



NextFEM Designer
Section Analyzer manual

Version 1.8

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Chapter 1

About Section Analyzer

NextFEM Section Analyzer is an easy-to-use program for calculating strength of any transversal section, starting from material properties, geometry and design forces. This program supports:

- Reinforced Concrete (RC) sections, with steel reinforcements or strands
- Steel and aluminium alloy sections
- Timber section, with or without reinforcing steel
- Steel-concrete composite sections.

Installing NextFEM Designer

NextFEM designer is designed to work with Windows 7 SP1 or above and it is available for 32 or 64 bit Windows versions.

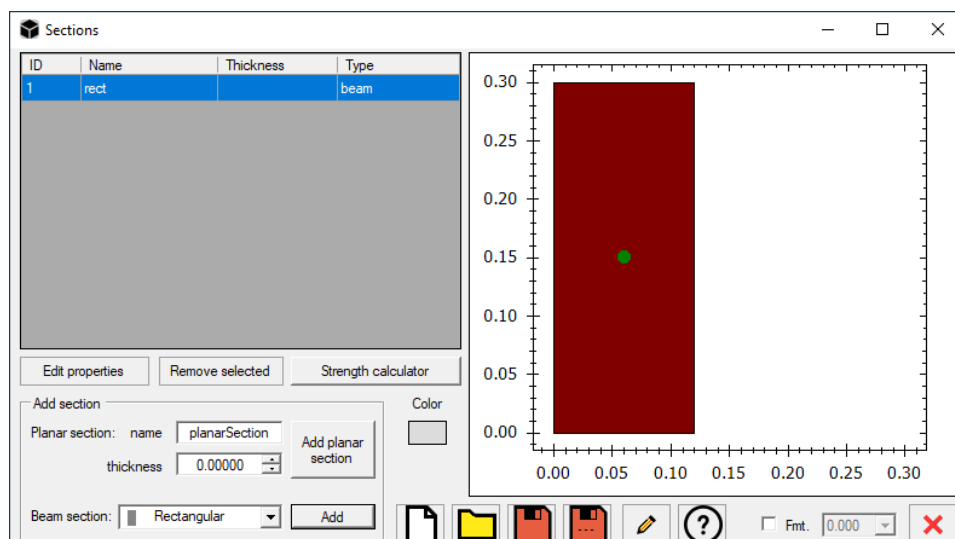
License activation

To activate the program you must be connected to the Internet at the first run. For the licensed installation, please refer to the command *?!License...*

User interface

La finestra principale del programma è mostrata in figura seguente. Le funzionalità principali sono le seguenti:

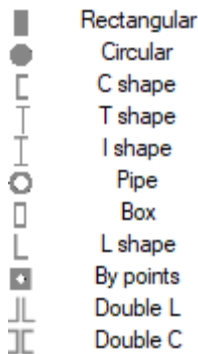
- In Add section box there are commands to add planar sections (equivalent width of 1m) or beam transversal sections, from the bottom menu. Sections added are visible in the table above.
- The command Edit properties allows to modify the selected section, by adding shapes or importing them from DXF drawings
- The button Strength calculator shows the mask for the checking the selected section.



Chapter 2

Section properties

The built-in beam sections available are:



Further section shapes are available: Omega and cold-formed non-thin-walled C shapes, that can be set from inside the section properties.

Other custom libraries can be present in this list. For each of them, the following mask will be displayed to allow selection. Several libraries for steel sections are included in the program.

