



Project 225 Manchester New Road, Middleton, M24 1JT				Job Ref. M24-3541-ENG	
Section Structural Calculations				Sheet no./rev. A	
Calc. by KL	Date 02/03/2023	Chk'd by	Date	App'd by	Date

Structural Calculations for the proposed steelworks for house alteration and extension at 225 Manchester New Road, Middleton, M24 1JT

Project number: M24-3541-ENG
Date : MAR 2023



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General Note

1. These structural calculations are for the new steel beams only and that all other elements are to be to Building Control direction and approval.
2. Steel grade to be S355 unless noted otherwise.
3. All dimensions shown within these calculations are for design purposes only and are to be checked on site before ordering materials.
4. All details are subject to Building Control approval, which should be obtained before construction commences.
5. Temporary works and propping of the existing structure is the responsibility of the Contractor, who shall consider the existing building loads and ensure stability is maintained at all times. The Contractor is to be suitably experienced and competent in the type of work.
6. The Contractor is to have a coordinated construction plan and method statement for non-traditional works.
7. Any assumptions made by the designer have been stated within this document. If any findings differ from these assumptions, engineer from CK Architectural Ltd shall be informed immediately for further clarification.
8. The condition of supporting walls to be verified on site before ordering materials.
9. All proprietary items (lintels, precast floors, trussed rafters etc.) to be installed in accordance with manufacturer's instructions.

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1.0 DESIGN BRIEF:

The client requires structural calculations to support house alteration and extension at 225 Manchester New Road, Middleton, M24 1JT. This calculation is to propose 2 loose steel beams to support house alteration and extension works.

REFERENCE:

BS 6399 -1: 1997 Loadings for Buildings.

BS 5950-1: 2000 Structural use of steelwork in building – Part 1.

2.0 ELEMENT LOAD SUMMARY:

Element Load Summary

ROOF LOADING (PITCHED TILED ROOF)

Roof slope $\theta = 45.0^\circ$

Dead load

Tiles	Roof _{D1} = 0.60 kN/m ²
Battens	Roof _{D2} = 0.05 kN/m ²
Felt	Roof _{D3} = 0.02 kN/m ²
Rafters	Roof _{D4} = 0.08 kN/m ²
Dead load on slope	Roof _{DL_slope} = sum(Roof _{D1} ,Roof _{D2} ,Roof _{D3} ,Roof _{D4}) = 0.75 kN/m ²
Ceiling joists	Roof _{D5} = 0.07 kN/m ²
Insulation	Roof _{D6} = 0.03 kN/m ²
Plasterboard and skim	Roof _{D7} = 0.1 kN/m ²
Dead load on plan	Roof _{DL_plan} = sum(Roof _{D5} ,Roof _{D6} ,Roof _{D7} ,Roof _{D8}) = 0.2 kN/m ²
Total dead load on plan	Roof _{DL} = Roof _{DL_slope} / cos(θ) + Roof _{DL_plan} = 1.26 kN/m ²

Imposed load

Roof imposed load	Roof _{IL} = 0.60 kN/m ² on plan
Loft Storage/access	Loft _{IL} = 0.250 kN/m ² on plan

TIMBER FLOOR LOADING

Dead load

Boards	Floor _{1_DL} = 0.15 kN/m ²
Joists	Floor _{1_DL} = 0.15 kN/m ²
Ceiling	Floor _{1_DL} = 0.20 kN/m ²
Total dead load	Floor _{1_DL} = sum(Floor _{1_DL1} ,Floor _{1_DL2} ,Floor _{1_DL3}) = 0.50 kN/m ²

Imposed load

Imposed load	Floor _{1_IL} = 1.50 kN/m ²
Partitions	Floor _{1_IL} = 0.50 kN/m ²
Total imposed load	Floor _{1_IL} = sum(Floor _{1_IL1} ,Floor _{1_IL2}) = 2.00 kN/m ²



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STUD WALL LOADING

Dead load

Plaster board (one side)

$$SW_{D1} = 0.15 \text{ kN/m}^2$$

Stud

$$SW_{D2} = 0.20 \text{ kN/m}^2$$

Plaster board (other side)

