Concrete One-way Slabs

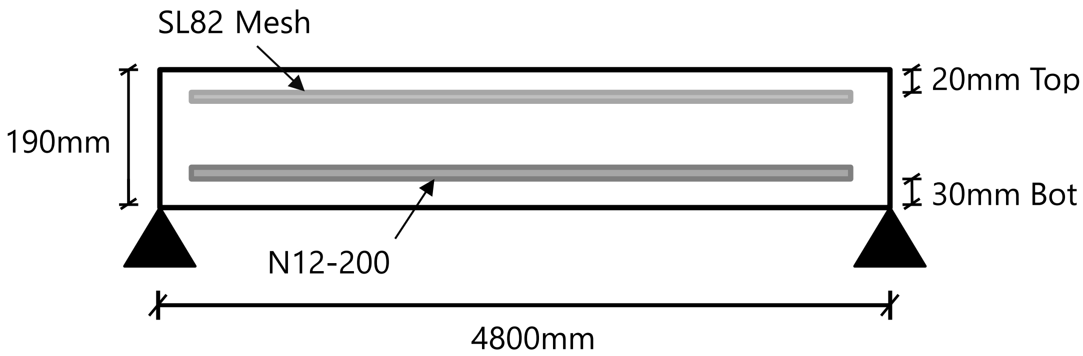
Rev 2, Updated 1 October 2020

By using the **[Concrete Member]** design module linked to the **[Analysis]** design module, one-way slabs can be designed. The following tutorial will outline the procedure for a few common one-way slab arrangements.

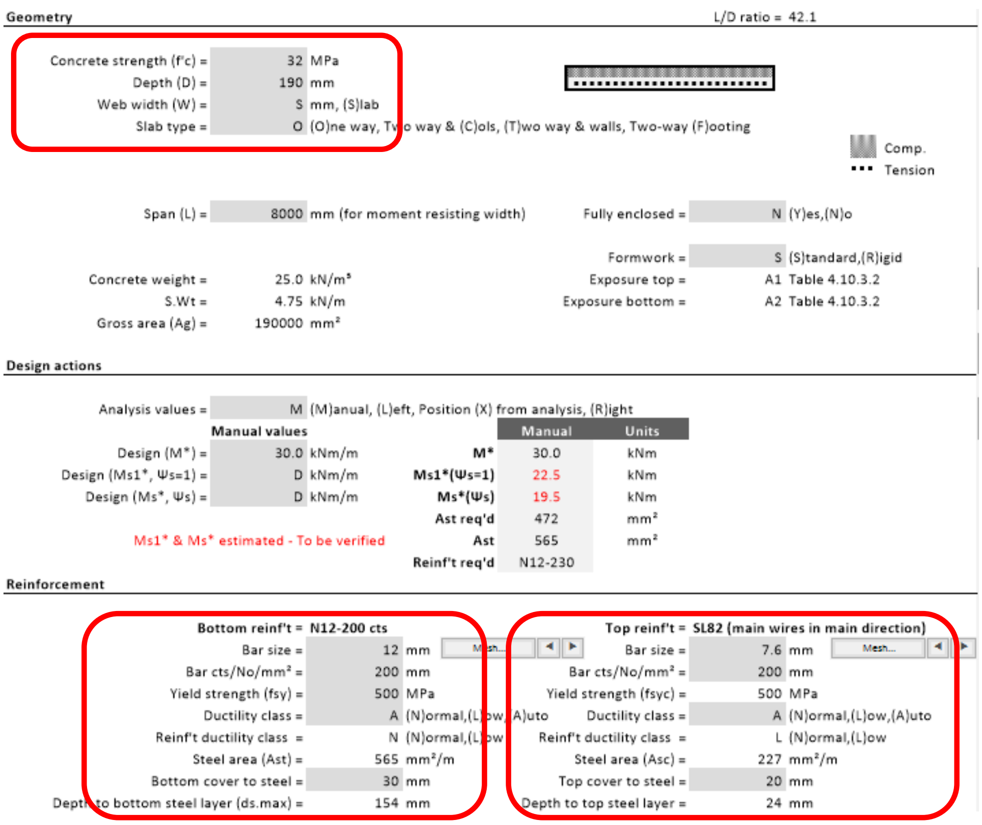
Simply supported One-way Slab

The first example is a simply supported concrete slab spanning 4.8m, supporting a superimposed dead load (finishes) of 0.5kPa and a domestic live load of 1.5kPa.

An initial trial thickness of 190mm will be used with the bottom reinforcement being ductile N12 at 200mm centres, and top reinforcement being low ductility SL82 mesh. Top cover will be 20mm, and bottom cover will be 30mm (Refer below). A strength of 32MPa is used for this example.



Using the above configuration, the design parameters are input into [Concrete Member] as shown below.



After inputting the basic design values, the loading for the analysis needs to be linked and input. This is done by clicking the [Analysis] button of to the side of the design page (see below). This will create a linked analysis document (Ana), which will be used to determine the moments and deflections for the slab.

