Analysing a two span slab using Structural Toolkit

In this tutorial:

- Slab Member Analysis using Structural Toolkit Analysis
- Slab Member Moment Capacity check using Structural Toolkit
- Slab Member Deflection check using Structural Toolkit
- Slab Member Comparison using RAPT (Reinforced And Post-Tensioned Concrete design software)

This will be a two span continuous slab (4.9m in the left span and 4.2m in the right span) with office type loading

Step 1 – Slab Member Analysis using Structural Toolkit Analysis

Using **Structural Toolkit Analysis** we will determine the positive and negative moments using pattern loads.

We will determine the maximum positive moment from the live load in the larger left span, and maximum negative moment with live loads in each adjacent span.

To start, create a new **Analysis** in **Structural Toolkit Analysis**.

Select the predefined pattern loadcase combinations.

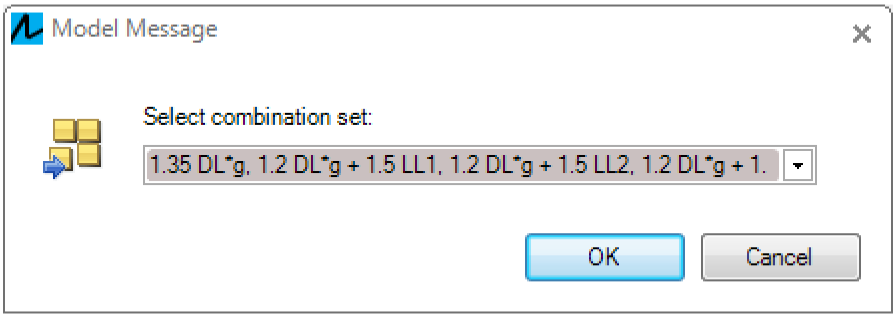

Figure 1 – Loadcase Combinations

Rename the document name to something sensible. (Remember to save the project also).

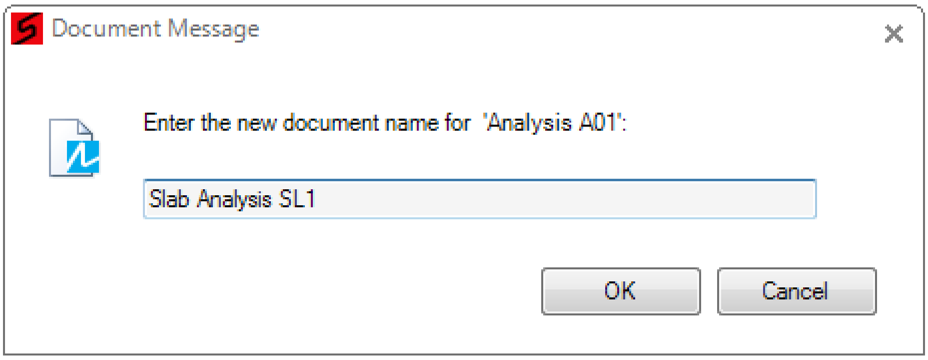

Figure 2 – Analysis Name

<u>Enter the frame geometry</u>

Type Ctrl-D and then hit the "0" key to bring up the input coordinate dialog.

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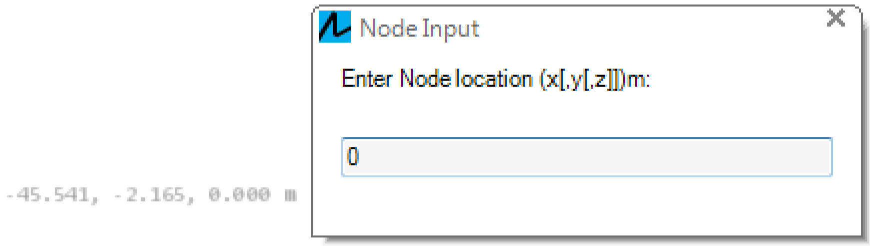


Figure 3 – Node Input Diaglog

Press enter to create the node, the type “@4.9” to create the next node relative to the first node.

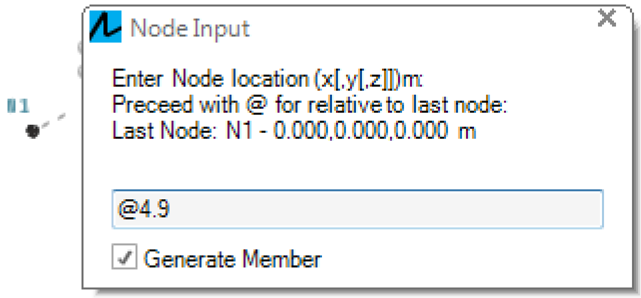


Figure 4 – Node Input Dialog (after first node)

Repeat for the next span being 4.2m.

Right click and assign a **Pinned** restraint to the left end.

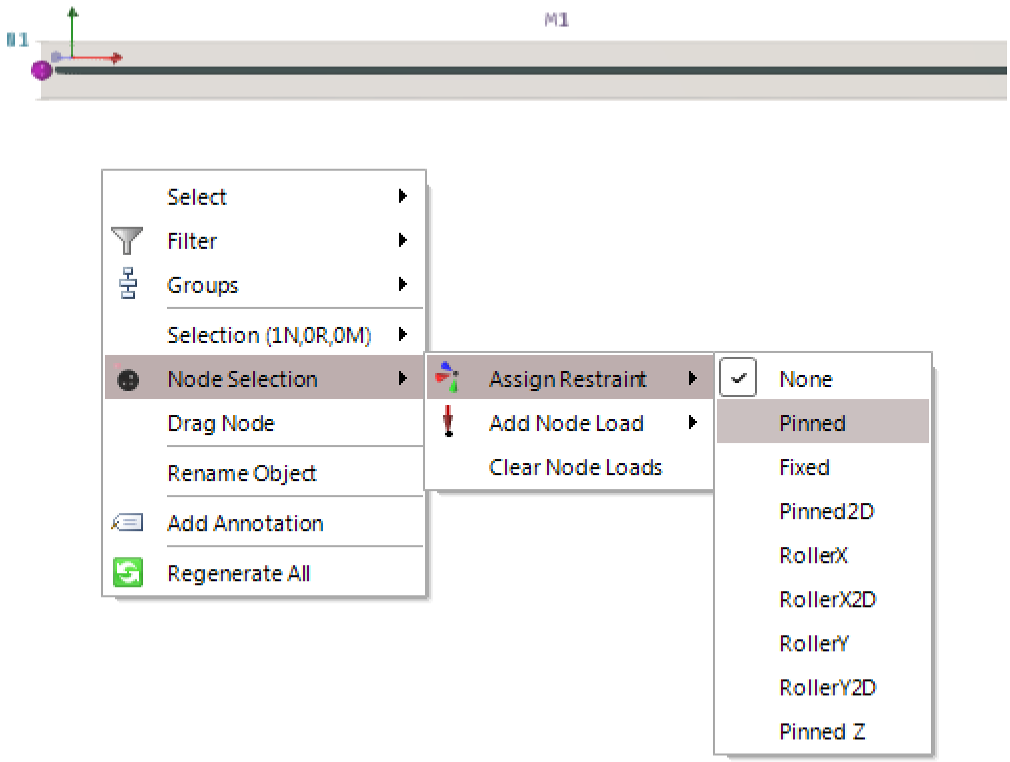


Figure 5 – Assign restraints

Assign restraints to the other two nodes using the RollerX2D. Remember to provide a pin for one support, and rollers for the others (this is not essential for a linear analysis that is horizontal, but good practise.)

Figure 6 – Beam geometry

<u>Create the section</u>

Enter the gross section shapes for each span. In this example we will use a 170mm thick section (x 1m strip).

First **Rename** the section for good practise.

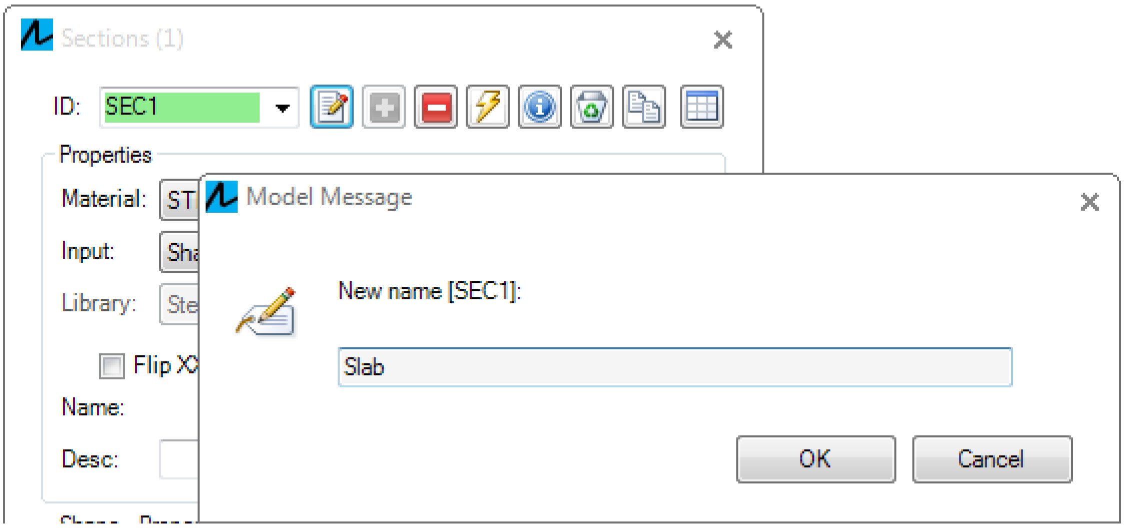


Figure 7 – Rename Section Dialog

Change the **Material** to **CONCN32** (predefined value of Concrete with 32MPa strength) and change the **Input** to **Shape**.

