CONSULTING ENGINEERS	Engineering Calculation Sheet Consulting Engineers	Job No.: jXXX	Sheet No.: 1	Rev.
		Member/Location		
Job Title	Member Design - Steel Non Composite Beam BS5950 v	Drg.		
Member Design - Steel Non Composite Beam		Made by XX	Date 21/11/2021	Chd.

Input Parameters

Primary beam spacing (= secondary beam span) =	6.500	m	
Primary beam span =	4.000	m	
Secondary beam spacing =	3.000	m	
Support condition for primary beam =	Simply Supported		
Support condition for secondary beam =	Simply Supported		
Redistribution of hogging moment (where applicable) =	0	%	
Internal or edge beam (primary) (affects loading tributary) =	Edge Beam		
Internal or edge beam (secondary) (affects loading tributary) =	Edge Beam		
Steel grade =	S275 (43)		
Primary beam =	UB 610x305x149		
Secondary beam =	UB 533x210x101		
Mass per area of primary beam, m_p = mass per metre / spacing =	23.0	kg/m^2	
Mass per area of secondary beam, m_s = mass per metre / spacing =	33.7	kg/m^2	
Mass per area of structural steelwork = m_p + m_s =	**56.6**	kg/m^2	
Thickness of precast slab, t_p =	250	mm	
Density of precast slab, ρ_p =	24	kN/m^3	
Live load (including partitions), LL =	6.00	kPa	
Super dead load, SDL =	1.78	kPa	
Dead load, DL = $\rho_p.t_p$ + for pri $(m_p+m_s).g$ = 6.56 kpa and sec $m_s.g$ =	6.33	kPa	
ULS pressure load (primary beam) = 1.6LL + 1.4SDL + 1.4DL =	21.27	kPa	
Internal or external facade primary beam (from load on elevation) =	4.0	kN/m	
Internal or external facade secondary beam (from load on elevation) =	4.0	kN/m	
Concentrated dead point load (design case) on primary beam, P_{DL+SDL} =	0.0	kN	
Concentrated live point load (design case) on primary beam, P_{LL} =	0.0	kN	
Shorter distance of primary beam point load from beam end, a =	0.000	m	**OK**
Construction loading (for construction stage checks, >=0.5 kPa) =	0.50	kPa	**OK**
Method of construction (affects all construction effects) =	Unpropped Construction		
LTB prop restraint for construction case (0% < $\%LTB_{res}$ <= 100%) =	100.0	%	
Percentage of dead and superimposed dead load deflection precamber, %pcar	80.0	%	

Steel Beam Parameters

Modulus of elasticity, E =	205.0	GPa
Primary beam second moment of area, I =	125876	cm^4
Secondary beam second moment of area, I =	61519	cm^4
Primary beam LTB length for design sag = $L_{E,no\ LTB}$ =	0.271	m
Primary beam LTB length for construction sag = 1.0.($\%LTB_{res}$.sec spacing)+2I	4.225	m
Primary beam LTB length for design hog = 1.0.(0.85.sec spacing)+2D_p =	3.775	m
Primary beam LTB length for construction hog = 1.0.(0.85.$\%LTB_{res}$.sec spacin	3.775	m
Secondary beam LTB length for design sag = $L_{E,no\ LTB}$ =	0.179	m
Secondary beam LTB length for construction sag = 1.0.($\%LTB_{res}$.sec span)+2I	7.573	m
Secondary beam LTB length for design hog = 1.0.(0.85.sec span)+2D_s =	6.598	m
Secondary beam LTB length for construction hog = 1.0.(0.85.$\%LTB_{res}$.sec spa	6.598	m
Primary beam depth, D_p =	612.4	mm
Secondary beam depth, D_s =	536.7	mm

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Utilisation Summary

Perform design primary and secondary beam — Floor Design

Peform design primary beam — Primary Beam Design

Peform design secondary beam — Secondary Beam Design

Utilisation Checks					
	Primary Beam	Design Sagging	11%	OK	28%
		Design Hogging	10%	OK	
		Live Load Deflection	2%	OK	
		SLS Load Deflection	2%	OK	
		Construction Sagging	5%	OK	
		Construction Hogging	4%	OK	
	Secondary Beam	Design Sagging	25%	OK	
		Design Hogging	10%	OK	
		Live Load Deflection	9%	OK	
		SLS Load Deflection	7%	OK	
		Construction Sagging	28%	OK	
		Construction Hogging	4%	OK	

Dead and superimposed dead load deflection precamber primary beam, %pca	0.3	mm
Dead and superimposed dead load deflection precamber secondary beam, %p	2.4	mm

LTB Restraint

Design sag	No LTB	*Note that nominal studs are still required*
Construction sag	$L_{LTB,SAG}$	*in the steel beams in order to provide*
Design hog	$L_{LTB,HOG}$	*LTB restraint and maintain diaphragm*
Construction hog	$L_{LTB,HOG}$	*action of the slab.*

