Structural Engineering Justification

Project Type:	Side Extension	General Comments:
Client Name:	-	
Address:	-	
Revision:	v1	

Section Summary

Section	Size	Material Grade	Connection
Floor Joists	1 No. 225 x 50mm	Timber Grade C16	Approved flooring to be spiked to every floor joist.
Timber Rafters	1 No. 150 x 50mm	Timber Grade C16	Spiked to wall plate & ridge board.
Beam A	305 x 165 x 54 kg/m UB	Grade S275 UB	Sliced connection - see detail.
Beam B	356 x 171 x 51 kg/m UB	Grade S275 UB	Sliced connection - see detail.
Roof Trimmer	3 No. 225 x 50mm	Timber Grade C16	50 mm DS toothed plate connector with M10 bolts at 400 mm c/c's.

Imposed loadings are in accordance with BS6399-1:1996 Loading for buildings.

Roof	
Dead Load	**0.85** kN/m²
Imposed Load	**0.85** kN/m²
Ceiling	
Dead Load	**0.25** kN/m²
Imposed Load	**0.25** kN/m²
Floor	
Dead Load	**0.50** kN/m²
Imposed Load	**1.50** kN/m²
Walls	
Partitions	**0.50** kN/m²
Blockwork (100)	**1.80** kN/m²
Brickwork (112.5)	**2.50** kN/m²

Floor Joist Design (BS5268-2:2002)

Max opening span	L =	**4.2**	m
Floor Dead Load DL	DL =	**0.50**	kN/m^2
Floor Live Load LL	LL =	**1.50**	kN/m^2
Joist spacing S	S =	**0.40**	m

Joist Dead Load wd	=	S x DL	
	=	**0.20**	kN/m
Joist Live Load w_l	=	S x LL	
	=	**0.60**	kN/m
Joist self weight Fj	=	**0.15**	kN/m
Total Service Load	=	**0.95**	kN/m
Ra = Rb = W / 2	=	0.95	x L / 2
	=	**2.00**	kN
BM_{max}	=	W L / 8	
	=	**2.09**	kN/m

Consider long term uniformly distributed load

Load duration factor K_3 = **1.00**

Modification factors

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

Bending stress

Bending stress σ_m = **5.30** N/mm^2 (Class C16 BS5268:Part2:2002)

Permissible bending stress

$$\sigma_{m\_adm} = \sigma_m \times K_3 \times K_7 \times K_8$$

= **6.00** N/mm^2

Z required $Z = BM_{max} / \sigma_{m\_adm}$

= **349** cm^3

Specified Joist details

Joist breadth	b =	**50**	mm	(Class C16 BS5268:Part2:2002)
Joist depth	h =	**225**	mm	
Joist spacing	s =	**400**	mm	
Joist span	L =	**5300**	mm	
Modulus of elasticity	E_{mean} =	**8800**	N/mm^2	SEPB P128

Strength Class C16 Timber (BS5268:Pt 2:2002)

Section properties

Second moment of area $I = b \times h^3 / 12$

$= \mathbf{47460938}$ mm^4

Section modulus $Z = b \times h^2 / 6$

$= \mathbf{421875}$ mm^3

Applied bending stress

σ_{m_max} = BM / Z

= **4.97** N/mm^2

OK - Applied bending stress
within permissible limits of: 6.00 N/mm^2

Check shear stress

Shear stress τ = **0.67** N/mm^2 SEPB P128

(Class C16 BS5268:Part2:2002)

Permissible shear stress

$\tau_{adm} = \tau \times K_3 \times K_8$

= **0.737** N/mm^2

Applied shear stress

$\tau_{max} = 3 \times W \times L / (4 \times b \times h)$

= **0.34** N/mm^2

OK - Applied shear stress
within permissible limits of: 0.737 N/mm2

Check deflection

Permissible deflection δ_{adm} = min(0.003 x L)

= 15.9 (should not be greater than 14 mm)

= **14** mm

Maximum deflection $\delta_{max} = 5 \times W \times L^3 / 384 \times E_{mean} \times I$

= **4.41** mm

OK - Actual deflection
within permissible limits of: 14 mm

Therefore use 225mm x 50mm C16 joists @ 400c/c's

Timber Rafters (BS5268-2:2002)