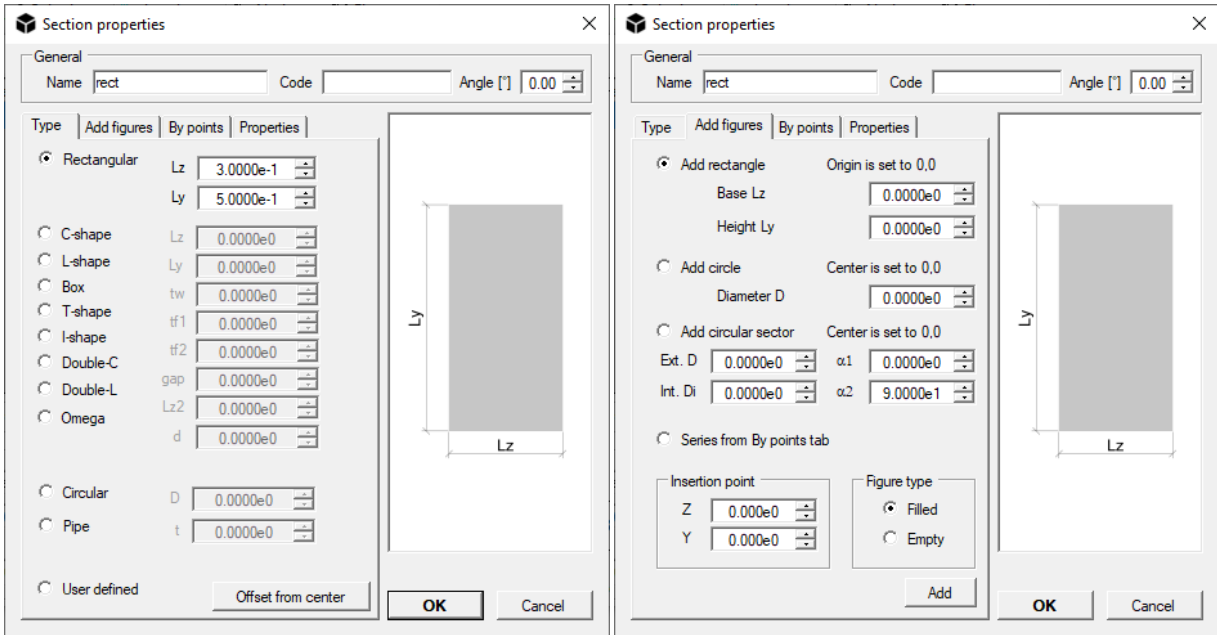
Add by section type

Name	Code	h [mm]	b [mm]	tw [mm]	tf [mm]	r [mm]	A [cm ²]	Jz [cm ⁴]	Wey [cm ³]	Wpz [cm ³]	iz [cm]	Avz [cm ²]	Jy [cm ⁴]	Wey [cm ³]	Wpy [cm ³]	iy [cm]	Type
HE 1...	UNI	91	100	4.2	5.5	12	15.6	236.5	52.0	58.4	3.89	6.15	92.06	18.41	28.44	2.43	Dou...
HE 1...	UNI	96	100	5	8	12	21.2	349.2	72.8	83.0	4.06	7.56	133.81	26.76	41.14	2.51	Dou...
HE 1...	UNI	100	100	6	10	12	26.0	449.5	89.9	104.2	4.16	9.04	167.27	33.45	51.42	2.53	Dou...
HE 1...	UNI	120	106	12	20	12	53.2	1142.6	190.4	235.8	4.63	18.04	399.15	75.31	116.31	2.74	Dou...
HE 1...	UNI	109	120	4.2	5.5	12	18.6	413.4	75.8	84.1	4.72	6.90	158.81	26.47	40.62	2.93	Dou...
HE 1...	UNI	114	120	5	8	12	25.3	606.2	106.3	119.5	4.89	8.46	230.90	38.48	58.85	3.02	Dou...
HE 1...	UNI	120	120	6.5	11	12	34.0	864.4	144.1	165.2	5.04	10.96	317.52	52.92	80.97	3.06	Dou...
HE 1...	UNI	140	126	12.5	21	12	66.4	2017.6	288.2	350.6	5.51	21.15	702.77	111.55	171.63	3.25	Dou...
HE 1...	UNI	128	140	4.3	6	12	23.0	719.5	112.4	123.8	5.59	7.92	274.83	39.26	59.93	3.45	Dou...
HE 1...	UNI	133	140	5.5	8.5	12	31.4	1033.1	155.4	173.5	5.73	10.12	389.32	55.62	84.85	3.52	Dou...
HE 1...	UNI	140	140	7	12	12	43.0	1509.2	215.6	245.4	5.93	13.08	549.67	78.52	119.78	3.58	Dou...
HE 1...	UNI	160	146	13	22	12	80.6	3291.4	411.4	493.8	6.39	24.46	1144...	156.76	240.51	3.77	Dou...
HE 1...	UNI	148	160	4.5	7	15	30.4	1282.9	173.4	190.4	6.50	10.38	478.73	59.84	91.36	3.97	Dou...

