CONSULTING ENGINEERS	Engineering Calculation Sheet Consulting Engineers	Job No.	Sheet No.	Rev.
		jXXX	1	
		Member/Location		
Job Title	Member Design - Reinforced Concrete One Way Spanni	Drg.		
Member Design - RC One Way Spanning Slab		Made by XX	Date 21/11/2021	Chd.

Material Properties

Characteristic strength of concrete, f_{cu} (≤ 60N/mm^2; HSC N/A)	35	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 24	kN/m^3	

Slab Parameters

Effective span of slab and number, l (number affects slab m	Multi Span	5.000	m
Effective span of beam and number, l_b (number affects bea	Multi Span	6.000	m
Slab support conditions (affects effective beam section, mo	Continuous - Continuous End		ia)
Panel (affects moments for continuous case, shear for conti	Corner		

case, supports for beam and edge beam and whether interior or edge beam for both precast and continuous ca

Overall slab depth, h_{slab} (l/22-l/30 s/s; l/28-l/36 cont; l/7-l/10 cant)	250	mm
Cover to all reinforcement, cover (usually MAX(25, ϕ) internal; 40 external)	40	mm
Effective depth to sagging steel, $d_s = h_{slab}$ - cover - $\phi_s/2$	204	mm
Effective depth to hogging steel, $d_h = h_{slab}$ - cover - ϕ_{link} - $\phi_h/2$	202	mm
Sagging steel reinforcement diameter, ϕ_s	12	mm
Sagging steel reinforcement pitch, p_s	100	mm
Sagging steel area provided, $A_{s,prov,s} = (\pi.\phi_s^2/4)/p_s$	1131	mm^2/m
Hogging steel reinforcement diameter, ϕ_h	16	mm
Hogging steel reinforcement pitch, p_h	100	mm
Hogging steel area provided, $A_{s,prov,h} = (\pi.\phi_h^2/4)/p_h$	2011	mm^2/m
Shear link diameter, ϕ_{link}	None	mm
Number of links per metre, n_{link}	10	/m
Area provided by all links per metre, $A_{sv,prov} = n_{link}.\pi.\phi_{link}^2/4$	0	mm^2/m
Pitch of links, S	200	mm

Slab Loading (Plan Loading) — Elastic Moments Effects

(Internal elev load not on beam must be checked on effective widths [span/(5 or 7.14)] within slab depth)

Live load, LL	20.00	kPa
Superimposed dead load, SDL_{plan}	0.00	kPa
Dead load of slab, DL = $h_{slab}.\rho_c$	6.00	kPa
ULS slab loading, $\omega_{ULS,slab}$ (a.k.a. n) = 1.4 (DL + SDL_{plan}) + 1.6 LL	40.40	kPa

Beam Loading (Elevation Loading) — Elastic Moments Effects

Superimposed dead load on beam, $SDL_{elev,beam}$	0.00	kN/m

Edge Loading (Elevation Loading) — Elastic Moments Effects

Superimposed dead load on edge, $SDL_{elev,edge}$	0.00	kN/m

Parameters of Beam

Interior or edge beam ?	Edge Beam	
(affects tributary width for loading on beam, available beam spacing for effective width in cont case)		
Downstand depth of beam (excluding slab), $h_{d,beam}$	1000	mm
Width of beam, $b_{w,beam}$	300	mm
Dead load on beam downstand, $DL_{beam} = h_{d,beam} b_{w,beam} \rho_c$	7.20	kN/m
Sag moment beam, $M_{sag,beam}$	297	kNm
Hog moment beam, $M_{hog,beam}$	464	kNm
Shear beam, V_{beam}	371	kN
Span (for effective width and deflection calcs) = l_b	6.000	m
Available beam spacing (effective width calcs in continuous case) = l	2.500	m
Sag section type	L - continuous	
Hog section type	Rect - continuous	
Overall depth, h_{beam} (downstand if precast, downstand + slab if cont)	1250	mm

For sagging: tension steel diameter, $\phi_{t,sag}$ and number	25	6	
For sagging: compression steel diameter, $\phi_{c,sag}$ and number	None	0	
For sagging: add cover to compression steel, $cover_{add,c,sag} = \phi_h$		16	mm
For hogging: tension steel diameter, $\phi_{t,hog}$ and number	25	6	
For hogging: add cover to tensile steel, $cover_{add,t,hog} = cover_{add,c,sag}$		16	mm
For hogging: compression steel diameter, $\phi_{c,hog}$ and number	None	0	
Link diameter ϕ_{link}, number and pitch	10 / 2	200	mm

For sagging: number of layers of tensile steel, $n_{layers,tens,sag}$		2	layer(s)
For sagging: number of layers of compression steel, $n_{layers,comp,sag}$		1	layer(s)
Ratio β_b=1.2 (sagging) or 0.8 (hogging) unless single span or conti	1.0	1.0	
For hogging: number of layers of tensile steel, $n_{layers,tens,hog}$		2	layer(s)
For hogging: number of layers of compression steel, $n_{layers,comp,hog}$		1	layer(s)

