◆ **DAVID SMITH ASSOCIATES LLP** ◆ **Consulting Structural & Civil Engineers** ◆
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6 MANOR WAY
HIGHAM FERRERS

STRUCTURAL CALCULATIONS

.

Prepared by: **MF / SJA**

Date: **November 2023**

Reference: **23/54177**

DSA LLP VAT REG : 443 6613 95

Eur Ing **David Smith** BSc(Hons), C.Eng, MICE, FIStructE, CMaPS, MFPWS, FCABE, ACIArb,
Hitesh Jethwa BSc Eng (Hons), I.Eng, AMIStructE **Steven Ainge** B.Eng (Hons), I.Eng, AMIStructE
Thomas Garrod B.Eng (Hons),**Ben Mason** BSc (Hons), IEng, MICE

London	Northampton	Cheltenham	Birmingham
16 Upper Woburn Place	8 Duncan Close	Unit 2, 1 The Hayloft	Central Boulevard,
London	Moulton Park	Far Peak	Blythe Valley Business Park
WC1H 0AF	Northampton, NN3 6WL	Northleach, GL54 3AP	Solihull, B90 8AG.
0203 741 8042	01604 782620	01285 657328	01564 711008
london@dsagroup.co.uk	northampton@dsagroup.co.uk	cheltenham@dsagroup.co.uk	birmingham@dsagroup.co.uk

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Design Notes **Job Ref: 23/54177**

RE: 6 MANOR WAY, HIGHAM FERRERS

The following calculations are in respect of our clients brief relating to **specific structural elements listed on the following page(s).** No responsibility is accepted in respect of other elements of the building. Any assumed bearing stresses must be confirmed on site to the satisfaction of the Building Control Officer.

Dimensions have been obtained from information provided and where no figured dimensions have been provided, scaling has been used. **Dimensions indicated on the following calculations are for design purposes only and must not be used for constructional purposes. All dimensions for construction are to be obtained by site measurements prior to manufacture / building**.

Appended sketches are to demonstrate certain features of the design and are not intended as working drawings. Where shown, details are intended to identify the main structural features. It is assumed that the work will be carried out by experienced and competent personnel, therefore exhaustive detailing is not required.

Where constructional connection details are indicated on these calculations, these shall not be varied. Any proposed changes should be substantiated by calculation, submitted and approved in writing by the Engineer before fabrication is commenced.

Where Building Control approval is required it is essential that this be obtained before the works proceed or materials are ordered. The contractor must ensure the stability of each element, and overall stability of the construction is maintained until all the works are completed.

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london@dsagroup.co.uk	northampton@dsagroup.co.uk	cheltenham@dsagroup.co.uk	birmingham@dsagroup.co.uk

QMS ISO 9001 REGISTERED FIRM

constructionline

REFERENCES

British Standards and Codes of Practice indicated 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, associated standards or manufacturer's recommendations and details and normal good practice.

Loadings	[BS 6399 - Part 1:1996, Part 2:1997, Part 3:1988] [BS 648:1964]
Concrete	[BS 8110 - Part 1:1997, Part 3:1985] [BS 8007 : 1987]
Foundations	[BS 8004:1986] [BS 8002 : 1994]
Timber	[BS 5268 - Part 2:2002]
Masonry	[BS 5628 - Part 1:2005, Part 2:2005, Part 3:2005]
Industrial Floor Slabs	[Concrete Society Technical Report 34 (2nd Edition)] [C & CA Technical Report 550] [BCA Tech Note 11]
Steelwork	[BS 5950 - Part 1:2000, Part 3:1990, Part 5:1987, Part 8:1990] [BS 2853:1957]

ISSUE RECORD

Prep. by	Chkd by	Documents / Sheets / Drawings Issued	Description of Relating Structural Elements	Issue Date
MF	[illegible]	Structural calculations pages 1-10 Drawing No. 23/54177/01/P1	Steel beams	08/11/2023

HEALTH & SAFETY

Where appropriate, the Client will be the/or appoint a, Principal Designer to act on his behalf who will ensure that where applicable the "Construction (Design and Management) Regulations 2015" are adhered to.

The Principal Contractor must at all times ensure safe working practices, maintain the integrity of the existing structures and conform to all the appropriate requirements of the Health and Safety Executive including the "Construction (Design and Management) Regulations 2015".

The working methods of any hazardous operations must first be discussed with the Principal Designer and the designer prior to commencement.

Below are identified hazards that are either impractical or uneconomic to eliminate at the design stage. The list is not exhaustive and must be read in conjunction with the main contractors own Health & Safety policy.

Hazard	Solution/Precaution/Sequence
Demolition and creation of new openings	To be carried out in accordance with prepared demolition statement ensuring structural integrity of existing building at all times. Openings should follow published procedure in Building Research Establishment publication GBG20 "Removing internal loadbearing walls in older dwellings".
Scaffolds	Scaffolds erected and used in accordance with BS5973. Scaffolds and propping must be inspected by a qualified person before use and at least once per week to ensure they are fit for use.
Personnel working at height	Works to be properly supervised with personnel provided with safe working platforms.
Lifting	Adequate means for moving and positioning elements to be available. Handling and construction to be carried out in accordance with relevant HSE 7 BS guidelines. Individuals are not to manually lift more than 25kg.
Deep excavation	No one shall enter an excavation deeper than 1.2m without adequately designed temporary shoring being in place. Where foundations are deeper than 2.5m they should be constructed in two pours.
Open trenched footings	Access to unattended trenches to be protected.

