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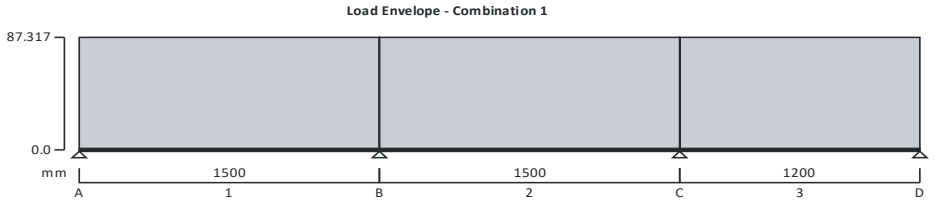
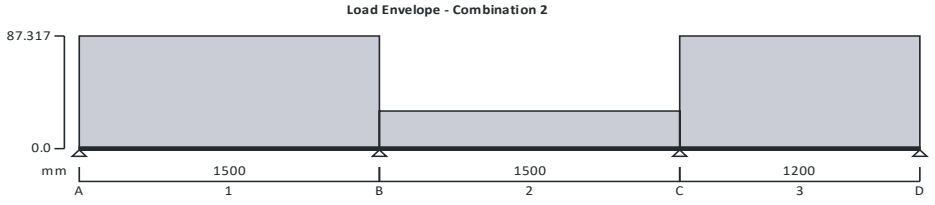
| Project | | | | Job no. | |
|---|---|---|---|---|---|
| Loft Conversion - BEAM 1 - Support Floor Timbers & Stud | | | | 7456-233 | |
| Calcs for | | | | Start page no./Revision | |
| Mr Andrew Rose | | | | 1 A - beam 203x102x23 | |
| Calcs by | Calcs date | Checked by | Checked date | Approved by | Approved date |
| SB | 18/05/2023 | SB | 18/05/2023 | DB | 18/05/2023 |

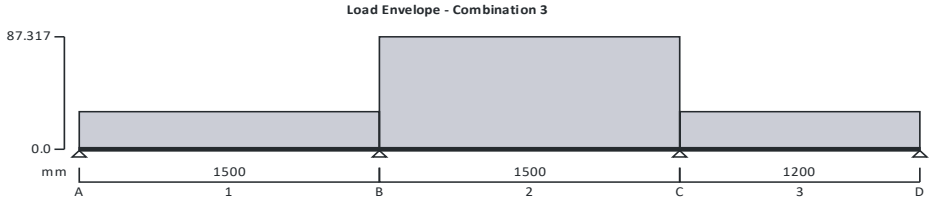
## STEEL BEAM ANALYSIS & DESIGN (BS5950)

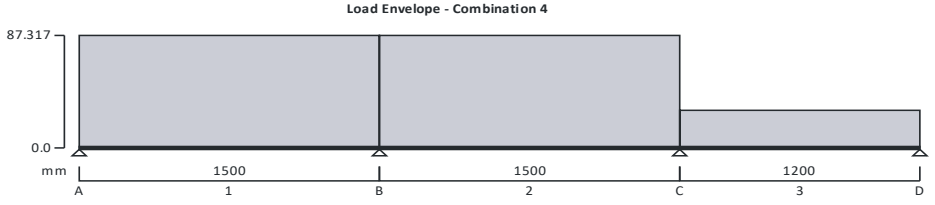
**In accordance with BS5950-1:2000 incorporating Corrigendum No.1**