Please select a section from the list

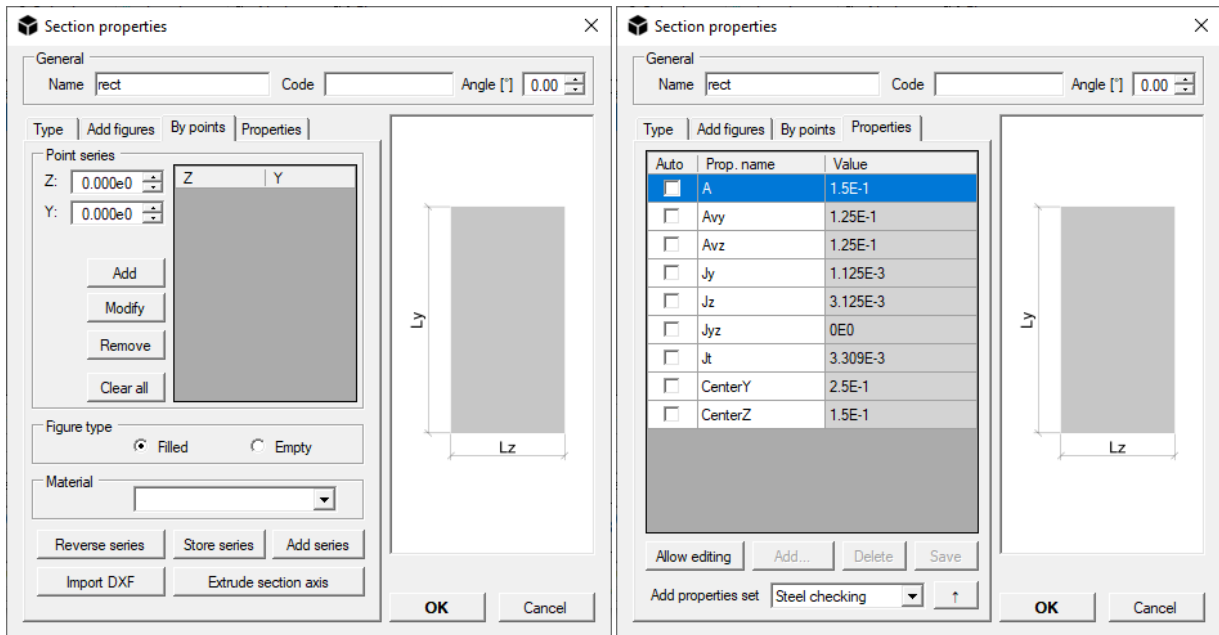
Pick Close

To see the properties (area and moments of inertia) of the inserted sections select a section and press the *Edit properties* button. This mask allows also to import a section from DXF file and define a section by points or by composing single figures.



⚠ WARNING: it is strongly advised to insert units consistent with the initial choices (see *Edit > Set units*).

In the Properties mask it is possible to specify the design properties of the section to be used during checking.

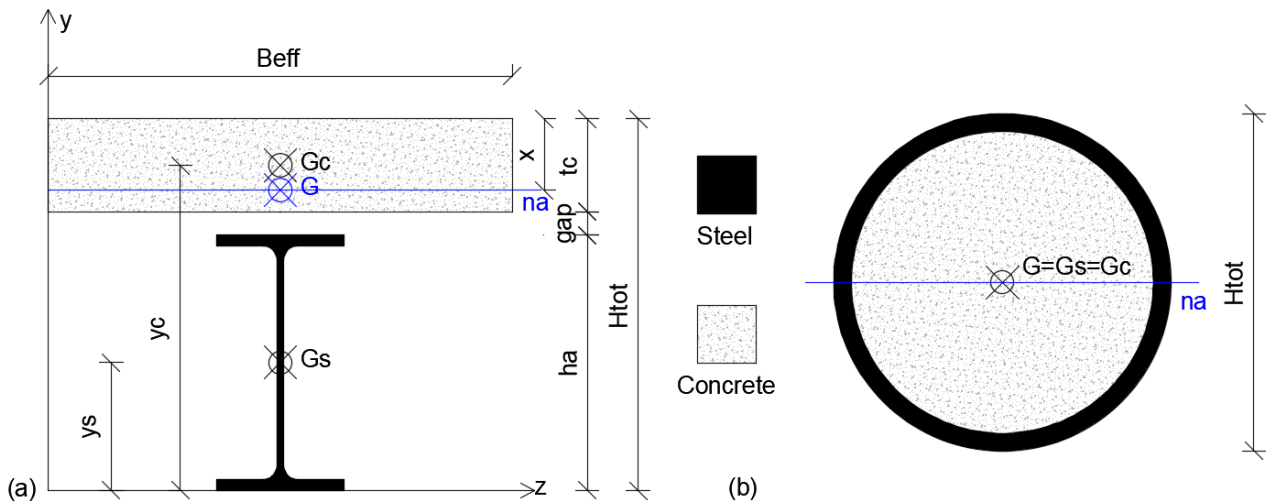


⚠ WARNING: by changing the sectional properties, the section will be converted in "Custom" type. Such operation is not reversible.

Composite sections

The support for composite sections includes:

- Beams with slab like in figure (a) and
- Columns with coincident centres of gravity (b).



A composite section is automatically detected when:

- Two or more filled figures, one of them associated to a steel material and one to a concrete material;
- Properties of the composite section are defined inside the mask *Section properties / Properties* in order to distinguish a beam or a column section.

⚠ WARNING: The effective width of the section *Beff* must be evaluate by the user as per current code of practice.

The stiffness of beam elements having such sections is evaluated as follows. With subscript *s*, steel properties are described, while the ones related to concrete have the subscript *c*.