Job Ref: 23/54177

RE: 6 MANOR WAY, HIGHAM FERRERS

Dimensions

1. **All dimensions for construction to be obtained by site measurements prior to manufacture / building**

Steelwork Specifications

1. Unless noted otherwise, all steelwork to be Grade S375 to BS 5950-2. All materials to comply with BS 5950:2000 and to B.S.C.A. 1/89 - National Structural Steelwork Specification.

2. Unless noted otherwise, all steelwork to be shot blasted to SA 2.5 or mechanically wire brushed to remove all surface contamination, rust or millscale and have 2 coats of zinc phosphate primer applied to achieve a minimum dry film thickness of 75 microns per coat, prior to site delivery.

3. Grade 4.6 bolts to BS4190 and Grade 8.8 bolts to BS3692.

4. Unless stated otherwise, all structural connections to have minimum of 2 bolts. Minimum bolt size for any connection to be M16 Grade 8.8 bolts.

5. Fire surround to all steelwork as per Architects/Local Authority requirements but generally cased in a layer of 12.5mm thick plasterboard and skim.

6. For steel within an external wall cavity (this includes shelf angles and plates supporting external skins that are welded to the bottom flange of beams) the steel should be shot blasted to SA2½ and use 450μm coat of solvent free epoxy applied. Alternatively, the steel may be galvanized to a thickness of 85μm and 200μm of heavy duty bitumen applied in two coats.

ISO 9001 REGISTERED FIRM

London
16 Upper Woburn Place
London
WC1H 0AF
0203 741 8042
london@dsagroup.co.uk

Northampton
8 Duncan Close
Moulton Park
Northampton, NN3 6WL
01604 782620
northampton@dsagroup.co.uk

Cheltenham
Unit 2, 1 The Hayloft
Far Peak
Northleach, GL54 3AP
01285 657328
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Solihull, B90 8AG.
01564 711008
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General Notes

Works to be carried out regarding installation of new beams/lintels

All works should be carried out by a competent contractor/builder familiar and experienced with the procedures.

1. All works to comply with current British EN Standards and Building Regulations and to be to good building practice.

2. All new steelwork to be to BS EN 10025 1993: Minimum Grade S375 unless noted otherwise.

3. Any bolts to be Grade 8.8 and zinc plated with washers and nuts.

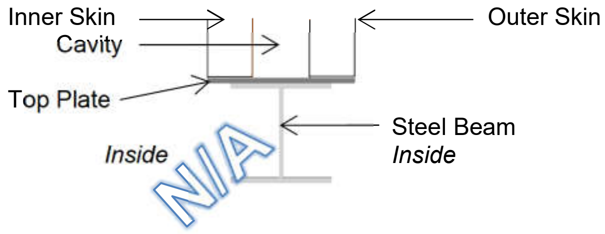
4. All mortar to be 1: 1: 6 (cement: lime: sand) unless noted otherwise.

5. Where new steelwork or other fabricated components are specified, site dimensions must be undertaken by the builder/fabricator to ensure an accurate fit and adequate clearance, etc.

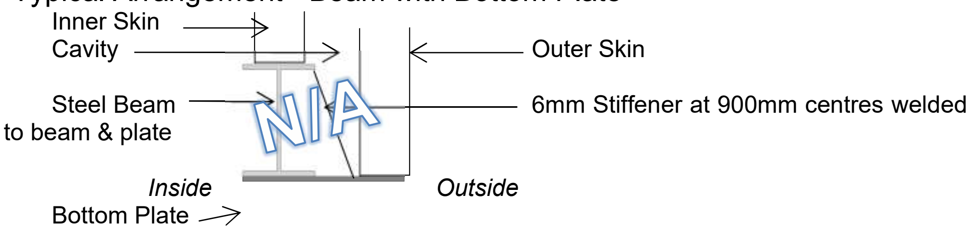
6. Unless noted otherwise, generally steel beam is to be installed so that its centerline coincides with centerline of the wall it is supporting. In case of cavity walls, this will generally be centerline of the overall thickness of the wall including the thickness of the inner skin, cavity and outer-skin (See also Note 8 for variations).

7. Where multiple beams/lintels are indicated to support existing walls, the exact number of beams/lintel is to be determined by the builder on site to suit thickness of wall(s) prior to commencing works in that area and ordering/fabrication of materials. Report immediately to DSA for further advice if site conditions differ to that indicated on the drawings/details.

8. Scenarios for supporting external walls on single beam:
   (a) Typical Arrangement - Beam with Top Plate



(b) Typical Arrangement - Beam with Bottom Plate



9. Where steel beams bear into walls at right angles, fully surround the beam with brickwork to prevent any rotation of the beam.

10. Where steel beams/lintels are required to be concealed within floor/ceiling void, the contractor must take measurements of floor/ceiling void and review the size of beam/lintel specified on the drawings prior to ordering/fabrication of material. Report to DSA for further advice if the specified beam/lintel size cannot be concealed within the floor/ceiling zone due to existing site details.