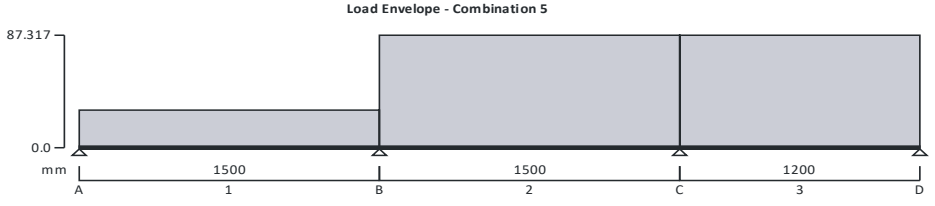
TEDDS calculation version 3.0.07



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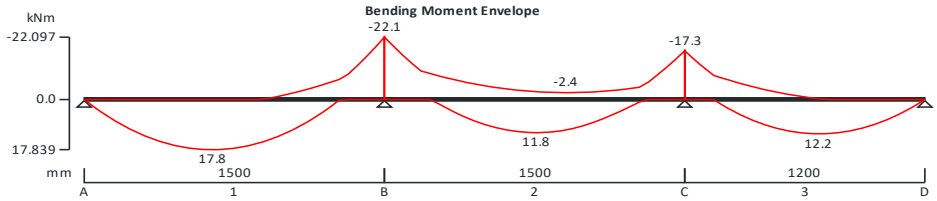
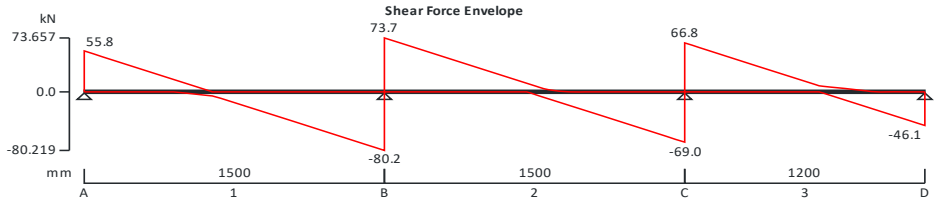



**Support conditions**

| | |
|---|---|
| Support A | Vertically restrained |
| | Rotationally free |
| Support B | Vertically restrained |
| | Rotationally free |
| Support C | Vertically restrained |
| | Rotationally free |
| Support D | Vertically restrained |
| | Rotationally free |

**Applied loading**

| | |
|---|---|
| Beam loads | Dead self weight of beam × 1 |
| | Dead full UDL 29 kN/m |
| | Imposed full UDL 29 kN/m |

**Load combinations**

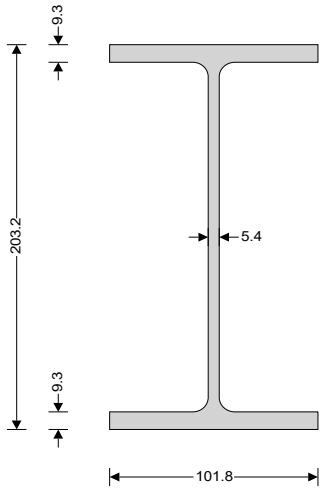
| | | |
|---|---|---|
| Load combination 1 | Support A | Dead × 1.40 |
| | | Imposed × 1.60 |
| | | Dead × 1.40 |
| | | Imposed × 1.60 |
| | Support B | Dead × 1.40 |
| | | Imposed × 1.60 |
| | | Dead × 1.40 |
| | | Imposed × 1.60 |
| | Support C | Dead × 1.40 |
| | | Imposed × 1.60 |
| | | Dead × 1.40 |
| | | Imposed × 1.60 |
| | Support D | Dead × 1.40 |
| | | Imposed × 1.60 |

| | | |
|---|---|---|
| Load combination 2 | Support A | Dead × 1.40 |
| | | Imposed × 1.60 |
| | | Dead × 1.40 |
| | | Imposed × 1.60 |
| | Support B | Dead × 1.40 |
| | | Imposed × 1.60 |
| | | Dead × 1.00 |
| | Support C | Dead × 1.40 |
| | | Imposed × 1.60 |
| | | Dead × 1.40 |
| | | Imposed × 1.60 |
| | Support D | Dead × 1.40 |
| | | Imposed × 1.60 |
| Load combination 3 | Support A | Dead × 1.00 |
| | | Dead × 1.00 |
| | Support B | Dead × 1.40 |
| | | Imposed × 1.60 |
| | | Dead × 1.40 |
| | | Imposed × 1.60 |
| | Support C | Dead × 1.40 |
| | | Imposed × 1.60 |
| | | Dead × 1.00 |
| | Support D | Dead × 1.00 |
| Load combination 4 | Support A | Dead × 1.40 |
| | | Imposed × 1.60 |
| | | Dead × 1.40 |
| | | Imposed × 1.60 |
| | Support B | Dead × 1.40 |
| | | Imposed × 1.60 |
| | | Dead × 1.40 |
| | | Imposed × 1.60 |
| | Support C | Dead × 1.40 |
| | | Imposed × 1.60 |
| | | Dead × 1.00 |
| | Support D | Dead × 1.00 |
| Load combination 5 | Support A | Dead × 1.00 |
| | | Dead × 1.00 |
| | Support B | Dead × 1.40 |
| | | Imposed × 1.60 |
| | | Dead × 1.40 |
| | | Imposed × 1.60 |
| | Support C | Dead × 1.40 |
| | | Imposed × 1.60 |
| | | Dead × 1.40 |

