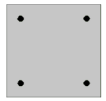
NextFEM

NextFEM **Designer**

Verifications Guide

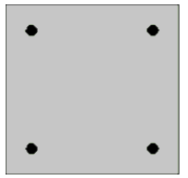


Concrete module

FireSafe module

for RC structures

Concrete module



The Concrete module covers checking for RC structures as per Eurocode 2 and 8, both for static and seismic conditions.

It supports:

- Static checking as per EC2
- Seismic checking with different Ductility Classes as per EC8
- Checking of section reinforcements through Section Analyzer, with unlimited shapes and materials
- Geotechnical checks on shallow foundations (slabs, girders, etc.)
- Support for checking beams, columns and walls
- Automatic dimensioning of rebars in beams, columns and walls

Concrete module

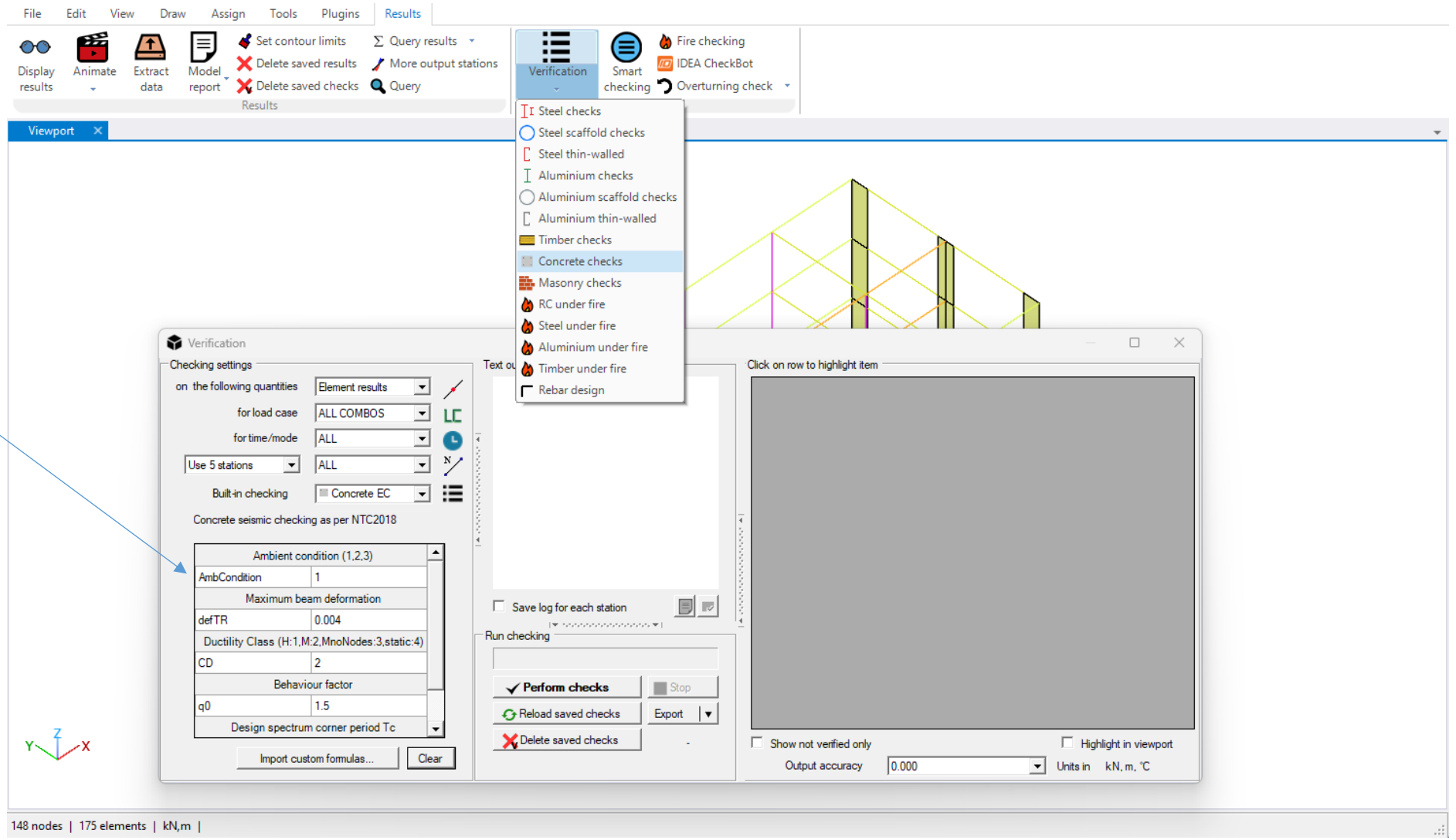
RC checking as per EC

Checking global settings:

AmbCondition sets the environmental conditions for RC checking:
1- normal (classes X0, XC1, XC2, XC3,XF1)

2-aggressive (classes XC4, XD1, XS1,XF2)

3- very aggressive



Concrete module

RC checking as per EC

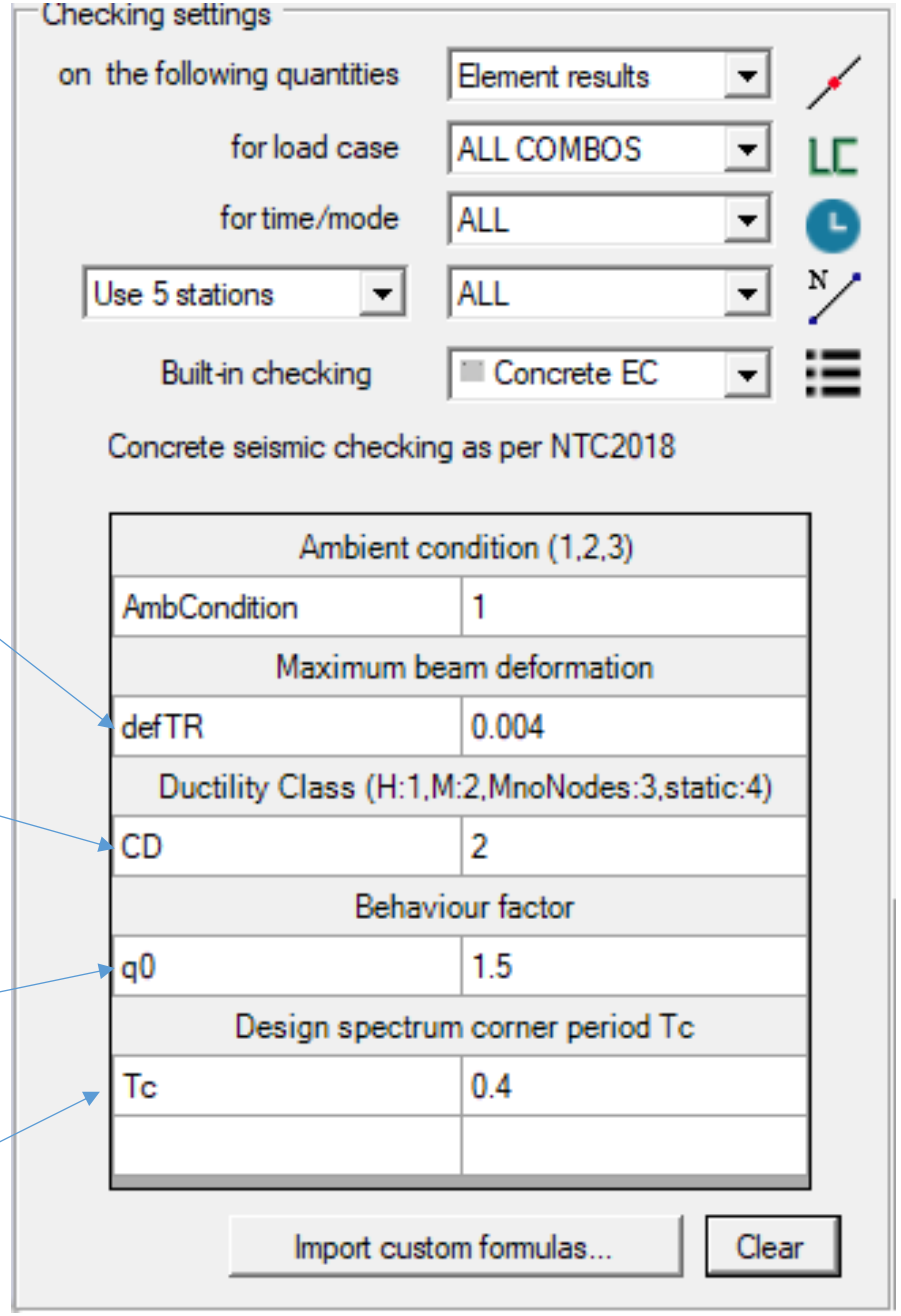
Checking global settings:

defTR sets the maximum beam deformations as a ratio of the span

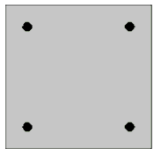
CD sets the Ductility Class for checking against seismic combos:
1-High
2-Medium/moderate
3-Medium with no checks on RC nodes in frames
4-static checking only (applicable to static combinations), low ductility, non-dissipative structures

Behaviour factor q0: is the maximum behaviour factor applicable for the structure, without considering the overstrenght ratio

Tc: corner period of the spectrum used by design, which is involved in ductility checking of sections fo CD=H or M.



Reinforced Concrete rebar design



Steel reinforcements (rebars) can be designed by the program with static and seismic detailing.