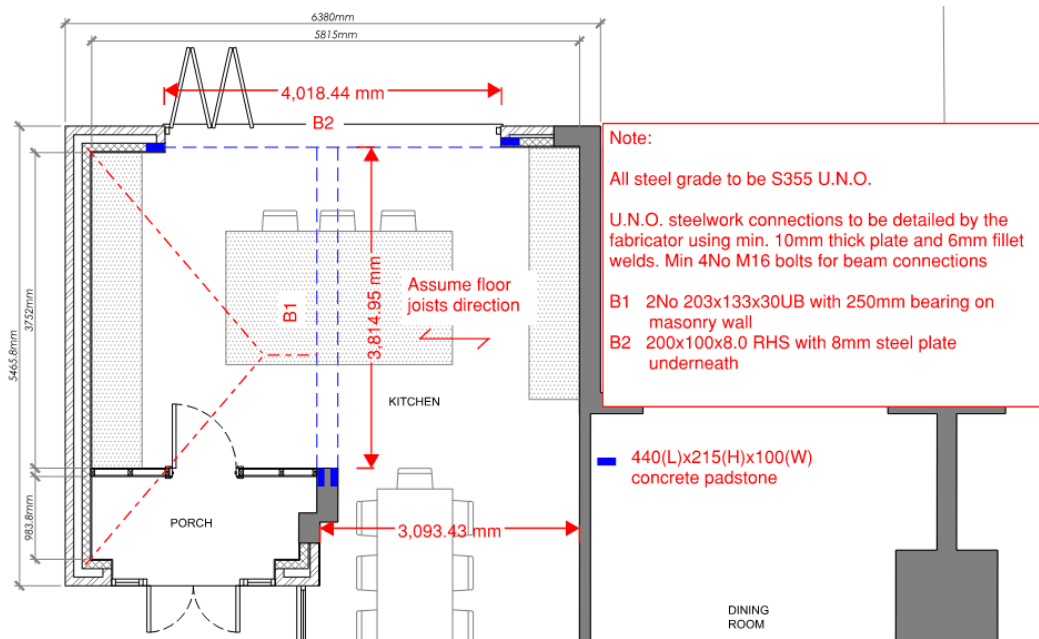
$$SW_{D3} = 0.15 \text{ kN/m}^2$$

Total dead load

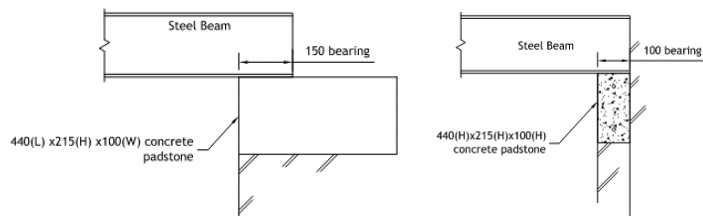
$$SW_{DL} = \text{sum}(SW_{D1}, SW_{D2}, SW_{D3}) = 0.50 \text{ kN/m}^2$$

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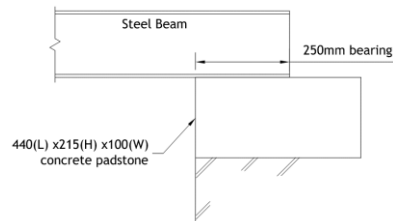
Ground floor plan



Typical steel beam bearing detail



Steel beam B1 bearing detail





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Load assessments

Steel beam B1

Inner leaf critical

Roof load (Assume trussed roof)