Façade Loading

Note that the façade loading on the secondary beam does not automatically feature as a load on the primary beam; Employ instead the point load option for the primary beam where applicable;

Limiting Slenderness for No LTB Effects

Limiting equivalent slenderness, $\lambda_{L0} = 0.4(\pi^2E/p_y)^{0.5}$	34.3	
Percentage of L_E for limiting slenderness for no LTB effects =	10	%
Primary Beam		
Set equivalent slenderness, $\lambda_{LT} = uv\lambda = \lambda_{L0}$ for λ =	38.7	
Buckling parameter, u =	0.886	
Say slenderness factor, ν = 1	1.00	
Radius of gyration y-y axis, r_y =	7	cm
Minor axis effective length for limiting λ_{L0}, $L_E = \lambda.r_y$ =	2.711	m
Effective unrestrained length for no LTB effects, $L_{E,no\ LTB}$ =	0.271	m
Secondary Beam		
Set equivalent slenderness, $\lambda_{LT} = uv\lambda = \lambda_{L0}$ for λ =	39.3	
Buckling parameter, u =	0.874	
Say slenderness factor, ν = 1	1.00	
Radius of gyration y-y axis, r_y =	4.57	cm
Minor axis effective length for limiting λ_{L0}, $L_E = \lambda.r_y$ =	1.794	m
Effective unrestrained length for no LTB effects, $L_{E,no\ LTB}$ =	0.179	m

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Primary Beam Design

Type of support condition =	Simply Supported	
Tributary width i.e. beam spacing (divided by 2 if edge beam), t_w =	3.250	m
Live load (including partitions), LL =	6.00	kPa
Super dead load, SDL =	1.78	kPa
Super dead load (from elevation loading), SDL_{elev} =	4.0	kN/m
Unfactored live load, ω_{LL} = LL . t_w =	19.5	kN/m
Unfactored dead load, ω_{DL+SDL} = (SDL + DL) . t_w + SDL_{elev} =	31.1	kN/m
Unfactored SLS load, ω_{SLS} = (LL + SDL + DL) . t_w + SDL_{elev} =	50.6	kN/m
Factored ULS load, ω_{ULS} = (1.6LL + 1.4SDL + 1.4DL) . t_w + $1.4SDL_{elev}$ =	74.7	kN/m
Concentrated dead point load on primary beam, P_{DL+SDL} =	0.0	kN
Concentrated live point load on primary beam, P_{LL} =	0.0	kN
Shorter distance of primary beam point load from beam end, a =	0.000	m

