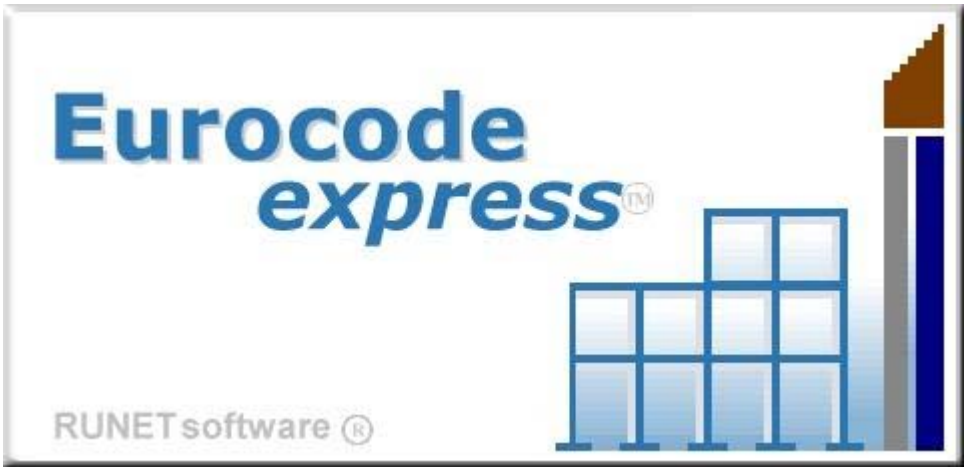

A comprehensible and integrated design tool for the structural Eurocodes

EUROCODEexpress is a work and study companion for all the Eurocodes, from Eurocode 0 to Eurocode 8. Design principles (EC0), loads (EC1), snow load (EC1-3), wind load (EC1-4), reinforced concrete (EC2), structural steel (EC3), timber (EC5), masonry (EC6), foundation and retaining walls(EC7), seismic loads (EC8). A complete package, and source of information on designing and understanding the Eurocodes, and the National Annexes.

USER's Manual

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1 Design with Eurocodes

Below a short description of subjects of the Eurocodes included in the program EUROCODEexpress and the codes the subjects are based on:

1.1 Eurocode 0, Basis of structural design

Basic design principles and verification equations
Partial safety factors
Load combinations
Material factors

EN 1990:2002/A1:2005/AC:2010
Eurocode - Basis of structural design

1.2 Eurocode 1, Actions on structures

General action
  Category of use
  Imposed loads on building parts
Snow load
  Snow load on the ground
  Snow load on roofs
  Snow load on snowguards
  Snow overhanging the edge of the roof
Wind Load
  Wind velocity pressure
  Wind pressure on vertical walls
  Wind pressure on flat roofs
  Wind pressure on Monopitch and duopitch roofs

EN 1991-1-1:2002/AC:2009
Eurocode 1: Actions on structures - Part 1-1: General actions - Densities, self-weight, imposed loads for buildings
EN 1991-1-3:2003/AC:2009
Eurocode 1 - Actions on structures - Part 1-3: General actions - Snow loads
EN 1991-1-4:2005/A1:2010 /AC:2010
Eurocode 1: Actions on structures - Part 1-4: General actions - Wind actions

1.3 Eurocode 2, Design of concrete structures

Design charts of Reinforced concrete
  Concrete-steel properties, creep, shrinkage, concrete cover
  Section capacity in bending, shear and axial loading
   Design charts for bending
   Design charts for columns in single and double bending
   Effective length of columns
   Design charts for deflection control
Reinforced concrete slabs
  Slab sections in bending
  Ribbed slab sections in bending
  Flat slab sections punching shear
  Slab sections in bending, lightweight concrete
  One way continuous slabs
  Cantilever slabs
 Two way slabs
Reinforced concrete beams
  Rectangular beam cross section in bending
  T beam cross section in bending
  Beam cross section in torsion
  Rectangular beam cross section, lightweight concrete

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T beam cross section, lightweight concrete
One span beams in composite loading
Continuous beams with distributed loads
Reinforced concrete columns
Column section in biaxial bending
Isolated column in simple bending
Column strength (single eccentricity)

EN 1992-1-1:2004/AC:2010
Eurocode 2: Design of concrete structures - Part 1-1: General rules and rules for buildings
EN 1992-1-2:2004/AC:2008

1.4 Eurocode 3, Design of steel structures

Tables and graphs from Eurocode 3
Flexural buckling
Lateral torsional buckling
Effective length of columns
Steel sections
Steel section properties, all international profiles
Classification and resistance of steel cross sections
Resistance of steel cross section
Single actions
Double actions
Combined actions
Buckling resistance
Buckling, members in compression Nc
Buckling, members in compression and bending Nc-My-Mz
Lateral torsional buckling My
Lateral torsional buckling Nc-My
Design of beams
One span beams
Two span continuous beams
One span with cantilever
Design of columns
Column under axial load
Column under axial load and bending
Column under axial load and double bending
Design of bolted connections
Double shear joints
Beam to beam connection with web cleats
Beam to column connection with end plate
Simple column base connection

EN 1993-1-1:2005/AC:2009
Eurocode 3: Design of steel structures - Part 1-1: General rules and rules for buildings
EN 1993-1-3:2006/AC:2009
Eurocode 3 - Design of steel structures - Part 1-3: General rules - Supplementary rules for cold-formed members and sheeting
EN 1993-1-5:2006/AC:2009
Eurocode 3 - Design of steel structures - Part 1-5: Plated structural elements
EN 1993-1-6:2007/AC:2009
Eurocode 3 - Design of steel structures - Part 1-6: Strength and Stability of Shell Structures
EN 1993-1-7:2007/AC:2009
Eurocode 3 - Design of steel structures - Part 1-7: Plated structures subject to out of plane loading
EN 1993-1-8:2005/AC:2009
Eurocode 3: Design of steel structures - Part 1-8: Design of joints

1.5 Eurocode 4, Design of composite steel and concrete structures

Steel concrete composite floors
Timber concrete composite floors

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EN 1994-1-1:2004 Design of composite steel and concrete structures, General rules and rules for buildings

1.6 Eurocode 5, Design of timber structures

Design of cross-sections in Ultimate limit state
- Tension
- Compression
- Bending
- Shear
- Torsion
- Stability

Design of timber connections
- Timber-to timber (single shear and double shear)
- Panel to timber (single shear and double shear)
- Steel plate to timber (single shear and double shear)

Design of timber beams
- Simply supported
- Continuous over two spans

Design of single span floors
Design of two span floors
Design of Roofs
- Truss rafter roofs
- Truss rafter roofs with carpentry connections
- Collar roofs
- Monopitch roofs

EN 1995-1-1:2003 Design of timber structures – General – Common rules and rules for buildings
EN 1995-1-2:2003 Design of timber structures – General – Structural fire design

1.7 Eurocode 6, Design of masonry structures

Mechanical properties of masonry
- Material factors
- Compressive strength
- Shear strength
- Flexural strength

Eurocode 6 design charts
- Out of plane eccentricity
- Reduction factor for slenderness and eccentricity
- Bending moment coefficients for flexural design

Strength
- Compressive strength
- Shear strength
- Flexural strength

Design
- Masonry subjected to vertical load
- Masonry subjected to shear load
- Masonry subjected to lateral load

Masonry building design

Eurocode 6 EN 1996-1-1:2005 Design of masonry structures, General rules for reinforced and unreinforced masonry structures

1.8 Eurocode 7, Geotechnical design

Soil bearing capacity
- Drained conditions
- Undrained conditions

Spread footings

Flexible centrically loaded footings
Flexible eccentrically loaded footings
Footings of steel columns (pinned)
Footings of steel columns (fixed)
Retaining walls
Cantilever type without back heel
Cantilever type with back heel
Basement walls
Earth pressure coefficients (active and passive)

EN 1997-1:2004/AC:2009
Eurocode 7: Geotechnical design - Part 1: General rules

1.9 Eurocode 8, Design of structures for earthquake resistance

Elastic response spectrum
Design response spectrum

EN 1998-1:2004/A1:2013/AC:2009
Eurocode 8: Design of structures for earthquake resistance - Part 1: General rules, seismic actions and rules for buildings

1.10 FRAME2D Design

Design of 2-dimensional Frame structures and grillages, from reinforced concrete, structural steel or structural timber. A 2-dimensinal finite element model, with additional design in ultimate limit state of the members according to Eurocodes 2,3 or 5.

2 After program installation

2.1 National annex, Structural parameters and report settings

The program is based on the structural Eurocodes. The application as well as the parameters of Eurocodes may differ from country to country.
It is advisable to consult the National Application Documents, which define the parameters, the supporting standards and provide national guidance on the application of Eurocodes.

After the installation of the program, you must select the National Annex of your area. If it is necessary you may also adjust various parameters such as material constants, safety factors Eurocode options, snow and wind regions, and default values.
The user can decide the appearance of the report by adjusting: user defined graphic and logo text, page margins, font selection, size of indentation etc. The Report settings must also be adjusted to meet the requirements of the program user.

From **Parameters**:

- **NA-National Annex**, Select the National Annex to apply in the design
- **Design Parameters**, Check and select options or modify (if it is necessary) the various design parameters of every particular Eurocode.
- **Materials,** You can adjust the characteristic material properties for concrete, steel, timber, soil etc.. It is advisable to consult the National Application Document of the Eurocodes 0,1, 2, 6, 7, 8.
- **Snow load on the ground** Default region and snow zone
- **Basic wind velocity** Default region and wind zone
- **Seismic design** Default region and seismic zone

From **Report setup**:
You can adjust the report appearance (margins, font, cover, company logo, page caption, page footnote, indentations, graphic appearance, pagination).

From **[Setup/Decimal point]** you can select type of decimal point symbol.

You can change program language from **[Setup/Language Set-Up]**. By changing the language and confirm it by [apply]. You must recalculate the design objects to take the new language in the report.
From [**Help/Program user's manual]** you can read or print the program user's manual.

2.2 Basic philosophy in program use

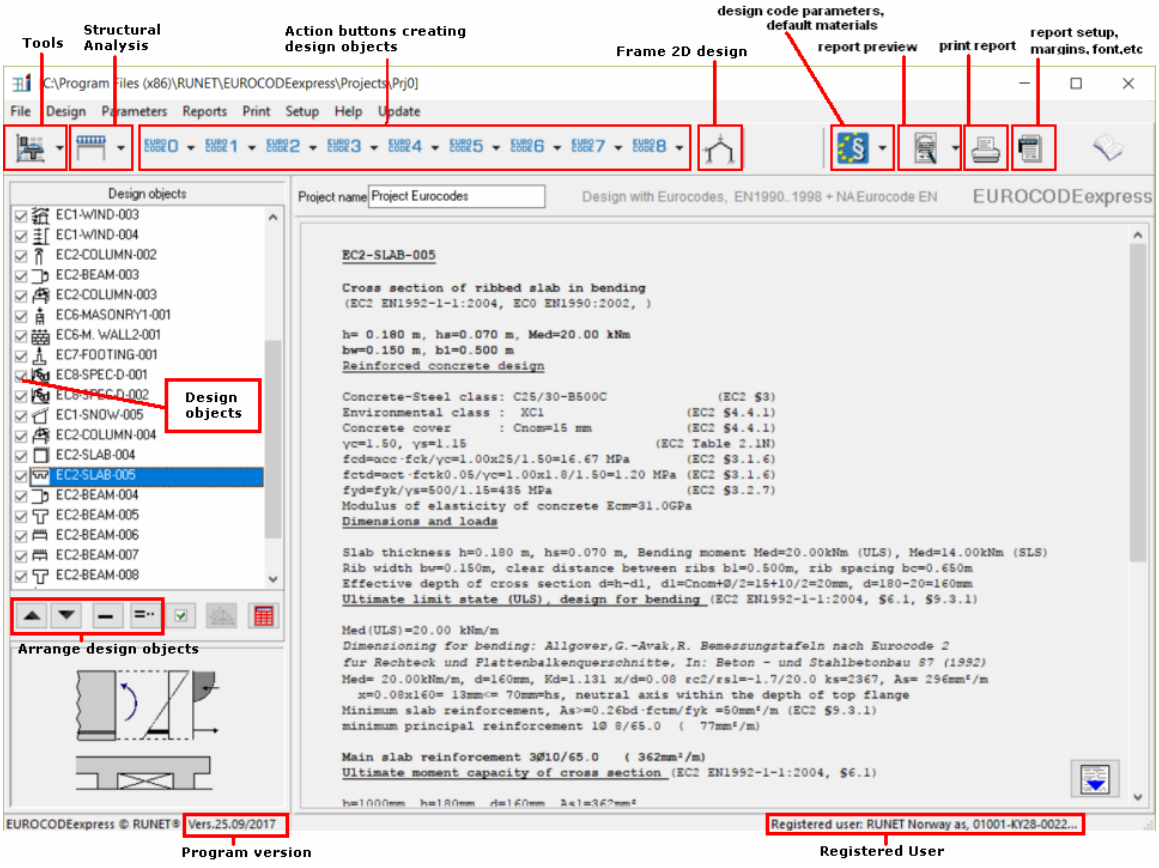
With the program you create and manipulate various design objects or structural elements. The design objects can be a variety of structural elements such as: beams, columns, connections, simple frame structures, footings, etc. All the program activity takes place within the main window.
Within a project you may create as many design object as you want. All the data are saved in one project file. A common report is created. You can select the structural objects that you want to include in the report. The main window displays and handles all the necessary information and actions for the design objects of the project.
You can create new design objects with the action buttons (one for each Eurocode) at the top of the main program window.
Each design object, with a name you specified, the Eurocode number, and a characteristic icon, is shown in a list in the [Design objects] window. From this window you can regulate their appearance and the order of appearance in the report. The right side window shows the calculations of the selected design object.
By double clicking a design object you enter its calculation window, where you specify the dimensions, the loads and the design code parameters. When the object is created the parameters

take the default values. All the required data are well marked with a sketch, and the appropriate dimensions. The program constantly checks for wrong or inappropriately entered values.
With right clicking a design object you can select from the popup menu actions like computation, report previewing, printing, exporting, or CAD drawing.
In front of every design object is a check box. Only the objects that are checked will be included in the common report.
The basic steps in using the program are:

Open a Project File from menu [File].

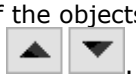
- Select a design object, from the [Design objects] window, or create a new one from the action buttons at the top of the main program window.
- Activate the computations of the object, by double clicking the design object or by clicking the computations button. If it is a new object the computations are activated automatically.
- In the object's calculation window enter the necessary data for the particular design object and do the computations.
- In the calculation window you can see the drawing of the object, its characteristic properties, and you can preview or print the report of that particular design object.
- Check the objects you would like to appear in the report, and adjust their order of appearance in the [Design objects] window.
- Preview and Print the report and the reinforcing bar schedules, for the marked objects.

