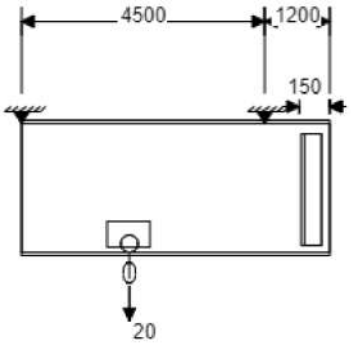
1.0 INPUT

1.1 Section

Type	Type	= **Standard**
Section	Section	= **UB 406x178x60**
Overall Height	H	= **406.4** mm
Width of Flange	B	= **177.9** mm
Thickness of Flange	T	= **12.8** mm
Thickness of Web	t	= **7.9** mm
Root Radius	r	= **10.2** mm



1.2 Support

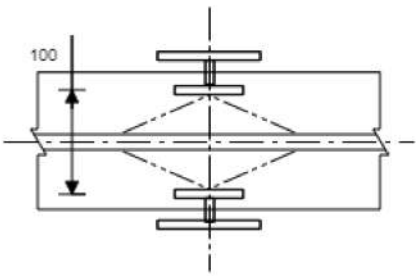
Simply Supported Span	L_s	= **4500** mm
Cantilever Span	L_c	= **1200** mm
Stopper Distance from Cantilever Edge	D_s	= **150** mm
Effective Restraint Factor - Simply Supported	K_s	= **1**
Effective Restraint Factor - Cantilever	K_c	= **2**

1.3 Monorail

Monorail Capacity	P_L	= **20** kN
Hoist Pulley Weight	S_h	= **2** kN
Dynamic Factor for Vertical Loads	Ψ_v	= **10** %
Dynamic Factor for Horizontal Loads	Ψ_h	= **0** %

1.4 Wheel Arrangement

No. of Wheels	N	= **2**
Distance between Wheels	G	= **100** mm



1.5 Settings

Steel Grade	f_y	= **275** N/mm^2
Elastic Modulus of Steel	E	= **200000** N/mm^2
Def. / Span Ratio - Simply Supported	Δ_{lims}	= **500**
Def. / Span Ratio - Cantilever	Δ_{limc}	= **250**
Vibration Check		**No**
Stiffened Flanges		**No**

2.0 OUTPUT

Ref: BS 2853:1957

2.1 Section Properties

2.1.1 I Section [From Section Table]

Cross Sectional Area	A	= **76.5** cm^2	
Moment of Inertia - Major	I_{xx}	= **21600** cm^4	
Moment of Inertia - Minor	I_{yy}	= **1200** cm^4	
Radius of Gyration - Minor	R_{yy}	= **39.7** cm	
Elastic Section Modulus - Major	Z_{xx}	= **1060** cm^3	
Elastic Section Modulus - Minor	Z_{yy}	= **135** cm^3	
Modulus of Resistance for Torsion	R_{ta}	= **39405.7** mm^3	

2.2 Calculation for Simply Supported Span

Simply Supported Span	L_{bs}	= **4500** mm	

2.2.1 Loads Acting on Beam - Bending Check

Concentrated Load - Vertical	Q_v	= $(1 + \Psi_v) * (P_L + S_h)$ = **24.2** kN	
Horizontal Load	Q_h	= $\Psi_h * (P_L + S_h)$ = **0** kN	
Self-Weight	q_v	= A * 78.5 = **0.6** kN/m	
Torsional Moment	T_m	= $Q_h * (H / 2 - T)$ = **0** kN-m	
Vertical Bending Moment	M_v	= $(Q_v * (L_{bs} / 4)) + (q_v * L_{bs}^2 / 8)$ = **28.7** kN-m	
Horizontal Bending Moment	M_h	= $(Q_h * (L_{bs} / 4))$ = **0** kN-m	

2.2.2 Check for Longitudinal Stress

Stress due to Vertical Moments	f_{bv}	= M_v / Z_{xx} = **27.118** N/mm^2	
Stress due to Horizontal Moments	f_{bh}	= M_h / Z_{yy} = **0** N/mm^2	
Slenderness Ratio	S_{lr}	= $(L_{bs} * K_s) / R_{yy}$ = **113.35**	
Depth to Thickness Ratio	D / T	= H / T = **31.7**	
Allowable Bending Stress - Vertical Loads	P_{bc}	= **134.313** N/mm^2	*Table 1*
Allowable Bending Stress - Horizontal Loads	P_{bt}	= **162.12** N/mm^2	*Clause 4 (b)*
Unity Check Ratio	UC_t	= $f_{bv} / P_{bc} + f_{bh} / P_{bt}$ = **0.202**	

