JS CONSULTING
STRUCTURAL ENGINEERS

STRUCTURAL CALCULATIONS

For

Structural Alterations

At

5 Cross Lane
Aldwincle
NN14 3EG

Client

Mr Graeme Stretton

JOB No. JS21025

June 2021

DESIGN NOTES

Dimensions used in the following calculations are for design only and shall not be used for constructional purposes.

The following details have been used in the preparation of these calculations:

An initial site for assessment of existing structure.

THE FOLLOWING CALCULATIONS ARE FOR STRUCTURAL STEELWORK DESIGNED FOR PROPOSED INTERNAL ALTERNATIONS.

Any construction details and dimensions indicated in the following calculations shall not be varied unless they are substantiated by calculation, and approved in writing by the Engineer.

The British Standards and Codes of Practice highlighted below have been used in the preparation of these calculations - all constructional details must be in accordance with all relevant clauses contained in these same standards or associated standards.

NOTE

- No structural assessment has been carried out on the existing foundations.
- All structural steel to be grade S355JR to BS EN 10 025
- Installation of new beams in existing structures can cause cracking to rooms above due to deflections. Some masonry repairs and decoration costs should be allowed for.
- Dimensions should be checked on site prior to fabrication.
- Minimum steelwork protective treatment applied immediately after surface preparation to be 2No coats zinc phosphate epoxy primer minimum 75 microns DFT for an internal application.
- Plasterboard or alternative fire protection may be required around beams and columns or posts to building control approval.
- Steel fabrication details to be based on actual site dimensions.
- Maximum beam spans must not be exceeded without rechecking of calculations.

DESIGN CODES

Code	Title	Referenced
Loadings		
BS 6399: Part 1: 1996	Loadings for Buildings Code of Practice for Dead and Imposed Loads	✓
BS 6399: Part 2: 1997	Loadings for Buildings Code of Practice for Wind Loads	
BS6399: Part 3: 1988	Loadings for Buildings Code of Practice for Imposed Roof Loads	✓
Steelwork		
BS 5950: Part 1: 2000	Structural Use of Steelwork in Buildings: Codes of Practice for Design in Simple and Continuous Construction; Hot Rolled Sections	✓
BS 5950: Part 3	Structural Use of Steelwork in Buildings Design in Composite Construction	
BS 5950: Part 3: S 3.1; 1990	Structural Use of Steelwork in Buildings Code of Practice for Design of Simple and Continuous Composite Beams	
BS 5950: Part 5: 1987	Structural Use of Steelwork in Buildings Code of Practice for Design of Cold Formed Sections	
BS 5950: Part 8: 1990	Structural Use of Steelwork in Buildings Code of Practice for Fire Resistant Design	
Concrete		
BS 8110: Part 1: 1997	Structural Use of Concrete Code of Practice for Design and Construction	
BS 8110: Part 3: 1985	Design Charts for Singly Reinforced Beams, Doubly Reinforced Beams and Rectangular Columns	
BS 8007: 1987	Code of Practice for Design of Concrete Structures for Retaining Aqueous Liquids	
Timberwork		
BS 5268: Part 2: 2002	Structural Use of Timber Code of Practice for Permissible Stress Design, Materials and Workmanship	✓
BS 5268: Part 3:1998	Structural Use of Timber Code of Practice for trussed rafter roofs	

Pitched Roof

Pitch = 40

DEAD	Tiles	0.80	kN/m²
	Battens & Felt	0.05	kN/m²
	Timber Rafters	0.10	kN/m²
			kN/m²
	Dead Load on slope	0.95	kN/m²
	Dead load on plan	1.25	kN/m²
	Ceiling Ties	0.05	kN/m²
	Insulation	0.10	kN/m²
	Plasterboard and skim	0.15	kN/m²
	Total Dead Load on Plan	**1.55**	kN/m²
IMPOSED	Roof [BS6399: Part 3: 1988] 0.75kN/m² Reduced For Pitch	0.50	kN/m²
	Ceilings [BS6399: Part 1 1996 cl5.2 (b)]	0.25	kN/m²
	Total live Load	**0.75**	kN/m²
TOTAL CHARACTERISTIC		**2.30**	**kN/m²**
TOTAL ULTIMATE		**3.40**	**kN/m²**

