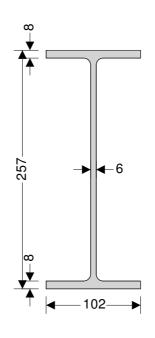
Tedds	Project		Job no.			
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	Calcs by MG	Calcs date 27/04/2018	Checked by	Checked date	Approved by	Approved date

## STEEL BEAM TORSION DESIGN

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

Tedds calculation version 2.0.01



Section details						
Section type	UKB 254x102x25					
Steel grade	S275					
Design stength	$p_{yw} = p_y = 275 \text{ N/mm}^2$					
Constant	$\epsilon = \sqrt{(275 \text{ N/mm}^2 / p_y)} = 1.000$					
Calculated torsional properties						
Shear area of web	$A_{vy} = t \times D = 15.4 \text{ cm}^2$					
Plastic modulus of web	$S_{vx} = t \times D^2 / 4 = 99.2 \text{ cm}^3$					
Torsion bending constant	a = $\sqrt{(E \times H / (G \times J))}$ = 966 mm					
Normalised warping function	$W_{n0} = (D - T) \times B / 4 = 63.4 \text{ cm}^2$					
Statical moment in the flange	$Q_{f}$ = ( $S_{x}$ - t $_{\times}$ D <sup>2</sup> / 4 ) / 4 = <b>52</b> cm <sup>3</sup>					
Statical moment at mid-depth of section	$Q_w = S_x / 2 = 153 \text{ cm}^3$					
Warping statical moment	$S_{w1}$ = ( $D$ -T ) $_{\times}B^2_{\times}T/$ 16 = <b>136</b> $cm^4$					
Geometry - Beam unrestrained against lateral-to	orsional buckling between supports.					
Effective span	L = <b>4000</b> mm					
Length of segment for LT buckling	L <sub>LT</sub> = <b>4000</b> mm					
Compression flanges laterally restrained						
Compression flange partially restrained against rotation on plan						
Effective length for LT buckling	$L_{E\_LT} = L_{LT} \times 0.85 = 3400 \text{ mm}$					
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 <sub>vy</sub> = <b>6.0</b> kN					
Maximum bending moment	$M_{LT} = M_x = 11.90 \text{ kNm}$					
Applied torque	T <sub>q</sub> = <b>0.46</b> kNm					

