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		Member/Location		
Job Title	Structure, Member Design - Precast Concrete Frame, Be	Drg. Ref.		
Structure, Member Design - PC Frame, Beam and Slab		Made by **XX**	Date **9/11/2023**	Chd.

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Material Properties

Characteristic strength of concrete, f_{cu} / f_c' (f_{cu} ≤ 75 or 105N/mm^2;	55	45	N/mm^2	**OK**
Yield strength of longitudinal steel, f_y		460	N/mm^2	
Yield strength of shear link steel, f_{yv}		460	N/mm^2	
Type of concrete and density, ρ_c	Normal Weight 25kN/m3	25	kN/m^3	

Section Dimensions and Reinforcement [Stage 1: Precast Simply-Supported]

Slab insitu depth, $insitu_{slab}$	100	mm	
Beam (precast) width, $b_{w1} = b_w$	950	mm	
Beam (precast) depth, h_1	700	mm	
Cover, $cover_{bot1}$ (usually 35 (C35) or 30 (C40) internal; 40 external)	25	mm	
Sag steel reinforcement diameter, ϕ_{t1}	32	mm	
Sag steel reinforcement number, n_{t1}	18		
Sag steel area provided, $A_{s,sag,prov} = n_{t1}.\pi.\phi_{t1}^2/4$	**14476**	mm^2	
Number of layers of sag steel, $n_{layers,sag1}$	2	layer(s)	
Spacer for sag steel, $s_{r,sag1}$ (≥ MAX (ϕ_{t1}, 25mm))	50	mm	**OK**
Shear link diameter, ϕ_{link}	12	mm	
Number of shear links in a cross section, i.e. number of legs, n_{leg}	6		
Area provided by all shear links in a cross-section, $A_{sv,prov} = \pi.\phi_{link}^2/4.n_{leg}$	**679**	mm^2	
Pitch of shear links, S	200	mm	
Eff. depth to sag steel, $d_{sag1} = h_1 - cover_{bot1} - \phi_{link} - [\phi_{t1}+(n_{layers,sag1}-1)(\phi_{t1}+s_{r,sag}$	606	mm	

Section Dimensions [Stage 2: Insitu]

Beam (composite) width, $b_{w2} = b_w$	950	mm	
Beam insitu depth, $insitu_{beam}$	200	mm	
Beam (composite) depth, $h_2 = h_1 + insitu_{beam}$	900	mm	
Cover, $cover_{top2}$ (usually 35 (C35) or 30 (C40) internal; 40 external)	25	mm	
Add cover to hog steel (due to transverse steel layer(s)), $cover_{add,t}$	12	mm	
Hog steel reinforcement diameter, ϕ_{t2}	32	mm	
Hog steel reinforcement number, n_{t2}	12		
Hog steel area provided, $A_{s,hog,prov} = n_{t2}.\pi.\phi_{t2}^2/4$	**9651**	mm^2	
Number of layers of hog steel, $n_{layers,hog2}$	2	layer(s)	
Spacer for hog steel, $s_{r,hog2}$ (≥ MAX (ϕ_{t2}, 25mm))	50	mm	**OK**
Eff. depth to sag steel, $d_{sag2} = h_2 - cover_{bot1} - \phi_{link} - [\phi_{t1}+(n_{layers,sag1}-1)(\phi_{t1}+s_{r,sag}$	806	mm	
Eff. depth to hog steel, $d_{hog2} = h_2 - cover_{top2}$ - MAX(ϕ_{link}, $cover_{add,t}$) - [$\phi_{t2}+(n_{laye}$	806	mm	

