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59 STRAND STREET
SANDWICH

FLOOR STRENGTHENING

STRUCTURAL ENGINEERING CALCULATIONS

Job Reference : J127

Revision -

November 2023

Introduction

The existing floor to the loft room is undulating and undersized to be used for anything other than light storage. It is proposed to strengthen the floor by constructing an entirely new floor over the top of the existing. Calculations are required to facilitate the proposals.

The existing building is understood to be of conventional construction i.e. timber roof, timber first floor, loadbearing masonry walls and non-loadbearing stud partitions. It is assumed to have concrete ground-bearing slabs and shallow spread foundations.

General

The following details and calculations are based solely on information provided by the Architect.

These calculations are to be read in conjunction with the design statement and drawing

The scope of the work covered by these documents is only that specifically shown – for all other aspects of the proposed works refer to the Architect's details.

Standards

The following British Standards have been referred to in the design of the works :

- BS 6399 Part 1 : Imposed Loads
- BS 6399 Part 2 : Wind Loads
- BS 6399 Part 3 : Roof Loads
- BS 5268 Part 2 : Timber
- BS 5628 Part 1 : Masonry
- BS 5950 Part 1 : Steelwork
- BS 8110 Part 1 : Concrete

Design Output

The calculations are on sheet 2 onwards.

The design statement is a separate document.

The drawing number is given in the design statement.

Lined Pitched Roof		Dead	Imposed	
Tiles, clay		0.70		kN/m^2 on slope
Battens		0.05		"
Roofing felt		0.03		"
Rafters		0.10		"
Noggings etc.		**0.02**		"
Fixings		0.01		"
Sheathing		**0.07**		"
Insulation		**0.04**		"
Plaster		**0.22**		"
Services		**0.01**		"
Total load on slope :		1.25		"
Roof pitch :		**45**		degrees
Total load on plan :		1.77		kN/m^2 on plan
Imposed load (BS 6399 Part 3 cl. 4.3.2.)			**0.75**	"
Adjustment factor for pitch 30° - 60°			0.50	
Adjusted imposed load			**0.38**	"
	Total (unfactored) :	**1.77**	**0.38**	kN/m^2 on plan

Roof Void		Dead	Imposed	
Joists		**0.10**		
Insulation		**0.06**		
Plaster		**0.22**		
Fixings		**0.01**		
Services		**0.01**		
Water storage tanks, none allowed for				
Imposed load (BS 6399 Part 1 cl. 5.2.)			**0.25**	
	Total (unfactored) :	**0.40**	**0.25**	kN/m^2

Timber Floor		Dead	Imposed	
Flooring		**0.22**		
Joists		**0.14**		
Noggings		**0.04**		
Restraint straps		**0.01**		
Plaster		**0.22**		
Insulation		**0.01**		
Finishes (carpet, tiles etc.)		**0.03**		
Fixings		**0.01**		
Services		**0.01**		
Imposed load (BS 6399 Part 1 Table 1)			**1.50**	
	Total (unfactored) :	**0.69**	**1.50**	kN/m^2

Ashlar Stud Wall		Dead	
Plaster		**0.22**	
Studs		**0.07**	
Head & sole plates		**0.02**	
Sheathing		**0.07**	
Noggings, allow		**0.03**	
Insulation		**0.02**	
Fixings		**0.01**	
Services		**0.01**	
	Total (unfactored) :	**0.45**	kN/m^2

External Solid Masonry Wall		Dead	
Brickwork		**4.40**	
Wall ties		**0.01**	
Plaster		**0.22**	
Services		**0.01**	
	Total (unfactored) :	**4.64**	kN/m^2

Design Assumptions

1. No water tanks, baths or other unusually heavy loads
2. Normal domestic usage only, floor not used for storage

Design Loading

	Dead u.d.l. w_G kN/m^2	Live u.d.l. w_Q kN/m^2	Live point load P kN
Case 1 -	**0.69**	**1.5**	-
Case 2 -	**0.69**	-	**1.4**

Trial Joists

Width	b	=	**47**	mm
Depth	d	=	**175**	mm
Maximum spacing	s	=	**400**	mm
Timber grade		=	**C24**	
Load duration		=	**Long**	
Service class		=	**1 or 2**	

Material Properties and Modification Factors

Grade stress, bending parallel to grain	$\sigma_{m.g.\|\|}$	=	7.5	N/mm^2
Grade stress, compression perpendicular to grain	$\sigma_{c.g.\perp}$	=	2.4	N/mm^2
Grade stress, shear parallel to grain	$\sigma_{v.g.\|\|}$	=	0.71	N/mm^2
Modulus of elasticity (mean)	E_{mean}	=	10,800	N/mm^2
Modulus of elasticity (minimum)	E_{min}	=	7,200	N/mm^2
Load duration factor	K_3	=	1.0	
Depth factor	K_7	$(300/d)^{0.11}$	1.06	
Load sharing factor	K_8	=	1.1	
Service factor	K_2	=	1.0	