Simply Supported		
M_{HOG}=0.0=	0	kNm
$M_{SAG}=[0.125(1.4\omega_{DL+SDL}+1.6\omega_{LL})]L^2+M_{max}(P=1.4P_{DL+SDL}$ … $M_{max.}=\frac{Pab}{L}$	149	kNm
$V=[0.500(1.4\omega_{DL+SDL}+1.6\omega_{LL})]L+R_A(P=1.4P_{DL+SDL}+1.6P_{LL})$ $R_A=Pb/L$	149	kN
$\delta_{LL}=5\omega_{LL}L^4/(384EI)+d_{centre}(P=P_{LL})=$ $d_{centre}=\frac{PL^3}{48EI}\left[\frac{3a}{L}-4\left(\frac{a}{L}\right)^3\right]$	0.3	mm
$\delta_{SLS}=5\omega_{SLS}L^4/(384EI)+d_{centre}(P=P_{DL+SDL}+P_{LL})=$	0.7	mm
Continuous 2 Span		
$M_{HOG}=[0.125(1.4\omega_{DL+SDL})+0.125(1.6\omega_{LL})]L^2+M_A(P=1.4$ … $M_A=-\frac{Pb(L^2-b^2)}{2L^2}$	149	kNm
$M_{SAG}=[0.070(1.4\omega_{DL+SDL})+0.096(1.6\omega_{LL})]L^2+M_C(P=1$ … $M_C=\frac{Pb}{2}\left(2-\frac{3b}{L}+\frac{b^3}{L^3}\right)$	97	kNm
$V=[0.625(1.4\omega_{DL+SDL})+0.625(1.6\omega_{LL})]L+R$ … $R_B=\frac{Pa^2}{2L^3}(b+2L)$ $R_A=P-R_B$	187	kN
$\delta_{LL}=\omega_{LL}L^4/(185EI)+d_c(P=P_{LL})=$ $d_C=\frac{Pa^2b^3}{12EIL^3}(4L-a)$	0.1	mm
$\delta_{SLS}=\omega_{SLS}L^4/(185EI)+d_c(P=P_{DL+SDL}+P_{LL})=$	0.3	mm
Continuous 3 Span (End Span)		
$M_{HOG}=[0.100(1.4\omega_{DL+SDL})+0.117(1.6\omega_{LL})]L^2+M_A(P=1.4$ … $M_A=-\frac{Pb(L^2-b^2)}{2L^2}$	128	kNm
$M_{SAG}=[0.080(1.4\omega_{DL+SDL})+0.101(1.6\omega_{LL})]L^2+M_C(P=1$ … $M_C=\frac{Pb}{2}\left(2-\frac{3b}{L}+\frac{b^3}{L^3}\right)$	106	kNm
$V=[0.600(1.4\omega_{DL+SDL})+0.617(1.6\omega_{LL})]L+R$ … $R_B=\frac{Pa^2}{2L^3}(b+2L)$ $R_A=P-R_B$	182	kN
$\delta_{LL}=\omega_{LL}L^4/(185EI)+d_c(P=P_{LL})=$ $d_C=\frac{Pa^2b^3}{12EIL^3}(4L-a)$	0.1	mm
$\delta_{SLS}=\omega_{SLS}L^4/(185EI)+d_c(P=P_{DL+SDL}+P_{LL})=$	0.3	mm
Continuous 3 Span (Interior Span)		
$M_{HOG}=[0.100(1.4\omega_{DL+SDL})+0.117(1.6\omega_{LL})]L^2+M_A(P=1.4P$ … $M_A=-\frac{Pab^2}{L^2}$	128	kNm
$M_{SAG}=[0.025(1.4\omega_{DL+SDL})+0.075(1.6\omega_{LL})]L^2+M_C(P=1.4$ … $M_C=\frac{2Pa^2b^2}{L^3}$	55	kNm
$V=[0.500(1.4\omega_{DL+SDL})+0.583(1.6\omega_{LL})]L+R_A(P=1.$ … $R_A=P\left(\frac{b}{L}\right)^2\left(1+2\frac{a}{L}\right)$	160	kN
$\delta_{LL}=\omega_{LL}L^4/(384EI)+d_{max}(P=P_{LL})=$ $d_{max}=\frac{2Pa^3b^2}{3EI(3L-2a)^2}$	0.1	mm
$\delta_{SLS}=\omega_{SLS}L^4/(384EI)+d_{max}(P=P_{DL+SDL}+P_{LL})=$	0.1	mm
Continuous 4 or More Span (End Span)		
$M_{HOG}=[0.107(1.4\omega_{DL+SDL})+0.121(1.6\omega_{LL})]L^2+M_A(P=1.4$ … $M_A=-\frac{Pb(L^2-b^2)}{2L^2}$	135	kNm
$M_{SAG}=[0.077(1.4\omega_{DL+SDL})+0.100(1.6\omega_{LL})]L^2+M_C(P=1$ … $M_C=\frac{Pb}{2}\left(2-\frac{3b}{L}+\frac{b^3}{L^3}\right)$	104	kNm
$V=[0.607(1.4\omega_{DL+SDL})+0.620(1.6\omega_{LL})]L+R$ … $R_B=\frac{Pa^2}{2L^3}(b+2L)$ $R_A=P-R_B$	183	kN
$\delta_{LL}=\omega_{LL}L^4/(185EI)+d_c(P=P_{LL})=$ $d_C=\frac{Pa^2b^3}{12EIL^3}(4L-a)$	0.1	mm
$\delta_{SLS}=\omega_{SLS}L^4/(185EI)+d_c(P=P_{DL+SDL}+P_{LL})=$	0.3	mm
Continuous 4 or More Span (Interior Span)		
$M_{HOG}=[0.107(1.4\omega_{DL+SDL})+0.121(1.6\omega_{LL})]L^2+M_A(P=1.4P$ … $M_A=-\frac{Pab^2}{L^2}$	135	kNm
$M_{SAG}=[0.036(1.4\omega_{DL+SDL})+0.081(1.6\omega_{LL})]L^2+M_C(P=1.4$ … $M_C=\frac{2Pa^2b^2}{L^3}$	66	kNm
$V=[0.536(1.4\omega_{DL+SDL})+0.603(1.6\omega_{LL})]L+R_A(P=1.$ … $R_A=P\left(\frac{b}{L}\right)^2\left(1+2\frac{a}{L}\right)$	169	kN
$\delta_{LL}=\omega_{LL}L^4/(384EI)+d_{max}(P=P_{LL})=$ $d_{max}=\frac{2Pa^3b^2}{3EI(3L-2a)^2}$	0.1	mm
$\delta_{SLS}=\omega_{SLS}L^4/(384EI)+d_{max}(P=P_{DL+SDL}+P_{LL})=$	0.1	mm

Note for udl loads (DL and SDL) uniform loading considered;

For udl loads (LL) patch loading considered;

For points loads (DL, SDL and LL) patch loading considered;