Section:	**(Slab SL01) 190mm thk slab, f'c=32MPa**		
Reinf't:	**SL82 (main wires in main direction) top, N12-200 cts bottom, ku = 0.08**		
Strength:	**(+ve M) M* = 30.0kNm < øMuo = 35.3kNm**	**OK (0.85)**	
Cracking:	**fscr = 240MPa > Fscr = 225MPa & fscr1 = 276MPa < Fscr1 = 400MPa, crack width = 0.2mm**	**No Good (0.69,1.06)**	Minimum steel:
Ast.min:	**Ast.min = 318mm² < Ast = 565mm² (Minimum of Deemed and actual)**	**OK (0.56)**	Based on =
	Interior environment with εcsd.b*=800x10⁻⁶, εcs*=570x10⁻⁶		

Geometry L/D ratio = 42.1 Effective flange - Cl 8.8.2:

Concrete strength (f'c) = 32 MPa
Depth (D) = 190 mm
Web width (W) = S mm, (S)lab
Slab type = O (O)ne way, Two way & (C)ols, (T)wo way & walls, Two-way (F)ooting

Dist. b/n points of zero ben
Eff. flange (T-beam) = bw
Eff. flange (L-beam) = bw
Effective
Design wi
Design flang

Comp.
Tension

Span (L) = 8000 mm (for moment resisting width)
Fully enclosed = N (Y)es,(N)o

Fully enclosed element:
Refer clause 9.4.1 where internal

Formwork = S (S)tandard,(R)igid
Concrete weight = 25.0 kN/m³
Exposure top = A1 Table 4.10.3.2
S.Wt = 4.75 kN/m
Exposure bottom = A2 Table 4.10.3.2
Gross area (Ag) = 190000 mm²

Max M+*...

Design actions

Max M-*...

Analysis values = M (M)anual, (L)eft, Position (X) from analysis, (R)ight

Analysis...

	Manual values		**Manual**	**Units**
Design (M*) =	30.0 kNm/m	**M***	30.0	kNm

On the analysis loading document, input the span type and loadings. For this example, a superimposed dead load 0.5kPa (kN/m) and live load of 1.5kN/m is used. Note that this design is of a 1000mm wide slab strip. The span type is "S" representing a simply supported span, with the span length as 4800mm. Also ensure that the correct live load type has been set. The section properties are automatically calculated. Also note the Include S.Wt (self weight) is included and can be optionally removed.

Geometry for (Slab SL01 (Ana)): Concrete simple beam

Description = 190mm thk slab
Span (L) = 4800 mm
Span type = S (S)imple,(E)xt,(I)nt,(C)ant,(P)rop,(F)ixed,(O)ther
Material type = C (T)imber,(S)teel,(C)onc.,(SC)comp. steel,(O)ther

Ix = 571.5833333 x10⁶ mm⁴
Ag = 190000 mm²
Density = 25 kN/m³
E = 30024 MPa

Loading

Uniform loads (kN/m)			
Uniform loads	**UDL**	**Partial 1**	**Partial 2**
Dead load (wdl) =	0.50		
Live load (wll) =	1.50		
Start from LHS (mm) =	0		
End from LHS (mm) =	4800		
S.Wt =	4.75	kN/m	
Ultimate load (w*) =	8.55	0.00	0.00

Point loads (kN)			
Point loads	**PL 1**	**PL 2**	**PL 3**
Dead load (pdl) =			
Live load (pll) =			
Pos. from LHS (mm) =			
Ultimate load (p*) =	0.00	0.00	0.00

Include S.Wt = Y (Y)es,(N)o
Strength loadcase = C (D)ead Only,(C)omb.

Live Load type = Floor (Concrete)

Short term LL (Ψsu) =	0.70	(Ψsp) =	1.00
Long term LL (Ψlu) =	0.40	(Ψlp) =	0.60
Actual LL (Ψsa) =	0.70	(Ψla) =	0.40