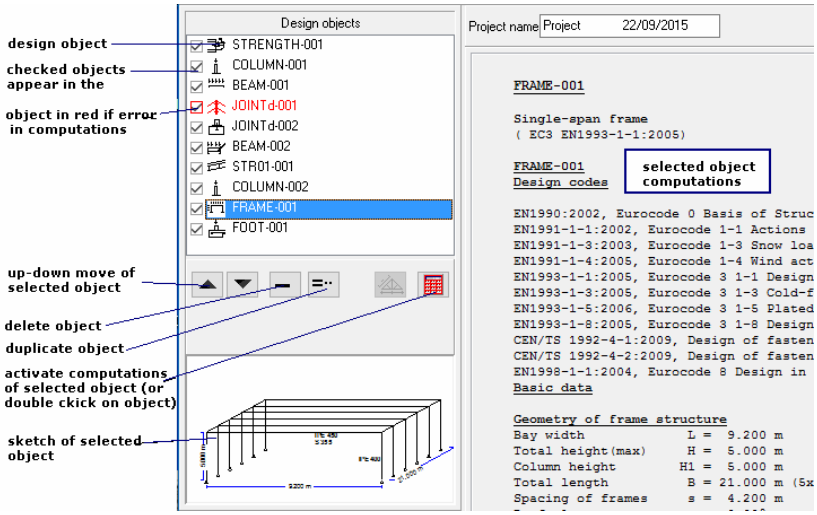
Specify the design and code parameters, and the default values from the menu Parameters
Adjust the report appearance and the contents. Adjust also the units used in the report.
Adjust program appearance and basic parameters.



2.3 Design objects

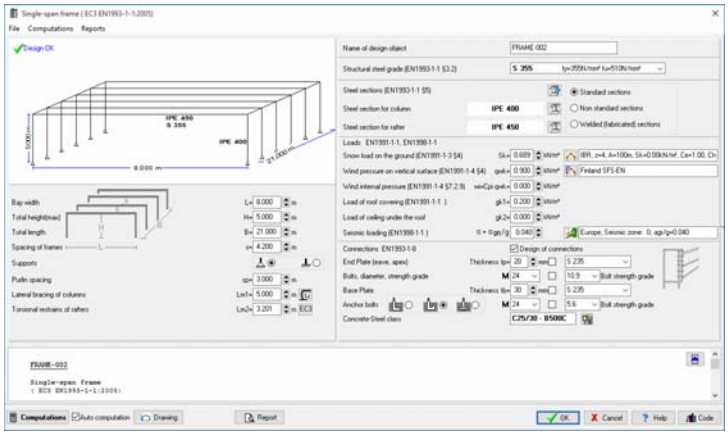
The design objects can be a variety of structural parts of a structure such as : beams, columns, connections, bracing systems, footings etc...
We refer to these calculations as design objects or structural elements.
You create the design objects with the action buttons on the top. In a project you may create as many design objects, as you want. Automatically the program gives a default name to each object, (which you may change), and assigns a small characteristic icon in front to recognize the

type of the design object. You may change the name of the design object. Design objects must NOT have same names. Design objects **must** have different names. This is absolutely necessary. The design objects are autonomous and each one has its own drawings, material properties and computations. All the design objects of the project are listed in the window at the left, which is the basic window in working with the design objects. By selecting (clicking at) an object, the corresponding computations appear on the right window. If the object appears in red colour, the computations have errors or are not satisfying. A characteristic sketch of the selected design object appears underneath.
With double clicking on a design object you enter its calculation window. With right clicking on a design object you can select actions like computations, report previewing and printing exporting, or drawing.
The objects checked in front, ☑ are included in the report. A common report is produced from the selected objects. In the Report Setup you may specify the report of each design object to start in a new page.
The order of the objects, which is also the order of appearance in the report, is regulated with the two buttons  . You can delete one or more selected objects by clicking at Del key or , (multiple selection of design objects with [Shift] and mouse click, or [Ctrl] and mouse click). You can duplicate a selected object by clicking at .



2.4 Calculation Window

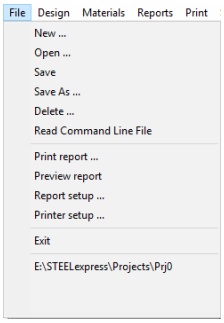
A calculation window has a typical sketch of the steelwork object that is to be designed. All the necessary input data are marked with their dimensions. Depending on the speed of the computer the user can choose to have the computations performed simultaneously with the data input/change or when clicking the button [Computations]
The calculations appear in the window underneath. This window can expand by clicking [Report Up]. Warnings and errors for inadequate design values are shown in red in the calculations.



When the object is created all the parameters take default values. A check is always made for wrong or erroneous input values. After the computations an OK or Error (in red) message is shown

on top left. With Preview you can preview the full report of that design object. From the preview window you can print or export the report to PDF or Word file.

2.5 Files



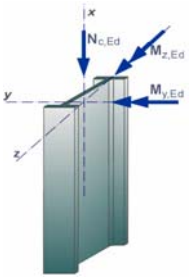
You create, open and save files. The data are saved automatically as you change them and you do computations. All the structure objects are saved in the same unique file with an extension [xxxxxxExpressData]. When you specify a new file name you don't have to type in the extension.

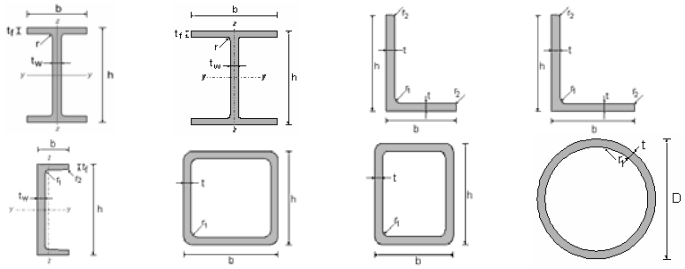
2.6 Units

The units used in the program are **SI (**System International Metric) units. The unit of any input value is marked next to the place you enter the data. The unit of every value in the report is also marked.

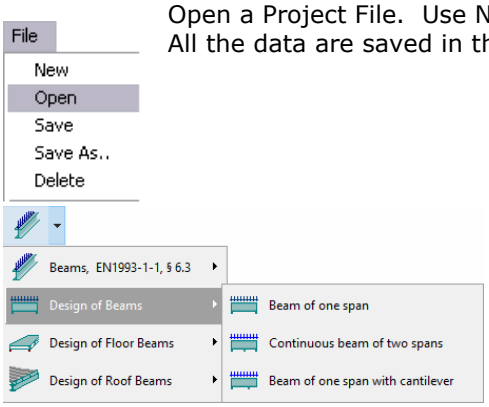
Units used in the program:
length [m] . and [mm]
forces [kN]
moments [kNm]
stresses [N/mm²] = [GPa]
concentrated loads [kN]
distributed loads [kN/m²]
line loads [kN/m]

2.7 Coordinate system





2.8 Step by step, program use

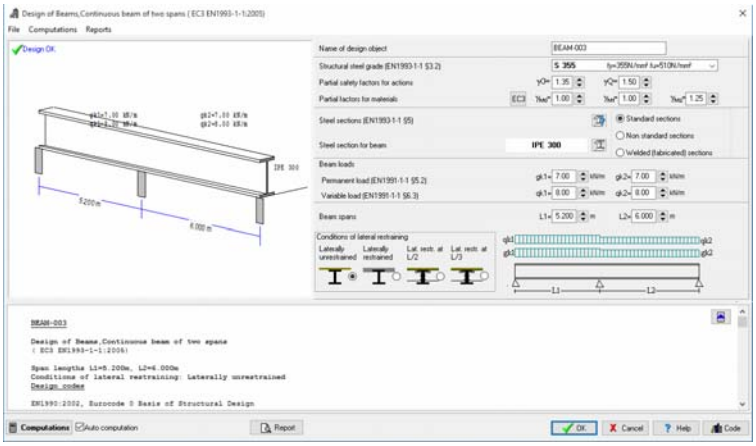


Open a Project File. Use New for new project and Open for an existing project file. All the data are saved in the same file. The data are saved automatically.

Create a new Design object, From the drop-down buttons on the top, automatically you enter the computation window for this object.
You may select an existing design object, from the [Design objects] window, and activate the computations by double clicking at the object, e.g. BEAM-001, or by clicking at .

In the window with the computations, enter the necessary data for the particular design object and click on

.
When the Auto-computation is checked, the calculations are performed automatically when you change the data.



Click to see more of calculations.

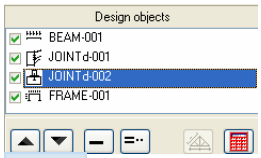
All the computations for the design object are performed.

A message appears if design is OK, the computations and the dimensions are adequate.

If the design has problems due to inadequate dimensions this message will appear.

Automatic generation of CAD drawings.

Preview report. From preview you can export the file to PDF or Word format.



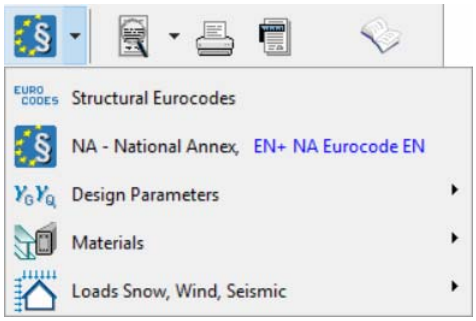
Select (check) the objects you want to include in the report. With the arrows you can adjust their order of appearance in the report. In the report only the objects checked in front will appear.

Report setup. Adjust the appearance of the report. You can adjust: font size, margins, captions and footnotes, line distances, character font, new page after each object printout, line thickness and paragraph indentation

Print the report

2.9 Parameters

Basic program parameters for materials, design parameters and regions for snow, wind and earthquake loading.

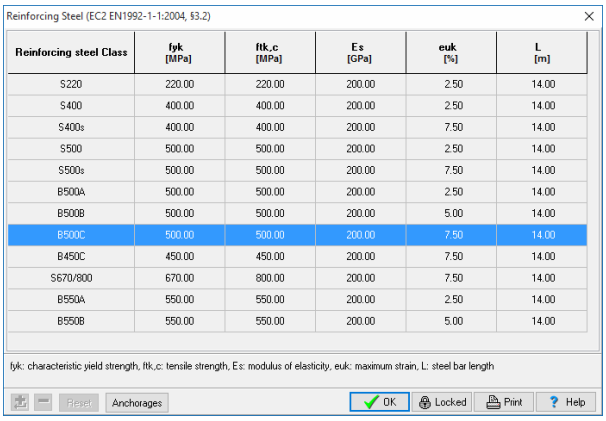


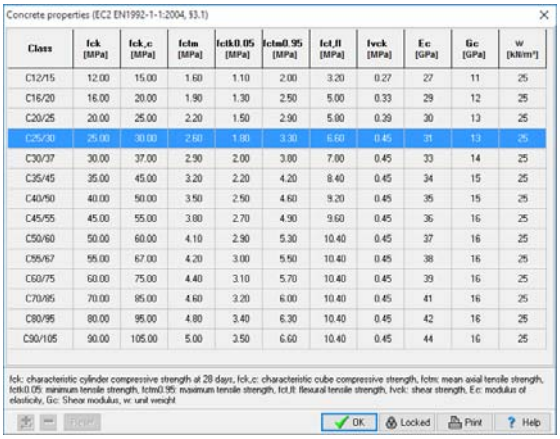
2.9.1 National Annex

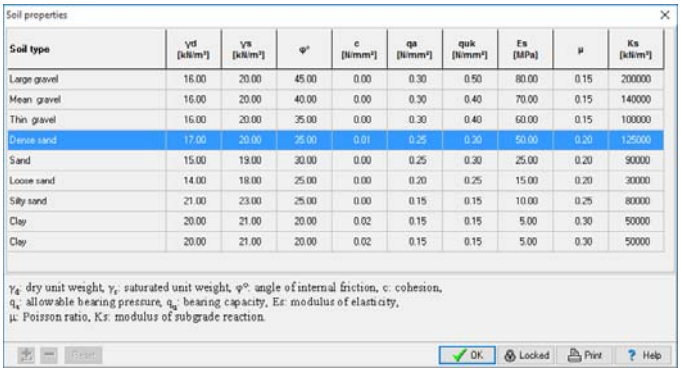
Select the National Annex of the country you want to work. To do this, first click [Locked] to unlock. The various design parameters (load factors, material factors etc..) are set according to the National annex. This does don affect the regions for snow, wind and earthquake, which have to be selected from the next menu lines of the parameter menu.

2.9.2 Materials

Structural steel, Concrete, Reinforcing steel and Soils for the foundation. You can change (edit) material properties.
In order to avoid accidental material changes the edit capabilities are locked. To edit, click first Locked to unlock the edit capabilities. With + − you add or delete lines from the property tables, with Reset the original program values are loaded.

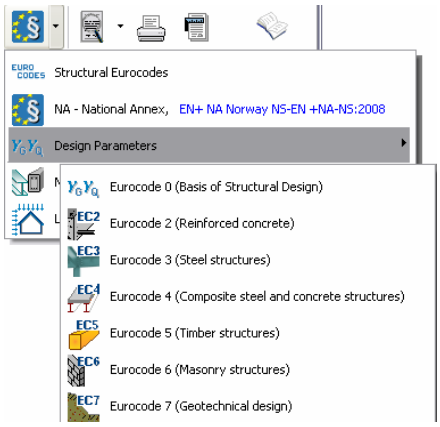






2.9.3 Design Parameters

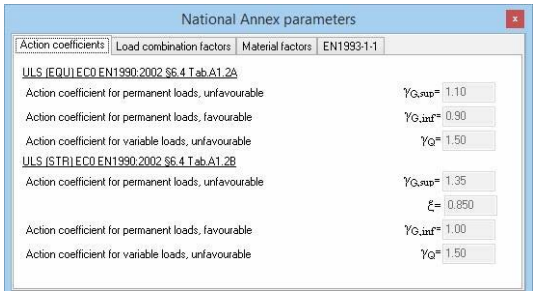
The National Annex parameters are set according to the National Annex you select. You may although want to change some of them, or specify some design considerations not mentioned in the national Annex.



NAD parameters

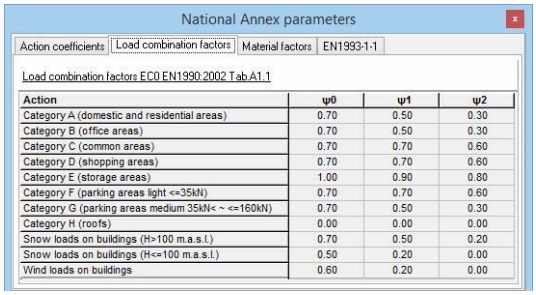
- **Action coefficients for Ultimate limit states EQU and STR**. According to Eurocode 0 Table A1.2A and Table A1.2B.

Click Reset to reset to National Annex values.



- **Load Combination coefficients** according to Eurocode0 Table A1.1.

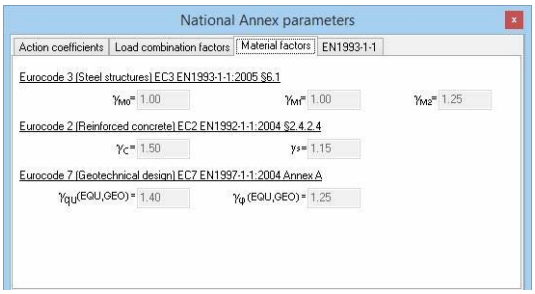
Click Reset to reset to National Annex values



- **Material factors for Steel** according to Eurocode 3 §6.1

- **Material factors for Reinforced concrete** according to Eurocode 2 §2.4.2.4., used for the reinforced concrete in the foundation.