Roof Dead Load DL	DL =	**0.85**	kN/m^2
Roof Live Load LL	LL =	**0.85**	kN/m^2
Ceiling Dead Load	DL =	**0.25**	kN/m^2
Ceiling Live Load	LL =	**0.25**	kN/m^2
Rafter spacing S	S =	**0.40**	m
Roof pitch	PR =	**33.0**	Deg
Length	RLR =	**3.20**	m

Roof Dead Load = 0.85/ cos (PR)
= **1.01** kN/m

Roof Live Load = **0.85** kN/m

Joist self weight Fj = **0.15** kN/m

Ceiling Dead Load = S x DL
= **0.10** kN/m

Ceiling Live Load = S x LL
= **0.10** kN/m

UDL Total Service Load = **2.21** kN/m

Ra = Rb = W / 2 = **1.42** kN

BMmax = W L / 8 = **1.81** kNm

Consider long term uniformly distributed load

Load duration factor K_3 = **1.00**

Modification factors

Section depth factor $K_7 = (300 / h)^{0.11}$
= **1.03**

Load sharing factor K_8 = **1.10**

Bending stress

Bending stress σ_m = **5.30** N/mm^2 SEPB P128
(Class C16 BS5268:Part2:2002)

Permissible bending stress

$$\sigma_{m\_adm} = \sigma_m \times K_3 \times K_7 \times K_8$$
= **6.00** N/mm^2

Z required $Z = BM_{max} / \sigma_{m\_adm}$
= **302** cm^3

Specified Joist details

Joist breadth	b =	**50**	mm	(Class C16 BS5268:Part2:2002)
Joist depth	h =	**150**	mm	
Joist spacing	s =	**400**	mm	
Joist span	L =	**3200**	mm	
Modulus of elasticity	E_{mean} =	**8800**	N/mm^2	SEPB P128

Strength Class C16 Timber (BS5268:Pt 2:2002)

Section properties

Second moment of area $I = b \times h^3 / 12$

$= \mathbf{14062500}$ mm^4

Section modulus $Z = b \times h^2 / 6$

$= \mathbf{187500}$ mm^3

Applied bending stress

$\sigma_{m\_max} = BM / Z$

$= \mathbf{9.67}$ N/mm^2

OK - Applied bending stress within permissible limits of: 6.00 N/mm^2

Check shear stress

Shear stress $\tau = \mathbf{0.67}$ N/mm^2 SEPB P128

(Class C16 BS5268:Part2:2002)

Permissible shear stress

$\tau_{adm} = \tau \times K_3 \times K_8$

$= \mathbf{0.737}$ N/mm^2

Applied shear stress

$\tau_{max} = 3 \times W \times L / (4 \times b \times h)$

$= \mathbf{0.71}$ N/mm^2

OK - Applied shear stress within permissible limits of: 0.737 N/mm2

Check deflection

Permissible deflection δ_{adm} = min(0.003 x L)

$= \mathbf{9.6}$ mm (maximum of 14 mm)

Maximum deflection $\delta_{max} = 5 \times W \times L^3 / 384 \times E_{mean} \times I$

$= \mathbf{7.63}$ mm

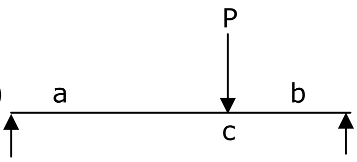
OK - Actual deflection within permissible limits of: 9.6 mm

Therefore use 50mm x 150mm C16 timbers.
2 No. Rafters either side of Velux window locations.

►

Beam A

(BS5950 Part 1: 2000)



with UDL & Point Load from Trimmer

Max opening span	L	=	**7.00**	m
Spacing	S	=	**4.00**	m
Floor Dead Load DL	DL	=	**0.50**	kN/m^2
Floor Live Load LL	LL	=	**1.50**	kN/m^2
Wall Dead Load DL	DL	=	**2.50**	kN/m^2
Wall Height	H	=	**3.20**	m
Roof pitch	PR	=	**32.5**	Deg
Length - wall to ridge	RLR	=	**3.00**	m
Length - wall to eave	RLE	=	**1.00**	m

