| | | |
|---|---|---|
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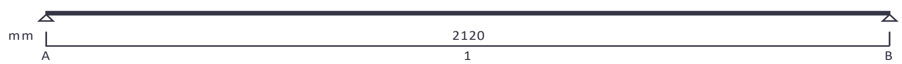
| | Calcs for<br>Mr Sonu Nazran BEAM 2 - 2120mm | Start page no./Revision<br>1 |

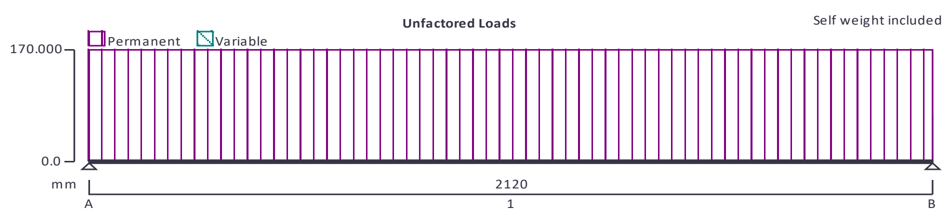
| Calcs by | Calcs date | Checked by | Checked date | Approved by | Approved date |
|---|---|---|---|---|---|
| SB | 09/08/2023 | DB | 08/08/2023 | SB | 09/08/2023 |

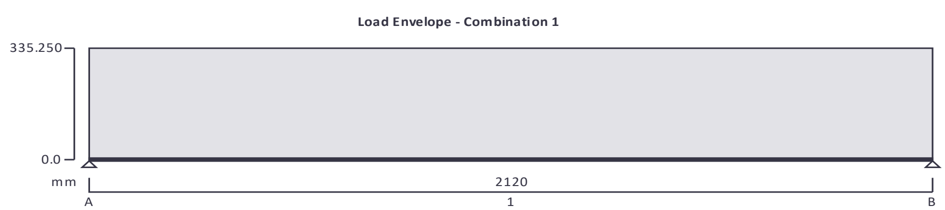
## STEEL BEAM ANALYSIS & DESIGN (EN1993-1-1:2005)

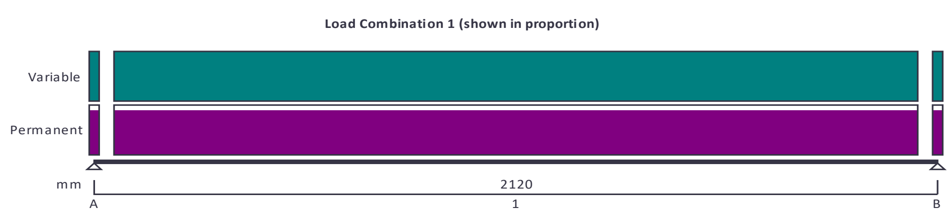
**In accordance with EN1993-1-1:2005 incorporating Corrigenda February 2006 and April 2009 and the UK national annex**

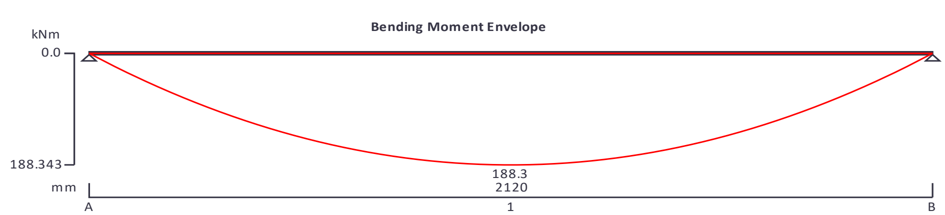
TEDDS calculation version 3.0.14

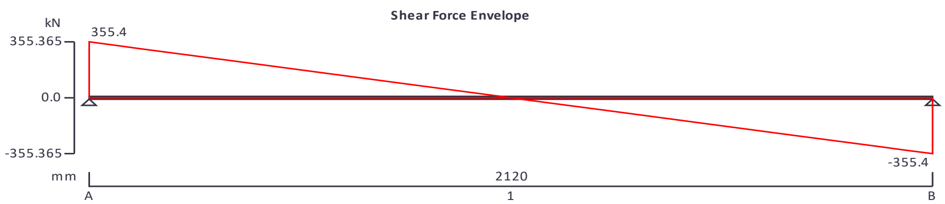





**Support conditions**

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

**Applied loading**

| | |
|---|---|
| Beam loads | Permanent self weight of beam × 1 |
| | Variable full UDL 70 kN/m |
| | Permanent full UDL 170 kN/m |

