Reference	**Clause**		**Calculation**							**id**	**Results**	**Units**
Trimmer 1 (A)	***STOP***								**Checked**			
		220x45 mm C24 joists and 10x200 mm plate										
Dimensions			Span	**s1**	3000	mm						
			Left bearing	**b1**	0	mm						
			Right bearing	**b2**	0	mm						
			Length	**L**	3000	mm						
									Total mass timber: $V_t.\rho_t$	$\mathbf{m_t}$	25	kg
Self-weight									Total mass steel: $V_s.\rho_s$	$\mathbf{m_s}$	48.300	kg
BSEN338 Table 1									Self Weight: $(m_t + m_s).g / L$	$\mathbf{g_{sw}}$	0.240	kN/m
Actions (*See Top Sheet*)						**UDL**	**g.udl**	1.000	kN/m	**q.udl**	2.000	kN/m
Number of additional actions		**0**										
Action Type	**Position of action from A**			**Span of action**			**Unfactored Actions**					
				Point Load N/A = 0			**Permanent Action**			**Variable Action**		
No Load	**a1**	0	mm	**s1**	0	mm	**g.P1**	0.000		**q.P1**	0.000	
No Load	**a2**	0	mm	**s2**	0	mm	**g.P2**	0.000		**q.P2**	0.000	
No Load	**a3**	0	mm	**s3**	0	mm	**g.P3**	0.000		**q.P3**	0.000	
No Load	**a4**	0	mm	**s4**	0	mm	**g.P4**	0.000		**q.P4**	0.000	
No Load	**a5**	0	mm	**s5**	0	mm	**g.P5**	0.000		**q.P5**	0.000	
No Load	**a6**	0	mm	**s6**	0	mm	**g.P6**	0.000		**q.P6**	0.000	
Unfactored Reactions						**Permanent**	**RA.g**	1.860	kN	**RB.g**	1.860	kN
						Variable	**RA.q**	3.000	kN	**RB.q**	3.000	kN
Safety Factors	*NA.A1.2 (A) (B)*				Permanent action	γ_G	1.35		Variable action	γ_Q	1.50	
Factored Actions	**UDL**	**Fd**	4.674	kN/m		**Reactions**	**RA**	7.010	kN	**RB**	7.010	kN
								7.010			*7.010*	
									Position of zero shear-stress	**x**	1.501	m
					5.258				Factored bending moment	**M**	5.258	kNm
									Factored Shear Force: V = MAX(RA:RB)	**V**	7.010	kN
Design procedure as described in TRADA Document: GD9 'How to design a bolted steel flitch beam' - ISBN 978-1-900510-54-7												
Beam Properties					**Timber**						**Steel**	
			Type		Sawn				Type		Mild Steel	
			Grade		C24				Grade		S272	
			Number pieces	**n**	2	no.			Yield stength	f_y	272	N/mm^2
			Width	**b**	45	mm			Thickness	**t**	10	mm
			Depth	**h**	220	mm			Depth	**d**	200	mm
			Volume: n.b.h	$\mathbf{V_t}$	0.0198	m^3/m			Volume: t.d	$\mathbf{V_s}$	0.0020	m^3/m
			Density	$\boldsymbol{\rho_t}$	420.000	kg/m^3			Density	$\boldsymbol{\rho_s}$	8050.000	kg/m^3
	Section modulus		$n.b.h^2/6$	$\mathbf{W_t}$	7.26E+05	mm^3			$t.d^2/6$	$\mathbf{W_s}$	6.67E+04	mm^3
	Moment of mass		$n.b.h^3/12$	$\mathbf{I_t}$	7.99E+07	mm^4			$t.d^3/12$	$\mathbf{I_s}$	6.67E+06	mm^4
Material properties												
	BS338		Bending strength	$\mathbf{f_{m.k}}$	24.000	N/mm^2						
	BS338		Shear	$\mathbf{f_{v.k}}$	2.500	N/mm^2						
	BS338		0.05 Modulus	$\mathbf{E_{0.05}}$	7400	N/mm^2				$\mathbf{E_s}$	210000	N/mm^2
	BS338		Mean Modulus	$\mathbf{E_m}$	11000	N/mm^2						
	BS338		Shear Modulus	$\mathbf{G_t}$	462.500	N/mm^2						