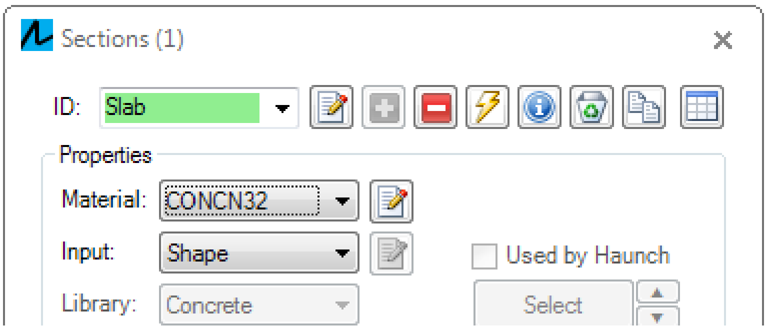


Figure 8 – Section Properties (Material)

Select the **Rect** shape for the **Profile** and assign a shape of:

D = 170mm
Bf = 1000mm

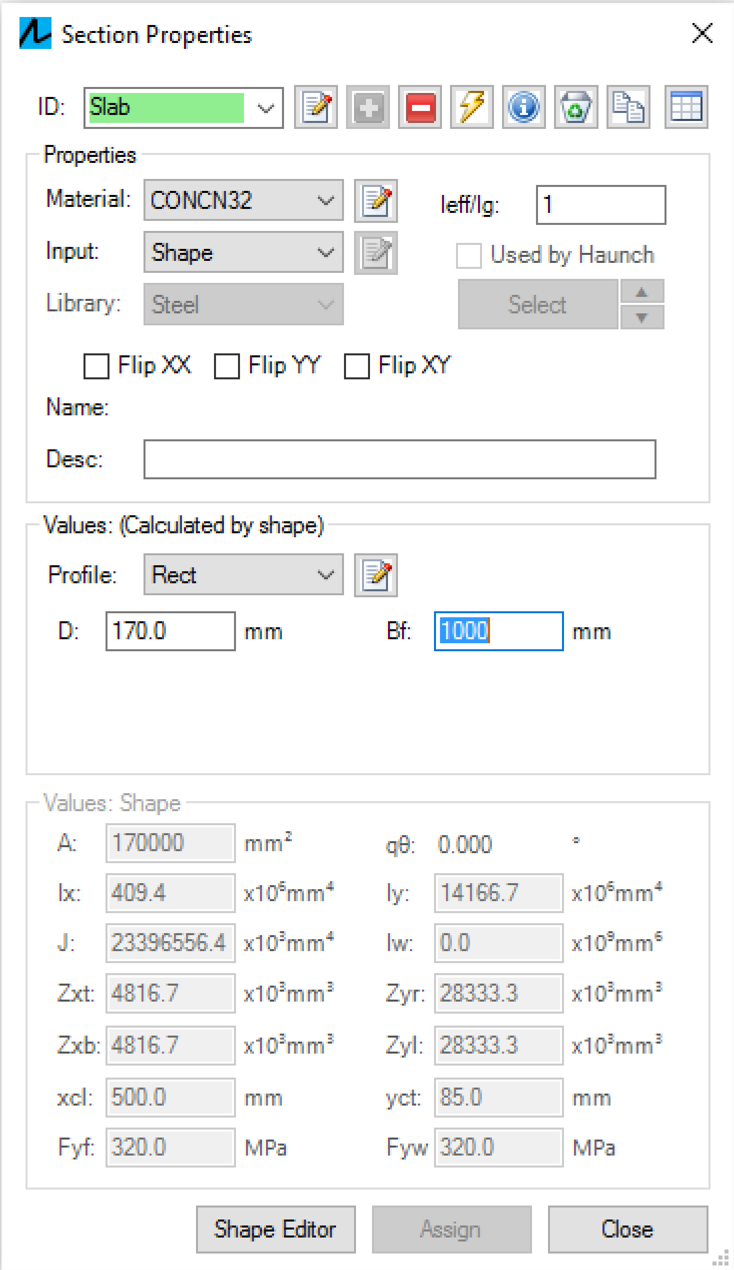


Figure 9 – Section Properties (Profile)

You may also want to open the **Material** properties and change the **Concrete Density** to 2500kg/m^3 and open the **Cases** (Loadcases) and change within the **DL** case **Gravity** to **-10**m/s^2 (to have the results align with RAPT outputs for this example).

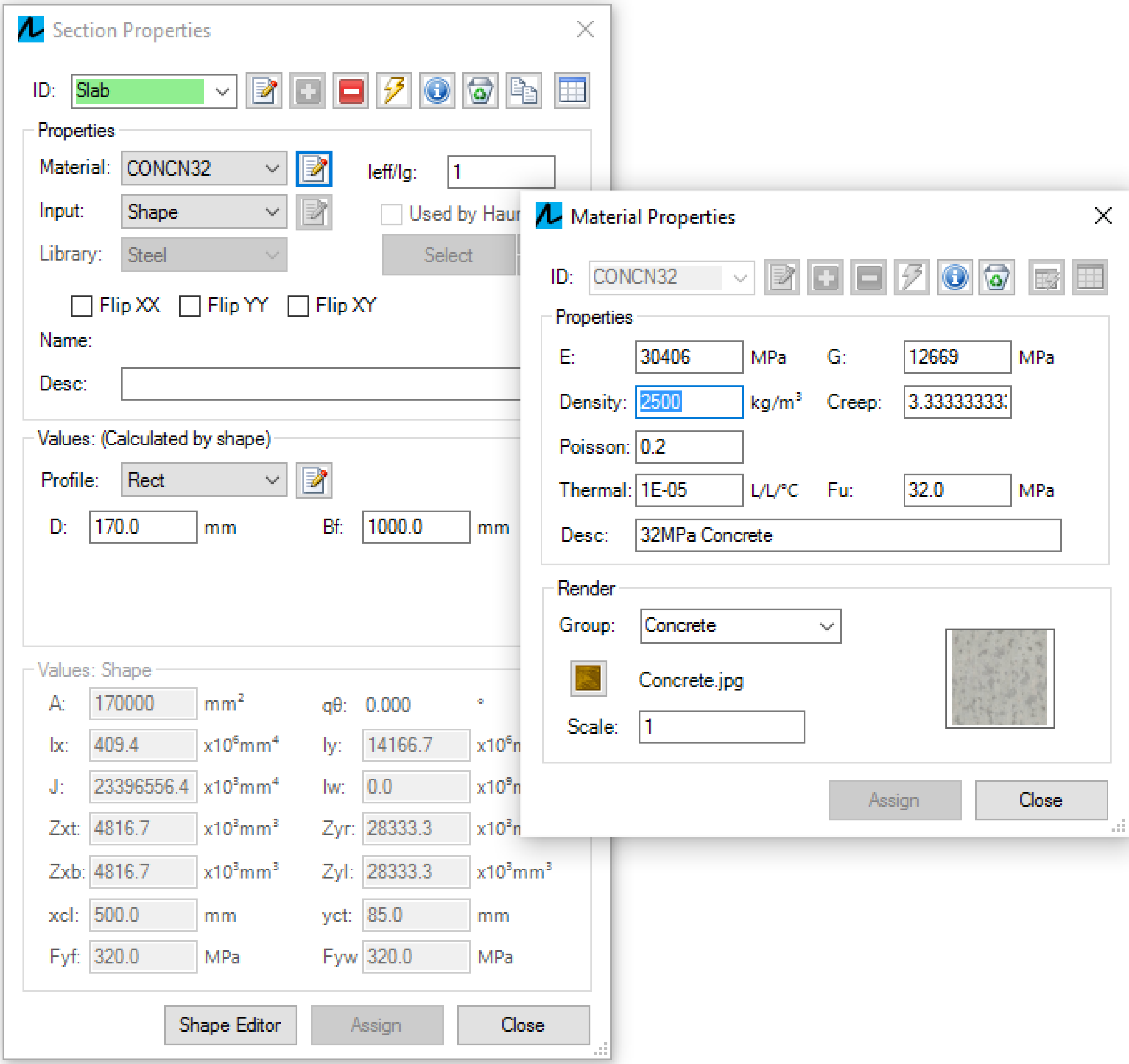


Figure 10 – Material Properties Dialog

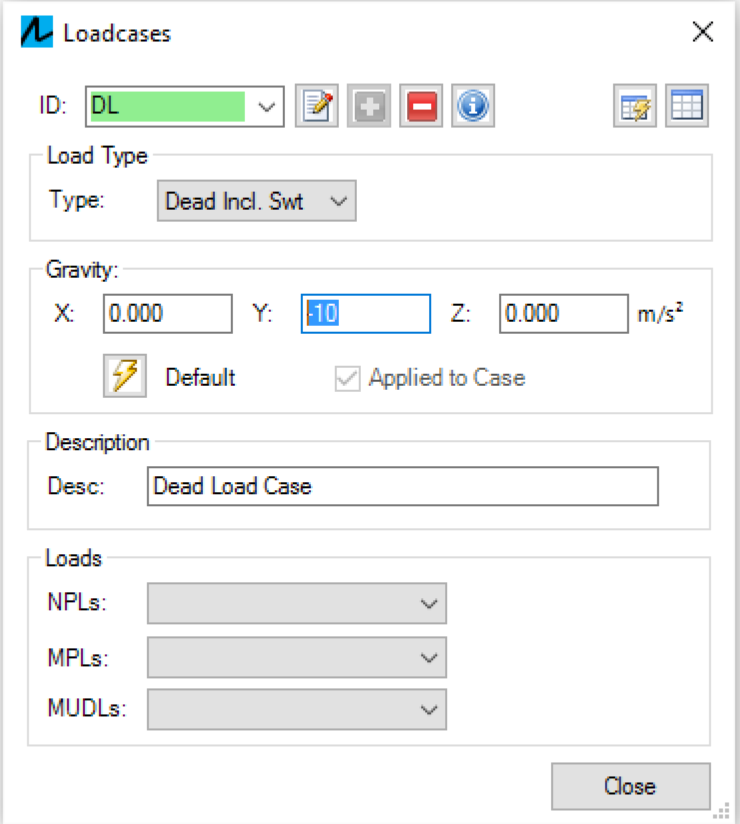


Figure 11 – Loadcases Dialog

<u>Define the loads</u>

Use the **Load Definitions** (below the Loads button) to define the loads.