Results at midspan (Max +ve M) Position of result (x) = 2400 mm

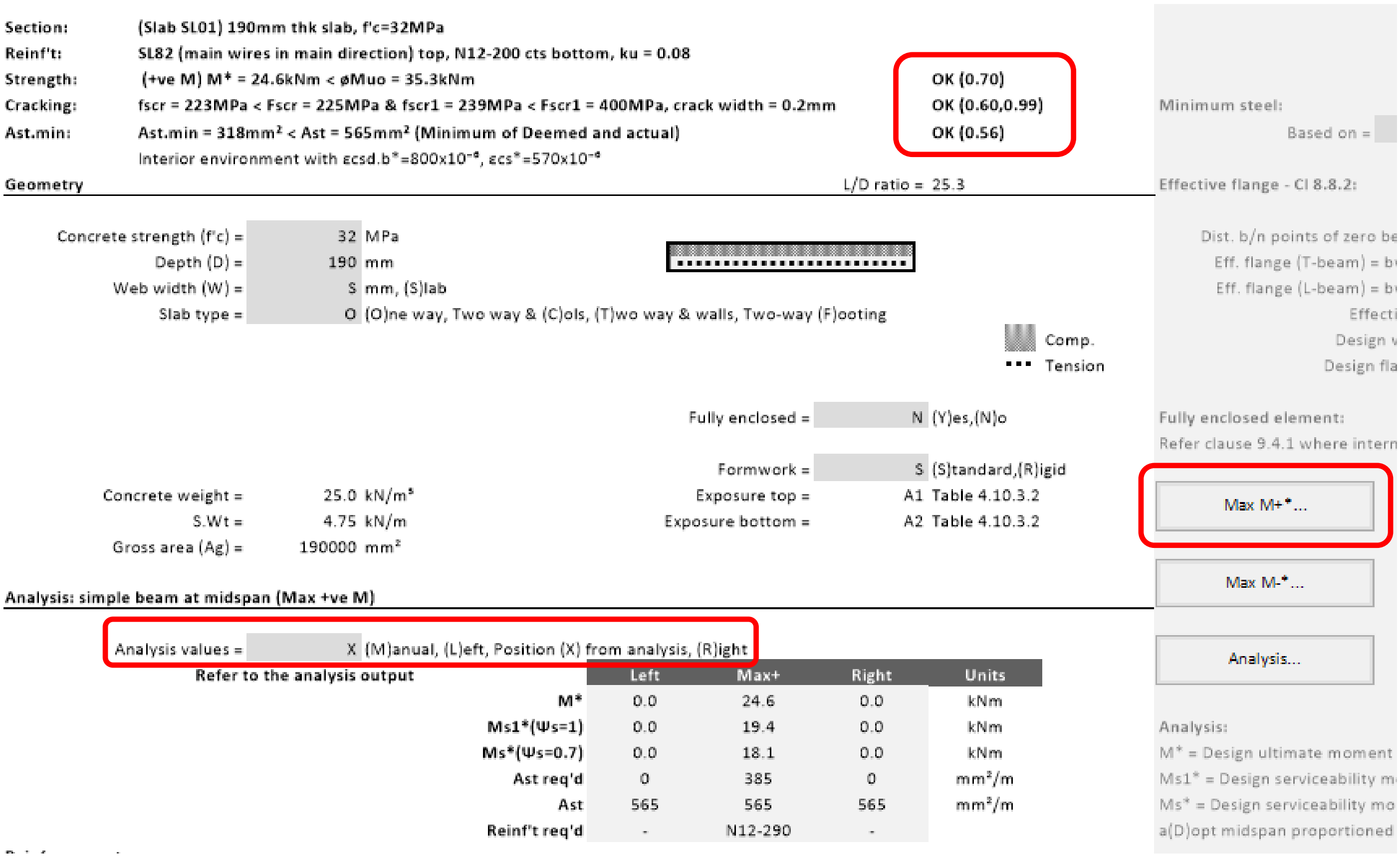
After the load input is complete, you will see the summary of actions and graphs representing moment, shear and gross immediate deflection. The deflections shown on this document do not represent the long-term concrete deflection (creep etc). This is calculated in a later step.

The maximum moment then needs to be transferred to the design document. This is done by clicking the [Max M+*...] button on the main document (see below) which transfers the maximum moment and position this occurs at (x) from the linked loading document.

Note that for a simply supported member, we are concerned with the positive sagging moments which will occur mid-span. There are no negative hogging moments for this case. If there were, we would be also considering these by clicking the [Max M-*...] button. We will see this used in a later example of a double span slab.

Note that a moment from a different location of the slab can be selected using the "Analysis values =" input box shown below along with the "Position of result (x) =" input box shown on the previous page in the analysis/loading document.

With the moment transferred, the moment capacity, cracking stresses and minimum steel requirements need to be verified.



Section: (Slab SL01) 190mm thk slab, f'c=32MPa
Reinf't: SL82 (main wires in main direction) top, N12-200 cts bottom, ku = 0.08
Strength: (+ve M) M* = 24.6kNm < øMuo = 35.3kNm — OK (0.70)
Cracking: fscr = 223MPa < Fscr = 225MPa & fscr1 = 239MPa < Fscr1 = 400MPa, crack width = 0.2mm — OK (0.60,0.99)
Ast.min: Ast.min = 318mm² < Ast = 565mm² (Minimum of Deemed and actual) — OK (0.56)
Interior environment with εcsd.b*=800x10⁻⁶, εcs*=570x10⁻⁶

Minimum steel:
Based on =

Geometry — L/D ratio = 25.3

Effective flange - Cl 8.8.2:

Concrete strength (f'c) = 32 MPa
Depth (D) = 190 mm
Web width (W) = S mm, (S)lab
Slab type = O (O)ne way, Two way & (C)ols, (T)wo way & walls, Two-way (F)ooting

Comp.
Tension

Dist. b/n points of zero be
Eff. flange (T-beam) = b
Eff. flange (L-beam) = b
Effecti
Design v
Design fla

Fully enclosed = N (Y)es,(N)o
Formwork = S (S)tandard,(R)igid
Exposure top = A1 Table 4.10.3.2
Exposure bottom = A2 Table 4.10.3.2

Fully enclosed element:
Refer clause 9.4.1 where intern

Concrete weight = 25.0 kN/m³
S.Wt = 4.75 kN/m
Gross area (Ag) = 190000 mm²

Max M+*...
Max M-*...
Analysis...