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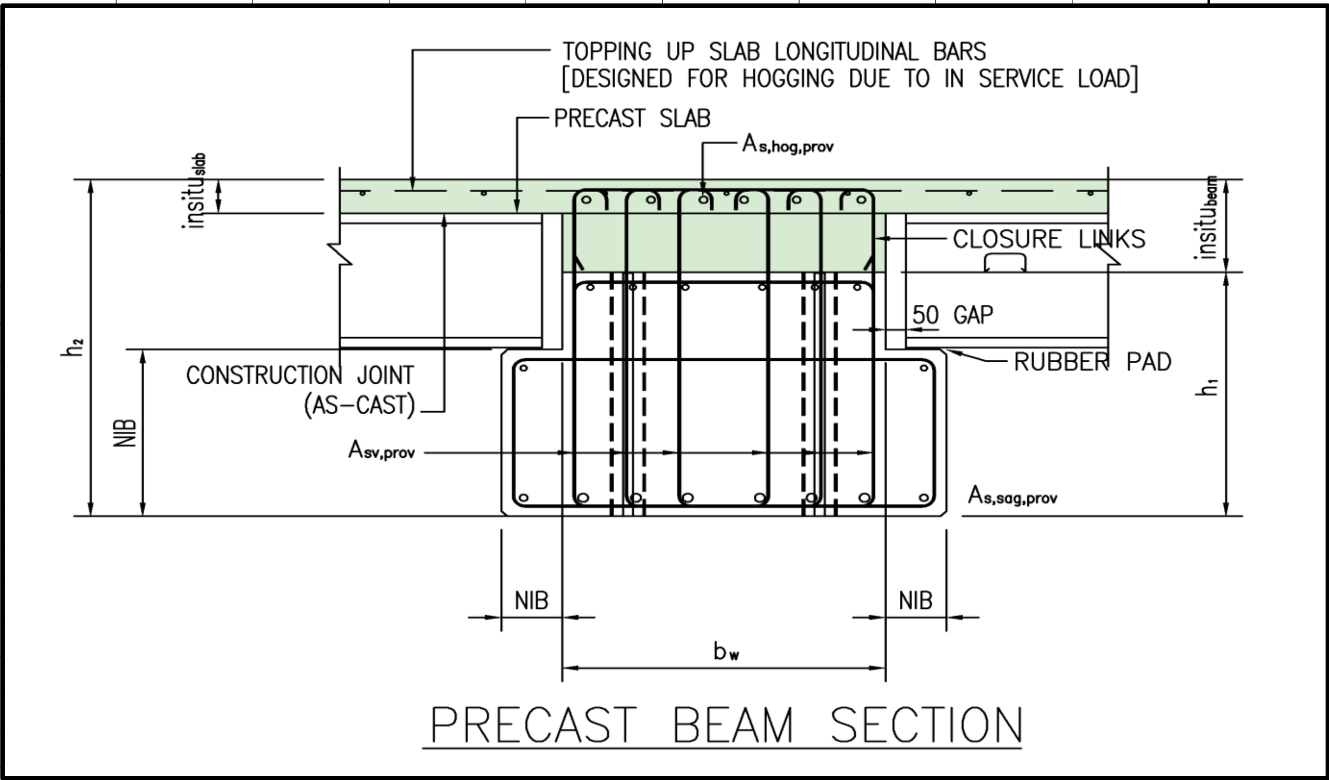
Detailing Instructions



cover =	25 mm		b_w =	950 mm		$insitu_{slab}$ =	100 mm	
f_{cu} =	55		h_1 =	700 mm		$insitu_{beam}$ =	200 mm	
f_y =	460		h_2 =	900 mm		nib_b =	125 mm	
f_{yv} =	460					nib_h =	440 mm	
$A_{s,sag,prov}$ =	18 no.	32	rebar in	2	layers @	50 mm	spacer	1.7%
$A_{s,hog,prov}$ =	12 no.	32	rebar in	2	layers @	50 mm	spacer	1.1%
$A_{sv,prov}$ =	6 no.	12	shear link	legs	@	200 mm	pitch	

stage 2 support conditions = **Continuous Internal Span**

precast concrete beam total weight for erection = **21.022** tonnes

stage 2 beam bottom section modulus, Z_{b2} 1.8E+08 mm^3

Utilisation Summary

Item	UT	Remark
Precast beam sag section ductility	N/A	OK
Precast beam sag steel area provided	41%	OK
Precast beam ultimate shear stress	18%	OK
Precast beam design shear links area	26%	OK
Precast beam design shear resistance	34%	OK
Precast beam deflection	86%	OK
Composite beam sag section ductility	N/A	OK
Composite beam sag steel area provided	89%	OK
Composite beam hog section ductility	N/A	OK
Composite beam hog steel area provided	97%	OK
Composite beam ultimate shear stress	31%	OK
Composite beam design shear links area	42%	OK
Composite beam design shear resistance	91%	OK
Composite beam deflection	83%	OK
Precast and composite beam miscellaneous checks	N/A	OK

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Loading and Structural Analysis [Stage 1: Precast Simply-Supported]