2.2.3 Maximum Shear Force due to Vertical Load

Shear Force due to Concentrated Loads	V_c	= Q_v = **24.2** kN	
Shear Force due to Distributed Loads	V_d	= $q_v * (L_{bs} / 2)$ = **1.4** kN	
Maximum Shear Force	V_v	= $V_c + V_d$ = **25.6** kN	

2.2.4 Check for Shear Stress

Shear Stress due to Vertical Shear	τ_v	= $V_v / ((H - 2 * T) * t)$ = **8.494** N/mm^2	
Shear Stress due to Torsion	τ_t	= T_m / R_{ta} = **0** N/mm^2	
Total Shear Stress	τ	= $\tau_v + \tau_t$ = **8.494** N/mm^2	
Allowable Shear Stress	F_v	= **110** N/mm^2	*Table 11 BS 449*
Unity Check Ratio	UC_v	= τ / F_v = **0.077**	

2.2.5 Cross Flange Bending Check

Constant Dependent on Wheel Centres of Beam	C	= **1**	*Table 3*
Constant Dependent on Set in Wheel for Trolleys	K_1	= **1.4**	*Table 4*
Mean Flange Thickness	T_{fm}	= 0.022 * ((B - t) / 2) + T = **14.7** mm	*Appendix G.Eq(3)*
Transverse Stress (Trolley is Remote from End of the Beam)	f_{21}	= $(1.4 * C * Q_v) / (K_1 * T_{fm}^2)$ = **116.159** N/mm^2	*Appendix G.Eq(1)*
Constant Dependent on Set in Wheel for Trolleys	K_2	= **0.7**	*Table 5*
Transverse Stress (Trolley is at the End of	f_{22}	= $(1.4 * C * Q_v) / (K_2 * T_{fm}^2)$ = **217.059** N/mm^2	*Appendix G.Eq(2)*

the Beam)			
Allowable Transverse Stress	F_{2max}	= **223.88** N/mm^2	*Clause 4 (b)*

2.2.6 Combined Stress Check

Longitudinal Stress	f_1	= f_{bv} = **27.118** N/mm^2	
Transverse Stress (Trolley is Remote from End of the Beam)	f_{21}	= **116.159** N/mm^2	*Appendix G.Eq(1)*
Allowable Cross Flange Bending Stress (For f_1)	F_2	= **223.88** N/mm^2	*Figure 5*

2.2.7 Check for Deflection

Deflection due to Concentrated Loads	δ_1	= $(Q_v * L_{bs}^3) / (48 * E * I_{xx})$ = **1.063** mm	
Deflection due to Distributed Loads	δ_2	= $(5 * q_v * L_{bs}^4) / (384 * E * I_{xx})$ = **0.074** mm	
Total Deflection	δ	= $\delta_1 + \delta_2$ = **1.138** mm	
Allowable Deflection	δ_{allow}	= L_{bs} / Δ_{lims} = **9** mm	*Clause 4 (k)*
Unity Check Ratio	UC_d	= δ_{allow} / δ = **0.126**	

2.3 Calculation for Cantilever Span

Cantilever Span	L_{bc}	= $(L_c - D_s)$ = **1050** mm	

2.3.1 Loads Acting on Beam - Bending Check

Concentrated Load - Vertical	Q_{vc}	= $(1 + \Psi_v) * (P_L + S_h)$ = **24.2** kN	
Horizontal Load	Q_{hc}	= $\Psi_h * (P_L + S_h)$ = **0** kN	
Self-Weight	q_{vc}	= A * 78.5 = **0.6** kN/m	
Torsional Moment	T_{mc}	= $Q_{hc} * (H / 2 - T)$ = **0** kN-m	
Vertical Bending Moment	M_{vc}	= $(Q_{vc} * L_{bc}) + q_{vc} * (L_{bc}^2 / 2)$ = **25.7** kN-m	
Horizontal Bending Moment	M_{hc}	= $(Q_{hc} * L_{bc})$ = **0** kN-m	