Add a superimposed dead load of **Wsdl = -0.5kN**, and a live load of **Wll = -(3.0 + 1.0)kN = -4.0kN**

When applying these load definitions to members, this load can be either a point loads (**kN**), or a start or end distributed load (**kN**/m).

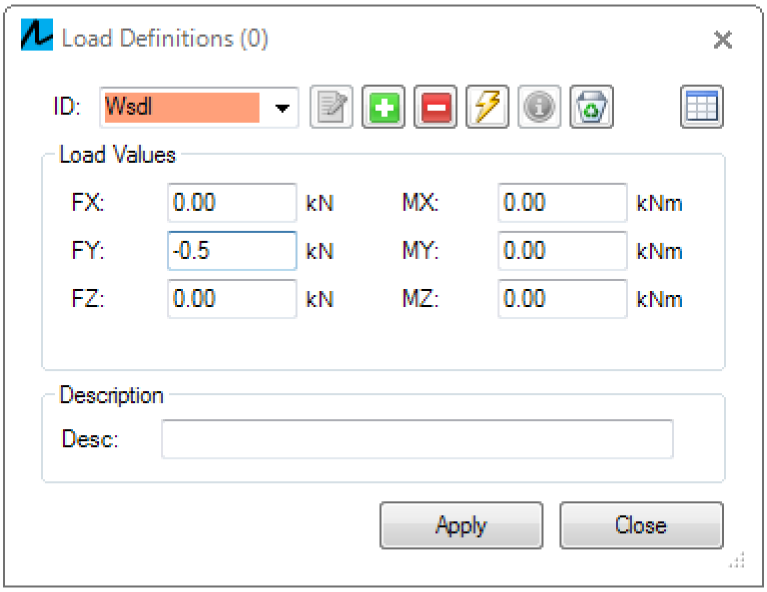


Figure 12 – Load Definitions Dialog

Change to the **DL*g** case in the Case selector in the ribbon to assign the **Wsdl**.

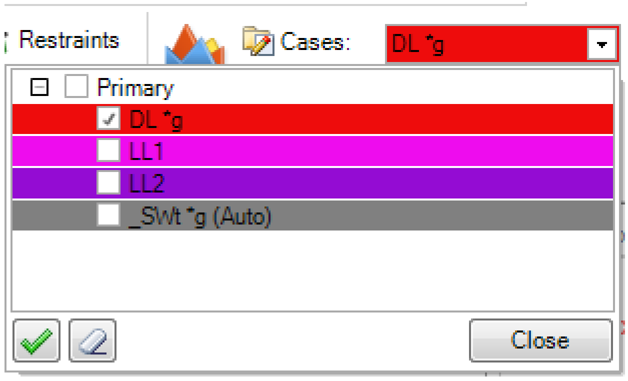


Figure 13 - Loadcases

NOTE: the “***g**” is automatically added to cases where the gravity is applied.

Assign the load by first selecting the members, then **right click > Member Selection > Add Member UDL** and select the **Wsdl** from the defined loads.

NOTE: If there are more than 10 loads defined, this right-click feature will not be available and you will need to define loads in the **Loads dialog**.

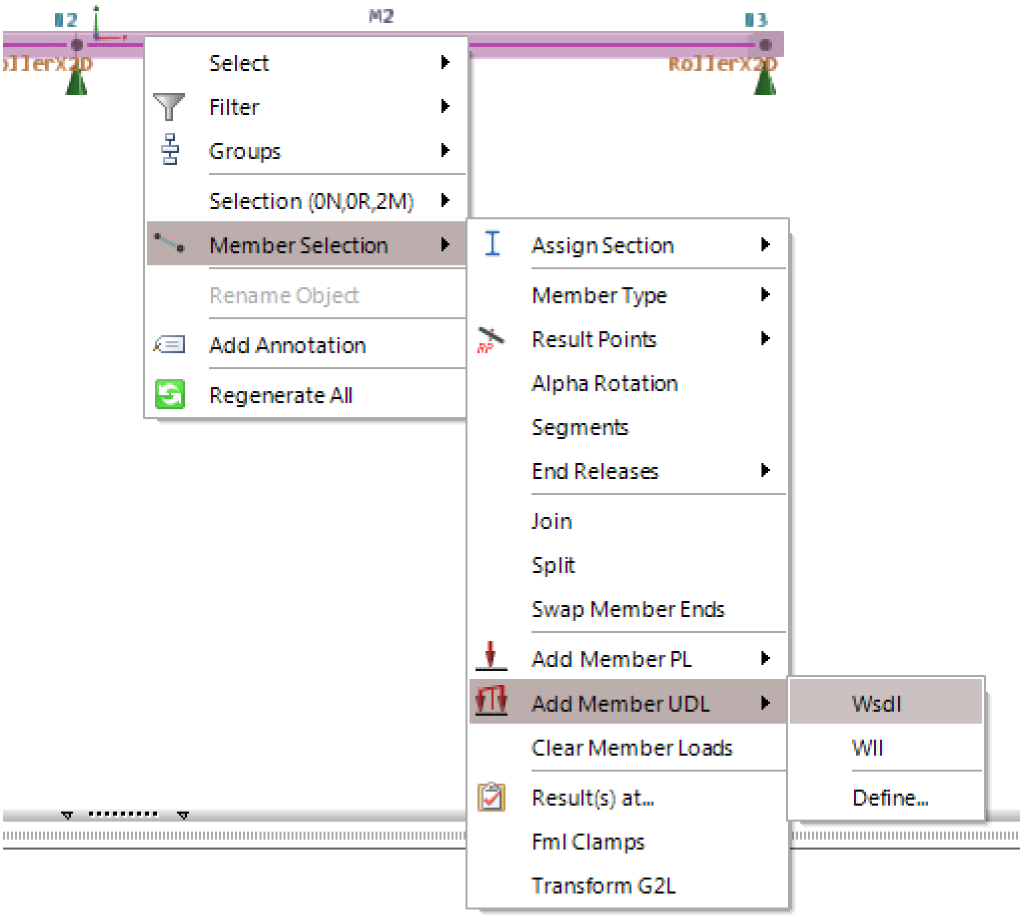


Figure 14 – Assign Member UDL

NOTE: Remember to hit the Esc key between selections to cancel the previous selection set.

Change the **Case** to **LL1** and assign the live load **Wll** to the first span (**M1**).

Change the **Case** to **LL2** and assign the live load **Wll** to the second span (**M2**).

Check that all loads are correctly applied by toggling through the **Cases** selector.

<u>Analyse</u>

Press **F5** to perform a linear analysis.

You may get a message regarding creep. This simply reminds you that the concrete long term deflections will not be calculated and the deflections are gross uncracked.

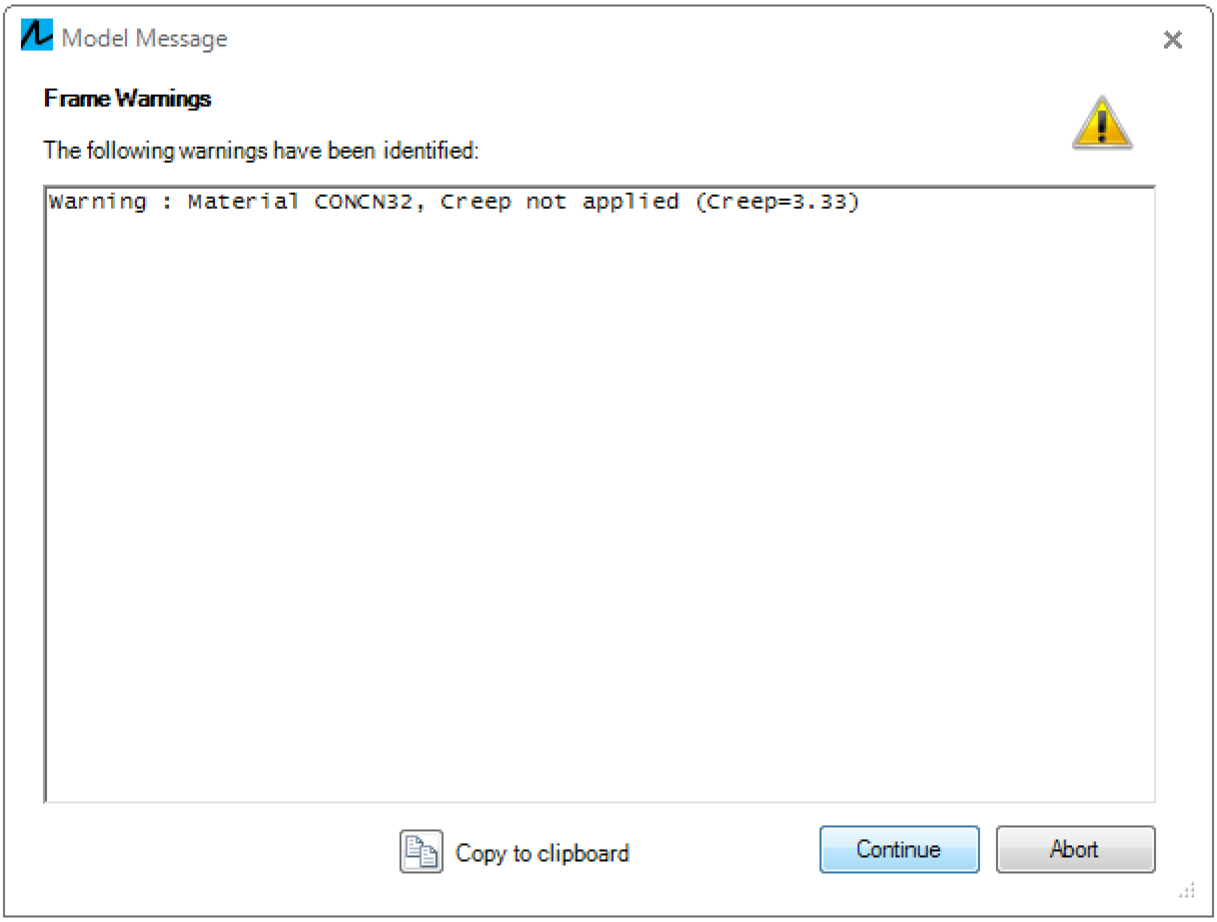


Figure 15 – Creep Warning Dialog

Press **F6** to show the Bending Moment diagram (this shows automatically on first analysis).