Analysis: simple beam at midspan (Max +ve M)

Analysis values = X (M)anual, (L)eft, Position (X) from analysis, (R)ight

Refer to the analysis output

	Left	Max+	Right	Units
M*	0.0	24.6	0.0	kNm
Ms1*(Ψs=1)	0.0	19.4	0.0	kNm
Ms*(Ψs=0.7)	0.0	18.1	0.0	kNm
Ast req'd	0	385	0	mm²/m
Ast	565	565	565	mm²/m
Reinf't req'd	-	N12-290	-	

Analysis:
M* = Design ultimate moment
Ms1* = Design serviceability m
Ms* = Design serviceability mo
a(D)opt midspan proportioned

If the section is over capacity, the initial geometry and reinforcement can be adjusted accordingly.

afs

Anthony Furr Software
ABN 74 992 513 430

97 Mount Pleasant Road
Nunawading, Victoria 3131

P 03 9878 4684
F 03 9878 4685

www.structuraltoolkit.com.au
support@structuraltoolkit.com.au

After verifying the moment capacity, crack stresses and minimum steel requirements, the next step is to verify the deflections. To do this, select the [Defl] tab at the bottom of the main document. Click [Max Deflection...] to transfer the results and position of the location of maximum deflection, and [Transfer Reinf't...], to transfer the current reinforcement configuration specified into the table shown.

These reinforcement areas may need to be manually adjusted depending on whether the reinforcement is different at the left side, middle and right sides of the span; and if the compression reinforcement is outside the compression zone, therefore not acting to stiffen the slab (kcs).

As can be seen below the SL82 mesh (N7.6-200mm) was transferred to the "Top reinf't" section, and the N12-200mm to the "bottom reinf't". As there is only a positive sagging moment in the centre of the slab (simply supported), the "Ast =" only designates reinforcement to this middle segment with the left and right ends not effective.

Section: (Slab SL01) 190mm thk slab, f'c=32MPa

Reinf't: SL82 (main wires in main direction) top, N12-200 cts bottom (Additional reo specified)

Defl'n: δ.dl = 8.0mm, δ.ll = 1.1mm, δ.inc = 10.0mm, δtotal = 15.3mm (span / 313) Warning

σcs for Interior environment with εcsd.b*=800x10⁻⁶, εcs*=570x10⁻⁶

[Max Deflection...]

Deflections - Cl 8.5.3 simple beam at midspan (Max +ve Def)

Concrete density (ρ) =	2400	kg/m³ Cl 3.1.3	Gross area (Ag) =	190000	mm²
Use fcmi? =	Y	(Y)es,(N)o	Uncr.g. neutral axis (NA) =	95	mm from top
fcmi =	35.3	MPa	Gross Stiffness (Ig) =	572	x10⁶ mm⁴ (w/o reinf't)
Deflection at =	X	(M)anual, (C)ritical, (L)eft, Position (X) from analysis, (R)ight			
Position (x) =	2400	mm	Steel Modulus (Es) =	200000	MPa Cl 3.2.2
Span type =	S		Mod. of elast. (Ec = ρ¹·⁵*0.043*√fcmi) =	30024	MPa ± 20% Cl 3.1.2
			Modular ratio (n = Es/Ec) =	6.661	

Stiffness based on bef or bf:
Use bef =
Note: Ag, Ig and na shown as
when bf used (rather than be

Position (x) for deflection:
Ensure position is at maximur

Deflection calculation

		Left	At x	Right	Units		
	Manual (M*) =				kNm		
	Manual (Ms*) =				kNm		
	Analysis (M*) =	0.0	24.6	0.0	kNm	Red values manually input	
	Analysis (Ms*) =	0.0	18.1	0.0	kNm		
Top reinf't:	Ast req'd =	0	0	0	mm²/m		
	Design Ast =	227	227	227	mm²/m		
	Ast =	0	227	0	mm²/m		
		-	N8-200	-		Short term LL factor (ψs) =	0.7
Bottom reinf't:	Ast req'd =	0	385	0	mm²/m	Long term LL factor (ψl) =	0.4
	Design Ast =	565	565	565	mm²/m		
	Ast =	0	565	0	mm²/m		
		-	N12-200	-			
	Uncracked NA =	95	96	95	mm	OS RCB-1.1(1) Fig 5.3	
	Uncracked uκ =	1.000	1.031	1.000	x10⁶ mm⁴		
	Iuncrk = uκ*W*D³/12 =	572	589	572	x10⁶ mm⁴	OS RCB-1.1(1) Eq 7.2(2)	
	Tensile steel (Ast) =	0	565	0	mm²/m		
	Depth to ds =	166	154	166	mm (From comp. face)		
	Comp. steel (Asc) =	0	227	0	mm²/m		
	dc =	36	24	36	mm (From comp. face)		
	Cracked κ =	0.000	0.198	0.000	mm	OS RCB-1.1(1) Fig 5.7	
	Depth to cracked NA = κ*ds =	0.0	30.5	0.0	mm (From top)		
	Use Comp. steel =	-	Yes	-			
	yt =	95	94	95	mm (From tensile fibre)		
	Design shrinkage strain εcs =	570	570	570	x10⁻⁶ ±30%	Interior env. refer Shrinkage tab	
	W (slab) =	1000	1000	1000	mm		
	Tension steel ratio (pw=Ast/(ds*W)) =	0.0000	0.0037	0.0000	pw < 0.005, Ief.max = 0.6*Ig		
	Comp. steel ratio (pcw=Asc/((D-dc)*W)) =	0.0000	0.0014	0.0000			
	σcs =	0.00	0.78	0.00	MPa		
	Mcr = (f'ct.f-σcs)*Ig/yt =	20.4	16.3	20.4	kNm	f'ct.f =	3.39 MPa
	Cracked κc =	0.000	0.220	0.000		OS RCB-1.1(1) Fig 5.7	

[Transfer Reinf't...]