Parameters of Edge Beam

Downstand edge beam ?		Yes	
(obtains relevant values from the two sections below)			
Width (no downstand), b_{eff} or web width (with downstand), $b_{w,edge}$		300	mm
Dead load on edge beam downstand, DL_{edge}		7.20	kN/m
Sag moment edge beam, $M_{sag,edge}$		31	kNm
Hog moment edge beam, $M_{hog,edge}$		49	kNm
Shear edge beam, V_{edge}		47	kN
Span (for effective width and deflection calcs) = l		5.000	m
Available beam spacing (effective width calcs in continuous case) = $l_b/2$		3.000	m
Sag section type		L - continuous	
Hog section type		Rect - continuous	
Overall depth, h_{edge}		1250	mm
Effective width, b_{eff} = span/10 if single span, span/14.29 if multi-span		350	mm
Dead load excluding downstand, $\omega_{edge,DL}$ = (b_{eff} or $b_{w,edge}$ + b_{eff}).h_{slab}.ρ_c		3.90	kN/m
With Downstand Depth			
Downstand depth of edge beam (excluding slab), $h_{d,edge}$		1000	mm
Width of edge beam, $b_{w,edge}$		300	mm
Dead load on edge beam downstand, DL_{edge} = $h_{d,edge}b_{w,edge}\rho_c$		7.20	kN/m
Sag section type		L - continuous	
Hog section type		Rect - continuous	
Overall depth, h_{edge} (downstand if precast, downstand + slab if con		1250	mm
Without Downstand Depth			
Downstand depth of edge beam (excluding slab), $h_{d,edge}$ = 0.0		0	mm
Width of edge beam, $b_{w,edge}$ = 0.0		0	mm
Dead load on edge beam downstand, DL_{edge} = 0.0		0.00	kN/m
Sag section type		Rect - continuous	
Hog section type		Rect - continuous	
Overall depth, h_{edge} (slab)		250	mm
For sagging: tension steel diameter, $\phi_{t,sag}$ and number	20	6	
For sagging: compression steel diameter, $\phi_{c,sag}$ and number	None	0	
For hogging: tension steel diameter, $\phi_{t,hog}$ and number	20	6	
For hogging: compression steel diameter, $\phi_{c,hog}$ and number	None	0	
Link diameter ϕ_{link}, number and pitch	10 / 2	200	mm
For sagging: number of layers of tensile steel, $n_{layers,tens,sag}$		2	layer(s)
For sagging: number of layers of compression steel, $n_{layers,comp,sag}$		1	layer(s)
Ratio β_b=1.2 (sagging) or 0.8 (hogging) unless single span or conti	1.0	1.0	
For hogging: number of layers of tensile steel, $n_{layers,tens,hog}$		2	layer(s)
For hogging: number of layers of compression steel, $n_{layers,comp,hog}$		1	layer(s)

Note b_{eff} is the assumed (insitu) continuous (without downstand) edge beam width in the case of precast slab.

CONSULTING ENGINEERS	Engineering Calculation Sheet Consulting Engineers	Job No.	Sheet No.	Rev.
		jXXX	4	
		Member/Location		
Job Title	Member Design - Reinforced Concrete One Way Spanni	Drg.		
Member Design - RC One Way Spanning Slab		Made by XX	Date 21/11/2021	Chd.

Utilisation Summary (Slab)

Item	UT	Remark
Sag moment, M_s	86%	OK
Hog moment, M_h	80%	OK
% Min sag reinforcement	29%	OK
% Min hog reinforcement	16%	OK
Ultimate shear stress	10%	OK
Shear design capacity	55%	OK
Deflection requirements	91%	OK
Total utilisation precast slab	**91%**	**OK**
Total utilisation continuous slab	**91%**	**OK**
Detailing requirements	**OK**	

Utilisation Summary (Beam)

Automatic design **All Beams**

Item	UT	Detailing	Remark	
Beam sagging	**35%**	**OK**	**OK**	Beam Sag
Beam hogging	**35%**	**OK**	**OK**	Beam Hog
Edge beam sagging	**35%**	**OK**	**OK**	EBeam Sag
Edge beam hogging	**35%**	**OK**	**OK**	EBeam Hog