British or Eurocode loading combination factors	Eurocode		
Beam span, L_1		10.850	m
Tributary width (slab clear span), t_{w1}		7.150	m
Dead load of incoming precast slab (pressure load), DL_{slab}		4.25	kPa
Dead load of incoming precast slab insitu topping (pressure load), DL_{top}		2.50	kPa
Note dead load of incoming precast slab insitu topping (pressure load), $DL_{top} = insitu_{slab} \cdot \rho_c$			
SLS slab loading (pressure load), $SLS_{slab1} = DL_{slab} + DL_{top}$		6.75	kPa
Dead load of precast and wet beam (line load), $DL_{beam} = b_{w1}.(\%h_1+insitu_{beam})$		21.4	kN/m
Dead load of precast beam nibs (line load), $DL_{nib} = 2.nib_w.nib_h.\rho_c$		2.8	kN/m
Dead load of precast beam incl. nibs (line load)	100%	19.4	kN/m
Note dead load of precast beam incl. nibs (line load), $b_{w1}.h_1.\rho_c+DL_{nib}$			
Dead load of incoming precast slab and topping concrete (line load)		53.0	kN/m
Note dead load of incoming precast slab and topping concrete (line load), $b_{w1}.insitu_{beam}.\rho_c + SLS_{slab1}.t_{w1}$			
ULS beam loading (line load), ω_{ULS1}		97.7	kN/m
Note $\omega_{ULS1} = (1.35\text{-}1.4)SLS_{slab1}.t_{w1}+(1.35\text{-}1.4)DL_{beam}+(1.35\text{-}1.4)DL_{nib}$			
Beam unpropped or propped ?	Unpropped		
Beam ULS sag bending moment, $M_{1,sag} = 0.125.\omega_{ULS1}.L_1^2$ (if unpropped only)		1438	kNm
Beam ULS shear force, $V_1 = 0.5.\omega_{ULS1}.L_1$ (if unpropped only)		530	kN

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		jXXX	4	
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Loading and Structural Analysis [Stage 2: Insitu]

British or Eurocode loading combination factors — Eurocode

Beam span, L_2	11.400	m
Tributary width (grid to grid), t_{w2}	8.100	m
Superimposed dead load on slab (pressure load), SDL_{slab}	1.20	kPa
Superimposed dead load on beam (line load), SDL_{beam}	0.0	kN/m
Superimposed dead load on beam (midspan point load), SDL_{point}	0	kN
Live load on slab (pressure load), LL_{slab} [with pattern loading]	16.00	kPa
Superimposed dead and live load on beam (line load), $[SDL_{slab} + LL_{slab}].t_{w2}$ + S	139.3	kN/m
ULS beam loading (line load), ω_{ULS2}	207.5	kN/m

Note $\omega_{ULS2} = ((1.35\text{-}1.4)SDL_{slab} + (1.5\text{-}1.6)LL_{slab}).t_{w2} + (1.35\text{-}1.4)SDL_{beam}$

Beam ULS sag bending moment, $M_{2,sag}$ — Continuous Internal Span — **2251** kNm

Note $M_{2,sag} = k_{DL|SDL,sag}.\omega_{ULS1}.L_2^2$ *(if propped only)* $+ k_{DL|SDL,sag}.(1.35\text{-}1.4).[SDL_{slab}.t_{w2} + SDL_{beam}].L_2^2$
$+ k_{SDL,p,sag}.(1.35\text{-}1.4).[SDL_{point}].L_2 + k_{LL,sag}.(1.5\text{-}1.6).[LL_{slab}.t_{w2}].L_2^2$

	$k_{DL\|SDL,sag}$	$k_{SDL,p,sag}$	$k_{LL,sag}$
Continuous Internal Span	0.046	0.125	0.086
Continuous End Span	0.078	0.170	0.100
Simply-Supported	0.125	0.250	0.125

Beam SLS sag bending moment, $M_{2,sag,SLS}$ — **1507** kNm

Note $M_{2,sag,SLS}$ *calculated as per* $M_{2,sag}$ *but without load combination factors.*

Beam bottom SLS stress at end of stage 1 (comp. -ve), $\sigma_{b1,SLS}$ — -4.80 N/mm^2

Note beam bottom stress at end of stage 1 results from prestressing, dead load of precast beam including nibs and dead load of precast slab and topping concrete.