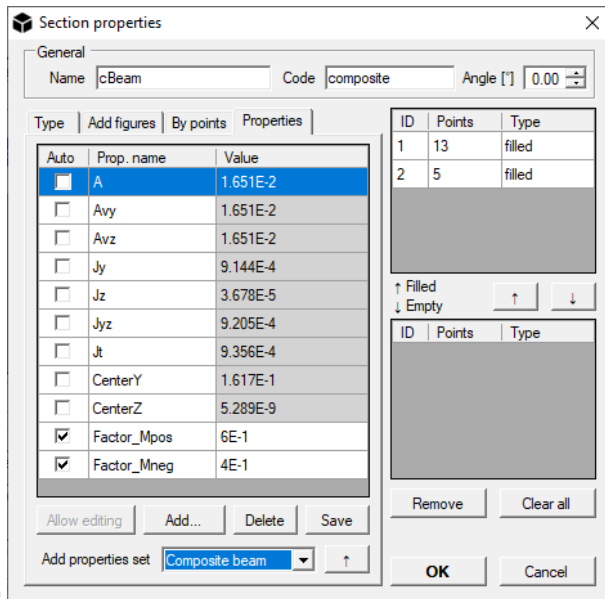
For beams, the moment of inertia for positive bending around the elastic neutral axis *na* is calculated as:

$$I_{z1} = I_{zs} + A_{zs} \cdot (H_{tot} - y_s - x)^2 + \frac{I_{zc}}{n} + \frac{A_{zc}}{n} (x - H_{tot} + y_c)^2$$

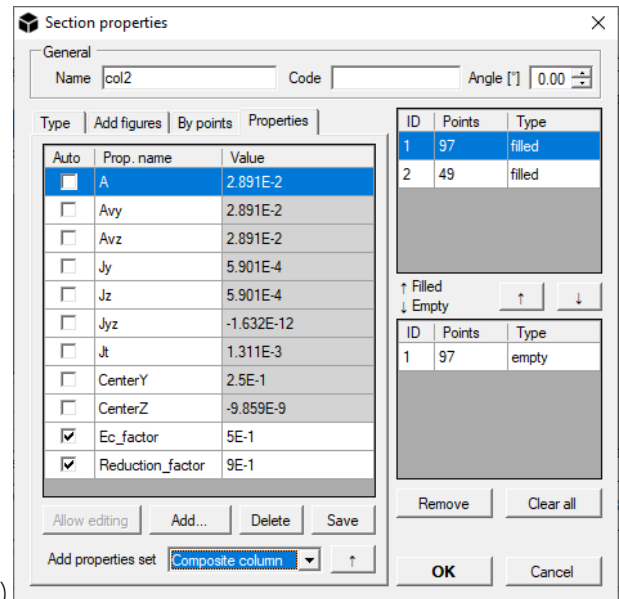
$$\text{with } n = \frac{E_s}{E_c} \text{ and } x = H_{tot} - \frac{n \cdot A_{zs} \cdot y_s + A_{zc} \cdot y_c}{n \cdot A_{zs} + A_{zc}}$$

The moment of inertia of the section for negative bending around the plastic neutral axis is equal to the inertia given by the steel section, as the concrete part is considered as cracked.

As a whole, bending stiffness is estimated as per EC4 and as a function of the factors *Mpos* and *Mneg* which can be changed in the "Properties" input mask (figure a).



(a)



(b)

Hence, the resulting bending stiffness is:

$$I_z = f_{Mpos} \cdot I_{z1} + f_{Mneg} \cdot I_{z2}$$

The remaining properties for the beam section are all calculated by dividing the concrete contribution by n .

For composite columns, once the factors E_c and R have been specified in the "Properties" mask (figure b), the inertial properties of the section are calculated as follows:

$$I_z = R \cdot \left(I_{zs} + \frac{I_{zsc}}{n} \right); I_y = R \cdot \left(I_{ys} + \frac{I_{yyc}}{n} \right); I_{yz} = R \cdot \left(I_{yzs} + \frac{I_{yzc}}{n} \right);$$

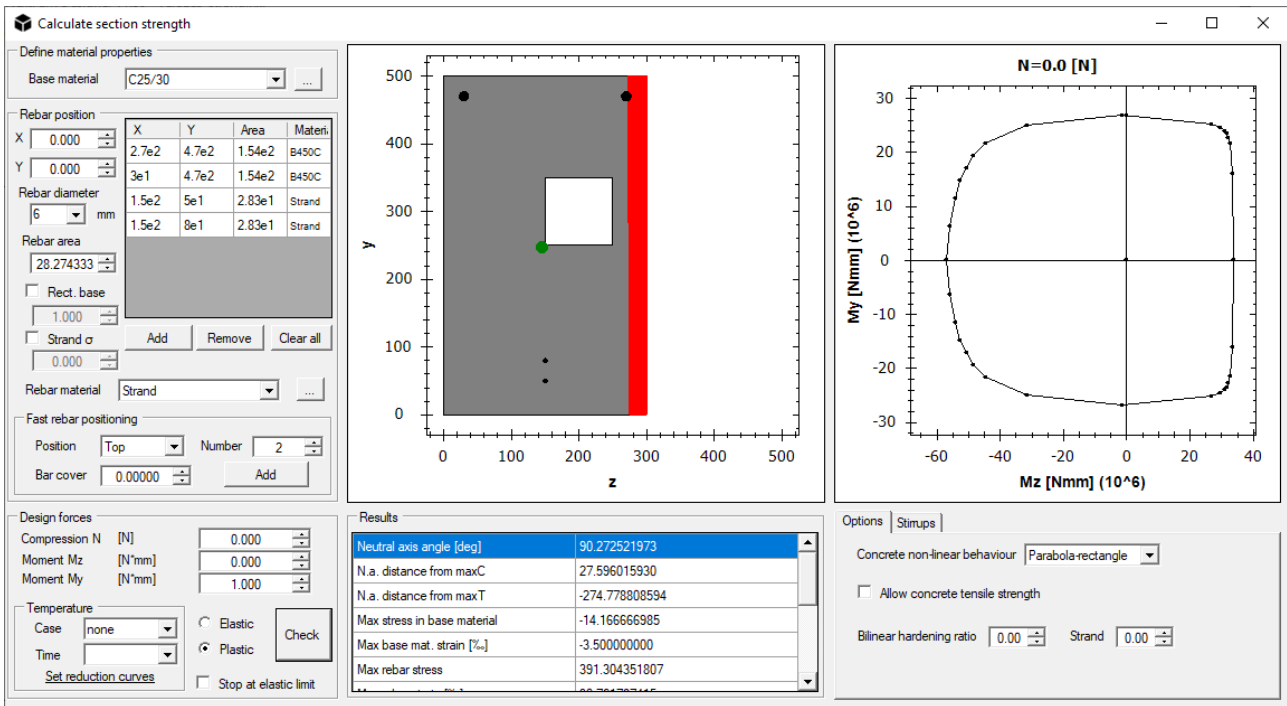
$$\text{with } n = \frac{E_s}{f_{Ec} E_c}$$

