dead load (Gk)	0.5566 kN/m ²
Live load (Qk)	1.5 kN/m ²

Total load (Gk+Qk)	2.057 kN/m ²
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Ultimate dead load (Factor 1.4)	0.7793 kN/m ²
Ultimate live load (Factor 1.6)	2.4 kN/m ²

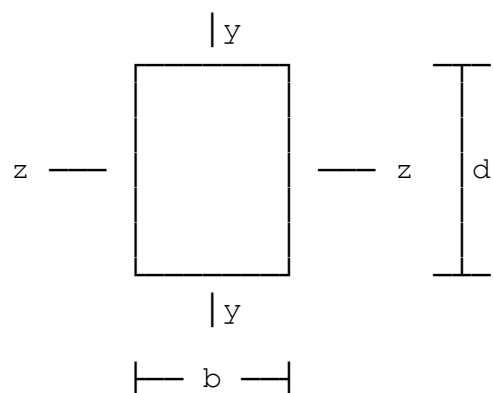
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Job ref : 20/095
 Sheet : -
 Made by : MW
 Date : 26-May-20
 Checked : MW
 Approved : MW

Ref:	Timber Rafter Analysis	Output.
	Roof Pitch = 35 degrees	
	Consider Rafters = C 16 47 x 147 @ 400 c/c	
	Young's Modulus, $E = 8800 \text{ N/mm}^2$ load-sharing $E = 8.8 \times 10^6 \text{ KN/m}^2$	
	Moment of Inertia, $I = bd^3 / 12 = 47 \times 147^3 / 12$	
	$I_{xx} = 12.441 \times 10^{-6} \text{ m}^4$ $I_{yy} = 1.2718 \times 10^{-6} \text{ m}^4$	
	Vertical Dead load, $G_k = 1.2 \text{ KN/m}^2$	
	Vertical Dead load per unit length = $1.2 \times 0.4 = 0.48 \text{ KN/m}$	
	Vertical Live load $Q_k = 0.6 \text{ KN/m}^2$	
	Vertical Live load per unit length = $0.6 \times 0.4 = 0.24 \text{ KN/m}$	
	Rafter projection onto horizontal = 2.60 m	
	Rafter projection onto vertical = $2.60 \tan 35.0 = 1.82 \text{ m}$	
	Length of rafter = 3.174 m	
	Effective length $L_{ex} = \text{Length on slope between restraints} = 3.17 \text{ m}$	
	Effective length $L_{ey} = \text{Typical roof Battens at 400mm ctrs} = 0.4 \text{ m}$	
	Maximum deflection in Rafter: (based on UDL over full length)	
	Max. Deflection, $d = (5 \times W \times L^3) / (384 \times E \times I_{xx}) = 5.8316 \text{ mm}$	
	span / deflection ratio = $544.28 > 333$ therefore acceptable	
	Radius of gyration, $R_{xx} = 42.435 \text{ mm}$ Slenderness Ratio, $_{xx} = 74.797$	
	Radius of gyration, $R_{yy} = 13.568 \text{ mm}$ Slenderness Ratio, $_{yy} = 29.482$	
	xx axis controls slenderness at $74.797 < 180$ therefore acceptable	
	Total load on rafter, $W = 1.87 \text{ KN}$	
	Max. Moment (+ve sagging), $M_z = 0.6084 \text{ KNm}$	
	Horiz. Reaction at bottom support, $H_1 = 0 \text{ KN}$, support is on rollers	
	Horiz. Reaction at top support, $H_2 = 0 \text{ KN}$, by resolving horizontally	
	Vertical reaction at bottom support, $R_1 = 1.87 / 2 = 0.936 \text{ KN}$	
	Vertical reaction at top support, $R_2 = 1.87 / 2 = 0.936 \text{ KN}$	
	Axial Force at bottom support, $F_1 = 0.936 \sin 35 = 0.5369 \text{ KN}$	
	Shear Force at bottom support, $V_1 = 0.936 \cos 35 = 0.7667 \text{ KN}$	

Location: Rafter Design



Rectangular timber member

subject to axial load and

bending about z-z axis

Calculations in accordance
with BS5268-2:2002.