$$W_{DL} = 1.26 \times 3.1/2 = 1.95 \text{ kN/m}$$

$$W_{IL} = 0.85 \times 3.1/2 = 1.32 \text{ kN/m}$$

1st floor load

$$W_{DL} = 0.5 \times 3.1/2 = 0.78 \text{ kN/m}$$

$$W_{IL} = 2 \times 3.1/2 = 3.1 \text{ kN/m}$$

$$\text{Masonry wall} = 1.55 \times 2.4 = 3.72 \text{ kN/m}$$

$$\text{Span} = 3820 + 150 = 3970 \text{ mm}$$

Propose 2No 203x133x30UB

Masonry bearing check

$$R_{DL} = 13.4 \text{ kN}, R_{IL} = 8.8 \text{ kN}$$

Propose 440x215x100 concrete padstone with 250mm bearing

Steel beam B2

Reaction from B1@mid span

$$\text{Additional moment} = 32.8 \times 4.17/4 = 34.2 \text{ kNm}$$

$$\text{Additional shear} = 32.8 \text{ kN}$$

Lean to roof

$$W_{DL} = 1.26 \times 5.47/8 = 0.86 \text{ kN/m}$$

$$W_{IL} = 0.85 \times 5.47/8 = 0.58 \text{ kN/m}$$

$$\text{Span} = 4020 + 150 = 4170 \text{ mm}$$

Propose 200x100x8.0RHS with 8mm steel plate underneath

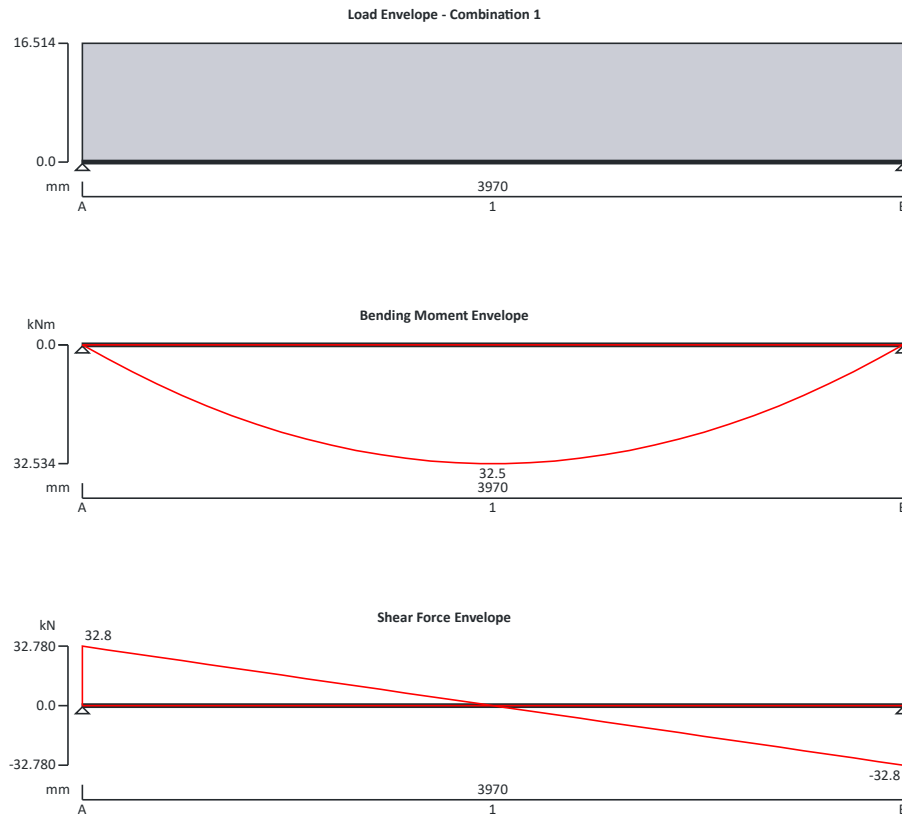
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STEEL BEAM ANALYSIS & DESIGN (BS5950)

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 $\times 1$

Dead full UDL 1.95 kN/m

Imposed full UDL 1.32 kN/m

Dead full UDL 0.78 kN/m

Imposed full UDL 3.1 kN/m

Dead full UDL 3.72 kN/m

Load combinations

Load combination 1

Support A

Dead $\times 1.40$

Imposed $\times 1.60$

Dead $\times 1.40$

Imposed $\times 1.60$

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Support B

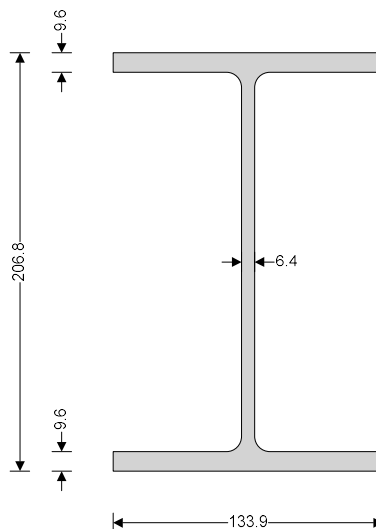
Dead $\times 1.40$
Imposed $\times 1.60$