The remaining properties are all calculated by dividing the concrete contribution by n .

Chapter 3

Strength calculator

By the *Strength calculator* button it is possible to define the rebar in a RC section and to evaluate its flexural strength.



In *Define material properties* the base material is specified.

The box *Rebar position* can be used to specify the rebar coordinates (eventually of rectangular shape by checking the option *Rect. rebar* and by specifying the base dimension of the plate in *Rect. base*). The rebar coordinates are input on the base of the section local coordinate system, by specifying the diameter and the associated material (that can be **set or added by the command “...”**). The available materials should be customized by modifying or adding *.nfm files in *data/design* subfolder in the software installation directory.

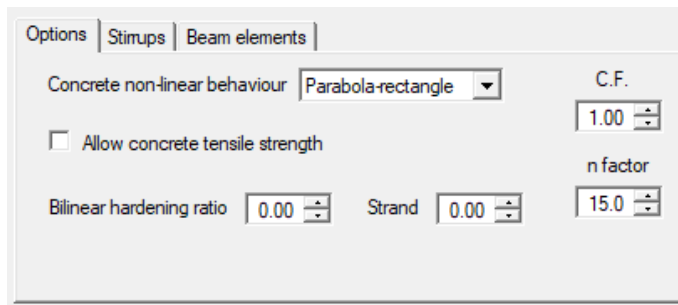
In order to insert strands for prestressed RC sections, it is possible to input the initial strand stress by activating the *Strand σ* option and by inputting the stress in consistent dimensions.

To obtain the resistant values of the section, specify the *Design forces* in the required units. By selecting the *Elastic* option, the response of the section is computed with elastic materials. By selecting *Plastic*, elastic-perfectly plastic laws are used for material behaviour. In the *Results* box, the results of the performed computation are reported, linked to the overlying graphs.

The window allows also resistant domains calculations reduced by thermal action. The software will compute the strengths parameters of the section at the selected instant of time and thermal case, on the base of strengths reductions laws for mechanical and resistant features of base material and rebar, if present.

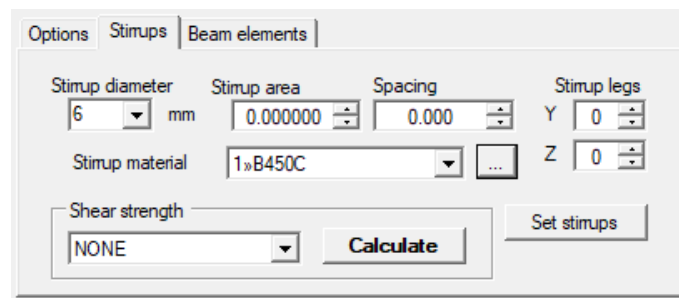
The available options in this mask are:

- *Concrete non-linear behaviour* allows to choose between parabola-rectangle and bilinear material behaviour for the concrete material. If a simple rectangular or circular section are present, the *Confined concrete* option is available in this menu, allowing to consider the confined part of the section inside stirrups. In this case, data in *Stirrups* tab are required. Spirals are not supported.