Common Floor Joists

Dimensions

Maximum Clear Span	S_C	3.5	m
Effective Span	S	3.6	m
Maximum spacing	s	400	mm

Analysis

Design forces (worst case), per joist -

Maximum bending moment	(unfactored)	M_{max}	M	**1.7**	kNm
Equivalent uniform total load	(unfactored)	$W_{E,max}$	W_E	**3.8**	kN
Maximum shear	(unfactored)	V_{max}	V	**1.9**	kN

Bending

Maximum bending moment	M_{max}	from above	1.7	kNm
Elastic modulus	Z	$b.d^2/6$	240	cm^3
Maximum bending stress	$\sigma_{m.a,\|\|}$	M_{max}/Z	7.1	N/mm^2

Permissible bending stress	$\sigma_{m.adm,\|\|}$	$K_2.K_3.K_7.K_8.\sigma_{m.g.\|\|}$	8.8	N/mm^2
Unity Factor :	$\sigma_{m.a,\|\|} / \sigma_{m.adm,\|\|}$	**0.81**	**< 1.0**	✓

therefore adequate in bending

Deflection

Equivalent uniform total load	$W_{E,max}$	from above	3.8	kN
Second moment of area	I	$b.d^3/12$	2,099	cm^4
Maximum deflection due to total load	δ_{max}	$5W_{E,max}S^3/384E_{mean}.I.K_2$	10.2	mm
Acceptable deflection	δ_{adm}	0.003.S or 12	10.8	mm
Unity Factor :	$\delta_{max} / \delta_{adm}$	**0.94**	**< 1.0**	✓

therefore total deflection O.K.

Timber at Bearings

Maximum reaction	V_{max}	from above	1.9	kN
Minimum bearing width	$L_{bearing}$	=	40	mm
Bearing stress	$\sigma_{c.a,\perp}$	$V_{max}/b.L_{bearing}$	1.0	N/mm^2
Permissible compressive stress	$\sigma_{c,adm,\perp}$	$K_2.K_3.K_7.K_8.\sigma_{c.g.\perp}$	2.8	N/mm^2
Unity Factor :	$\sigma_{c.a,\perp} / \sigma_{c.adm.\perp}$	**0.36**	**< 1.0**	✓

therefore adequate in compression

Maximum shear parallel to grain	$V_{\|\|.max}$	$V_{max}.3/2$	2.8	kN
Shear stress parallel to grain	$\sigma_{v.a.\|\|}$	$V_{\|\|.max}/b.d$	0.35	N/mm^2
Permissible shear stress	$\sigma_{v,adm,\|\|}$	$K_2.K_3.K_7.K_8.\sigma_{v.g.\|\|}$	0.83	N/mm^2
Unity Factor :	$\sigma_{v.a.\|\|} / \sigma_{v.adm.\|\|}$	**0.42**	**< 1.0**	✓

therefore adequate in shear

Allow for notching of top edge at supports -

Beam depth	d	from above	175	mm
Maximum percentage of beam notched	β	=	**20**	%
Maximum depth of notch	z	β.d	35	mm
Remaining beam depth	h	d - z	140	mm
Cross-sectional area after deducting bolt holes	A	b.h	6,580	mm^2
Length of notch from face of support	a	=	**25**	mm
Notching factor	K_5	$(d(h-a)+a.h) / h^2$	1.21	(1.0 min)
Shear stress parallel to grain	$\sigma_{v.a.\|\|}$	$V_{\|\|.max}/A$	0.43	N/mm^2
Permissible shear stress	$\sigma_{v,adm,\|\|}$	$K_2.K_3.K_5.K_7.K_8.\sigma_{v.g.\|\|}$	1.0	N/mm^2
Unity Factor :	$\sigma_{v.a.\|\|} / \sigma_{v.adm.\|\|}$	**0.43**	**< 1.0**	✓

therefore timber is adequate in shear where notched at top at support

Allow for notching of bottom edge at supports -

Maximum percentage of beam notched	β	=	**20**	%
Maximum depth of notch	z	β.d	35	mm
Remaining beam depth	h	d - z	140	mm
Cross-sectional area after deducting bolt holes	A	b.h	6,580	mm^2
Notching factor	K_5	h / d	0.80	
Shear stress parallel to grain	$\sigma_{v.a.\|\|}$	$V_{\|\|.max}/A$	0.43	N/mm^2
Permissible shear stress	$\sigma_{v,adm,\|\|}$	$K_2.K_3.K_5.K_7.K_8.\sigma_{v.g.\|\|}$	0.66	N/mm^2