Beam bottom SLS stress stage 2 loading (comp. -ve), $\sigma_{b2,SLS} = M_{2,sag,SLS}/Z_{b2}$ — **8.24** N/mm^2

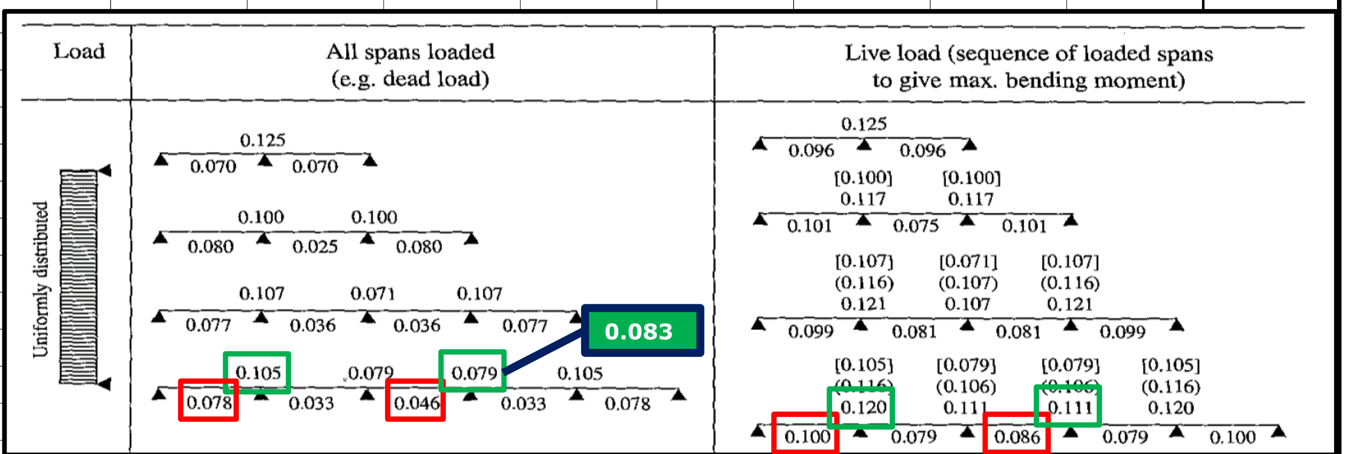
Beam bottom SLS stress at end of stage 2 (comp. -ve), $\sigma_{b1,SLS} + \sigma_{b2,SLS}$ — **3.44** N/mm^2

Beam total ULS sag bending moment, $M_{1,sag} + M_{2,sag}$ — **3689** kNm

Beam ULS hog bending moment, $M_{2,hog}$ — Continuous Internal Span — **2946** kNm

Note $M_{2,hog} = k_{DL|SDL,hog}.\omega_{ULS1}.L_2^2$ *(if propped only)* $+ k_{DL|SDL,hog}.(1.35\text{-}1.4).[SDL_{slab}.t_{w2} + SDL_{beam}].L_2^2$
$+ k_{SDL,p,hog}.(1.35\text{-}1.4).[SDL_{point}].L_2 + k_{LL,hog}.(1.5\text{-}1.6).[LL_{slab}.t_{w2}].L_2^2$

	$k_{DL\|SDL,hog}$	$k_{SDL,p,hog}$	$k_{LL,hog}$
Continuous Internal Span	0.083	0.125	0.111
Continuous End Span	0.105	0.161	0.120
Simply-Supported	0.040	0.040	0.040



Beam ULS shear force, V_2 — **1183** kN

Note $V_2 = 0.5.\omega_{ULS1}.L_2$ *(if propped only)* $+ 0.5.\omega_{ULS2}.L_2 + 0.5.((1.35\text{-}1.4)SDL_{point})$