11. Where walls are to be removed:

    a) Fully support wall over the new beams by needling through the wall and supporting needles on Acrow props. Number of needles and props required will depend on the existing structural format, loading and site conditions. Contractor/Builder to be responsible for the necessary temporary works.
    b) When wall is supported cut out openings and prepare piers and padstones. Ensure padstone size and full bearing lengths as specified are achieved.
    c) Install steel beams and shim / dry pack beams as necessary onto padstones to ensure full load transfer.
    d) To minimize cracking of the walls above, preload the new beams by using machined steel folding wedges rammed home.
       If the beam is not preloaded there is a risk of initial cracking to the walls above as the load is transferred but this will not be progressive.
    e) After preloading the beams dry pack the gap between existing wall and the beam using a minimum thickness of 30mm of sand and cement 3:1 mixed to just bind and then rammed home to ensure a fully packed joint for the full width of the beam/wall.
    f) Leave props in place for at least 7 days until the packing is cured.

<u>Exact arrangement of works to suit site specific conditions; if in doubt, Contractor/Builder to contact DSA for further advice prior to commencing of works and ordering/fabrication of materials.</u>

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Job Title	Job No.
6 MANOR WAY, HIGHAM FERRERS	23/54177

Compliance with BS EN 1090-1:2009 +A1:2011
Execution of steel structures and aluminium structures.
Requirements for conformity assessment of structural components
CE Marking of Fabricated Structural Steelwork

DERIVATION OF EXECUTION CLASS

Table A.1 - Categorisation of Consequence Classes

Example of categorisation of building type and occupancy	Consequence Class
Single occupancy house not exceeding 4 storeys.	**1**

Table A.1 - Definition of Consequence Classes

Description	Consequence Class
Medium consequence for loss of human life; economic, social or environmental consequences considerable Example Residential and office buildings, public buildings where consequences of failure are medium (e.g. an office building)	**CC2**

Table B.1 - Suggested Criteria for Service Categories

Criteria	Categories
Buildings and components designed for quasi static actions only (Example: Buildings)	**SC1**

Table B.2 - Suggested Criteria for Production Categories

Criteria	Categories
Welded components manufactured from steel grade products below S355	**PC1**

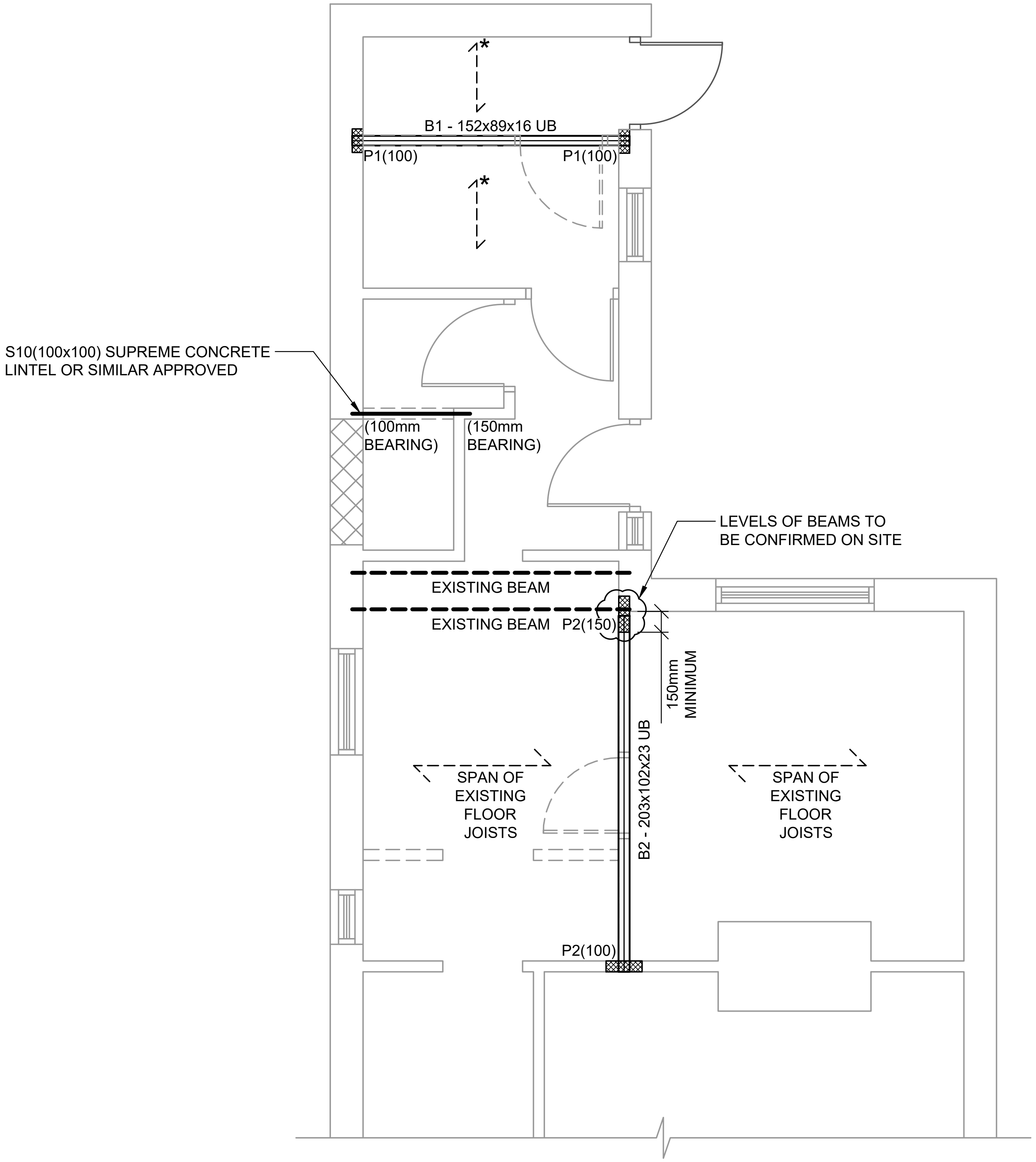
Table B.3 - Recommended Matrix for Determination of Execution Classes