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Minor axis bending moment		M <sub>y</sub> = 0 kNr	n					
Compression force		$F_{c} = 0 \ kN$						
Equivalent uniform moment fa EUM factor (Cl. 4.3.6.6 and T18		m <sub>LT</sub> = <b>1.00</b>	0					
Torsional deflection paramete	rs							
Beam is torsion fixed and warpir	ng free at each	end. (as defined	d in SCI-P-057	section 2.1.6) - A	Appendix B cas	se 4		
Dist along the beam for first deri	vative of twist	$z_1 = 0 mm$						
Dist along the beam for second derivative of twist								
First derivative of angle of twist	$\phi'_{1} = T_{q} / (C_{q})$	G <sub>×</sub> J) <sub>×</sub> a/L <sub>×</sub>	$[L^2 / (2 \times a) \times (1 /$	$L - 2 \times z_1 / L^2)$	+ sinh(z <sub>1</sub> /			
		tanh(L / (2	$tanh(L / (2 \times a)) \times cosh(z_1 / a)] \times 1 rads = 2.42 \times 10^{-2} rads/m$					
Third derivative of angle of twist		$\phi^{\prime\prime\prime} = T_q / ($	$G \times J \times a^2$ × $a^2$ × $a^2$	$L_{\times}$ [sinh(z <sub>1</sub> / a) -	$tanh(L / (2 \times a))$	$)) \times \cosh(z)$		
		a)] <sub>×</sub> 1 rad	s = <b>-2.28<sub>X</sub>10</b> <sup>-2</sup> r	ads/m <sup>3</sup>				
Angle of twist		$\phi^2 = T_q \times a$	$\phi^2 = T_q \times a / (G \times J) \times a / L \times [L^2 / (2 \times a^2) \times (z_2 / L - z_2^2 / L^2) + cosh(z_2 / L^2) + cos$					
		a) - tanh(L	a) - tanh(L / (2 $\times$ a)) $\times$ sinh(z <sub>2</sub> / a) - 1] $\times$ 1 rads = <b>0.030</b> rads					
Second derivative of angle of tw	ist	$\phi''_2 = T_q / (q)$	$_{\emptyset}$ " <sub>2</sub> = T <sub>q</sub> / (G × J × a) × a / L × [cosh(z <sub>2</sub> / a) - tanh(L / (2 × a)) × sinh(z <sub>2</sub>					
	a) - 1] <sub>×</sub> 1	a) - 1] <sub>×</sub> 1 rads = <b>-1.71<sub>×</sub>10<sup>-2</sup></b> rads/m <sup>2</sup>						
Design parameters								
Total angle of twist		$\phi = abs(\phi_2)$	= <b>0.030</b> rads					
First derivative of $\phi$		1 1	) = <b>2.42<sub>×</sub>10</b> <sup>−2</sup> r	ads/m				
Second derivative of $\phi$	1 1	'2) = 1.71 <sub>×</sub> 10 <sup>-2</sup>						
Third derivative of $\phi$	1 1	"1) = 2.28 <sub>×</sub> 10 <sup>-2</sup>						
I		$\varphi = \alpha \delta \delta (\varphi$	1) = <b>1.10</b> X10	1446/111				
Section classification		b / T = <b>6.1</b>						
		d / t = <b>37.5</b>						
				=c / (d x t x pyw)))	= 0.000			
			$A_{g \times} p_{yw}) = 0.00$		- 01000			
		125 - 1 07 (7	(g X Pyw) - 0.00		tion classifica	ation is pla		
Shear capacity (parallel to y-a	ris)					•		
Design shear force		F <sub>vy</sub> = <b>6.0</b> k	N					
Design shear resistance (Cl. 4.2	2.3)	$P_{vy} = 0.6 \times$	$p_{y} \times A_{vy} = 254$	<b>1.6</b> kN				
						Pass - S		
Moment capacity (x-axis)								
Design bending moment		M <sub>x</sub> = <b>11.9</b>	kNm					
Moment capacity	ncity N		$M_{cxu} = p_y \times S_x = 84.0 \text{ kNm}$					
Moment capacity low shear (Cl.	4.2.5.1)	$M_{cx} = min($	$M_{cx} = min(p_y \times S_x, 1.2 \times p_y \times Z_x) = \textbf{84.0 kNm}$					
				capacity excee		nding mor		
Lateral torsional buckling								
Effective length for lateral torsion	nal buckling	L <sub>E_LT</sub> = <b>340</b>	<b>)0</b> mm					
Slenderness ratio		$\lambda = L_{E_{\perp}T} / r_y = 158$						
Buckling parameter		u = <b>0.866</b>						
Flange ratio	-							
Torsional index		x = <b>31.5</b>						
Slenderness factor		v = 1 / (1 +	$0.05 \times (\lambda / x)^2$	<sup>0.25</sup> = <b>0.82</b>				
Ratio - cl 4.3.6.9		$\beta_{w} = 1.0 =$	= 1.000					