Unity Factor : $\sigma_{v.a.||} / \sigma_{v.adm.||}$ **0.65** **< 1.0** ✓

therefore timber is adequate in shear where notched at bottom at support

Summary

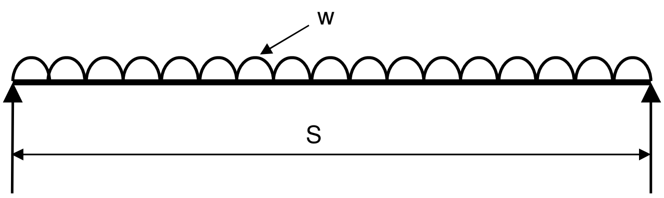
Common - **47 wide x 175 deep Grade C24 joists @ 400 max c/c, max clear span 3500**

Maximum reactions at supports -

Common joists -	**1.9**	kN (unfactored)
Under partitions ⊥ span -	**1.9**	kN (unfactored)
Under partitions || span -	**1.9**	kN (unfactored)

Arrangement and Loading

See below for derivation of loading



Not to scale
w = u.d.l.

End 1, Existing External Wall — End 2, Trimming Beam

Clear Span	S_C	**2.65**	m
Effective Span	S	**2.80**	m

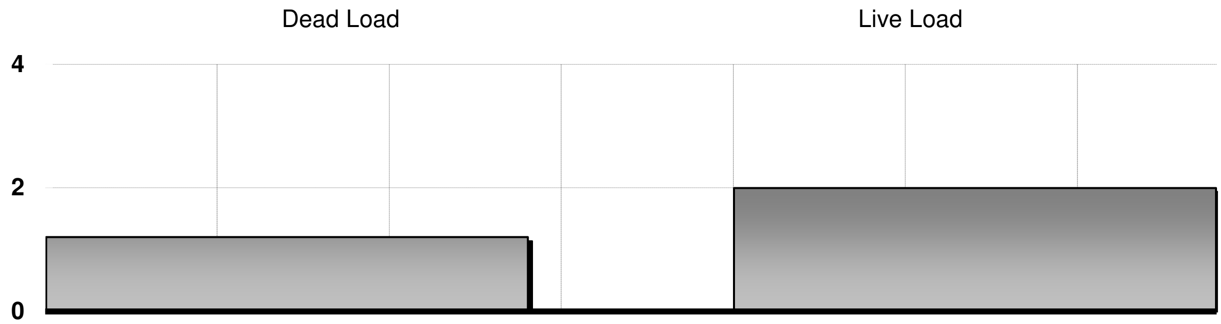
Loading

Load factor for dead loads	$\gamma_{f.G}$	**1.4**
Load factor for live loads	$\gamma_{f.Q}$	**1.6**

Uniformly Distributed Load w	(kN/m^2) Dead Load	(kN/m^2) Live Load	(m) Load width	Proportion inc el shear	(kN/m) Dead UDL	(kN/m) Live UDL
First Floor	**0.69**	**1.5**	**2.6**	**50%**	0.9	2.0
Self-weight					**0.3**	
Total unfactored dead & live loads			w_G & w_Q		1.2	2.0

Load Distribution

Unfactored distributed loads (kN/m)



Design Forces

From analysis -

	Dead	Live	Total		
	unfactored			factored	
Maximum bending moment -	-	-	-	**4.8**	kNm
Equivalent uniform load -	-	**5.6**	**9.0**	-	kN
Maximum shear -	-	-	-	**6.9**	kN
Reaction at Existing External Wall -	**1.7**	**2.8**	**4.5**	**6.9**	kN
Reaction at Trimming Beam -	**1.7**	**2.8**	**4.5**	**6.9**	kN

<u>Analysis Results at SLS</u> (unfactored)

Maximum bending moment	M_{sls}	$M / \gamma_{f.av}$	**3.1**	kNm
Maximum shear	V_{sls}	$V / \gamma_{f.av}$	**4.5**	kN
Reaction at End 1	$R_{1.sls}$	$R_1 / \gamma_{f.av}$	**4.5**	kN
Reaction at End 2	$R_{2.sls}$	$R_2 / \gamma_{f.av}$	**4.5**	kN
Load duration			**Long**	

<u>Trial Section</u>

Try a timber beam as detailed below

Number of timbers	N	=	**3**	
Width of each timber	b	=	**47**	mm
Timber depth	d	=	**175**	mm
Timber grade		=	**C24**	
Bolt diameter	Φ	=	**12**	

<u>Lateral Support</u>

Ends held in position

Maximum depth to breadth ratio	λ_{max}	from Table 19	**3**	
Actual depth to breadth ratio	λ_{act}	d / N.b	**1.2**	$< \lambda_{max}$ ✓

<u>Material Properties and Modification Factors</u>

Grade stress, bending parallel to grain	$\sigma_{m.g.\|\|}$	=	**7.5**	N/mm^2
Grade stress, compression perpendicular to grain	$\sigma_{c.g.\perp}$	=	**2.4**	N/mm^2
Grade stress, shear parallel to grain	$\sigma_{v.g.\|\|}$	=	**0.71**	N/mm^2
Modulus of elasticity (minimum)	E	=	**7,200**	N/mm^2
Service class		=	**1 or 2**	
Load duration factor	K_3	=	**1.0**	
Depth factor	K_7	$(300/d)^{0.11}$	**1.06**	
Load sharing factor	K_8	=	**1.1**	
Modulus of elasticity factor	K_9	=	**1.21**	
Service factor	K_2	=	**1.0**	