Consequence classes	**CC2**
Service categories	**SC1**
Production categories	**PC1**
Execution Class	**EXC2**

a EXC4 should be applied to special structures or structures with extreme consequences of a structural failure as required by national provisions

Execution Class	4-Copy of Execution Class Calculations - Copy	**EXC2**

ALL DIMENSIONS TO BE CONFIRMED ON SITE PRIOR TO ORDERING / FABRICATION OF MATERIALS AND COMMENCEMENT OF WORKS



PART GROUND FLOOR PLAN
SHOWING STRUCTURE ABOVE
1:50

WHERE STRUCTURAL ELEMENTS ARE ASSUMED / INDICATED TO BE CONFIRMED (TBC), THESE ARE TO BE EXPOSED AND CONFIRMED PRIOR TO ORDERING/FABRICATION OF MATERIALS. REPORT TO DSA IF FOUND OTHERWISE AND/OR IN DOUBT.

CDM 2015 DESIGNER NOTES

IN ADDITION TO THE HAZARDS, AND RISKS NORMALLY ASSOCIATED WITH THE TYPE OF WORK DETAILED ON THIS DRAWING, NOTE THE FOLLOWING SIGNIFICANT RISKS AND INFORMATION.

CONSTRUCTION:

1. N/A

FOR INFORMATION RELATING TO END USE, MAINTENANCE, DEMOLITION, SEE THE HEALTH AND SAFETY FILE.

IT IS ASSUMED THAT ALL WORKS WILL BE CARRIED OUT BY A COMPETENT CONTRACTOR, WHERE APPROPRIATE, TO AN APPROVED METHOD STATEMENT.

KEY

*ASSUMED SPAN OF EXISTING CONCRETE ROOF (TBC ON SITE PRIOR TO ORDERING STEELWORK)

PADSTONES SIZES	
REF	SIZE
P1	215x102x150mm DP ENG (BLUE) BRICKS IN CLASS (i) MORTAR AS PADSTONE
P2	330x102x215mm DP ENG (BLUE) BRICKS IN CLASS (i) MORTAR AS PADSTONE
NOTE:- BEAM BEARING LENGTH SHOWN IN BRACKETS	

ALL WELDS TO COMPLY WITH BS EN 1090-1:2009 +A1:2011 EXECUTION CLASS EXC2

Notes

1. IF IN DOUBT - ASK !!! DO NOT SCALE
2. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL ARCHITECTS AND ENGINEERS DRAWINGS.
3. ALL WORK TO BE CARRIED OUT IN ACCORDANCE WITH THE RELEVANT BRITISH STANDARDS, CODES OF PRACTICE AND BUILDING PRACTICE.
4. ALL DIMENSIONS TO BE CHECKED PRIOR TO STARTING THE WORKS ON SITE. ANY DISCREPANCIES TO BE REPORTED TO THE ENGINEER IMMEDIATELY.
5. CONTRACTOR TO ASCERTAIN THE LOCATION OF SERVICES ON SITE PRIOR TO STARTING THE WORK.
6. ALL DIMENSIONS FOR CONSTRUCTION ARE TO BE OBTAINED FROM SITE MEASUREMENTS OR ARCHITECTS SETTING OUT DRAWINGS PRIOR TO MANUFACTURE/BUILDING.

STEELWORK NOTES:

7. ALL STEELWORK TO BE GRADE S355 TO B.S.5950-2. ALL MATERIALS TO COMPLY WITH B.S. 5950:2000 AND TO B.S.C.A.1/89 - NATIONAL STRUCTURAL STEELWORK SPECIFICATION.
8. ALL STEELWORK TO BE SHOT BLASTED TO SA 2.5 OR MECHANICALLY WIRE BRUSHED TO REMOVE ALL SURFACE CONTAMINATION, RUST OR MILLSCALE AND HAVE 2 COATS OF ZINC PHOSPHATE PRIMER APPLIED TO ACHIEVE A MINIMUM DRY FILM THICKNESS OF 75 MICRONS PER COAT, PRIOR TO SITE DELIVERY. AFTER ERECTION OF STEELWORK IS COMPLETE ANY DAMAGED SURFACES TO BE MADE GOOD WITH 2 COATS OF ZINC PHOSPHATE PRIMER TO ACHIEVE A MINIMUM DRY FILM THICKNESS OF 75 MICRONS PER COAT.
9. GRADE 4.6 BOLTS TO B.S.4190 AND GRADE 8.8 BOLTS TO B.S.3692. ALL BOLTS AND NUTS TO BE HOT DIP SPUN GALVANISED TO B.S. 729. A ROUND WASHER, TO B.S. 4320 AND HOT SPUN GALVANISED TO B.S. 729, TO BE PROVIDED UNDER EVERY NUT TO MINIMISE DAMAGE TO COATING. ALL NUTS TO BE CORRECTLY TIGHTENED AND HAVE AT LEAST 2 THREADS PROJECTING BEYOND THE NUT. ALL BOLTS TO HAVE STRUCTURAL THREAD AND ROUND SHANK.
10. FIRE SURROUND TO ALL STEELWORK AS PER ARCHITECTS REQUIREMENTS