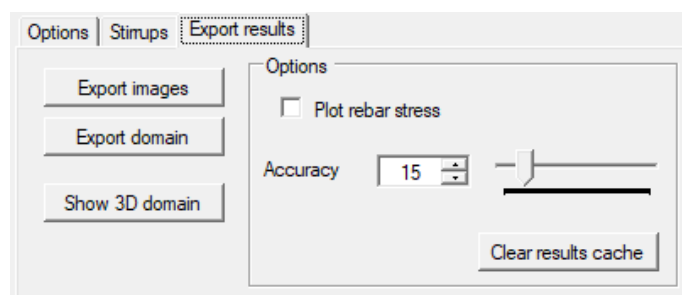


- *Allow concrete tensile strength* can be enabled to activate the contribution of tensile strength of the base material;
- *Bilinear hardening ratio* allows to specify the ratio between the plastic branch of rebar and their elastic modulus. In case of Steel or Aluminium base material, it specifies the hardening ratio to be used.
- *Steel class section* sets the class of the section in case of Steel or Aluminium base material, i.e. if the section can be calculated in plastic field or not.
- *Confidence Factor (C.F.)* sets the confidence factor for strength of base material and rebar.
- *n factor* specifies the value of the homogenization factor (modular ratio between steel and concrete). The default is 15.

Stirrups tab helps to define the stirrups for the current section and to obtain a resisting strength for both direction of the section.



Export results contains options to plot rebar stresses after analysis and to customize calculation accuracy, plus some commands to save section images, export strength domain or show 3D domain.



Checking FRP reinforcements

The verifications of the sections in c.a. reinforced with carbon fiber polymers (FRP) tapes are described below. The calculation procedure refers to the following Italian standards:

- CNR-DT 200 R1 / 2013 - 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;
- Guidelines for the Design, Execution and Testing of Reinforcement Interventions of reinforced concrete structures and masonry through FRP - Document approved on July 24, 2009 by the General Assembly of the Superior Council LL PP.

With reference to the CNR-DT200, the resistance of the FRP tape at the ultimate limit state is assumed to be the minimum between:

- Resistance due to detachment of ends, evaluated with the expression:

$$f_{\text{fdd}} = \frac{1}{\gamma_{\text{fd}}} \cdot \sqrt{\frac{2 \cdot E_f \cdot \Gamma_{\text{Fd}}}{t_f}}, \quad (4.4)$$

in which the specific fracture energy is evaluated as:

$$\Gamma_{\text{Fd}} = \frac{k_b \cdot k_G}{FC} \cdot \sqrt{f_{\text{cm}} \cdot f_{\text{ctm}}}. \quad (4.2)$$

- Resistance for intermediate detachment, evaluated as:

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

also assuming an ultimate deformation equal to the minimum between the maximum declared by the manufacturer (multiplied by) and:

$$\varepsilon_{\text{fdd}} = \frac{f_{\text{fdd},2}}{E_f} \geq \varepsilon_{\text{sy}} - \varepsilon_0, \quad (4.7)$$

In output, the program reports the maximum tension that can be absorbed by the tape, the fracture energy and the minimum anchor length, obtained from the relationship:

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

in which $f_{\text{bd}} = \frac{2 \cdot \Gamma_{\text{Fd}}}{s_u}$, con $s_u = 0.25 \text{ mm}$ and $\gamma_{\text{Rd}} = 1.25$.

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2. Any other service (e.g. installation, verification, assistance requested by the Customer to let his employees to use NextFEM software) will be performed by NextFEM SRLS after a Customer’s request and in any case after a quotation made by NextFEM Srls and its acceptance by the Customer.

3. The Customer is solely responsible that his technological equipment (hardware and software) meets the minimum and essential requirements to install and use the software, as indicated in the users’ manual included in the program.

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3. According to the Italian law art. 64 ter Law 22nd of April 1941, n. 633 as amended and supplemented and art. 5 par. 2 Directive 2009/24/EC of the European Parliament and of the Council of 23 April 2009 as amended and supplemented, it is allowed to the Licensee Customer, having the right to use a copy of the software produced by NextFEM SRLS, to make a back-up copy of the software and of the included documentation, so far as it is necessary for that use.

4. According to the Italian law art. 64 bis, lett. a) and b) ,64 ter Law 22nd of April 1941, n. 633 as amended and supplemented and art. 4 par. 1 lett. a) and b) Directive 2009/24/EC of the European Parliament and of the Council of 23 April 2009 as amended and supplemented, it is explicitly forbidden to the Customer the permanent or temporary reproduction of the software produced by NextFEM SRLS and of the included documentation, by any means and in any form, in part or in whole, without the authorisation by the right-holder. In so far as loading, displaying, running, transmission or storage of the aforementioned software necessitate such reproduction, even such acts shall be subject to authorisation by the right-holder. At the same conditions and with the same restrictions, it is equally forbidden to the Customer the translation, adaptation, arrangement and any other alteration of the software produced by NextFEM SRLS and of the included documentation and the reproduction of the results thereof, without prejudice to the rights of the person who alters the program.

5. The acts of the aforementioned paragraphs 2 and 3, even when they are necessary for the use of the aforementioned software by the lawful Licensee Customer in accordance with its intended purpose, including for error correction, are subjected to the authorisation by the right-holder.