Floor Dead Load wd = 0.5 x L x DL
= **1.75** kN/m

Floor Live Load w_l = 0.5 x L x LL
= **5.25** kN/m

Wall Dead Load = DL x Wall Height
= **8.00**

Beam self weight Fj = **0.25** kN/m

UDL Total Service Load = **15.25** kN/m

UDL - Design Load (w) = 1.5 x UDL
= **22.88** kN/m

Point Load from Trimmer = **2.00** kN

Point Design Load - (P) = 1.5 x P
= **3.00** kN

Distance a = **3.50** m
Distance b = **2.50** m

Rb = (Pb + wL x L/2) / 4
= **42.78** kN

W Total (Ra + Rb) = wL + P
= **163.13** kN

Ra = W - Rb
= **120.34** kN

BM under point load P = Pab / L
= **3.75** kN

BM due to UDL = W L / 8
= **140.11** kNm

BM Total = **143.86** kNm

Py = **275** N/mm²
(BS5950 Part 1:2000 Table 9 for Grade S275 steel)

Sx Required	= BM / Py	
	= **523.13**	cm^3
I required	= S x W x L^3	
	= **22381**	cm^3
Max Deflection	= L / 360	
	= **19.44**	mm
Le	= 1.0 x L	
	= **7000**	mm

Try **305 x 165 x 54 kg/m UB** (SEPB P214)

Section Depth	= **310.4**	mm
Flange Thickness (t)	= **7.9**	mm
Beam Sx	= **846.0**	
Second moment of area	= Ix	
	= **11700**	cm^4

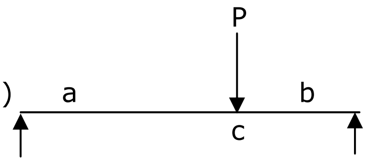
OK - Actual beam greater than require limit of: 22381 cm^3

Minor axis slendernesss (h)	= Le/ry	
	= **201**	
x	= Depth / Thickness	
	= **39.29**	
h / x	= **5.12**	
Slenderness factor (V)	= **0.79**	BS5950:Table 14
Slenderness correction factor (n)		
	= **1.0**	
Buckling parameter (u)	= **0.89**	
Lateral torsional buckling (hLT)		
	= n x u x V x h	
	= **141.43**	
Pb	= 107.74	N/mm^2 BS5950:Table 11
Buckling resistance moment (Mb)		
	= Sx x Pb	
	= **91.1**	kNm

OK - Actual beam greater than require limit of: 143.86 kNm

Therefore use **305 x 165 x 54 kg/m** UB as Beam A.

Beam B
(BS5950 Part 1: 2000)



with UDL & Point Load from Beam A

Max opening span	L	=	**4.50**	m
Spacing	S	=	**6.00**	m
Floor Dead Load DL	DL	=	**0.50**	kN/m^2
Floor Live Load LL	LL	=	**1.50**	kN/m^2
Wall Dead Load DL	DL	=	**2.50**	kN/m^2
Wall Height	H	=	**3.20**	m
Roof pitch	PR	=	**32.5**	Deg
Length - wall to ridge	RLR	=	**3.00**	m
Length - wall to eave	RLE	=	**1.00**	m

Roof Dead Load = ((0.85 / cos(RP) x (RLR + RLE/2))
= **3.53** kN/m

Roof Live Load = (0.85 x (RLR + RLE/2))
= **5.31** kN/m

Wall Dead Load = DL x Wall Height
= **8.00**

Beam self weight Fj = **0.25** kN/m

UDL Total Service Load = **17.09** kN/m

UDL - Design Load (w) = 1.5 x UDL
= **25.63** kN/m

Point Load from Beam A = **81.57** kN

Point Design Load - (P) = **81.57** kN

Distance a = **4.00** m
Distance b = **0.50** m

Rb = (Pb + wL x L/2) / 4
= **39.60** kN

W Total (Ra + Rb) = wL + P
= **196.92** kN

Ra = W - Rb
= **157.32** kN

BM under point load P = Pab / L
= **36.25** kN

BM due to UDL = W L / 8
= **64.89** kNm

BM Total = **101.14** kNm

Py = **275** N/mm^2
(BS5950 Part 1:2000 Table 9 for Grade S275 steel)