ISSUE	REVISION	BY	DATE
P1	FIRST ISSUE	OP	08.11.23

ISSUE: *PRELIMINARY*

CLIENT: KEYSTONE BUILDING & RENOVATIONS

CONTRACT: 6 MANOR WAY HIGHAM FERRERS

TITLE: PART GROUND FLOOR PLAN SHOWING STRUCTURE ABOVE

ARCHITECT:

DRAWN	CHECKED	DATE	SCALE
OP	SJA	NOV ' 23	1:50 @ A3

David Smith Associates
Consulting Structural & Civil Engineers
Tel: (01604)782620
Email: northampton@dsagroup.co.uk
Website: www.dsagroup.co.uk
8 Duncan Close
Moulton Park
Northampton NN3 6WL

DRAWING NUMBER			REVISION
	23	54177/01	P1

♦ David Smith Associates ♦
8 Duncan Close ♦ Moulton Park ♦ Northampton NN3 6WL
Tel: (01604) 782620 ♦ Fax: (01604) 782629
E-mail: northampton@dsagroup.co.uk

Project No:	23/ 54177	Sheet No:	1
Made By:	MF	Revision:	
Date:	Nov-23	Checked By:	

Project: **6 MANOR WAY, HIGHAM FERRERS**

LOAD INFORMATION

ROOF LOADS

Flat Roofs (100mm Concrete)

	Felt	0.12	
	Chipping	0.19	
	100mm Concrete	2.40	
	Plasterboards + Insulation	0.15	
	Ceiling Load	0.28	
Total Dead Load, g_k =		**3.14**	kN/m^2
	Superimposed Ceiling Load	0.00	
	Imposed Load	0.75	
Total Imposed Load, q_k =		**0.75**	kN/m^2

FLOOR LOADS

Timber Floors, Type 1

	Timber Boards + Joists	0.35	
	Plasterboards	0.15	
Total Dead Load, g_k =		**0.50**	kN/m^2
	Superimposed Ceiling Load	0.00	
	Imposed Load	1.50	
Total Imposed Load, q_k =		**1.50**	kN/m^2

WALLS

102 Brick Wall

	102 Brick	2.20	
	Plaster both sides	0.44	
Total Dead Load, g_k =		**2.64**	kN/m^2

♦ David Smith Associates ♦
8 Duncan Close ♦ Moulton Park ♦ Northampton NN3 6WL
Tel: (01604) 782620 ♦ Fax: (01604) 782629
E-mail: northampton@dsagroup.co.uk

Project No:	23/ 54177	Sheet No:	2
Made By:	MF	Revision:	
Date:	Nov-23	Checked By:	

Project: **6 MANOR WAY, HIGHAM FERRERS**

BEAM B1			Span = 2.600 m		
Load Analysis					
Factor of Safety, g_f		Dead Load = 1.4		Live Load = 1.6	
Load from	**Cover (m)**	**gk (kN/m2)**	**DL (KN/m)**	**qk (kN/m2)**	**IL (kN/m)**
Flat Roof	1.250	3.14	**3.93**	0.75	**0.94**
Total Service Load =			**3.93**		**0.94**

USE 152x89x16 UB

see pages 3-6

PADSTONE R max = 9.4 kN (ULS)

BY INSPECTION USE 215x102x150 mm DEEP ENG (BLUE) BRICKS IN CLASS (i) MORTAR - 100 mm BEARING.

BEAM B2			Span = 3.500 m		
Load Analysis					
Factor of Safety, g_f		Dead Load = 1.4		Live Load = 1.6	
Load from	**Cover (m)**	**gk (kN/m2)**	**DL (KN/m)**	**qk (kN/m2)**	**IL (kN/m)**
Timber Floor	2.800	0.50	**1.40**	1.50	**4.20**
102 Brick Wall	2.400	2.64	**6.34**		
Total Service Load =			**7.74**		**4.20**

USE 203x102x23 UB

see pages 7-10

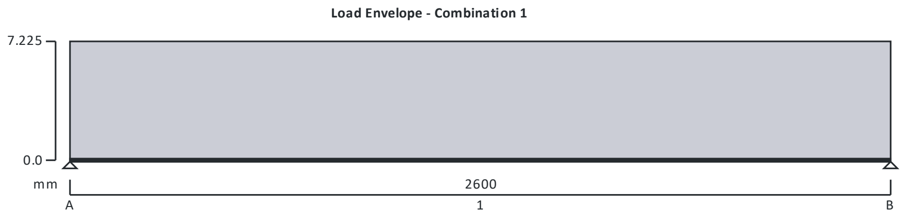
PADSTONE R max = 31.3 kN (ULS)