Verification

Checking settings

on the following quantities: Element results
for load case: SLU9
for time/mode: ALL
Use 5 stations | On selected items
Built-in checking: Auto Rebar Desig

Concrete rebar dimensioning

Rebar material ID	
rebarMatID	2
Ambient condition (1,2,3)	
AmbCondition	1
Minimum bars per edge	
nBars	3
Seismic Ductility Class (H:1,M:2)	
CD	2
Rebar net size for wall [mm]	

Import custom formulas... | Clear

Text output for selected item

```
ddZ=0.45
alphaVs=1.5707963267949
Asmin=0.000607499967813492
Myymax=28.31574585
Mzzmax=4.69540275
Myymin=-28.31574585
Mzzmin=-4.69540275
minAreaCol=0.160710390562673
@ColumnArea=0.793631600382303
@ColumnRebar=0.00446804312183092
dBL=0.012
reqIst=0.14
reqDst=8
intNod=0
```

Save log for each station

Run checking

Perform checks | Stop
Reload saved checks | Export
Delete saved checks | 0s

Click on row to highlight item

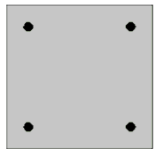
ID	Case_Time	BeamRebarTop	BeamRebarBot	ColumnArea	ColumnRebar
52-I	SLU9-1			0.794	0.004
52-¼	SLU9-1			0.776	0.004
52-M	SLU9-1			0.759	0.004
52-¾	SLU9-1			0.742	0.004
52-J	SLU9-1			0.725	0.004
85-I	SLU9-1				
85-¼	SLU9-1				
85-M	SLU9-1				
85-¾	SLU9-1				
85-J	SLU9-1				
131-I	SLU9-1	0.006	0.002		
131-¼	SLU9-1	0.006	0.002		
131-M	SLU9-1	0.002	0.002		
131-¾	SLU9-1	0.006	0.002		
131-J	SLU9-1	0.006	0.002		

Show not verified only | Highlight in viewport

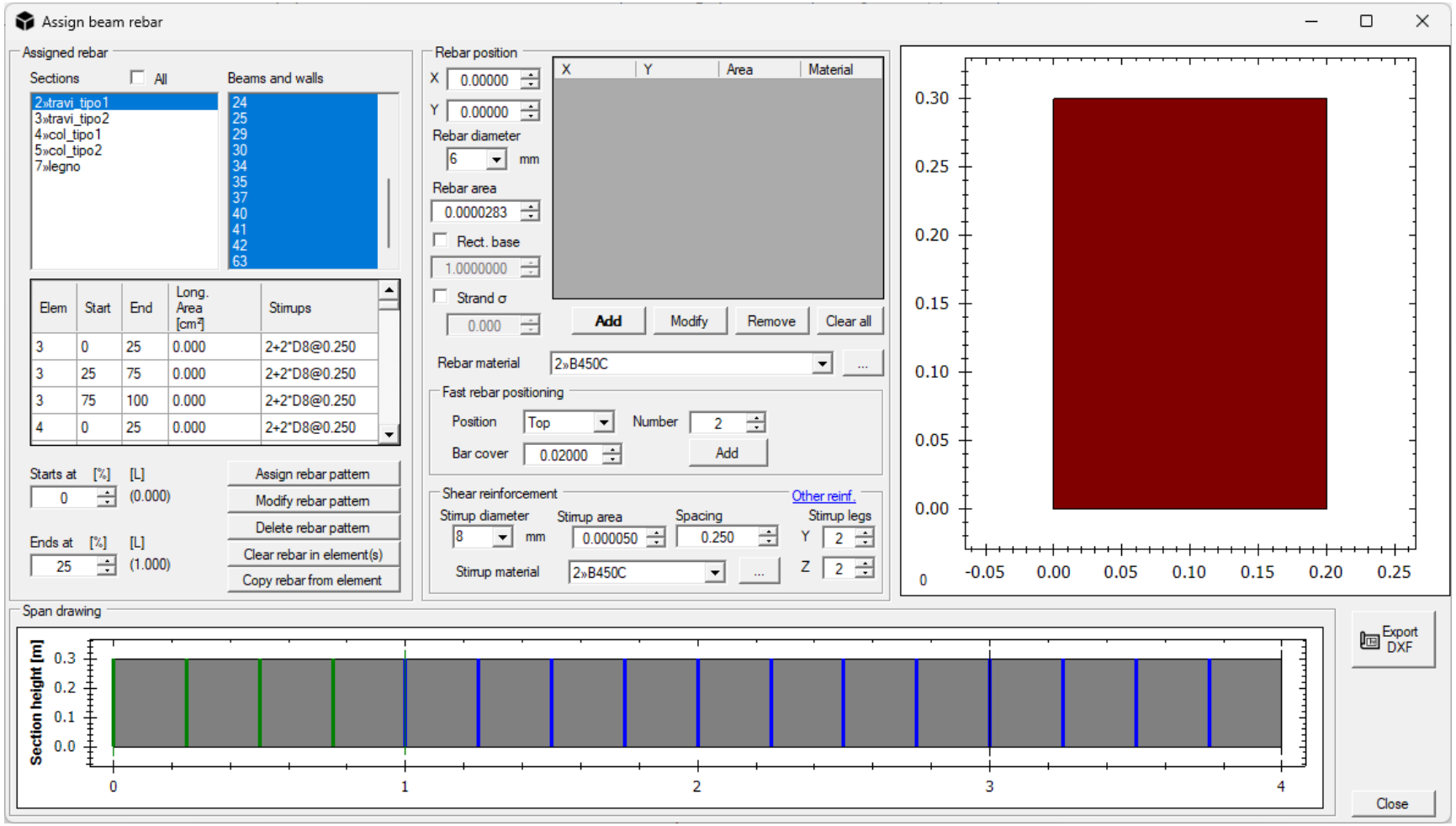
Output accuracy: 0.000 | Units in kN, m, °C

RebarMatID is the ID of the design steel material specified in *Assign / Design materials*.

Reinforced Concrete checking - Concrete



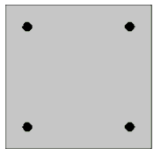
Before proceeding with verification, enter the reinforcement for beams, columns and walls using the *Assign / Rebars* command.



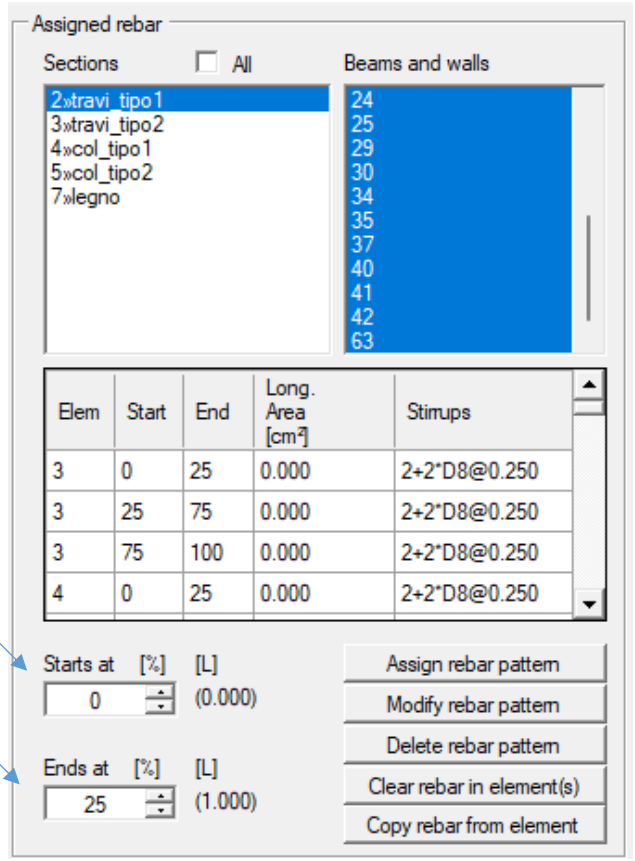
From the *Sections* panel, select the name of the section.
All beams with that section will be displayed in the *Beam and Wall Elements* pane.
To assign reinforcement to all beams, select all beams.

Note
If the *Sections* box is empty, assign a concrete type material to the concrete beams.

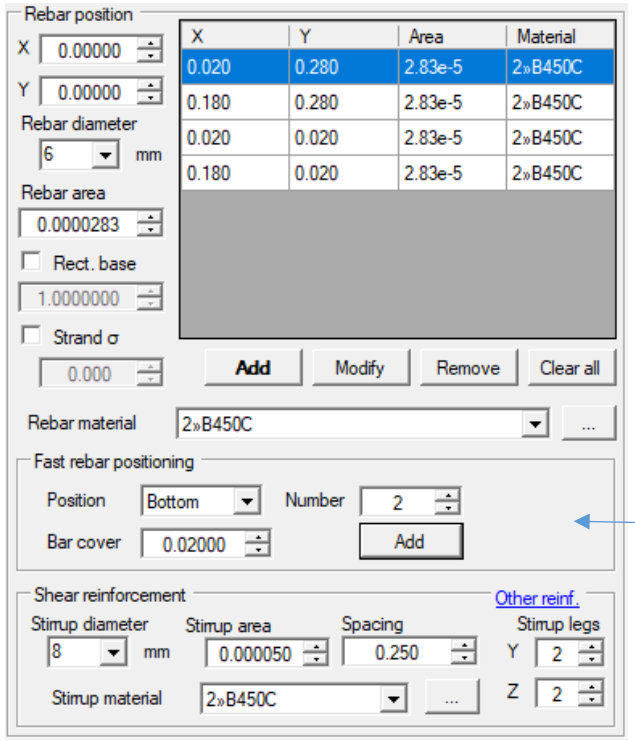
Reinforced Concrete checking - Concrete



Up to 100 segments of different reinforcement per beam can be specified from this mask. Specify start and end of segment