<u>Bending</u>

Maximum bending moment	M_{sls}	from above	3.1	kNm
Elastic modulus	Z	$N.b.d^2/6$	720	cm^3
Maximum bending stress	$\sigma_{m.a,\|\|}$	M_{sls}/Z	4.4	N/mm^2
Permissible bending stress	$\sigma_{m.adm,\|\|}$	$K_2.K_3.K_7.K_8.\sigma_{m.g.\|\|}$	8.8	N/mm^2
Unity Factor :	$\sigma_{m.a,\|\|} / \sigma_{m.adm,\|\|}$	**0.50**	**< 1.0**	✓

therefore timber is adequate in bending

Deflection

Equivalent uniform live load (unfactored)	$W_{E.Q}$	from above	5.6	kN
Second moment of area	I	$N.b.d^3/12$	6,297	cm^4
Maximum deflection due to live load	$\delta_{max.Q}$	$5.W_{E.Q}.S^3/384.E.I.K_2.K_9$	2.9	mm
Acceptable deflection	$\delta_{adm.Q}$	0.003.S	8.4	mm
Unity Factor :	$\delta_{max.Q} / \delta_{adm.Q}$	**0.35**	**< 1.0**	✓
			therefore live load deflection O.K.	
Equivalent uniform total load (unfactored)	$W_{E.T}$	from above	9.0	kN
Maximum deflection due to total load	$\delta_{max.T}$	$5.W_{E.T.}S^3/384.E.I.K_2.K_9$	4.7	mm
Acceptable deflection	$\delta_{adm.T}$	0.003.S	8.4	mm
Unity Factor :	$\delta_{max.T} / \delta_{adm.T}$	**0.56**	**< 1.0**	✓
			therefore total deflection O.K.	

Bearings

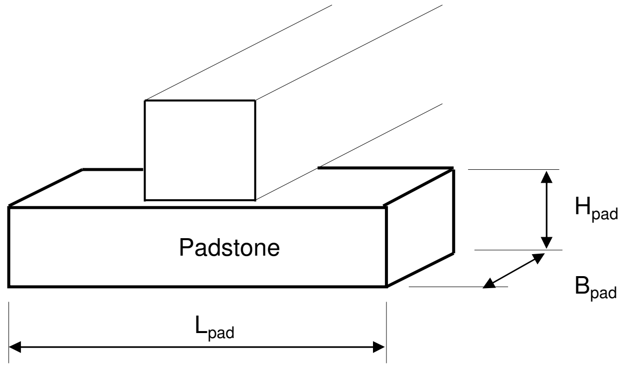
Maximum reaction (unfactored)	R_{sls}	max of $R_{1.sls}$ & $R_{2.sls}$	4.5	kN
Minimum width available for bearing	$L_{bearing}$	=	**100**	mm
Bearing stress	$\sigma_{c.a,\perp}$	$R_{sls}/N.b.L_{bearing}$	0.3	N/mm^2
Permissible compressive stress	$\sigma_{c,adm,\perp}$	$K_2.K_3.K_7.K_8.\sigma_{c.g.\perp}$	2.8	N/mm^2
Unity Factor :	$\sigma_{c.a,\perp} / \sigma_{c.adm.\perp}$	**0.11**	**< 1.0**	✓
			therefore timber is adequate in compression	
Maximum shear parallel to grain	$V_{\|\|.sls}$	$R_{sls}.3/2$	6.7	kN
Cross-sectional area after deduction for bolt holes	A	N.b.d - N.b.Φ.1.1	22,814	mm^2
Shear stress parallel to grain	$\sigma_{v.a.\|\|}$	$V_{\|\|.sls}/A$	0.29	N/mm^2
Permissible shear stress	$\sigma_{v,adm,\|\|}$	$K_2.K_3.K_7.K_8.\sigma_{v.g.\|\|}$	0.83	N/mm^2
Unity Factor :	$\sigma_{v.a.\|\|} / \sigma_{v.adm.\|\|}$	**0.36**	**< 1.0**	✓
			therefore timber is adequate in shear	
Allow for notching of top edge at supports -				
Beam depth	d	from above	175	mm
Maximum percentage of beam notched	β	=	**20**	%
Maximum depth of notch	z	β.d	35	mm
Remaining beam depth	h	d - z	140	mm
Cross-sectional area after deducting bolt holes	A	N.b.h - N.b.Φ.1.1	17,879	mm^2
Length of notch from face of support	a	=	**25**	mm
Notching factor	K_5	$(d(h-a)+a.h) / h^2$	1.21	(1.0 min)
Shear stress parallel to grain	$\sigma_{v.a.\|\|}$	$V_{\|\|.sls}/A$	0.38	N/mm^2
Permissible shear stress	$\sigma_{v,adm,\|\|}$	$K_2.K_3.K_5.K_7.K_8.\sigma_{v.g.\|\|}$	1.0	N/mm^2
Unity Factor :	$\sigma_{v.a.\|\|} / \sigma_{v.adm.\|\|}$	**0.38**	**< 1.0**	✓
			therefore timber is adequate in shear where notched at top at support	
Allow for notching of bottom edge at supports -				
Maximum percentage of beam notched	β	=	**20**	%
Maximum depth of notch	z	β.d	35	mm
Remaining beam depth	h	d - z	140	mm
Cross-sectional area after deducting bolt holes	A	N.b.h - N.b.Φ.1.1	17,879	mm^2
Notching factor	K_5	h / d	0.80	