Sx Required	= BM / Py		
	= **367.78**	cm^3	
I required	= S x W x L^3		
	= **10767**	cm^3	
Max Deflection	= L / 360		
	= **12.50**	mm	
Le	= 1.0 x L		
	= **4500**	mm	

Try **356 x 171 x 51 kg/m UB** (SEPB P214)

Section Depth	= **355.0**	mm	
Flange Thickness (t)	= **7.4**	mm	
Beam Sx	= **896.0**		
Second moment of area	= Ix		
	= **14140**	cm^4	
OK - Actual beam greater than require limit of:	10767	cm^3	
Minor axis slendernesss (h)	= Le/ry		
	= **129**		
x	= Depth / Thickness		
	= **47.97**		
h / x	= **2.70**		
Slenderness factor (V)	= **0.79**	BS5950:Table 14	
Slenderness correction factor (n)			
	= **1.0**		
Buckling parameter (u)	= **0.89**		
Lateral torsional buckling (hLT)			
	= n x u x V x h		
	= **90.92**		
Pb	= 107.74	N/mm²	BS5950:Table 11
Buckling resistance moment (Mb)			
	= Sx x Pb		
	= **96.5**	kNm	
OK - Actual beam greater than require limit of:	101.14	kNm	

Therefore use **356 x 171 x 51 kg/m** UB as Beam B.

Roof Trimmer (BS5268-2:2002)

Max opening span	L =	**4.00**	m
Joist spacing S	S =	**3.00**	m
Roof pitch	PR =	**33.0**	Deg
Length - wall to ridge	RLR =	**3.00**	m

Roof Dead Load = ((0.85 / cos(RP) x (RLR + RLE/2)) x 0.4
= **1.22** kN/m

Roof Live Load = (0.85 x (RLR + RLE/2)) x 0.4
= **1.02** kN/m

Joist self weight Fj = **0.15** kN/m

Total Service Load = **2.39** kN/m

Ra = Rb = W / 2 = 2.39 x L / 2
= **4.77** kN

BM_{max} = W L / 8
= **4.77** kN/m

Consider long term uniformly distributed load

Load duration factor K_3 = **1.00**

Modification factors

Section depth factor K_7 = $(300 / h)^{0.11}$
= **1.03**

Load sharing factor K_8 = **1.10**

Bending stress

Bending stress σ_m = **5.30** N/mm^2 (Class C16 BS5268:Part2:2002)

Permissible bending stress

$\sigma_{m\_adm} = \sigma_m \times K_3 \times K_7 \times K_8$
= **6.00** N/mm^2

Z required Z = $BM_{max} / \sigma_{m\_adm}$
= **795** cm^3

Specified Joist details

Joist breadth	b =	**150**	mm	(Class C16 BS5268:Part2:2002)
Joist depth	h =	**225**	mm	
Joist spacing	s =	**400**	mm	
Joist span	L =	**4800**	mm	
Modulus of elasticity	E_{mean} =	**8800**	N/mm^2	SEPB P128

Strength Class C16 Timber (BS5268:Pt 2:2002)

Section properties

Second moment of area $I = b \times h^3 / 12$

= **######** mm^4

Section modulus $Z = b \times h^2 / 6$

= **1265625** mm^3

Applied bending stress

σ_{m_max} = BM / Z

= **3.77** N/mm^2

OK - Applied bending stress
within permissible limits of: 6.00 N/mm^2

Check shear stress

Shear stress τ = **0.67** N/mm^2 SEPB P128

(Class C16 BS5268:Part2:2002)

Permissible shear stress

$\tau_{adm} = \tau \times K_3 \times K_8$

= **0.737** N/mm^2

Applied shear stress

$\tau_{max} = 3 \times W \times L / (4 \times b \times h)$

= **0.25** N/mm^2

OK - Applied shear stress
within permissible limits of: 0.737 N/mm2

Check deflection

Permissible deflection δ_{adm} = min(0.003 x L)

= 14.4 (should not be greater than 14 mm)

= **14** mm

Maximum deflection $\delta_{max} = 5 \times W \times L^3 / 384 \times E_{mean} \times I$

= **2.74** mm

OK - Actual deflection
within permissible limits of: 14 mm

Therefore use 3no. 225 x 50mm C16 timbers

Sections to be connected together using **50 mm** DS toothed plate connector with **M10 bolts** at **400** mm c/c's.