Manual values:
To calculate the correct Iav, s
type in the Analysis module.

Area of steel:
+ve value overrides, -ve value
Comp.
Tension

fcmi - Table 3.1.2:
fcmi is approximated using th
fcmi = (-0.0015*f'c² +

Use Ast for Ig calculation:
Include the reinforcement in
Include reinf't =

Using compression steel:
If 'No' then comp. steel is in t

σcs: refer Cl 8.5.3.1
Use σcs =
σcs = (

Info / Design / Preview / Detailed / Shear / Defl / Creep&Shrink / Secondary / BeamDefl / SlabDefl

Note that there is a warning for **σcs** shown at the top in red. This is to alert the user to ensure the correct environment has been selected in the [Creep & Shrink] tab at the bottom – refer Clause 3.1.7.2. This variable will affect the Mcr (Cracking) value.

Another important factor to note is the **kcs** value (Clause 8.5.3.2), which is used for the long-term deflection calculation. It is a function of the ratio of compression steel to tension steel. This value is limited to 0.8 (when the compression steel area is greater or equal to the tension steel area). Increasing the amount of compression steel above the tensile steel area yields no benefit to long-term deflection with the kcs approach. The value of kcs is 2.0 when there is no compression steel contribution. Compression steel must be in compression and a warning is provided when the compression steel is in the tension zone there-fore being ineffective for kcs.

kcs = [2-1.2*(Asc/Ast)] ≥ 0.8 =	1.519	kcs at position x	Cl 8.5.3.2

For the example shown, the calculated deflection is slightly above what is desired in this case. To improve the performance, either the slab thickness must be changed, or the addition of greater compression steel which reduces the kcs, decreasing long-term deflections (providing the compression steel is not in the tension zone).

The area of compression steel can be changed two ways; by either manually editing the transferred reinforcement in the [Defl] tab (see below), or by changing the mesh in the [Design] tab and then clicking [Transfer Reinf't...] in the [Defl] tab again. **Ensure that if any change is made to the document or linked document that the [Max Deflection...] button is pressed again to re-verify.**

Top reinf't:	Ast req'd =	0	0	0	mm²/m
	Design Ast =	290	290	290	mm²/m
	Ast =	0	290	0	mm²/m
		-	N9-200	-	

OR

Top reinf't =	SL92 (main wires in main direction)	
Bar size =	8.6	mm
Bar cts/No/mm² =	200	mm
Yield strength (fsyc) =	500	MPa
Ductility class =	A	(N)ormal,(L)ow,(A)uto
Reinf't ductility class =	L	(N)ormal,(L)ow
Steel area (Asc) =	290	mm²/m

By changing the top reinforcement to SL92, the deflection is now acceptable, as seen below.

Section:	**(Slab SL01) 190mm thk slab, f'c=32MPa**	
Reinf't:	**SL92 (main wires in main direction) top, N12-200 cts bottom (Additional reo specified)**	
Defl'n:	**δ.dl = 6.8mm, δ.ll = 1.0mm, δ.inc = 8.6mm, δtotal = 13.6mm (span / 353)**	**OK**
	σcs for Interior environment with $\varepsilon_{csd.b}$*=800x10⁻⁶, ε_{cs}*=570x10⁻⁶	

afs

Anthony Furr Software
ABN 74 992 513 430

97 Mount Pleasant Road
Nunawading, Victoria 3131

P 03 9878 4684
F 03 9878 4685

www.structuraltoolkit.com.au
support@structuraltoolkit.com.au

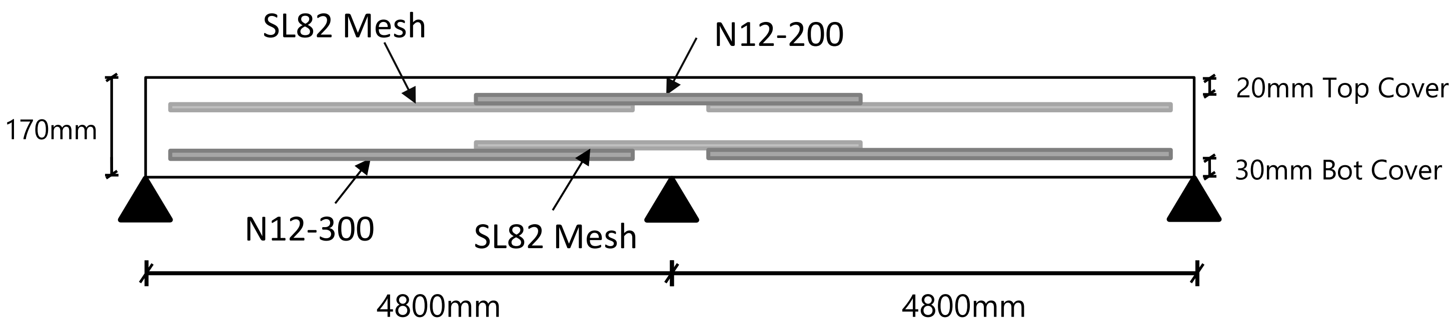
Double Span One-way Slab

Using the same process as the single span, a double span one-way slab can be designed using a few extra steps.

