



## STRUSOFT

## **EXAMPLES PRE-STRESS 6.4**



STEP BY STEP EXAMPLES 6.04.005 - 2014-07-018

## CONTENTS

<u>1</u> BASIC CONCEPT	2
1.1 CODES	2
1.2 LAYOUT OF THE PROGRAM	3
<b>1.3</b> LIMITATIONS IN THE CURRENT VERSION	3
<u>2</u> EXAMPLES	4
2.1 MODELLING OF A TT/F 240/54 WITH NON-STRUCTU	RAL TOPPING 4
2.1.1 INPUT GEOMETRY	4
2.1.2 INPUT LOADS	12
2.1.3 CALCULATION	16
2.1.4 PRESENTING THE RESULTS	17
2.2 SLOPED I-BEAM (COMING SOON)	23
2.3 HOLLOWCORE SLAB (COMING SOON)	24
2.4 How to add a fire loadcombination	25
2.4.1 CREATING A LOADCOMBINATION THROUGH THE WIZ	ARD 25
2.4.2 MAKING A LOAD COMBINATION FROM THE PROJECT	MANAGER 26
2.4.3 COMBINATION OF LOADS	27
2.4.4 Settings for the fire	28
2.4.5 CALCULATION AND RESULTS	29

## 1 BASIC CONCEPT

## 1.1 CODES



Choose code	
Eurocode	- ОК
Concrete : Eurocode concrete 6.4.000	Path
Code version:	
EN 1992-1-1 (standard)	-
EN 1992-1-1 (standard)	
EN 1992-1-1 (British annex)	
EN 1992-1-1 (Danish annex)	
EN 1992-1-1 (Swedish annex)	
EN 1992-1-1 (Finnish annex)	
EN 1992-1-1 (Norwegian annex)	

When starting a new file, a question about selecting the code will appear. The possible codes to select depending on your license are:

- Eurocode EN 1992-1-1:2004 (Standard)
- Eurocode EN 1992-1-1:2004 (British NA)
- Eurocode EN 1992-1-1:2004 (Danish NA)
- Eurocode EN 1992-1-1:2004 (Swedish NA)
- Eurocode EN 1992-1-1:2004 (Finnish NA)
- Eurocode EN 1992-1-1:2004 (Norwegian NA)
- Old national codes are only available up to version 6.3.

In the program there is an option to calculate shear and fire with EN1168 (Precast concrete products – Hollow core slabs).

## 1.2 LAYOUT OF THE PROGRAM

PRE-Stress is based on the StruSoft Frame Analysis-engine to make calculations. The Frame Analysis core is a 2D-FEM equation solver. The two programs have many similarities but there are many differences as well due to the prestressing forces/effects.

## 1.3 LIMITATIONS IN THE CURRENT VERSION

It is not possible to make sloped TT-slabs (STT), this feature will be added in a future update.



Figure 1-1 Sloped TT-slab (STT-slab), picture from StruSoft FEM-Design

One limitation with hollow core slabs is that they can only have cores of equal size and geometry.

## 2 EXAMPLES

## 2.1 MODELLING OF A TT/F 240/54 WITH NON-STRUCTURAL TOPPING

The first example is a 12m TT-slab. It will be calculated with Eurocode with Swedish annex.



Figure 2-1 3D-view of a TT/F 240/54 (FEM-Design)

## 2.1.1 INPUT GEOMETRY

The width of the slab is 2.4m, but version 6.4 currently only supports single T-beams, so the calculations will focus on one of the legs. After selecting the code the project manager-window pops up. In the Inputtab to the right the name, length and cross-section can be entered, along with structural topping, if present.

<b>«</b> Prestressed input/[PRE-Stress1*]						
Input - Prestressed	Input					
Se Project			Length [m]	Section		
	Name:	TT 501	12		▼	
				Topping		
					▼	
	Ad	d <u>C</u> hange <u>D</u> elete			Gone	
	L					

Figure 2-2 Input of elements

In the Name-box an identifier for the element should be entered, in this example we will use *TT 501*. The length of the slab is 12m. When entering the section of the slab it is possible to select already used sections in the dropdown-box, if none are present then click on the [...]-box to the right of the dropdown-box.

StruSoft Academy	Guide to PRE-Stress 6.4
I	

<b>D</b>				
Database Standard Eurocode concrete Non-standard concrete Non-standard concrete	Non-standard concrete Rectangular solid Variable rectangular section Solid circular Solid circular Singlesym. I-section Fr-section D-section A HD-section SIB	A = -  y = -  z = - ey = -	- m2 m4 m4	
			ΟΚ	Cancel

Figure 2-3 Crossection database, overview

Select Non-standard concrete to the left and Variable T-section to the right. (In order to use standard profiles from a few companies that want their cross-sections in the database, then we could use the Standard Eurocode concrete-database and directly select the section.)

Section				x
Non-standard concrete Rectangular solid Variable rectangular section T-section Solid circular Singlesym. I-section F-section Fh-section C Previous Database	Section name	A = - ly = - lz = - ey = -	- m2 m4 m4	
			0K Canc	el

Figure 2-4 Crossection database

If this is the first time entering variable T-sections, then this sub-library is most likely empty. The more section you use the longer the selection of possible sections will be. To add a new section press [Add].



Change Non-Standard sections				×
Get	▼ Set to zero	Name	TT 240/54	
. в.			(all measures in	n mm)
		н	540	B 1200
		d1	210	d2 280
║  ┖┓   ┍┛───┤	~	t	100	
	H	Add	<u>C</u> hange	e <u>D</u> elete
		A = lx =	ז י	m2 m4
		Ca	ancel	ОК

Figure 2-5 Entering a new variable T-section.

Enter the values according to Figure 2-5 and press [Add] and then [OK].

The cross section name should now be visible in the list of available cross sections. Select *TT 240/54* in the list and press [OK]

<pre>     Prestressed input/[PRE-Stress1*] </pre>		
Input - Prestressed	Input	
Service Project	Length [m] Section	
	Name: TT 501 12.000 TT 240/54	
	Topping	
	▼ …	
	Add Qhange Delete Qone	
4		

Figure 2-6 Project overview

In this example we will not use any structural topping so leave this box empty. To finalize the input of the geometry and add the element to the project-list press [Add] as shown in Figure 2-6.

Now a window will appear (Figure 2-7) where different kinds of support conditions and automatic calculation of dead loads can be set.

StruSoft Academy	Guide to PRE-	Stress 6.4
	1	Create new prestressed beam
		Use the options below to create a new prestressed beam element
		Create default load combinations according to the current code settings.
		Automatically generate dead loads and add the dead loads to these base loadcases:
		Base loadcase
		Automatically create supports according to current code settings
		Only show this dialog when the Shift key is down or if there is an error according to the options above OK Cancel

Figure 2-7 Create a new prestressed beam

We want to generate the dead loads automatically, select the [...]-button to the right of the Base load casedropdown box.

Basic loadcases	The Party States	-		X
Name:				
				Add Change Delete Copy
			Cancel	ОК

Figure 2-8 Basic load cases without entered loads

Now a dialogue box will appear (Figure 2-8) to define the basic load cases. After entering the dead load case it is now also possible to enter all the other ordinary loads acting on the element. Enter the names and add them. Enter all the loads according to Figure 2-9. When ready, select the load case where the dead load will be automatically generated in: select *Dead load*. If you should miss to select the right load case then you have the possibility to change it afterwards (Figure 2-10).

Basic loadcases	The Rengthern Saller in court of the part	×
Name: Dead load		
Dead load Installations Topping Live load		Add Change Delete Copy
	Cancel	OK

Figure 2-9 Entering basic loadcases

Since we haven't defined any structural topping the *Base load case (topping)* is inactive, Figure 2-10. If you want other support options then it is better to go in and change existing supports, rather than defining new. Press [OK] to create the beam, and the supports for the beam.