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Primary Beam Design Hogging

ULS hogging bending moment, $M_{ULS,HOG,Elastic}$ =	0	kNm	
Redistribution of hogging moment for continuous beams, RD =	0	%	
ULS hogging bending moment, $M_{ULS,HOG}$ = (1-RD)$M_{ULS,HOG,Elastic}$ =	**0**	kNm	
ULS shear force, V_{ULS} =	**149**	kN	

Primary Beam Design Sagging

ULS sagging bending moment, $M_{ULS,SAG,Elastic}$ =	149	kNm	
ULS sagging bending moment, $M_{ULS,SAG}$ = $M_{ULS,SAG,Elastic}$ + RD.$M_{ULS,HOG,Elastic}$ =	**149**	kNm	

Primary Beam Live Load Deflection

Live load deflection, δ_{LL} =	0.3	mm	
Live load deflection utilisation = δ_{LL} / (L/360) =	**2%**		**OK**

Primary Beam SLS Load Deflection

SLS load deflection, δ_{SLS} =	0.7	mm	
Dead and superimposed dead load deflection, δ_{DL} = δ_{SLS} - δ_{LL} =	0.4	mm	
Percentage of dead and superimposed dead load deflection precamber, %pcar	80.0	%	
Dead and superimposed dead load deflection with precamber, $\delta_{DL,p}$ = (1-%pca	0.1	mm	
SLS load deflection with precamber, $\delta_{SLS,p}$ = δ_{LL} + $\delta_{DL,p}$ =	0.3	mm	
SLS load deflection utilisation = $\delta_{SLS,p}$ / (L/200) =	**2%**		**OK**
Dead and superimposed dead load deflection precamber, %pcam . δ_{DL} =	**0.3**	mm	

Primary Beam ULS Connection Force

Shear force at either end of beam = V_{ULS} =	**149**	kN
Moment at either end of beam = M_{ULS} =	**0**	kNm

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Secondary Beam Design

Type of support condition =	Simply Supported	
Tributary width i.e. beam spacing (divided by 2 if edge beam), t_w =	1.500	m
Live load (including partitions), LL =	6.00	kPa
Super dead load, SDL =	1.78	kPa
Super dead load (from elevation loading), SDL_{elev} =	4.0	kN/m
Unfactored live load, ω_{LL} = LL . t_w =	9.0	kN/m
Unfactored dead load, ω_{DL+SDL} = (SDL + DL) . t_w + SDL_{elev} =	16.2	kN/m
Unfactored SLS load, ω_{SLS} = (LL + SDL + DL) . t_w + SDL_{elev} =	25.2	kN/m
Factored ULS load, ω_{ULS} = (1.6LL + 1.4SDL + 1.4DL) . t_w + 1.4SDL_{elev} =	37.1	kN/m

Simply Supported		
M_{HOG}=0.0=	0	kNm
M_{SAG}=[0.125(1.4ω_{DL+SDL}+1.6ω_{LL})]L^2=	196	kNm
V=[0.500(1.4ω_{DL+SDL}+1.6ω_{LL})]L=	120	kN
δ_{LL}=5$\omega_{LL}L^4$/(384EI)=	1.7	mm
δ_{SLS}=5$\omega_{SLS}L^4$/(384EI)=	4.6	mm
Continuous 2 Span		
M_{HOG}=[0.125(1.4ω_{DL+SDL})+0.125(1.6ω_{LL})]L^2=	196	kNm
M_{SAG}=[0.070(1.4ω_{DL+SDL})+0.096(1.6ω_{LL})]L^2=	125	kNm
V=[0.625(1.4ω_{DL+SDL})+0.625(1.6ω_{LL})]L=	151	kN
δ_{LL}=5$\omega_{LL}L^4$/(384EI)=	1.7	mm
δ_{SLS}=$\omega_{SLS}L^4$/(185EI)=	1.9	mm
Continuous 3 Span (End Span)		
M_{HOG}=[0.100(1.4ω_{DL+SDL})+0.117(1.6ω_{LL})]L^2=	167	kNm
M_{SAG}=[0.080(1.4ω_{DL+SDL})+0.101(1.6ω_{LL})]L^2=	138	kNm
V=[0.600(1.4ω_{DL+SDL})+0.617(1.6ω_{LL})]L=	146	kN
δ_{LL}=5$\omega_{LL}L^4$/(384EI)=	1.7	mm
δ_{SLS}=$\omega_{SLS}L^4$/(185EI)=	1.9	mm
Continuous 3 Span (Interior Span)		
M_{HOG}=[0.100(1.4ω_{DL+SDL})+0.117(1.6ω_{LL})]L^2=	167	kNm
M_{SAG}=[0.025(1.4ω_{DL+SDL})+0.075(1.6ω_{LL})]L^2=	70	kNm
V=[0.500(1.4ω_{DL+SDL})+0.583(1.6ω_{LL})]L=	128	kN
δ_{LL}=5$\omega_{LL}L^4$/(384EI)=	1.7	mm
δ_{SLS}=$\omega_{SLS}L^4$/(384EI)=	0.9	mm
Continuous 4 or More Span (End Span)		
M_{HOG}=[0.107(1.4ω_{DL+SDL})+0.121(1.6ω_{LL})]L^2=	176	kNm
M_{SAG}=[0.077(1.4ω_{DL+SDL})+0.100(1.6ω_{LL})]L^2=	135	kNm
V=[0.607(1.4ω_{DL+SDL})+0.620(1.6ω_{LL})]L=	147	kN
δ_{LL}=5$\omega_{LL}L^4$/(384EI)=	1.7	mm
δ_{SLS}=$\omega_{SLS}L^4$/(185EI)=	1.9	mm
Continuous 4 or More Span (Interior Span)		
M_{HOG}=[0.107(1.4ω_{DL+SDL})+0.121(1.6ω_{LL})]L^2=	176	kNm
M_{SAG}=[0.036(1.4ω_{DL+SDL})+0.081(1.6ω_{LL})]L^2=	84	kNm
V=[0.536(1.4ω_{DL+SDL})+0.603(1.6ω_{LL})]L=	135	kN
δ_{LL}=5$\omega_{LL}L^4$/(384EI)=	1.7	mm
δ_{SLS}=$\omega_{SLS}L^4$/(384EI)=	0.9	mm