Like with the single span, the trial geometry and reinforcement are input. It would be reasonable to assume that for the same span, there will be a reduction in thickness. A double span results in the same maximum w*L^2/8 moment as a single span except this occurs at the middle support. The mid-span moment will reduce. Because of the reduction in thickness, the total moments as a result of dead load also reduces.

For this example, we will try using a 170mm thick slab with N12-200mm top and nominal SL82 bottom for negative bending, and N12-300mm bottom and SL82 top in positive bending. Top cover will be 20mm, and bottom cover will be 30mm as pre the previous example.

Note that the bottom reinforcement would generally be run continuously through, however, for simplicity we will maintain the reinforcement shown below.

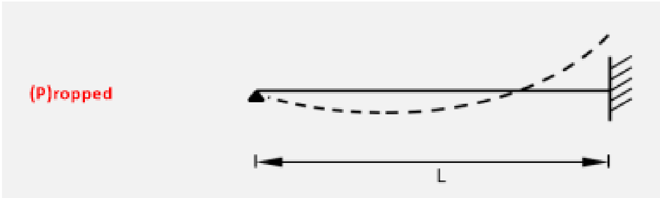


The above values are input as with the single span. Firstly the negative bending is reviewed. Enter N12-200mm in the top and SL82 in the bottom. The document then needs to be linked to the Analysis (Ana) loading document, by clicking the [Analysis...] button.

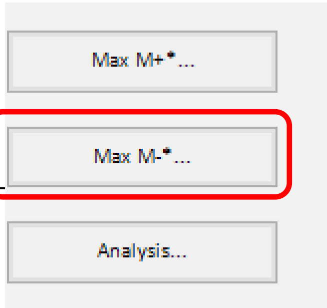
Bottom reinf't =	**SL82 (main wires in main direction)**		**Top reinf't =**	**N12-200 cts**	
Bar size =	7.6	mm	Bar size =	12	mm
Bar cts/No/mm² =	200	mm	Bar cts/No/mm² =	200	mm
Yield strength (fsy) =	500	MPa	Yield strength (fsyc) =	500	MPa
Ductility class =	A	(N)ormal,(L)ow,(A)uto	Ductility class =	A	(N)ormal,(L)ow,(A)uto
Reinf't ductility class =	L	(N)ormal,(L)ow	Reinf't ductility class =	N	(N)ormal,(L)ow
Steel area (Asc) =	227	mm²/m	Steel area (Ast) =	565	mm²/m
Bottom cover to steel =	30	mm	Top cover to steel =	20	mm

In the linked document, input the loading configuration. This is similar to the single span, except, in order to represent a double span, the “Span type” needs to be changed to propped (P) – see below. This will result in force and deflection diagrams that represent one span of a double span slab. Note that a propped cantilever results in the same moments and deflections as a double span of equal spans.

Description =	170mm thk slab	
Span (L) =	4800	mm
Span type =	P	(S)imple,(E)xt,(I)nt,(C)ant,(P)rop,(F)ixed,(O)ther
Material type =	C	(T)imber,(S)teel,(C)onc.,(SC)comp. steel,(O)ther



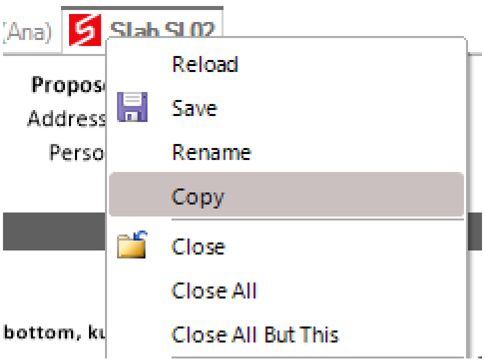
Once the loading has been input and the span type set as "P", the maximum negative (hogging) moment can be transferred to the main document by clicking [Max M-*...]. Note that the reactions for this segment (shown in the Analysis/Loading document) only represent one of the spans in isolation. This means that the middle support's reaction is half of its true double span reaction.



Once the section has been verified for moment capacity and cracking stress and minimum steel, the maximum positive moment needs to be checked. To do this, the reinforcement needs to be changed to the positive (sagging) moment location. This is done by manually editing the current document – in this example the top reinforcement is changed to SL82, and the bottom to N12-300mm.

Bottom reinf't =	N12-300 cts		Top reinf't =	SL82 (main wires in main direction)	
Bar size =	12	mm	Bar size =	7.6	mm
Bar cts/No/mm² =	300	mm	Bar cts/No/mm² =	200	mm
Yield strength (fsy) =	500	MPa	Yield strength (fsyc) =	500	MPa
Ductility class =	A	(N)ormal,(L)ow,(A)uto	Ductility class =	A	(N)ormal,(L)ow,(A)uto
Reinf't ductility class =	N	(N)ormal,(L)ow	Reinf't ductility class =	L	(N)ormal,(L)ow
Steel area (Ast) =	377	mm²/m	Steel area (Asc) =	227	mm²/m
Bottom cover to steel =	30	mm	Top cover to steel =	20	mm

Alternatively, the main document can be copied and edited separately, meaning each case is assessed on different documents. This can be done by right clicking on the document tab at the top and selecting [Copy]. The suggestion is to do this once the design has been fully completed.