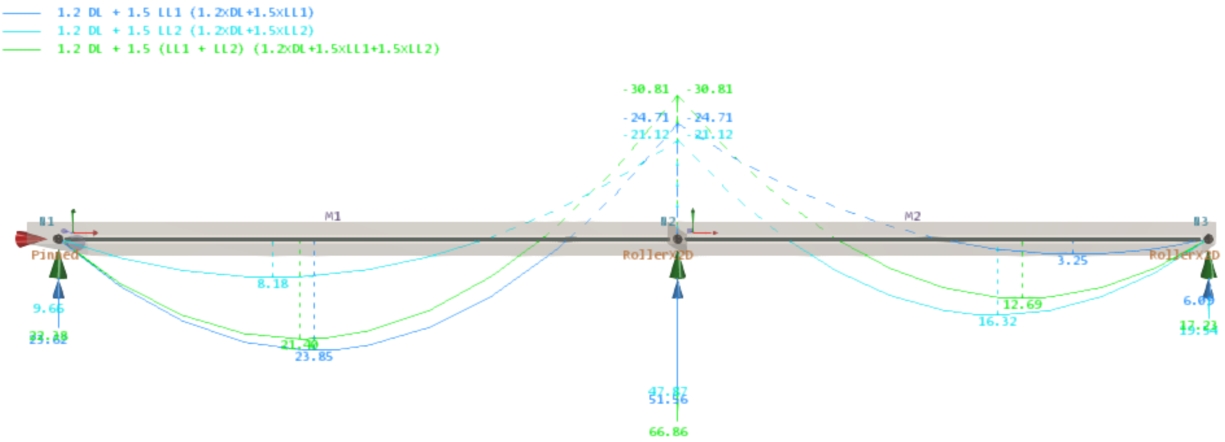


Figure 16 – Bending Moment Analysis

M*+ = 30.81kNm (first span)
M*- = 23.85kNm (at central support)

Step 2 – Slab Member Moment Capacity check using Structural Toolkit

Now we have our maximum positive and negative design moments, we can use the **Structural Toolkit Concrete Member** to check the flexural capacity.

Create a new **Concrete Member** within **Structural Toolkit** and enter the Depth (170mm), concrete strength (32MPa) and web width of "S" type representing a slab.

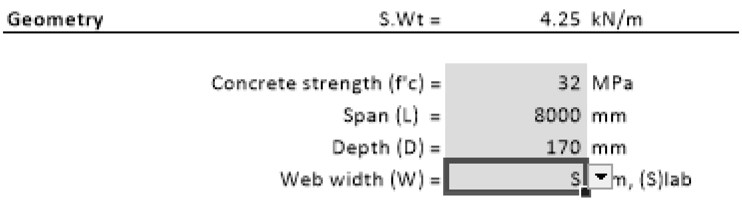
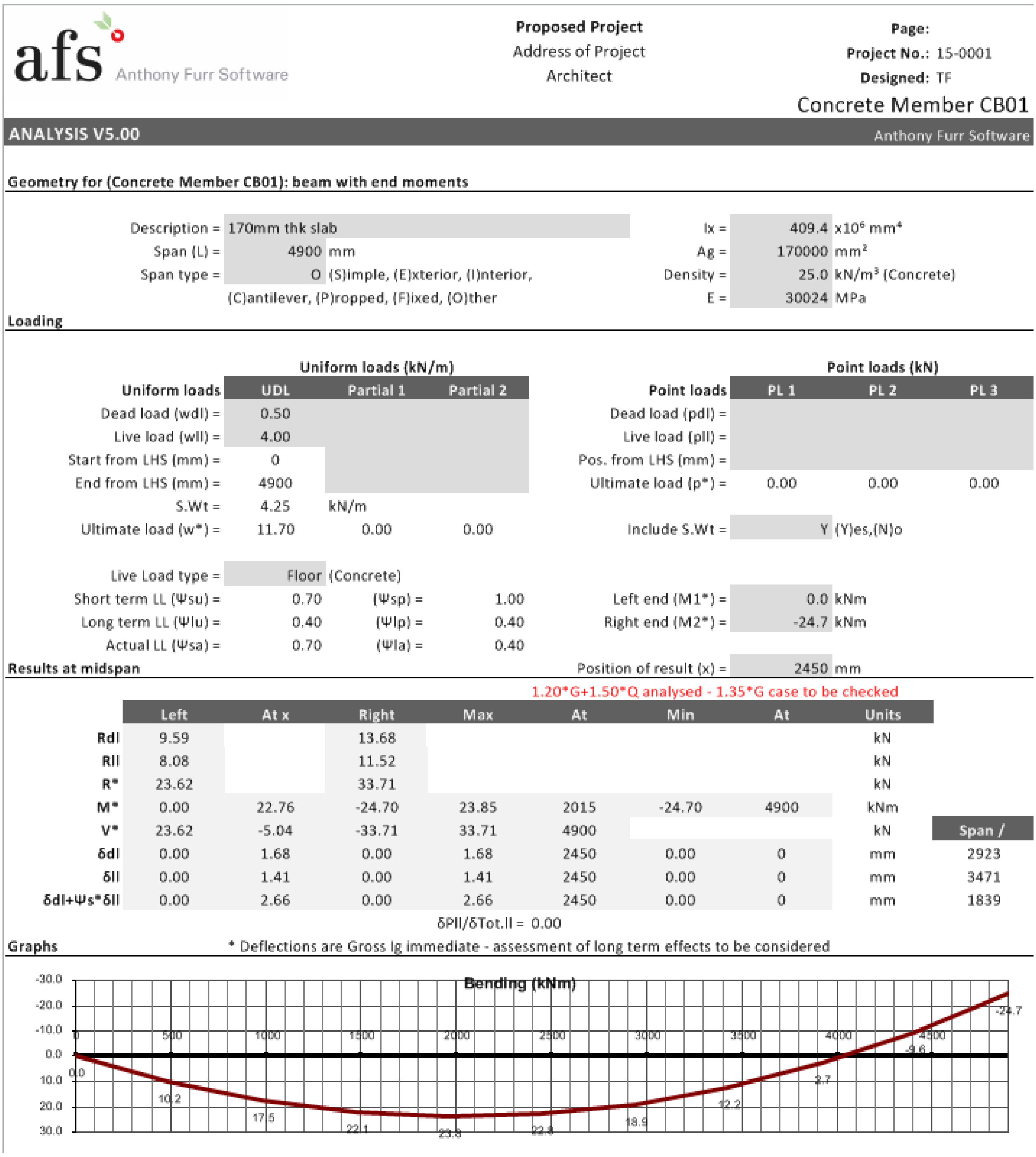


Figure 17 – Concrete Geometry Inputs

Press the **[Analysis]** button in the side Notes section and create a linked analysis.

First, for the larger span enter a span of 4900mm, and the loads Wsdl = 0.5kN/m and the Wll = 4.0kN/m. Self weight is automatically calculated based on the thickness entered in the Design module.

Set the span type as "O" other to manually input the end moments and in the right side **M2***, enter the negative value at the central support. From the analysis, this is **-24.7kNm** corresponding to the greater sag case of **+23.9kNm**.



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Concrete Member CB01

ANALYSIS V5.00 Anthony Furr Software

Geometry for (Concrete Member CB01): beam with end moments

Description =	170mm thk slab		Ix =	409.4	$x10^6$ mm^4
Span (L) =	4900	mm	Ag =	170000	mm^2
Span type =	O	(S)imple, (E)xterior, (I)nterior, (C)antilever, (P)ropped, (F)ixed, (O)ther	Density =	25.0	kN/m^3 (Concrete)
			E =	30024	MPa

Loading

Uniform loads	UDL	Partial 1	Partial 2	Point loads	PL 1	PL 2	PL 3
	Uniform loads (kN/m)				Point loads (kN)		
Dead load (wdl) =	0.50			Dead load (pdl) =			
Live load (wll) =	4.00			Live load (pll) =			
Start from LHS (mm) =	0			Pos. from LHS (mm) =			
End from LHS (mm) =	4900			Ultimate load (p*) =	0.00	0.00	0.00
S.Wt =	4.25	kN/m					
Ultimate load (w*) =	11.70	0.00	0.00	Include S.Wt =	Y	(Y)es,(N)o	

Live Load type =	Floor	(Concrete)				
Short term LL (Ψsu) =	0.70	(Ψsp) =	1.00	Left end (M1*) =	0.0	kNm
Long term LL (Ψlu) =	0.40	(Ψlp) =	0.40	Right end (M2*) =	-24.7	kNm
Actual LL (Ψsa) =	0.70	(Ψla) =	0.40			

Results at midspan Position of result (x) = 2450 mm

1.20*G+1.50*Q analysed - 1.35*G case to be checked

	Left	At x	Right	Max	At	Min	At	Units	Span /
Rdl	9.59		13.68					kN	
Rll	8.08		11.52					kN	
R*	23.62		33.71					kN	
M*	0.00	22.76	-24.70	23.85	2015	-24.70	4900	kNm	
V*	23.62	-5.04	-33.71	33.71	4900			kN	
δdl	0.00	1.68	0.00	1.68	2450	0.00	0	mm	2923
δll	0.00	1.41	0.00	1.41	2450	0.00	0	mm	3471
δdl+Ψs*δll	0.00	2.66	0.00	2.66	2450	0.00	0	mm	1839

δPll/δTot.ll = 0.00

Graphs * Deflections are Gross Ig immediate - assessment of long term effects to be considered

Figure 18 – Analysis Module

Press the **[Switch to Design…]** button in the side Notes area to return to the **Concrete Member** design module.

Press the **[Max M+*]** to begin designing the section for the positive moment and enter bar sizes of 12mm and at centres of 250mm **(N12-250)** as the bottom reinforcement with 20mm bottom cover, and bar sizes of 12mm at centres of 300mm **(N12-300)** as the top steel, again with 20mm cover.