Analysis results

Maximum moment	$M_{\max} = 32.5 \text{ kNm}$	$M_{\min} = 0 \text{ kNm}$
Maximum shear	$V_{\max} = 32.8 \text{ kN}$	$V_{\min} = -32.8 \text{ kN}$
Deflection	$\delta_{\max} = 2.4 \text{ mm}$	$\delta_{\min} = 0 \text{ mm}$
Maximum reaction at support A	$R_{A_{\max}} = 32.8 \text{ kN}$	$R_{A_{\min}} = 32.8 \text{ kN}$
Unfactored dead load reaction at support A	$R_{A_{\text{Dead}}} = 13.4 \text{ kN}$	
Unfactored imposed load reaction at support A	$R_{A_{\text{Imposed}}} = 8.8 \text{ kN}$	
Maximum reaction at support B	$R_{B_{\max}} = 32.8 \text{ kN}$	$R_{B_{\min}} = 32.8 \text{ kN}$
Unfactored dead load reaction at support B	$R_{B_{\text{Dead}}} = 13.4 \text{ kN}$	
Unfactored imposed load reaction at support B	$R_{B_{\text{Imposed}}} = 8.8 \text{ kN}$	

Section details

Section type **UKB 203x133x30 (Tata Steel Advance)** Steel grade **S355**



Classification of cross sections - Section 3.5

Tensile strain coefficient $\epsilon = 0.88$ Section classification **Plastic**

Shear capacity - Section 4.2.3

Design shear force $F_v = 32.8 \text{ kN}$ Design shear resistance $P_v = 281.9 \text{ kN}$
PASS - Design shear resistance exceeds design shear force

Moment capacity - Section 4.2.5

Design bending moment $M = 32.5 \text{ kNm}$ Moment capacity low shear $M_c = 111.6 \text{ kNm}$

Buckling resistance moment - Section 4.3.6.4

Buckling resistance moment $M_b = 42 \text{ kNm}$ $M_b / m_{LT} = 45.5 \text{ kNm}$
PASS - Buckling resistance moment exceeds design bending moment

Check vertical deflection - Section 2.5.2

Consider deflection due to imposed loads

Limiting deflection $\delta_{\text{lim}} = 11.028 \text{ mm}$ Maximum deflection $\delta = 2.408 \text{ mm}$
PASS - Maximum deflection does not exceed deflection limit

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MASONRY BEARING DESIGN (BS5628)

MASONRY BEARING DESIGN TO BS5628-1:2005

TEDDS calculation version 1.0.08

Masonry details

Masonry type

Compressive strength

Least horiz dim of units

Masonry units

Partial safety factor

Leaf thickness

Wall height

Aggregate concrete blocks (25% or less formed voids)