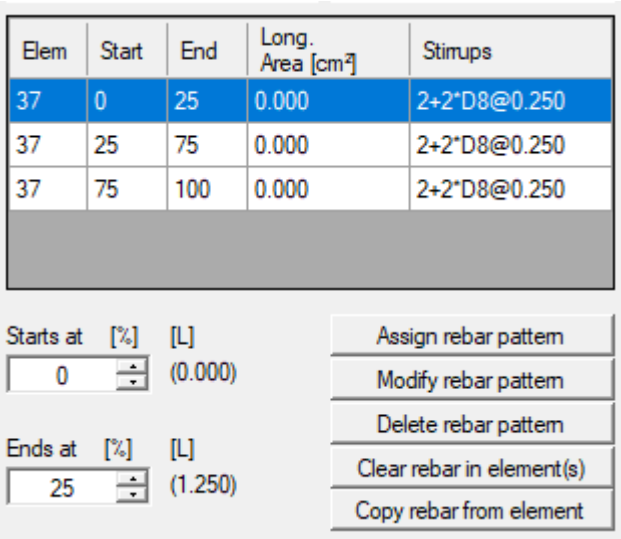


We then insert the reinforcements, either by co-ordinates, or using a preset for quick positioning. Also specify the brackets for the segment

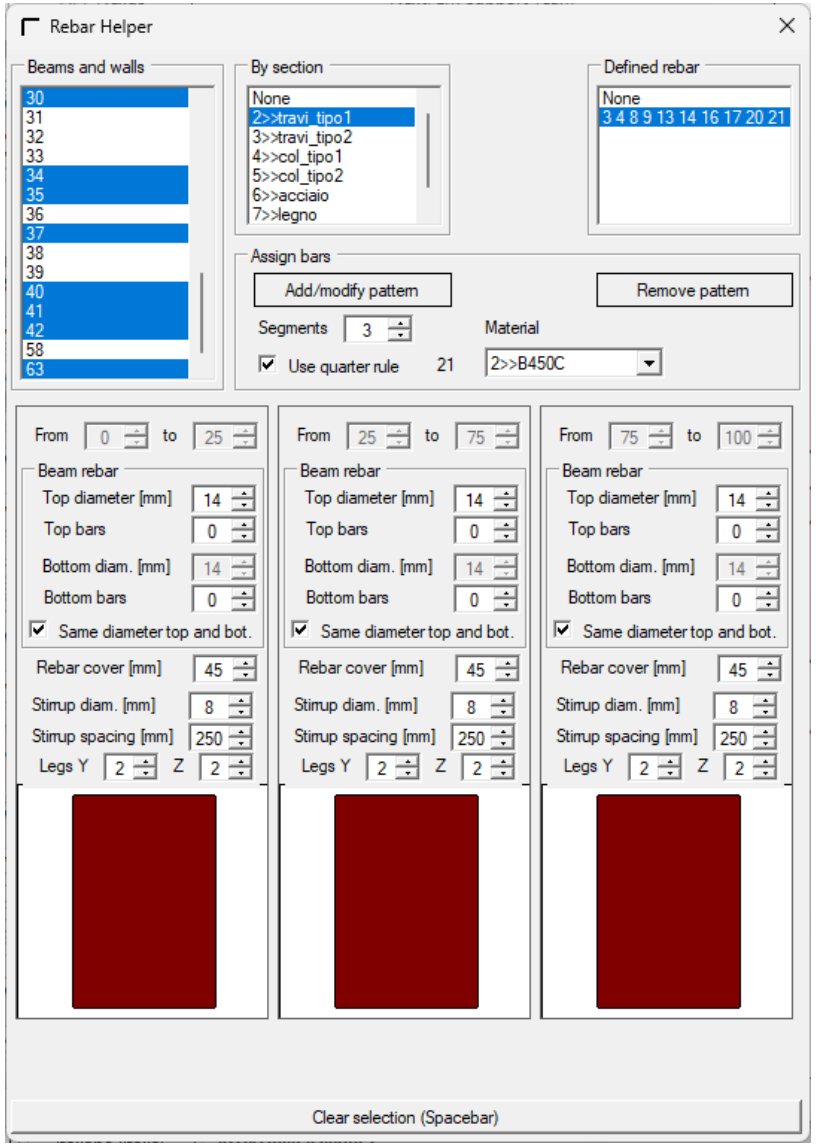


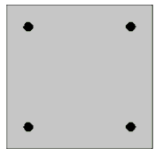
Finally, press *Assign rebar pattern* to write the segment. A line is completed per ashlar showing the element, the start and end of the ashlar, the total area of longitudinal bars and the brackets in the format:

nbY+nbZ*diam@step



Reinforced Concrete checking - Concrete





ALTERNATIVE

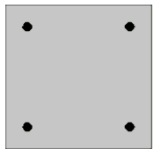
The Rebar Helper plugin (from the Plugin tab of the ribbon) works for rectangular sections of beams, columns and walls, to facilitate the input of bottom and top bars or wall bars.

It must be used as an alternative to the previous Assign Rebar mask. The previous mask can be used to locally modify the entered reinforcement.

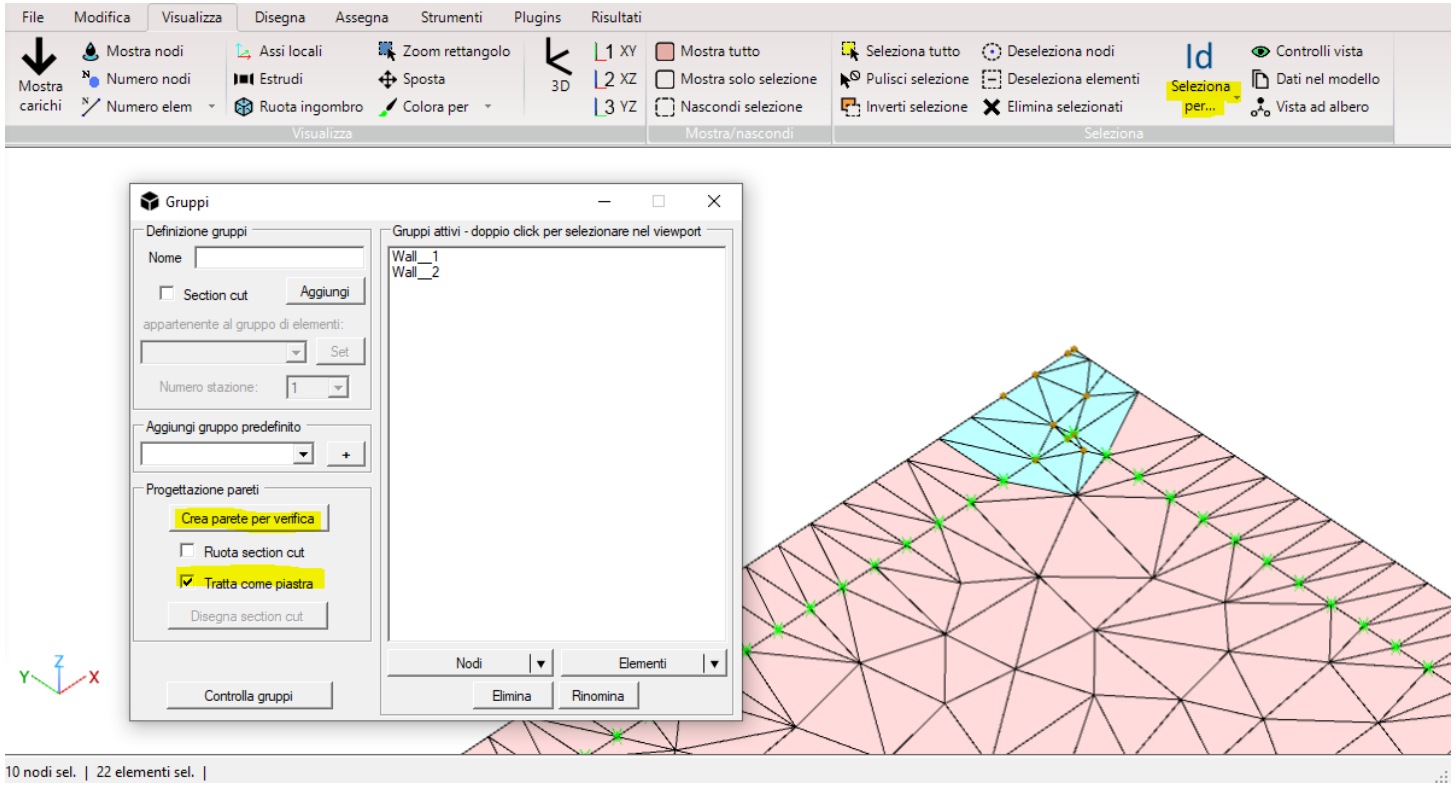
To set the bars for beams:
- set the number of segments (e.g. with No. 3 and with the option "Divide into quarters", segments 0-25%, 25-75% and 75-100% are created)
- set diameters and number of bottom and top beams
- press *Add/modify pattern*.

The ‘Defined rebar' box will populate with the list of elements having the same bars.