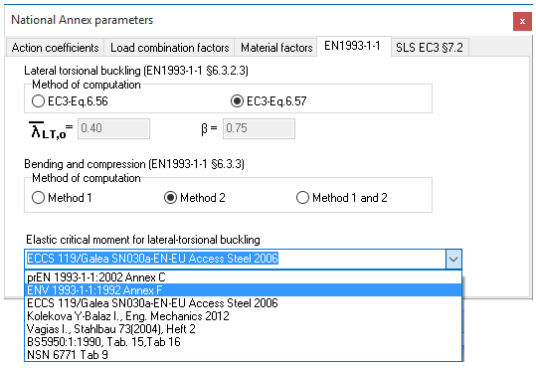
- **Material factors for Soil** according to Eurocode 7 Annex A. Used for the foundation design.

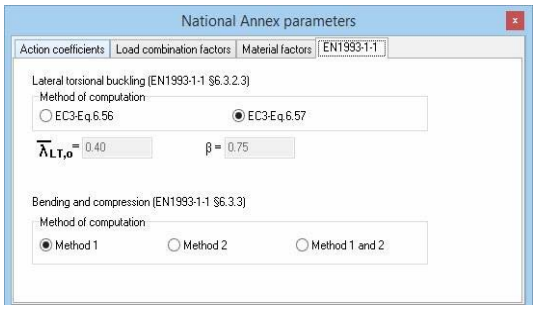


Eurocode 3, design parameters

Lateral torsional buckling computations base on Eurocode 3 Eq. 6.56, and Tables T 6.3, and T 6.4. (most common)
Lateral torsional buckling computations base on Eurocode 3 Eq. 6.57, and Table T 6.5.

Method for Bending and compression.
Method 1 Annex A or method 2 Annex B (most common)





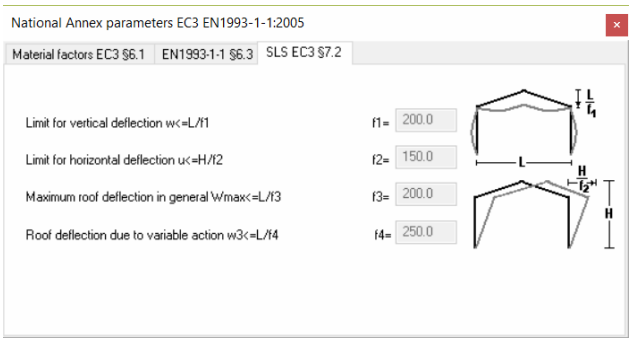
Critical elastic moment for lateral torsional buckling Mcr

The values of coefficients C1,C2,C3, for the evaluation of elastic critical moment Mcr can be found in literature. You may choose the source of definition of these parameters

- **prEN 1993-1-1:2002 Annex C** This is an intermediate publication of Eurocode 3 in 2002. After this the subject has been removed from Eurocode 3.
- **ENV 1993-1-1:1992 Annex F**
- **ECCS 119/Galea SN030a-EN-EU Access Steel 2006**
- **Kolekova Y-Balaz I. Engineering Mechanics 2012**
- **Vagias I., Stahlbau 73(2004), Heft 2**
- **BS5958:1:1990 tables 15 and 16**
- **NSN 6771 Table 9**

Deflection limits for Serviceability limit state (SLS)

The limits for these deflections are usually defined in the National Annex. EN1993-1-1 § 7.2 and EN 1990 Annex A1.4 According to EN1993-1-1 these limits may be specified for each project and agree with the client.
Usual values: vertical deflection L/200, horizontal deflection H/150, vertical deflection due to bending L/200.



Design parameters for buckling control

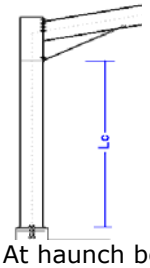
Columns

(1): (most reasonable default)

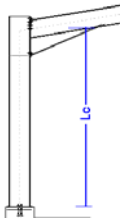
- In plane buckling, critical buckling length Lcr=system length points of axis.
- Out of plane buckling and torsional buckling and lateral torsional buckling, critical buckling Lcr the column height up to the haunch, or the distance of lateral restrains Lm1, if is specified smaller than the column length.

(2): (conservatively)

- In plane buckling Lcr=system length points of axis.
- Out of plane buckling and torsional buckling and lateral torsional buckling, Lcr the system length or the distance of lateral restrains Lm1.



At haunch bottom



At system length

Rafters

(1) (most reasonable default)

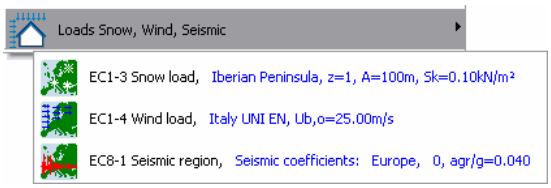
- In plane buckling Lcr = system length. This s computed from the total span L and the first buckling mode.
- Lateral buckling length at span the purlin space, torsional buckling the distance between torsional restraints Lm2

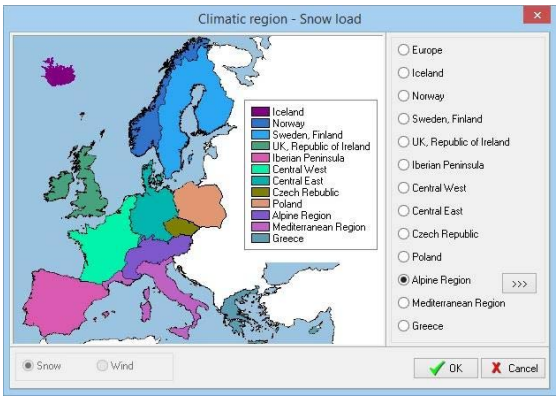
(2) (conservatively)

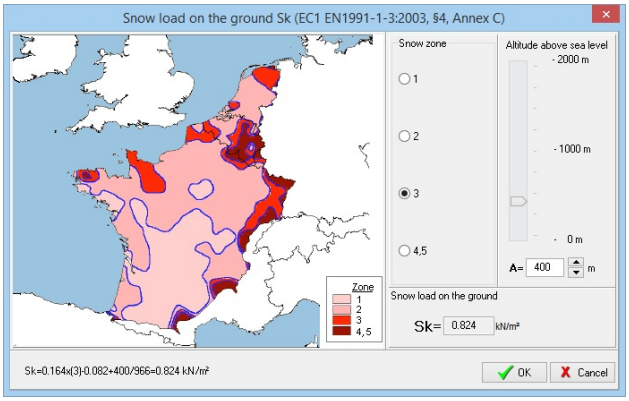
- In plane buckling Lcr=system length
- Lateral and torsional buckling length, the distance between torsional restraints Lm2.

2.9.4 Snow load on the ground

Default region and snow zone.
Click and select the snow region of your area. The snow zone and the amplitude, and the characteristic snow load value on the ground sk is set according to Eurocode EN1991-1-3:2003.

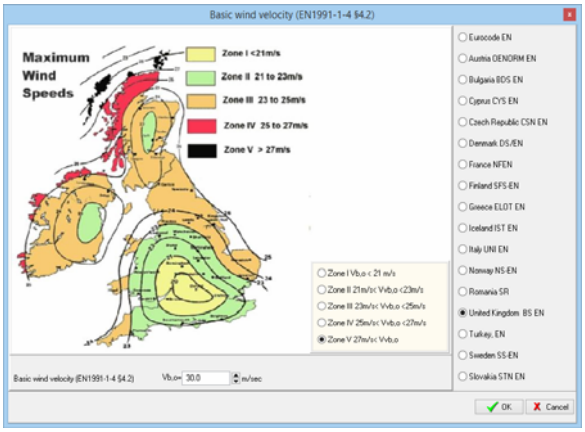






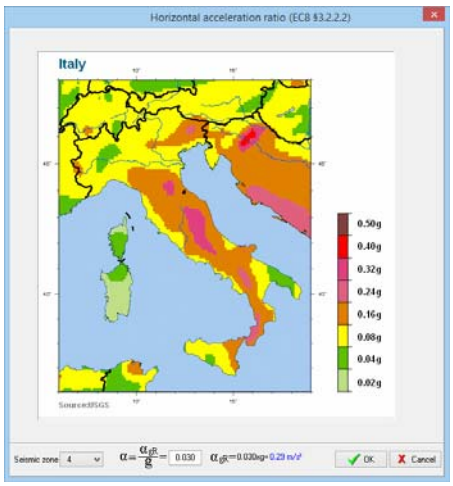
2.9.5 Basic wind velocity

Select wind region and wind zone. The default basic wind velocity is set.



2.9.6 Seismic zone

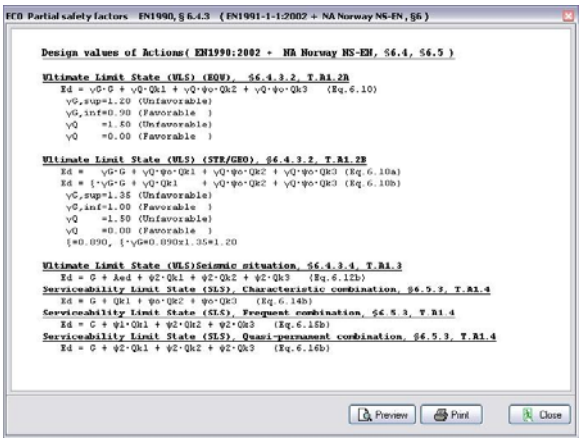
Default seismic region and seismic zone. The ground acceleration $\alpha=\alpha_{gr}/g$ is set.



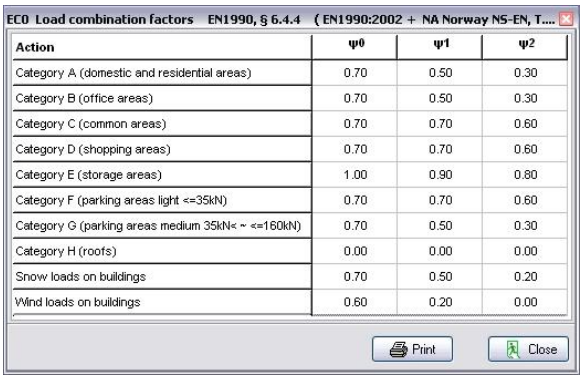
3 Eurocode 0, Basis of structural design

EN 1990:2002/A1:2005/AC:2010

A source for all the partial factors , load combination factors, and material factors.

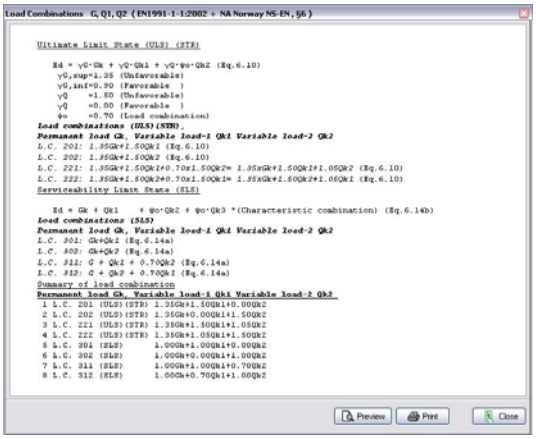


Partial safety factors



Action	ψ0	ψ1	ψ2
Category A (domestic and residential areas)	0.70	0.50	0.30
Category B (office areas)	0.70	0.50	0.30
Category C (common areas)	0.70	0.70	0.60
Category D (shopping areas)	0.70	0.70	0.60
Category E (storage areas)	1.00	0.90	0.80
Category F (parking areas light <=35kN)	0.70	0.70	0.60
Category G (parking areas medium 35kN< ~ <=160kN)	0.70	0.50	0.30
Category H (roofs)	0.00	0.00	0.00
Snow loads on buildings	0.70	0.50	0.20
Wind loads on buildings	0.60	0.20	0.00

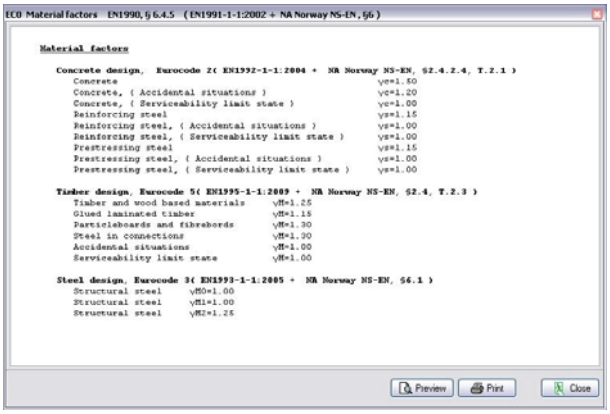
Load combination factors



Material factors

Load combinations

You obtain the complete list of load combinations for various structural load cases.

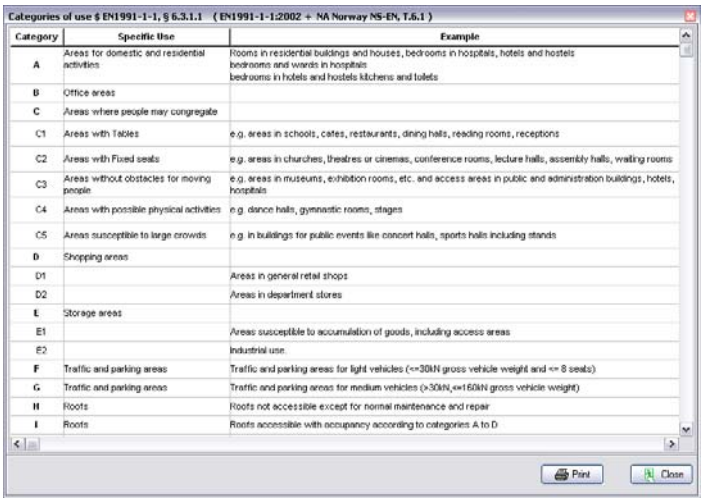


4 Eurocode 1, Actions on structures

EN 1991-1-1 General Actions
Categories of use of buildings
Imposed loads
EN 1991-1-3 Snow load
EN 1991-1-4 Wind load
EN 1991-1-1:2002/AC:2009
Eurocode 1: Actions on structures - Part 1-1: General actions - Densities, self-weight, imposed loads for buildings
EN 1991-1-3:2003/AC:2009
Eurocode 1 - Actions on structures - Part 1-3: General actions - Snow loads
EN 1991-1-4:2005/A1:2010
Eurocode 1: Actions on structures - Part 1-4: General actions - Wind actions
EN 1991-1-4:2005/AC:2010
Eurocode 1: Actions on structures - Part 1-4: General actions - Wind actions

4.1 General Actions

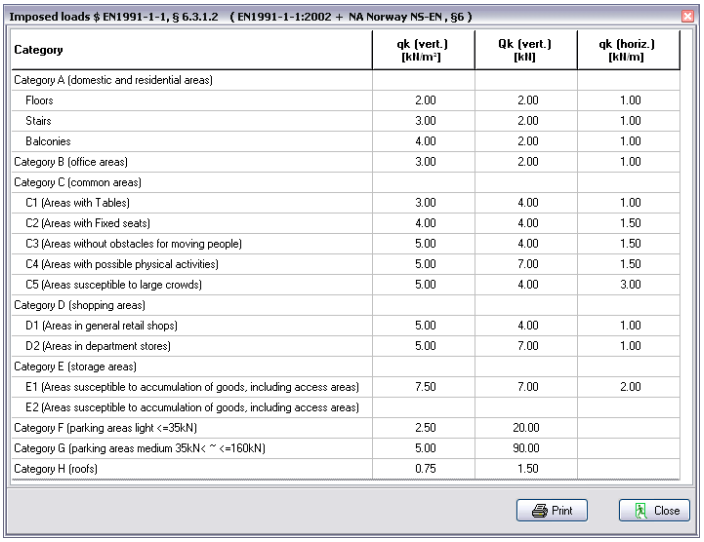
4.1.1 Categories of use of buildings


Categories of use § EN1991-1-1, § 6.3.1.1 (EN1991-1-1:2002 + NA Norway NS-EN, T.6.1)