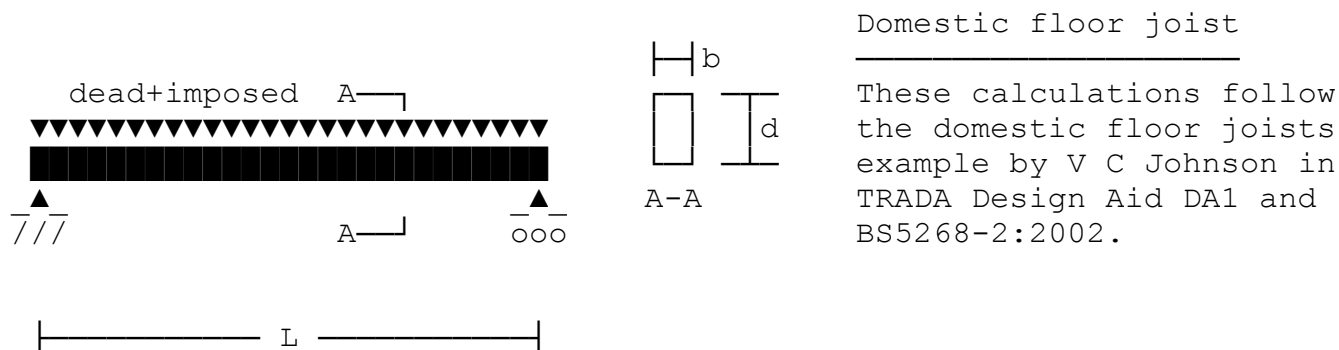
Design BM about zz (positive) $M_z=0.6084$ kNm
Design shear force in y direction $V=0.767$ kN
Design axial load (+ve compress) $F=0.537$ kN
Eff length for bending about zz $L_{ez}'=3.174$ m
Depth of section $d=147$ mm
Width of section $b=47$ mm
Eff length for bending about yy $L_{ey}'=0.6$ m
Strength class C16 to Table 8
Timber service class adopted $tmclass=2$
Timber service class modification factor $K_2=1$ as Table 16.
Duration of loading $K_3=1.25$
Depth factor $K_7=(300/d)^{0.11}=1.0816$
Load-sharing modification factor $K_8=1.1$
Modification factor $K_{12}=(0.5+(1+\eta)*C/2)-((0.5+(1+\eta)*C/2)^2-C)^{0.5}=0.50109$

Interaction factor $factor=\sigma/(\sigma_{ad}*b_{smf})+\sigma_{ca}/\sigma_{cad}=0.47519$

DESIGN
SUMMARY

Depth of section	147 mm
Width of section	47 mm
Strength class C16 to Table 8	
Timber moisture class	2
Applied comprn stress	0.077725 N/mm ²
Permiss comprn stress	4.6852 N/mm ²
Applied bending stress	3.5942 N/mm ²
Permiss bending stress	7.8824 N/mm ²
Interaction factor	0.47519
Applied shear stress	0.16652 N/mm ²
Permiss shear stress	0.92125 N/mm ²

Location: Attic Floor Joists - max 4.7m clear span



The following assumptions are made in these calculations:

- that the timber has a moisture content of service class 1 or 2 (i.e. $K_2=1$)
- the floor can adequately distribute any concentrated point load to at least two joists.
- the centres of joists do not exceed 610 mm
- that load sharing of the joists can occur & $K_8 = 1.1$.

Effective span of joist	$L=4.8$ m
Centres of joists	$crs=400$ mm
Dead load including self weight	$dead=0.55$ kN/m ²
Imposed udl load (on floor)	$live=1.5$ kN/m ²
Imposed point load (on one joist)	$PL=1.4$ kN
Depth of section	$d=220$ mm
Width of section	$b=47$ mm
Bearing length	$lb=76$ mm
Strength class C24 to Table 8	
Duration of loading	$K_3=1$
Depth factor	$K_7=(300/d)^{0.11}=1.0347$
Load sharing (Clause 2.9)	$K_8=1.1$
From BS5268-2 Table 18, bearing is < 75 mm from joist end.	
Bearing Modification factor	$K_4=1.0$