Reinforced Concrete checking - Concrete



Walls, slab and plates

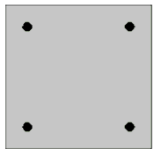


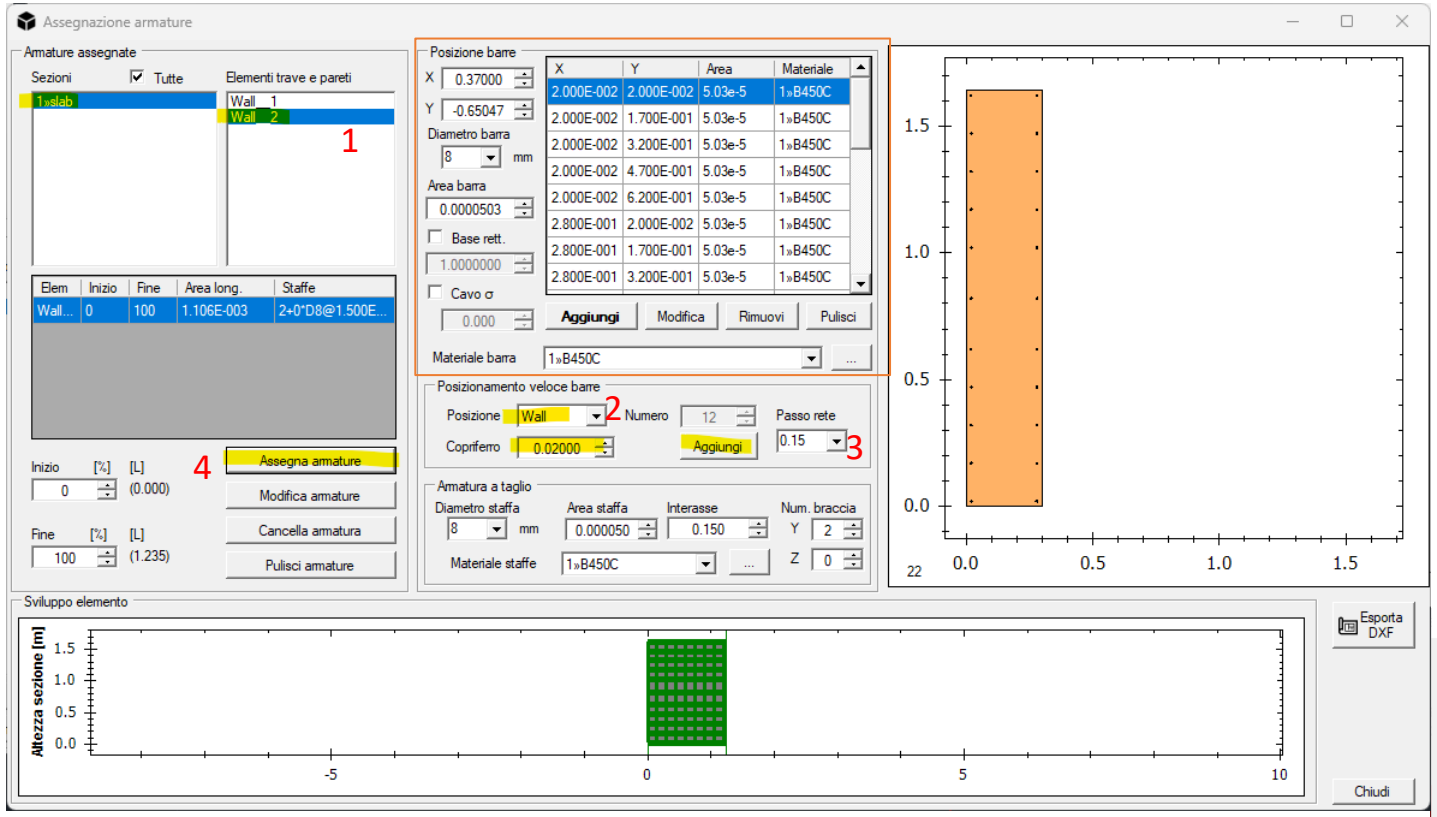
i. Select plate elements affected by reinforcement

ii. From *View/Select by.../Groups*, press "Create wall for verification" having selected "Treat as plate".

N.B. if the command Create wall for verification has no effect, re-enter the Groups mask without selecting any in the 'Active Groups' box

Reinforced Concrete checking - Concrete





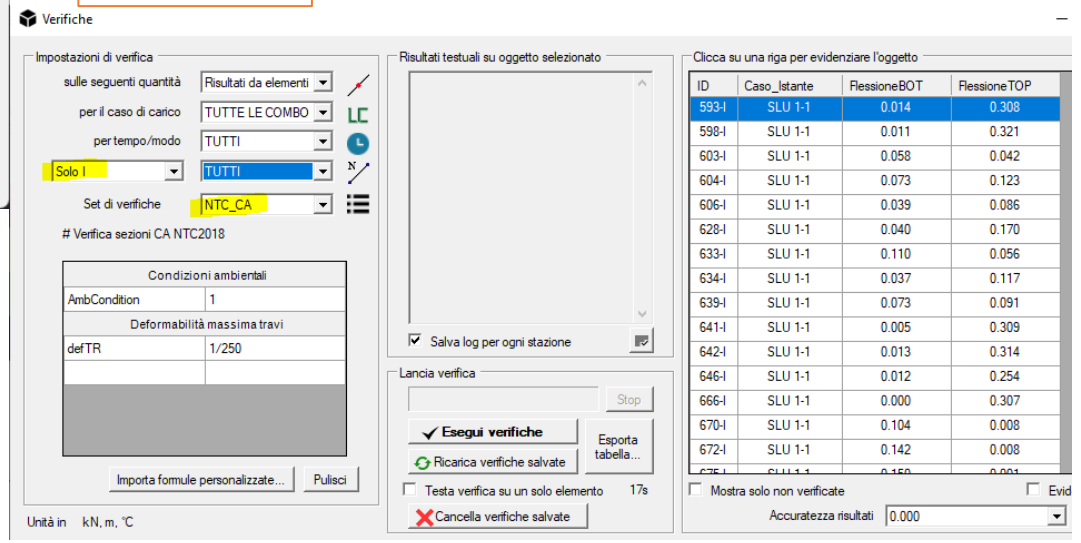
iv. To edit armour, open the Assign / Armour mask and:

1. Select the newly created *Wall* group
2. Select 'Wall' type bar placement and check rebar cover
3. Choose a net step and press *Add*
4. Press *Assign rebar*

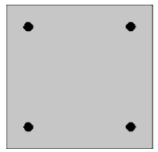
To add more individual bars, use the *Bar Position* box

v. Open the Results/Verifications command and set it as in the figure

By pressing 'Perform checks' all plate elements will be checked for bending, indicating their D/C ratio in the table on the right.



Reinforced Concrete checking - Concrete



Opening the verification for reinforced concrete (or CTRL+6) allows the verification of each element. Each column collects the D/C ratios for each verification. The codes in the “Not processed" column are shown on the following slide.

Verification

Checking settings

on the following quantities: Element results
for load case: ALL COMBOS
for time/mode: ALL
Use 5 stations: ALL
Built-in checking: Concrete EC

Concrete seismic checking as per NTC2018

Ambient condition	
AmbCondition	1
Maximum beam deformation	
defTR	0.004
Ductility Class (H: 1,M:2,noNodes:3,static:4)	
CD	2
Behaviour factor	
q0	1.5
Design spectrum corner period Tc	

Import custom formulas... | Clear

Text output for selected item

Save log for each station

Run checking

Stop | Perform checks | Reload saved checks | Export table... | Delete saved checks

Test checking on 1 item only | 1s

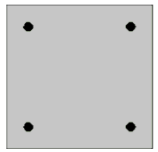
Click on row to highlight item

ID	Case_Time	Not checked	ShearY	ShearZ	RebarArea	Bending	ShearTorsion
1-¾	Comb1-1	105.000					
1-J	Comb1-1	105.000					
2-I	Comb1-1	105.000					
2-¼	Comb1-1	105.000					
2-M	Comb1-1	105.000					
2-¾	Comb1-1	105.000					
2-J	Comb1-1	105.000					
3-I	Comb1-1		45.724	0.025	0.257	127.005	45.729
3-¼	Comb1-1		32.248	0.025	0.257	23.650	32.253
3-M	Comb1-1	104.000					
3-¾	Comb1-1	104.000					
3-J	Comb1-1	104.000					
4-I	Comb1-1		45.459	0.067	0.257	45.096	45.468
4-¼	Comb1-1		32.368	0.067	0.257	4.007	32.378
4-M	Comb1-1	104.000					

Show not verified only | Highlight in viewport

Output accuracy: 0.000 | Units in kN, m, °C

Reinforced Concrete checking - Concrete



Rows in the table represent a single station

Columns represent a single check

ID	Case_Time	Not checked	ShearY	ShearZ	RebarArea	Bending	ShearTorsion

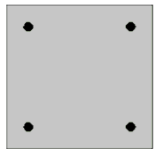
Values are always ratios between Demand/Capacity

$$\rho = \frac{E_d}{R_d} = \frac{E_d}{\frac{R_k}{\gamma_M}}$$

For instance, ***Stability in compression*** is evaluated as follows:

$$\rho_{slend} = \frac{\max\left(\frac{L_{0y}}{i_y}, \frac{L_{0z}}{i_z}\right)}{25} \cdot \sqrt{\frac{|N|}{A \cdot f_{cd}}}$$

Reinforced Concrete checking - Concrete



Shear for members without shear reinforcement

For each local direction y and z:

$$V_{rd} = \max\left\{\left[\frac{0.18}{\gamma_m}\cdot k\cdot\left(100\rho_l\cdot f_{ck}\right)^{\frac{1}{3}}+0.15\sigma_{cp}\right]b_w\cdot \mathrm{ds},\ \left(\nu_{\min}+0.15\sigma_{cp}\right)b_w\cdot \mathrm{ds}\right\}$$

$$k = 1+\sqrt{\frac{200}{ds}}\le 2 \qquad \nu_{\min} = 0.035k^{1.5}f_{ck}{}^{0.5} \qquad \rho_l = \frac{A_{sl}}{b_w\cdot ds} \qquad \sigma_{cp} = \min\left(\frac{N}{A_{cls}}, 0.2\,\mathrm{f_{cd}}\right)$$

Shear for members with shear reinforcement

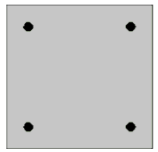
$$V_{Rsd} = 0.9d\,\frac{A_{sw}}{s}f_{yd}\left(\cot\alpha+\cot\theta\right)\sin\alpha$$

$$V_{Rcd} = 0.9d\cdot b_w\cdot\alpha_{cw}\cdot 0.5f_{cd}\,\frac{\left(\cot\alpha+\cot\theta\right)}{\left(1+\cot^2\theta\right)}$$

$$V_{Rd} = \min(V_{Rsd}, V_{Rcd})$$

Check NextFEM Validation manual – Chapter 5, for further details

Reinforced Concrete checking - Concrete



EC8 Seismic Design

Geometry checks are always performed for all beam, pillars and walls, as per EC8.