StruSoft Academy	Guide to PRE-	Stress 6.4
		Create new prestressed beam
		Use the options below to create a new prestressed beam element
		Create default load combinations according to the current code settings.
		Automatically generate dead loads and add the dead loads to these base loadcases:
		Base loadcase: Dead load   Base loadcase (topping):
		Automatically create supports according to current code settings
		Only show this dialog when the Shift key is down or if there is an error according to the options above OK Cancel

Figure 2-10 Basic load case for dead load entered

Now the beam is created with support, nine load combinations and some assorted information about the element. It is now possible to continue entering additional elements with various spans, geometries and load cases. With one element in the project manager the view should be similar to Figure 2-11.

Stressed input/[PRE-Stress1 (PRE-Stress	ss examples.ccp)]	
Input - Prestressed	Input	
	Length [m] Section Name: TT 501 12.000 TT 240/54 Topping	
<ul> <li>Transport</li> <li>Frection</li> <li>Intermediate stage (</li> <li>Final stage (Long ter</li> <li>Final stage (Short ter</li> <li>Final stage (6.10a, ul</li> <li>Final stage (6.10b, ul</li> </ul>	TT 501       12 000       TT 240/54         Add       Qhange       Delete	
I ← III → IIII → IIII → III → II		

Figure 2-11 Project overview with one element

To get an overview of the element and its load combinations, select the name (TT 501) and then it is possible to graphically show the beam with all the combinations. In some cases the project overview window may cover. To make the project window smaller, click on << in the upper left corner. To restore the window again, click on >> instead. To open and close the project window, press the beam as shown in Figure 2-12.



Figure 2-12 Open/close the project window



Figure 2-13 Overview of the load combinitions

To add more load combinations look at 2.3 Hollowcore slab (coming soon) or 2.4 How to add a fire loadcombination.

Open up the project overview and select *TT 501* to the left. On the right side the input form for the reinforcement will now be visible (Figure 2-15).

# STRUSOFTGuide to PRE-Stress 6.4ACADEMY

Before defining reinforcement we need to set the different exposure classes in the later stages and ultimate limit stages, this to get the correct cover from the code. Go through the load combinations release to the final stages to verify the correct exposure class, life class and if possible, the concrete class as well, according to Figure 2-14. For this example we use either X0 or XC1.

<b>44</b> Prestressed input/[PRE-Stress2 (Training e	example 1 6.4.001.ccp)*]	
Prestressed input/IPRE-Stress2 (Training of Input - Prestressed           Project           TT 501           Isolations           Release           Storage/Maturing           Transport           Erection           Intermediate stage (           Final stage (Long term	example 1 6.4.001.ccp)*]  Materia  General  Exposure class XC1 Dry or permanently wet XC2 User, arely dry  Quality control = XC3 Moderate humidity Reduced or mei XC4 Cyclic wet and dry XD1 Moderate humidity XD2 Wet, rarely dry XD3 Cyclic wet and dry XD1 Exposed to airborne salt but nc XS2 Exposed to airborne salt but nc XS2 Exposed to airborne salt but nc	Concrete (MPa) Strength class: C40/50  C40/50  Concrete (MPa) Low strength variation (< 10 %) fod 40.00 fod 40.00 fod 2.46 E0d 35220
Final stage (Chot) ter Final stage (Short ter Final stage (6.10a, ul Final stage (6.10b, ul	XS2 Permanently submerged XS3 Irdal, splash and spray zones XA1 Slightly aggressive chemical er XA2 Moderately aggressive chemical en XA3 Highly aggressive chemical en	

Figure 2-14 Exposure classes

K Prestressed input/[PRE-Stress2 (Training exam	nple 1 6.4.	)03.ccp)*	]		8 8							_		
Input - Prestressed	Main reinf	prcement	Stirrup	reinforce	ment R	einforcement	details	Calculation	settings Fire	,	Calculation sections			
Project     TT 501     Release     Storage/Maturing     Fransport     Kertion		540					12000				×		540 1200	*
Intermediate stage (S		Start coordinate [mm] Length Diameter Area Pre-stress										*	X-coord. for section [r	nm]: 6000
Final stage (Long ter		х	у	z	[mm]	[mm]	[mm²]	[MPa]	Full bond	ł	Material			Edit reinforcement
🕼 Final stage (Short ter	1	0	529	36	12000	12.9	100	1300	At no side	•	SS3620LR		Copy	Adjust
Final stage (6.10a, ult	2	0	562	36	12000	12.9	100	1300	At no side	•	SS3620LR		Incent	measurement
🖉 Final stage (6.10b, ult	3	0	638	36	12000	12.9	100	1300	At no side	•	SS3620LR		insen	Std
	4	0	671	36	12000	12.9	100	1300	At no side	•	SS3620LR		Delete	reinforcement
	5	0	527	69	12000	12.9	100	1300	At no side	•	SS3620LR			Layer of
	6	0	673	69	12000	12.9	100	1300	At no side	•	SS3620LR			ion of content
	7	0	37	503	12000	12.9	100	1300	At no side	•	SS3620LR		Split	
	8	0	492	503	12000	12.9	100	1300	At no side	•	SS3620LR		Modify	
	9	0	708	503	12000	12.9	100	1300	At no side	•	SS3620LR	-	x=	L=
4						-				_				

Figure 2-15 Reinforcement view

Click [Std reinforcement] and select Reinforcement Proposal 5, finish with [OK].

Now the reinforcement list will be filled with the predefined reinforcement position, these can be modified in the table, and more reinforcement wires/bars can be added below. The start coordinate is the left end of the wire/bar and with length it is possible to define the position along the element.

To control the prestressing stress, enter the value in the Pre-stress column and Material governs the material and possible wire/bar diameters. Full bond is a function to solve reinforcement with a variable location in the cross section (sloped I-beams and the function will also be used for sloped TT-elements in the future). It is not possible to change it for variable T-sections, hence the default value is set to *At no side*.

# STRUSOFTGuide to PRE-Stress 6.4ACADEMY

Next tab, Stirrup reinforcement, contains information about the stirrups in the element. Enter Ø8 s300 along the whole element, according to Figure 2-16. Be sure to have the group(s) fill the whole element, do not start 40mm in from the end, the program will see that small part as unreinforced and might fail the shear calculation.



Figure 2-16 Stirrup reinforcement

The next two tabs, Reinforcement details (Figure 2-17) and Calculation settings (Figure 2-18), contains settings for code checks for the reinforcement and the calculations.

According to Swedish NA, 6.2.3 (2), can  $\cot(\theta) = 3,0$  be used for prestressed members (Figure 2-18), check this setting if it is possible to use other values than the normal  $(1 \le \cot(\theta) \le 2.5)$  for your current code.

<b>«</b> Prestressed input/[PRE-Stress2 (Training e	example 1 6.4.003.ccp)*]							x
Input - Prestressed	Main reinforcement Stirrup	reinforcement	Reinforc	ement details	Calculation	settings Fire	Calculation sections	
Project	Diameter (mm)	Bottom	Code	Top 12.9 -	Code	Use stimups	8 -	
i Icoad combinations	Cover (mm) Cover side (mm)	29	29 29	30	29			
Storage/Maturing	Distance between bars:	20	20	20		Min. s dist (mm)	: 30 In whole length	
Erection	In same layer (mm) In different layers (mm)	20	20	20	20 20			
<ul> <li>Interintenate stage (5</li> <li>Final stage (Long ter</li> </ul>	Vibration space (mm)	0		Gener	al			
Final stage (Short ter	Largest aggregate size Cover deviation (mm)	10		Code va	lues			
G.10b, ult	Use regular spacing in la	ayer	🔽 Cod	e control				
	L							

Figure 2-17 Code check concerning the reinforcement against the current code.