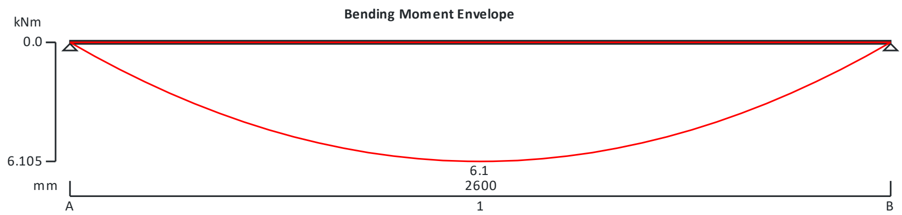
BY INSPECTION USE 330x102x215 mm DEEP ENG (BLUE) BRICKS IN CLASS (i) MORTAR - 225 mm BEARING.

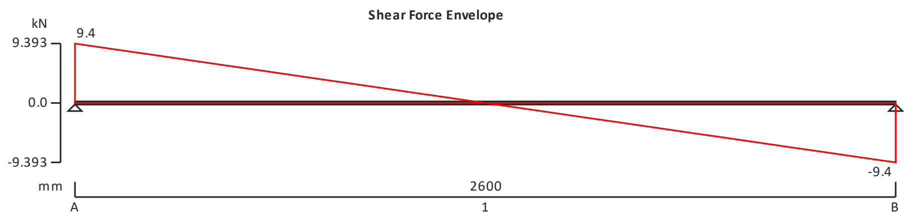
STEEL BEAM ANALYSIS & DESIGN (BS5950)

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

TEDDS calculation version 3.0.07







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 3.93 kN/m
	Imposed full UDL 0.94 kN/m

Load combinations

Load combination 1	Support A	Dead × 1.40
		Imposed × 1.60
		Dead × 1.40
		Imposed × 1.60
	Support B	Dead × 1.40
		Imposed × 1.60

Analysis results

Maximum moment	M_{max} = **6.1** kNm	M_{min} = **0** kNm
Maximum shear	V_{max} = **9.4** kN	V_{min} = **-9.4** kN
Deflection	δ_{max} = **1.7** mm	δ_{min} = **0** mm
Maximum reaction at support A	R_{A_max} = **9.4** kN	R_{A_min} = **9.4** kN
Unfactored dead load reaction at support A	R_{A_Dead} = **5.3** kN	
Unfactored imposed load reaction at support A	$R_{A\_Imposed}$ = **1.2** kN	
Maximum reaction at support B	R_{B_max} = **9.4** kN	R_{B_min} = **9.4** kN
Unfactored dead load reaction at support B	R_{B_Dead} = **5.3** kN	
Unfactored imposed load reaction at support B	$R_{B\_Imposed}$ = **1.2** kN	

Section details

Section type: **UB 152x89x16 (British Steel Section Range 2022 (BS4-1))**

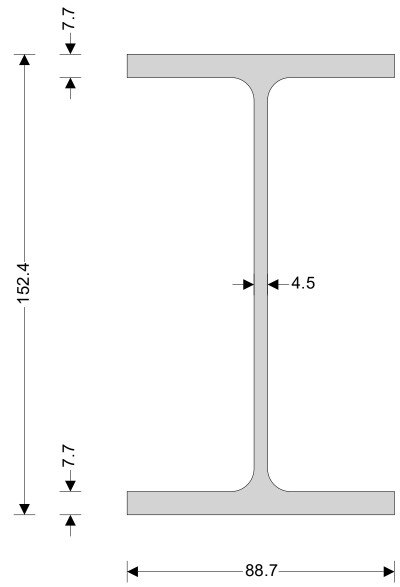
Steel grade: **S355**

From table 9: Design strength p_y

Thickness of element: max(T, t) = **7.7** mm

Design strength: p_y = **355** 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

$\varepsilon = \sqrt{[275 \text{ N/mm}^2 / p_y]}$ = **0.88**

Internal compression parts - Table 11

Depth of section: d = **121.8** mm

$d / t = 30.8 \times \varepsilon <= 80 \times \varepsilon$ Class 1 plastic

Outstand flanges - Table 11

Width of section $b = B / 2 =$ **44.4** mm

$b / T = 6.5 \times \varepsilon <= 9 \times \varepsilon$ Class 1 plastic

Section is class 1 plastic

Shear capacity - Section 4.2.3

Design shear force $F_v = max(abs(V_{max}), abs(V_{min})) =$ **9.4** kN

$d / t < 70 \times \varepsilon$

Web does not need to be checked for shear buckling

Shear area $A_v = t \times D =$ **686** mm^2

Design shear resistance $P_v = 0.6 \times p_y \times A_v =$ **146.1** kN

PASS - Design shear resistance exceeds design shear force

Moment capacity - Section 4.2.5

Design bending moment $M = max(abs(M_{s1\_max}), abs(M_{s1\_min})) =$ **6.1** kNm

Moment capacity low shear - cl.4.2.5.2 $M_c = min(p_y \times S_{xx}, 1.2 \times p_y \times Z_{xx}) =$ **43.8** kNm

Effective length for lateral-torsional buckling - Section 4.3.5

Effective length for lateral torsional buckling $L_E = 1.2 \times L_{s1} + 2 \times D =$ **3425** mm