Note for udl loads (DL and SDL) uniform loading considered;
For udl loads (LL) patch loading considered;

Secondary Beam Design Hogging

ULS hogging bending moment, $M_{ULS,HOG,Elastic}$ =	0	kNm	
Redistribution of hogging moment for continuous beams, RD =	0	%	
ULS hogging bending moment, $M_{ULS,HOG}$ = (1-RD)$M_{ULS,HOG,Elastic}$ =	**0**	kNm	
ULS shear force, V_{ULS} =	**120**	kN	

Secondary Beam Design Sagging

ULS sagging bending moment, $M_{ULS,SAG,Elastic}$ =	196	kNm	
ULS sagging bending moment, $M_{ULS,SAG}$ = $M_{ULS,SAG,Elastic}$ + RD.$M_{ULS,HOG,Elastic}$ =	**196**	kNm	

Secondary Beam Live Load Deflection

Live load deflection, δ_{LL} =	1.7	mm	
Live load deflection utilisation = δ_{LL} / (L/360) =	**9%**		**OK**

Secondary Beam SLS Load Deflection

SLS load deflection, δ_{SLS} =	4.6	mm	
Dead and superimposed dead load deflection, δ_{DL} = δ_{SLS} - δ_{LL} =	3.0	mm	
Percentage of dead and superimposed dead load deflection precamber, %pcar	80.0	%	
Dead and superimposed dead load deflection with precamber, $\delta_{DL,p}$ = (1-%pca	0.6	mm	
SLS load deflection with precamber, $\delta_{SLS,p}$ = δ_{LL} + $\delta_{DL,p}$ =	2.3	mm	
SLS load deflection utilisation = $\delta_{SLS,p}$ / (L/200) =	**7%**		**OK**
Dead and superimposed dead load deflection precamber, %pcam . δ_{DL} =	**2.4**	mm	

Secondary Beam ULS Connection Force

Shear force at either end of beam = V_{ULS} =	**120**	kN	
Moment at either end of beam = M_{ULS} =	**0**	kNm	

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Primary Beam Construction

Type of support condition =	Simply Supported	
Tributary width i.e. beam spacing (divided by 2 if edge beam), t_w =	3.250	m
Construction load =	0.50	kPa
Unfactored live load, ω_{LL} = construction load . t_w =	1.6	kN/m
Unfactored dead load, ω_{DL} = DL . t_w =	21.3	kN/m
Factored ULS load, ω_{ULS} = (1.6construction load + 1.4DL) . t_w =	32.4	kN/m

(Note propped construction will not produce any construction effects, and vice versa)