Figure 2-18 Calculation settings

In the last tab, Calculation sections, a good spacing between the sections should be used. As a rule of thumb, use a value slightly less than the cross section height. In the current example 0.5[m] is used then press [s]-button. The result should look like Figure 2-19. This setting is auto generated by the program, but it is always a good idea to verify that there are calculation sections spread evenly over the whole element.

K Prestressed input/[PRE-Stress2 (Training e	example 1 6.4.003.ccp)*]					
Input - Prestressed	Main reinforcement Stin	up reinforcement	e Calculation sections			
	Calculation sections [m]	Calci More secti This ete te all	ulation sections accurate results are nor ons and non linearity if th is possible by defining mo	mally reached considerin, e members are split into s re calculation sections.	cracked maller parts.	
<ul> <li>Final stage (Short ter</li> <li>Final stage (6.10a, ult</li> <li>Final stage (6.10b, ult</li> </ul>	4.800 5.400 6.000 • Length 12.000	[m]	Section heigh 540	t [mm]		
< >		_				



### 2.1.2 INPUT LOADS

Now with the geometry and calculation settings done, the next step will be to combine the loads. Select *Load combinations* to the left. To the right two tabs will appear *Load combinations* and *Long term parameters*. In the *Load combinations*-tab combine the loads to the very right according to Figure 2-20.



Prestressed input/[PRE-Stress2 (Training Input - Prestressed	example 1 6.4.003.ccp)*]		X
<ul> <li>Project</li> <li>TT 501</li> <li>Release</li> <li>Storage/Maturing</li> <li>Transport</li> <li>Frection</li> <li>Intermediate stage (S</li> <li>Final stage (Chong ter</li> <li>Final stage (Short ter</li> <li>Final stage (6.10b, ult</li> <li>Final stage (6.10b, ult</li> </ul>	Name         Combination of loadcases (ex. 1.4*B1+0.7B           ID         ID           ID         ID <td>Imit-state     Type     Dependent of       ULS     V     V       SLS     Short       ULS     7       ULS     7</td> <td></td>	Imit-state     Type     Dependent of       ULS     V     V       SLS     Short       ULS     7       ULS     7	
< <u> </u>	Add Qhange Delete Insert	☑ Original text	

Figure 2-20 Load combinations

As for the long term parameters a creep value of 2 shall be divided in the different fields. If 25% of the creep is introduced at the Storage/maturing and 75% at the Final stage (Long term) then the creep should be entered as 2\*0.25 = 0.5 and 2\*0.75 = 1.5. The same goes for the shrinkage, but here we divide the 0.2% equal between the two long term cases.

K Prestressed input/[PRE-Stress2 (Training)	example 1 6.4.003.ccp)*]					
Input - Prestressed	Load combinations Long term parame	ters				
	Cree Load combination coef	Ever p shrinka ficient (perm	e :)			
Load combinations	Storage/Maturing 0.50	0.10	A	A		
🖉 Release	Final stage (Long term) 1.50	0.10				
🖉 Storage/Maturing						
🖉 Transport						
🖉 Erection						
🖉 Intermediate stage (S						
🖉 Final stage (Long ter			-			
Final stage (Short ter						
Final stage (6.10a, ult						
Final stage (6.10b. ult						

Figure 2-21 Long-term parameters

Next step is to check the supporting conditions and the material properties for each specific load combination. It is in this stage that it will be possible to change the supports etc. Select Release to get the option to change the material properties and supports at the release stage in the factory.

# STRUSOFTGuide to PRE-Stress 6.4ACADEMY



Figure 2-22 Release

In order to change the support conditions, double click on support 1 or 2, or node 3 or 4, depending on if the support isn't located at the end. It can be a little bit tricky to get the support, but with a little bit of experience and a lot of technique then it will be possible. When it comes to the material of the element then the default option is that there is a bit of increase in the concrete strength from release to the final stages.

Continue to *Input loads* (Figure 2-23). Here is a overview of each load case (1) and the input of loads are inactive in the overview (2). To be able to enter loads in the different load combinations a load combination in the project overview must be selected.

## Guide to PRE-Stress 6.4

## STRUSOFT ACADEMY



Figure 2-23 Inputloads, overview

The reason for the load combination *Intermediate stage* is that the cracking would be as fully developed before going into the long term stage. That gives a more correct picture of the deflection and cracking in the long term checks.

The dead load is defined automatically, so there is no need to define it again manually.

Enter an installation load of 0.5 kN/m<sup>2</sup> \* 1.2m = **0.6** kN/m in the following load combinations:

- Erection
- Intermediate stage (Short term)
- Final stage (Long term)
- Final stage (Short term)
- Final stage (6.10a, ultimate)
- Final stage (6.10b, ultimate)

Enter a 50mm topping as a permanent load. 50mm \* 25kN/m<sup>3</sup> \* 1.2m = **1.5** kN/m in the following load combinations:

- Erection
- Intermediate stage (Short term)
- Final stage (Long term)
- Final stage (Short term)
- Final stage (6.10a, ultimate)
- Final stage (6.10b, ultimate)

And finally the live load 8 kN/m<sup>2</sup> \* 1.2m = 9.6 kN/m. It should be applied as a characteristic load on the intermediate and final load combinations.

- Intermediate stage (Short term)
- Final stage (Long term)
- Final stage (Short term)
- Final stage (6.10a, ultimate)
- Final stage (6.10b, ultimate)

PRE-Stress - [PRE-Stress2 (Training example 1 6.4.003.ccp)* - EN 1992-1-1 (Swedish annex)]			
Eile Edit View Loadcases Loads Calculate Option Window Help			_ 8 ×
Input geometry Results X (m): 0.5     Member: TT 501		Loadcase	
Input loads Design Y (m): 1.5     Load combinations: 9		Live load	•
<b>*</b>			
	Release		
The The Test of th	- <b>##</b>		
>> Prestressed input/			
	2 Storage/Maturing		
Input - Prestressed	111111		
Project	Transport		
· · · · · · · · · · · · · · · · · · ·	· · · · · · · · · · · ·		
	Ct Exection		
M Starses (Matuing			
	Intermediate stage (Shor	t term)	
🖓 Intermediate stage (S			
- 🖉 Final stage (Long ter	Final stage (Long term)		
Final stage (Short ter			
🧬 Final stage (6.10a, ult			
Simme Brinal stage (6.10b, ult	Final stage (Short term)		
	Final stage (6.10a, ultimation of the stage	ate)	
$ \longrightarrow x $			
	Final stage (6.100, ultima	atej	
Y [Input loads]	<i></i>		EXI 1992 1 1 (Durafich annix)
Readyl (For help press F1)			NUM

Figure 2-24 Loads defined

## 2.1.3 CALCULATION

To start the calculation, select *Calculate...* in the menu bar. Unselect *Second order analysis* in the calculation since it will not be relevant for calculation of single elements (see Figure 2-25).

Calculate		×
Second order analysis All prestressed element	s	Calculate Cancel
No. of displayed sections	20	
Convergence cond. (%):	2.00	
Max. no. of iterations	20	Standard
Calculation parameters for	concrete	
Convergence cond. (%):	0.10	
Max. no. of iterations	20	
Min. stiffness red. (%):	10	
Cracked section analysis		Standard

Figure 2-25 Calculate... [Calculate]

STRUSOFTGuide to PRE-Stress 6.4ACADEMY

## 2.1.4 PRESENTING THE RESULTS



Figure 2-26 Deflections

The deflections are shown as two values, the first is the shortening of the element the second value is camber (pos.)/deflection (neg.) ie. deformation in (x,y). The program also presents values for deflection in ultimate limit state, but these can be ignored since deflections are not relevant and that the program uses material strengths with safety factors. After checking support reactions, moment curves and equilibrium, then continue to (select) the Design-part of the program. Select *Calculate* in the menu bar.