Category	Specific Use	Example
A	Areas for domestic and residential activities	Rooms in residential buildings and houses, bedrooms in hospitals, hotels and hostels bedrooms and wards in hospitals bedrooms in hotels and hostels kitchens and toilets
B	Office areas	
C	Areas where people may congregate	
C1	Areas with Tables	e.g. areas in schools, cafes, restaurants, dining halls, reading rooms, receptions
C2	Areas with Fixed seats	e.g. areas in churches, theatres or cinemas, conference rooms, lecture halls, assembly halls, waiting rooms
C3	Areas without obstacles for moving people	e.g. areas in museums, exhibition rooms, etc. and access areas in public and administration buildings, hotels, hospitals
C4	Areas with possible physical activities	e.g. dance halls, gymnastic rooms, stages
C5	Areas susceptible to large crowds	e.g. in buildings for public events like concert halls, sports halls including stands
D	Shopping areas	
D1		Areas in general retail shops
D2		Areas in department stores
E	Storage areas	
E1		Areas susceptible to accumulation of goods, including access areas
E2		Industrial use.
F	Traffic and parking areas	Traffic and parking areas for light vehicles (<=30kN gross vehicle weight and <= 8 seats)
G	Traffic and parking areas	Traffic and parking areas for medium vehicles (>30kN,<=160kN gross vehicle weight)
H	Roofs	Roofs not accessible except for normal maintenance and repair
I	Roofs	Roofs accessible with occupancy according to categories A to D

Print Close

4.1.2 Imposed loads


Imposed loads § EN1991-1-1, § 6.3.1.2 (EN1991-1-1:2002 + NA Norway NS-EN , §6)

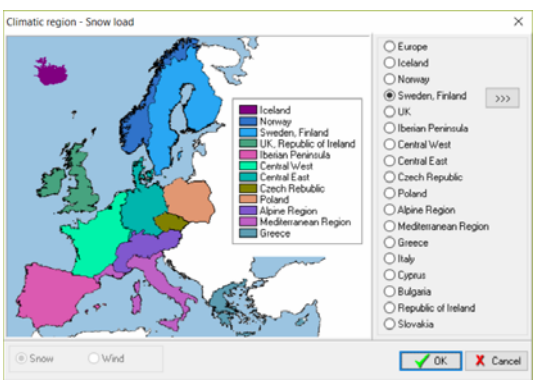
Category	qk (vert.) [kN/m²]	Qk (vert.) [kN]	qk (horiz.) [kN/m]
Category A (domestic and residential areas)			
Floors	2.00	2.00	1.00
Stairs	3.00	2.00	1.00
Balconies	4.00	2.00	1.00
Category B (office areas)	3.00	2.00	1.00
Category C (common areas)			
C1 (Areas with Tables)	3.00	4.00	1.00
C2 (Areas with Fixed seats)	4.00	4.00	1.50
C3 (Areas without obstacles for moving people)	5.00	4.00	1.50
C4 (Areas with possible physical activities)	5.00	7.00	1.50
C5 (Areas susceptible to large crowds)	5.00	4.00	3.00
Category D (shopping areas)			
D1 (Areas in general retail shops)	5.00	4.00	1.00
D2 (Areas in department stores)	5.00	7.00	1.00
Category E (storage areas)			
E1 (Areas susceptible to accumulation of goods, including access areas)	7.50	7.00	2.00
E2 (Areas susceptible to accumulation of goods, including access areas)			
Category F (parking areas light <=35kN)	2.50	20.00	
Category G (parking areas medium 35kN< ~ <=160kN)	5.00	90.00	
Category H (roofs)	0.75	1.50	

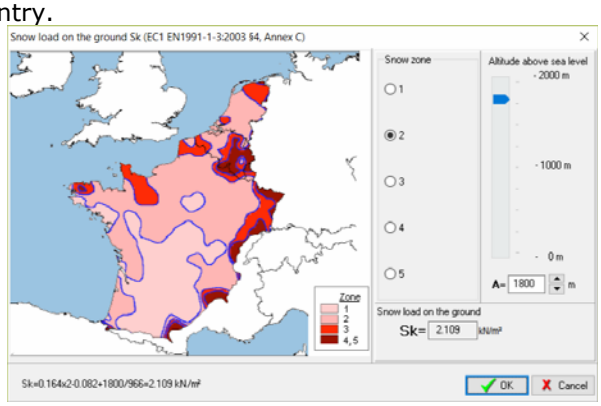
Print Close

4.2 Snow loads

4.2.1 Snow load on the ground

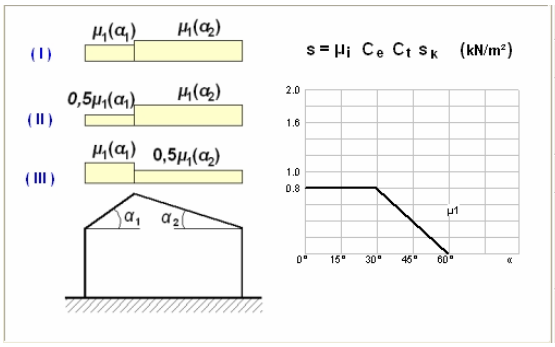
Click and select the snow region of your area. The snow zone and the amplitude, and the characteristic snow load value on the ground sk is set according to Eurocode EN1991-1-3:2003. and the National Annex of the country.

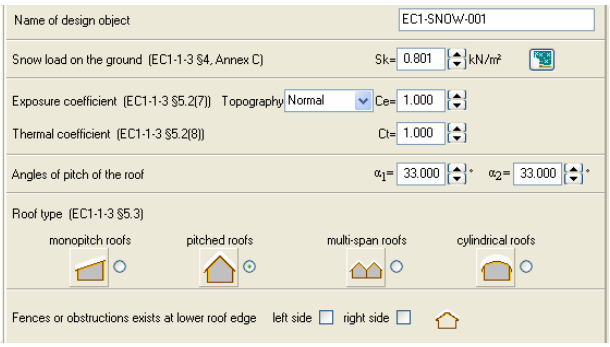




Default region and snow zone.

4.2.2 Snow load on roofs

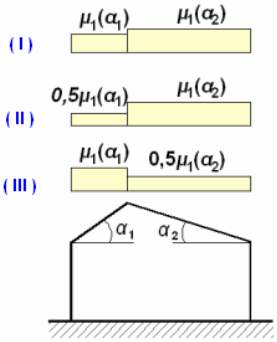




Select the type of the roof, monopitch, pitched, multi span or cylindrical.
The roof angle of pitch, or other dimensions.
From the topography, windswept, normal or sheltered roof, the exposure coefficient is set (usually 1.0).
Set the temperature coefficient (usually 1.00)

The snow load is computed according to Eurocode 1-3 EN1991-3:2003, from the characteristic snow load on the ground and the roof slope.

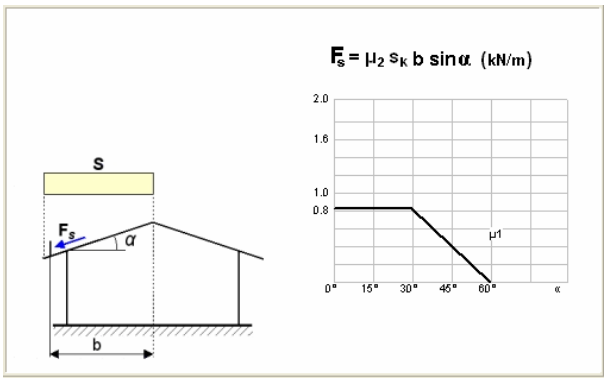
$s=\mu_i C_e C_t s_k$ (EN1991-3:2003 §5.2) [kN/m²]

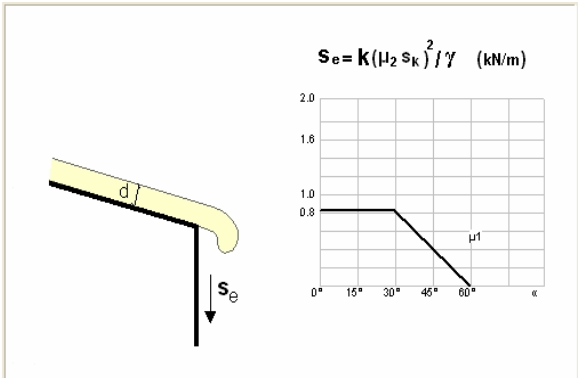


The three characteristic load arrangements of EN1991-3:2003 §5.3.3 are considered in the load cases. If the roof is flat (α=0°) one load arrangement is considered s= 0.80 C_e C_t s_k.
The characteristic snow load on the ground s_k can be defined directly by selecting the snow region, snow zone and the altitude, according to EN1991-3:20 Annex C.

The snow load arrangements according to Eurocode 1-3 are
Flat roofs. Load case (I)
Pitched roofs Load cases (I) (II) III)

4.2.3 Snow load on Snowguards and snow overhanging the edge of a roof



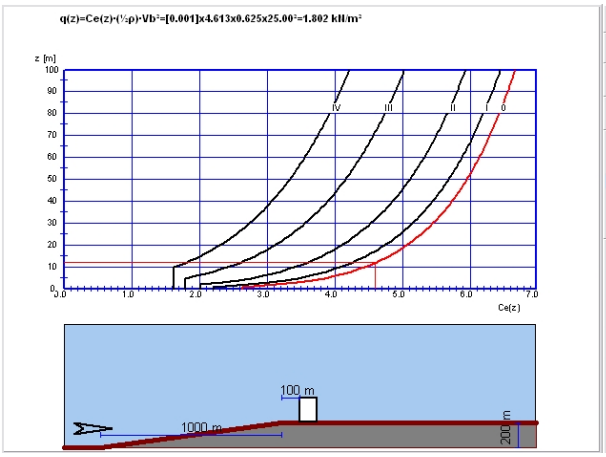


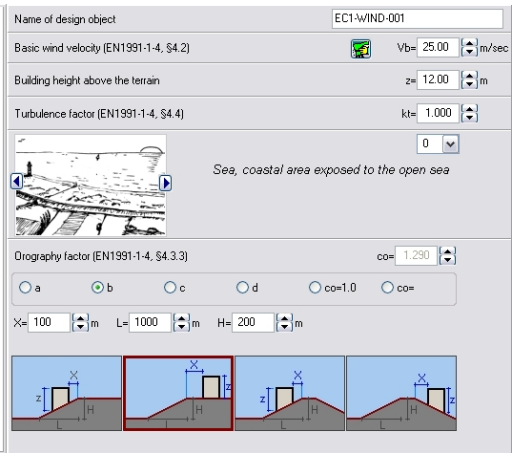
4.3 Wind load

4.3.1 Wind peak pressure

Wind pressure on vertical surface in kN/m2. The wind pressure is computed from the wind velocity and the topography of the region according to Eurocode 1-4:2005.

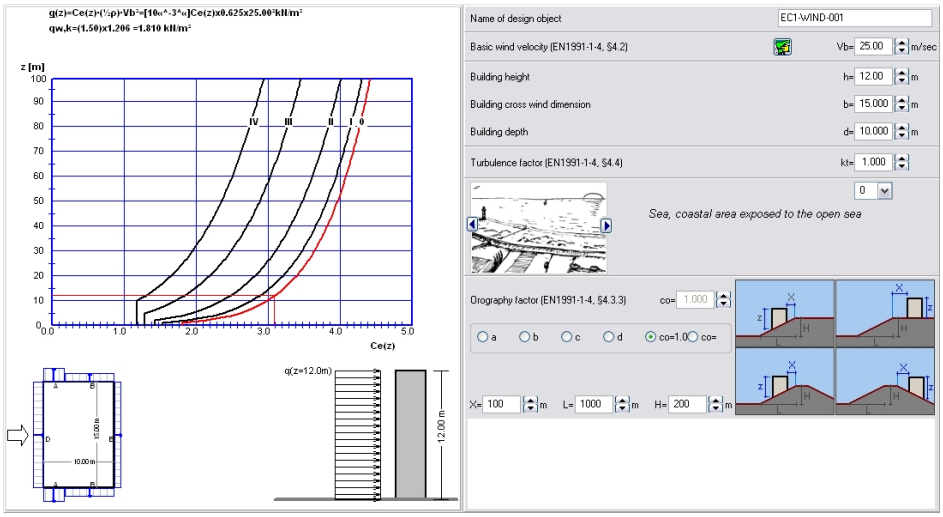
Set wind velocity. Click at to set wind velocity from the wind zones and amplitude of the region.
Select the terrain type (0 to IV).
Define oreography factor by selecting the type of terrain a,b,c,or d, and setting the distances X, L and H according to the drawings. You may select co=1, for orography factor 1.0 or co= and you specify freely any value you want.





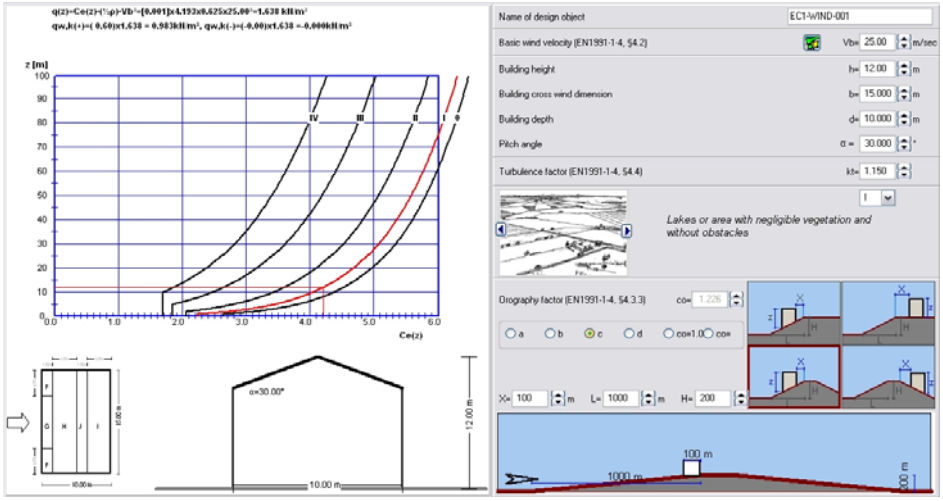
4.3.2 Wind load on vertical walls

The wind pressure in front and back of the wall are computed according to Eurocode 1-4:2005 §7.2.5 and Tab 7.4a and Tab. 7.1, The horizontal load and overturning moment on the wall are evaluated.



4.3.3 Wind load on roofs

The wind load is computed for various places at the roof according to Eurocode 1-4:2005 §7.2.5 and Tab 7.4a and Tab. 7.1. for flat roofs monopitched and duopitched roofs. The total wind forces on the roof and total moments of the wind forces around the roof edge are computed.