Ductility checks

The ductility check is performed for sections of beams and columns inside the critical length, in the section facing the foundations. Ductility demand is evaluated as follows:

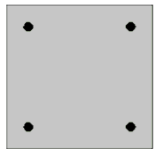
$$\mu_\phi = 2q_o - 1 \qquad \text{if } T_1 \geq T_C \qquad (5.4)$$

$$\mu_\phi = 1+2(q_o - 1)T_C/T_1 \qquad \text{if } T_1 < T_C \qquad (5.5)$$

Ductility of the RC section is automatically calculated by the program by evaluating moment-curvature for each axis of the section.

Check NextFEM Validation manual –
Chapter 5, for further details

Reinforced Concrete checking - Concrete

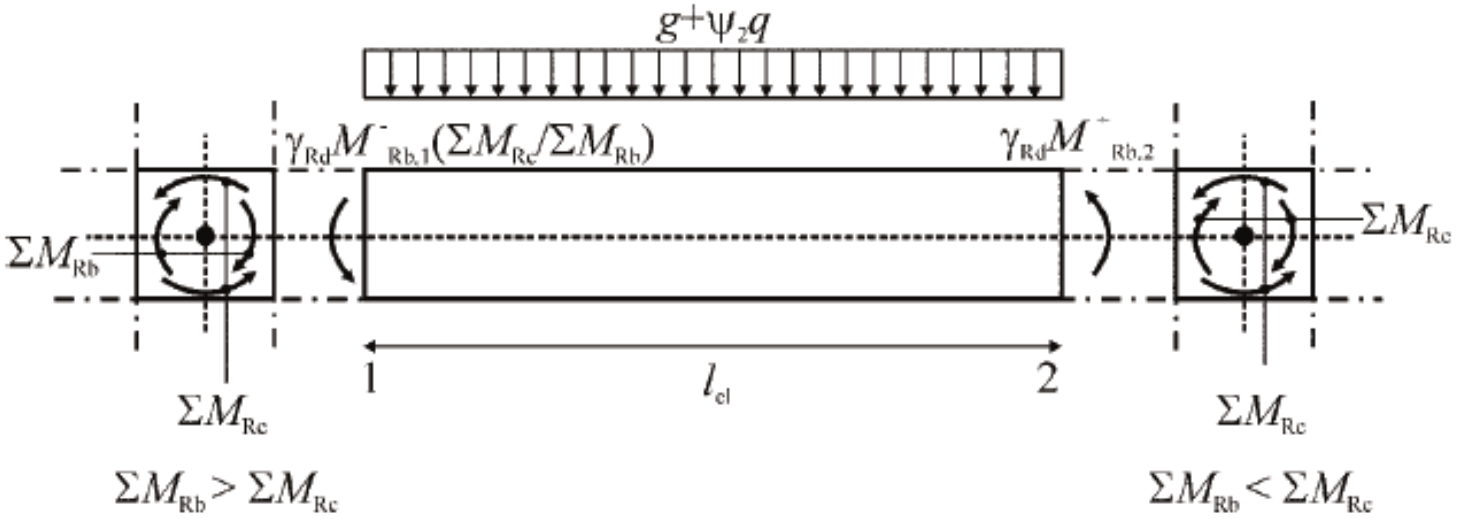


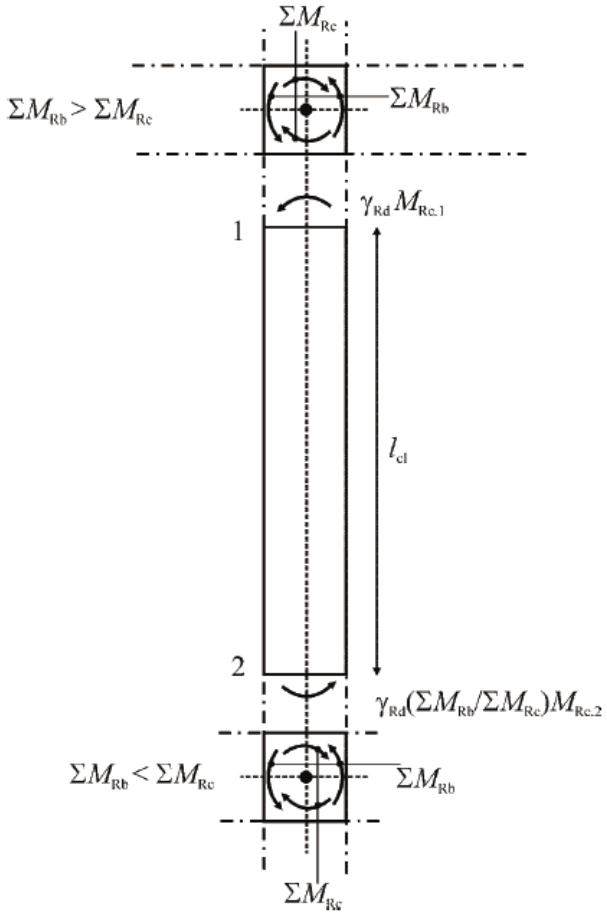
EC8 Seismic Design

Capacity design provisions are applied as well.

$$M_{i,d} = \gamma_{Rd} M_{Rc,i} \min\left(1, \frac{\sum M_{Rb}}{\sum M_{Rc}}\right)$$

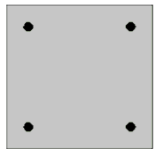
$$V_{Ed} l_p = \gamma_{Rd} \left(M^s_{i,d} + M^i_{i,d} \right)$$





Check NextFEM Validation manual – Chapter 5, for further details

Reinforced Concrete checking - Concrete



FRP and FRCM reinforcements

The verifications of the sections in c.a. reinforced with carbon fiber polymers (FRP) tapes are allowed in the program. The calculation procedure refers to the following Italian standard: CNR-DT 200 R2 - Instructions for the Design, Execution and Control of Static Consolidation Interventions through the use of Fiber-reinforced Composites - Materials, reinforced concrete structures and of c.a.p., masonry structures

$$f_{fdd} = \frac{1}{\gamma_{f,d}} \cdot \sqrt{\frac{2 \cdot E_f \cdot \Gamma_{Fd}}{t_f}}, \qquad (4.4)$$

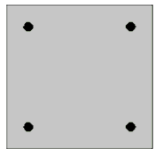
$$f_{fdd,2} = \frac{k_q}{\gamma_{f,d}} \cdot \sqrt{\frac{E_f}{t_f} \cdot \frac{2 \cdot k_b \cdot k_{G,2}}{FC} \cdot \sqrt{f_{cm} \cdot f_{ctm}}}, \qquad (4.6)$$

minimum anchor length

$$l_{ed} = \max\left\{ \frac{1}{\gamma_{Rd} \cdot f_{bd}} \sqrt{\frac{\pi^2 \cdot E_f \cdot t_f \cdot \Gamma_{Fd}}{2}}, 200 \text{ mm} \right\}, \qquad (4.1)$$

Check NextFEM Validation manual – Chapter 5, for further details

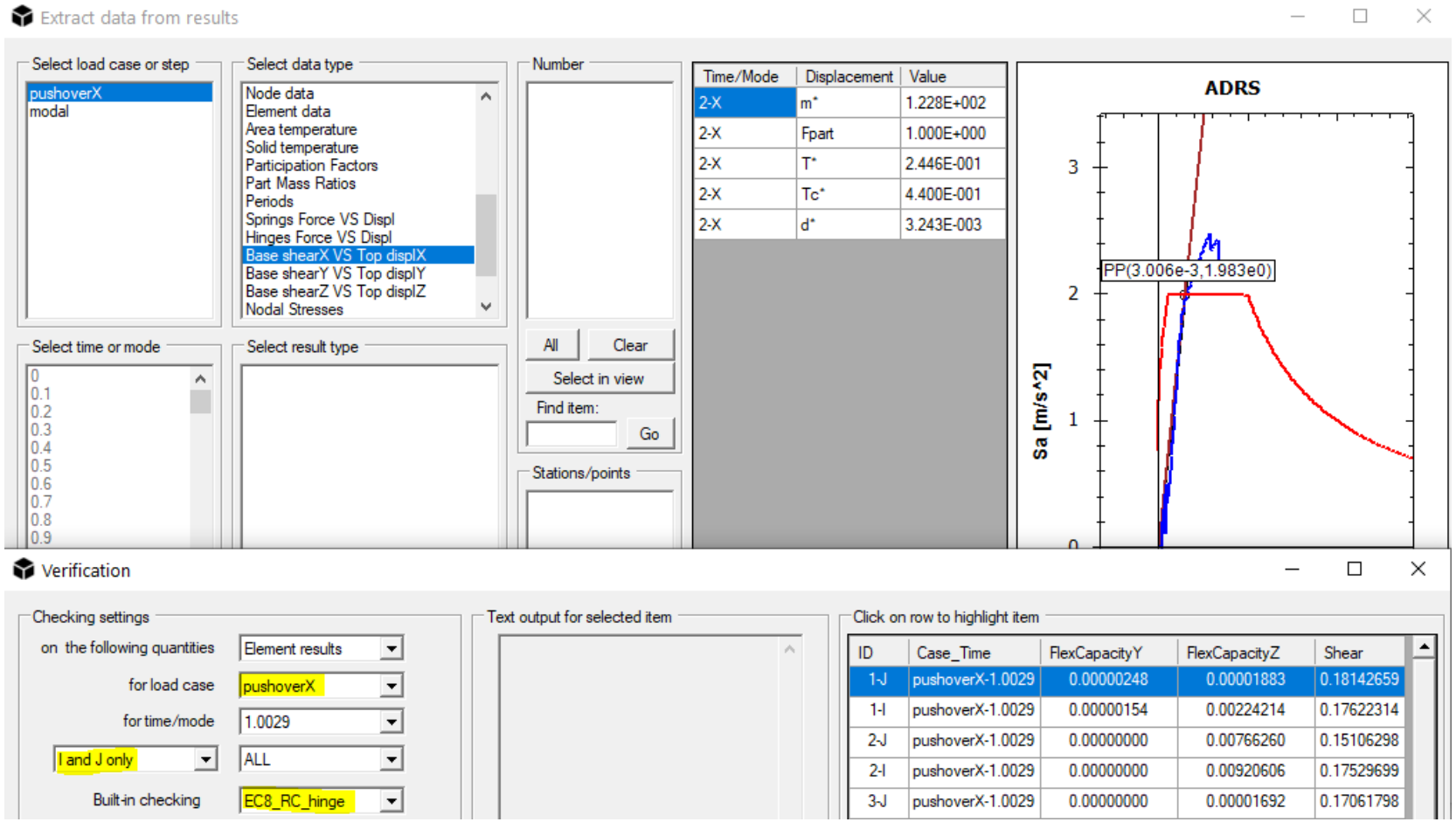
Reinforced Concrete checking - Concrete



Checking by pushover analysis

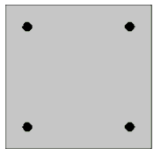
Non-linear static analysis (pushover) needs a global check (performed in ADRS plane by the mash *Extract Data*) and local verifications, carried-out for each element, for brittle (shear) and ductile (flexure) mechanism