DESIGN	Joists: 220 mm x 47 mm @ 400 mm crs
SUMMARY	Strength class C24 to Table 8
	Bending stress 6.2289 N/mm ²
	Permissible bending 8.5363 N/mm ²
	Deflection 12.99 mm
	Limiting deflection 14 mm
	Shear stress 0.28549 N/mm ²
	Permissible shear 0.781 N/mm ²
	Bearing stress 0.55095 N/mm ²
	Permissible bearing 2.64 N/mm ²

Location: Attic Floor Trimmer Joist

Timber beam to BS5268-2:2002



Simply supported
beam subjected to
vertical loads.

Beam span $L=4.60$ m

Dist. from left support to start $L_{au}(1)=0$ m

Distance from left support to end $L_{bu}(1)=4.60$ m

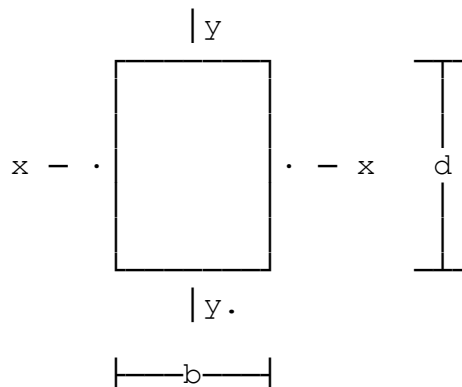
Dead load (unfactored) $G_{ku}(1)=0.55 \times 1.8/2=0.495$ kN/m

Imposed load (unfactored) $Q_{ku}(1)=1.50 \times 1.8/2=1.35$ kN/m

Maximum span bending moment 4.88 kNm

Design shear force $F_{ve}'=4.2435$

Section design parameters



Design axial load (+ve compress) $F_a=0.0$ kN

Depth of section $d=220$ mm

Width of section $b=47 \times 3=141$ mm

Eff length for bending about xx $L_{ex}=4600$ mm

Eff length for bending about yy $L_{ey}=4600/3=1533.3$ mm

Length of bearing $l_b=76$ mm

From BS5268-2 Table 18, bearing is > 75 mm from joist end.

Bearing modification factor $K_4=1.1384$

Strength class C24 to Table 8

Timber service class adopted $tmclass=2$

Timber service class modification factor $K_2=1$ as Table 16.

Duration of loading $K_3=1.00$

Depth factor $K_7=(300/d)^{0.11}=1.0347$

Load-sharing modification factor $K_8=1.0$ clause 2.10.11

No notches exist at the support $K_5=1.0$

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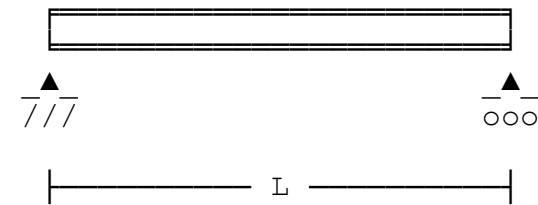
DESIGN
SUMMARY

Member: 220 mm x 141 mm
Strength class C24 to Table 8
Moisture service class 2
Bending stress 4.2905 N/mm²
Permissible bending 7.7603 N/mm²
Deflection 12.36 mm
Limiting deflection 13.8 mm
Shear stress 0.2052 N/mm²
Permissible shear 0.71 N/mm²
Bearing stress 0.396 N/mm²
Permissible bearing 2.7322 N/mm²

Location: Steel Ridge Beam - spanning gable to gable

Simply supported steel beam

Calculations are in accordance
with BS5950-1:2000.