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				BS8110
Structural Design [Stage 1: Precast Simply-Supported]				
Bending Design				
Stress coefficient, $M_{1,sag}/b_{w1}d_{sag1}^{2}$		**4.1**	N/mm^2	
Stress coefficient, $K_{sag1} = M_{1,sag}/b_{w1}d_{sag1}^{2}f_{cu}$		**0.075**		**OK**
Lever arm, $z_{sag1} = d_{sag1}.[0.5(0.25-K_{sag1}/0.9)^{0.5}] \leq 0.95d_{sag1}$		**550**	mm	
Area of req. sag steel, $A_{s,sag1} = M_{1,sag} / (0.95f_y.z_{sag1})$		**5978**	mm^2	
Sag steel area provided, $A_{s,sag,prov}$		14476	mm^2	
Sag steel area provided utilisation, $A_{s,sag1} / A_{s,sag,prov}$		**41%**		**OK**
Shear Design				
Ultimate shear stress, $v_{ult1} = V_1/b_{w1}d_{sag1}$ ($< 0.8f_{cu}^{0.5}$ & $5.0N/mm^2$)		**0.92**	N/mm^2	
Ultimate shear stress utilisation, v_{ult1} / ($0.8f_{cu}^{0.5}$ & $5.0N/mm^2$)		**18%**		**OK**
Design shear stress, $v_{d1} = V_1/b_{w1}d_{sag1}$		**0.92**	N/mm^2	
Enhanced shear strength, $2d_{sag1}/a_v.v_c$ ($< 0.8f_{cu}^{0.5}$ & $5.0N/mm^2$)	*x 1.00*	**1.12**	N/mm^2	
Distance, a_v	2.00d	1212	mm	
(Shear capacity enhancement by calculating v_d within 2d of support and comparing against enhanced v_c within 2d of the support as clause 3.4.5.8 BS8110 employed instead of calculating v_d at d from support and comparing against unenhanced v_c as clause 3.4.5.10 BS8110;)				
Sag steel area provided, $A_{s,sag,prov}$		14476	mm^2	
$\rho_w = 100A_{s,sag,prov}/b_{w1}d_{sag1}$		2.51	%	
$v_c = (0.79/1.25)(\rho_w f_{cu}/25)^{1/3}(400/d_{sag1})^{1/4}$; $\rho_w<3$; $f_{cu}<80$; $(400/d_{sag}$		**1.12**	N/mm^2	
Provide shear links $(A_{sv}/S)_1 > b_{w1}MAX[0.4,(v_{d1}-2d_{sag1}/a_v.v_c)]/(0.95f_{yv})$ i.e. $(A_{sv}$		**0.87**	mm^2/mm	
Area provided by all shear links in a cross-section, $A_{sv,prov}/S$		**3.39**	mm^2/mm	
Concrete and design links shear capacity, $V_{cap1} = (A_{sv,prov}/S).(0.95f_{yv}).d_{sag1}$ + 2		**1542**	kN	
Design shear links area utilisation, $(A_{sv}/S)_1 / (A_{sv,prov}/S)$		**26%**		**OK**
Design shear resistance utilisation, V_1 / V_{cap1}		**34%**		**OK**
Deflection Design				
Span		10.850	m	
Span / effective depth ratio		**17.9**		
Basic span / effective depth ratio criteria		**20.0**		
Multiplier $C_{1,rect\ or\ flanged}$		1.00		*cl.3.4.6.3*
Multiplier $C_{1,span\ more\ or\ less\ than\ 10m}$	Include	0.92		*cl.3.4.6.4*
Modification factor for tension C_2 $\quad 0.55 + \frac{(477 - f_s)}{120\left(0.9 + \frac{M}{bd^2}\right)} \leq 2.0$		**1.13**		*T.3.10*
$M_{1,sag}/b_{w1}.d_{sag1}^{2}$		4.12	N/mm^2	*cl.3.4.6.2*
$f_s = \frac{2f_y A_{s\ req}}{3A_{s\ prov}} \times \frac{1}{\beta_b}$		127	N/mm^2	
Modified span / effective depth ratio criteria		**20.9**		
Deflection utilisation		**86%**		**OK**