Reference	Clause	Calculation					id	Results	Units
Material properties cont/.									
			Timber				**Steel**		
Stiffness		0.05 Stiffness	$E_{0.05}I_t$	5.91E+11	Nmm^2	Stiffness	E_sI_s	1.40E+12	Nmm^2
		Mean Stiffness	E_mI_t	8.78E+11	Nmm^2				
Modification factors	*Table NA.3*	Material	γ_M	1.20		Bending	γ_{M0}	1.00	
		Service class		2		Web	γ_{M1}	1.10	
						Bolt	γ_{M2}	1.25	
	Table 3.1	Permanent	$k_{mod.p}$	0.60					
		Medium	$k_{mod.m}$	0.70					
		Load sharing	k_{sys}	1.00					
	3.2 (3)	Depth of form	k_h	1.300					
	Table 3.2	Deformation	k_{def}	0.80					
	Table.NA.A1.1	Variable	ψ_2	0.30					
	6.3.3 (5)	Lateral stability	k_{crit}	1.000					
Bolts									
		Type		M12		Total factored action	$F_{d.Ed}$	14.021	kN
		Class		8.8		Unthreaded area of bolt	A	84.300	mm^2
.		No. bolts at bearing	n_v	3	no.	Bolt strength	f_{ub}	800.000	N/mm^2
		Bolt centres	c_{bolt}	600.000	mm	Action per bolt: $F_{d.Ed}/n_{bolts}$	$F_{v.Ed}$	2.337	kN
		No. bolts in bending	n_{bolts}	6	no.	Shear: $0.6.f_{ub}.A/\gamma_{M2}$	$F_{v.Rd}$	32.371	kN
		Diameter of holes	d_{holes}	13	mm		$F_{v.Ed} <= F_{v.Rd}$	OK	
Modified values of E									
		$E_{fin} = E_{0.05}((u_{inst.g}+u_{inst.q})/(u_{instg}+u_{inst.q}+k_{def}(u_{instg}+\psi_2 u_{instq})$				0.05 E_{fin}	$E_{0.05.fin}$	5081.620	N/mm^2
		See Deflection below for values of u				Mean E_{fin}	$E_{m.fin}$	7553.759	N/mm^2
Load distribution									
		Timber				E_mI_t / (E_mI_t + E_sI_s)	k_t	0.297	*29.7%*
		Steel				$1.1E_sI_s$ / ($E_{0.05.fin}I_t$ + E_sI_s)	k_s	0.853	*85.3%*
		Deflection applied to timber				$E_{m.fin}I_t$ / ($E_{m.fin}I_t$ + E_sI_s)	$k_{t.def}$	0.301	*30.1%*
Effects of holes on Bending and Shear Strength									
						Distance hole from N.A.	y	55.0	mm
		Factor				$h^2(h^2-hd_{holes}+2d_{holes}y)/(h^4-h^3d_{holes}-hd_{holes}^3+d_{holes}^4-12hd_{holes}y^2)$	k_{holes}	1.083	
Bending Strength									
			Timber				**Steel**		
Applied moment:		$k_t.M$	M_t	1.561	kNm	$k_s.M$	M_s	4.484	kNm
Bending stress:		$k_{holes}.M_t/W_t$	σ_t	2.327	N/mm^2	$k_{holes}.M_s/W_s$	σ_s	72.814	N/mm^2
Bending strength:		$k_{mod.per}.k_{sys}.k_h.k_{crit}.f_{m.k}/\gamma_M$	f_t	15.600	N/mm^2	f_y/γ_{M1}	f_s	247.273	N/mm^2
			$\sigma_t<=f_t$	OK			$\sigma_s<=f_s$	OK	*55.457*
Shear strength									
	Area:	$n.b.(h-n_v.d_{holes})$	A_t	16290	mm^2	$t.(d-n_v.d_{holes})$	A_v	1610	mm^2
	Shear Force:	$k_{hol}.k_t.V$	V_t	2.253	kN	$k_{hol}.k_s.V$	V_s	6.472	kN
	Shear stress:	$\tau = 3/2.V/A_t$	τ_t	0.171	N/mm^2	$3/2.V_s/A_v$	τ_t	6.030	N/mm^2
	Shear strength:	$k_{mod.med}.k_{sys}.f_{v.k}/\gamma_M$	f_t	1.458	N/mm^2	Shear strength: f_y/γ_{M1}	f_v	247.273	N/mm^2
			$\tau_t <= f_t$	OK			$\tau_s <= f_s$	OK	