Simply Supported		
M_{HOG}=0.0=	0	kNm
M_{SAG}=[0.125(1.4ω_{DL}+1.6ω_{LL})]L^2=	65	kNm
V=[0.500(1.4ω_{DL}+1.6ω_{LL})]L=	65	kN
Continuous 2 Span		
M_{HOG}=[0.125(1.4ω_{DL})+0.125(1.6ω_{LL})]L^2=	65	kNm
M_{SAG}=[0.070(1.4ω_{DL})+0.096(1.6ω_{LL})]L^2=	37	kNm
V=[0.625(1.4ω_{DL})+0.625(1.6ω_{LL})]L=	81	kN
Continuous 3 Span (End Span)		
M_{HOG}=[0.100(1.4ω_{DL})+0.117(1.6ω_{LL})]L^2=	53	kNm
M_{SAG}=[0.080(1.4ω_{DL})+0.101(1.6ω_{LL})]L^2=	42	kNm
V=[0.600(1.4ω_{DL})+0.617(1.6ω_{LL})]L=	78	kN
Continuous 3 Span (Interior Span)		
M_{HOG}=[0.100(1.4ω_{DL})+0.117(1.6ω_{LL})]L^2=	53	kNm
M_{SAG}=[0.025(1.4ω_{DL})+0.075(1.6ω_{LL})]L^2=	15	kNm
V=[0.500(1.4ω_{DL})+0.583(1.6ω_{LL})]L=	66	kN
Continuous 4 or More Span (End Span)		
M_{HOG}=[0.107(1.4ω_{DL})+0.121(1.6ω_{LL})]L^2=	56	kNm
M_{SAG}=[0.077(1.4ω_{DL})+0.100(1.6ω_{LL})]L^2=	41	kNm
V=[0.607(1.4ω_{DL})+0.620(1.6ω_{LL})]L=	79	kN
Continuous 4 or More Span (Interior Span)		
M_{HOG}=[0.107(1.4ω_{DL})+0.121(1.6ω_{LL})]L^2=	56	kNm
M_{SAG}=[0.036(1.4ω_{DL})+0.081(1.6ω_{LL})]L^2=	21	kNm
V=[0.536(1.4ω_{DL})+0.603(1.6ω_{LL})]L=	70	kN

Note DL and SDL considers uniform loading only whilst LL includes patch loading as well.

Primary Beam Construction Hogging

ULS construction hogging moment, $M_{ULS,construct,HOG}$ =	0	kNm
Redistribution of hogging moment for continuous beams, RD =	0	%
ULS construction hogging moment, $M_{ULS,construct,HOG}$ = (1-RD)$M_{ULS,construct,HOG}$ =	**0**	kNm
ULS construction shear force, $V_{ULS,construct}$ =	**65**	kN

Primary Beam Construction Sagging

ULS construction sagging moment, $M_{ULS,construct,SAG}$ =	65	kNm
ULS construction sag moment, $M_{ULS,construct,SAG}$ = $M_{ULS,construct,SAG}$ + RD.$M_{ULS,constr}$	**65**	kNm

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Secondary Beam Construction

Type of support condition =	Simply Supported	
Tributary width i.e. beam spacing (divided by 2 if edge beam), t_w =	1.500	m
Construction load =	0.50	kPa
Unfactored live load, ω_{LL} = construction load . t_w =	0.8	kN/m
Unfactored dead load, ω_{DL} = DL . t_w =	9.5	kN/m
Factored ULS load, ω_{ULS} = (1.6construction load + 1.4DL) . t_w =	14.5	kN/m

(Note propped construction will not produce any construction effects, and vice versa)

Simply Supported		
M_{HOG}=0.0=	0	kNm
M_{SAG}=[0.125(1.4ω_{DL}+1.6ω_{LL})]L^2=	77	kNm
V=[0.500(1.4ω_{DL}+1.6ω_{LL})]L=	47	kN
Continuous 2 Span		
M_{HOG}=[0.125(1.4ω_{DL})+0.125(1.6ω_{LL})]L^2=	77	kNm
M_{SAG}=[0.070(1.4ω_{DL})+0.096(1.6ω_{LL})]L^2=	44	kNm
V=[0.625(1.4ω_{DL})+0.625(1.6ω_{LL})]L=	59	kN
Continuous 3 Span (End Span)		
M_{HOG}=[0.100(1.4ω_{DL})+0.117(1.6ω_{LL})]L^2=	62	kNm
M_{SAG}=[0.080(1.4ω_{DL})+0.101(1.6ω_{LL})]L^2=	50	kNm
V=[0.600(1.4ω_{DL})+0.617(1.6ω_{LL})]L=	57	kN
Continuous 3 Span (Interior Span)		
M_{HOG}=[0.100(1.4ω_{DL})+0.117(1.6ω_{LL})]L^2=	62	kNm
M_{SAG}=[0.025(1.4ω_{DL})+0.075(1.6ω_{LL})]L^2=	18	kNm
V=[0.500(1.4ω_{DL})+0.583(1.6ω_{LL})]L=	48	kN
Continuous 4 or More Span (End Span)		
M_{HOG}=[0.107(1.4ω_{DL})+0.121(1.6ω_{LL})]L^2=	66	kNm
M_{SAG}=[0.077(1.4ω_{DL})+0.100(1.6ω_{LL})]L^2=	48	kNm
V=[0.607(1.4ω_{DL})+0.620(1.6ω_{LL})]L=	57	kN
Continuous 4 or More Span (Interior Span)		
M_{HOG}=[0.107(1.4ω_{DL})+0.121(1.6ω_{LL})]L^2=	66	kNm
M_{SAG}=[0.036(1.4ω_{DL})+0.081(1.6ω_{LL})]L^2=	24	kNm
V=[0.536(1.4ω_{DL})+0.603(1.6ω_{LL})]L=	51	kN

Note DL and SDL considers uniform loading only whilst LL includes patch loading as well.