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Concrete Member CB01

CONCRETE MEMBER V5.00 Anthony Furr Software

Section:	**(Concrete Member CB01) 170mm thk slab, f'c=32MPa**	
Reinf't:	**N12-300 cts top, N12-250 cts bottom, ku = 0.07**	
Strength:	**(+ve M) M* = 23.9kNm < øMuo = 24.8kNm (øMuo.min = 16.3kNm)**	**OK (0.96)**
	Ast.req'd = 426mm² (N12-260)	
Cracking:	**fscr = 252MPa < Fscr = 297MPa & fscr1 = 292MPa < Fscr1 = 400MPa**	**OK (0.73,0.85)**
Ast.min:	**Ast.min = 272mm² < Ast = 452mm² (Minimum of Deemed and actual)**	**OK (0.60)**

Geometry S.Wt = 4.25 kN/m L/D ratio = 28.8

Concrete strength (f'c) = 32 MPa

Depth (D) = 170 mm
Web width (W) = S mm, (S)lab

Comp.
Tension

Slab type = O (O)ne way, Two way & (C)ols, (T)wo way & walls, (F)ooting
Formwork = S (S)tandard,(R)igid
Concrete weight = 25.0 kN/m³ Exposure Top = A1 Tab 4.10.3.2
Fully enclosed = N (Y)es,(N)o Bottom = A1 Tab 4.10.3.2
Gross area (Ag) = 170000 mm²

Analysis: beam with end moments at 2015mm from LHS (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	23.9	-24.7	kNm
Ms1*	0.0	17.8	-18.5	kNm
Ms*	0.0	15.4	-15.9	kNm
Ast req'd	0	426	442	mm²/m
Ast	452	452	377	mm²/m
Reinf't req'd	-	N12-260	N12-250	

Reinforcement

Bottom steel =	**N12-250 cts**	**Top steel =**	**N12-300 cts**
Bar size =	12 mm (Mesh...)	Bar size =	12 mm (Mesh...)
Bar cts/No/mm² =	250 mm	Bar cts/No/mm² =	300 mm
Yield strength (fsy) =	500 MPa	Yield strength (fsyc) =	500 MPa
Bottom cover to steel =	20 mm	Top cover to steel =	20 mm
Steel area (Ast) =	452 mm²/m	Steel area (Asc) =	377 mm²/m
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
Depth to bottom steel layer (ds.max) =	144 mm	Depth to top steel layer =	26 mm

Figure 19 – Concrete Module (Positive Moment Check)

The summary at the top indicates that the section capacity is **OK** for the positive moment case.

For the negative bending, we can not simply transfer the moment, because the pattern load we have input into the Analysis module was for the maximum deflection and sage case. So we need change the **Analysis values** to “M” manual method and enter the –ve moment of M* = -30.8kNm.

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Section:	(Concrete Member CB01) 170mm thk slab, f'c=32MPa	
Reinf't:	N12-200 cts top, N12-400 cts bottom, ku = 0.09	
Strength:	(-ve M) M* = 30.8kNm < øMuo = 31.0kNm (øMuo.min = 16.4kNm)	OK (0.99)
	Ast.req'd = 556mm² (N12-200)	
Cracking:	fscr = 264MPa < Fscr = 297MPa & fscr1 = 304MPa < Fscr1 = 400MPa	OK (0.76,0.89)
Ast.min:	Ast.min = 272mm² < Ast = 565mm² (Minimum of Deemed and actual)	OK (0.48)

Geometry S.Wt = 4.25 kN/m L/D ratio = 47.1

Concrete strength (f'c) = 32 MPa
Span (L) = 8000 mm
Depth (D) = 170 mm
Web width (W) = S mm, (S)lab

Comp.
Tension

Slab type = O (O)ne way, Two way & (C)ols, (T)wo way & walls, (F)ooting
Formwork = S (S)tandard,(R)igid
Concrete weight = 25.0 kN/m³
Exposure Top = A1 Tab 4.10.3.2
Fully enclosed = N (Y)es,(N)o
Bottom = A1 Tab 4.10.3.2
Gross area (Ag) = 170000 mm²

Design actions

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

Manual values

Design (M*) = -30.8 kNm/m
Design (Ms1*) = d kNm/m
Design (Ms*) = d kNm/m

	Manual	Units
M*	-30.8	kNm
Ms1*	-23.1	kNm
Ms*	-20.0	kNm
Ast req'd	556	mm²
Ast	565	mm²
Reinf't req'd	N12-200	

Estimates for Ms1* and Ms* used - To be verified

Reinforcement

	Bottom steel = N12-400 cts			Top steel = N12-200 cts	
Bar size =	12	mm	Bar size =	12	mm
Bar cts/No/mm² =	400	mm	Bar cts/No/mm² =	200	mm
Yield strength (fsy) =	500	MPa	Yield strength (fsyc) =	500	MPa
Bottom cover to steel =	20	mm	Top cover to steel =	20	mm
Steel area (Asc) =	283	mm²/m	Steel area (Ast) =	565	mm²/m
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
Depth to bottom steel layer (ds.max) =	144	mm	Depth to top steel layer =	26	mm
Depth to bottom steel (ds) =	144	mm	Depth to top steel =	26	mm
D-ds =	26	mm	D-ds =	144	mm
No. bars =	2.5	No.	No. bars =	5.0	No.

Figure 20 – Concrete Module (Negative Moment Check)

Enter the top reinforcement of 12mm bars at 200mm centres **(N12-200)**, and the bottom reinforcement of 12mm bars at 400mm centres **(N12-400)** (cover as previous).

The summary at the top indicates that the section capacity is **OK** for the negative moment case.

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Step 3 – Slab Member Deflection check using Structural Toolkit

To check the deflections, we first we need to set up the reinforcement again for this span.

Enter the **N12-250 bars** in the bottom and **N12-200 bars** in the top on the **[Design]** sheet.

Go to the **[Defl]** tab and press the **[Max. Deflection]** button in the Notes.

Press the **[Transfer Reinf't]** to transfer the reinforcement to the Defl tab. Note that some of the reinforcement areas do not transfer as the steel is in a compression zone which is in tension.

NOTE: If you enter the value manually in the middle span top reinforcement you will notice an error message further down advising that the top compression reinfrocement is actuially in tension and should be ignored.

NOTE: Ensure you go to the **[Shrink & Creep]** tab to set the exposure and location of the slab (ie. Environment and City) which will affect the σcs which in turn affects Mcr which then alters the deflections.

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Project No.: 15-0001
Designed: TF
Concrete Member CB01

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Section:	**(Concrete Member CB01) 170mm thk slab, f'c=32MPa**	
Reinf't:	**N12-200 cts top, N12-250 cts bottom (Additional reo specified)**	
Defl'n:	**δ.dl = 6.4mm, δ.ll = 1.9mm, δ.inc = 10.4mm, δtotal = 13.6mm (span / 359)**	**OK**
	σcs for interior environment with εcsd.b*=1000x10⁻⁶ ±30%, εcs*=672x10⁻⁶	

Deflections - Cl 8.5.3 beam with end moments at midspan (Max +ve Def)

Concrete density (ρ) =	2400	kg/m³ Cl 3.1.3	Gross area (Ag) =	170000	mm²
Use fcmi? =	Y	(Y)es,(N)o	Uncr.g. neutral axis (NA) =	85	mm from top
fcmi =	35.3	MPa	Gross Stiffness (Ig) =	409	x10⁶ mm⁴ (w/o reinf't)
Deflection at =	X	(M)anual, (C)ritical, (L)eft, Position (X) from analysis, (R)ight			
Position (x) =	2450	mm	Steel Modulus (Es) =	200000	MPa Cl 3.2.2
Span type =	O		Mod. of elast. (Ec = ρ¹·⁵*0.043*√fcmi) =	30024	MPa ± 20% Cl 3.1.2
			Modular ratio (n = Es/Ec) =	6.661	

Deflection calculation

		Left	At x	Right	Units		
	Manual (M*) =				kNm		
	Manual (Ms*) =				kNm		
	Analysis (M*) =	0.0	22.8	-24.7	kNm	Red values manually input	
	Analysis (Ms*) =	0.0	14.7	-15.9	kNm		
Top Steel:	Ast req'd =	0	0	442	mm²/m		
	Design Ast =	565		565	mm²/m		
	Ast =	0	0	565	mm²/m		
		-	-	N12-200		Short term LL factor (ψs) =	0.7
Bottom steel:	Ast req'd =	0	406	0	mm²/m	Long term LL factor (ψl) =	0.4
	Design Ast =	452	452		mm²/m		
	Ast =	0	452	0	mm²/m		
		-	N12-250	-			
	Uncracked NA =	85	86	84	mm	OS RCB-1.1(1) Fig 5.3	
	Uncracked uκ =	1.000	1.021	1.027	x10⁶ mm⁴		
	Iuncrk = uκ*W*D³/12 =	409	418	420	x10⁶ mm⁴	OS RCB-1.1(1) Eq 7.2(2)	
	Tensile steel (Ast) =	0	452	565	mm²/m		
	Depth to ds =	144	144	144	mm (From comp. face)		
	Comp. steel (Asc) =	0	0	0	mm²/m		
	dc =	26	26	26	mm (From comp. face)		
	Cracked κ =	0.000	0.185	0.204	mm	OS RCB-1.1(1) Fig 5.7	
	Depth to cracked NA = κ*ds =	0.0	26.6	29.4	mm (From top)		
	Use Comp. steel =	-	-	-			
	yt =	85	84	84	mm (From tensile fibre)		
	Design shrinkage εcs* =	672	672	672	x10⁻⁶ ±30%	Interior env. refer Shrinkage tab	
	W (slab) =	1000	1000	1000	mm		
	Tension steel ratio (pw=Ast/(ds*W)) =	0.0000	0.0031	0.0039			
	Comp. steel ratio (pcw=Asc/((D-dc)*W)) =	0.0000	0.0000	0.0000			
	σcs =	0.00	0.91	1.10	MPa		
	Mcr = (f'ct.f-σcs)*Ig/yt =	16.3	12.3	11.5	kNm	f'ct.f =	3.39 MPa
	Cracked κc =	0.000	0.192	0.233		OS RCB-1.1(1) Fig 5.7	
	Icr=κc*W*ds³/12=	0	48	58	x10⁶ mm⁴		
	Ief.max =	246	246	246	x10⁶ mm⁴	Cl 8.5.3.1	
	Ief =	0	246	193	x10⁶ mm⁴		
	Iav =	(M + R) / 2 value = 220x10⁶ mm⁴					
	Ratio Iuncrk/Iav =	1.90	Iuncrk at position x				
	kcs = [2-1.2*(Asc/Ast)] ≥ 0.8 =	2.000	kcs at position x			Cl 8.5.3.2	