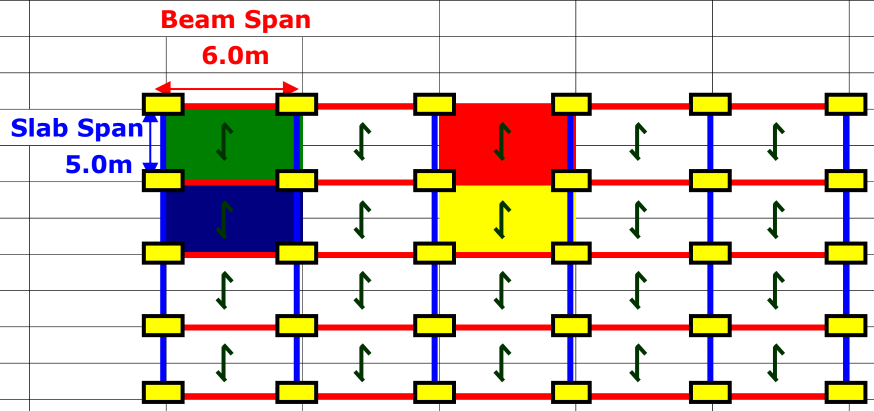
Overall Utilisation Summary

Overall utilisation	**91%**	
Overall detailing requirements	**OK**	
% Sagging reinforcement	**0.45**	%
% Hogging reinforcement	**0.80**	%
Estimated steel reinforcement quantity (130 – 220kg/m^3)	**99**	kg/m^3
[7.850 . ($A_{s,prov,s}$ +$A_{s,prov,h}$) / h_{slab}]; No curtailment; No laps; Links ignored; Distribution steel igno		
Estimated steel reinforcement quantity (130 – 220kg/m^3)	**157**	kg/m^3 *IStructE*
[12.5 . ($A_{s,prov,s}$ +$A_{s,prov,h}$) / h_{slab}]; Curtailment; Laps; Links ignored; Distribution steel;		
[Note that steel quantity in kg/m^3 can be obtained from 125.0 x % rebar];		
Material cost: concrete, c 180 units/m^3 steel, s	4500	units/tonne
Reinforced concrete material cost = [c+(est. rebar quant).s].h_{slab}	**222**	units/m^2

CONSULTING ENGINEERS	Engineering Calculation Sheet Consulting Engineers	Job No.	Sheet No.	Rev.
		jXXX	5	
		Member/Location		
Job Title	Member Design - Reinforced Concrete One Way Spanni	Drg.		
Member Design - RC One Way Spanning Slab		Made by XX	Date 21/11/2021	Chd.

Plan Layout

Multi-Span Slab Multi-Span Beam Floor Plate



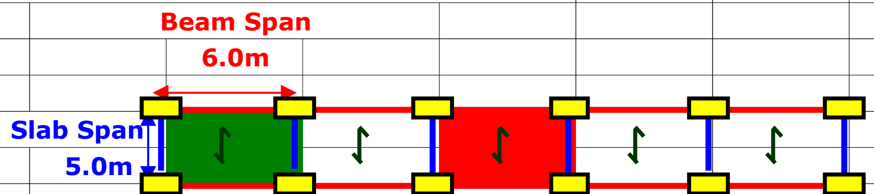
Relevant Panels		
	Interior	
	Edge of Slab Span	
	Edge of Beam Span	
	Corner	

Construction Type	***Support Conditions***
Continuous (Simple or Cont End)	*Continuous*
Precast	*Simply Supported*

Number of slab spans	*Multi-span*
Number of beam spans	*Multi-span*

Single-Span Slab Multi-Span Beam Floor Plate

ed;



Relevant Panels		
	Interior	N/A
	Edge of Slab Span	
	Edge of Beam Span	N/A
	Corner	

Construction Type	***Support Conditions***
Continuous (Simple or Cont End)	*Continuous*
Precast	*Simply Supported*

Number of slab spans	*Single-span*
Number of beam spans	*Multi-span*

CONSULTING ENGINEERS	Engineering Calculation Sheet Consulting Engineers	Job No.	Sheet No.	Rev.
		jXXX	6	
		Member/Location		
Job Title	Member Design - Reinforced Concrete One Way Spanni	Drg.		
Member Design - RC One Way Spanning Slab		Made by XX	Date 21/11/2021	Chd.

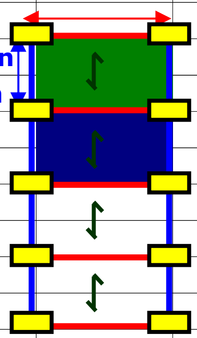
Multi-Span Slab Single-Span Beam Floor Plate

Beam Span

6.0m

Slab Span

5.0m



Relevant Panels

Interior	N/A
Edge of Slab Span	N/A
Edge of Beam Span	
Corner	

Construction Type	***Support Conditions***
Continuous (Simple or Cont End)	*Continuous*
Precast	*Simply Supported*

Number of slab spans	*Multi-span*
Number of beam spans	*Single-span*

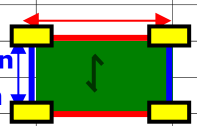
Single-Span Slab Single-Span Beam Floor Plate

Beam Span

6.0m

Slab Span

5.0m



Relevant Panels

Interior	N/A
Edge of Slab Span	N/A
Edge of Beam Span	N/A
Corner	

Construction Type	***Support Conditions***
Continuous (Simple or Cont End)	*Continuous*
Precast	*Simply Supported*

Number of slab spans	*Single-span*
Number of beam spans	*Single-span*

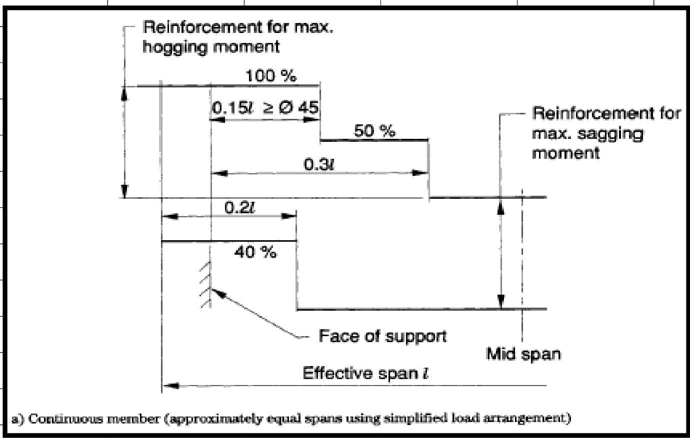
Note that simple or continuous end slab support conditions refer to the end supports of multi-span continuous slabs and not single-span slabs, where the end connection is continuous unless precast.