## Guide to PRE-Stress 6.4

## STRUSOFT ACADEMY

	PRE-Stress	- (PRE	-Stress2	2 (Trainir	ng exam	nple <b>1</b> 6.4	4.003.ccp	)* - EN 1	1992-1-	1 (Swe	dish ar	nnex)]											x
	<u>F</u> ile <u>E</u> di	t <u>V</u> iev	w Inpu	ut Calc	ulate	Results	Option	<u>W</u> ind	ow <u>H</u>	elp													- 8 ×
C	Input geor Input load	netry s	⊘ Resi ⊚ Desi	ults ign		≺ (m): 5.0 Y (m): 1.5			Me Loa	mber: T ad comb	T 501 pinations	: 9											
C	I 🖻 🛛		2.0		)₩  €	3 G.	8																
	I 🖽 🔍	9.4	D Q:	<u>n</u>																			
Ø																							
		•																					
-					1										Relea	se							· · ·
⊿					<i>"</i>																		
_				. 📲	1.43									- 4	2 Stora	je/Ma	turing	].					
+					1 3										2 Trans	port							
-			•	•											•		•						· ·
				· _	<u>.</u> 13									· _	Erecti	on						•	• •
				. 7///	<i>"</i>		•		•			•	•		π.								
				. 🛉	13									· 🗼	A Intern	nediat	e stag	je (Shi	ort te	rm)			
					m 										π.								
				4	13										Final	stage	(Long	term)	]				
		·		· 7///									· · · ·		7		•						
		•		· •	<u>.</u>		•			•		•		· .	Final	stage	(Shor	t term]		•		•	· ·
				. 7/10	· ·	· · · ·		·			· · ·			•	<i>.</i>			•		•			
				· -	43										Final	stage	(6.10	a, ultir	nate)	}			
	. <b>Y</b> .														77 .								
	. ↑.				una .										Final	stage	(6.10	b, ultir	nate)	]			
	<del> </del>	ightarrow X Desig	n]	The										1111	7					EN	1992-1-	1 (Swed	ish annex)
Rea	l dy! (For he	elp, pre	ss F1)	• •																	1	NUM	

Figure 2-27 Design, utilization

With a quick overview of the utilizations (Figure 2-27) it is possible to get an immediate idea if the element is ok, or if the utilization is too high the curve turns red at those sections.

The results that will be presented more thorough can be found under the menu item *Results*, Figure 2-28.

Code check
Capacity
Utilization colours
Utilization table
Table - bending
Table - bending (topping)
Table - shear
Table - shear (topping)
Table - crackdata
Interaction diagram
Table - Fire - Reduced concrete parameters
Table - Fire - Reinforcement
Section - Temperature Gradient

Figure 2-28 Design, Result menu



To check the different load combinations more in detail, select *Results* > Code check... (Figure 2-29)

Control			×
Section / Material: TT 240/54 / C30/37 Direction: y-y	k 0/37 Member: TI 501 Close Release Section: Storage/Mauring Transport Erection Intermediate stage (Short term) Final stage (Long term) Final stage (Short term) Fi		
Calculation only made according to 1:st o Crack width control Control for crack width according to code was not Initial prestress (Design section x=0.00) $f_{\rm pi}/0.80f_{\rm lk}$ = 1300/1386 = 0.938 < 1 Stress after release (Design section x=0. $f_{\rm pe}/0.75f_{\rm lk}$ = 1288/1395 = 0.923 < 1	rder theory. needed (see tat	Intermediate stage (Short term) Final stage (Long term) (je Final stage (S. 10a, ultimate) Final stage (S. 10b, ultimate) Final stage (S. 10b, ultimate)	

Figure 2-29 Results, Code check...

It is possible to flip through the different load combinations to get a numerical verification of the element. Depending on different types of load combinations (SLS or ULS), the program makes different checks at different stages.

- For serviceability limit states the program presents checks of stresses and cracks, there is also a possibility to check deflection criteria.
- For ultimate limit states the program present checks containing moment and shear capacities. It does check the most critical section, not always necessary mid-span or at the supports.

Next item in the list is *Capacity*. In this list the moment and shear capacities are shown along different sections of the element.

Figure 2-30 and Figure 2-31 shows values for bending moment capacity. These tables can be found from the *Table – Bending*-option from Figure 2-28.

Bending		- 34 - 15			-								
Member: TT & Loadcase: Fina	501 Il stage (Shi	ort term)	•	Calculation theory.	n only made	according to 1:	st order				C	Close	
Table -	- bend	ling											
Section	M <sub>d</sub>	Ni	M	$\sigma_{c,top}$	$\sigma_{c,btm}$	Crack	σ <sub>s,top</sub>	σ <sub>s,btm</sub>	M	Wk	Z		
m	KNm 0.0	34.5	4.4	MPa 0.02	MPa 0.41	stadium T	-36	-31	K.Nm	mm	mm 0.03		
0.099	-0.1	-193.0	-32.7	0.12	-2.80	T	159	200	-136.5	0.00	0.00		
0.101	0.0	-197.6	-33.4	0.12	-2.86	I	163	205	114.4	0.00	-0.00		
0.468	30.5	-932.2	-137.7	-0.93	-10.41	I	873	910	268.5	0.00	-0.16		
0.599	40.9	-1007.1	-129.2	-1.82	-9.57	I	1047	920	265.0	0.00	-0.25		
0.601	41.0	-1007.2	-129.2	-1.82	-9.56	I	1046	920	265.0	0.00	-0.25		
1.199	85.3	-1014.9	-133.2	-3.04	-7.13	I	1033	951	269.6	0.00	-0.95		
1.799	124.5	-1021.7	-136.8	-4.12	-4.98	I	1020	979	273.6	0.00	-1.99		
2.399	158.5	-1027.6	-139.9	-5.05	-3.12	I	1010	1003	277.1	0.00	-3.22		
2.999	187.2	-1032.6	-142.5	-5.84	-1.54	I	1001	1023	280.0	0.00	-4.49		
3.599	210.7	-1036.7	-144.6	-6.49	-0.25	I	993	1040	282.5	0.00	-5.69		
4.199	229.0	-1039.9	-146.3	-6.99	0.75	I	988	1053	284.3	0.00	-6.72		
4.799	242.1	-1042.2	-147.5	-7.35	1.47	I	984	1062	285.7	0.00	-7.51		
113%	1/1 -				Ready								

Figure 2-30 Table Bending, serviceability limit state

# STRUSOFTGuide to PRE-Stress 6.4ACADEMY

The different columns in the serviceability limit state means:

- Section [m]: Position of calculation sections
- M<sub>d</sub> [kNm]: Moment due to loads
- N<sub>i</sub> [kN]: Prestressing force
- M<sub>i</sub> [kNm]: The effect of the moment due to the prestressing force on the cross section
- σ<sub>c,top</sub> [MPa]: Concrete stress in the top of the cross section (shows dep. of cracking stadium)
- σ<sub>c,btm</sub> [MPa]: Concrete stress in the bottom of the cross section (shows dep. of cracking stadium)
- Crack stadium: Stadium I uncracked, Stadium II cracked
- $\sigma_{s,top}$  [MPa]: Steel stress in the top of the cross section
- $\sigma_{s,btm}$  [MPa]: Steel stress in the bottom of the cross section
- M<sub>cr</sub> [kNm]: Moment when the cross section cracks
- w<sub>k</sub> [mm]: Crack width
- z [mm]: Deformation deflection (negative values) / camber (positive values)