Once the displacement demand is known, local checking will be performed for **brittle and ductile mechanisms**, directly on data supplied by hinges



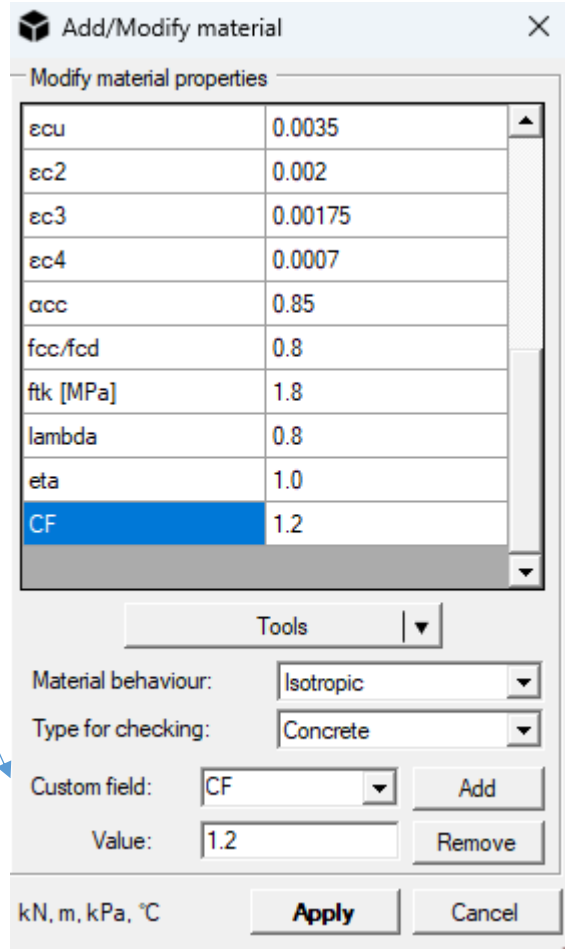
Check NextFEM Validation manual – Chapter 5, for further details

Reinforced Concrete checking - Concrete



Existing buildings

Checking of existing RC buildings can be performed by assigning a Confidence Factor to the RC materials

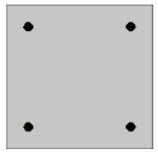


For existing buildings, checking set is automatically adjusted:

- By including CF in material strenght determination
- By considering a different set of nodal checking for RC structures, as prescribed by EC8

Check NextFEM Validation manual – Chapter 5, for further details

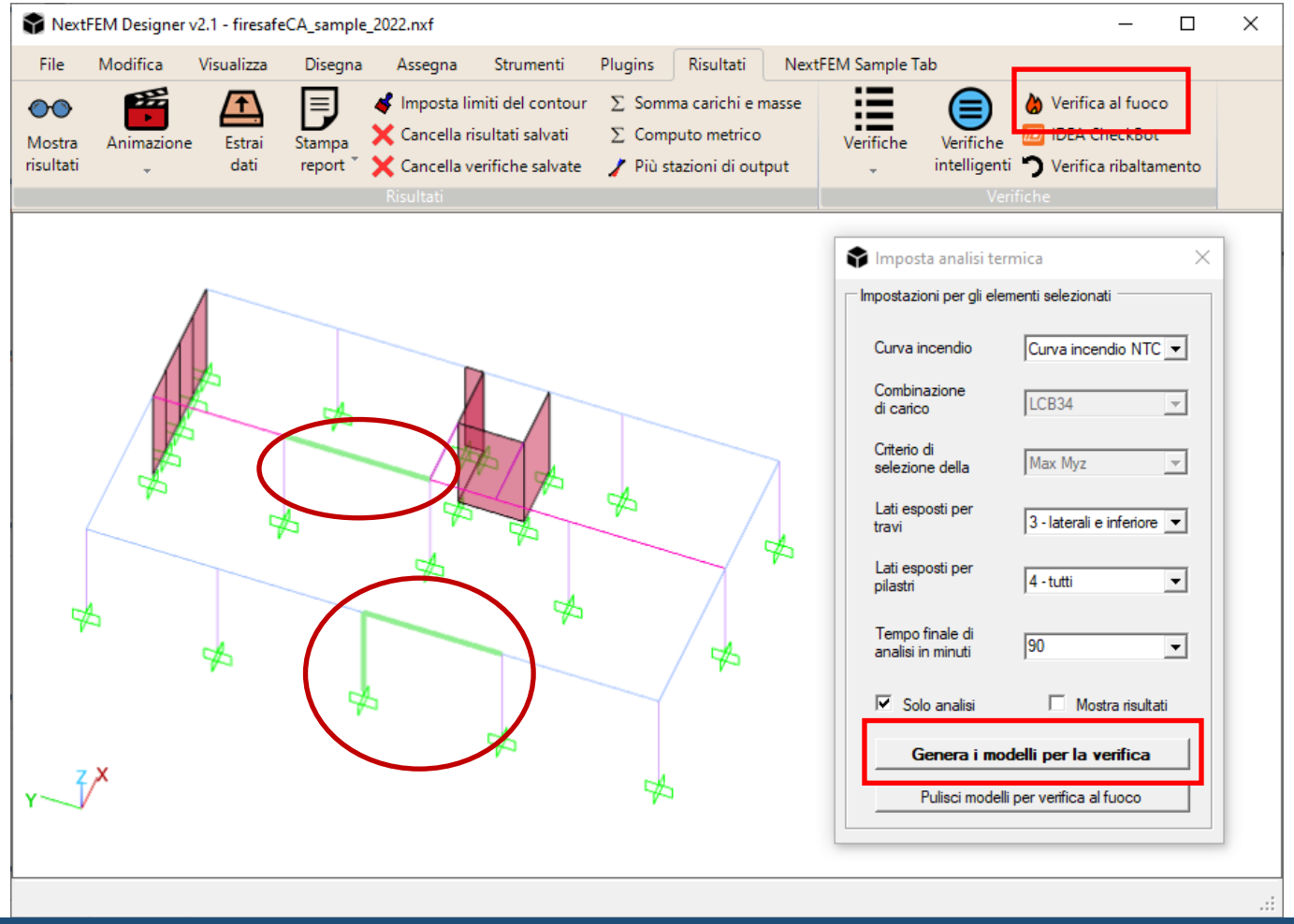
Reinforced Concrete checking - Concrete



	Error code description in the "Not processed" column:
100	element not processed because of material other than reinforced concrete or reinforcement missing
102	material for bars missing
103	incorrect bar material (missing design deformations)
104	stress exceeds maximum tension
105	stress exceeds maximum compression
106	(only in case of elastic analysis) N=0, analysis not possible in absence of stresses
107	(only in the case of elastic analysis) elastic analysis does not converge
108	material not set for a solid or hollow figure in section
109	(only for timber material) characteristic bending stress fmk missing
110	(only for confined sections) stirrups not set
111	(only for steel-cls composite sections) wrong base material for composite section
112	(wood thermal analysis only) wrong cross-section shape - rectangular and circular cross-sections only
113	(only for steel-cls composite sections) missing material for section part
115	resistance fk of material not set
116	(only for calculation with concrete also tensile) material resistance ftk not set
117	deformation e_c2 missing
118	Deformation e_c3 missing
119	deformation e_cu missing
120	(only for FRP sections) impossible to continue calculation, EpsU<EpsSy-Eps0 (4.7 CNR DT 200)
121	meshing not succeded (don't use FRP strips in meshed sections)
131	EC8 beam capacity - beam rotation is not correct
132	EC8 beam capacity - too many beams connected in y direction
133	EC8 beam capacity - too many beams connected in z direction
134	EC8 beam capacity - multiple columns connected to this beam
141	EC8 column capacity - Error in calculating resistance for this element
142	EC8 column capacity - Too many columns connected
143	EC8 column capacity - Too many columns connected in y direction
144	EC8 column capacity - Too many columns connected in z direction
145	Static reinforcement details: unreinforced element
146	Seismic reinforcement details: non-shear reinforced element
147	Seismic reinforcement details: unreinforced element long.
150	Missing rebar material in auto rebar design
199	Missing value

Check fire resistance

General non-linear thermal analyzes of the sections are necessary before proceeding with the verification.
Select the beams and columns on which to carry out the thermal analysis, then press CTRL+F or «Fire test» from the *Results tab.*



The mask allows you to choose:

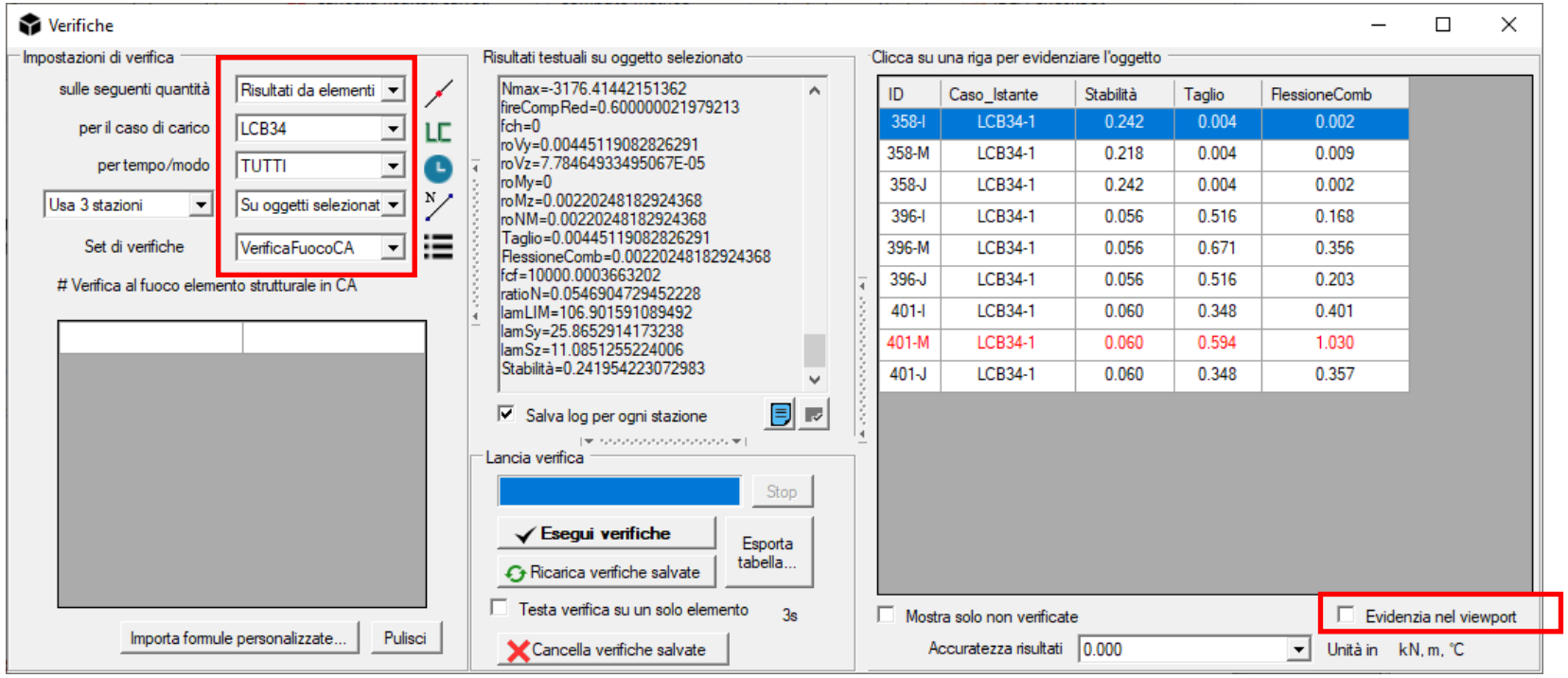
- The fire curve to use (default is NTC; alternatively *external* or *hydrocarbons*)
- The sides of the section exposed for the beams , by default bottom and sides
- The exposed sides for the pillar (default: all)
- The final analysis time in minutes, to be set for the R requirement (if R90 required, set 90)

Fire exposure is uniform per element.
Finally, press **Generate models for verification** .

Check fire resistance

8 . From the *Results* menu , select **Tests** , or press CTRL+G. Setting up:

- the load case on the imported exceptional combination
- select 3 or 5 stations and «On selected objects»
- the set of checks on **VerifyFireRC**
- Finally, press **Run checks**



The results are in tabular format (1 column = 1 check) and report the Demand / Capacity ratios of the single verified **station .** The central pane presents all the variables used for testing and their values.
The lines in red contain unsatisfied checks.
To select the item in 3D view, enable «Highlight
in viewport» and select the desired row.

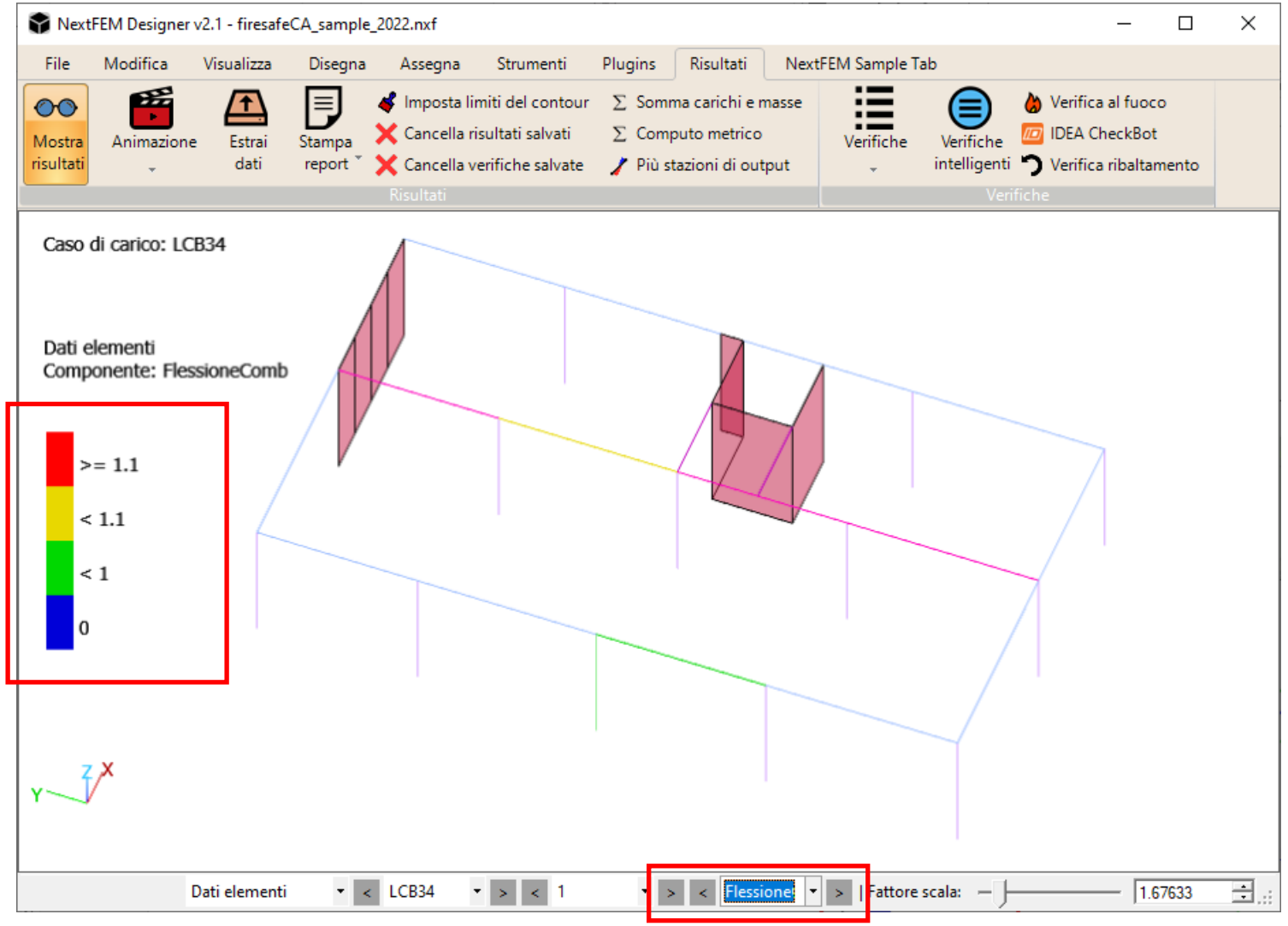
Check fire resistance

The viewport displays the filled rods according to the D/C ratio with the color scale highlighted below.

The status bar (bottom) contains all the menus for switching between load cases and showing the verification results (“Element data”).

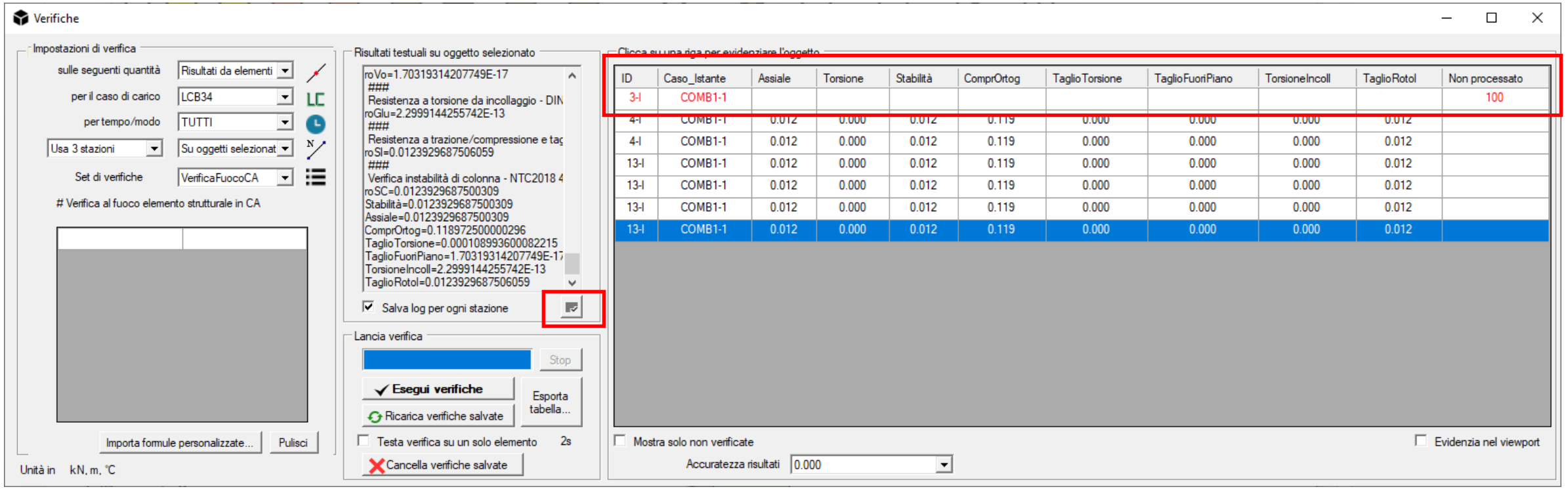
By pressing F10 you can view the test reports for the selected test in the status bar in the *Component menu* .