| | | |
|---|---|---|
| | | Imposed × 1.60 |
| | Support D | Dead × 1.40 |
| | | Imposed × 1.60 |
| **Analysis results** | | |
| Maximum moment | $M_{max}$ = **17.8** kNm | $M_{min}$ = **-22.1** kNm |
| Maximum moment span 1 | $M_{s1\_max}$ = **17.8** kNm | $M_{s1\_min}$ = **-22.1** kNm |
| Maximum moment span 1 segment 1 | $M_{s1\_seg1\_max}$ = **17** kNm | $M_{s1\_seg1\_min}$ = **0** kNm |
| Maximum moment span 1 segment 2 | $M_{s1\_seg2\_max}$ = **17.8** kNm | $M_{s1\_seg2\_min}$ = **-1.6** kNm |
| Maximum moment span 1 segment 3 | $M_{s1\_seg3\_max}$ = **12.2** kNm | $M_{s1\_seg3\_min}$ = **-22.1** kNm |
| Maximum moment span 2 | $M_{s2\_max}$ = **11.8** kNm | $M_{s2\_min}$ = **-22.1** kNm |
| Maximum moment span 2 segment 1 | $M_{s2\_seg1\_max}$ = **11.8** kNm | $M_{s2\_seg1\_min}$ = **-22.1** kNm |
| Maximum moment span 2 segment 2 | $M_{s2\_seg2\_max}$ = **11.8** kNm | $M_{s2\_seg2\_min}$ = **-17.3** kNm |
| Maximum moment span 3 | $M_{s3\_max}$ = **12.2** kNm | $M_{s3\_min}$ = **-17.3** kNm |
| Maximum moment span 3 segment 1 | $M_{s3\_seg1\_max}$ = **12** kNm | $M_{s3\_seg1\_min}$ = **-17.3** kNm |
| Maximum moment span 3 segment 2 | $M_{s3\_seg2\_max}$ = **12.2** kNm | $M_{s3\_seg2\_min}$ = **-0.9** kNm |
| Maximum shear | $V_{max}$ = **73.7** kN | $V_{min}$ = **-80.2** kN |
| Maximum shear span 1 | $V_{s1\_max}$ = **55.8** kN | $V_{s1\_min}$ = **-80.2** kN |
| Maximum shear span 1 segment 1 | $V_{s1\_seg1\_max}$ = **55.8** kN | $V_{s1\_seg1\_min}$ = **-1.6** kN |
| Maximum shear span 1 segment 2 | $V_{s1\_seg2\_max}$ = **12.2** kN | $V_{s1\_seg2\_min}$ = **-36.6** kN |
| Maximum shear span 1 segment 3 | $V_{s1\_seg3\_max}$ = **0** kN | $V_{s1\_seg3\_min}$ = **-80.2** kN |
| Maximum shear span 2 | $V_{s2\_max}$ = **73.7** kN | $V_{s2\_min}$ = **-69** kN |
| Maximum shear span 2 segment 1 | $V_{s2\_seg1\_max}$ = **73.7** kN | $V_{s2\_seg1\_min}$ = **-3.5** kN |
| Maximum shear span 2 segment 2 | $V_{s2\_seg2\_max}$ = **8.2** kN | $V_{s2\_seg2\_min}$ = **-69** kN |
| Maximum shear span 3 | $V_{s3\_max}$ = **66.8** kN | $V_{s3\_min}$ = **-46.1** kN |
| Maximum shear span 3 segment 1 | $V_{s3\_seg1\_max}$ = **66.8** kN | $V_{s3\_seg1\_min}$ = **0** kN |
| Maximum shear span 3 segment 2 | $V_{s3\_seg2\_max}$ = **14.4** kN | $V_{s3\_seg2\_min}$ = **-46.1** kN |
| Deflection segment 3 | $\delta_{max}$ = **0.2** mm | $\delta_{min}$ = **0** mm |
| Deflection span 1 segment 3 | $\delta_{s1\_max}$ = **0.2** mm | $\delta_{s1\_min}$ = **0** mm |
| Deflection span 2 segment 3 | $\delta_{s2\_max}$ = **0.1** mm | $\delta_{s2\_min}$ = **0** mm |
| Deflection span 3 segment 3 | $\delta_{s3\_max}$ = **0.1** mm | $\delta_{s3\_min}$ = **0** mm |
| Maximum reaction at support A | $R_{A\_max}$ = **55.8** kN | $R_{A\_min}$ = **13** kN |
| Unfactored dead load reaction at support A | $R_{A\_Dead}$ = **17.3** kN | |
| Unfactored imposed load reaction at support A | $R_{A\_Imposed}$ = **17.1** kN | |
| Maximum reaction at support B | $R_{B\_max}$ = **153.9** kN | $R_{B\_min}$ = **92** kN |
| Unfactored dead load reaction at support B | $R_{B\_Dead}$ = **49.8** kN | |
| Unfactored imposed load reaction at support B | $R_{B\_Imposed}$ = **49.4** kN | |
| Maximum reaction at support C | $R_{C\_max}$ = **135.7** kN | $R_{C\_min}$ = **75.9** kN |
| Unfactored dead load reaction at support C | $R_{C\_Dead}$ = **42.3** kN | |
| Unfactored imposed load reaction at support C | $R_{C\_Imposed}$ = **41.9** kN | |
| Maximum reaction at support D | $R_{D\_max}$ = **46.1** kN | $R_{D\_min}$ = **7.3** kN |
| Unfactored dead load reaction at support D | $R_{D\_Dead}$ = **13.4** kN | |
| Unfactored imposed load reaction at support D | $R_{D\_Imposed}$ = **13.3** kN | |
| **Section details** | | |
| Section type | **UB 203x102x23 (BS4-1)** | |
| Steel grade | **S275** | |
| **From table 9: Design strength $p_y$** | | |
| Thickness of element | max(T, t) = **9.3** mm | |