5 Eurocode 2 , Reinforced concrete design

Design charts for Reinforced concrete
Material properties, creep, shrinkage
Capacity of cross-sections in bending, shear and axial loading.
Design charts for Kd , med ω,.
Interaction diagrams, biaxial bending and compression charts.
Effective length
Deflection control

Solid and ribbed slabs

- slab sections (solid, ribbed, flat, light weight)
- one-way continuous slabs
- two-way slabs
- cantilever slabs

Beams of rectangular or T section

- beam sections in bending shear and torsion, light weight concrete
- one span in composite loading
- continuous beams in uniformly distributed loading

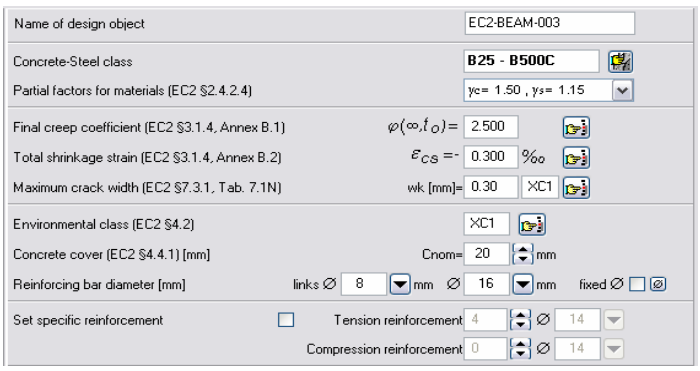
Columns

- column sections in biaxial bending
- isolated columns in single bending
- isolated columns in double bending
- section capacity

5.1 General input data for concrete components

Most of the concrete design objects have some basic common data as follows:

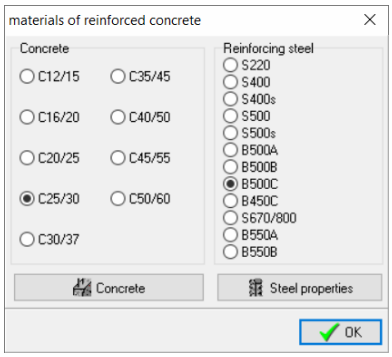
- Name of design object
- Concrete and reinforcing steel class
- Partial safety factors for actions
- Environmental class
- Load combination coefficients for variable actions
- Concrete cover
- Reinforcing bar diameter
- Final creep coefficient
- Total shrinkage strain
- Include rebar schedule in report
- Set specific reinforcement



5.1.1 Name of design object

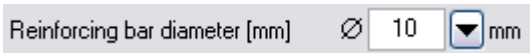
Every design object has a name that appears in the report. In the creation of each object the program assigns a default name e.g. slab-001, Beam-002 etc., which may be changed any time. (names up to 16 characters long). Design objects must have different names.

5.1.2 Concrete-Steel Class

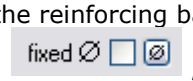


Concrete and steel classes used in the calculations of the design object. When a design object is created the concrete and steel classes are set automatically to the default values. The default values for the program are set from [Parameters/Concrete and Steel class].

5.1.3 Reinforcing bar diameter

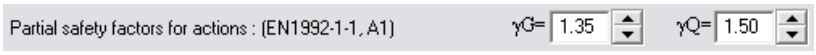


You specify the reinforcing bar diameter used in the design of the concrete object.

If you check 

, then only the selected bar diameter will be used in the design of the concrete element. If you do not check next to the bar diameter, the reinforcing bar diameter which is going to be selected in the design, is going to be a bar diameter, resulting in economical reinforcement. If the selected diameter although is outside the limits (minimum and maximum rebar diameter) is not going to be used. The lower and upper limits of rebar diameters for the concrete objects are specified in [Parameters/parameters for reinforcing concrete], [Parameters/Parameters of footings], [Parameters/Parameters of retaining walls].
The initial values for the reinforcing bar diameter, when a design object is created, are the ones specified in the [Parameters/Reinforced Concrete]. The rebar diameter for beam stirrup reinforcement is defined in [Parameters/Reinforced Concrete].
To select other bar diameter, click the arrow and choose from the standard diameters for reinforcing bars.

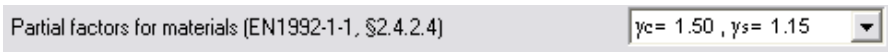
5.1.4 Partial safety factors for actions (Eurocode 0, Annex A1)



Factors for the combination of permanent and variable actions, Eurocode 0 Annex A 1.
Usual values defined in Eurocodes for these factors are **γG=1.35**, and **γQ=1.50**
The design values for actions are combined as:

$$\sum \gamma_{G,j}\, G_{k,j} + \gamma_{Q,1}\, Q_{k,1} + \sum \gamma_{Q,i}\, \psi_{Q,i}\, Q_{ki}$$

5.1.5 Partial safety factors for materials (Eurocode 2 §2.4.2.4 Table 2.1.N)



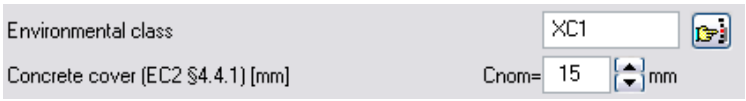
Factors to take account for the differences between the strength of test specimens of the structural material and their strength in situ. (Eurocode 2 §2.4.2.4 Table 2.1.N)

The design strength of the materials is **fd=fk/γm** where **γm** is the material factor, **γc** for concrete, and **γs** for reinforcing steel.

Table 2.1N

Design situations	γ_c concrete	γ_s reinforcing steel	γ_s prestressing steel
Persistent & Transient	1,5	1,15	1,15
Accidental	1,2	1,0	1,0

5.1.6 Concrete cover (Eurocode 2 §4.4.1.2)



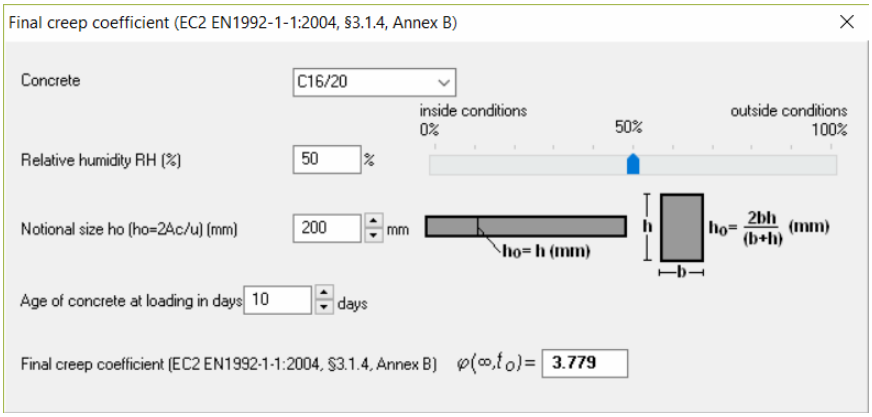
By clicking at you can select concrete cover from the environmental conditions according to table 4.3N and 4.4N

Concrete cover **Cnom** is the distance between the outer surface of the reinforcement and the nearest concrete surface. Minimum required concrete cover depending on the environmental conditions is given in Eurocode 2 §4.4.1.2.

In general: The minimum cover for dry environment and for interior of buildings is 15 mm, for humid environment without frost 20 mm, and for humid environment with frost 25 mm. For more severe environment as humid environment with frost and de-icing salts, or seawater environment.

5.1.7 Creep and shrinkage coefficient

The final creep coefficient is used in the calculations of deflections and crack control in Serviceability limit states (SLS). You can compute the creep coefficient from the environmental parameters and the sizes of the cross sections according to EN 1992-1-1:2004, par 3.1.4. and Annex B.



5.1.8 Include rebar schedule in report.

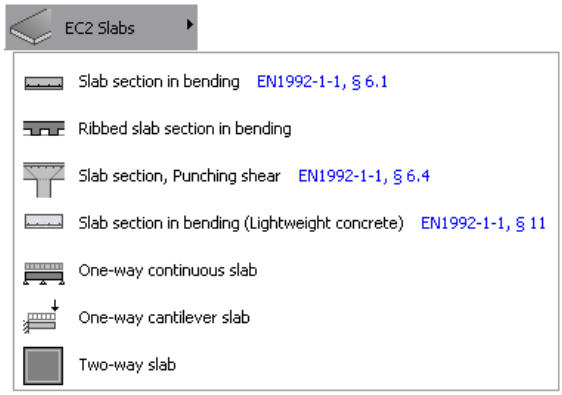
If checked, the corresponding rebar schedule is included in the end of the report of each concrete object.

5.1.9 Set specific reinforcement

In all the design objects (plates, beams, columns, fundaments, retaining walls) you can specify the desired reinforcement.

If [Set specific reinforcement] is Not checked (default), the program computes the necessary reinforcement in ULS. Then checks with this reinforcement the defections and crack width in SLS is performed. If it is not enough, a warning shows in red.
If you check [Set specific reinforcement], you can specify more reinforcement. This is the reinforcement to be used in SLS checks and reinforcement schedules.

5.2 Concrete slabs

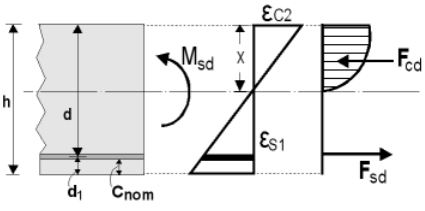


Dimensioning of concrete slabs of **solid**, **ribbed** cross sections or cross sections of **flat slabs**. You can design two-way slabs, or one-way multiple span concrete slabs. Full code check, according to Eurocode 2, is performed. A detailed report with all the computations, graphs, and code references is produced. The reinforcing bars are automatically placed in the reinforcing bar schedules.
The design actions are obtained with combination of permanent and variable actions $\gamma G\ Gk + \gamma Q\ Qk$, (Eurocode 0, EN 1990:2002).
The flexural reinforcement is computed according to Eurocode 2 § 6.1, in ultimate limit state (ULS) for bending.
The crack and deflection are calculated according to Eurocode 2 §7.3, §7.4 requirement in serviceability limit state (SLS).
The reinforcing steel detailing and minimum requirements are according to Eurocode 2 §8, §9.3.

You specify the desired diameter for flexural reinforcement, and the spacing and number of reinforcing bars are obtained. You may check to use specific reinforcement diameter or the program optimises the reinforcement around the desired diameter. The reinforcing bars are automatically placed in the reinforcing bar schedules. The default diameter for longitudinal reinforcement is defined in [Parameters/Reinforced Concrete/Plates].

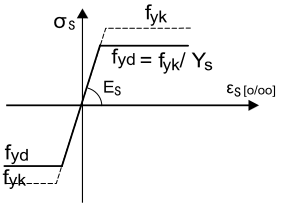
You can design the following slabs:
Slab sections. Design of slab section of solid or ribbed type subjected to a bending moment. Sections of flat slabs in punching shear, and sections of solid light weight concrete.
Two-way slabs. The type of each edge support (simply supported or fixed), can be specified for each slab side. Linear elastic theories are used for the computation of bending moments. Marcus method, or tables by Czerny or Bares of linear analysis are used for the computation of the bending moments.
One-way multiple span slab. Design of one-way continuous slabs up to 8 spans with optional end cantilevers, and uniform load with dead and live components on the spans. The lengths, the slab height and the loading may be specified for every span. The static solution is performed with finite element analysis taking into account the most unfavourable placing of live loads on the spans in order to obtain the maximum or minimum design values for bending moments. The support moments are computed at the faces of the supports. The design moments can be modified by a moment redistribution, Eurocode 2 §5.5, if the percentage of moment redistribution is specified >0. A load factor <=1.00 can be specified for each span to introduce the load distribution in continuous 2-way slabs.
Cantilever slabs. Design of cantilever slabs of variable thickness. Uniformly distributed dead and live loads and concentrated line loads (dead and live) at the free end, can be specified.

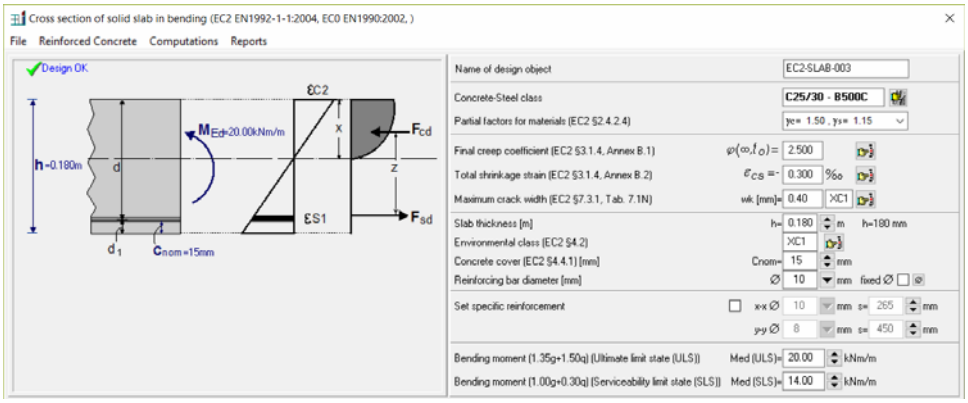
5.2.1 Slabs section design



Design of slab section, of solid or ribbed type, subjected to a bending moment.
Ultimate Limit state for bending, Eurocode 2 §6.1.
Basic principles:

- Plane sections remain plain
- The strain in bonded reinforcement is the same as the surrounding concrete.
- The tensile strength of concrete is ignored.
- The stress-strain diagram for concrete and steel is as in the figures below.

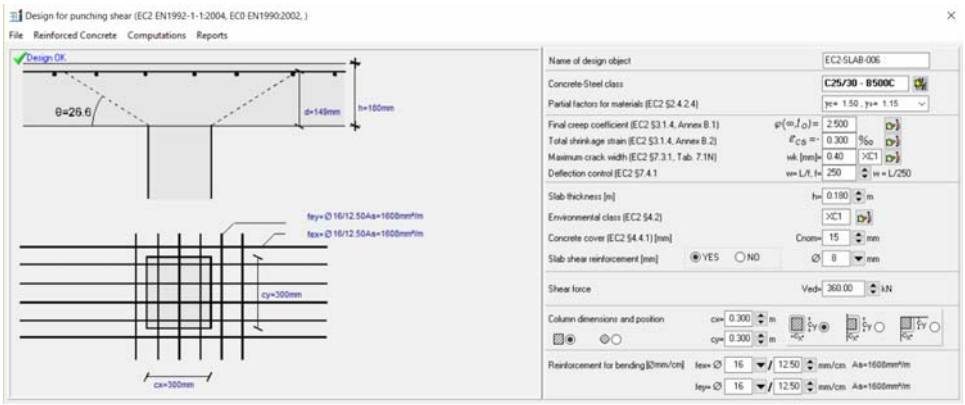




Slab thickness h in meters [m]. The minimum slab thickness according to Eurocode 2 §5.3.1 for solid slabs is 50 mm.

5.2.2 Flat slab, Punching shear

Design of slab section in punching shear according to Eurocode 2 § 6.4. Verification of the shear capacity at the control perimeters around a rectangular column. If the design shear v_{Ed} exceeds the shear capacity $v_{Rd,c}$ the program computes the necessary shear (links) reinforcement.