Slenderness ratio $\lambda = L_E / r_{yy} =$ **162.961**

Equivalent slenderness - Section 4.3.6.7

Buckling parameter $u =$ **0.890**

Torsional index $x =$ **19.566**

Slenderness factor $v = 1 / [1 + 0.05 \times (\lambda / x)^2]^{0.25} =$ **0.688**

Ratio - cl.4.3.6.9 $\beta_W =$ **1.000**

Equivalent slenderness - cl.4.3.6.7 $\lambda_{LT} = u \times v \times \lambda \times \sqrt{[\beta_W]} =$ **99.748**

Limiting slenderness - Annex B.2.2 $\lambda_{L0} = 0.4 \times (\pi^2 \times E / p_y)^{0.5} =$ **30.198**

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

Bending strength - Section 4.3.6.5

Robertson constant $\alpha_{LT} =$ **7.0**

Perry factor $\eta_{LT} = max(\alpha_{LT} \times (\lambda_{LT} - \lambda_{L0}) / 1000, 0) =$ **0.487**

Euler stress $p_E = \pi^2 \times E / \lambda_{LT}^2 =$ **203.4** N/mm^2

$\phi_{LT} = (p_y + (\eta_{LT} + 1) \times p_E) / 2 =$ **328.7** N/mm^2

Bending strength - Annex B.2.1 $p_b = p_E \times p_y / (\phi_{LT} + (\phi_{LT}^2 - p_E \times p_y)^{0.5}) =$ **139.4** N/mm^2

Equivalent uniform moment factor - Section 4.3.6.6

Moment at quarter point of segment $M_2 =$ **4.6** kNm

Moment at centre-line of segment $M_3 =$ **6.1** kNm

Moment at three quarter point of segment $M_4 =$ **4.6** kNm

Maximum moment in segment $M_{abs} =$ **6.1** kNm

Maximum moment governing buckling resistance $M_{LT} = M_{abs} =$ **6.1** 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 $M_b = p_b \times S_{xx} =$ **17.2** kNm

$M_b / m_{LT} =$ **18.6** 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 $\delta_{lim} = L_{s1} / 360 =$ **7.222** mm

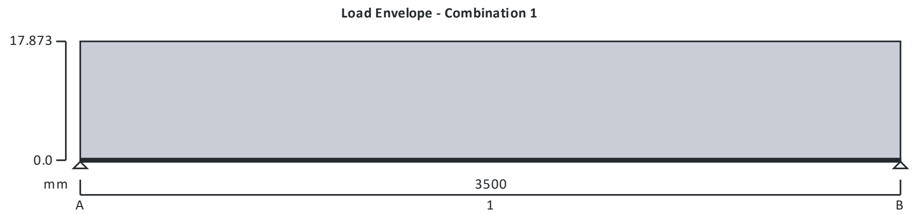
Maximum deflection span 1 $\delta = \max(\text{abs}(\delta_{max}), \text{abs}(\delta_{min})) =$ **1.749** mm

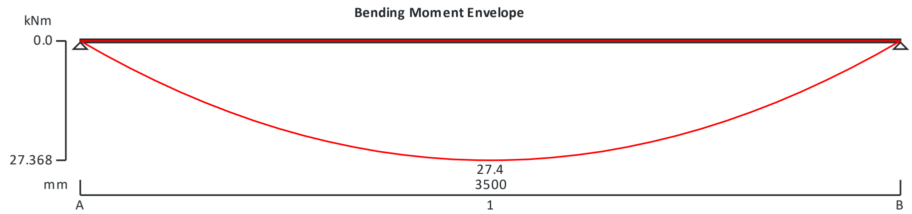
PASS - Maximum deflection does not exceed deflection limit

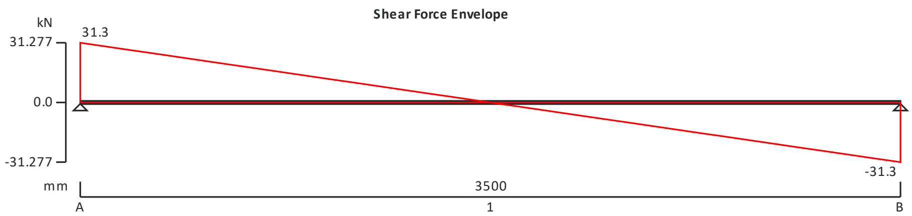
STEEL BEAM ANALYSIS & DESIGN (BS5950)

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

TEDDS calculation version 3.0.07







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 7.74 kN/m
	Imposed full UDL 4.2 kN/m

Load combinations

Load combination 1	Support A	Dead × 1.40
		Imposed × 1.60
		Dead × 1.40
		Imposed × 1.60
	Support B	Dead × 1.40
		Imposed × 1.60

Analysis results

Maximum moment	M_{max} = **27.4** kNm	M_{min} = **0** kNm
Maximum shear	V_{max} = **31.3** kN	V_{min} = **-31.3** kN
Deflection	δ_{max} = **5.5** mm	δ_{min} = **0** mm
Maximum reaction at support A	R_{A_max} = **31.3** kN	R_{A_min} = **31.3** kN
Unfactored dead load reaction at support A	R_{A_Dead} = **13.9** kN	
Unfactored imposed load reaction at support A	$R_{A\_Imposed}$ = **7.4** kN	
Maximum reaction at support B	R_{B_max} = **31.3** kN	R_{B_min} = **31.3** kN
Unfactored dead load reaction at support B	R_{B_Dead} = **13.9** kN	
Unfactored imposed load reaction at support B	$R_{B\_Imposed}$ = **7.4** kN	