By pressing F9 you can switch to decimal format for the displayed reports.



Check fire resistance

Any verification errors or absence of results are reported in red (*Not processed column* with value 100).



Clicking on each line produces a text log on the verification carried out, which opens the command 

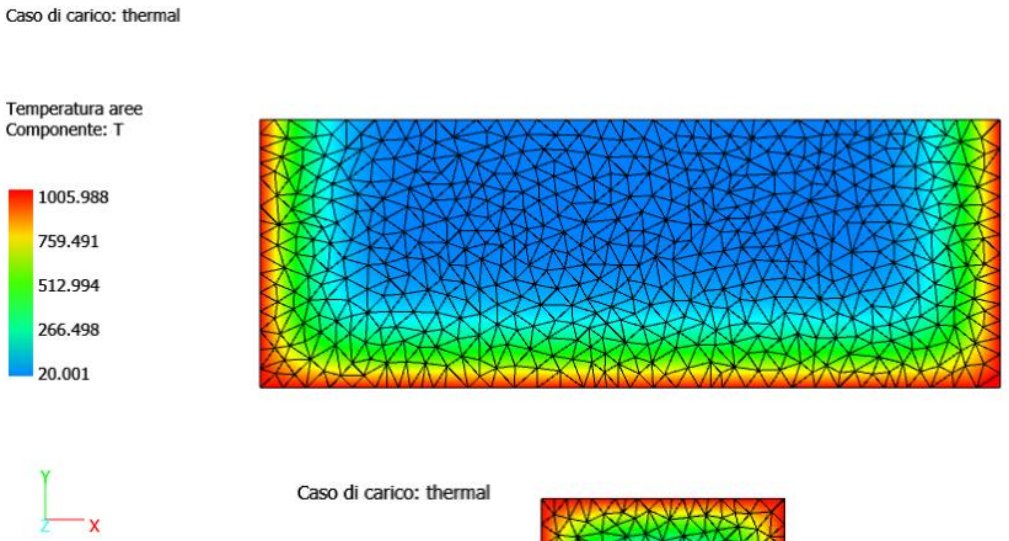
Check fire resistance

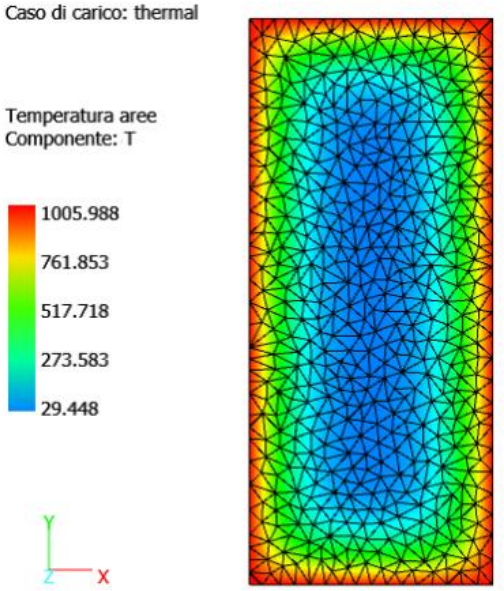
To view the **heat maps** of the analyzed sections, open the files generated by the program in the same folder where the model is saved. The files are named as follows:
thermal_el.NUM_sect.ID»SectionName

with
NUM = element number
ID number of the section

Once the file is open:

- Press ALT+1 to show the section in the XY plane
- Press CTRL+R to view the final stage of the thermal analysis
- Press F9 to view the legend in decimal format
- Press ALT+S to copy a screenshot

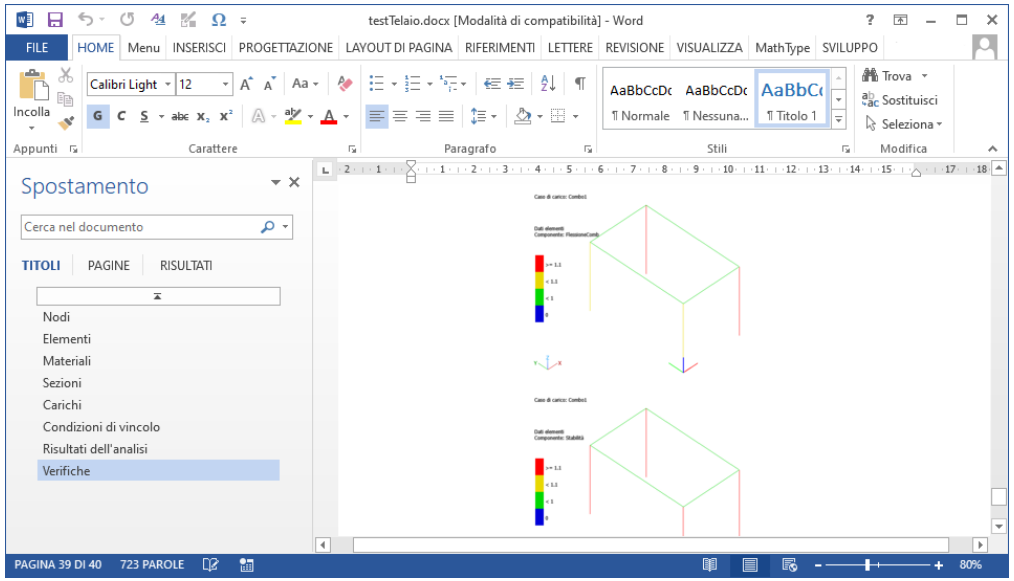


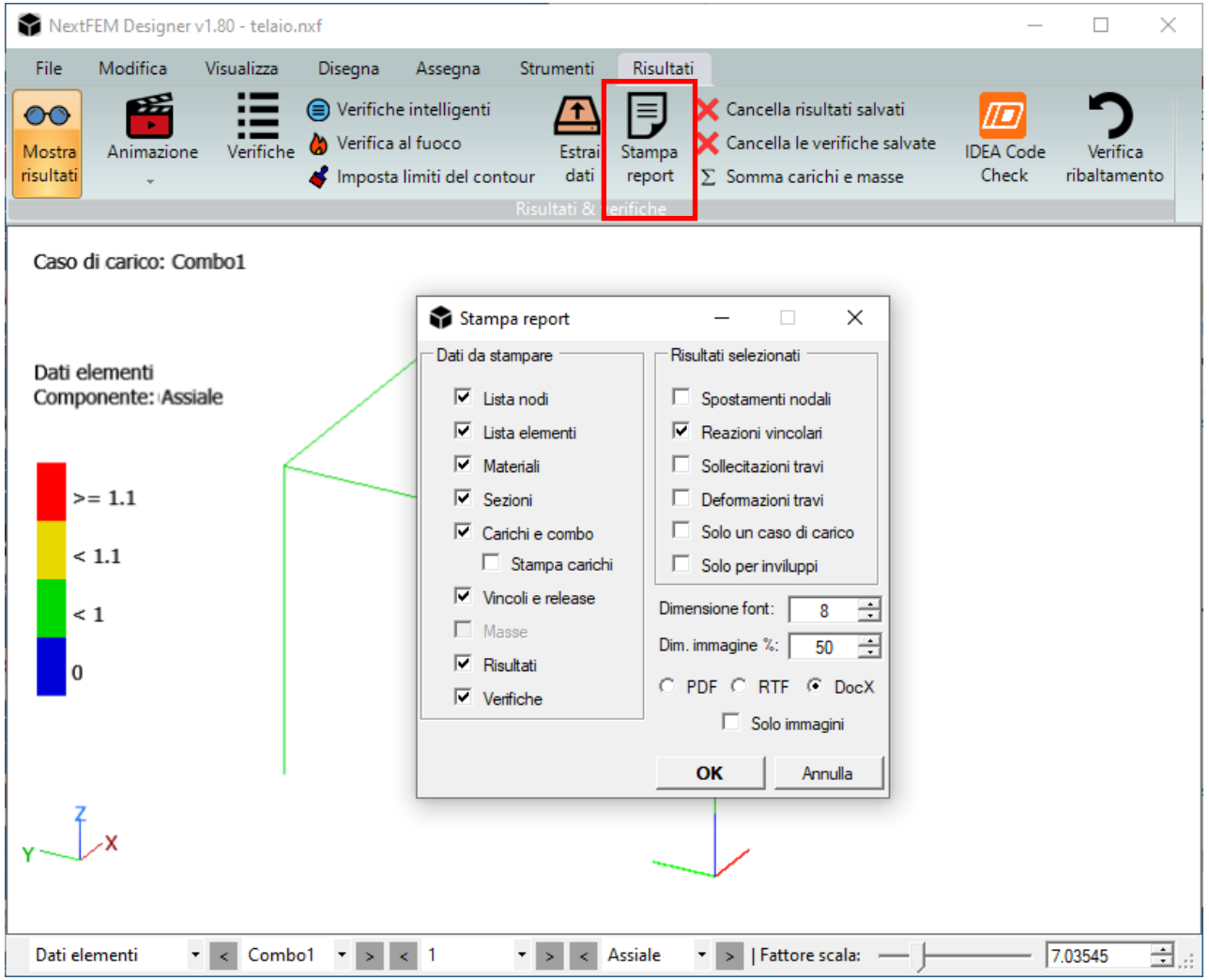


Verification report

From the Results menu, the Print report button allows you to create a report in PDF, RTF or DocX format .

The RTF and DocX formats can also contain images, automatically compiled based on the imported template.





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