Shear stress parallel to grain	$\sigma_{v.a.\|\|}$	$V_{\|\|.sls}/A$	0.38	N/mm^2
Permissible shear stress	$\sigma_{v,adm,\|\|}$	$K_2.K_3.K_5.K_7.K_8.\sigma_{v.g.\|\|}$	0.66	N/mm^2
Unity Factor :	$\sigma_{v.a.\|\|} / \sigma_{v.adm.\|\|}$	**0.57**	**< 1.0**	✓

therefore timber is adequate in shear where notched at bottom at support

<u>Support at End 1 - Existing External Wall</u>

N.T.S.



Factored reaction	R_1	=	6.9	kN
Padstone width & length of bearing	B_{pad}	=	**100**	mm
Width of beam	B	total width of timbers	141	mm
Thickness of wall	t	=	100	mm
Compressive strength of masonry		=	7.0	N/mm^2
Mortar type		from Table 1	M2/(iv)	
Characteristic compressive strength	f_k	from Table 2	2.4	N/mm^2
Partial safety factor for material strength	γ_m	from Table 4	3.5	
Increased local stress factor	γ_{local}	from Figure 4	**1.0**	
Local design bearing strength	σ_{local}	$f_k.\gamma_{local}/\gamma_m$	0.7	N/mm^2
Minimum padstone length required	L_{min}	$R_1/t.\sigma_{local}$	100	mm

< width of beam so padstone not required

<u>Summary</u>

Timber - **3 No. 47 wide x 175 deep Grade C24**
Bolts - **M12 @ 350 c/c maximum throughout length**
Maximum clear span - **2,650** mm
Maximum deflection under live load - 2.9 mm
Maximum deflection under total load - 4.7 mm

<u>Support at End 1 on Existing External Wall</u>

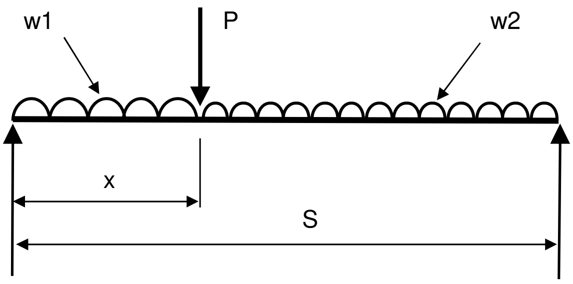
Provide 100 direct bearing (no padstone necessary)

Support at End 2 on Trimming Beam

Reaction - dead	(unfactored)	R_G	from analysis	1.7	kN
Reaction - live	(unfactored)	R_Q	from analysis	2.8	kN
Reaction - total	(unfactored)	R_2	from analysis	4.5	kN
Reaction - total	(factored)	R_2	from analysis	6.9	kN

<u>Arrangement and Loading</u>

Schematic arrangement. Not to scale. See below for derivation and distribution of loading



Not to scale
P = point load
w = u.d.l.

Distance to P and end of w1 (from End 1)	x	**2.50**	m
Clear Span	S_C	**3.60**	m
Effective Span	S	**3.75**	m

<u>Loading</u>

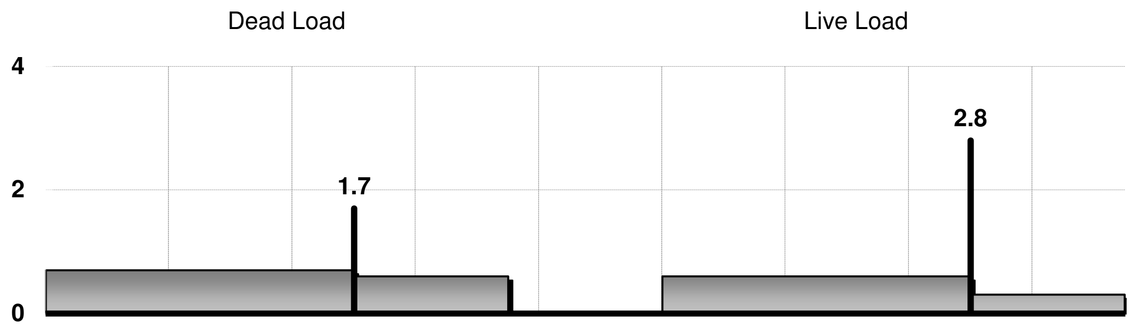
Load factor for dead loads	$\gamma_{f.G}$	**1.4**
Load factor for live loads	$\gamma_{f.Q}$	**1.6**