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	Calcs for	Calcs for				Start page no./Revision 3		
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Equvalent slenderness – cl 4	1.3.6.7	$\lambda_{LT} = U \times V$	$\times \lambda \times \sqrt{(\beta w)} = 11$	11				
Limiting slendernes – Annex	B2.2	$\lambda$ LO = 0.4 $\times$	√(π²× Es₅950 / p	y) = <b>34</b>				
Euler stress	$p_{\rm E} = \pi^2 \times {\rm Ess}_{5950} / \lambda_{\rm L} \pi^2 = 163  {\rm N/mm}^2$							
Perry factor		η∟⊤ = max(7	7.0 × ( λιτ - λιο)	/ 1000, 0) = <b>0.5</b>	40			
		$\phi_{\text{LT}} = (p_y + p_y)$	( <sub>η</sub> <sub>LT</sub> + 1) <sub>×</sub> p <sub>E</sub> ) /	2 = <b>262880916</b> .	767			
Bending strength	$p_b = p_E \times p_E$	, / ( <sub>φ</sub> ∟τ + √( <sub>φ</sub> ∟τ <sup>2</sup>	- p <sub>E ×</sub> p <sub>y</sub> )) = <b>107</b>	N/mm²				
Buckling resistance moment			<sub>x</sub> = <b>32.7</b> kNm					
Max moment governing buck		M <sub>LT</sub> = <b>11.9</b>	kNm					
Equiv uniform moment factor	r for LTB	m∟⊤ = <b>1.00</b>						
		$M_b / m_{LT} = 3$	<b>32.7</b> kNm		_			
					Pass - lat.	tors. buck		
Buckling under combined	-							
For simplicity, a conservative		-			separate load	effects, ev		
though these do not necessa	arily all occur at the		-	ber.				
Span factor		L/a = <b>4.1</b> 4						
Angle of twist	$\phi = 0.030$ rads							
Second derivative of $\phi$	$\phi'' = 17.1 \times 10^{-3} \text{ rads/m}^2$							
Induced minor axis moment		$M_{yt} = M_x \times \phi / 1 \text{ rad} = 0.35 \text{ kNm}$						
Normal stress at flange tip de		0.1	<sub>y</sub> = <b>12</b> N/mm <sup>2</sup>					
Normal stress at flange tip de	ue to warping	$\sigma^{w} = E_{S5950}$	$_{O^{W}} = E_{S5950 \times} W_{n0 \times \phi}$ " / 1 rad = 22 N/mm <sup>2</sup> i <sub>b</sub> = M <sub>x ×</sub> m <sub>LT</sub> / M <sub>b</sub> + ( $_{O^{byt}} + _{O^{w}}$ ) / p <sub>y ×</sub> (1 + 0.5 × M <sub>x ×</sub> m <sub>LT</sub> / M <sub>b</sub> ) = 0.51					
Interaction index		$i_b = M_x \times m$						
			Pass - Con	nbined bending	and torsion c	heck satis		
Local capacity under comb	-							
For simplicity, a conservative	e check is applied	using the maxim			separate load	effects, ev		
For simplicity, a conservative though these do not necessa	e check is applied	using the maxim e same section a	long the meml		separate load	effects, ev		
For simplicity, a conservative though these do not necessa Max. direct stress due to M <sub>x</sub>	e check is applied	using the maxim e same section a <sub>O</sub> bx = M <sub>x</sub> / Z	long the memi $x = 45 \text{ N/mm}^2$	ber.	separate load	effects, ev		
For simplicity, a conservative though these do not necessa Max. direct stress due to M <sub>x</sub> Combined stress - eqn 2.22	e check is applied	using the maxim e same section a $\sigma^{\rm bx} = M_{\rm x} / Z$ $\sigma^{\rm bx} + \sigma^{\rm byt} +$	long the meml <sub>x</sub> = <b>45</b> N/mm <sup>2</sup> <sub>ow</sub> = <b>79</b> N/mm <sup>2</sup>	ber.	separate load	effects, ev		
For simplicity, a conservative though these do not necessa Max. direct stress due to M <sub>x</sub>	e check is applied	using the maxim e same section a <sub>O</sub> bx = M <sub>x</sub> / Z	long the meml <sub>x</sub> = <b>45</b> N/mm <sup>2</sup> <sub>ow</sub> = <b>79</b> N/mm <sup>2</sup>	ber.				
For simplicity, a conservative though these do not necessa Max. direct stress due to M <sub>x</sub> Combined stress - eqn 2.22 Design strength	e check is applied arily all occur at th	using the maxim e same section a $\sigma^{bx} = M_x / Z$ $\sigma^{bx} + \sigma^{byt} +$ $p_y = 275 N_z$	long the meml <sub>x</sub> = <b>45</b> N/mm <sup>2</sup> <sub>ow</sub> = <b>79</b> N/mm <sup>2</sup>	ber.		effects, ev Local capa		
For simplicity, a conservative though these do not necessa Max. direct stress due to M <sub>x</sub> Combined stress - eqn 2.22 Design strength Combined shear stresses	e check is applied arily all occur at th • <b>SCI-P-057 sectio</b>	using the maxim e same section a $\sigma^{bx} = M_x / Z$ $\sigma^{bx} + \sigma^{byt} +$ $p_y = 275 N_z$ con 2.3	long the meml <sub>x</sub> = <b>45</b> N/mm <sup>2</sup> <sub>ow</sub> = <b>79</b> N/mm <sup>2</sup> /mm <sup>2</sup>	ber.	Pass - L	Local capa		