CONSULTING ENGINEERS	Engineering Calculation Sheet Consulting Engineers	Job No. jXXX	Sheet No. 7	Rev.
		Member/Location		
Job Title	Member Design - Reinforced Concrete One Way Spanni	Drg.		
Member Design - RC One Way Spanning Slab		Made by XX	Date 21/11/2021	Chd.

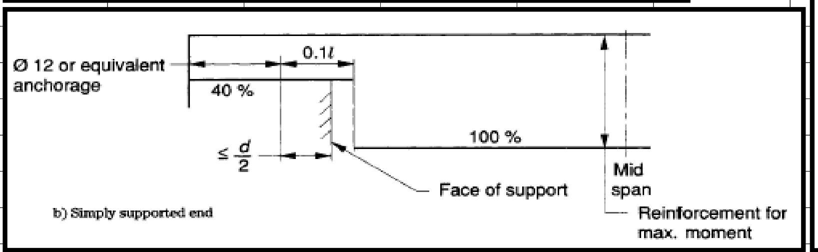
Assumptions and Limitations

1 *Moment effects for slabs may be calculated based on redistributed effects or elastic effects.*
2 *Moment effects for beams may be calculated based on redistributed effects or elastic effects.*

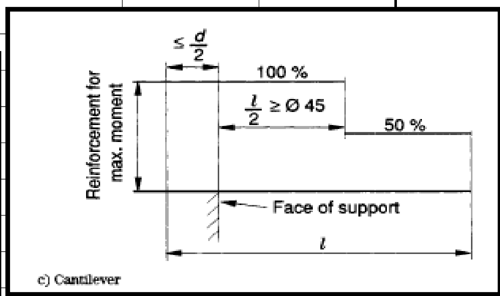
Detailing Instructions



a) Continuous member (approximately equal spans using simplified load arrangement)



b) Simply supported end



c) Cantilever

Detailing Steel Positions

Note that the distribution slab reinforcement is assumed to be interior to main slab reinforcement;
Note that the main beam reinforcement is assumed to be interior to main slab reinforcement;
Note that the main edge beam reinforcement is assumed to be at same level as main slab reinforcement;

Note the same cover to all reinforcement used for the slab is used for the beam;

CONSULTING ENGINEERS	Engineering Calculation Sheet Consulting Engineers	Job No.	Sheet No.	Rev.
		jXXX	8	
		Member/Location		
Job Title	Member Design - Reinforced Concrete One Way Spanni	Drg.		
Member Design - RC One Way Spanning Slab		Made by **XX**	Date **21/11/2021**	Chd.

Structural Analysis Slab

Design ULS total load for per span, F = n.l **202** kN/m

Table 3.12 — Ultimate bending moment and shear forces in one-way spanning slabs

	End support/slab connection				At first interior support	Middle interior spans	Interior supports
	Simple		Continuous				
	At outer support	Near middle of end span	At outer support	Near middle of end span	*– 0.125Fl*	*0.050Fl[#PL]*	*– 0.083Fl*
Moment	0	$0.086Fl$	$-0.04Fl$	$0.075Fl$	$-0.086Fl$	$0.063Fl$	$-0.063Fl$
Shear	$0.4F$	*0.080Fl*	$0.46F$	*0.080Fl*	$0.6F$	—	$0.5F$

NOTE F is the total design ultimate load ($1.4G_k + 1.6Q_k$);
l is the effective span.

Note elastic moment effects. [#PL]

Note allowance has been made in this

Design for a single load case of maximum design ultimate load on all spans or panels will be sufficient provided that the following conditions are met:

(a) In a one-way spanning slab the area of each bay exceeds 30m². In this context, a bay means a strip across the full width of a structure bounded on the other two sides by lines of supports (see Fig. 2)
(b) The variation in the spans does not exceed 15% of the longest span
(c) The ratio of the characteristic imposed load to the characteristic dead load does not exceed 1.25
(d) The characteristic imposed load does not exceed 5kN/m², excluding partitions
(e) In the analysis the elastic support moments other than at a cantilever support should be reduced by 20%, with a consequential increase in the span moments. The resulting bending moment envelope should satisfy the following provisions:
(i) Equilibrium must be maintained
(ii) The redistributed moment at any section should not be less than 70% of the elastic moment.

Sag moment for s/s case = 0.125F.l *(precast or single span)* 126 kNm/m
Hog moment for s/s case = 63 kNm/m
0.0F.l *(precast)* , 0.0625F.l *(single span continuous - simple or continuous end)*
Shear for s/s case = 0.5F *(precast or single span)* 101 kN/m

	Simple End		**Continuous End**		**Interior**			
	At outer support	Near middle of end span	At outer support	Near middle of end span	At first interior support	Middle of interior spans	Interior supports	
Moment	0	81	40	81	126	51	84	kNm/m
Shear	81	N/A	93	N/A	121	N/A	101	kN/m

Note that for edge panels, the shear force has been calculated for the less critical outer support instead of the first interior support because the SDL will be more critical here due to the external cladding.

Sag moment, M_{sag} **81** kNm/m
Hog moment, M_{hog} **126** kNm/m
Shear, V **93** kN/m

CONSULTING ENGINEERS	Engineering Calculation Sheet Consulting Engineers	Job No.	Sheet No.	Rev.
		jXXX	9	
		Member/Location		
Job Title	Member Design - Reinforced Concrete One Way Spanni	Drg.		
Member Design - RC One Way Spanning Slab		Made by **XX**	Date **21/11/2021**	Chd.