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				BS8110
Structural Design [Stage 2: Insitu]				
Bending Design				
Stress coefficient, $M_{2,sag}/b_{w2}d_{sag2}^2$		**3.6**	N/mm^2	
Stress coefficient, $M_{1,sag}/b_{w1}d_{sag1}^2 + M_{2,sag}/b_{w2}d_{sag2}^2$		**7.8**	N/mm^2	
Stress coefficient, $K_{sag2} = M_{2,sag}/b_{w2}d_{sag2}^2 f_{cu}$		**0.066**		**OK**
Lever arm, $z_{sag2} = d_{sag2}.[0.5(0.25-K_{sag2}/0.9)^{0.5}] \le 0.95d_{sag2}$		**741**	mm	
Area of req. sag steel, $A_{s,sag2} = M_{2,sag} / (0.95f_y.z_{sag2})$		**6948**	mm^2	
Sag steel area provided, $A_{s,sag,prov}$		14476	mm^2	
Sag steel area provided utilisation, $[A_{s,sag1} + A_{s,sag2}] / A_{s,sag,prov}$		**89%**		**OK**
Stress coefficient, $M_{2,hog}/b_{w2}d_{hog2}^2$		**4.8**	N/mm^2	
Stress coefficient, $K_{hog2} = M_{2,hog}/b_{w2}d_{hog2}^2 f_{cu}$		**0.087**		**OK**
Lever arm, $z_{hog2} = d_{hog2}.[0.5(0.25-K_{hog2}/0.9)^{0.5}] \le 0.95d_{hog2}$		**719**	mm	
Area of req. hog steel, $A_{s,hog2} = M_{2,hog} / (0.95f_y.z_{hog2})$		**9378**	mm^2	
Hog steel area provided, $A_{s,hog,prov}$		9651	mm^2	
Hog steel area provided utilisation, $A_{s,hog2} / A_{s,hog,prov}$		**97%**		**OK**
Shear Design				
Ultimate shear stress, $v_{ult2} = V_2/b_{w2}d_{hog2}$ ($< 0.8f_{cu}^{0.5}$ & $5.0N/mm^2$)		**1.54**	N/mm^2	
Ultimate shear stress utilisation, v_{ult2} / ($0.8f_{cu}^{0.5}$ & $5.0N/mm^2$)		**31%**		**OK**
Design shear stress, $v_{d2} = V_2/b_{w2}d_{hog2}$		**1.54**	N/mm^2	
Enhanced shear strength, $2d_{hog2}/a_v.v_c$ ($< 0.8f_{cu}^{0.5}$ & $5.0N/mm^2$)	*x 1.00*	**0.89**	N/mm^2	
Distance, a_v	2.00d	1612	mm	
(Shear capacity enhancement by calculating v_d within 2d of support and comparing against enhanced v_c within 2d of the support as clause 3.4.5.8 BS8110 employed instead of calculating v_d at d from support and comparing against unenhanced v_c as clause 3.4.5.10 BS8110;)				
Hog steel area provided, $A_{s,hog,prov}$		9651	mm^2	
$\rho_w = 100A_{s,hog,prov}/b_{w2}d_{hog2}$		1.26	%	
$v_c = (0.79/1.25)(\rho_w f_{cu}/25)^{1/3}(400/d_{hog2})^{1/4}$; $\rho_w<3$; $f_{cu}<80$; $(400/d_{hoc}$		**0.89**	N/mm^2	
Provide shear links $(A_{sv}/S)_2 > b_{w2}MAX[0.4,(v_{d2}-2d_{hog2}/a_v.v_c)]/(0.95f_{yv})$ i.e. $(A_{sv}$		**1.43**	mm^2/mm	
Area provided by all shear links in a cross-section, $A_{sv,prov}/S$		**3.39**	mm^2/mm	
Concrete and design links shear capacity, $V_{cap2} = (A_{sv,prov}/S).(0.95f_{yv}).d_{hog2}$ +		**1875**	kN	
Design shear links area utilisation, $[(A_{sv}/S)_1 + (A_{sv}/S)_2] / (A_{sv,prov}/S)$		**42%**		**OK**
Design shear resistance utilisation, $[V_1 + V_2] / V_{cap2}$		**91%**		**OK**
Deflection Design				
Span		11.400	m	
Span / effective depth ratio		**14.1**		
Basic span / effective depth ratio criteria	Continuous Internal Span	**26.0**		
Multiplier $C_{1,rect\ or\ flanged}$		1.00		*cl.3.4.6.3*
Multiplier $C_{1,span\ more\ or\ less\ than\ 10m}$	Include	0.88		*cl.3.4.6.4*
Modification factor for tension C_2	$0.55 + \frac{(477 - f_s)}{120\left(0.9 + \frac{M}{bd^2}\right)} \le 2.0$	**0.75**		*T.3.10*
$M_{1,sag}/b_{w1}d_{sag1}^2 + M_{2,sag}$		7.77	N/mm^2	*cl.3.4.6.2*
$f_s = \frac{2f_y A_{s\ req}}{3A_{s\ prov}} \times \frac{1}{\beta_b}$		274	N/mm^2	
Modified span / effective depth ratio criteria		**17.0**		
Deflection utilisation		**83%**		**OK**