Reference	Clause	Calculation	id	Results	Units
Mid-Span Deflection in timber to calculate the values of $K_{t,def}$ and k_s					
		Stiffness	$E_{0.05}I_t$	5.91E+11	Nmm^2
		Cross-sectional area (n.b.h)	**A**	19800	mm^2
		Form Factor for rectangular section	**K**	1.2	

		Permanent Actions		
Unfactored BM:	k_t applied	$M_{t.g}$	0.494	kNm
Bending deflection:	k_t applied	$u_{m.g}$	0.657	mm
Shear deflection:	$M_{t.g}.K/G_{0.05}.b.h$	$u_{v.g}$	0.065	mm
Instantaneous deflection:	$u_{m.g} + u_{v.g}$	$u_{inst.g}$	0.721	mm

	Variable Actions		
k_t applied	$M_{t.q}$	0.668	kNm
k_t applied	$u_{m.q}$	1.059	mm
$M_{t.q}.K/G_{0.05}.b.h$	$u_{v.q}$	0.088	mm
$u_{m.q} + u_{v.q}$	$u_{inst.q}$	1.147	mm

Final deflection of the Flitch-beam

Permanent	$k_s.5/384(g_{sw} + g_{udl}).L^4 / E_sI_s$	**δ'**	0.796	mm
Variable	$k_s.5/384.q_{udl}.L^4 / E_sI_s$	**δ"**	1.285	mm
		δ	2.081	mm

		Permitted		
Table 7.2	L/300	δ_p	10.000	mm
		$\delta_a < \delta$	**OK**	

Alternative method to checking the size of a Flitch Beam

	Steel Plate Only		
f_y/γ_{M1}	f_s	247.273	N/mm^2
M/W_s	**f'**	78.866	N/mm^2
	$f' <= f_s$	**OK**	
$3/2.V_s/A_v$	**V'**	6.030	N/mm^2
	$V' <= f_s$	**OK**	
$5/384 * (g_{sw} + g_{udl})*L^4 / E_sI_s$	**d'**	0.934	mm
$5/384 * q_{udl}*L^4 / E_sI_s$	**d"**	1.507	mm
		2.441	mm

	Tranformed Section		
Modular ratio	**m**	28.378	
Steel 't' transformed	t_{tr}	283.784	mm
Steel depth to N.A.: d/2	y_s	100.000	mm
Timber depth to N.A.: h/2	y_t	110.000	mm
Transformed I to timber	I_{tr}	2.69E+08	mm^4
Transformed stiffness	E_tI_{tr}	1.99E+12	Nmm^2
	Bending Stress		
Steel: $M.m.y_s/I_{tr}$	$f_{s,tr}$	55.457	N/mm^2
Timber: $M.y_t/I_{tr}$	$f_{t,tr}$	2.150	N/mm^2
	Deflection		
Permanent	**δ'**	0.657	mm
Variable	**δ"**	1.059	mm
		1.716	mm

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