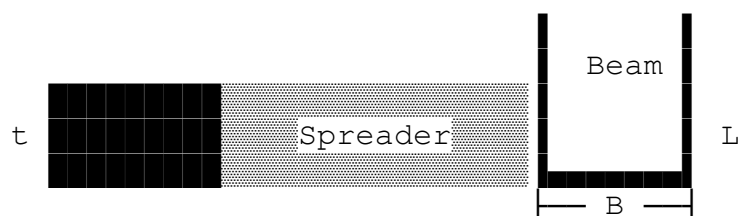
Beam span	L=7.0 m
254 x 146 x 37 UB.	
Young's Modulus	E=205 kN/mm ²
Dead load factor	gamd=1.4
Imposed load factor	gami=1.6
Dist. from left support to start	Lau(1)=0 m
Distance from left support to end	Lbu(1)=7.0 m
Dead load (unfactored)	Gku(1)=1.2*4.7/2=2.82 kN/m
Imposed load (unfactored)	Qku(1)=0.6*4.7/2=1.41 kN/m
Maximum span bending moment	38 kNm
Design shear force	Fv=21.714 kN
Bending strength	pb=(pey)/(phiLT+((phiLT^2-pey)^0.5)) =92.233 N/mm ²

UNIVERSAL BEAM	254 x 146 x 37 UB Grade S 355
DESIGN SUMMARY	
	Maximum shear force 21.714 kN
	Shear capacity 343.53 kN
	Max. applied moment 38 kNm
	Moment capacity 171.47 kNm
	Buckling resistance 44.548 kNm
	Moment factor (mLT) 0.925
	Resistance (Mb/mLT) 48.161 kNm
	Unfactored DL defln 7.7628 mm
	Unfactored LL defln 3.8814 mm
	Limiting deflection 19.444 mm
	DL shear at LHE 9.87 kN
Unfactored	LL shear at LHE 4.935 kN
end shears	DL shear at RHE 9.87 kN
	LL shear at RHE 4.935 kN

Location: Padstones beneath ends of ridge beam

Masonry bearing

Design in accordance with BS5628-1:2005.



Plan view on wall

Bearing type 3
see Figure 5(c) in
BS5628.

t=wall thickness L=length of bearing ed=0 L=t

Proposed width of bearing	B=100 mm
Proposed length of bearing	L=100 mm
Thickness of leaf carrying load	t=t=100 mm
local bearing safety factor	lbsf=2.0

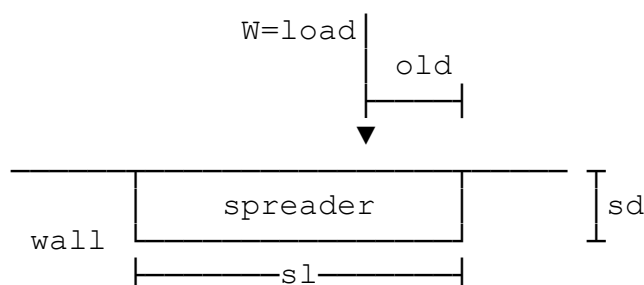
Masonry details

Mortar designation to Table 1	mortar=3
Masonry type (1=clay 2=cal silicate 3=conc brick 4=block)	typ(1)=4
Concrete Blocks Dimensions	
Height	hb=215 mm
Least horiz dimension	lhd=100 mm
ratio height/least horiz. dim	rb=hb/lhd=215/100=2.15
Compressive Strength of Units	po=3.6 N/mm ²
Char comp strength - Table 2(d)	fk(a)=TABLE 2.4 for mortar=3, po=3.6 =3.5 N/mm ²
Partial Safety Factor Material	gammam=3.5

Bearing requirements

Characteristic dead load	DL=10 kN
Characteristic live load	LL=5 kN
Design load on bearing	W=1.4*DL+1.6*LL=1.4*10+1.6*5 =22 kN

Spreader Beam



For bearing reference 3	lbsf=lbsf=2
Design stress capacity	fk1=lbsf*fk(a)/gammam=2*3.5/3.5 =2 N/mm ²

Office: 1616

Design load $Wl=W*1000=22*1000=22000$ N
Length of spreader beam $sl=400$ mm
Width of spreader beam $sb=x=100$ mm (B or L to suit type)
Offset load distance $old=200$ mm
Triangular stress distribution is assumed for spreader not tied down.
Eccentricity of load $ecc=ABS(sl/2-old)=ABS(400/2-200)$
 $=0$ mm
Maximum stress under spreader $fk_m=Wl/(sl*sb)+Wl*ecc/((sb*sl^2)/6)$
 $=22000/(400*100)+22000*0/((100$
 $*400^2)/6)$
 $=0.55$ N/mm²