Bending		- 10			-	-							×
Member: TT Loadcase: Fina	501 al stage (6.1	l Ob, ultima	ate)	▼ Ca the	lculatior ory.	ı only	made acco	ording to 1::	st order			Close	
💕 🖬 🎒	🗄 🖻	) • =	₩ /	- M - M	$\vdash$								
Table ·	- bend	ling											Î
Section	N <sub>d</sub>	M <sub>d</sub>	M	$M_{d}/M_{u}$	z	x	8 <sub>c</sub>	8 <sub>5</sub>	σsc	σ <sub>st</sub>			
m		CNm 0 0	10 3	0 000	483	mm 5	-0 46	45 00	1594	MPa 1594			
0.099	0.0 -	-0.1 -	-34.8	0.003	460	39	-3.50	42.94	1584	1584			
0.101	0.0 (	0.0	66.7	0.000	478	13	-1.17	45.00	1594	1594			
0.468	0.0 4	9.9	284.7	0.175	479	37	-3.17	45.00	1594	1594			
0.599	0.0 6	56.9	286.8	0.233	479	39	-3.35	45.00	1594	1594			
0.601	0.0 6	57.1 3	286.9	0.234	479	39	-3.35	45.00	1594	1594			
1.199	0.0 13	39.6	327.5	0.426	479	41	-3.50	44.36	1591	1591			
1.799	0.0 20	03.8	377.2	0.540	479	45	-3.50	41.15	1576	1576			
2.399	0.0 2	59.4	425.6	0.610	479	48	-3.50	38.39	1563	1563			
2.999	0.0 30	06.5	446.5	0.687	479	50	-3.50	37.40	1558	1558			
3.599	0.0 34	45.0	446.6	0.773	479	49	-3.50	37.49	1559	1559			
4.199	0.0 3	75.0	446.7	0.839	479	49	-3.50	37.56	1559	1559	1		
4.799	0.0 3	96.4	446.7	0.887	479	49	-3.50	37.61	1559	1559			
113%	1/1 <					► F	leady			_			 

Figure 2-31 Table Bending, ultimate limit state

...and the equivalent for ultimate limit states:

- Section [m]: Position of calculation sections
- N<sub>d</sub> [kN]: Normal force due to imposed loads, does not consider prestressing.
- M<sub>d</sub> [kNm]: Moment due to loads
- M<sub>u</sub> [kNm]: Design moment
- M<sub>d</sub>/M<sub>u</sub>: Utilization with regards to the moments
- z [mm]: Interior lever
- x [mm]: Height of compressed zone
- $\epsilon_c$  [‰]: Concrete strain
- $\epsilon_s$  [‰]: Steel strain
- σ<sub>sc</sub> [MPa]: Equivalent steel stress for steel in compression
- $\sigma_{st}$  [MPa]: Equivalent steel stress for steel in tension

There are a few results in the Results-menu that contains"... (topping)", these will be active only if you have a structural topping defined.

Next table is Shear, it can only be checked in ultimate limit states, Figure 2-32.

Shear			10.00			- all resident	10 cm				
Member:	TT 501			•	Calcula	ation only made	e according to "	1:st order theory.			
Loadcase:	Final stage	(6.10b, u	ultimate)	•							
pi 🔒	a 🖪	Ð	Θ	<b>Ⅲ</b> II	- 	ы					
Table	- shear										
Section	V <sub>sd</sub>	۷'	VRd, a	V'/V <sub>Rd, a</sub>	V <sub>Rd, max</sub>	$(A_{sv}/s)_{cur}$	$(A_{sy}/s)_{req}$	(A <sub>sy</sub> /s) <sub>reg min</sub>	b,	z	
(m)	(kN)	(kN)	(kN)		(kN)	(mm <sup>2</sup> /m)	(mm <sup>2</sup> /m)	(mm <sup>2</sup> /m)	(mm)		
0.00	-0.0	0.0	197.9	0.000	397.0	335	0	221	217	483	
0.09	9 -2.4	0.0	197.9	0.000	408.2	335	0	220	217	460	
0.10	140.2	131.5	193.9	0.678	401.4	335	228	221	217	478	
0.46	3 131.5	131.5	193.9	0.678	447.3	335	228	221	217	479	
0.59	9 128.4	131.5	193.9	0.678	452.0	335	228	221	217	479	
0.60	L 128.3	108.6	193.9	0.560	452.0	335	188	221	217	479	
1.19	9 114.1	108.6	193.9	0.560	452.5	335	188	221	217	479	
1.79	99.8	77.0	193.9	0.397	452.9	335	133	221	217	479	
2.39	9 85.6	77.0	193.9	0.397	453.3	335	133	221	217	479	
2.99	ə 71.3	45.3	193.9	0.234	453.6	335	79	221	217	479	
3.59	9 57.1	45.3	193.9	0.234	453.9	335	79	221	217	479	
4.19	9 42.8	13.7	193.9	0.071	454.1	335	24	221	217	479	
4.79	9 28.5	13.7	193.9	0.071	454.2	335	24	221	217	479	
5.39	9 14.3	13.7	193.9	0.071	454.3	335	24	221	217	479	
5.99	9 0.0	0.0	193.9	0.000	454.3	335	0	221	217	479	
6.60	L -14.3	13.7	193.9	0.071	454.3	335	24	221	217	479	
7.20	L -28.5	13.7	193.9	0.071	454.2	335	24	221	217	479	
7.80	L -42.8	13.7	193.9	0.071	454.1	335	24	221	217	479	
8.40	L -57.1	45.3	193.9	0.234	453.9	335	79	221	217	479	
9.00	1 -71.3	45.3	193.9	0.234	453.6	335	79	221	217	479	
9.60	L -85.6	77.0	193.9	0.397	453.3	335	133	221	217	479	
10.20	1 -99.8	77.0	193.9	0.397	452.9	335	133	221	217	479	
10.80	1 -114.1	108.6	193.9	0.560	452.5	335	188	221	217	479	
11.39	9 -128.3	108.6	193.9	0.560	452.0	335	188	221	217	479	
11.40	1 -128.4	131.5	193.9	0.678	452.0	335	228	221	217	479	
92 %	1/1	1	102 0	0 690	445 0	Bead	1	201	017	4.20	
02.70						, neady	,				

Figure 2-32 Shear capacity

Here are the explanations for Figure 2-32:

- Section [m]: Position of calculation sections
- V<sub>sd</sub> [kN]: Shear force due to load
- V' [kN]: Shear force that you need to reinforce with stirrups for.
- V<sub>Rd,s</sub> [kN]: Capacity of the stirrups
- V<sub>Rd,max</sub> [kN]: Maximum shear capacity of the cross section (lower limit of compression failure)
- (A<sub>sw</sub>/s)<sub>cur</sub> [mm2/m]: Amount of stirrups, current amount
- (A<sub>sw</sub>/s)<sub>req</sub> [mm2/m]: Amount of stirrups, requirement due to loads
- (A<sub>sw</sub>/s)<sub>req min</sub> [mm2/m]: Amount of stirrups, minimum requirement due to the code
- b<sub>w</sub> [mm]: Calculated width
- z [mm]: Interior lever