Section details

Section type **UB 203x102x23 (British Steel Section Range 2022 (BS4-1))**

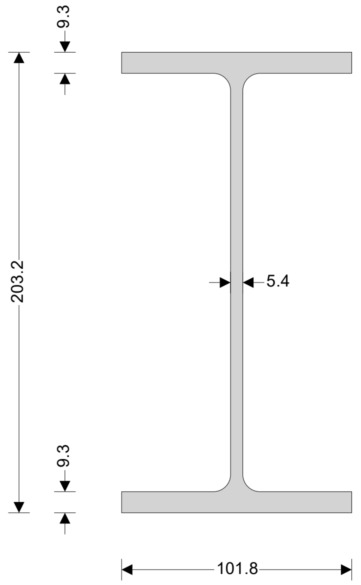
Steel grade **S355**

From table 9: Design strength p_y

Thickness of element max(T, t) = **9.3** mm

Design strength p_y = **355** 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 $K_{LT.A}$ = **1.00** + 2 × D

$K_{LT.B}$ = **1.20** + 2 × D

Classification of cross sections - Section 3.5

$\varepsilon = \sqrt{[275 \text{ N/mm}^2 / p_y]}$ = **0.88**

Internal compression parts - Table 11

Depth of section d = **169.4** mm

$d / t = 35.6 \times \varepsilon <= 80 \times \varepsilon$ Class 1 plastic

Outstand flanges - Table 11

Width of section $b = B / 2 =$ **50.9** mm

$b / T = 6.2 \times \varepsilon <= 9 \times \varepsilon$ Class 1 plastic

Section is class 1 plastic

Shear capacity - Section 4.2.3

Design shear force $F_v = \max(\text{abs}(V_{max}), \text{abs}(V_{min})) =$ **31.3** kN

$d / t < 70 \times \varepsilon$

Web does not need to be checked for shear buckling

Shear area $A_v = t \times D =$ **1097** mm^2

Design shear resistance $P_v = 0.6 \times p_y \times A_v =$ **233.7** kN

PASS - Design shear resistance exceeds design shear force

Moment capacity - Section 4.2.5

Design bending moment $M = \max(\text{abs}(M_{s1\_max}), \text{abs}(M_{s1\_min})) =$ **27.4** kNm

Moment capacity low shear - cl.4.2.5.2 $M_c = \min(p_y \times S_{xx}, 1.2 \times p_y \times Z_{xx}) =$ **83.1** kNm

Effective length for lateral-torsional buckling - Section 4.3.5

Effective length for lateral torsional buckling $L_E = ((1.0 + 1.2) \times L_{s1} + 2 \times D \times 2) / 2 =$ **4256** mm

Slenderness ratio $\lambda = L_E / r_{yy} =$ **180.285**

Equivalent slenderness - Section 4.3.6.7

Buckling parameter $u =$ **0.888**

Torsional index $x =$ **22.460**

Slenderness factor $v = 1 / [1 + 0.05 \times (\lambda / x)^2]^{0.25} =$ **0.698**

Ratio - cl.4.3.6.9 $\beta_W =$ **1.000**

Equivalent slenderness - cl.4.3.6.7 $\lambda_{LT} = u \times v \times \lambda \times \sqrt{[\beta_W]} =$ **111.692**

Limiting slenderness - Annex B.2.2 $\lambda_{L0} = 0.4 \times (\pi^2 \times E / p_y)^{0.5} =$ **30.198**

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

Bending strength - Section 4.3.6.5

Robertson constant $\alpha_{LT} =$ **7.0**

Perry factor $\eta_{LT} = \max(\alpha_{LT} \times (\lambda_{LT} - \lambda_{L0}) / 1000, 0) =$ **0.570**

Euler stress $p_E = \pi^2 \times E / \lambda_{LT}^2 =$ **162.2** N/mm^2

$\phi_{LT} = (p_y + (\eta_{LT} + 1) \times p_E) / 2 =$ **304.9** N/mm^2

Bending strength - Annex B.2.1 $p_b = p_E \times p_y / (\phi_{LT} + (\phi_{LT}^2 - p_E \times p_y)^{0.5}) =$ **116.8** N/mm^2

Equivalent uniform moment factor - Section 4.3.6.6

Moment at quarter point of segment $M_2 =$ **20.5** kNm

Moment at centre-line of segment $M_3 =$ **27.4** kNm

Moment at three quarter point of segment $M_4 =$ **20.5** kNm

Maximum moment in segment $M_{abs} =$ **27.4** kNm

Maximum moment governing buckling resistance $M_{LT} = M_{abs} =$ **27.4** 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 $M_b = p_b \times S_{xx} =$ **27.3** kNm

$M_b / m_{LT} =$ **29.6** 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 $\delta_{lim} = L_{s1} / 360 =$ **9.722** mm

Maximum deflection span 1 $\delta = \max(\text{abs}(\delta_{max}), \text{abs}(\delta_{min})) =$ **5.509** mm

PASS - Maximum deflection does not exceed deflection limit