Design strength $p_y$ = **275** N/mm$^2$

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




**Lateral restraint**

Span 1 has lateral restraint at supports plus third points
Span 2 has lateral restraint at supports plus midspan
Span 3 has lateral restraint at supports plus midspan

**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**
$K_{LT.B}$ = **1.00**
$K_{LT.C}$ = **1.00**
$K_{LT.D}$ = **1.00**

**Classification of cross sections - Section 3.5**

$\varepsilon = \sqrt{[275\ N/mm^2 / p_y]}$ = **1.00**

**Internal compression parts - Table 11**

Depth of section d = **169.4** mm

d / t = 31.4 × ε <= 80 × ε Class 1 plastic

**Outstand flanges - Table 11**

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

b / T = 5.5 × ε <= 9 × ε Class 1 plastic

***Section is class 1 plastic***

**Shear capacity - Section 4.2.3**

Design shear force $F_v = max(abs(V_{max}), abs(V_{min}))$ = **80.2** kN

d / t < 70 × ε

***Web does not need to be checked for shear buckling***

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

Design shear resistance $P_v = 0.6 \times p_y \times A_v$ = **181.1** kN

***PASS - Design shear resistance exceeds design shear force***

**Moment capacity at span 2 segment 1 - Section 4.2.5**

Design bending moment $M = \max(\text{abs}(M_{s2\_seg1\_max}), \text{abs}(M_{s2\_seg1\_min})) =$ **22.1** kNm

Moment capacity low shear - cl.4.2.5.2 $M_c = \min(p_y \times S_{xx}, 1.5 \times p_y \times Z_{xx}) =$ **64.4** kNm

**Effective length for lateral-torsional buckling - Section 4.3.5**

Effective length for lateral torsional buckling $L_E = 1.0 \times L_{s2\_seg1} =$ **750** mm

Slenderness ratio $\lambda = L_E / r_{yy} =$ **31.767**

**Equivalent slenderness - Section 4.3.6.7**

Buckling parameter $u =$ **0.888**

Torsional index $x =$ **22.460**

Slenderness factor $v = 1 / [1 + 0.05 \times (\lambda / x)^2]^{0.25} =$ **0.976**

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

Equivalent slenderness - cl.4.3.6.7 $\lambda_{LT} = u \times v \times \lambda \times \sqrt{[\beta_W]} =$ **27.546**

Limiting slenderness - Annex B.2.2 $\lambda_{L0} = 0.4 \times (\pi^2 \times E / p_y)^{0.5} =$ **34.310**

***$\lambda_{LT} < \lambda_{L0}$ - No allowance need be made for lateral-torsional buckling***

**Buckling resistance moment - Section 4.3.6.4**

Bending strength $p_b = p_y =$ **275** N/mm$^2$

Buckling resistance moment $M_b = p_b \times S_{xx} =$ **64.4** kNm

***PASS - Moment capacity exceeds design bending moment***

**Check vertical deflection - Section 2.5.2**

Consider deflection due to imposed loads

Limiting deflection $\delta_{lim} = L_{s1} / 360 =$ **4.167** mm

Maximum deflection span 1 $\delta = \max(\text{abs}(\delta_{max}), \text{abs}(\delta_{min})) =$ **0.222** mm

***PASS - Maximum deflection does not exceed deflection limit***