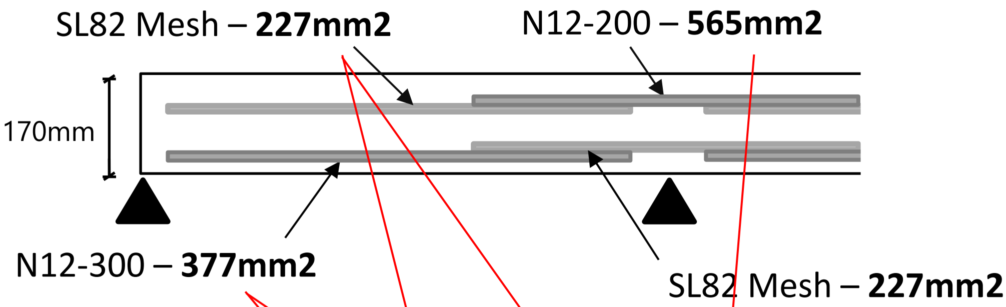
Once the reinforcement has been swapped, the maximum positive moment needs to be transferred by clicking the [Max M+*...] button on the main document's [Design] tab. This will then allow the verification of the moment capacity, cracking stresses and minimum steel in the sagging section.
Once the strength and cracking limits of both moment cases have been checked and any adjustments required made, the deflection can then be verified. Set the top and bottom bars to the maximum size (On the [Design] tab) to ensure appropriate cover and depth, N12 in this case – see below. Once done, move to the [Defl] tab.

Bottom reinf't =	N12-300 cts		Top reinf't =	N12-200 cts	
Bar size =	12	mm	Bar size =	12	mm
Bar cts/No/mm² =	300	mm	Bar cts/No/mm² =	200	mm
Yield strength (fsy) =	500	MPa	Yield strength (fsyc) =	500	MPa
Ductility class =	A	(N)ormal,(L)ow,(A)uto	Ductility class =	A	(N)ormal,(L)ow,(A)uto
Reinf't ductility class =	N	(N)ormal,(L)ow	Reinf't ductility class =	N	(N)ormal,(L)ow
Steel area (Asc) =	377	mm²/m	Steel area (Ast) =	565	mm²/m
Bottom cover to steel =	30	mm	Top cover to steel =	20	mm

Click [Max Deflection...] on the [Defl] tab to transfer the results and position of the location of maximum deflection. Check that the moments have been transferred correctly as shown below.

	Left	At x	Right	Units
Manual (M*) =				kNm
Manual (Ms*) =				kNm
Analysis (M*) =	0.0	12.8	-22.9	kNm
Analysis (Ms*) =	0.0	9.4	-16.7	kNm

Next, transfer the reinforcement by clicking [Transfer Reinf't] on the [Defl] tab. However, as the [Design] tab where the reinforcement is taken from only represents one segment of the slab (which is where the design was last performed which could be a negative or positive moment region). These reinforcement areas will need to be manual corrected to represent all segments. To do this, make note of the area of reinforcement for the left, middle and right sides both top and bottom and input them as shown below.



Top reinf't:	Ast req'd =	0	0	384	mm²/m
	Design Ast =	227	227	565	mm²/m
	Ast =	0	227	565	mm²/m
		-	N12-500	N12-200	
Bottom reinf't:	Ast req'd =	0	229	0	mm²/m
	Design Ast =	377	377	227	mm²/m
	Ast =	0	377	227	mm²/m
		-	N12-300	N12-500	

Depending on the geometry of the slab, the compression reinforcement (coloured in blue) may be in tension, and therefore provide no compression capacity. In this case a warning will appear like shown below. To amend this, remove the reinforcement highlighted in red by deleting the steel area.

Leaving these erroneous areas will result in a kcs that is unconservative.