6. According to the Italian law art. 64 ter, subparagraph 3 Law 22nd of April 1941, n. 633 as amended and supplemented and art. 5 par. 3 Directive 2009/24/EC of the European Parliament and of the Council of 23 April 2009 as amended and supplemented, it is allowed to the Licensee Customer to observe, study or test the functioning of the software produced by NextFEM SRLS and of which he holds the License, in order to determine the ideas and principles which underlie any element of the program if he does so while performing any of the acts of loading, displaying, running, transmitting or storing the program which he is entitled to do.

7. According to the Italian law art. 64 quater Law 22nd of April 1941, n. 633 as amended and supplemented and art. 6 Directive 2009/24/EC of the European Parliament and of the Council of 23 April 2009 as amended and supplemented, the previous authorisation of NextFEM SRLS shall not be required where reproduction of the code and translation of its form within the meaning of art. 64bis, lett. a) and b) Law 22nd of April 1941, n. 633 as amended and supplemented and of points (a) and (b) of Article 4 par.1 are done to modify the form of the code and are indispensable to obtain the information necessary to achieve the interoperability of an independently created computer program with other programs, provided that the following conditions are met:
(a) those acts are performed by the Licensee or by another person having a right to use a copy of a program, or on their behalf by a person authorised to do so;
(b) the information necessary to achieve interoperability has not previously been readily available to the persons referred to in point (a);
(c) those acts are confined to the parts of the original program which are necessary in order to achieve interoperability.

8. The provisions of preceding paragraph 7 shall not permit the information obtained through its application:
(a) to be used for goals other than to achieve the interoperability of the independently created computer program;
(b) to be given to others, except when necessary for the interoperability of the independently created computer program;
(c) to be used for the development, production or marketing of a computer program substantially similar in its expression, or for any other act which infringes copyright.

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3. This clause will remain in force even after the termination or the expiration in whatever manner of this agreement.

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1. NextFEM SRLS provides the software **“as is” and is not obliged to provide maintenance, support, updates, improvements or changes.** Different conditions may apply to paid software and for Education licenses.

2. To ensure the continuity of the license and of paid modules, the Customer must pay the relative fee at least 15 days before the **current license expires; if the deadline is not respected, NextFEM SRLS can't guarantee such continuity, and the licensed modules** may be blocked. For no reason the payment of the annual fee regarding the software and/or its single component module and/or required services can be delayed or suspended; eventual exceptions or Customer's disputes will be managed and solved separately.

3. NextFEM SRLS provides software updates for 12 (twelve) months starting from the delivery date, limited to the functionalities of paid module/s. During this period, encountered malfunctions in paid modules will be fixed to ensure the correct functionality. This guarantee does not apply to functionalities not included in the paid modules.

Art. 9 – Warranty and liability –

1. For both the basic software version and the paid modules, NextFEM SRLS provides the software “as is” and it is not obliged to provide maintenance, support, updates, improvements or changes. During the validity of this agreement, eventual software updates or patches may be released.

2. NextFEM SRLS is committed, only for functionalities of the paid modules, and for 12 months from the purchase, to keep the software able to perform the tasks described in the user manual. During this period, encountered malfunctions of the paid modules will be fixed to ensure the correct functionality. This guarantee does not apply to functionalities not included in paid modules, nor to Educational licenses, as stated in art. 14 of this agreement.

3. The warranty is conditioned to the correct original functioning of the Client's machine, hardware and system software and the existence of the minimum requirements prescribed for the correct software installation, as well to the circumstances in which the Customer installs the updates and patches that can be made available by the Licensor via an independent download made from the nextfem.it website, and also to the correct use of the system and software by the Customer.

4. The Customer is the sole responsible for the choice of the software produced by NextFEM SRLS and its compliance to his own needs and purpose of use, for any input fed to the software and any output coming from the program or from its parts, and must verify results, reports and the checks conducted with it.

5. The software provided by NextFEM SRLS are a representation of the current state of development, so NextFEM SRLS cannot grant that they will always work correctly in every applications and in any situation.

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7. This warranty is not valid whenever a software fault is due to accident, improper and/or non-conforming and/or wrongful usage. Any change to the software made directly by the Customer will result in the withdrawal of this warranty.

8. NextFEM SRLS does not take any responsibility and is not liable for any direct and/or indirect, special, collateral, incidental and/or consequential damage, including lost profits, incurred by the Customer or third parts caused through the use or lack of use of the software and by any means related and/or consequential to eventual software quality, adequacy, use and usability flaws, which are therefore to be exclusively borne by the Customer, except as what is compulsorily required by law.

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2. As a consequence of the termination of this agreement as in the previous subparagraph, the license of use is revoked and cannot be use anymore by the Customer for any purpose.

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2. The possible existence of other contractual relationships between NextFEM SRLS and the Customer does not affect other connections between them, that will remain separated and independent.
3. The free licenses of use granted by NextFEM SRLS (i.e. basic program, Educational license, etc.) are not covered by any kind of support.
4. The paid licenses of use granted by NextFEM SRLS to the Customer can be issued with a first-installation assistance via email, until 7 days after the payment. Further paid support can be supplied for one year starting from the license acquisition. Support period can be bought or renewed only together with the program license or renewal, respectively. Assistance is supplied only via email and concerns the sole software use or program functioning. NextFEM SRLS does not supply support on the engineering choices made or to be made for designing any structures. Any advice given by support cannot substitute the engineering judgement of the Customer, who is the sole responsible of the structure designed, analysed and checked with the program, including the obtained results.