Deflection summary - Located at midspan (Max +ve Def)

			Manual Values:		
Gross δdl.g.imm =	1.7	mm	Gross δdl.g.imm =	1.26	mm
Gross δll.g.imm =	1.4	mm	Gross δll.g.imm =	1.47	mm
Short term δ.short = [δdl.g+ψs*δll.g]*Iuncrk/Ief =	5.1	mm	Short term δdl.short =	3.2	mm
Sustained δ.sus = [δdl.g+ψl*δll.g]*Iuncrk/Ief =	4.3	mm	Short term δll.short =	1.9	mm
Long term δ.long = kcs*δ.sus =	8.5	mm	Long term δdl.long =	6.4	mm
Incremental δ.inc = δ.long + δll.short =	10.4	mm	Long term δll.long =	2.2	mm
			Total δdl.total =	11.7	mm
Total δ.total = δ.short + δ.long =	13.6	mm	Span / 359		

Deflection limits

δDL lim. = Span/	250	= 20mm or	mm	δDL lim. =	20	mm
δLL lim. = Span/	300	= 16mm or	mm	δLL lim. =	16	mm
δInc lim. = Span/	250	= 20mm or	mm	δLL inc. =	20	mm
δTot. lim. = Span/	250	= 20mm or	mm	δTot. lim. =	20	mm

Figure 21 – Concrete Module, Deflections

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The Concrete Member module calculates a total deflection of 13.6mm. This compares to the RAPT output of 14mm total deflection (see Appendix A).