For simplicity, a conservative though these do not necessa Max. direct stress due to M <sub>x</sub> Combined stress - eqn 2.22 Design strength Combined shear stresses For simplicity, a conservative	e check is applied arily all occur at the <b>SCI-P-057 section</b> e check is applied	using the maxim e same section a $\sigma^{bx} = M_x / Z$ $\sigma^{bx} + \sigma^{byt} +$ $p_y = 275 N_z$ on 2.3 using the maxim	long the meml x = <b>45</b> N/mm <sup>2</sup> o <sup>w</sup> = <b>79</b> N/mm <sup>2</sup> /mm <sup>2</sup> um shear stres	ber. 2 sses due to each	Pass - L	Local capa		
For simplicity, a conservative though these do not necessa Max. direct stress due to M <sub>x</sub> Combined stress - eqn 2.22 Design strength <b>Combined shear stresses</b> For simplicity, a conservative even though these do not ne	e check is applied arily all occur at the <b>SCI-P-057 section</b> e check is applied ocessarily all occur	using the maxim e same section a $d^{bx} = M_x / Z$ $d^{bx} + d^{byt} + p_y = 275 N_z$ on 2.3 using the maxim r at the same sector	long the meml $x = 45 \text{ N/mm}^2$ $\sigma w = 79 \text{ N/mm}^2$ $\sigma w = 79 \text{ N/mm}^2$ $\sigma w = 79 \text{ N/mm}^2$	ber. 2 sses due to each member.	Pass - L	Local capa		
For simplicity, a conservative though these do not necessa Max. direct stress due to Mx Combined stress - eqn 2.22 Design strength Combined shear stresses For simplicity, a conservative even though these do not ne Max shear stresses due to b	e check is applied arily all occur at the SCI-P-057 section e check is applied accessarily all occur ending in web	using the maxim e same section a $\sigma^{bx} = M_x / Z$ $\sigma^{bx} + \sigma^{byt} +$ $p_y = 275 N_z$ on 2.3 using the maxim r at the same sec $\tau^{bw} = F_{vy} \times$	long the meml $f_x = 45 \text{ N/mm}^2$ $f_{OW} = 79 \text{ N/mm}^2$ $f_{OW}^2$ um shear stress tion along the $Q_W / (I_x \times t) = 0$	ber. 2 sses due to each member. <b>4</b> N/mm <sup>2</sup>	Pass - L	Local capa		
For simplicity, a conservative though these do not necessa Max. direct stress due to M <sub>x</sub> Combined stress - eqn 2.22 Design strength <b>Combined shear stresses</b> For simplicity, a conservative even though these do not ne Max shear stresses due to b Max shear stresses due to b	e check is applied arily all occur at the SCI-P-057 section cessarily all occur ending in web ending in flange	using the maxim e same section a $\sigma^{bx} = M_x / Z$ $\sigma^{bx} + \sigma^{byt} +$ $p_y = 275 N_z$ on 2.3 using the maxim $\tau$ at the same sect $\tau^{bw} = F_{vy} \times C$ $\sigma^{by} = F_{vy} \times C$	long the meml $f_x = 45 \text{ N/mm}^2$ $f_{ow} = 79 \text{ N/mm}^2$ $f_{mm}^2$ um shear stress tion along the $Q_w / (I_x \times t) = 1$	ber. 2 sses due to each member. <b>4</b> N/mm <sup>2</sup> N/mm <sup>2</sup>	Pass - L	Local capa		
For simplicity, a conservative though these do not necessa Max. direct stress due to Mx Combined stress - eqn 2.22 Design strength Combined shear stresses For simplicity, a conservative even though these do not ne Max shear stresses due to b Max shear stresses due to b	e check is applied arily all occur at the e check is applied cessarily all occur ending in web ending in flange orsion in web	using the maxim e same section a $d^{bx} = M_x / Z$ $d^{bx} + d^{byt} +$ $p_y = 275 N_z$ on 2.3 using the maxim r at the same sect $\tau^{bw} = F_{vy} \times C$ $\tau^{bf} = F_{vy} \times C$ $\tau^{tw} = abs(G$	long the meml $f_x = 45 \text{ N/mm}^2$ $f_{ow} = 79 \text{ N/mm}^2$ $f_{om}^2$ um shear strest tion along the $Q_w / (I_x \times t) = 1$ $f_x t \times \phi' / 1rad)$	ber. sses due to each member. 4 N/mm² N/mm² = <b>11</b> N/mm²	Pass - L	Local capa		