**Load combinations**

| | | |
|---|---|---|
| Load combination 1 | Support A | Permanent × 1.35 |
| | | Variable × 1.50 |
| | | Permanent × 1.35 |
| | | Variable × 1.50 |
| | Support B | Permanent × 1.35 |
| | | Variable × 1.50 |

**Analysis results**

| | | |
|---|---|---|
| Maximum moment | $M_{max}$ = **188.3** kNm | $M_{min}$ = **0** kNm |
| Maximum moment span 1 segment 1 | $M_{s1\_seg1\_max}$ = **135.8** kNm | $M_{s1\_seg1\_min}$ = **0** kNm |
| Maximum moment span 1 segment 2 | $M_{s1\_seg2\_max}$ = **187.7** kNm | $M_{s1\_seg2\_min}$ = **0** kNm |
| Maximum moment span 1 segment 3 | $M_{s1\_seg3\_max}$ = **188.3** kNm | $M_{s1\_seg3\_min}$ = **0** kNm |
| Maximum moment span 1 segment 4 | $M_{s1\_seg4\_max}$ = **155.9** kNm | $M_{s1\_seg4\_min}$ = **0** kNm |
| Maximum shear | $V_{max}$ = **355.4** kN | $V_{min}$ = **-355.4** kN |
| Maximum shear span 1 segment 1 | $V_{s1\_seg1\_max}$ = **355.4** kN | $V_{s1\_seg1\_min}$ = **0** kN |
| Maximum shear span 1 segment 2 | $V_{s1\_seg2\_max}$ = **187.7** kN | $V_{s1\_seg2\_min}$ = **0** kN |
| Maximum shear span 1 segment 3 | $V_{s1\_seg3\_max}$ = **20.1** kN | $V_{s1\_seg3\_min}$ = **-147.5** kN |
| Maximum shear span 1 segment 4 | $V_{s1\_seg4\_max}$ = **0** kN | $V_{s1\_seg4\_min}$ = **-325.2** kN |
| Deflection segment 5 | $\delta_{max}$ = **1.1** mm | $\delta_{min}$ = **0** mm |
| Maximum reaction at support A | $R_{A\_max}$ = **355.4** kN | $R_{A\_min}$ = **355.4** kN |
| Unfactored permanent load reaction at support A | $R_{A\_Permanent}$ = **180.8** kN | |
| Unfactored variable load reaction at support A | $R_{A\_Variable}$ = **74.2** kN | |
| Maximum reaction at support B | $R_{B\_max}$ = **355.4** kN | $R_{B\_min}$ = **355.4** kN |
| Unfactored permanent load reaction at support B | $R_{B\_Permanent}$ = **180.8** kN | |
| Unfactored variable load reaction at support B | $R_{B\_Variable}$ = **74.2** kN | |

**Section details**

| | |
|---|---|
| Section type | **2 x UB 254x102x28 (BS4-1)** |
| Steel grade | **S275** |

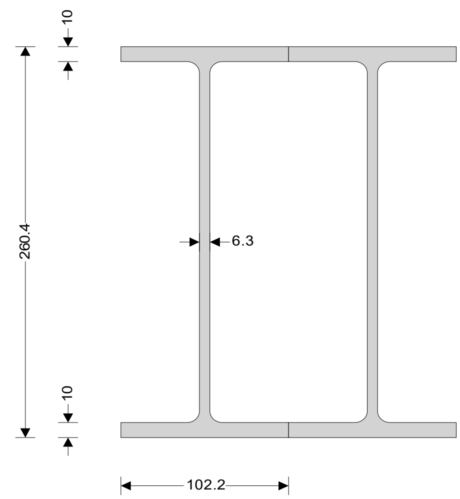
**EN 10025-2:2004 - Hot rolled products of structural steels**