#### The last table is Crack data, Figure 2-33.

Crack wi	<i>i</i> dth	1000		1.000	-							×
Member: Loadcase:	TT 5 Final	01 stage (Short term)		Calculation only mad theory.	le accord	ing to 1:st or	der				Close	
Res	ult	table for (	crack wi	dths								
Sect	ion (	Crack stage	A	I	ζ	M <sub>ct</sub>	A <sub>s,min</sub>	A <sub>s, cutt</sub>	S <sub>r,max</sub>	Wk		
(m	1)		(m <sup>2</sup> )	(m <sup>4</sup> )		(kNm)	(mm <sup>2</sup> )	(mm <sup>2</sup> )	(mm)	(mm)		
0.	.000	I	0.232337	0.00596357	0.00	0.0	0	0	-	0.00		
0	.099	I	0.232337	0.00596357	0.00	-136.5	0	0	-	0.00		
0	.101	I	0.232337	0.00596357	0.00	114.4	0	0	-	0.00		
0	.468	I	0.232337	0.00596357	0.00	268.5	0	0	-	0.00		
0	.599	I	0.232337	0.00596357	0.00	265.0	0	0	-	0.00		
0	.601	I	0.232337	0.00596357	0.00	265.0	0	0	-	0.00		
1.	.199	I	0.232337	0.00596357	0.00	269.6	0	0	-	0.00		
1	.799	I	0.232337	0.00596357	0.00	273.6	0	0	-	0.00		
2	.399	I	0.232337	0.00596357	0.00	277.1	0	0	-	0.00		
2	.999	I	0.232337	0.00596357	0.00	280.0	0	0	-	0.00		
3	.599	I	0.232337	0.00596357	0.00	282.5	0	0	-	0.00		
4	.199	I	0.232337	0.00596357	0.00	284.3	0	0	-	0.00		
4	.799	I	0.232337	0.00596357	0.00	285.7	0	0	-	0.00		
5	.399	I	0.232337	0.00596357	0.00	286.5	0	0	-	0.00		-
113 %		1/1 •		▶ Rea	dv							

Figure 2-33 Crack data

... and the explanations for Figure 2-33:

- Section [m]: Position of calculation sections
- Crack stage: Check if the crossection is uncracked (I) or cracked (II).
- A [m<sup>2</sup>]: Crossection area, if section is cracked this value will be reduced accordingly.
- I [m<sup>4</sup>]: Moment of inertia, if section is cracked this value will be reduced accordingly.
- ζ: Coefficient due to tension stiffening
- M<sub>cr</sub> [kNm]: Moment when the crossection cracks
- A<sub>s,min</sub> [mm<sup>2</sup>]: Minimum amount of crack reinforcement
- A<sub>s,curr</sub> [mm<sup>2</sup>]: Current amount of crack reinforcement
- s<sub>r.max</sub> [mm]: Distance between cracks
- w<sub>k</sub> [mm]: Crack width



## 2.2 SLOPED I-BEAM (COMING SOON)



## 2.3 HOLLOWCORE SLAB (COMING SOON)

## 2.4 How to add a fire loadcombination

This chapter will show two different ways to add a fire load combination to the calculation and to show the unique results that will be available.

### 2.4.1 CREATING A LOAD COMBINATION THROUGH THE WIZARD

The first place where you will be able to add a fire load combination is with the Create new prestressed beam-wizard. Just check the second checkbox and a fire combination called "Fire (6.11)" will appear last in the combination-list.

Cr	eate new prestressed beam
	Use the options below to create a new prestressed beam element
	Create default load combinations according to the current code settings.
	Create a default fire load combination according to the current code settings.
1	Automatically generate dead loads and add the dead loads to these loadcases:
	Loadcase: Dead load 🗸
	Loadcase (topping):
	Automatically create supports according to current code settings
	OK Cancel
	Only show this dialog when the Shift key is down or if there is an error according to the options above

Figure 2-34 Adding a fire load combination

If this had been activated for example in chapter 2.1 the result would have looked like this:

Prestressed input/[PRE-Stress2*]		
Input - Prestressed	Combination of loadcases (e	ex. 1.4*B1+0.7B2) Line state Ture Dependent
Project     TT501     Value     Release     Storage/Maturing     Transport     Project     Projec	Name D ID I Release Storage/Maturing Stransport Ferction S Intermediate stage (Short term) S Intermediate stage (Short term) S Final stage (Short term)	SLS     Short     B1     December I       SLS     Short     B1     December I       SLS     Short     B2     Live load       SLS     Short     3     B3     Installations       SLS     Short     4     SLS     Short     4       SLS     Short     4     SLS     Short     4       SLS     Short     6     ULS     7
<ul> <li>Final stage (Long ter</li> <li>Final stage (Short ter</li> <li>Final stage (6.10a, ul</li> <li>Final stage (6.10b, ul</li> <li>Final stage (6.10b, ul</li> <li>Fire (6.11, ultimate)</li> </ul>	<ul> <li>9 Final stage (6.10b, ultimate)</li> <li>10 Fire (6.11, ultimate)</li> </ul>	ULS 7 ULS Fire
4 <u> </u>	Add Change Delete Insert	☑ Original text

Figure 2-35 Fire load combination added

## 2.4.2 MAKING A LOAD COMBINATION FROM THE PROJECT MANAGER

Another way to add a fire load combination to an older file or if you forgot to check the checkbox in 2.4.1 is to do it manually.

<pre>     Prestressed input/[PRE-Stress2*] </pre>	
Input - Prestressed	Load combinations Long term parameters
Project	Name Combination of loadcases (ex. 1.4"B1+0.7B2) Limit-state Type Dependent of
1701     170     1701     170     17	ID         Hre (6.11)         ULS         Fire         •         Loadcase           1         1         Release         SLS         Short         B1         Dead load           2         2         Storage/Maturing         SLS         Long         1         B2         Live load           3         3         Transport         SLS         Short         2         B3         Installations           4         4         Erection         SLS         Short         3         B4         Topping           45         5         Intermediate stage (Short term)         SLS         Short         4         E
<ul> <li>Berection</li> <li>Intermediate stage (</li> <li>Final stage (Long ter</li> <li>Final stage (Short ter</li> <li>Final stage (6.10a, ul</li> <li>Final stage (6.10b, ul</li> </ul>	6       Final stage (Long term)       SLS       Long       5         7       7 Final stage (Short term)       SLS       Short       6         8       Final stage (6.10a, ultimate)       ULS       7         9       Final stage (6.10b, ultimate)       ULS       7
۲	Add Change Delete Insert I Original text

Figure 2-36 Entering a fire load combination

Go to Load combinations, click on an existing load combination that will be used as a template with regards to supports and material. Enter a unique name for the load combination (eg. *Fire (6.11)*), set limit state to *ULS*, Type as *Fire* and Dependent of to "-". Click *Add* to add the combination last in the list.

What will happen now is that you will get an option if you want to copy the selected load combination with regards to material and placement of the supports. See Figure 2-37. It is recommended to do this copy, by pressing Yes<sup>1</sup>. If you don't do this copy you will have to define the supports for this load combination manually.



Figure 2-37 Create a load combination by copying an old combination

Verify that the correct type and dependency is selected. Dependency should be set to "-" because in the fire combination the cross section will be reduced depending on fire time. This will cause a different stress distribution. If you would try to set a dependency of a fire calculation you will get an error message, see Figure 2-38.

<sup>&</sup>lt;sup>1</sup> Since these buttons are connected to the current language in Windows it will be "Yes" in your current language settings, (Swe: "Ja" = Eng. "Yes")





Figure 2-38 Setting an illegal dependency

If you successfully set the load combination you will se the result similar to Figure 2-35.

#### 2.4.3 COMBINATION OF LOADS

According to EN 1990 6.4.3.3. (3) fire is an exceptional design situation, but only to some extent. EN 1992-1-1 2.4.2.4 mention that the fire is exceptional regarding combination of loads, but material properties should be picked from EN 1992-1-2 2.3 (1).

So to combine the loads, use formula 6.11 from EN 1990, see Figure 2-39.