Room In Roof

Pitch = 40

DEAD	Tiles	0.80	kN/m²
	Battens & Felt	0.05	kN/m²
	Timber Rafters	0.10	kN/m²
	Plywood	0.15	kN/m²
	Insulation	0.15	kN/m²
	Plasterboard and skim	0.15	kN/m²
	Dead Load on slope	1.40	kN/m²
	Total Dead Load on plan	**1.85**	kN/m²
IMPOSED	Roof [BS6399: Part 3: 1988] 0.75kN/m² Reduced For Pitch	0.50	kN/m²
	Total live Load	**0.50**	kN/m²
TOTAL CHARACTERISTIC		**2.35**	**kN/m²**
TOTAL ULTIMATE		**3.40**	**kN/m²**

Room In Roof

Pitch = 0

DEAD	Roof Covering	0.40	kN/m²
	Battens & Felt	0.05	kN/m²
	Timber Rafters	0.10	kN/m²
	Plywood	0.15	kN/m²
	Insulation	0.15	kN/m²
	Plasterboard and skim	0.15	kN/m²
	Dead Load on slope	1.00	kN/m²
	Total Dead Load on plan	**1.00**	kN/m²
IMPOSED	Roof [BS6399: Part 3: 1988] 0.75kN/m² Reduced For Pitch	0.75	kN/m²
	Total live Load	**0.75**	kN/m²
TOTAL CHARACTERISTIC		**1.75**	**kN/m²**
TOTAL ULTIMATE		**2.60**	**kN/m²**

Timber Floors

DEAD	22	mm Floor Joists	0.20	kN/m²
		Timber Joists	0.10	kN/m²
		Insulation	0.05	kN/m²
		Plasterboard & skim	0.15	kN/m²
		Fixed Partitions	0.50	kN/m²
		Total Dead Load on Plan	**1.00**	kN/m²
IMPOSED		Floors [BS6399: Part 1: 1996 Table 1]	1.50	kN/m²
TOTAL CHARACTERISTIC			**2.50**	**kN/m²**
TOTAL ULTIMATE			**3.80**	**kN/m²**

Precast Concrete Stair/Landings

DEAD			0.00	
			0.00	
		mm concrete screed on floor or added SW on Stair	0.00	kN/m²
		mm thick PC hollowcore floor or PC Stair	0.00	kN/m²
		Ceiling	0.00	kN/m²
			0.00	
		Total Dead Load	**0.00**	kN/m²
IMPOSED		Floors [BS6399: Part 1: 1996 Table 1 - C3]	0.00	kN/m²
TOTAL CHARACTERISTIC			**0.00**	**kN/m²**
TOTAL ULTIMATE			**0.00**	**kN/m²**

Concrete Ground Floor

DEAD	22	mm Chipboard	0.15	kN/m²
	75	mm Insulation	0.10	kN/m²
	75	mm Concrete Screed	1.80	kN/m²
	150	mm thick Concrete Floor	2.75	kN/m²
		Fixed Partitions	0.50	kN/m²
		Total Dead Load - Ground Floor	5.30	kN/m²
		Total Dead Load - Storage	4.55	kN/m²
IMPOSED		Floors [BS6399: Part 1: 1996 Table 1]	1.50	kN/m²
		Garage	2.50	kN/m²
TOTAL CHARACTERISTIC - Ground Floor			**6.85**	**kN/m²**
TOTAL ULTIMATE - Ground Floor			**9.85**	**kN/m²**
TOTAL CHARACTERISTIC - Garage			**7.05**	**kN/m²**
TOTAL ULTIMATE - Garage			**10.40**	**kN/m²**

Wall Loadings

1	Aerated Concrete Blocks	590	kg/m³	LAID
2	Concrete Blocks	1350	kg/m³	LAID
3	Dense Concrete Blocks	1600	kg/m³	LAID
4	Brickwork	2100	kg/m³	LAID