END OF TUTORIAL

V5.0.1.2

Appendix A - RAPT Comparison

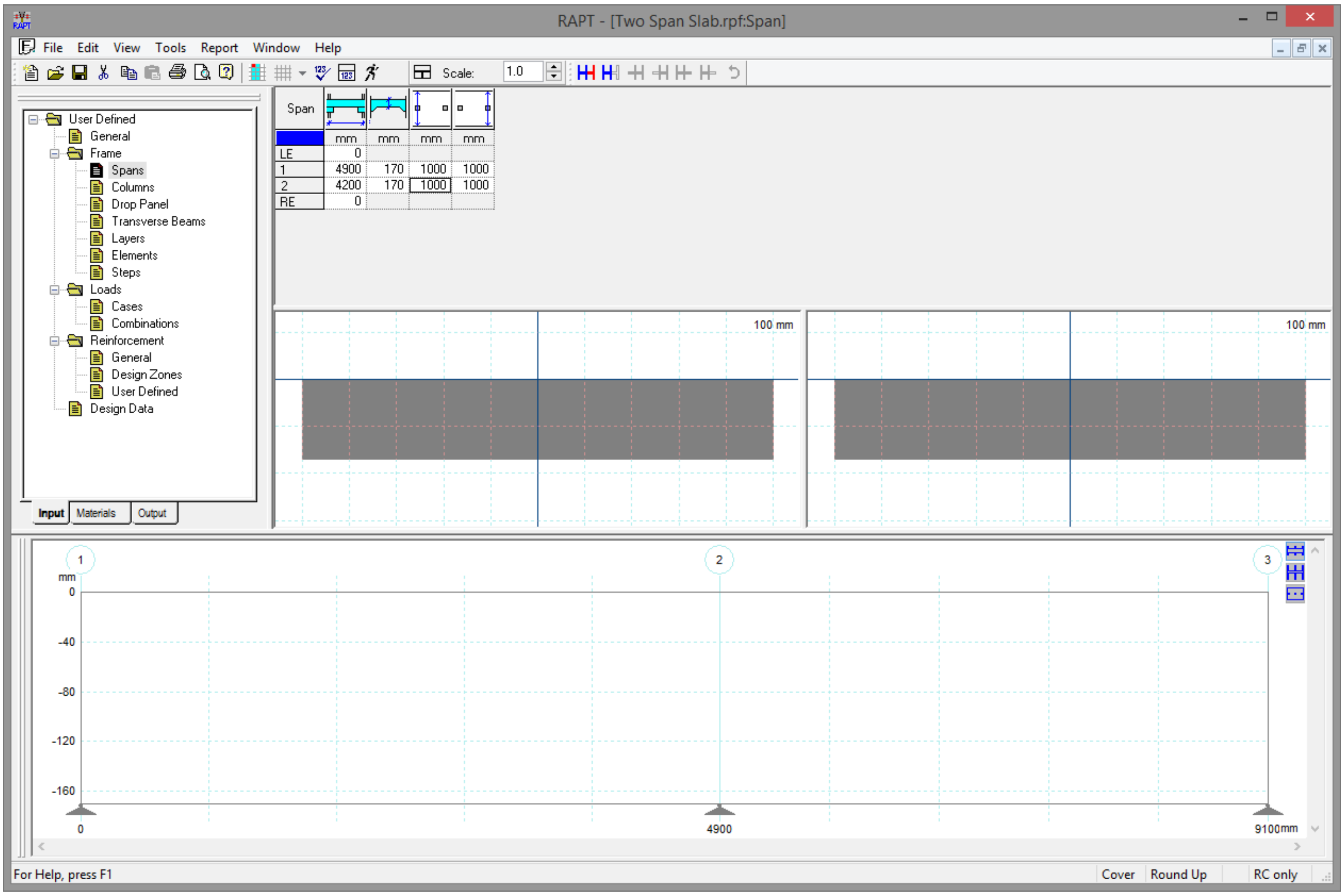


Figure A1 – Rapt Frame Geometry

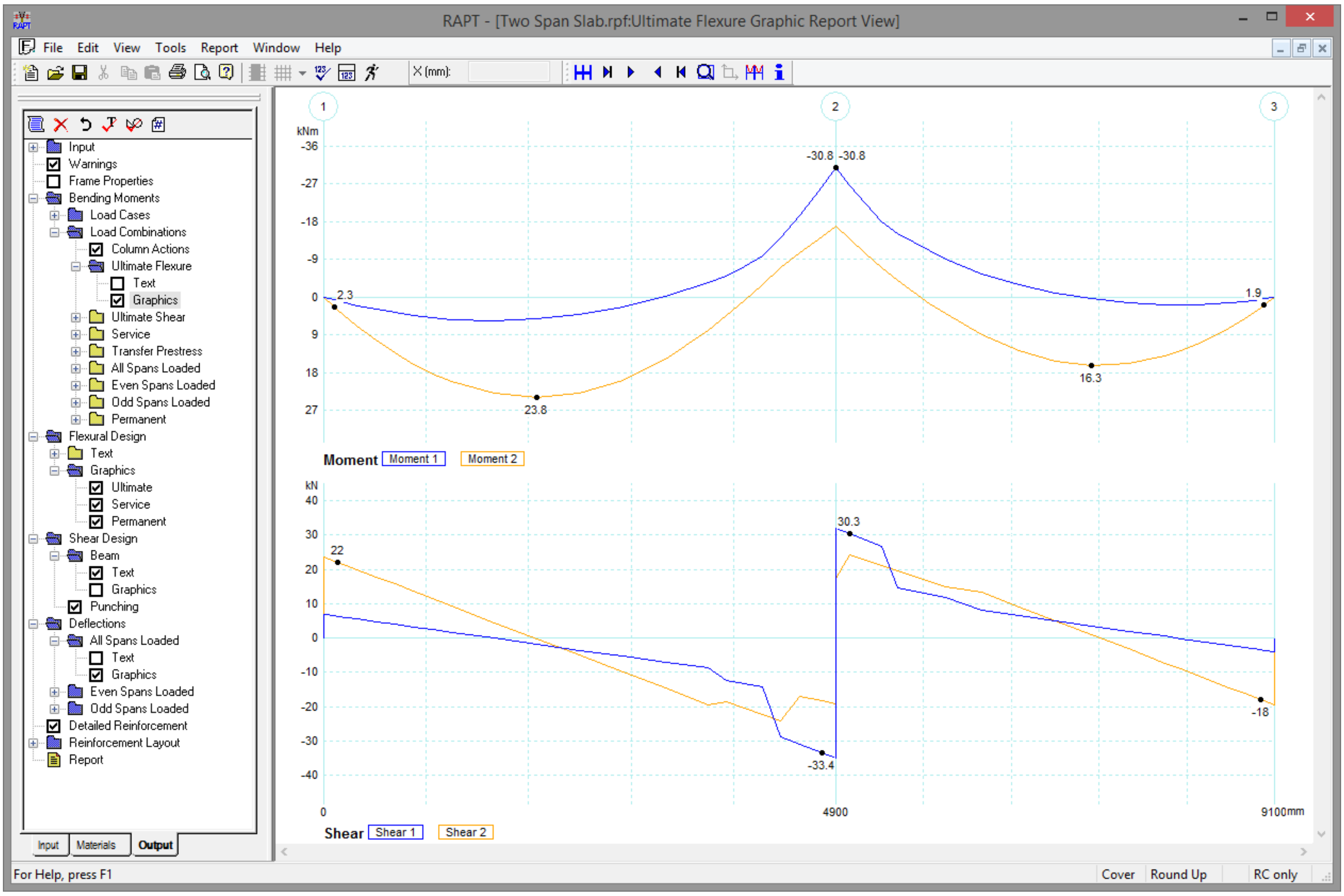


Figure A2 – Shear Force Diagram

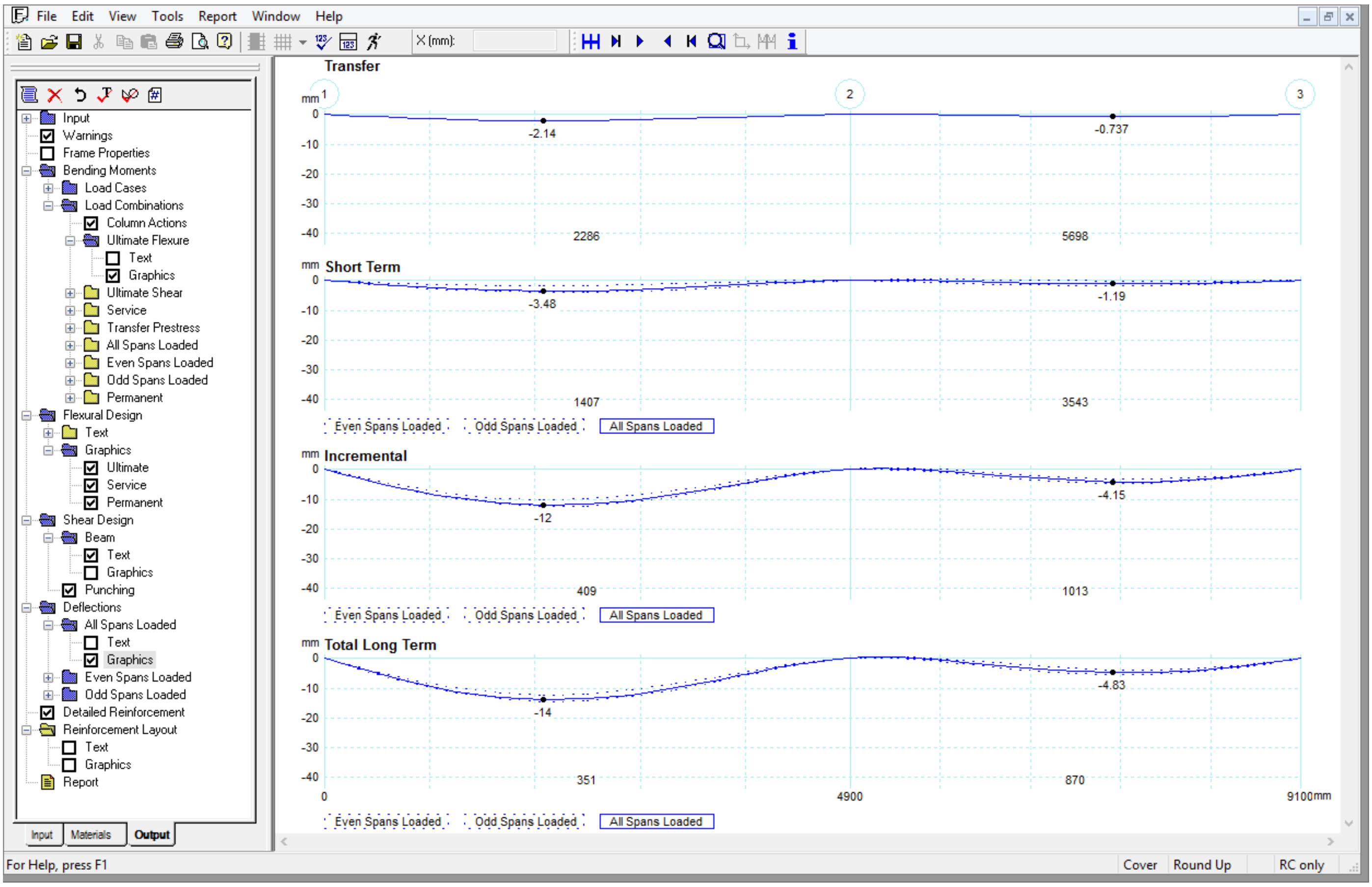
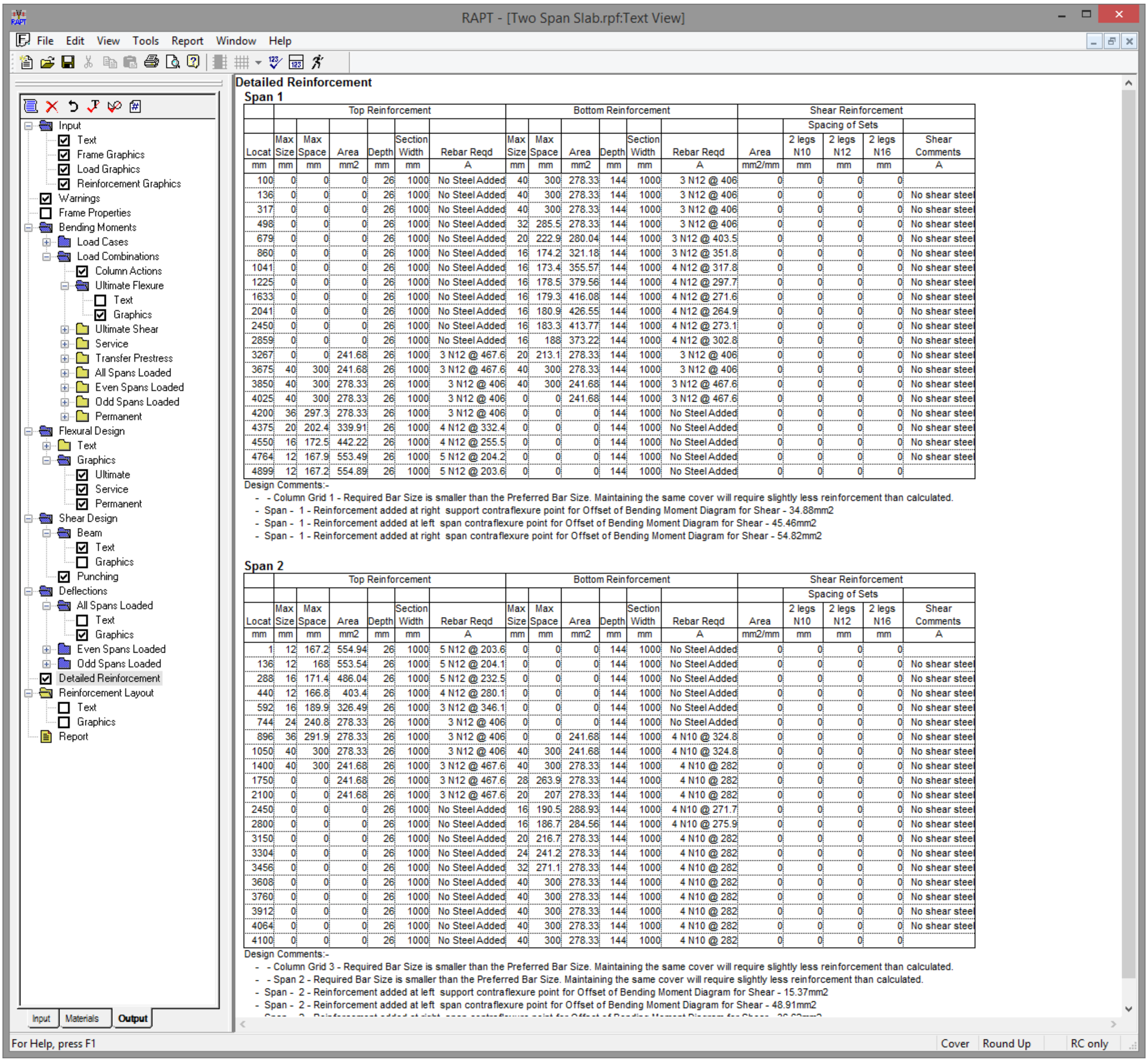


Figure A3 - Deflections



Detailed Reinforcement

Span 1

	Top Reinforcement						Bottom Reinforcement						Shear Reinforcement				
														Spacing of Sets			
Locat	Max Size	Max Space	Area	Depth	Section Width	Rebar Reqd	Max Size	Max Space	Area	Depth	Section Width	Rebar Reqd	Area	2 legs N10	2 legs N12	2 legs N16	Shear Comments
mm	mm	mm	mm2	mm	mm	A	mm	mm	mm2	mm	mm	A	mm2/mm	mm	mm	mm	A
100	0	0	0	26	1000	No Steel Added	40	300	278.33	144	1000	3 N12 @ 406	0	0	0	0	
136	0	0	0	26	1000	No Steel Added	40	300	278.33	144	1000	3 N12 @ 406	0	0	0	0	No shear steel
317	0	0	0	26	1000	No Steel Added	40	300	278.33	144	1000	3 N12 @ 406	0	0	0	0	No shear steel
498	0	0	0	26	1000	No Steel Added	32	285.5	278.33	144	1000	3 N12 @ 406	0	0	0	0	No shear steel
679	0	0	0	26	1000	No Steel Added	20	222.9	280.04	144	1000	3 N12 @ 403.5	0	0	0	0	No shear steel
860	0	0	0	26	1000	No Steel Added	16	174.2	321.18	144	1000	3 N12 @ 351.8	0	0	0	0	No shear steel
1041	0	0	0	26	1000	No Steel Added	16	173.4	355.57	144	1000	4 N12 @ 317.8	0	0	0	0	No shear steel
1225	0	0	0	26	1000	No Steel Added	16	178.5	379.56	144	1000	4 N12 @ 297.7	0	0	0	0	No shear steel
1633	0	0	0	26	1000	No Steel Added	16	179.3	416.08	144	1000	4 N12 @ 271.6	0	0	0	0	No shear steel
2041	0	0	0	26	1000	No Steel Added	16	180.9	426.55	144	1000	4 N12 @ 264.9	0	0	0	0	No shear steel
2450	0	0	0	26	1000	No Steel Added	16	183.3	413.77	144	1000	4 N12 @ 273.1	0	0	0	0	No shear steel
2859	0	0	0	26	1000	No Steel Added	16	188	373.22	144	1000	4 N12 @ 302.8	0	0	0	0	No shear steel
3267	0	0	241.68	26	1000	3 N12 @ 467.6	20	213.1	278.33	144	1000	3 N12 @ 406	0	0	0	0	No shear steel
3675	40	300	241.68	26	1000	3 N12 @ 467.6	40	300	278.33	144	1000	3 N12 @ 406	0	0	0	0	No shear steel
3850	40	300	278.33	26	1000	3 N12 @ 406	40	300	241.68	144	1000	3 N12 @ 467.6	0	0	0	0	No shear steel
4025	40	300	278.33	26	1000	3 N12 @ 406	0	0	241.68	144	1000	3 N12 @ 467.6	0	0	0	0	No shear steel
4200	36	297.3	278.33	26	1000	3 N12 @ 406	0	0	0	144	1000	No Steel Added	0	0	0	0	No shear steel
4375	20	202.4	339.91	26	1000	4 N12 @ 332.4	0	0	0	144	1000	No Steel Added	0	0	0	0	No shear steel
4550	16	172.5	442.22	26	1000	4 N12 @ 255.5	0	0	0	144	1000	No Steel Added	0	0	0	0	No shear steel
4764	12	167.9	553.49	26	1000	5 N12 @ 204.2	0	0	0	144	1000	No Steel Added	0	0	0	0	No shear steel
4899	12	167.2	554.89	26	1000	5 N12 @ 203.6	0	0	0	144	1000	No Steel Added	0	0	0	0	