Structural Analysis Beam

Slab UDL on beam, ω_{beam} = V	93	kN/m
ULS beam, $\omega_{ULS,beam}$ = F.ω_{beam}+1.4$SDL_{elev,beam}$+1.4DL_{beam}	103	kN/m

(Factor F: Interior beams F = 2, whilst edge beams F = 1)

Table 3.5 — Design ultimate bending moments and shear forces

	At outer support	Near middle of end span	At first interior support	At middle of interior spans	At interior supports
Moment	0	$0.09Fl$	$-0.11Fl$	$0.07Fl$	$-0.08Fl$ / $-0.083Fl$
Shear	$0.45F$	$0.08Fl$	$0.6F$ / $-0.125Fl$	$0.05Fl^{\#PL}$	$0.55F$

NOTE l is the effective span; F is the total desi... No redistribution of the m...

Note elastic moment effects. #PL pattern loading factor 1.2;

Note allowance has been made in this table for 20% moment redistribution;

Interior or End Beam ? End Beam

Note that the coefficients above are appropriate to the interior or edge panel as follows.

	Sag	*Hog*	*Shear*
Interior Beam	*0.050*	*0.083*	*0.550*
End Beam	*0.080*	*0.125*	*0.600*
Single Span Beam	*0.125*	*0.063*	*0.500*

Note that the beams are always continuous (unless single span) since monolithic with columns, but the slab can be continuous (unless single span) or precast.

Sag moment beam, $M_{sag,beam}$ = coeff.($\omega_{ULS,beam}$. l_b)l_b	**297**	kNm
Hog moment beam, $M_{hog,beam}$ = coeff.($\omega_{ULS,beam}$. l_b)l_b	**464**	kNm
Shear beam, V_{beam} = coeff.($\omega_{ULS,beam}$. l_b)	**371**	kN

Structural Analysis Edge Beam

Slab UDL on edge beam, ω_{edge} = assumed 1.4 x $\omega_{edge,DL}$	5	kN/m
ULS beam, $\omega_{ULS,edge}$ = ω_{edge}+1.4$SDL_{elev,edge}$+1.4DL_{edge}	16	kN/m

Table 3.5 — Design ultimate bending moments and shear forces

	At outer support	Near middle of end span	At first interior support	At middle of interior spans	At interior supports
Moment	0	$0.09Fl$	$-0.11Fl$	$0.07Fl$	$-0.08Fl$ / $-0.083Fl$
Shear	$0.45F$	$0.08Fl$	$0.6F$ / $-0.125Fl$	$0.05Fl^{\#PL}$	$0.55F$

NOTE l is the effective span; F is the total desi... No redistribution of the m...

Note elastic moment effects. #PL pattern loading factor 1.2;

Note allowance has been made in this table for 20% moment redistribution;

Interior or End Beam ? End Beam

Note that the coefficients above are appropriate to the interior or edge panel as follows.

	Sag	*Hog*	*Shear*
Interior Edge Beam	*0.050*	*0.083*	*0.550*
End Edge Beam	*0.080*	*0.125*	*0.600*
Single Span Edge Beam	*0.125*	*0.063*	*0.500*

Note that the beams are always continuous (unless single span) since monolithic with columns, but the slab can be continuous (unless single span) or precast.

Sag moment edge beam, $M_{sag,edge}$ = coeff.($\omega_{ULS,edge}$. l)l	**31**	kNm
Hog moment edge beam, $M_{hog,edge}$ = coeff.($\omega_{ULS,edge}$. l)l	**49**	kNm
Shear edge beam, V_{edge} = coeff.($\omega_{ULS,edge}$. l)	**47**	kN

CONSULTING ENGINEERS	Engineering Calculation Sheet Consulting Engineers	Job No.	Sheet No.		Rev.
		jXXX	10		
		Member/Location			
Job Title	Member Design - Reinforced Concrete One Way Spanni	Drg.			
Member Design - RC One Way Spanning Slab		Made by XX	Date 21/11/2021		Chd.

Slab Moment Design

Sag moment, M_{sag}	81	kNm/m
Hog moment, M_{hog}	126	kNm/m

Ensure singly reinforced $K = M/bd^2f_{cu}$ $z = d\left\{0.5+\sqrt{\left(0.25-\frac{K}{0.9}\right)}\right\}$ z <=0.95d $A_s = \frac{M}{(0.95f_y)z}$

$K' = 0.156$ $K' = 0.402(\beta_b - 0.4) - 0.18(\beta_b - 0.4)^2$

	K'	K	z	A_s	$A_{s,prov}$	UT	
Sag moment, M_{sag}	0.156	0.055	191	970	1131	86%	OK
Hog moment, M_{hog}	0.156	0.088	180	1608	2011	80%	OK

Note unless precast, single span or continuous elastic whereby β_b = 1.00 and K' = 0.156, K' calculated with β_b = 1.20 (sagging) or 0.80 (hogging), however K' for β_b ≥ 0.90 truncated at 0.156.
If K > K', then UT = 999%. Note that A_s and $A_{s,prov}$ above are in units of mm^2/m.