External Wall	102.5	mm External Masonry	Type	4	2.15	kN/m²
	102.5	mm Internal Masonry	Type	4	2.15	kN/m²
		Cavity Insulation			0.10	kN/m²
	12.5	mm Plaster			0.25	kN/m²
		Total			**4.70**	kN/m²
Soild Wall	215.0	mm External Masonry	Type	3	3.44	kN/m²
	12.5	mm Plaster			0.25	kN/m²
		Total			**3.70**	kN/m²
Blockwork Wall	102.5	mm Internal Masonry	Type	4	2.15	kN/m²
	12.5	mm Plaster both sides			0.50	kN/m²
		Total			**2.70**	kN/m²
Party Wall	102.5	mm Internal Masonry	Type	4	2.15	kN/m²
	102.5	mm Internal Masonry	Type	4	2.15	kN/m²
		Cavity Insulation			0.10	kN/m²
	12.5	mm Plaster both sides			0.50	kN/m²
		Total			**4.95**	kN/m²
Timber Frame		Tiles			0.80	kN/m²
		SW Battens			0.05	kN/m²
	12.5	mm OSB			0.25	kN/m²
		Insulation			0.15	kN/m²
		SW Timber Studwork			0.10	kN/m²
	12.5	mm Plasterboard			0.15	kN/m²
		Total			**1.50**	**kN/m²**
Stud Partition with Insulation		Timber & Insulation			0.20	kN/m²
		Plasterboard both sides			0.30	kN/m²
		Total			**0.50**	**kN/m²**

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	Part of Works. Steelwork Design		Page No. C/6
	Calculations By. PS	Checked by.	Date. Jun-2021

REF	CALCULATIONS

Unit Loads taken from sheets C/3 to C/5

Roof Purlin Beam A

Roof Dead Load

1.85	x	3.50	x	0.50	=	3.25	kN/m
Total Dead Load					**=**	**3.25**	**kN/m**

Roof Imposed Load

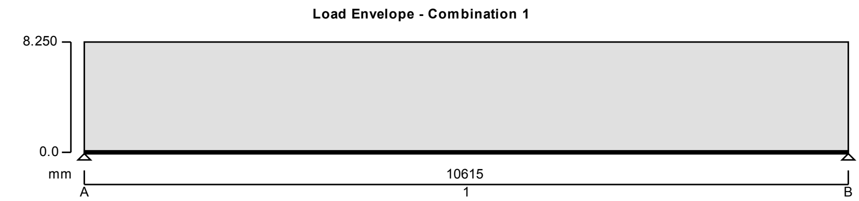
0.50	x	3.50	x	0.50	=	0.90	kN/m
Total Imposed Load					**=**	**0.90**	**kN/m**

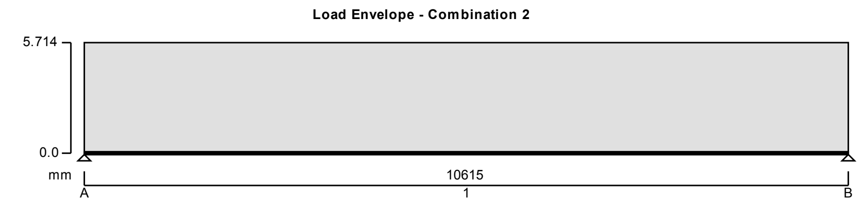
From Spreadsheet output, adopt: 457x191x98 UB

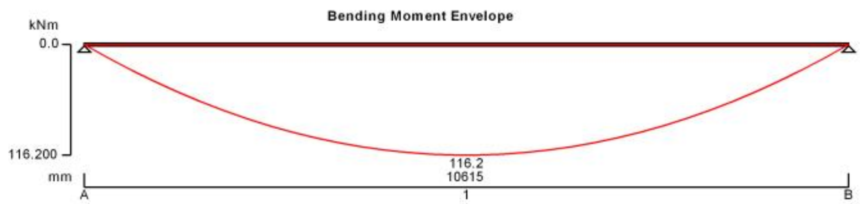
STEEL BEAM ANALYSIS & DESIGN (BS5950)