Input values

- Shear force V_{Ed} on the column face.
- Longitudinal reinforcement over the column in x and y directions.
- Specify with *Yes* or *No* if you want to use shear reinforcement.
  If Yes, then the appropriate shear reinforcement will be computed if the shear force $\beta V_{Ed} > V_{Rd,c}$.
- Column dimensions.
- Column position (internal, edge or corner).

Punching shear reinforcement

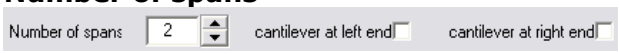
The selected diameter for the reinforcement is used. If it is not enough, a higher reinforcement diameter is selected.
For shear reinforcement the minimum number of perimeters is 3.
The radial spacing of links does not exceed 0.75d.
The tangential spacing of links does not exceed 1.5d within the 2d distance of the column face.

The first shear perimeter is at distance <0.35d of the column face.
The last perimeter is at distance 1.5d inside the outer perimeter where shear reinforcement is no longer required, Eurocode 2 Eq. 6.54 and Fig. 6.22

5.2.3 One-way multiple span slabs (up to 4 spans)

Design of one-way continuous slabs up to 4 spans with optional end cantilevers, and uniform dead and live loading on the spans. The slabs may have solid or ribbed cross section. The span length, the slab height and the loading can be specified for every span. Cantilevers at the left and right end can be specified. The loads are multiplied by a load factor k (default value 1.00). This factor is used for the load distribution when two dimensional in plane solution of a slab system is performed. On the right window you specify slab thickness, span length, and loads and by pressing the set button you set these values for all the spans. On the left window you can change values for each span.
Full code check, according to Eurocode 2, is performed. A detailed report with all the computations, graphs, and code references is produced. The reinforcing bars are automatically placed in the reinforcing bar schedules.
The design actions are obtained with combination of permanent and variable actions as in EN 1990:2002 (**γG Gk +γQ Qk)**. They are analysed as continuous beams with rectangular cross section of width 1.00 m. The static solution is performed with finite element analysis taking into account the most unfavourable live load placing on the spans in order to obtain the maximum or minimum design values for the bending moments.
The support moments are computed at the faces of the supports. The design moments are redistributed (EC2 §5.5), if the percentage of moment redistribution is specified >0. In the moment redistribution the negative support moments, calculated using linear elastic analysis, are reduced by the ratio of moment redistribution, with a corresponding increase of the positive span moments, such as the resulting moments along the plate remain in equilibrium.
The flexural reinforcement is computed according to Eurocode 2, §6.1, in ultimate limit state for bending. The crack and deflection are calculated according to Eurocode 2 §7.3, §7.4 requirement in serviceability limit state (SLS). The reinforcing steel detailing and minimum requirements, are according to Eurocode 2 §8, §9.3.
You specify the desired diameter for flexural reinforcement, and the spacing and number of reinforcing bars is obtained. You may check to use specific reinforcement diameter or the program optimises the reinforcement around the desired diameter. The reinforcing bars are automatically placed in the reinforcing bar schedules. The default diameter for longitudinal reinforcement is defined in [Parameters/Reinforced Concrete/Plates].

Number of spans



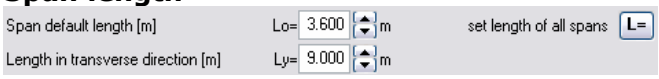
You specify the number of spans of the continuous slab. By checking cantilever at left or cantilever at right, you specify the existence of cantilevers at the left or the right end.
The spans are automatically created with the default length Lo, the default thickness ho, and the default loads g and q. From the left window you may change these values for span length L, thickness h, and loads g and q.

Slab thickness

Slab thickness ho, in meters [m], is the default slab thickness of the spans. Clicking at

the thickness at all spans is set to the default value. To set the thickness for each span click and edit the corresponding cells at the left window under the beam sketch.

Span length



Slab length Lo in meters [m], is the default span length. Clicking at

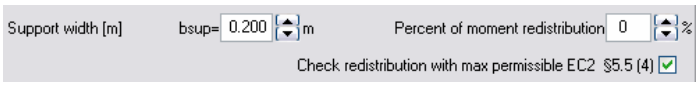
the span length is set to the default value at all the spans. At the cantilevers (if they exist) the span length is set to (1/4) of the default value. To set the span length for each span click and edit the corresponding cell at the left window under the beam sketch.

Loads

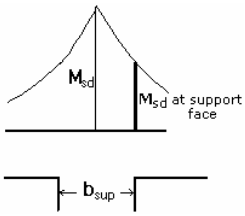
Default loads in [kN/m²], **g1** for the dead load of the slab finishing, and q for the live load on the slab. From the left window under the slab sketch, you may change these default values for every span. The total dead load is computed by the program as g=(g1+self weight).

By clicking at g,q= you set the values for the loads at all the spans to the default values.
The loads are multiply by a load factor k (default value 1.00), when two dimensional in plane solution of a slab system is performed. The design actions are obtained with combination of permanent and variable actions as in Eurocode EN 1990:2002, **γG Gk +γQ Qk).**
Load factor K. The loads are multiplied by a load factor k (default value 1.00). This factor is used for the load distribution when two dimensional in plane solution of a slab system is performed.

Percent of moment redistribution



The support moments, in continuous slab, calculated using linear elastic analysis, are reduced by the ratio of **moment redistribution**, with a corresponding increase of the span moments, such as the resulting moments remain in equilibrium (Eurocode 2, §5.5). The ratio of redistributed moment, to the moment before redistribution, is defined by the user in percent (%).



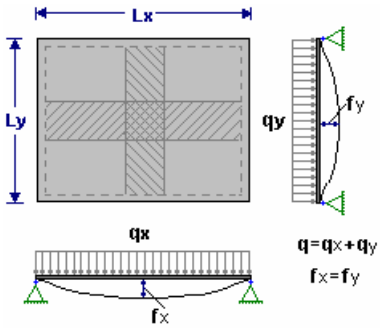
Support width

Mean support width in meters (m). The design support moments, for the computation of the reinforcement over the supports, are computed at the support faces at a distance b=bsup/2 from the axis of the support.

5.2.4 Two-way slabs

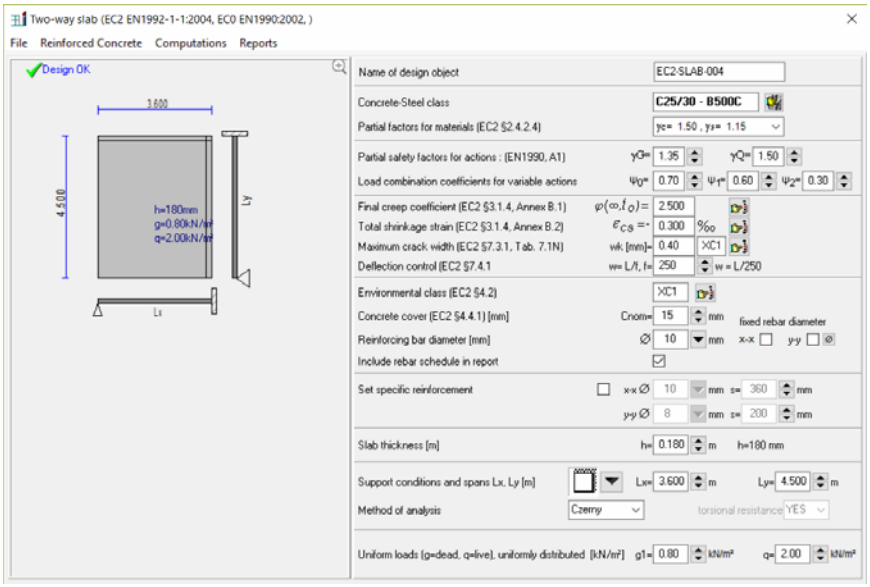
Linear elastic theories are used for the computation of bending moments.
The design methodology for computing the bending moments is:

Tables of Czerny Czerny F., Tafeln fur vierseitig und dreiseitig gelagerte Rechteckplatten , Beton Kalender 1983, Berlin, Ernst Sohn, 1983
the values for bending moments are mx=q.Lx²/TV mx=q.Lx²/TV
for shear forces are vx:=±q.Lx/TV vx:=±q.Lx/TV
TV are coefficients obtained from tables for various Lx/Ly ratios and support conditions.
Tables of Bares Bares R., Tables for the Analysis of Plates, Slabs and Diaphragms Based on the Elastic Theory, Bauverlag GmbH., Wiesbaden und Berlin 1971
the values for bending moments are mx=q.Lx².TV, my=q.Ly².TV
for shear forces are vx:=±q.Lx.TV vx:=±q.Lx.TV
TV are coefficients obtained from tables for various Lx/Ly ratios and support conditions

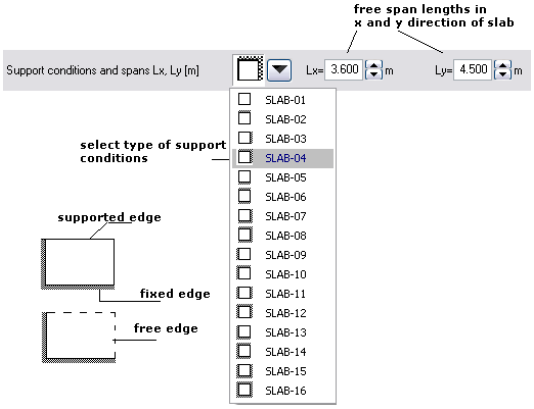


Marcus method of analysis. Marcus H., "*Die vereinfachte Barechnung biegsamer Platten*", 2nd ed., Springer-verlag, Berlin, 1929.
The method is based on two orthogonal strips of unit width at midspans having equal deflections in the middle. From this the total slab load **q** is split into two parts, in the two main directions, **qx=kq** and **qy=(1-k)q**. This simplified model does not take into account the transverse shear forces along the sides of the plate strips. These shear forces, caused by the continuity between individual plate strips produce torsional resistance, which reduces the deflections of the strips. The effect of torsional resistance of the plate in reducing the span moments, is taken care with additional approximate formulas introduced by Marcus.
The two directions x-x and y-y of the slab are designed separately. The direction with the maximum bending moment defines the lower reinforcement layer. Full code check, according to Eurocode 2, is performed. The reinforcing bars are automatically placed in the reinforcing bar schedules. The design actions are obtained by the combination of permanent and variable actions as in Eurocode 0, EN 1990:2002 (**γG Gk +γQ Qk).**
The flexural reinforcement is computed according to Eurocode 2 §6.1, in ultimate limit state for bending. The crack and deflection are calculated according to Eurocode 2 §7.3, §7.4 requirement in serviceability limit state (SLS). The reinforcing steel detailing and minimum requirements are according to Eurocode 2 §8, §9.3.

You specify the desired diameter for flexural reinforcement, and the spacing and number of reinforcing bars are obtained. You can check to use specific reinforcement diameter or the program optimise the reinforcement around the desired diameter. The reinforcing bars are automatically placed in the reinforcing bar schedules. The default diameter for longitudinal reinforcement is defined in [Parameters/Reinforced Concrete/Plates].

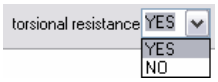


Support conditions



Torsional resistance

Specify to take into account or not the reduction of span moments due to the torsional resistance of the plate when you use Marcus method of analysis.



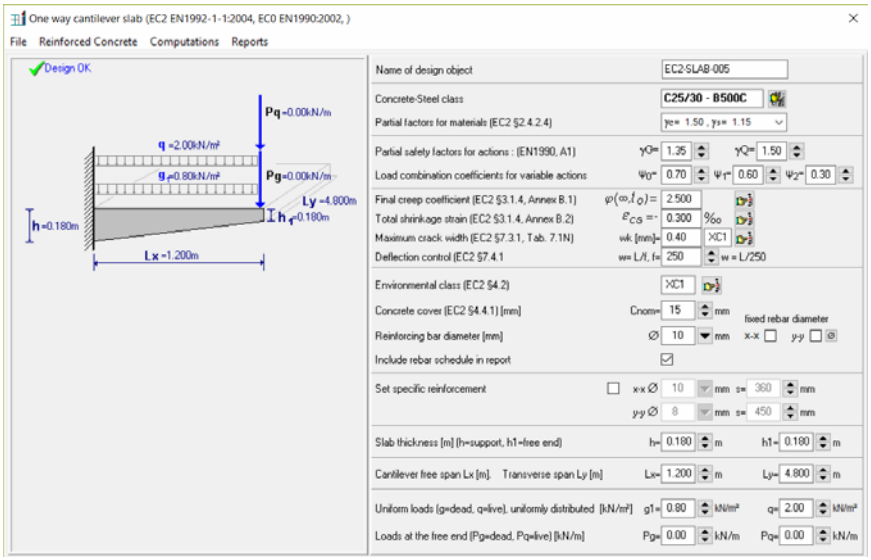
Loads

Loads in [kN/m²]. g1 for the dead load of the slab finishing, and q for the live load on the slab. The design actions are obtained with combination of permanent and variable actions as in Eurocode 2 EN 1990:2002, **γG Gk +γQ Qk.** The total dead load is computed by the program as g=(g1+self weight).

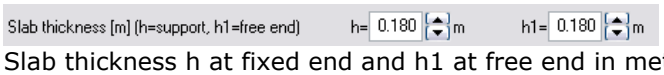
5.2.5 Cantilever slabs

Design of cantilever slabs of variable thickness. You can specify uniformly distributed load in [kN/m²] with dead and live components, and concentrated line loads in [kN/m] (dead and live components) at the free end. The design actions are obtained with combination of permanent and variable actions, (**γG Gk +γQ Qk**) (EN 1990:2002.). Full code check, according to Eurocode 2, is performed. The flexural reinforcement is computed according to Eurocode 2 §6.1, in ultimate limit

state for bending. The crack and deflection are calculated according to Eurocode 2 §7.3, §7.4 requirement in serviceability limit state (SLS). The reinforcing steel detailing and minimum requirements are according to Eurocode 2 §8, §9.3. A detailed report with all the computations, graphs, and code references is produced. The reinforcing bars are automatically placed in the reinforcing bar schedules.

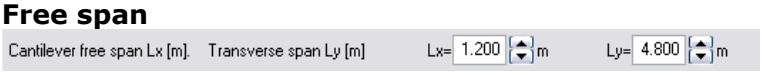


Slab thickness

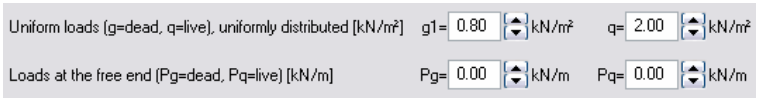


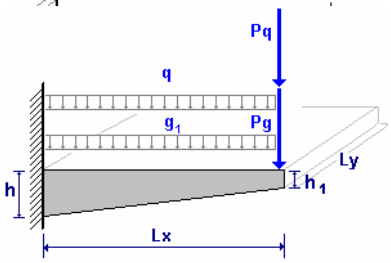
Slab thickness h at fixed end and h1 at free end in meters (m).