Secondary Beam Construction Hogging

ULS construction hogging moment, $M_{ULS,construct,HOG}$ =	0	kNm
Redistribution of hogging moment for continuous beams, RD =	0	%
ULS construction hogging moment, $M_{ULS,construct,HOG}$ = (1-RD)$M_{ULS,construct,HOG}$ =	**0**	kNm
ULS construction shear force, $V_{ULS,construct}$ =	**47**	kN

Secondary Beam Construction Sagging

ULS construction sagging moment, $M_{ULS,construct,SAG}$ =	77	kNm
ULS construction sag moment, $M_{ULS,construct,SAG}$ = $M_{ULS,construct,SAG}$ + RD.$M_{ULS,constr}$	**77**	kNm

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Multiple Primary Beam Designs

Parameters not entered here are as entered. Ensure m_s negligible and internal beam selected; Spacing is loading tributary; Lock sec beam spacing to primary beam span for no LTB restraint during construction;

Perform design for first 48 beams

Multiple Primary Beam Design

Beam Ref	Section	Spacing (m)	Cladding (kN/m)	P_{DL+SDL} (kN)	P_{LL} (kN)	a (m)	Span (m)
B1-3RD	UC 203x203x46	1.150	0.0	0.0	0.0	0.000	5.500
B3-3RD	UC 203x203x46	1.200	0.0	0.0	0.0	0.000	4.750
B4-3RD	UC 203x203x46	2.600	0.0	0.0	0.0	0.000	5.500
B5-3RD	UC 152x152x23	2.500	0.0	0.0	0.0	0.000	2.700
B6-3RD	UC 152x152x37	2.600	0.0	0.0	0.0	0.000	4.500
B7-3RD	UC 203x203x46	2.950	0.0	0.0	0.0	0.000	5.300
B9-3RD	UC 203x203x52	2.750	7.5	0.0	0.0	0.000	5.500
B11-3RD	UC 203x203x52	4.100	0.0	0.0	0.0	0.000	5.300
B12-3RD	UC 203x203x52	3.600	4.0	0.0	0.0	0.000	5.400
B13-3RD	UC 203x203x46	2.250	0.0	0.0	0.0	0.000	5.300
B17-3RD	UC 203x203x46	2.750	0.0	0.0	0.0	0.000	5.500
B28-3RD	UC 203x203x52	2.100	0.0	0.0	0.0	0.000	6.500
B29-3RD	UC 203x203x46	4.000	0.0	32.0	0.0	0.200	4.900
B4-4TH	UC 203x203x71	2.600	20.0	0.0	0.0	0.000	5.500
B5-4TH	UC 152x152x23	2.500	20.0	0.0	0.0	0.000	2.750
B7-4TH	UC 203x203x52	3.700	0.0	0.0	0.0	0.000	5.500
B12-4TH	UC 203x203x86	2.750	7.5	129.0	0.0	0.900	5.400
B13-4TH	UC 254x254x89	4.200	0.0	169.0	0.0	1.000	5.300
B14-4TH	UC 254x254x89	3.600	4.0	156.0	0.0	1.000	5.300
B25-4TH	UC 203x203x46	4.500	0.0	42.0	0.0	0.200	4.900
B29-4TH	UC 203x203x46	3.250	7.5	0.0	0.0	0.000	4.500
B34-4TH	UC 203x203x52	2.250	0.0	104.0	0.0	0.700	5.300
B40-4TH	UC 203x203x46	2.600	20.0	0.0	0.0	0.000	4.500
B2-5TH	UC 203x203x46	0.625	0.0	0.0	0.0	0.000	2.700
B4-5TH	UC 203x203x46	2.200	4.2	0.0	0.0	0.000	4.500
B5-5TH	UC 203x203x46	2.275	4.2	13.6	0.0	0.600	5.500
B6-5TH	UC 203x203x52	2.800	7.5	25.2	0.0	1.300	4.650
B7-5TH	UC 203x203x60	4.100	0.0	38.6	0.0	1.300	4.500
B8-5TH	UC 203x203x71	3.600	4.0	34.6	0.0	1.300	4.500
B9-5TH	UC 203x203x52	2.250	0.0	22.2	0.0	1.300	4.500
B10-5TH	UC 203x203x46	0.625	0.0	0.0	0.0	0.000	5.100
B11-5TH	UC 203x203x46	3.050	0.0	0.0	0.0	0.000	5.500
B16-5TH	UC 152x152x23	1.875	0.0	0.0	0.0	0.000	3.200
B17-5TH	UC 203x203x60	3.000	0.0	0.0	0.0	0.000	5.600
B20-5TH	UC 152x152x30	1.000	7.5	0.0	0.0	0.000	4.400
B23-5TH	UC 152x152x23	1.400	0.0	0.0	0.0	0.000	4.150
B24-5TH	UC 203x203x46	3.700	0.0	53.5	0.0	0.300	4.900
B30-5TH	UC 203x203x71	2.250	0.0	0.0	0.0	0.000	6.500
B35-5TH	UC 203x203x46	1.500	7.5	57.0	0.0	0.200	4.700
B2-6TH	UC 152x152x23	1.303	0.0	0.0	0.0	0.000	4.900
B4-6TH	UC 152x152x23	1.303	0.0	0.0	0.0	0.000	4.500
B5-6TH	UC 203x203x46	3.172	0.0	11.4	0.0	0.600	5.200
B7-6TH	UC 152x152x23	2.180	0.0	0.0	0.0	0.000	4.100
B9-6TH	UC 203x203x46	5.550	0.0	0.0	0.0	0.000	4.700
B12-6TH	UC 203x203x71	4.440	0.0	0.0	0.0	0.000	5.500
B18-6TH	UC 203x203x46	5.155	0.0	0.0	0.0	0.000	4.500
B21-6TH	UC 203x203x46	1.300	0.0	89.0	0.0	0.200	4.500
B22-6TH	UC 254x254x73	3.050	0.0	0.0	0.0	0.000	6.400