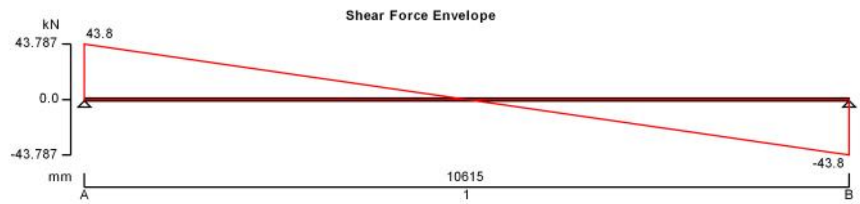
In accordance with BS5950-1:2000 incorporating Corrigendum No.1

TEDDS calculation version 3.0.05









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 3.5 kN/m

Imposed full UDL 1.25 kN/m

Load combinations

Load combination 1	Support A	Dead × 1.40
		Imposed × 1.60
	Span 1	Dead × 1.40
		Imposed × 1.60
	Support B	Dead × 1.40
		Imposed × 1.60
Load combination 2	Support A	Dead × 1.00
		Imposed × 1.00
	Span 1	Dead × 1.00
		Imposed × 1.00
	Support B	Dead × 1.00
		Imposed × 1.00

Analysis results

Maximum moment	M_{max} = **116.2** kNm	M_{min} = **0** kNm
Maximum shear	V_{max} = **43.8** kN	V_{min} = **-43.8** kN
Deflection	δ_{max} = **10.1** mm	δ_{min} = **0** mm
Maximum reaction at support A	R_{A_max} = **43.8** kN	R_{A_min} = **30.3** kN
Unfactored dead load reaction at support A	R_{A_Dead} = **23.7** kN	
Unfactored imposed load reaction at support A	$R_{A\_Imposed}$ = **6.6** kN	
Maximum reaction at support B	R_{B_max} = **43.8** kN	R_{B_min} = **30.3** kN
Unfactored dead load reaction at support B	R_{B_Dead} = **23.7** kN	
Unfactored imposed load reaction at support B	$R_{B\_Imposed}$ = **6.6** kN	

Section details

Section type — **UB 457x191x98 (BS4-1)**

Steel grade — **S355**

From table 9: Design strength p_y

Thickness of element — max(T, t) = **19.6** mm

Design strength — p_y = **345** N/mm^2

Modulus of elasticity — E = **205000** N/mm^2

Lateral restraint

Span 1 has lateral restraint at supports only

Effective length factors

Effective length factor in major axis — K_x = **1.00**

Effective length factor in minor axis — K_y = **1.00**

Effective length factor for lateral-torsional buckling — $K_{LT.A}$ = **1.20** + 2 × D

$K_{LT.B}$ = **1.20** + 2 × D

Classification of cross sections - Section 3.5

$\varepsilon = \sqrt{[275 \text{ N/mm}^2 / p_y]}$ = **0.89**

Internal compression parts - Table 11

Depth of section — d = **407.6** mm

$d / t = 40.0 \times \varepsilon <= 80 \times \varepsilon$ — Class 1 plastic

Outstand flanges - Table 11

Width of section — b = B / 2 = **96.4** mm

$b / T = 5.5 \times \varepsilon <= 9 \times \varepsilon$ — Class 1 plastic

Section is class 1 plastic

Shear capacity - Section 4.2.3

Design shear force — $F_v = \max(\text{abs}(V_{max}), \text{abs}(V_{min}))$ = **43.8** kN

$d / t < 70 \times \varepsilon$

Web does not need to be checked for shear buckling

Shear area — $A_v = t \times D$ = **5326** mm^2

Design shear resistance — $P_v = 0.6 \times p_y \times A_v$ = **1102.5** kN

PASS - Design shear resistance exceeds design shear force

Moment capacity - Section 4.2.5

Design bending moment — $M = \max(\text{abs}(M_{s1\_max}), \text{abs}(M_{s1\_min}))$ = **116.2** kNm

Moment capacity low shear - cl.4.2.5.2 — $M_c = \min(p_y \times S_{xx}, 1.2 \times p_y \times Z_{xx})$ = **770.2** kNm