	(kN/m^2)	(kN/m^2)	(m)	Proportion	(kN/m)	(kN/m)
<u>Uniformly Distributed Load w1</u>	<u>Dead Load</u>	<u>Live Load</u>	<u>Load width</u>	<u>inc el shear</u>	<u>Dead UDL</u>	<u>Live UDL</u>
First Floor	**0.69**	**1.5**	**0.4**	**100%**	0.3	0.6
Self-weight					**0.4**	
Total unfactored dead & live loads				w_{1G} & w_{1Q}	0.7	0.6
<u>Uniformly Distributed Load w2</u>	<u>Dead Load</u>	<u>Live Load</u>	<u>Load width</u>	<u>Proportion</u>	<u>Dead UDL</u>	<u>Live UDL</u>
First Floor	**0.69**	**1.5**	**0.2**	**100%**	0.1	0.3
Self-weight					**0.4**	
Total unfactored dead & live loads				w_{2G} & w_{2Q}	0.6	0.3

			(kN)	(kN)
<u>Point Load P</u>			<u>Dead PL</u>	<u>Live PL</u>
Reaction from Trimmer	from sheet **11**	R_G & R_Q	**1.7**	**2.8**
Total unfactored dead & live loads		P_G & P_Q	1.7	2.8

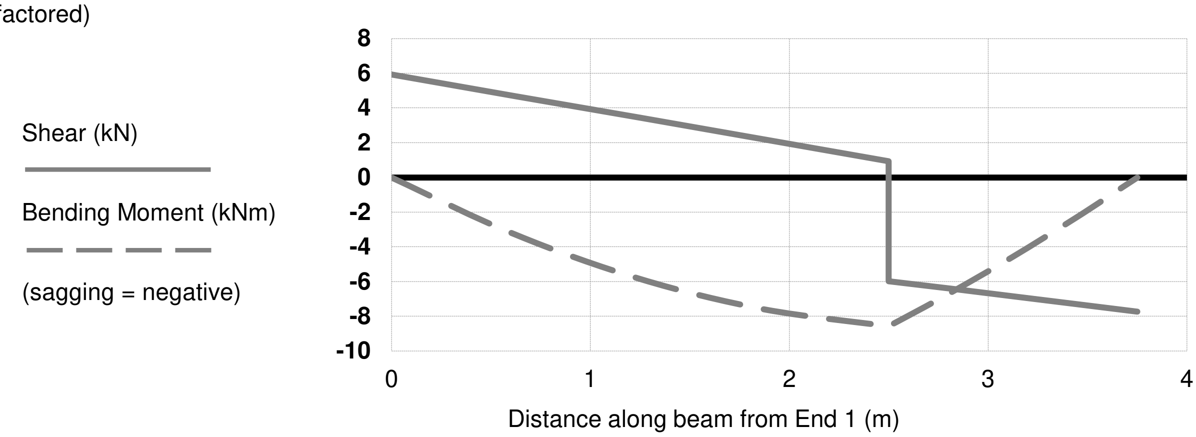
Load Distribution

Unfactored distributed loads (kN/m) and point loads (kN)



Design Forces

(factored)



Point of contraflexure is at P

From analysis -

	Dead	Live	Total		
	unfactored			factored	
Maximum bending moment -	-	-	-	**8.6**	kNm
Equivalent uniform load -	-	**6.4**	**12.1**	-	kN
Maximum shear -	-	-	-	**7.7**	kN
Reaction at Existing External Wall -	**1.9**	**2.0**	**3.9**	**5.9**	kN
Reaction at Existing External Wall -	**2.3**	**2.7**	**5.0**	**7.7**	kN

Analysis Results at SLS (unfactored)

Maximum bending moment	M_{sls}	$M / \gamma_{f.av}$	**5.7**	kNm
Maximum shear	V_{sls}	$V / \gamma_{f.av}$	**5.1**	kN
Reaction at End 1	$R_{1.sls}$	$R_1 / \gamma_{f.av}$	**3.9**	kN
Reaction at End 2	$R_{2.sls}$	$R_2 / \gamma_{f.av}$	**5.1**	kN
Load duration			**Long**	

Trial Section

Try a timber beam as detailed below

Number of timbers	N	=	**4**	
Width of each timber	b	=	**47**	mm
Timber depth	d	=	**175**	mm
Timber grade		=	**C24**	
Bolt diameter	Φ	=	**12**	

Lateral Support

Ends held in position

Maximum depth to breadth ratio	λ_{max}	from Table 19	**3**	
Actual depth to breadth ratio	λ_{act}	d / N.b	**0.9**	$< \lambda_{max}$ ✓