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Maximum utilisation = **100%**

	Utilisation						
Beam Ref	**Design Sag**	**Design Hog**	**LL Defln**	**SLS Defln**	**Construct Sag**	**Construct Hog**	**Overall**
B1-3RD	36%	36%	14%	34%	36%	36%	36%
B3-3RD	36%	36%	10%	23%	36%	36%	36%
B4-3RD	54%	36%	32%	73%	69%	36%	73%
B5-3RD	36%	36%	14%	31%	36%	36%	36%
B6-3RD	60%	25%	37%	83%	67%	25%	83%
B7-3RD	57%	36%	33%	74%	71%	36%	74%
B9-3RD	73%	33%	30%	98%	59%	33%	98%
B11-3RD	70%	33%	40%	89%	78%	33%	89%
B12-3RD	75%	33%	37%	98%	72%	33%	98%
B13-3RD	44%	36%	25%	57%	55%	36%	57%
B17-3RD	58%	36%	34%	78%	73%	36%	78%
B28-3RD	55%	33%	38%	86%	70%	33%	86%
B29-3RD	71%	41%	35%	83%	78%	36%	83%
B4-4TH	80%	32%	19%	100%	36%	26%	100%
B5-4TH	81%	37%	14%	75%	38%	36%	81%
B7-4TH	68%	33%	40%	90%	78%	33%	90%
B12-4TH	90%	42%	16%	91%	29%	20%	91%
B13-4TH	85%	52%	15%	71%	33%	31%	85%
B14-4TH	82%	50%	13%	68%	31%	31%	82%
B25-4TH	81%	49%	40%	94%	87%	36%	94%
B29-4TH	62%	36%	22%	69%	51%	36%	69%
B34-4TH	88%	52%	22%	94%	44%	33%	94%
B40-4TH	81%	37%	18%	91%	41%	36%	91%
B2-5TH	36%	36%	1%	2%	36%	36%	36%
B4-5TH	40%	36%	15%	45%	36%	36%	45%
B5-5TH	68%	36%	28%	90%	61%	36%	90%
B6-5TH	71%	33%	18%	76%	39%	33%	76%
B7-5TH	68%	29%	21%	67%	43%	28%	68%
B8-5TH	57%	27%	15%	54%	30%	26%	57%
B9-5TH	44%	33%	13%	44%	33%	33%	44%
B10-5TH	36%	36%	6%	15%	36%	36%	36%
B11-5TH	64%	36%	38%	86%	81%	36%	86%
B16-5TH	37%	36%	17%	38%	42%	36%	42%
B17-5TH	50%	28%	30%	67%	55%	28%	67%
B20-5TH	60%	31%	17%	85%	34%	31%	85%
B23-5TH	46%	36%	27%	62%	63%	36%	63%
B24-5TH	74%	48%	33%	84%	72%	36%	84%
B30-5TH	44%	26%	28%	64%	48%	26%	64%
B35-5TH	51%	43%	12%	56%	36%	36%	56%
B2-6TH	60%	36%	42%	95%	93%	36%	95%
B4-6TH	50%	36%	33%	74%	74%	36%	74%
B5-6TH	64%	36%	33%	80%	72%	36%	80%
B7-6TH	69%	36%	41%	93%	94%	36%	94%
B9-6TH	84%	37%	43%	97%	96%	36%	97%
B12-6TH	61%	26%	33%	75%	61%	26%	75%
B18-6TH	71%	36%	35%	79%	80%	36%	80%
B21-6TH	36%	47%	9%	31%	36%	36%	47%
B22-6TH	44%	38%	24%	55%	53%	38%	55%

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Scheme Design