Effective length for lateral-torsional buckling - Section 4.3.5

Effective length for lateral torsional buckling — $L_E = 1.2 \times L_{s1} + 2 \times D$ = **13672** mm

Slenderness ratio — $\lambda = L_E / r_{yy}$ = **315.862**

Equivalent slenderness - Section 4.3.6.7

Buckling parameter — u = **0.881**

Torsional index — x = **25.746**

Slenderness factor — $v = 1 / [1 + 0.05 \times (\lambda / x)^2]^{0.25}$ = **0.585**

Ratio - cl.4.3.6.9 — β_W = **1.000**

Equivalent slenderness - cl.4.3.6.7 — $\lambda_{LT} = u \times v \times \lambda \times \sqrt{[\beta_W]}$ = **162.795**

Limiting slenderness - Annex B.2.2 — $\lambda_{L0} = 0.4 \times (\pi^2 \times E / p_y)^{0.5}$ = **30.632**

$\lambda_{LT} > \lambda_{L0}$ - Allowance should be made for lateral-torsional buckling

Bending strength - Section 4.3.6.5

Robertson constant — α_{LT} = **7.0**

Perry factor — $\eta_{LT} = \max(\alpha_{LT} \times (\lambda_{LT} - \lambda_{L0}) / 1000, 0)$ = **0.925**

Euler stress — $p_E = \pi^2 \times E / \lambda_{LT}^2$ = **76.3** N/mm^2

$\phi_{LT} = (p_y + (\eta_{LT} + 1) \times p_E) / 2$ = **246** N/mm^2

Bending strength - Annex B.2.1 — $p_b = p_E \times p_y / (\phi_{LT} + (\phi_{LT}^2 - p_E \times p_y)^{0.5})$ = **61.1** N/mm^2

Equivalent uniform moment factor - Section 4.3.6.6

Moment at quarter point of segment — M_2 = **87.1** kNm

Moment at centre-line of segment — M_3 = **116.2** kNm

Moment at three quarter point of segment — M_4 = **87.1** kNm

Maximum moment in segment — M_{abs} = **116.2** kNm

Maximum moment governing buckling resistance $M_{LT} = M_{abs} =$ **116.2** kNm

Equivalent uniform moment factor for lateral-torsional buckling

$m_{LT} = \max(0.2 + (0.15 \times M_2 + 0.5 \times M_3 + 0.15 \times M_4) / M_{abs}, 0.44) =$ **0.925**

Buckling resistance moment - Section 4.3.6.4

Buckling resistance moment $M_b = p_b \times S_{xx} =$ **136.5** kNm

$M_b / m_{LT} =$ **147.5** 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 $\delta_{lim} = \min(14\text{ mm}, L_{s1} / 360) =$ **14** mm

Maximum deflection span 1 $\delta = \max(abs(\delta_{max}), abs(\delta_{min})) =$ **10.078** mm

PASS - Maximum deflection does not exceed deflection limit

MASONRY BEARING DESIGN TO BS5628-1:2005

TEDDS calculation version 1.0.04

Masonry details

Masonry type **Aggregate concrete blocks (25% or less formed voids)**

Compressive strength of unit p_{unit} = **3.6** N/mm^2

Mortar designation **iii**

Least horizontal dimension of masonry units l_{unit} = **100** mm

Height of masonry units h_{unit} = **215** mm

Category of masonry units **Category II**

Category of construction control **Normal**

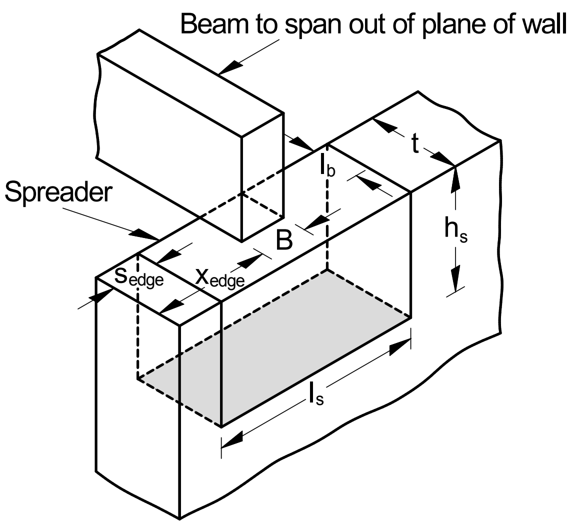
Partial safety factor for material strength γ_m = **3.5**