	Analysis (M*) =	0.0	12.8	-22.9	kNm	Red values of M*/Ms* manually input	
	Analysis (Ms*) =	0.0	9.4	-16.7	kNm		Manual valu
Top reinf't:	Ast req'd =	0	0	384	mm²/m		To calculate
	Design Ast =	565	227	565	mm²/m		type in the A
	Ast =	0	227	565	mm²/m		
		-	N12-500	N12-200		Short term LL factor (ψs) = 0.7	Area of stee
Bottom reinf't:	Ast req'd =	0	229	0	mm²/m	Long term LL factor (ψl) = 0.4	+ve value ov
	Design Ast =	227	377	227	mm²/m		Comp.
	Ast =	0	377	227	mm²/m		Tension
		-	N12-300	N12-500			
	Uncracked NA =	85	85	84	mm	OS RCB-1.1(1) Fig 5.3	fcmi - Table
	Uncracked uκ =	1.000	1.023	1.035	x10⁶ mm⁴		fcmi is appro
	Iuncrk = uκ*W*D³/12 =	409	419	424	x10⁶ mm⁴	OS RCB-1.1(1) Eq 7.2(2)	fcmi :
	Tensile steel (Ast) =	0	377	565	mm²/m		
	Depth to ds =	144	134	144	mm (From comp. face)		
	Comp. steel (Asc) =	0	227	227	mm²/m		
	dc =	36	26	36	mm (From comp. face)		Use Ast for I
	Cracked κ =	0.000	0.177	0.206	mm	OS RCB-1.1(1) Fig 5.7	Include the r
	Depth to cracked NA = κ*ds =	0.0	23.7	29.6	mm (From top)		I
	Use Comp. steel =	-	No	No	Error - set comp. reinf't = 0mm² (in tension)		
	yt =	85	85	84	mm (From tensile fibre)		
	Design shrinkage strain εcs =	580	580	580	x10⁻⁶ ±30%	Interior env. refer Shrinkage tab	Using compr
	W (slab) =	1000	1000	1000	mm		If 'No' then c
	Tension steel ratio (pw=Ast/(ds*W)) =	0.0000	0.0028	0.0039	pw < 0.005, Ief.max = 0.6*Ig		
	Comp. steel ratio (pcw=Asc/((D-dc)*W)) =	0.0000	0.0016	0.0017			σcs: refer Cl
	σcs =	0.00	0.59	0.82	MPa		
	Mcr = (f'ct.f-σcs)*Ig/yt =	16.3	13.9	12.9	kNm	f'ct.f = 3.39 MPa	
	Cracked κc =	0.000	0.175	0.233		OS RCB-1.1(1) Fig 5.7	
	Icr=κc*W*ds³/12=	0	35	58	x10⁶ mm⁴		
	Ief.max =	246	246	246	x10⁶ mm⁴, Ief = 0.6*Ig	Cl 8.5.3.1	Ief = Cl 8.5.3
	Ief =	0	246	120	x10⁶ mm⁴		When Ast/(b
	Iav =	(M + R) / 2 value = 183x10⁶ mm⁴					When Mcr>M
	Ratio Iuncrk/Iav =	2.29 Iuncrk at position x					
	kcs = [2-1.2*(Asc/Ast)] ≥ 0.8 =	1.277 kcs at position x				Cl 8.5.3.2	I.ef value:

Once a design has been found that works for moments, crack stresses and deflections, often it can be optimised to be more cost effective (or provide alternative options). In the example used for the double span, the deflection is well below the desired limit. This means that an aspect of the slab can be altered to save on costs.

Section:	(Concrete Member CB01) 170mm thk slab, f'c=32MPa	
Reinf't:	N12-200 cts top, N12-300 cts bottom (Additional reo specified)	
Defl'n:	δ.dl = 5.2mm, δ.ll = 0.6mm, δ.inc = 6.4mm, δtotal = 9.0mm (span / 531)	OK
	αcs for Interior environment with εcsd.b*=800x10^{-6}, εcs*=580x10^{-6}	

For the example used, the slab's thickness could be decreased to 150mm. Once the change has been made, the new capacities and reinforcement will need to be checked by applying the entire method detailed in the previous section – refer to the next page for a detailed flowchart.

By reducing the slab to 150mm the negative capacity can be met by using N12-175mm centres rather than N12-200mm centres

Section:	(Slab 150mm Double N12-175T) 150mm thk slab, f'c=32MPa	
Reinf't:	N12-175 cts top, N12-200 cts bottom, ku = 0.11	
Strength:	(-ve M) M* = 21.2kNm < øMuo = 31.3kNm	OK (0.68)
Cracking:	fscr = 204MPa < Fscr = 235MPa & fscr1 = 222MPa < Fscr1 = 400MPa, crack width = 0.2mm	OK (0.55,0.87)
Ast.min:	Ast.min = 246mm² < Ast = 646mm² (Minimum of Deemed and actual)	OK (0.38)

Reducing the thickness of the slab resulted in the following deflection.

Section:	(Slab 150mm Double N12-175T) 150mm thk slab, f'c=32MPa	
Reinf't:	N12-175 cts top, N12-200 cts bottom (Additional reo specified)	
Defl'n:	δ.dl = 7.1mm, δ.ll = 0.9mm, δ.inc = 9.0mm, δtotal = 12.6mm (span / 381)	OK

Multi-span One-way Slab

In a similar procedure, multi-span slabs (more than two-spans) can also be designed. This is accomplished using the Analysis Lite or Standard to determine the moments for each span. Each span is then entered into the analysis/loading document using the Span-Type = 'O' with a given Left end (M1*) or Right end (M2*) or both and inputting the loadings exactly as per the Analysis Standard model. The moment graphs are then matched before moving on to the design capacity step.

Use the [Max M-*...] and [Max M+*...] buttons or select a "position x" to design the capacity.

Deflections can also be designed with a similar approach to the double-span.

Refer to Analysing a Two Span slab tutorial for more detailed procedures.

End span and Internal Spans

The Analysis/Loading configuration for the end span and internal span should be used with caution. They are approximations based on AS 3600 -2018 clause 6.10.2.2.

There are limited situations in which these should be used. It is recommended to use the above method to determine moments in each span and the resulting deflections.

Cantilever Spans

Cantilever spans should also be used with caution. The right support is fixed and therefore does not rotate. If the cantilever span forms part of a continuous multi-span slab (or beam) then there will be rotation at the support. The resulting cantilever deflections could either be less (as a result of the cantilever support rotating up); or more problematically more (as a result of the cantilever support rotating down). The amount this magnifies can be assessed by using Analysis Lite or Standard. Once the configuration is finalised, copy the model and fix the cantilever support to determine the effect of the back spans.

Optimising

The process of designing a double-span one-way slab can be simplified into the following flowchart.