Art. 12 – Communication -

1. Any communication from one part to another of this agreement must be sent as a registered letter with signed return receipt or as a hand-delivered **registered letter addresses to "NextFEM SRLS, Piazza del Foro Romano 12, 31046 Oderzo (TV)"** or as a **certified e-mail to nextfem@pec.nextfem.it**.

Art. 13 – Litigation – Applied law -

1. This contract is subjected to the Italian law.
2. Any litigation in any case connected to this agreement shall be exclusively of the competence of the Court of Treviso.

Art. 14 – Educational license –

1. Educational licenses are distributed for a predetermined number of PCs prior oral or written agreement with NextFEM SRLS. NextFEM SRLS solely decides the number of distributed licenses prior consultation with the Customer.
2. Educational licenses can be given freely to a private or public Customer, when it is a training institution, a research and development company or a school, at the incontestable discretion of NextFEM SRLS. In such case, the given Educational licenses do not grant to the Customer the right to use them after the planned time period conceded to the Licensee, and they can be revoked at any time by NextFEM SRLS without any justification or notice to the Customer.
3. When given freely, Educational license does not allow for any refund of the cost of the software, for any reason.
4. When given freely, Educational license does not allow for any kind of support supplied by NextFEM SRLS, neither for malfunctioning of the program. Hence, the warranties described in art. 9, paragraph 2 of this agreement are excluded.

Art. 15 – Changes of terms in this agreement –

1. The Licensor has the right to modify the **conditions of the present License user's agreement for the software of NextFEM SRLS** by email to be sent to the Licensee to the address given during registration on nextfem.it website. The Licensee has the right of withdrawal by sending a registered letter with signed return receipt or as a hand-delivered **registered letter addresses to "NextFEM**

SRLS, Piazza del Foro Romano 12, 31046 Oderzo (TV)" or as a certified e-mail to nextfem@pec.nextfem.it compulsorily within 14 days from the receipt of the communication related to the changes of the agreement terms.

Art. 16 – Final provisions -

1. Whenever one of the clauses contained in this Contract will be declared invalid or without effects, entirely or in part, this will not invalidate the other clauses, except when the Licensor considers in bona fide the clause as essential, and consequently shall ask for the resolution of the contract.

2. For anything not expressly provided in this contract, the Italian Civil Code rules shall be applied and the Legislative Decree of 29th of December 1992, n. 518 as amended and supplemented, regarding the implementation of the Council Directive n. 91/250 CEE of 14th of May 1991 on the legal protection of computer programs which modifies and integrates Law 22nd of April 1941, n. 633, and this last law as amended and supplemented, and the Directive 2009/24/EC of the European Parliament and the Council of 23rd of April 2009 as amended and supplemented.

Oderzo (TV), (date of acceptance of this contractual conditions)

NextFEM SRLS

Licensee

Pursuant to and in accordance with art. 1341 and 1342 c.c., the Customer specifically approves, for having them read, understood and known, the articles: 2 (Duration – Agreement termination) paragraph 2, 3 (License delivery) paragraph 3, 4 (Installation) paragraph 3, 5 (Programs usage), 6 (Property – Transfer prohibition), 7 (Right holders – Secret – Modifications) paragraph 2, 8 (Fee – Solve et repete) paragraph 2, 9 (Warranty and liability) paragraphs 3,4,5,6,7,8,9, 10 (Software restitution - Software deletion) paragraph 4, 11 (Support and/or consultation), 13 (Litigation – Applied law), 14 (Educational license) paragraphs 2 and 3, 15 (Changes of terms in this agreement), 16 (Final provisions).

Oderzo (TV), (date of acceptance of this contractual conditions)

The Customer

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NextFEM Designer uses:

OOFEM v2.4
ZedGraph Library v.5.1.5.31366
Clipper Library v.6.1.3
net Dxf Library v.0.9.1
Poly2Tri Library
RichTextBoxLinks Library
SlimDX Library
Jace Library
UnitConversionLib Library
DotNetZip Library v1.13.7
Triangle.NET Library Beta 4
Netgen Mesh Generator Library v.6.0
PDFSharp v.1.32
RTF Document Constructor Library
log4net Library v.1.2.15
SharpZipLib Library v.0.86.0
Esent Managed Interface v.1.9.4
xBIM Essentials v.5
xBIM Geometry v.5
XbimWebUI for xBIM toolkit
Desktop Bridge Helpers v.1.1.0
DocX Library v.1.1.0
Splicer Library v.1.0
DirectShowLib v.2.1
OpenStreetMap site
IDEA StatiCa IOM

Newtonsoft.Json.NET v12.0

All the licenses, including the general one for the program and for paid modules, can be found in the dialog *?/About*

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