Thickness of load bearing leaf t = **100** mm

Effective thickness of masonry wall t_{ef} = **100** mm

Height of masonry wall h = **2400** mm

Effective height of masonry wall h_{ef} = **2400** mm



Bearing details

Beam spanning out of plane of wall

Width of bearing B = **190** mm

Length of bearing l_b = **100** mm

Edge distance x_{edge} = **0** mm

Compressive strength from Table 2 BS5628:Part 1 - aggregate concrete blocks (25% or less formed voids)

Mortar designation Mortar = **"iii"**

Block compressive strength p_{unit} = **3.6** N/mm^2

Characteristic compressive strength (Table 2c) f_{kc} = **1.70** N/mm²

Characteristic compressive strength (Table 2d) f_{kd} = **3.50** N/mm²

Height of solid block h_{unit} = **215.0** mm

Least horizontal dimension l_{unit} = **100.0** mm

Block ratio ratio = h_{unit} / l_{unit} = **2.2**

Ratio between 0.6 and 4.5 - OK

Characteristic compressive strength f_k = **3.50** N/mm²

Loading details

Characteristic concentrated dead load G_k = **24** kN

Characteristic concentrated imposed load Q_k = **7** kN

Design concentrated load F = (G_k × 1.4) + (Q_k × 1.6) = **44.8** kN

Characteristic distributed dead load g_k = **0.0** kN/m

Characteristic distributed imposed load q_k = **0.0** kN/m

Design distributed load f = (g_k × 1.4) + (q_k × 1.6) = **0.0** kN/m

Masonry bearing type

Bearing type **Type 1**

Bearing safety factor γ_{bear} = **1.25**

Check design bearing without a spreader

Design bearing stress f_{ca} = F / (B × l_b) + f / t = **2.358** N/mm²

Allowable bearing stress f_{cp} = γ_{bear} × f_k / γ_m = **1.250** N/mm²

FAIL - Design bearing stress exceeds allowable bearing stress, use a spreader

Spreader details

Length of spreader l_s = **440** mm

Depth of spreader h_s = **450** mm

Edge distance s_{edge} = max(0 mm, x_{edge} – (l_s - B) / 2) = **0** mm

Spreader bearing type

Bearing type **Type 3**

Bearing safety factor γ_{bear} = **2.00**

Check design bearing with a spreader

Loading acts eccentrically - stress distribution similar to semi-infinite beam on elastic foundation

Modulus of elasticity of masonry wall E_w = 700 × f_k = **2.5** kN/mm²

Modulus of elasticity of spreader beam E_b = 30 kN/mm²

Modulus of wall k = E_w / h = **1.0** N/mm³

Moment of inertia of spreader beam I_b = t × h_s^3 / 12 = **759.×10⁶ mm⁴**

Constant; γ = (t × k / (4 × E_b × I_b))$^{1/4}$ = **1.03×10⁻³** mm⁻¹

Maximum bearing stress; f_{ca} = k × F / (2 × γ^3 × E_b × I_b) + f / t = **0.922** N/mm²

Allowable bearing stress; f_{cp} = γ_{bear} × f_k / γ_m = **2.000** N/mm²

PASS - Allowable bearing stress exceeds design bearing stress

Check design bearing at 0.4 × h below the bearing level

Slenderness ratio; h_{ef} / t_{ef} = **24.00**

Eccentricity at top of wall; e_x = **0.0** mm

From BS5628:1 Table 7

Capacity reduction factor	β = **0.61**
Length of bearing distributed at 0.4 × h	l_d = **1150** mm
Maximum bearing stress	$f_{ca} = F / (l_d \times t) + f / t$ = **0.390** N/mm^2
Allowable bearing stress	$f_{cp} = \beta \times f_k / \gamma_m$ = **0.605** N/mm^2

PASS - Allowable bearing stress at 0.4 × h below bearing level exceeds design bearing stress