2.3.2 Check for Longitudinal Stress

Stress due to Vertical Moments	f_{bvc}	= M_{vc} / Z_{xx} = **24.284** N/mm^2	
Stress due to Horizontal Moments	f_{bhc}	= M_{hc} / Z_{yy} = **0** N/mm^2	
Slenderness Ratio	S_{lrc}	= $(L_{bc} * K_c) / R_{yy}$ = **52.9**	
Depth to Thickness Ratio	D / T_c	= H / T = **31.7**	
Allowable Bending Stress - Vertical Loads	P_{bcc}	= **162.12** N/mm^2	*Table 1*
Allowable Bending Stress - Horizontal Loads	P_{btc}	= **162.12** N/mm^2	*Clause 4 (b)*
Unity Check Ratio	UC_{tc}	= $f_{bvc} / P_{bcc} + f_{bhc} / P_{btc}$ = **0.15**	

2.3.3 Maximum Shear Force due to Vertical Load

Shear Force due to Concentrated Loads	V_{cc}	= Q_{vc} = **24.2** kN	
Shear Force due to Distributed Loads	V_{dc}	= $q_{vc} * L_{bc}$ = **0.6** kN	
Maximum Shear Force	V_{vc}	= $V_{cc} + V_{dc}$ = **24.8** kN	

2.3.4 Check for Shear Stress

Shear Stress due to Vertical Shear	τ_{vc}	= $V_{vc} / ((H - 2 * T) * t)$ = **8.254** N/mm^2	
Shear Stress due to Torsion	τ_{tc}	= T_{mc} / R_{ta} = **0** N/mm^2	
Total Shear Stress	τ_c	= $\tau_{vc} + \tau_{tc}$ = **8.254** N/mm^2	
Allowable Shear Stress	F_{vc}	= **110** N/mm^2	*Table 11 BS 449*
Unity Check Ratio	UC_{vc}	= τ_c / F_{vc} = **0.075**	

2.3.5 Cross Flange Bending Check

Constant Dependent on Wheel Centres of	C_c	= **1**	*Table 3*

Beam			
Constant Dependent on Set in Wheel for Trolleys	K_{1c}	= **1.4**	*Table 4*
Mean Flange Thickness	T_{fmc}	= 0.022 * (((B - t)) / 2) + T = **14.7** mm	*Appendix G.Eq(3)*
Transverse Stress (Trolley is Remote from End of the Beam)	f_{21c}	= $(1.4 * C_c * Q_{vc}) / (K_{1c} * T_{fmc}^2)$ = **116.159** N/mm^2	*Appendix G.Eq(1)*
Constant Dependent on Set in Wheel for Trolleys	K_{2c}	= **0.7**	*Table 5*
Transverse Stress (Trolley is at the End of the Beam)	f_{22c}	= $(1.4 * C_c * Q_{vc}) / (K_{2c} * T_{fmc}^2)$ = **217.059** N/mm^2	*Appendix G.Eq(2)*
Allowable Transverse Stress	F_{2maxc}	= **223.88** N/mm^2	*Clause 4 (b)*

2.3.6 Check for Deflection

Deflection due to Concentrated Loads	δ_{1c}	= $(Q_{vc} * L_{bc}^2 * (L_{bc} + L_{bs})) / (3 * E * I_{xx})$ = **1.143** mm	
Deflection due to Distributed Loads	δ_{2c}	= $((q_{vc} * L_{bc}^3 * (4 * L_{bs} + 3 * L_{bc})) / (24 * E * I_{xx}))$ = **0.014** mm	
Total Deflection	δ_c	= $\delta_{1c} + \delta_{2c}$ = **1.157** mm	
Allowable Deflection	δ_{allowc}	= L_{bc} / Δ_{limc} = **4.2** mm	*Clause 4 (k)*
Unity Check Ratio	UC_{dc}	= $\delta_{allowc} / \delta_c$ = **0.275**	

3.0 SUMMARY

3.1 Critical Section : Simply Supported Span

3.2 Check for Longitudinal Stress

Description	Actual	Allowable	Status
Stress due to Vertical Moment (N/mm^2)	27.118	134.313	**PASS**
Stress due to Horizontal Moment (N/mm^2)	0	162.12	**PASS**

3.3 Cross Flange Bending

Description	Actual	Allowable	Status
Transverse Stress - Remote from End of the Beam (N/mm^2)	116.159	223.88	**PASS**
Transverse Stress - At the End of the Beam (N/mm^2)	217.059	223.88	**PASS**

3.4 Shear Stress Check

Description	Actual	Allowable	Status
Total Shear Stress (N/mm^2)	8.494	110	**PASS**

3.5 Combined Stress Check

Description	Actual	Allowable	Status
Transverse Stress - Remote from End of the Beam + Longitudinal Stress (N/mm^2)	116.159	223.88	**PASS**

3.6 Deflection Check

Description	Actual	Allowable	Status
Total Deflection (mm)	1.138	9	**PASS**