$p_{unit} = 3.6 \text{ N/mm}^2$

$l_{unit} = 100 \text{ mm}$

Category II

$\gamma_m = 3.5$

$t = 100 \text{ mm}$

$h = 2400 \text{ mm}$

Mortar designation

Height of units

Construction control

Characteristic strength

Effective wall thickness

Effective height of wall

iii

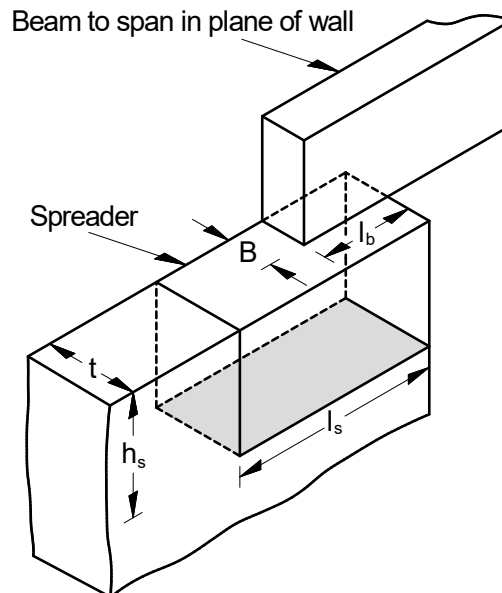
$h_{unit} = 215 \text{ mm}$

Normal

$f_k = 3.5 \text{ N/mm}^2$

$t_{ef} = 133 \text{ mm}$

$h_{ef} = 2400 \text{ mm}$



Bearing details

Beam spanning in plane of wall

Width of bearing

$B = 100 \text{ mm}$

Length of bearing

$l_b = 250 \text{ mm}$

Loading details

Concentrated dead load

$G_k = 13 \text{ kN}$

Concentrated imposed load

$Q_k = 9 \text{ kN}$

Design concentrated load

$F = 32.8 \text{ kN}$

Distributed dead load

$g_k = 0.0 \text{ kN/m}$

Distributed imposed load

$q_k = 0.0 \text{ kN/m}$

Design distributed load

$f = 0.0 \text{ kN/m}$

Masonry bearing type

Bearing type

Type 1

Bearing safety factor

$\gamma_{bear} = 1.25$

Check design bearing without a spreader

Design bearing stress

$f_{ca} = 1.314 \text{ N/mm}^2$

Allowable bearing stress

$f_{cp} = 1.250 \text{ N/mm}^2$

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

Spreader details

Length of spreader

$l_s = 440 \text{ mm}$

Depth of spreader

$h_s = 215 \text{ mm}$

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Edge distance $s_{edge} = 0 \text{ mm}$

Spreader bearing type

Bearing type **Type 3** Bearing safety factor $\gamma_{bear} = 2.00$

Check design bearing with a spreader

Loading acts eccentrically outside middle third – triangular stress distribution

Design bearing stress $f_{ca} = 1.751 \text{ N/mm}^2$ Allowable bearing stress $f_{cp} = 2.000 \text{ N/mm}^2$

PASS - Allowable bearing stress exceeds design bearing stress

Check design bearing at $0.4 \times h$ below the bearing level

Design bearing stress $f_{ca} = 0.271 \text{ N/mm}^2$ Allowable bearing stress $f_{cp} = 0.835 \text{ N/mm}^2$

PASS - Allowable bearing stress at $0.4 \times h$ below bearing level exceeds design bearing stress

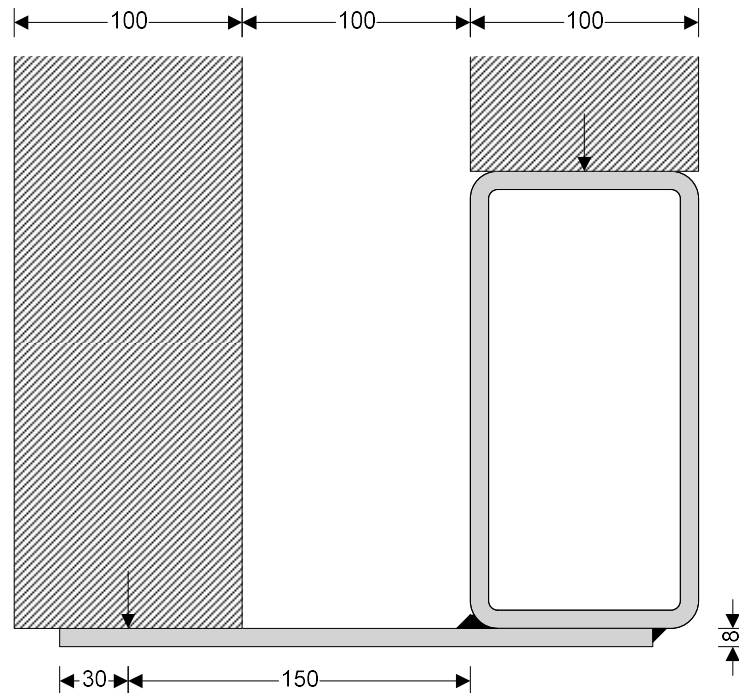
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STEEL MASONRY SUPPORT (BS5950)

STEEL MASONRY SUPPORT

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

Tedds calculation version 1.0.05



Steel member details

Torsion beam	RHS 200x100x8.0
Steel grade of support angle	User
Modulus of elasticity	$E = 205000 \text{ N/mm}^2$
Length of plate beyond beam	$l_h = \mathbf{180 \text{ mm}}$
Thickness of plate	$t_{sb} = \mathbf{8 \text{ mm}}$
Area of plate	$A_{sbu} = \mathbf{2080.0 \text{ mm}^2}$

Masonry support angle	plate
Design strength support angle	$p_{ysb} = 275 \text{ N/mm}^2$
Constant	$\varepsilon = 1.000$
Total length of plate	$l_{plate} = 260 \text{ mm}$
Width of main beam	$B_{mb} = 100 \text{ mm}$
Dist weld position to CoG	$C_{yy sb} = 50 \text{ mm}$