Nominal thickness of element $t = max(t_f, t_w) = \mathbf{10.0}$ mm

Nominal yield strength $f_y = \mathbf{275}$ N/mm$^2$

Nominal ultimate tensile strength $f_u = \mathbf{410}$ N/mm$^2$

Modulus of elasticity $E = \mathbf{210000}$ N/mm$^2$




**Partial factors - Section 6.1**

Resistance of cross-sections $\gamma_{M0} = \mathbf{1.00}$

Resistance of members to instability $\gamma_{M1} = \mathbf{1.00}$

Resistance of tensile members to fracture $\gamma_{M2} = \mathbf{1.10}$

**Lateral restraint**

Span 1 has lateral restraint at supports plus 500 mm, 1000 mm and 1500 mm

**Effective length factors**

Effective length factor in major axis $K_y = \mathbf{1.000}$

Effective length factor in minor axis $K_z = \mathbf{1.000}$

Effective length factor for torsion $K_{LT.A} = \mathbf{1.000}$

$K_{LT.B} = \mathbf{1.000}$

**Classification of cross sections - Section 5.5**

$\varepsilon = \sqrt{[235 \text{ N/mm}^2 / f_y]} = \mathbf{0.92}$

**Internal compression parts subject to bending - Table 5.2 (sheet 1 of 3)**

Width of section $c = d = \mathbf{225.2}$ mm

$c / t_w = 38.7 \times \varepsilon <= 72 \times \varepsilon$ Class 1

**Outstand flanges - Table 5.2 (sheet 2 of 3)**

Width of section $c = (b - t_w - 2 \times r) / 2 = \mathbf{40.3}$ mm

$c / t_f = 4.4 \times \varepsilon <= 9 \times \varepsilon$ Class 1

***Section is class 1***

**Check shear - Section 6.2.6**

Height of web $h_w = h - 2 \times t_f = \mathbf{240.4}$ mm

Shear area factor $\eta = \mathbf{1.000}$

$h_w / t_w < 72 \times \varepsilon / \eta$

***Shear buckling resistance can be ignored***

Design shear force $V_{Ed} = \max(\text{abs}(V_{max}), \text{abs}(V_{min}))$ = **355.4** kN

Shear area - cl 6.2.6(3) $A_v = \max(A - 2 \times b \times t_f + (t_w + 2 \times r) \times t_f, \eta \times h_w \times t_w)$ = **1779** mm$^2$

Design shear resistance - cl 6.2.6(2) $V_{c,Rd} = V_{pl,Rd} = N \times A_v \times (f_y / \sqrt{[3]}) / \gamma_{M0}$ = **564.9** kN

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

**Combined bending and shear - Section 6.2.8**

Reduction factor - cl.6.2.8(3) $\rho_v = [(2 \times V_{Ed} / V_{pl,Rd}) - 1]^2$ = **0.067**

**Check bending moment at span 1 segment 3 major (y-y) axis - Section 6.2.5**

Design bending moment $M_{Ed} = \max(\text{abs}(M_{s1\_seg3\_max}), \text{abs}(M_{s1\_seg3\_min}))$ = **188.3** kNm

Design bending resistance moment - eq 6.13 $M_{c,Rd} = M_{pl,Rd} = N \times [(W_{pl.y} - t_w \times h^2 / 4) + (t_w \times h^2 / 4) \times (1 - \rho_v)] \times f_y / \gamma_{M0}$ = **190.1** kNm

**Slenderness ratio for lateral torsional buckling**

Correction factor - Table 6.6 $k_c$ = **0.978**

$C_1 = 1 / k_c^2$ = **1.045**

Curvature factor $g = \sqrt{[1 - (I_z / I_y)]}$ = **0.977**

Poissons ratio $\nu$ = **0.3**

Shear modulus $G = E / [2 \times (1 + \nu)]$ = **80769** N/mm$^2$

Unrestrained length $L = 1.0 \times L_{s1\_seg3}$ = **500** mm

Elastic critical buckling moment $M_{cr} = C_1 \times \pi^2 \times E \times I_z / (L^2 \times g) \times \sqrt{[I_w / I_z + L^2 \times G \times I_t / (\pi^2 \times E \times I_z)]}$ = **2013** kNm

Slenderness ratio for lateral torsional buckling $\bar{\lambda}_{LT} = \sqrt{([(W_{pl.y} - t_w \times h^2 / 4) + (t_w \times h^2 / 4) \times (1 - \rho_v)] \times f_y / M_{cr})}$ = **0.217**

Limiting slenderness ratio $\bar{\lambda}_{LT,0}$ = **0.4**

***$\bar{\lambda}_{LT} < \bar{\lambda}_{LT,0}$ - Lateral torsional buckling can be ignored***

***PASS - Design bending resistance moment exceeds design bending moment***

**Check vertical deflection - Section 7.2.1**

Consider deflection due to variable loads

Limiting deflection $\delta_{lim} = L_{s1} / 360$ = **5.9** mm

Maximum deflection span 1 $\delta = \max(\text{abs}(\delta_{max}), \text{abs}(\delta_{min}))$ = **1.095** mm

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