Free span



Loads





Uniformly distributed loads in [kN/m²], g1 for the dead load of the slab finishing, and q for the live load on the slab. Pg [kN/m] is the dead concentrated load at the free end and Pq [kN/m] the live concentrated load at the free end.
The design actions are obtained with combination of permanent and variable actions as in Eurocode EN 1990:2002 **(γG Gk +γQ Qk).**

5.2.6 Ribbed slabs

Slabs with voids, in order to reduce the self weight. They are designed as solid slabs, but the reinforcement is placed in the ribs. Additional data from the solid slabs are the rib (web) width **bw**, and the overhanging (void) width **b1**. Some requirements for ribbed or waffle slabs are in Eurocode 2 §5.3.1 (6)

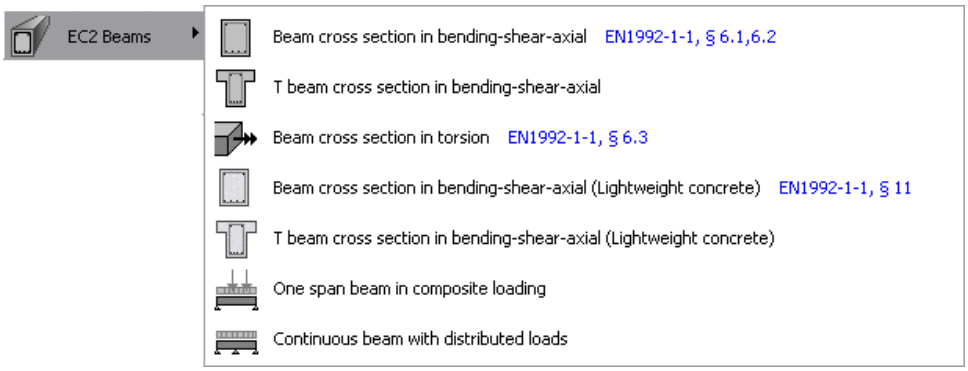
5.2.7 Light weight concrete

Select the concrete density ρ Kg/m^3

5.3 Beams

Dimensioning of concrete beams, of rectangular or T cross-section. You can design single or multiple span continuous beams. A complete check according to Eurocode 2, is performed. A detailed report with all the computations, graphs, and code references is produced. The reinforcing bars are automatically placed in the reinforcing bar schedules.
The loads can have dead and live components. The design actions are obtained with combination of permanent and variable actions as in Eurocode EN 1990:2002 (**γG Gk +γQ Qk).**
The flexural reinforcement is computed according to Eurocode 2 § 6.1, in ultimate limit sate for bending. The shear reinforcement is computed according to Eurocode 2 §6.2.
The crack and deflection are calculated according to Eurocode 2 §7.3, §7.4 requirement in serviceability limit state (SLS).The reinforcing steel detailing and minimum requirements are according to Eurocode 2 §9.2. The number of reinforcing bars and stirrup spacing is computed. You may check to use specific reinforcement diameter or the program optimise the reinforcement around the desired diameter. The reinforcing bars are automatically placed in the reinforcing bar schedules.

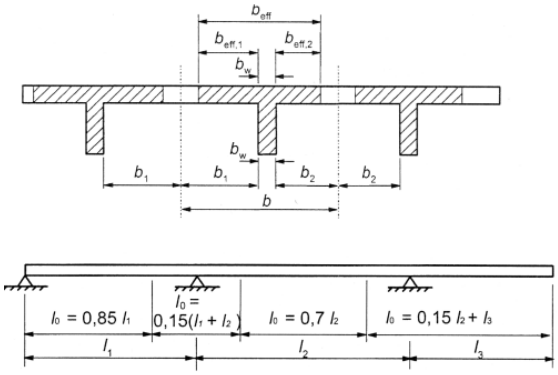
You can design the following beam types:



Beam section. Design of a rectangular or T beam section subjected to combined bending and shear and axial force large and small eccentricity.
Torsion. Design of a rectangular or T shape beam section subjected to combined torsion shear and bending.
Single span beam in composite loading. Dimensioning of single span beam under composite loading. The beam cross section can be rectangular, T section, or edge beam. The effective flange width is evaluated according to Eurocode 2 §5.3.2.1. The left or right end support conditions of the beam may be specified as simply supported or fixed. The loading is the superposition of uniformly and triangularly distributed loads, and concentrated loads.
Multiple Span Beam. Design of continuous beams, up to 4 spans with optional end cantilevers, and uniform dead and live loading on the spans. The beam cross section can be rectangular, T section, or edge beam. The effective flange width is evaluated according to Eurocode 2 §5.3.2.1. The lengths, the cross section data and the loading may be specified for every span. The linear static analysis is performed taking into account the most unfavourable placing of the live loads on the spans to obtain the maximum or minimum design values for bending moments and shear forces. The support moments are computed at the faces of the supports. The design moments may be redistributed (Eurocode 2 EC2 §5.5), if the specified percentage of moment redistribution is >0.

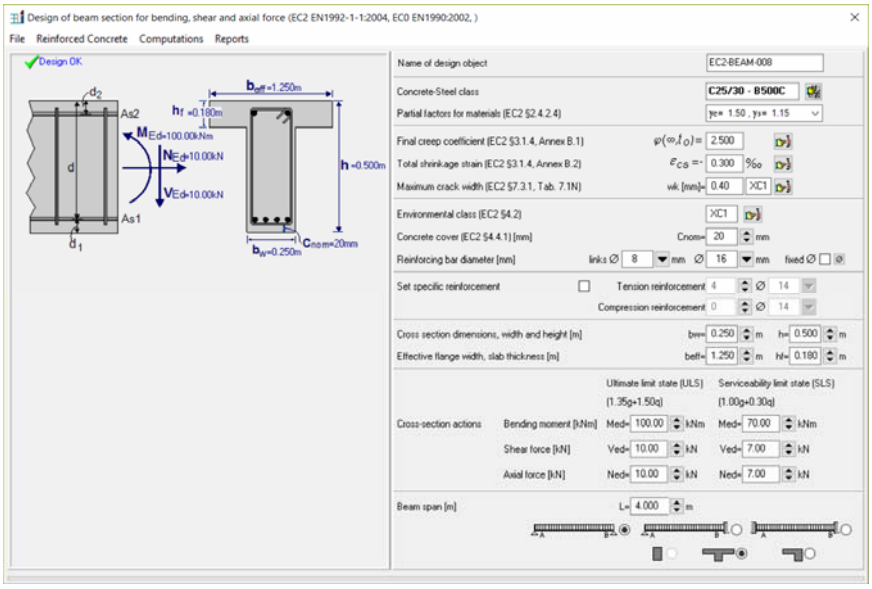
Effective flange width

The effective flange width for symmetrical T beams may be taken as beff=bw+(1/5)Lo<b and for beams with flange at one side only as beff=bw+(1/10)Lo<b1+bw. Eurocode 2 §5.3.2.1(3). The distance Lo is the distance between the point of zero moments in the span. In a continuous beam Lo may be taken as 0.85L for end span and 0.70L for internal spans Eurocode 2 §5.3.2.1(2).



5.3.1 Beam cross section subjected to bending- shear and axial load

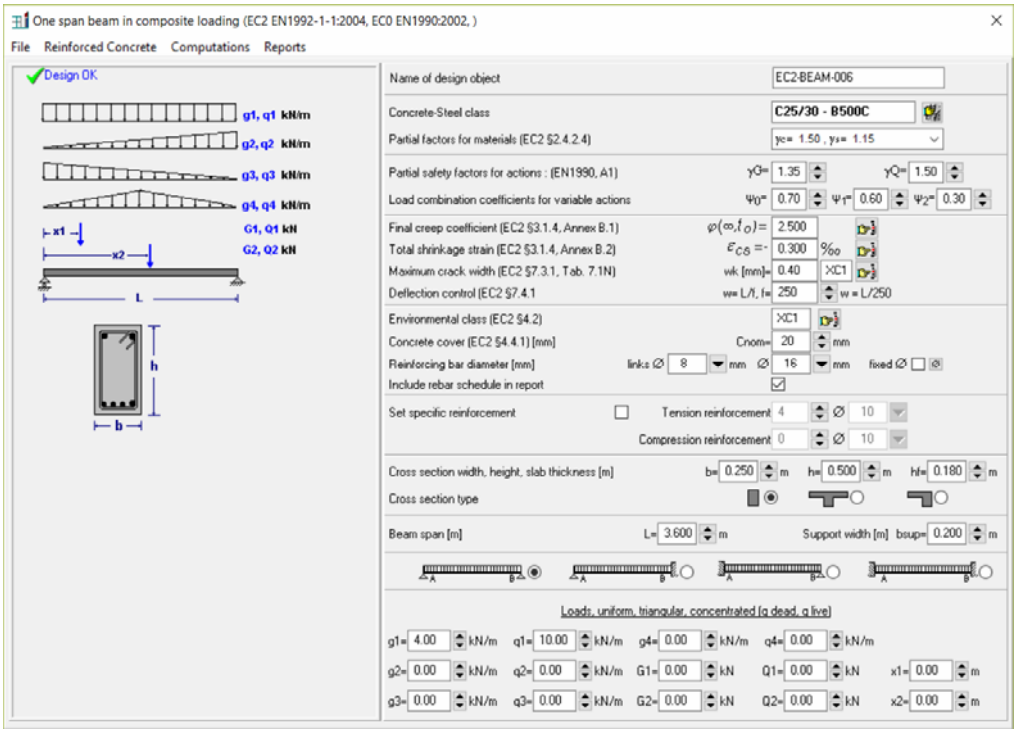
Design of a rectangular or T beam section under combined bending and shear loading. The flexural reinforcement is computed according to Eurocode 2, § 6.1, in ultimate limit sate for bending. The **shear reinforcement is computed according to Eurocode 2, § 6.2.



Support conditions and lengths are used for the design for shear between web and flanges for T sections, § 6.2.4.

5.3.2 One span beam under composite loading

Dimensioning of one span beam under composite loading. The beam cross section can be rectangular, T section, or edge beam. The effective flange width is evaluated according to Eurocode 2 §5.3.2.1. The end support conditions of the beam may be specified as simply supported or fixed. The loading is the superposition of uniformly and triangularly distributed loads, and concentrated loads. Full code check, according to Eurocode 2, is performed. The reinforcing bars are automatically placed in the reinforcing bar schedules.
The design actions are obtained by combination of permanent and variable actions as in Eurocode 0, EN 1990:2002 (**γG Gk +γQ Qk).**
The flexural reinforcement is computed according to Eurocode 2 § 6.1, in ultimate limit sate for bending. The shear reinforcement is computed according to Eurocode 2 § 6.2. The crack and deflection are calculated according to Eurocode 2 §7.3, §7.4 requirement in serviceability limit state (SLS). The reinforcing steel detailing and minimum requirements, are according to Eurocode 2, §9.2.
You specify the desired diameter for reinforcement and the number of reinforcing bars and stirrup spacing is obtained. You may check to use specific diameter for reinforcing bars, or the program optimises the reinforcement around the desired diameter. The reinforcement is automatically placed in the reinforcing bar schedules.
The default diameter for longitudinal reinforcement and the diameter for stirrup reinforcement are defined in [Parameters/Reinforced Concrete/Beams].



Beam span

The span L of the beam in meters (m). If you give support width>0 then for the fixed supports the negative moments are computed at support face, which basically means that the free span of the beam is L-bsup/2 for a beam fixed at one end and L-bsup for a beam fixed at both ends. For a simply supported beam the free span is L.

Loads

The values for the loads are according to the diagram on the left. The distributed loads are in [kN/m] and the concentrated loads in [kN]. The distance of the concentrated loads is measured always from the left beam support in meters (m). The design actions are obtained by combination of permanent and variable actions as in Eurocode 0, 1990:2002 (**γG Gk +γQ Qk**).

5.3.3 Multiple span continuous beams

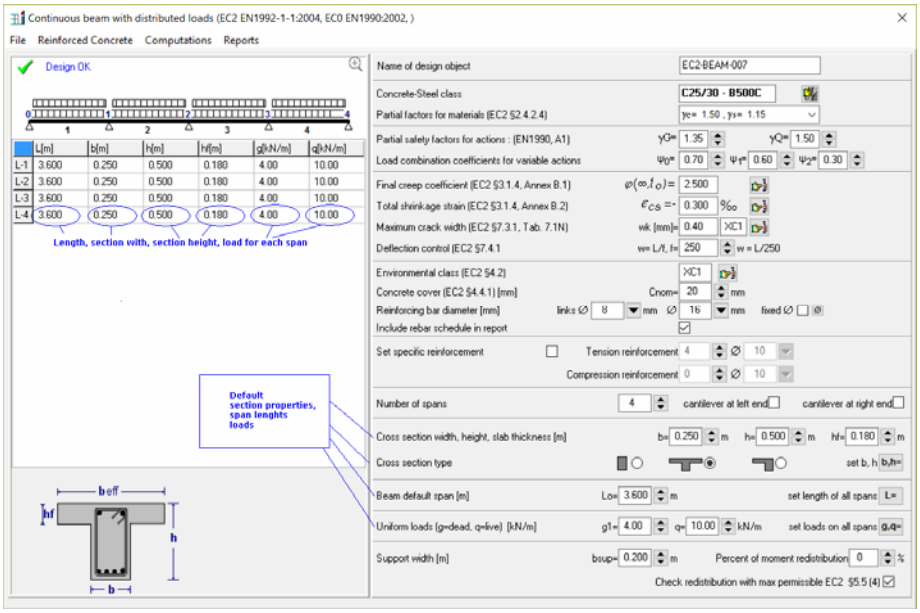
Design of continuous beams up to 4 spans with optional end cantilevers, under uniform loading on the spans. The load can have dead and live components. The beam cross section can be rectangular, T section, or edge beam. The effective flange width is evaluated according to Eurocode 2 §5.3.2.1. The lengths, the cross section data and the loading may be specified for every span. Cantilevers at the left and right end may be specified. Full code check, according to Eurocode 2, is performed. A detailed report with all the computations, graphs, and code references is produced. The reinforcing bars are automatically placed in the reinforcing bar schedules

The design actions are obtained with combination of permanent and variable actions as in Eurocode 0 1990:2002 (**γG Gk +γQ Qk**). The static solution is performed with finite element analysis taking into account the most unfavourable live load placing on the spans to obtain the maximum or minimum design values for bending moments and shear forces.

The support moments are computed at the faces of the supports. The design moments may be redistributed (Eurocode 2 §5.5), if the specified percentage of moment redistribution is >0. In the moment redistribution the support moments, calculated using linear elastic analysis, are reduced by the ratio of moment redistribution, with a corresponding increase of the span moments, such as the resulting moments remain in equilibrium.

The flexural reinforcement is computed according to Eurocode 2 § 6.1, in ultimate limit sate for bending . The shear reinforcement is computed according to Eurocode 2 § 6.2. The crack and deflection are calculated according to Eurocode 2 §7.3, §7.4 requirement in serviceability limit state (SLS). The reinforcing steel detailing and minimum requirements for reinforcement, is according to Eurocode 2 , §9.2.

The number of reinforcing bars and stirrup spacing is computed. You may check to use specific reinforcement diameter or the program optimises the reinforcement around the desired diameter. The reinforcing bars are automatically placed in the reinforcing bar schedules.
The default diameter for longitudinal reinforcement and the diameter for stirrup reinforcement are defined in [Parameters/Reinforced Concrete/Beams].