6.4.3.3 Combinations of actions for accidental design situations (1) The general format of effects of actions should be :  $E_d = E \left[ G_{k,j}; P; A_d; (\psi_{1,1} \text{ or } \psi_{2,1}) Q_{k,1}; \psi_{2,i} Q_{k,i} \right] \quad j \ge 1; i > 1$  (6.11a) (2) The combination of actions in brackets { } can be expressed as :  $\sum_{j\ge 1} G_{k,j}$ "+"P"+" $A_d$ "+"( $\psi_{1,1}$  or  $\psi_{2,1} Q_{k,1}$ "+" $\sum_{i>1} \psi_{2,i} Q_{k,i}$  (6.11b) (3) The choice between  $\psi_{1,1} Q_{k,1}$  or  $\psi_{2,1} Q_{k,1}$  should be related to the relevant accidental design situation (impact, fire or survival after an accidental event or situation). NOTE Guidance is given in the relevant Parts of EN 1991 to EN 1999.



For example: "1.0 \* Dead load + 1.0 \* Permanent loads +  $\psi_1$  \* Main load +  $\psi_2$  \* Other free loads"

Note that the prestressing load P will be handled automatically in the program. The term  $A_d$  is unique in this accidental load combination, it will symbolize the indirect effet of the fire, but not the effect of the temperature on the material – coefficient of thermal expansion etc. For example 1 (2.1 Modelling of a TT/F 240/54 with non-structural topping) it would be looking something like Figure 2-40.

<b>«</b> Prestressed input/[PRE-Stress2 (Training exa	nple 6.4.004. <mark>ccp</mark> )*]			
Input - Prestressed	Load combinations Long term parameters			
Project	Name	nation of loadcases (ex. 1.4*B1+0.7B2)	Limit-state Type Dependent	
	ID Fire (6.11)	+82+83+0.7*84	ULS - Fire Loadcas	e
<ul> <li>Lad combinations</li> <li>Release</li> <li>Storage/Maturing</li> <li>Transport</li> <li>Erection</li> <li>Intermediate stage (</li> <li>Final stage (Short ter</li> <li>Final stage (Short ter</li> <li>Final stage (Shot, ul</li> <li>Final stage (Gl0b, ul</li> <li>Final stage (Egl0b, ul</li> </ul>	1 1 Reset     2 Storage/Maturing     3 Transport     4 Erection     5 Intermediate stage (Shot term)     5 Intermediate (Shot term)	B1 1.25°B1 B1+82-B3 B1+82-B3 B1+82-B3+0.7°B4 B1+82-B3+0.7°B4 B1+82-B3+0.7°B4 1.35°(B1+82-B3)+1.5°B4 B1+82-B3+0.7°B4 B1+82-B3+0.7°B4	SLS         Shott         B1         D           SLS         Long         1         B2         In           SLS         Short         2         B3         T           SLS         Short         3         B4         U           SLS         Short         4         U           SLS         Short         4         U           SLS         Short         4         U           ULS         7         ULS         7           ULS         Fre         U         V	ead load stalatons poping ve load
	Add Qhange Delete	Insert	☑ Original text	

Figure 2-40 Load combination Fire (6.11) with loads combined

## 2.4.4 SETTINGS FOR THE FIRE

K Prestressed input/[PRE-Stress2 (Training exa	ample 6.4.004.ccp)*]						
Input - Prestressed	Main reinforcement Sti	irrup reinforcement Rei	nforcement details	Calculation settings	Fire Ca	alculation sections	
Project     P	Fire time 60 min	•					
Brelease     By Storage/Maturing	Fire sides	Class Manufacturing	Class B Hot rolled (Q)	•			
Ber Transport     Ber Transport     Berection     Berection     Berection     Berection     Berection     Berection     Berection	<ul><li>Left side</li><li>Right side</li></ul>	Pre-stressed reir Class Manufacturing	Class A Cold worked pre	▼ stress ▼			
<ul> <li>Final stage (Short ter</li> <li>Final stage (6.10a, ul</li> <li>Final stage (6.10b, ul</li> </ul>	Concrete aggregate: Siliceus	Epsilon values     ✓     Use E	psilon 0,2% values				
Fire (6.11)							

Under the Fire-tab there are a few settings (the manual will explain everything a bit furter in detail with references to EN 1992-2):

- Fire time: Fire resistance, time in minutes. R30, R60, R90, R120, R180 och R240
- Fire sides: What sides that will be subjected to fire, slabelement (hollowcores and slabs) can only be subjected by fire from the under and/or upper side. Beams and TT-elements can be subjected from the sides aswell.
- Concrete aggregate: Type of concrete aggregate. Siliconbased or limestonebased aggregate. This will affect the concrete strength at fire according to EN 1992 3.2.2.1.
- Reinforcement: Manufacturing class, see EN 1992-1-2 3.2.3. The class is shown in EN 1992-1-2, Annex C.
- Pre-stressed reinf: Manufacturing class for prestressing steel according to EN 1992-1-2 3.2.4
- Epsilon values: Strain limit used for fire calculation, according to EN 1992-1-2 3.2.3
  - $\circ$   $\ \epsilon$ =0.2%, default value.
  - $\circ~$  If not 0.2% is used then  $\epsilon$ =2% will be used. In order to use the 2%-limit the code demands justified assumptions for the calculation.

## 2.4.5 CALCULATION AND RESULTS

The calculation is being performed in the usual way, no need for activating anything, except be sure to have set the load combination to a frire-combination. So first perform an analysis then norm control (or 'design').

### 2.4.5.1 CODE CHECK

Here a verification of the actual load combination is made against the capacity for fire of the highest utilized sections. The three checks will be for highest positive moment, highest negative moment and highest shearforce.

Control       Close         Section / Material: TT 240/54 / C40/50       Member: TT 501         Direction: y-y       Loadcase: Fire (6.11)         Section: TT 240/54       Section: TT 240/54         Calculation only made according to 1:st order theory.       Section: TT 240/54         Calculation only made according to 1:st order theory.       Section: TT 240/54         Calculation only made according to 1:st order theory.       Section: TT 240/54         Calculation only made according to 1:st order theory.       Section: TT 240/54         Calculation only made according to 1:st order theory.       Section: TT 240/54         Calculation only made according to 1:st order theory.       Section: TT 240/54         Calculation only made according to 1:st order theory.       Section: TT 240/54         Calculation only made according to 1:st order theory.       Section: TT 240/54         Calculation only made according to 1:st order theory.       Section: TT 240/54         Calculation only made according to 1:st order theory.       Section: TT 240/54         Calculation only colored to the plane of the frame is made according to EN 5.8.7       Section: Advent capacity (Design section x=0.00, pos moment)         Ay/MRdy = 0.07/-38.38 = 0.002 < 1       Section x=0.10, neg moment)				
Control       Section / Material: TT 240/54 / C40/50         Direction: y-y       Member: TT 501         Calculation only made according to 1:st order theory.         Flexural buckling check in the plane of the frame is made according to EN 5.8.7         Flexural buckling check out of the plane of the frame is made according to EN 5.8.7         Moment capacity (Design section x=6.00, pos moment)         My/MRdy = 252.56/304.89 = 0.828 < 1         Moment capacity (Design section x=0.10, neg moment)         My/MRdy = -0.07/-38.38 = 0.002 < 1         Shear capacity (Design section x=0.10)				
TT 240/54 / C40/50		Eiro (6.11)		
Direction: y-y	Loadcase:	File (0.11)	Close	
	Section:	TT 240/54		
Section / Material: TT 240/54 / C40/50 Direction: y-y Calculation only made according to 1:st order theory. Flexural buckling check in the plane of the frame is made according to EN 5.8.7 Flexural buckling check out of the plane of the frame is made according to EN 5.8.7 Flexural buckling check out of the plane of the frame is made according to EN 5.8.7 Moment capacity (Design section x=6.00, pos moment) My/MRdy = 0.077/38.38 = 0.828 < 1 Moment capacity (Design section x=0.10, neg moment) My/MRdy = 0.077/38.38 = 0.022 < 1 Shear capacity (Design section x=0.10) VEd/VRd = 80.30/181.39 = 0.443 < 1				
Control Section / Material: TT 240/54 / C40/50 Direction: y-y Calculation only made according to 1:st order theory. Flexural buckling check in the plane of the frame is made according to EN 5.8.7 Flexural buckling check out of the plane of the frame is made according to EN 5.8.7 Flexural buckling check out of the plane of the frame is made according to EN 5.8.7 Flexural buckling check out of the plane of the frame is made according to EN 5.8.7 Homent capacity (Design section x=6.00, pos moment) My/MRdy = 252.56/304.89 = 0.828 < 1 Moment capacity (Design section x=0.10, neg moment) My/MRdy = -0.07/-33.83 = 0.002 < 1 Shear capacity (Design section x=0.10) VEd/VRd = 80.30/181.39 = 0.443 < 1				

Figure 2-41 Control / code check

### 2.4.5.2 TABLE - BENDING

The result is not different from the ordinary bending-table. Values are considered using the reduced crossection, parameters and material depending on the fire.