Material Properties and Modification Factors

Grade stress, bending parallel to grain	$\sigma_{m.g.\|\|}$	=	**7.5**	N/mm^2
Grade stress, compression perpendicular to grain	$\sigma_{c.g.\perp}$	=	**2.4**	N/mm^2
Grade stress, shear parallel to grain	$\sigma_{v.g.\|\|}$	=	**0.71**	N/mm^2
Modulus of elasticity (minimum)	E	=	**7,200**	N/mm^2
Service class		=	**1 or 2**	
Load duration factor	K_3	=	**1.0**	
Depth factor	K_7	$(300/d)^{0.11}$	**1.06**	
Load sharing factor	K_8	=	**1.1**	
Modulus of elasticity factor	K_9	=	**1.24**	
Service factor	K_2	=	**1.0**	

Bending

Maximum bending moment	M_{sls}	from above	5.7	kNm
Elastic modulus	Z	$N.b.d^2/6$	960	cm^3
Maximum bending stress	$\sigma_{m.a,\|\|}$	M_{sls}/Z	5.9	N/mm^2
Permissible bending stress	$\sigma_{m.adm,\|\|}$	$K_2.K_3.K_7.K_8.\sigma_{m.g.\|\|}$	8.8	N/mm^2
Unity Factor :	$\sigma_{m.a,\|\|} / \sigma_{m.adm,\|\|}$	**0.68**	**< 1.0**	✓

therefore timber is adequate in bending

Deflection

Equivalent uniform live load (unfactored)	$W_{E.Q}$	from above	6.4	kN
Second moment of area	I	$N.b.d^3/12$	8,396	cm^4
Maximum deflection due to live load	$\delta_{max.Q}$	$5.W_{E.Q}.S^3/384.E.I.K_2.K_9$	5.9	mm
Acceptable deflection	$\delta_{adm.Q}$	0.003.S	11.3	mm
Unity Factor :	$\delta_{max.Q} / \delta_{adm.Q}$	**0.52**	**< 1.0**	✓
				therefore live load deflection O.K.
Equivalent uniform total load (unfactored)	$W_{E.T}$	from above	12.1	kN
Maximum deflection due to total load	$\delta_{max.T}$	$5.W_{E.T.}S^3/384.E.I.K_2.K_9$	11.1	mm
Acceptable deflection	$\delta_{adm.T}$	0.003.S	11.3	mm
Unity Factor :	$\delta_{max.T} / \delta_{adm.T}$	**0.99**	**< 1.0**	✓
				therefore total deflection O.K.

Bearings

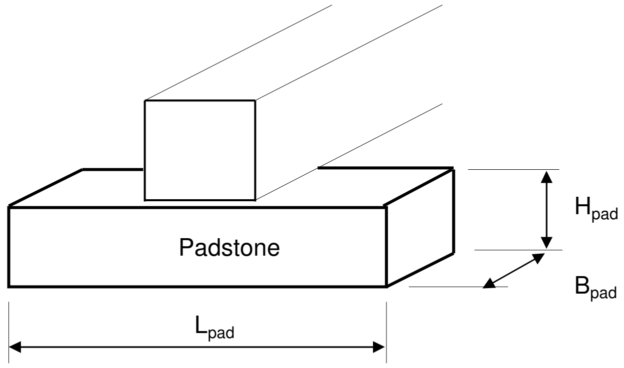
Maximum reaction (unfactored)	R_{sls}	max of $R_{1.sls}$ & $R_{2.sls}$	5.1	kN
Minimum width available for bearing	$L_{bearing}$	=	**100**	mm
Bearing stress	$\sigma_{c.a,\perp}$	$R_{sls}/N.b.L_{bearing}$	0.3	N/mm^2
Permissible compressive stress	$\sigma_{c,adm,\perp}$	$K_2.K_3.K_7.K_8.\sigma_{c.g.\perp}$	2.8	N/mm^2
Unity Factor :	$\sigma_{c.a,\perp} / \sigma_{c.adm.\perp}$	**0.10**	**< 1.0**	✓
				therefore timber is adequate in compression
Maximum shear parallel to grain	$V_{\|\|.sls}$	$R_{sls}.3/2$	7.7	kN
Cross-sectional area after deduction for bolt holes	A	N.b.d - N.b.Φ.1.1	30,418	mm^2
Shear stress parallel to grain	$\sigma_{v.a.\|\|}$	$V_{\|\|.sls}/A$	0.25	N/mm^2
Permissible shear stress	$\sigma_{v,adm,\|\|}$	$K_2.K_3.K_7.K_8.\sigma_{v.g.\|\|}$	0.83	N/mm^2
Unity Factor :	$\sigma_{v.a.\|\|} / \sigma_{v.adm.\|\|}$	**0.31**	**< 1.0**	✓
				therefore timber is adequate in shear
Allow for notching of top edge at supports -				
Beam depth	d	from above	175	mm
Maximum percentage of beam notched	β	=	**20**	%
Maximum depth of notch	z	β.d	35	mm
Remaining beam depth	h	d - z	140	mm
Cross-sectional area after deducting bolt holes	A	N.b.h - N.b.Φ.1.1	23,838	mm^2
Length of notch from face of support	a	=	**25**	mm
Notching factor	K_5	$(d(h-a)+a.h) / h^2$	1.21	(1.0 min)
Shear stress parallel to grain	$\sigma_{v.a.\|\|}$	$V_{\|\|.sls}/A$	0.32	N/mm^2
Permissible shear stress	$\sigma_{v,adm,\|\|}$	$K_2.K_3.K_5.K_7.K_8.\sigma_{v.g.\|\|}$	1.0	N/mm^2
Unity Factor :	$\sigma_{v.a.\|\|} / \sigma_{v.adm.\|\|}$	**0.32**	**< 1.0**	✓
				therefore timber is adequate in shear where notched at top at support
Allow for notching of bottom edge at supports -				
Maximum percentage of beam notched	β	=	**20**	%
Maximum depth of notch	z	β.d	35	mm
Remaining beam depth	h	d - z	140	mm
Cross-sectional area after deducting bolt holes	A	N.b.h - N.b.Φ.1.1	23,838	mm^2
Notching factor	K_5	h / d	0.80	