Design Comments:-

- \- Column Grid 1 - Required Bar Size is smaller than the Preferred Bar Size. Maintaining the same cover will require slightly less reinforcement than calculated.
- Span - 1 - Reinforcement added at right support contraflexure point for Offset of Bending Moment Diagram for Shear - 34.88mm2
- Span - 1 - Reinforcement added at left span contraflexure point for Offset of Bending Moment Diagram for Shear - 45.46mm2
- Span - 1 - Reinforcement added at right span contraflexure point for Offset of Bending Moment Diagram for Shear - 54.82mm2

Span 2

	Top Reinforcement						Bottom Reinforcement						Shear Reinforcement				
														Spacing of Sets			
Locat	Max Size	Max Space	Area	Depth	Section Width	Rebar Reqd	Max Size	Max Space	Area	Depth	Section Width	Rebar Reqd	Area	2 legs N10	2 legs N12	2 legs N16	Shear Comments
mm	mm	mm	mm2	mm	mm	A	mm	mm	mm2	mm	mm	A	mm2/mm	mm	mm	mm	A
1	12	167.2	554.94	26	1000	5 N12 @ 203.6	0	0	0	144	1000	No Steel Added	0	0	0	0	
136	12	168	553.54	26	1000	5 N12 @ 204.1	0	0	0	144	1000	No Steel Added	0	0	0	0	No shear steel
288	16	171.4	486.04	26	1000	5 N12 @ 232.5	0	0	0	144	1000	No Steel Added	0	0	0	0	No shear steel
440	12	166.8	403.4	26	1000	4 N12 @ 280.1	0	0	0	144	1000	No Steel Added	0	0	0	0	No shear steel
592	16	189.9	326.49	26	1000	3 N12 @ 346.1	0	0	0	144	1000	No Steel Added	0	0	0	0	No shear steel
744	24	240.8	278.33	26	1000	3 N12 @ 406	0	0	0	144	1000	No Steel Added	0	0	0	0	No shear steel
896	36	291.9	278.33	26	1000	3 N12 @ 406	0	0	241.68	144	1000	4 N10 @ 324.8	0	0	0	0	No shear steel
1050	40	300	278.33	26	1000	3 N12 @ 406	40	300	241.68	144	1000	4 N10 @ 324.8	0	0	0	0	No shear steel
1400	40	300	241.68	26	1000	3 N12 @ 467.6	40	300	278.33	144	1000	4 N10 @ 282	0	0	0	0	No shear steel
1750	0	0	241.68	26	1000	3 N12 @ 467.6	28	263.9	278.33	144	1000	4 N10 @ 282	0	0	0	0	No shear steel
2100	0	0	241.68	26	1000	3 N12 @ 467.6	20	207	278.33	144	1000	4 N10 @ 282	0	0	0	0	No shear steel
2450	0	0	0	26	1000	No Steel Added	16	190.5	288.93	144	1000	4 N10 @ 271.7	0	0	0	0	No shear steel
2800	0	0	0	26	1000	No Steel Added	16	186.7	284.56	144	1000	4 N10 @ 275.9	0	0	0	0	No shear steel
3150	0	0	0	26	1000	No Steel Added	20	216.7	278.33	144	1000	4 N10 @ 282	0	0	0	0	No shear steel
3304	0	0	0	26	1000	No Steel Added	24	241.2	278.33	144	1000	4 N10 @ 282	0	0	0	0	No shear steel
3456	0	0	0	26	1000	No Steel Added	32	271.1	278.33	144	1000	4 N10 @ 282	0	0	0	0	No shear steel
3608	0	0	0	26	1000	No Steel Added	40	300	278.33	144	1000	4 N10 @ 282	0	0	0	0	No shear steel
3760	0	0	0	26	1000	No Steel Added	40	300	278.33	144	1000	4 N10 @ 282	0	0	0	0	No shear steel
3912	0	0	0	26	1000	No Steel Added	40	300	278.33	144	1000	4 N10 @ 282	0	0	0	0	No shear steel
4064	0	0	0	26	1000	No Steel Added	40	300	278.33	144	1000	4 N10 @ 282	0	0	0	0	No shear steel
4100	0	0	0	26	1000	No Steel Added	40	300	278.33	144	1000	4 N10 @ 282	0	0	0	0	

Design Comments:-

- \- Column Grid 3 - Required Bar Size is smaller than the Preferred Bar Size. Maintaining the same cover will require slightly less reinforcement than calculated.
- \- Span 2 - Required Bar Size is smaller than the Preferred Bar Size. Maintaining the same cover will require slightly less reinforcement than calculated.
- Span - 2 - Reinforcement added at left support contraflexure point for Offset of Bending Moment Diagram for Shear - 15.37mm2
- Span - 2 - Reinforcement added at left span contraflexure point for Offset of Bending Moment Diagram for Shear - 48.91mm2

Figure A4 – Reinforcement Output

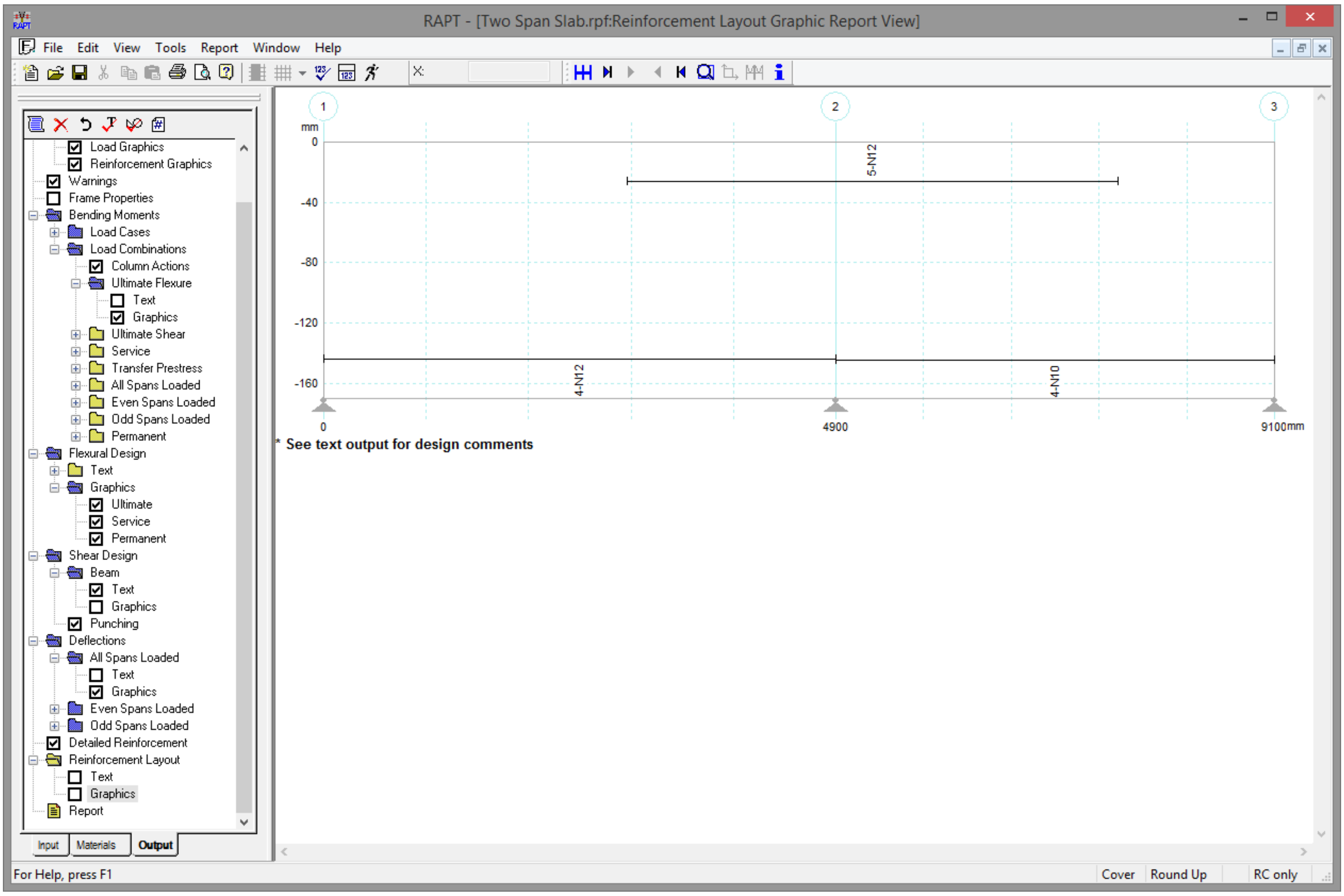


Figure A5 – Reinforcement Diagram