% Min sag reinforcement (>= 0.0024bh G250; >= 0.0013bh G460)	0.45	%	
% Min sag reinforcement utilisation	29%		OK
% Min hog reinforcement (>= 0.0024bh G250; >= 0.0013bh G460)	0.80	%	
% Min hog reinforcement utilisation	16%		OK

Slab Shear Design

Ultimate shear stress, v_{ult}=V/bd_h (< $0.8f_{cu}^{0.5}$ & 5N/mm^2)	0.46	N/mm^2	
Ultimate shear stress utilisation	10%		OK
Design shear stress, v_d=V/bd_h	0.46	N/mm^2	

*(Conservatively, shear capacity enhancement by **either** calculating v_d at d from support and comparing against unenhanced v_c as clause 3.4.5.10 BS8110 **or** calculating v_d at support and comparing against enhanced v_c within 2d of the support as clause 3.4.5.8 BS8110 ignored;)*

Area of tensile steel reinforcement provided, $A_{s,prov,h}$	2011	mm^2/m
ρ_w = 100$A_{s,prov,h}$/bd_h	1.00	%
$v_c = (0.79/1.25)(\rho_w f_{cu}/25)^{1/3}(400/d_h)^{1/4}$; ρ_w<3; f_{cu}<40; $(400/d_h)^{1/4}$>0.67	0.84	N/mm^2

Check v_d < v_c for no links	**VALID**	
Concrete shear capacity v_c.(bd_h)	169	kN/m
Check v_c < v_d < 0.4 + v_c for nominal links	**N/A**	
Provide nominal links such that A_{sv} / S > 0.4b/(0.95f_{yv}) i.e. A_{sv} / S	0.92	mm^2/mm/m
Concrete and nominal links shear capacity (0.4 + v_c).(bd_h)	250	kN/m
Check v_d > 0.4 + v_c for design links	**N/A**	
Provide shear links A_{sv} / S > b(v_d-v_c)/(0.95f_{yv}) i.e. A_{sv} / S >	0.92	mm^2/mm/m
Concrete and design links shear capacity ($A_{sv,prov}$/S).(0.95f_{yv}).d_h +	169	kN/m

Area provided by all links per metre, $A_{sv,prov}$	0	mm^2/m	
Tried $A_{sv,prov}$ / S value	0.00	mm^2/mm/m	
Design shear resistance utilisation	55%		OK

Detailing Requirements

All detailing requirements met ?	OK		
Max sagging steel reinforcement pitch (<3d_s, <750mm)	100	mm	OK
Max hogging steel reinforcement pitch (<3d_h, <750mm)	100	mm	OK

Maximum pitch of bars: (Notation as for BS 8110)

	%A_s/bh	Maximum Pitch (mm)
Main bars :	0.5 or less	300
	1.0 or more	150

Max sagging steel reinforcement pitch	100	mm	OK
Max hogging steel reinforcement pitch	100	mm	OK
Min sagging steel reinforcement pitch (>75mm+ϕ_s, >100mm+ϕ_s if T40)	100	mm	OK
Min hogging steel reinforcement pitch (>75mm+ϕ_h, >100mm+ϕ_h if T40)	100	mm	OK

Note an allowance has been made for laps in the min pitch by increasing the criteria by the bar diameter.

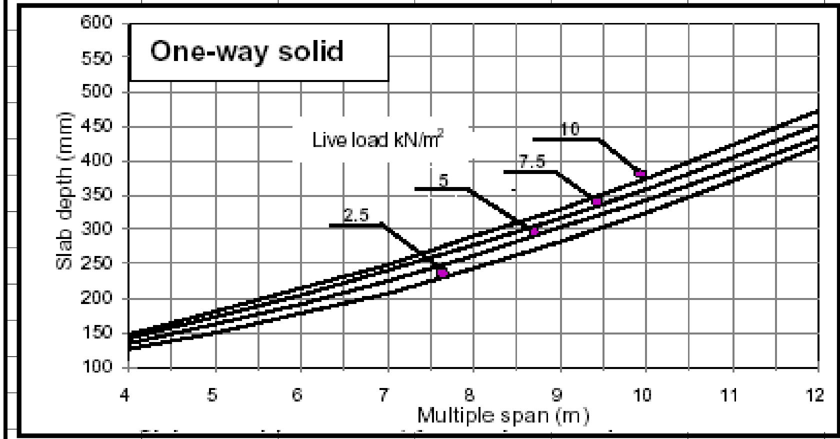
% Max sagging reinforcement (<= 0.04bh)	0.45	%	OK
% Max hogging reinforcement (<= 0.04bh)	0.80	%	OK
Sagging steel reinforcement diameter, ϕ_s (>=6mm)	12	mm	OK
Hogging steel reinforcement diameter, ϕ_h (>=6mm)	16	mm	OK