Shear stress parallel to grain	$\sigma_{v.a.\|\|}$	$V_{\|\|.sls}/A$	0.32	N/mm^2
Permissible shear stress	$\sigma_{v,adm,\|\|}$	$K_2.K_3.K_5.K_7.K_8.\sigma_{v.g.\|\|}$	0.66	N/mm^2
Unity Factor :	$\sigma_{v.a.\|\|} / \sigma_{v.adm.\|\|}$	**0.49**	**< 1.0**	✓

therefore timber is adequate in shear where notched at bottom at support

Support at End 1 - Existing External Wall

N.T.S.

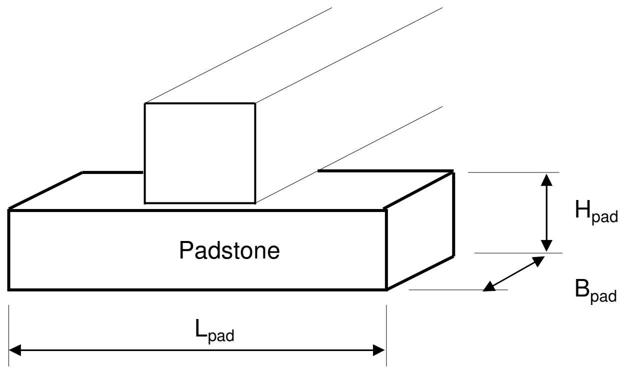


Factored reaction	R_1	=	5.9	kN
Padstone width & length of bearing	B_{pad}	=	**100**	mm
Width of beam	B	total width of timbers	188	mm
Thickness of wall	t	=	100	mm
Compressive strength of masonry		=	7.0	N/mm^2
Mortar type		from Table 1	M2/(iv)	
Characteristic compressive strength	f_k	from Table 2	3.5	N/mm^2
Partial safety factor for material strength	γ_m	from Table 4	3.5	
Increased local stress factor	γ_{local}	from Figure 4	**1.0**	
Local design bearing strength	σ_{local}	$f_k.\gamma_{local}/\gamma_m$	1.0	N/mm^2
Minimum padstone length required	L_{min}	$R_1/t.\sigma_{local}$	59	mm

< width of beam so padstone not required

Support at End 2 - Existing External Wall

N.T.S.



Factored reaction	R_2	=	7.7	kN
Padstone width & length of bearing	B_{pad}	=	**100**	mm

Width of beam	B	total width of timbers	188	mm
Thickness of wall	t	=	100	mm
Compressive strength of masonry		=	7.0	N/mm^2
Mortar type		from Table 1	M2/(iv)	
Characteristic compressive strength	f_k	from Table 2	3.5	N/mm^2
Partial safety factor for material strength	γ_m	from Table 4	3.5	
Increased local stress factor	γ_{local}	from Figure 4	**1.0**	
Local design bearing strength	σ_{local}	$f_k.\gamma_{local}/\gamma_m$	1.0	N/mm^2
Minimum padstone length required	L_{min}	$R_2/t.\sigma_{local}$	77	mm

< width of beam so padstone not required

<u>Summary</u>

Timber -	**4 No. 47 wide x 175 deep Grade C24**	
Bolts -	**M12 @ 350 c/c maximum throughout length**	
Maximum clear span -	**3,600**	mm
Maximum deflection under live load -	5.9	mm
Maximum deflection under total load -	11.1	mm

<u>Support at End 1 on Existing External Wall</u>

Provide 100 direct bearing (no padstone necessary)

<u>Support at End 2 on Existing External Wall</u>

Provide 100 direct bearing (no padstone necessary)