Supported materials detail

Density mas. main beam	$\rho_{m,mb} = 20.0 \text{ kN/m}^3$
Height masonry main beam	$h_{mmb} = 2000 \text{ mm}$
Ecc. of main beam material	$e_{mb} = 0 \text{ mm}$
Add dead force main beam	$P_{Gaddmb} = 0.9 \text{ kN/m}$
Density mas. support beam	$\rho_{m,sb} = 20.0 \text{ kN/m}^3$
Height masonry support beam	$h_{msb} = 2000 \text{ mm}$
Add dead force support beam	$P_{Gaddsb} = 0.0 \text{ kN/m}$

Width masonry main beam	$b_{\text{mmb}} = 100 \text{ mm}$
Add live force main beam	$P_{\text{Qaddmb}} = 0.6 \text{ kN/m}$
Width masonry support beam	$b_{\text{msb}} = 100 \text{ mm}$
Add live force support beam	$P_{\text{Qaddsb}} = 0.0 \text{ kN/m}$

Geometry

Cavity width $c = 100$ mm

Supported width of masonry $d_m = 80 \text{ mm}$

Biaxial stress effects in the plate (SCI-P-110)

Max overall bending moment $M_x = 64.7 \text{ kNm}$
 Second moment of area $I_{xx,all} = 3769 \text{ cm}^4$
 Section modulus of plate $Z_{xx,plate} = 10.67 \text{ cm}^3/\text{m}$

Dist to NA combined section	$y_{e,all} = 33 \text{ mm}$
Elastic section modulus	$Z_{xx,all} = 502.59 \text{ cm}^3$
Eccentricity on support beam	$e_1 = 150 \text{ mm}$

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Force on support plate $P_1 = 5.6$ kN/m Bending at heel $M_{x,plate} = 0.8$ kNm/m
Moment capacity of plate $M_c = 3.5$ kNm/m

PASS - Design strength exceeds stress at heel

Long stress overall bending $\sigma_1 = 128.8$ N/mm² Von Mises curve constant $C_{fp} = 502.7$ N/mm²
Trans bending stress ratio limit $\alpha_{ts} = 0.854$ Trans bending stress ratio $\alpha_{ts} = 0.239$

PASS - Transverse bending stress ratio less than allowable limit

Deflection at toe

Unfact force on plate $P_{1SLS} = 4.0$ kN/m Distance from weld to load $a_m = 150$ mm
Load resultant to edge of plate $b_m = 30$ mm Weld to load pos as ratio $a_l = 0.833$
Effect second mnt of inertia $I_{eff_def} = 42667$ mm⁴/m Deflection at toe $\delta = 0.67$ mm
Deflection limit $\delta_{lim} = 1.80$ mm

PASS - Deflection is within specified criteria

Weld details - assume a full length weld and that the plate acts as a propped cantilever with the prop at the weld position and the fixed end at the centre of the torsion beam

Leg length of weld $s_{weld} = 6$ mm Throat size of weld $a_{weld} = 4.2$ mm
Shear force at weld position $R_A = 30.8$ kN/m Max possible force in plate $R_p = 616.0$ kN
Long shear beam/plate $R_l = 295.4$ kN/m Horizontal shear beam/plate $R_h = 120.0$ kN/m
Resultant weld force $R_{weld} = 0.320$ kN/mm Strength of weld (Table 37) $p_{weld} = 220.0$ N/mm²
Capacity of full length weld $p_{c,weld} = 0.933$ kN/mm

$1/\sqrt{2} \times s_{weld}$

Torsional loading ULS

Loading support beam $W_{1ULS} = 5.60$ kN/m Loading of main beam $W_{2ULS} = 7.73$ kN/m
Self weight of support beam $W_{3ULS} = 0.23$ kN/m

Torsional loading SLS

Loading support beam $W_{1SLS} = 4.00$ kN/m Loading of main beam $W_{2SLS} = 5.44$ kN/m
Self weight of support beam $W_{3SLS} = 0.16$ kN/m

Eccentricities

Distance of shear centre $e_{0mb} = 0$ mm Ecc of support beam masonry $e_{1mb} = 200$ mm
Ecc of main beam masonry $e_{2mb} = 0$ mm Ecc of support beam $e_{3mb} = 100$ mm

Torsional effects

Applied torque $T_{qULS} = 1.14$ kNm/m Torsional moment (ULS) $T_q = 4.77$ kNm
Applied torque (SLS) $T_{qSLS} = 0.82$ kNm/m Torsional moment (SLS) $T_{qu} = 3.40$ kNm

STEEL BEAM TORSION DESIGN

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

Tedds calculation version 2.0.03

Section details

Section type RHS 200x100x8.0 Steel grade S355
Design strength $p_{yw} = p_y = 355$ N/mm² Constant $\varepsilon = 0.880$

Geometry - Beam unrestrained against lateral-torsional buckling between supports.