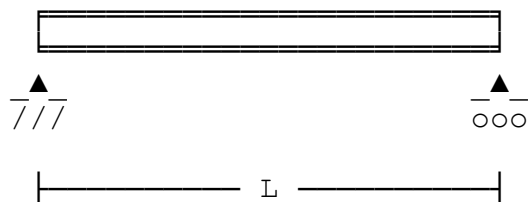
Max Stress under spreader < Max Permissible

fk_m (0.55 N/mm²) < fk_1 (2 N/mm²)

Therefore spreader satisfactory

DESIGN SUMMARY	Length of spreader beam	400 mm
	Width of spreader beam	100 mm
	Eccentricity of load	0 mm
	Char comp strength	2 N/mm ²
	Local bearing safety factor	2
	Design stress capacity	2 N/mm ²
	Max stress under spreader	0.55 N/mm ²

Location: Steel Attic Floor Beams - spanning gable to gable



Simply supported steel beam

Calculations are in accordance
with BS5950-1:2000.

Beam span

$L=7$ m

305 x 165 x 54 UB.

Young's Modulus

$E=205$ kN/mm²

Dead load factor

$g_{md}=1.4$

Imposed load factor

$g_{mi}=1.6$

Dist. from left support to start $L_{au}(1)=0$ m

Distance from left support to end $L_{bu}(1)=7$ m

Dead load (unfactored) $G_{ku}(1)=1.25 \times 2.5 / 2 = 1.5625$ kN/m

Imposed load (unfactored) $Q_{ku}(1)=0.60 \times 2.5 / 2 = 0.75$ kN/m

Dist. from left support to start $L_{au}(2)=0$ m

Distance from left support to end $L_{bu}(2)=7$ m

Dead load (unfactored) $G_{ku}(2)=1.0 \times 1.4 / 2 = 0.7$ kN/m

Imposed load (unfactored) $Q_{ku}(2)=0.6 \times 1.4 / 2 = 0.42$ kN/m

Dist. from left support to start $L_{au}(3)=0$ m

Distance from left support to end $L_{bu}(3)=7$ m

Dead load (unfactored) $G_{ku}(3)=0.55 \times 4.7 / 2 = 1.2925$ kN/m

Imposed load (unfactored) $Q_{ku}(3)=1.50 \times 4.7 / 2 = 3.525$ kN/m

Dist. from left support to start $L_{au}(4)=0$ m

Distance from left support to end $L_{bu}(4)=7$ m

Dead load (unfactored) $G_{ku}(4)=0.40 \times 1.4 / 2 = 0.28$ kN/m

Imposed load (unfactored) $Q_{ku}(4)=0.25 \times 1.4 / 2 = 0.175$ kN/m

Dist. from left support to start $L_{au}(5)=0$ m

Distance from left support to end $L_{bu}(5)=7$ m

Dead load (unfactored) $G_{ku}(5)=1$ kN/m

Imposed load (unfactored) $Q_{ku}(5)=0$ kN/m

Maximum span bending moment 89.186 kNm

Design shear force $F_v=50.964$ kN

Quarter point $m_2=66.89$ kNm

Mid-span $m_3=89.156$ kNm

Three quarter point $m_4=66.89$ kNm

Bending strength $p_b = (p_{ey}) / (\phi_i L T + ((\phi_i L T^2 - p_{ey})^{0.5}))$
 $= 114.36$ N/mm²

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UNIVERSAL BEAM
DESIGN SUMMARY

305 x 165 x 54 UB Grade S 355

Maximum shear force 50.964 kN

Shear capacity 522.31 kN

Max. applied moment 89.186 kNm

Moment capacity 300.33 kNm

Buckling resistance 96.748 kNm

Moment factor (mLT) 0.92483

Resistance (Mb/mLT) 104.61 kNm

Unfactored DL defln 6.3021 mm

Unfactored LL defln 6.3478 mm

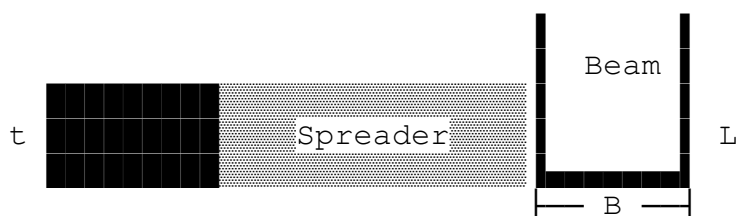
Limiting deflection 19.444 mm

Unfactored end shears	[	DL shear at LHE	16.923 kN
		LL shear at LHE	17.045 kN
		DL shear at RHE	16.923 kN
		LL shear at RHE	17.045 kN