For simplicity, a conservative though these do not necessa Max. direct stress due to Mx Combined stress - eqn 2.22 Design strength Combined shear stresses For simplicity, a conservative even though these do not ne Max shear stresses due to b Max shear stresses due to b Max shear stresses due to to Max shear stresses due to to	e check is applied arily all occur at the e check is applied cessarily all occur ending in web ending in flange orsion in web	using the maxim e same section a $d^{bx} = M_x / Z$ $d^{bx} + d^{byt} + p_y = 275 N_z$ on 2.3 using the maxim r at the same sect $\tau^{bw} = F_{vy} \times C$ $\tau^{bf} = F_{vy} \times C$ $\tau^{tw} = abs(G)$	long the meml $f_x = 45 \text{ N/mm}^2$ $f_{orw} = 79 \text{ N/mm}^2$ um shear stress tion along the $Q_w / (I_x \times t) = 1$ $f_x + x \phi' / 1 \text{ rad})$ $\chi + T \times \phi' / 1 \text{ rad}$	ber. sees due to each member. 4 N/mm <sup>2</sup> N/mm <sup>2</sup> = 11 N/mm <sup>2</sup> = 16 N/mm <sup>2</sup>	Pass - L of the separat	Local capa		
For simplicity, a conservative though these do not necessa Max. direct stress due to M <sub>x</sub> Combined stress - eqn 2.22 Design strength <b>Combined shear stresses</b> For simplicity, a conservative even though these do not ne Max shear stresses due to b Max shear stresses due to b Max shear stresses due to to Max shear stresses due to to	e check is applied arily all occur at the e check is applied e check is applied cessarily all occur ending in web ending in flange orsion in web orsion in flange rarping in flange	using the maxim e same section a $d^{bx} = M_x / Z$ $d^{bx} + d^{byt} +$ $p_y = 275 N_z$ on 2.3 using the maxim the same sect $\tau^{bw} = F_{vy} \times C$ $\tau^{bf} = F_{vy} \times C$ $\tau^{tf} = abs(G)$ $\tau^{wf} = abs(-1)$	long the meml $x = 45 \text{ N/mm}^2$ $g_w = 79 \text{ N/mm}^2$ um shear strest tion along the $Q_w / (I_x \times t) = 4$ $Q_t / (I_x \times T) = 1$ $i_x \times x_{\phi'} / 1 \text{ rad}$ $X = T_{X = \phi'} / 1 \text{ rad}$ $E_{S5950} \times S_{w1} \times C_{\phi}$	ber. sees due to each member. 4 N/mm <sup>2</sup> = 11 N/mm <sup>2</sup> ) = 16 N/mm <sup>2</sup> j''' / 1 rad / T) = 1	Pass - L of the separat N/mm <sup>2</sup>	Local capa		
For simplicity, a conservative though these do not necessa Max. direct stress due to M <sub>x</sub> Combined stress - eqn 2.22 Design strength <b>Combined shear stresses</b> For simplicity, a conservative even though these do not ne Max shear stresses due to b Max shear stresses due to b Max shear stresses due to b Max shear stresses due to to	• SCI-P-057 section • SCI-P-057 section • check is applied • ch	using the maxim e same section a $d^{bx} = M_x / Z$ $d^{bx} + d^{byt} + p_y = 275 N_z$ on 2.3 using the maxim the same sector $\tau^{bw} = F_{vy} \times C$ $\tau^{bf} = F_{vy} \times C$ $\tau^{tf} = abs(G)$ $\tau^{wf} = abs(-\tau)$ $\tau^{vtw} = \tau^{tw} \times C$	long the meml $x = 45 \text{ N/mm}^2$ $\sigma^w = 79 \text{ N/mm}^2$ um shear stress tion along the $Q_w / (I_x \times t) = -2$ $Q_t / (I_x \times T) = 1$ $i \times t \times \phi' / 1 \text{ rad}$ $X T \times \phi' / 1 \text{ rad}$ $E_{S5950} \times S_{w1} \times C$ $(1 + 0.5 \times M_x \times 2)$	ber. sees due to each member. 4 N/mm <sup>2</sup> N/mm <sup>2</sup> = 11 N/mm <sup>2</sup> = 16 N/mm <sup>2</sup>	<i>Pass - L</i> of the separat N/mm <sup>2</sup>	Local capa		

Combined shear stresses in web	$\tau w = \tau b w + \tau v t w = 18 \text{ N/mm}^2$
Combined shear stresses in flange	$\tau_{\rm f} = \tau_{\rm bf} + \tau_{\rm vtf} = 21 \text{ N/mm}^2$
Shear strength	$p_v = 0.6 \times p_y = 165 \text{ N/mm}^2$

Pass - Combined shear stresses

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## Twist check

Total applied torque (unfactored) Maximum twist under sls loading Twist limit 
$$\begin{split} T_{qu} &= \textbf{0.46 kNm} \\ _{\varphi sls} &= _{\varphi} \times T_{qu} \ / \ T_{q} = \textbf{1.69 deg} \\ _{\varphi lim} &= \textbf{2.00 deg} \end{split}$$

Pass - Twist