Effective span $L = 4170$ mm
Length of segment LTB $L_{LT} = 4170$ mm Effective length for LTB $L_{E_LT} = 5404$ mm

Loading - Torsional loading comprises only full-length uniformly distributed load(s)

Internal forces & moments on member under factored loading for uls design

Applied shear force $F_{vy} = 62.1$ kN Maximum bending moment $M_{LT} = M_x = 64.74$ kNm

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Applied torque $T_q = 4.77$ kNm Minor axis bending moment $M_y = 0$ kNm

Compression force $F_c = 0$ kN

Equivalent uniform moment factors

EUM factor (Cl.4.3.6.6 & T18) $m_{LT} = 1.000$

Torsional deflection analysis

Beam is torsion fixed at each end. (as defined in SCI-P-057 section 2.1.6)

Max torque (at supports) $T_o = 2.38$ kNm Avg torque support & CL $T_{av} = 1.19$ kNm

Max. angle of twist (midspan) $\phi = 0.002$ rads

Section classification

$b_x / t = 9.5$ $d_x / t = 22.0$

$b_y / t = 22.0$ $d_y / t = 9.5$

$r_{1sx} = 0.000$ $r_{1sy} = 0.000$

$r_{2s} = 0.000$

Section classification is plastic

Shear capacity (parallel to y-axis)

Design shear force $F_{vy} = 62.1$ kN Design shear resist (cl. 4.2.3) $P_{vy} = 635.5$ kN

Pass - Shear

Moment capacity (x-axis)

Design bending moment $M_x = 64.7$ kNm Mnt cap low shear (cl. 4.2.5.1) $M_{cx} = 95.2$ kNm

Pass - Moment capacity exceeds design bending moment

Lateral torsional buckling

Effective length for LTB $L_{E_LT} = 5404$ mm

Slenderness ratio - cl 4.3.6.5 $\lambda = 133$ $D / B = 2.0$

LTB check not required

Buckling resistance mnt $M_b = M_{cx} = 95.2$ kNm

Buckling under combined bending & torsion - SCI-P-057 section 2.3

For simplicity, a conservative check is applied using the maximum stresses due to each of the separate load effects, even though these do not necessarily all occur at the same section along the member.

Max angle of twist $\phi = 0.002$ rads Induced minor axis moment $M_{yt} = 0.11$ kNm

Norm stress corner due to M_{yt} $\sigma_{byt} = 1$ N/mm² Interaction index $i_b = 0.68$

Pass - Combined bending and torsion check satisfied

Local capacity under combined bending & torsion

For simplicity, a conservative check is applied using the maximum stresses due to each of the separate load effects, even though these do not necessarily all occur at the same section along the member.

Max. direct stress due to M_x $\sigma_{bx} = M_x / Z_x = 290$ N/mm²

Combined stress - eqn 2.22 $\sigma_{bx} + \sigma_{byt} = 291$ N/mm² Design strength $p_y = 355$ N/mm²

Pass - Local capacity

Combined shear stresses SCI-P-057 section 2.3

For simplicity, a conservative check is applied using the maximum shear stresses due to each of the separate load effects, even though these do not necessarily all occur at the same section along the member.

Max. shear stress bending $\tau_{bw} = 24$ N/mm² Max. shear stresses torsion $\tau_t = 9$ N/mm²

Amplified shear stress torsion $\tau_{vt} = 13$ N/mm² Combined shear bend & tors $\tau = 37$ N/mm²

Shear strength $p_v = 213$ N/mm²

Pass - Combined shear stresses

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Twist check

Total applied torque $T_{qu} = 3.40$ kNm
 Max twist under sls loading $\phi_{sls} = 0.07$ deg Twist limit $\phi_{lim} = 1.00$ deg
Pass - Twist

Deflection

Maximum y-axis deflection $\delta_{y_max} = 8.6$ mm Deflection limit - cl. 2.5.2 $\delta_{lim} = 10.0$ mm
Pass - Deflection within specified limit