Location: Padstones beneath ends of the steel floor beams

Masonry bearing

Design in accordance with BS5628-1:2005.



Plan view on wall

Bearing type 3
see Figure 5(c) in
BS5628.

t=wall thickness L=length of bearing ed=0 L=t

Proposed width of bearing	B=100 mm
Proposed length of bearing	L=100 mm
Thickness of leaf carrying load	t=t=100 mm
local bearing safety factor	lbsf=2.0

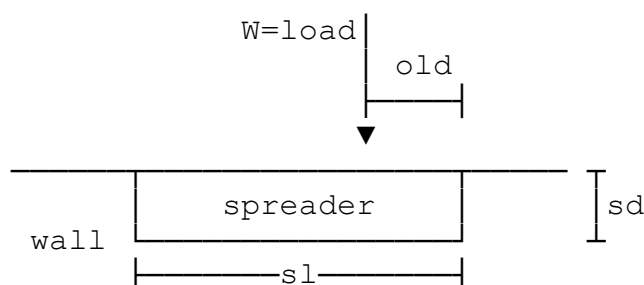
Masonry details

Mortar designation to Table 1	mortar=3
Masonry type (1=clay 2=cal silicate 3=conc brick 4=block)	typ(1)=4
Concrete Blocks Dimensions	
Height	hb=215 mm
Least horiz dimension	lhd=100 mm
ratio height/least horiz. dim	rb=hb/lhd=215/100=2.15
Compressive Strength of Units	po=3.6 N/mm ²
Char comp strength - Table 2(d)	fk(a)=TABLE 2.4 for mortar=3, po=3.6 =3.5 N/mm ²
Partial Safety Factor Material	gammam=3.5

Bearing requirements

Characteristic dead load	DL=17 kN
Characteristic live load	LL=17 kN
Design load on bearing	W=1.4*DL+1.6*LL=1.4*17+1.6*17 =51 kN

Spreader Beam



For bearing reference 3	lbsf=lbsf=2
Design stress capacity	fk1=lbsf*fk(a)/gammam=2*3.5/3.5 =2 N/mm ²

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Design load $Wl=W*1000=51*1000=51000$ N
Length of spreader beam $sl=400$ mm
Width of spreader beam $sb=x=100$ mm (B or L to suit type)
Offset load distance $old=200$ mm
Triangular stress distribution is assumed for spreader not tied down.
Eccentricity of load $ecc=ABS(sl/2-old)=ABS(400/2-200)$
 $=0$ mm
Maximum stress under spreader $fk_m=Wl/(sl*sb)+Wl*ecc/((sb*sl^2)/6)$
 $=51000/(400*100)+51000*0/((100$
 $*400^2)/6)$
 $=1.275$ N/mm²

Max Stress under spreader < Max Permissible

fk_m (1.275 N/mm²) < fk_l (2 N/mm²)

Therefore spreader satisfactory

DESIGN SUMMARY	Length of spreader beam	400 mm
	Width of spreader beam	100 mm
	Eccentricity of load	0 mm
	Char comp strength	2 N/mm ²
	Local bearing safety factor	2
	Design stress capacity	2 N/mm ²
	Max stress under spreader	1.275 N/mm ²