### 2.4.5.3 TABLE - SHEAR

Same as Table – Bendning, no unique results due to fire. Calculation of shear is made from the fire load combination.

### 2.4.5.4 TABLE - FIRE - REDUCED CONCRETE PARAMETERS

Fire r	educed cor	ncrete pa	rameters												
Membe	r: TT 50	1		•	Calculati theory.	on only ma	ade according	to 1:st orde	er			Clo	se		
			•	. # I	<u> </u>	M									
Та	able -	Fir	e -	Reduce	d cond	rete	parame	eters							
Se	ction	θ <sub>M</sub>	f	Ecd	θ <sub>M,f,top</sub>	k e	k <sub>c,f,top</sub>	a,	a s,f,top	Н	B <sub>w,top</sub>	B <sub>w,bot</sub>	H <sub>f,top</sub>	B <sub>f,top</sub>	
	m	°C	MPa	GPa	°C			mm	mm	mm	mm	mm	mm	mm	
	0.000	20.0	40.0	35.220	307.22	1.00	0.84	20.18	2.15	519.82	239.64	169.64	97.85	1045.39	
	0.099	20.0	40.0	35.220	307.22	1.00	0.84	20.18	2.15	519.82	239.64	169.64	97.85	1045.39	
	0.101	20.0	40.0	35.220	307.22	1.00	0.84	20.18	2.15	519.82	239.64	169.64	97.85	1045.39	
	0.468	20.0	40.0	35.220	307.22	1.00	0.84	20.18	2.15	519.82	239.64	169.64	97.85	1045.39	
	0.599	20.0	40.0	35.220	307.22	1.00	0.84	20.18	2.15	519.82	239.64	169.64	97.85	1045.39	
	0.601	20.0	40.0	35.220	307.22	1.00	0.84	20.18	2.15	519.82	239.64	169.64	97.85	1045.39	
	1.199	20.0	40.0	35.220	307.22	1.00	0.84	20.18	2.15	519.82	239.64	169.64	97.85	1045.39	
	1.799	20.0	40.0	35.220	307.22	1.00	0.84	20.18	2.15	519.82	239.64	169.64	97.85	1045.39	
			_												

Figure 2-42 Table – Fire – Reduced concrete parameters

The different columns in the fire load combination means:

- Section [m]: Section along the element
- $\Theta_M$  [°C]: Temperature in the middle of the crossection
- f<sub>cd</sub> [MPa]: Concrete strength
- E<sub>cd</sub> [GPa]: Module of elasticity for the concrete (reduced due to fire)
- $\Theta_{M,f,top}$  [°C]: Den temperature in the top flange, see more info about the indexes below.
- k<sub>c</sub> [-]: Factor used for reduction of the concrete material.
- k<sub>c,f,top</sub> [-]: Value of the reduction being used for different places of the section (indexes: see below)
- a<sub>z</sub> [mm]: Height of the damaged zone of the section
- a<sub>z,f,top</sub> [mm]: Height of the damaged zone (indexes: see below)
- H [mm]: Remaining height of the section after reductions

Depending on the section there are different measurements and parameters being presented:

Parameter B [mm]: width. H [mm]: height index: w: web, f: flange index: top (upper, flange for instance) and bot (bottom)

### 2.4.5.5 TABLE - FIRE - REINFORCEMENT

Fire reduced reinforcements parameters															
Member: Loadcase: Section:	Member:         TT 501         ▼           Loadcase:         Fire (6.11)         ▼           Section:         0.000         ▼						Calculation only made according to 1:st order theory.						Close		
	3			I	• • •	•H									
Tabl	Table - Fire - Reinforcement - section 0.00														
У	Z	Temp	f	fand	fance	Eand	f <sub>0.24</sub>	f <sub>0.201</sub>	f 24	fact	Ecologo	Ecd. conc. short			
mm	mm	°C	MPa	MPa	MPa	GPa	MPa	MPa	MPa	MPa	GPa	GPa			
529	36	235.6	863.7	591.5	591.5	180.39	863.7	863.7	1082.4	1082.4	29.45	29.45			
562	36	137.0	1100.9	825.0	825.0	188.93	1100.9	1100.9	1272.7	1272.7	33.93	33.93			
638	36	137.0	1100.9	825.0	825.0	188.93	1100.9	1100.9	1272.7	1272.7	33.93	33.93			
671	36	235.6	863.7	591.5	591.5	180.39	863.7	863.7	1082.4	1082.4	29.45	29.45			
527	69	126.9	1125.3	848.1	848.1	189.53	1125.3	1125.3	1290.4	1290.4	34.28	34.28			
673	69	126.9	1125.3	848.1	848.1	189.53	1125.3	1125.3	1290.4	1290.4	34.28	34.28			
37	503	138.2	1098.0	822.3	822.3	188.86	1098.0	1098.0	1270.6	1270.6	33.89	33.89			
492	503	20.0	1337.1	1337.1	1337.1	195.00	1337.1	1337.1	1337.1	1337.1	35.22	35.22			
708	503	20.0	1337.1	1337.1	1337.1	195.00	1337.1	1337.1	1337.1	1337.1	35.22	35.22			
1163	503	138.2	1098.0	822.3	822.3	188.86	1098.0	1098.0	1270.6	1270.6	33.89	33.89			
106 %		171	•			► Rea	ady								

Figure 2-43 Table - Fire – Reinforcement

The different columns in the fire load combination means:

- Y [mm]: Position of reinforcement in the local coordinatesystem of the element
- Z [mm]: Position of reinforcement in the local coordinatesystem of the element
- Temp [°C]: Temperature at the position of the reinforcement
- f<sub>yd</sub> [MPa]: Design strength of the reinforcement at current temperature
- f<sub>spd</sub> [MPa]: Tensile strength of prestressing wire
- f<sub>spcd</sub> [MPa]: Compressive strength of the prestressing wire
- E<sub>spd</sub> [GPa]: Module of elasticity of the prestressing wire
- f<sub>0,2d</sub> [MPa]: 0.2% design strength for tensile strength
- f<sub>0,2cd</sub> [MPa]: 0.2% design strength of compressive strength
- f<sub>2d</sub> [MPa]: 2% design strength for tensile strength (not recommended to use)
- f<sub>2cd</sub> [MPa]: 2% design strength of compressive strength (not recommended to use)
- E<sub>cd,conc</sub> [GPa]: Module of elasticity of the concrete (reduced due to fire)
- E<sub>cd,conc,short</sub> [GPa]: Short term module of elasticity of the concrete (reduced due to fire)



## 2.4.5.6 TEMPERATURE GRADIENT



Dashed line shows damaged zone. Concrete in the damaged zone is not being considered in calculations.