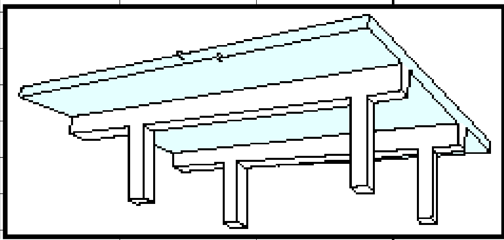
Deflection Criteria

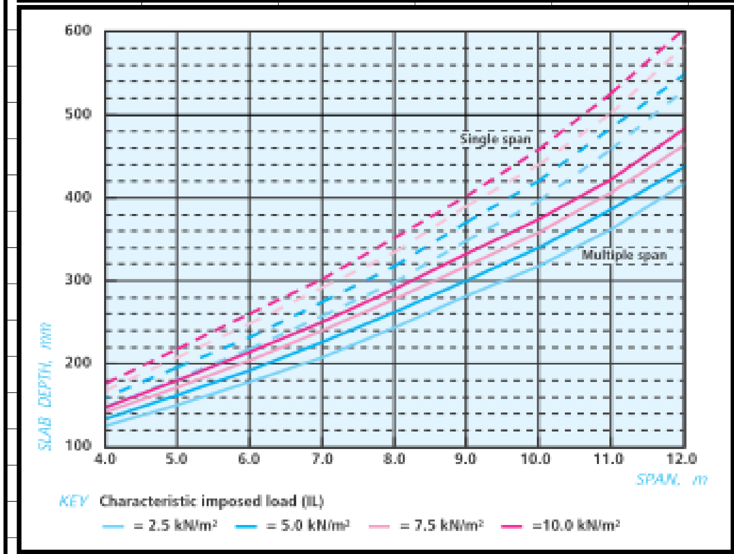
Span, l	5.000	m	
Span, l / effective depth, d_s ratio	**24.5**		
Basic span / effective depth ratio criteria (20 precast or single span; 23 edge;	23.0		
Multiplier $C_{1,\text{span more or less than 10m}}$ — Include	1.00		
Modification factor for tension C_2			
M_{sag}/bd_s^2	1.94	N/mm^2	
$f_s = \frac{2 f_y A_{s\ req}}{3 A_{s\ prov}} \times \frac{1}{\beta_b}$ (β_b=1.2 unless precast, single span or contir	263	N/mm^2	
Modification $0.55 + \frac{(477 - f_s)}{120\left(0.9 + \frac{M}{bd^2}\right)} \le 2.0$	1.18		
Modified span / effective depth ratio criteria	**27.1**		
Deflection utilisation	**91%**		**OK**

CONSULTING ENGINEERS	Engineering Calculation Sheet Consulting Engineers	Job No. jXXX	Sheet No. 13	Rev.
		Member/Location		
Job Title	Member Design - Reinforced Concrete One Way Spanni	Drg.		
Member Design - RC One Way Spanning Slab		Made by XX	Date 21/11/2021	Chd.

Scheme Design: One Way Spanning Solid Slab







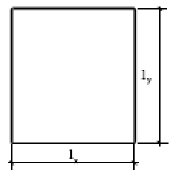
SLABS

Bending[3]

Simply supported on all sides:

$l_y > 1.5 l_x$ then one-way spanning, else $M = \frac{w l_x l_y}{24}$ kNm/m

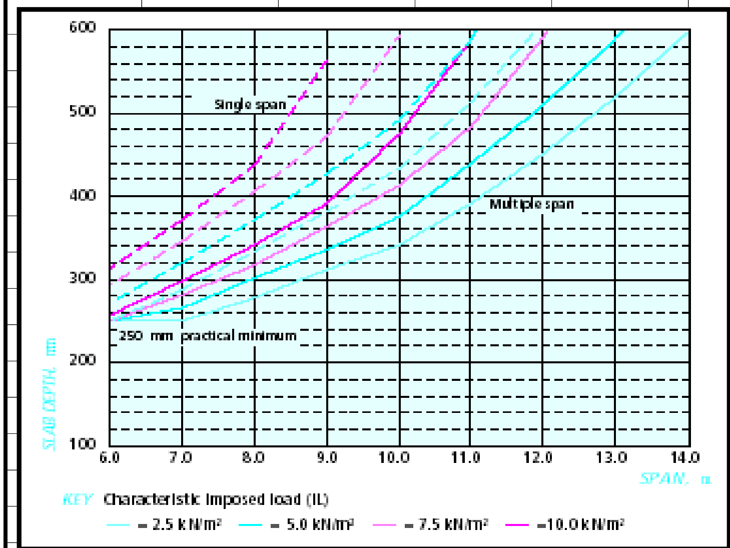
Design for bending as for beams (in 2 directions)

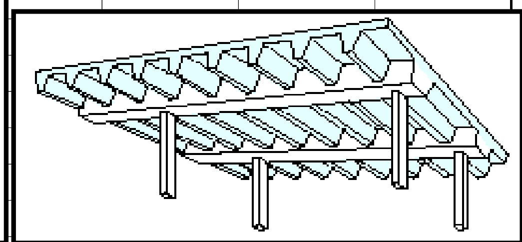


Continuous one-way spanning:

Bending moments and shear forces for one-way slabs					
	End support	End span	Penultimate support	Interior spans	Interior supports
Moment	0	0.086 Fl	-0.086 Fl	0.063 Fl	-0.063 Fl
Shear	0.4 F	-	0.6 F	-	0.5 F

Scheme Design: One Way Spanning Ribbed Slab





Beam Section Input Description

A. Beam

	Depth	Width	Sag Section
Continuous	*slab + downstand*	b_w	*T - continuous*
Precast	*downstand*	b_w	*Rect - continuous*

B. Beam at Edge of Slab Span

	Depth	Width	Sag Section
Continuous	*slab + downstand*	b_w	*L - continuous*
Precast	*downstand*	b_w	*Rect - continuous*