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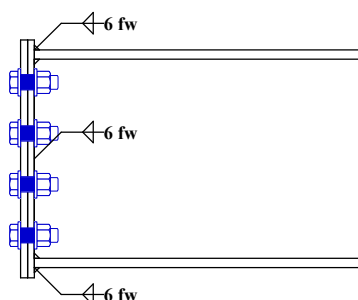
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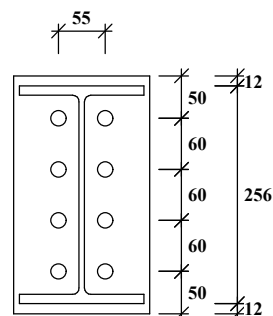
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Job Ref : 20/095**Sheet** : Beam Splices /**Made by** : MW**Date** : 26 May 2020 / Ver. 2019.12**Checked** : MW**Approved** :

Welds grd E 35 Plates S 275
Beam 254x146 UB 37 [S275]



End-Plate 280 x 160 x 8 mm (3 kg)
8 No. M16 Grade 8.8 Bolts in 18 mm holes

254 UB Ridge Beam Splice

Beam to Beam End-Plated Connection to BS 5950

Loading Case 001

Basic Data

User Defined Applied Forces at End-plate Interface

Resultant Forces M, Fv, F 38.0 kNm, 22.0 kN, 0.0 kN
Load directions Top of Joint in Tension, Rafter moving Down.
Design to BS 5950-1: 2000 and the SCI Green Book: SCI-P-207/95

Basic Dimensions

Beam-254x146UB37 [S 275] D=256.0, B=146.4, T=10.9, t=6.3, r=7.6, py=275
Bolts 16 mm Ø in 18 mm holes Grade 8.8 Bolts
Plates S 275, Welds E 35
Rafter Capacities Mc, Fvc, Fc 132.9 kN.m, 266.1 kN, 1296.9 kN

Mc = 132.9 kN.m OK

Summary of Results (Unity Ratios)

Moment Capacity 39.6 kNm (for 3 rows of bolts) (Modified Applied Moment Mm=38.0 kNm)	0.96	OK
Shear Capacity	0.08	OK
Flange Welds	0.59	OK
Web Welds	0.43, 0.37	OK

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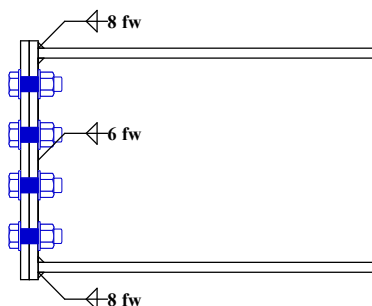
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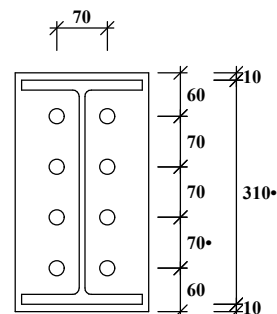
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Job Ref : 20/095**Sheet : Beam Splices /****Made by : MW****Date : 26 May 2020 / Ver. 2019.12****Checked : MW****Approved :**

Welds grd E 35 Plates S 275
Beam 305x165 UB 54 [S275]



End-Plate 330 x 185 x 12 mm (6 ke)
8 No. M20 Grade 8.8 Bolts in 21 mm holes

305 Attic Floor Beam Splice

Beam to Beam End-Plated Connection to BS 5950

Loading Case 001

Basic Data

User Defined Applied Forces at End-plate Interface

Resultant Forces M, Fv, F 90.0 kNm, 51.0 kN, 0.0 kN
Load directions Top of Joint in Tension, Rafter moving Down.
Design to BS 5950-1: 2000 and the SCI Green Book: SCI-P-207/95

Basic Dimensions

Beam-305x165UB54 [S 275] D=310.4, B=166.9, T=13.7, t=7.9, r=8.9, py=275
Bolts 20 mm Ø in 21 mm holes Grade 8.8 Bolts
Plates S 275, Welds E 35
Rafter Capacities Mc, Fvc, Fc 232.7 kN.m, 404.6 kN, 1890.9 kN Mc = 232.7 kN.m OK

Summary of Results (Unity Ratios)

Moment Capacity 94.9 kNm (for 3 rows of bolts) (Modified Applied Moment Mm=90.0 kNm)	0.95	OK
Shear Capacity	0.13	OK
Flange Welds	0.80	OK
Web Welds	0.72, 0.74	OK