C. Edge Beam

	Depth	Width	Sag Section
Continuous			
No downstand	*slab*	b_{eff}	*Rect - continuous*
With downstand	*slab + downstand*	b_w	*L - continuous*
Precast			
No downstand	*slab*	b_{eff}	*Rect - continuous*
With downstand	*downstand*	b_w	*Rect - continuous*

Typical Initial Span / Effective Depth Ratios

Table 3 Span/effective depth ratios for initial design of slabs

Imposed load kN/m²	One-way spanning: simply supported	One-way spanning: continuous	One-way spanning: cantilever	Two-way spanning: simply supported	Two-way spanning: continuous	Flat slab
5.0	23	30	11	30	39	28
10.0	21	27	10	27	35	25

Flat slab design should be based on the longer span dimension. For exterior panels, 85% of the ratios quoted in Table 3 should be used.

For ribbed slabs, 85% of the ratios quoted in Table 3 should be used.

Span-to-depth ratios for one-way spanning slabs

spans in the range 4 to 10 m.

Imposed load, Q_k (kN/m²)	Single span	Multiple span	Cantilever
2.5	27	32	10
5.0	25	30	9
7.5	24	28	8
10.0	23	27	7

Span-to-depth ratios for ribbed slabs

spans are in the range 6 to 12 m.

Imposed load, Q_k (kN/m²)	Supported by beams[a]			Ribs integral with band beam <11 m
	Single span <12 m	Multiple span		
		<10 m	10 – 12 m	
2.5	24	29	27	25
5.0	21	27	24	23
7.5	19	25	21	21
10.0	17	23	17	18

Key

a Refer to Section 2.10.1 to determine depth of beams

Table 1:
Span/depth ratios for *insitu* concrete slabs *(from Reynolds's Reinforced Concrete Designer's Handbook)*

Slab type	5 kN/m² Imposed load	10 kN/m² Imposed load
Simply supported one-way	27	24
Simply supported two-way	30	27
Continuous one-way	34	30
Continuous two-way	44	40
Cantilever	11	10
Flat slab	30	27

Table 2: Estimated depths of *insitu* concrete slabs spanning one way between down-stand beams

Span	4m	5m	6m	7m	8m	9m	10m
Single span thickness	150mm	175mm	225mm	250mm	300mm	350mm	450mm
Multi span thickness	125mm	150mm	175mm	200mm	250mm	300mm	325mm

Table 3: Estimated depths of *insitu* concrete slabs spanning one way between band-beams

Span	4m	5m	6m	7m	8m	9m	10m
Multi span thickness	125mm	125mm	125mm	175mm	200mm	200mm	225mm
End span thickness	125mm	125mm	150mm	175mm	200mm	250mm	275mm

One Way Spanning Ribbed Slab

*1. The one way spanning ribbed slab is beneficial for its **lighter weight** compared to the equivalent one way spanning solid slab;*

*2. The **dimensions** of the one way spanning ribbed slab should meet the following criteria:-*

(a) rib pitch <= 1500mm
*(b) rib width with one bar >= 75mm, rib width with two bars >= **125mm***
(c) rib depth (below topping slab) <= 4 x rib width (for avoidance of LTB effects)
*(d) topping slab thickness >= **50mm** AND >= 1/10th of the rib clear distance (not rib pitch)*
(e) solid slab the full thickness of the topping slab and the depth of the rib extending for a certain short distance from face of the support is required;

*3. The **design** of the one way spanning ribbed slab should incorporate the following with design moment and shear coefficients as per one way spanning solid slab:-*

*(a) **rib design: sagging moment and deflection design** of a **T-section** located at the point of maximum sagging moment, i.e. the midspan of the floor span*
Tributary loading width = rib pitch
Span = entire span of floor
Flange width = rib pitch
Flange depth = topping slab thickness
Web width = rib width
Web depth = rib depth (below topping slab)

*(b) **rib design: hogging moment and shear design** of a **rectangular section** located at the point the ribbed slab changes into the solid slab*
Tributary loading width = rib pitch
Span = span of ribbed floor only (excluding the solid slab)
Width = rib width
Depth = topping slab thickness + rib depth (below topping slab)

*(c) **solid slab design: hogging moment and shear design** of a **rectangular section** located at the point of maximum hogging moment, i.e. the support of the floor span*
Tributary loading width = arbitrary metre
Span = entire span of floor
Width = arbitrary metre
Depth = topping slab thickness + rib depth (below topping slab)

*(d) **topping slab design: sagging moment and deflection design** of a **rectangular section** located at the point of maximum sagging moment, i.e. the midspan of the topping slab span*
Tributary loading width = arbitrary metre
Span = rib pitch
Width = arbitrary metre
Depth = topping slab thickness

*(e) **topping slab design: hogging moment and shear design** of a **rectangular section** located at the point of maximum hogging moment, i.e. the support of the topping slab span*
Tributary loading width = arbitrary metre
Span = rib pitch
Width = arbitrary metre
Depth = topping slab thickness;

*4. The **minimum steel reinforcement** within the rib is 0.13% (high yield) or 0.24% (mild) of rib width x (topping slab thickness + rib depth (below topping slab)). Also the minimum bar diameter in a rib is 16mm. The minimum steel reinforcement within the topping slab is 0.12%;*