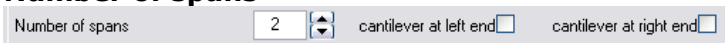
Beam cross-section

The cross section data are for the default cross section. By clicking at h= the default cross section data are set in all the spans. From the table at the left window under the beam sketch you may specify the cross section data for every span.

Span length

Beam length Lo in meters [m], is the default span length. By clicking at L= the span length is set to the default value at all the spans. At the cantilevers (if they exist) the span length is set to (1/4) of the default value. To set the span length for each span click and edit the corresponding cell at the left window under the beam sketch.

Number of spans

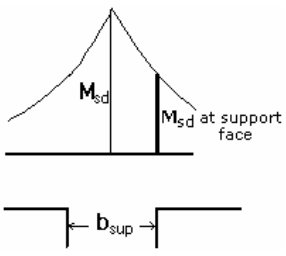


You specify the number of spans of the continuous beam. By checking cantilever at left or cantilever at right, you specify the existence of cantilevers at the left or the right end.
The spans are automatically created with the default length Lo, the default thickness ho, and the default loads g and q. From the left window you may change these values for span length L, thickness h, and loads g and q.

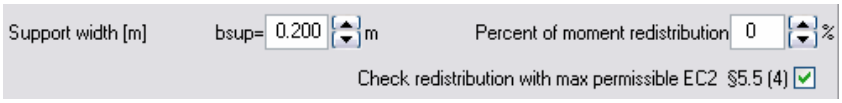
Loads

Default loads in [kN/m], g1 for the dead load on the beam, and q for the live load on the beam. From the left window under the beam sketch, you may change these default values for every span. (The total dead load is g=self weight + g1, the self weight is computed by the program)

By clicking at g,q= you set the values for the loads at all the spans to the default values.
The design actions are obtained with combination of permanent and variable actions as in Eurocode 0 1990:2002 (**γG Gk +γQ Qk**).



Percent of moment redistribution



The support moments, in continuous beams, calculated using linear elastic analysis, are reduced by the ratio of **moment redistribution**, with a corresponding increase of the span moments, such as the resulting moments remain in equilibrium (Eurocode 2, §5.5). The ratio of redistributed moment, to the moment before redistribution, is defined by the user in percent (%).

Support width

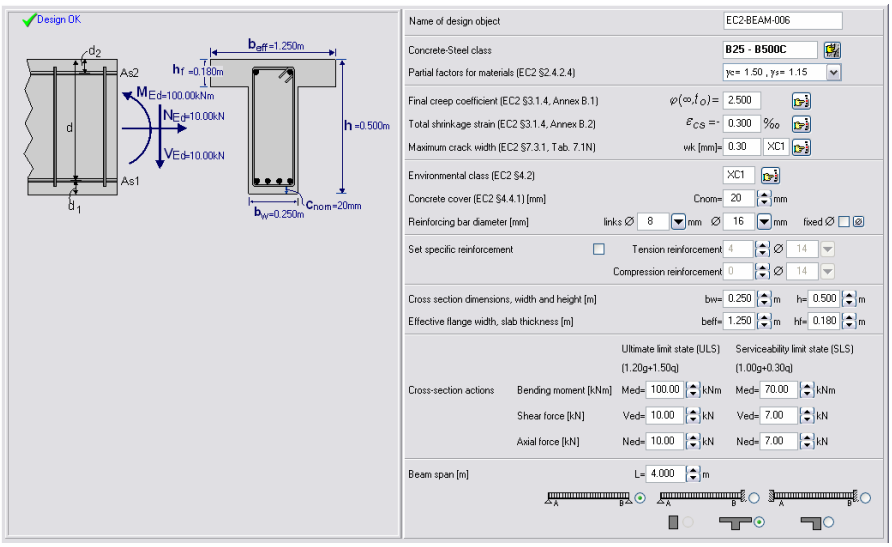
Mean support width in meters (m). The design support moments, for the computation of the reinforcement over the supports, are computed at the support faces at a distance b=bsup/2 from the axis of the support.

5.3.4 Beam section subjected to torsion

Design of a rectangular or T shape beam section, under combined torsion, shear and bending. The design is according to Eurocode 2, §6.3.2,
Trd,max is the design torsional resistance moment Eurocode 2 §6.3.2.
Vrd,max is the design resistance shear relating to a strut inclined at an angle 45°, Eurocode 2 §6.2.3.,

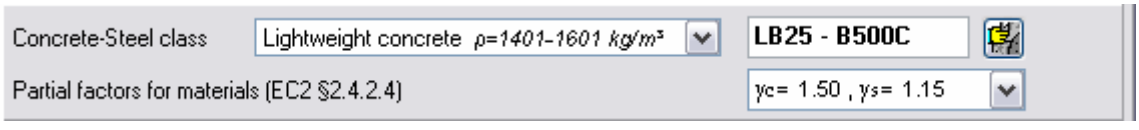
$$\left(\frac{T_{Ed}}{T_{Rd,max}}\right)+\left(\frac{V_{Ed}}{V_{Rd,max}}\right)\le 1$$

The calculation for necessary stirrups in torsion and shear are made separately.
You specify the desired diameter for reinforcement and the number of reinforcing bars and stirrup spacing is obtained. You may check to use specific diameter for reinforcing bars, or live the program to optimise the reinforcement around the desired diameter. The default diameter for longitudinal reinforcement and the diameter for stirrup reinforcement is defined in [Parameters/Reinforced Concrete/Beams].



5.3.5 Light weight concrete

Select the concrete density ρ Kg/m^3

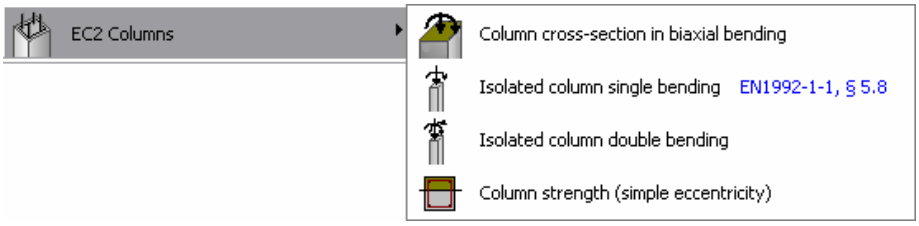


5.4 Concrete columns

Columns of rectangular or circular cross section in compression with biaxial bending. The dimensioning is according to biaxial bending interaction (P-Mx-My) diagrams which are obtained using a numerical integration. For rectangular columns you select the reinforcement arrangement (reinforcement at the corners or around the perimeter). The reinforcing bars are automatically placed in the reinforcing bar schedules.

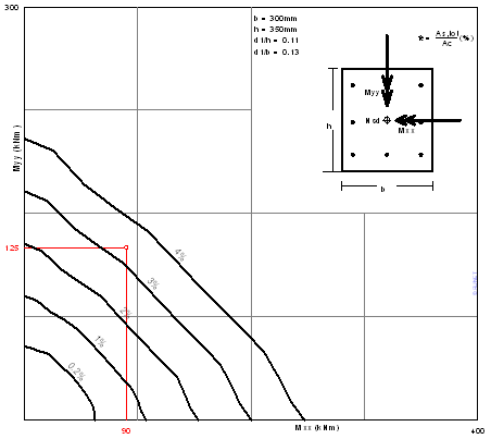
Isolated columns in single and double bending. The design is according to Eurocode 2 §5.8. The slenderness effects and second order effects are considered in the design. The effective length and end restrained conditions are specified as §5.8.3.2. The analysis method is according to §5.8.7.3. Moment magnification factor. The applied loads are axial loads and bending moments in x-x and y-y directions . The reinforcing bars are automatically placed in the reinforcing bar schedules.

Section capacity of rectangular or circular columns subjected to compression and uniaxial or biaxial bending moments. The ultimate capacity of a column cross section, with given dimensions and reinforcement, is computed by numerical integration of the forces acting on the cross-section at equilibrium. The internal forces are the forces of the concrete (parabolic compressive stress-strain diagram), and the forces (elasto-plastic stress-strain diagram) of the steel. The results are tabulated values and graphs for the failure surface, Pn-Mn values for the uniaxial bending, and Pn-Mx-My for the biaxial bending.



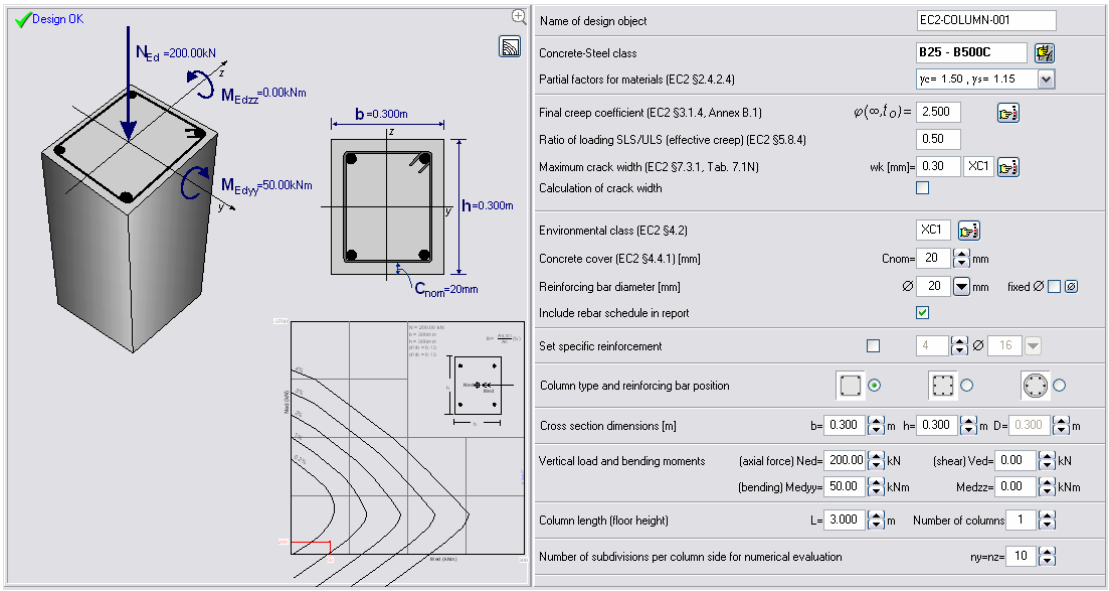
5.4.1 Design of column section in double bending

Design of column of rectangular or circular cross section in biaxial bending with compression. The dimensioning is done using a numerical integration of the concrete and steel forces over the column cross section. In addition approximate design values are obtained, using biaxial bending interaction (P-Mx-My) diagrams for concrete cover column side/10,*Kordina K, Bemessungshilfsmittel zu EC 2 Teil 1, Planung von Stahlbeton, Berlin, Beuth, 1992*.



For the numerical integration accuracy you give the number N of subdivisions per column side. The numerical integration is performed with a subdivision of the cross section in NxN elements. A value of N=10 seems to give adequate accuracy. The dimensioning is done using the biaxial bending interaction (P-Mx-My) diagrams. The slenderness effect or secondary moments due lateral deflection under load are not taken into account.

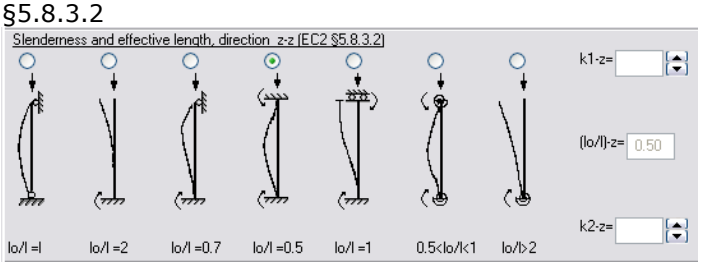
The axial force in [kN], positive for compression and the bending moments in [kNm]. You specify if the reinforcement is placed in the four corners of the cross section or if it is distributed around the perimeter of the section. The position of the reinforcement plays roll in the evaluation of the equilibrium of forces of the cross section.



The length and the number of columns are used for the rebar schedule.

5.4.2 Isolated columns in single and double bending

The design is according to Eurocode 2 §5.8. The slenderness effects and second order effects are considered in the design. The effective length and end restrained conditions are specified as §5.8.3.2



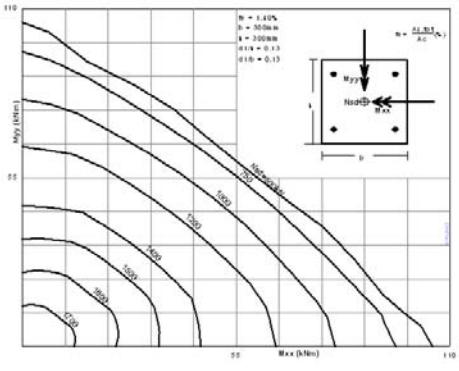
The analysis method is according to §5.8.7.3. Moment magnification factor. The applied loads are axial loads and bending moments in x-x and y-y directions . The reinforcing bars are automatically placed in the reinforcing bar.

5.4.3 Column section capacity

Section capacity of rectangular or circular columns with given reinforcement, and subjected to axial loading with uniaxial or biaxial bending moments. The dimensions and the reinforcement of the columns are specified. The ultimate capacity of the cross section is computed, by numerical integration of the internal forces on the cross section at equilibrium. These internal forces are the forces due to compression of the concrete, and due to tension and compression of the steel at the positions of the reinforcing bars.

The following assumptions are used:

- Plain sections remain plane.
- Parabolic stress-strain distribution diagram for the compressive stresses of concrete.
- Elasto-plastic stress-strain relationship for the steel.
- Tensile stresses of concrete are ignored.

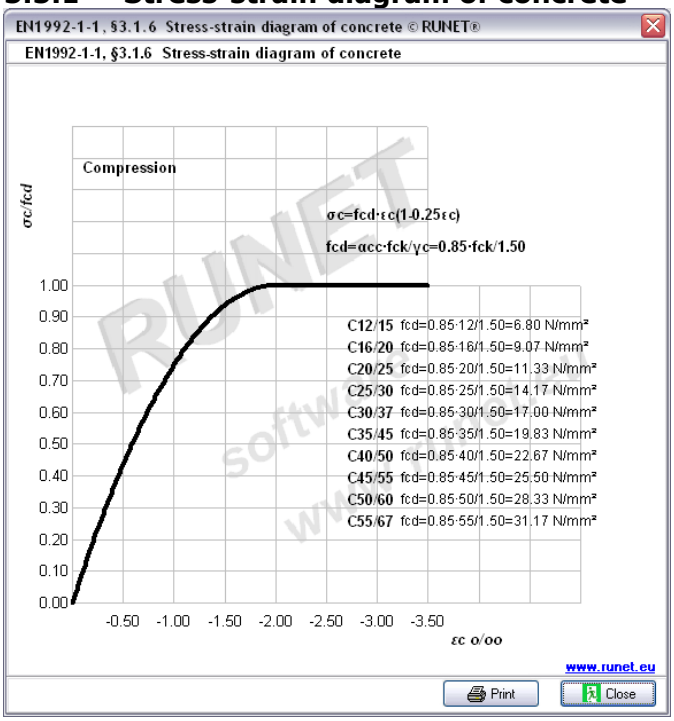


For the numerical integration accuracy you give the number N of subdivisions per column side. The numerical integration is performed with a subdivision of the cross section in NxN elements. A value of N=10 seems to give adequate accuracy.

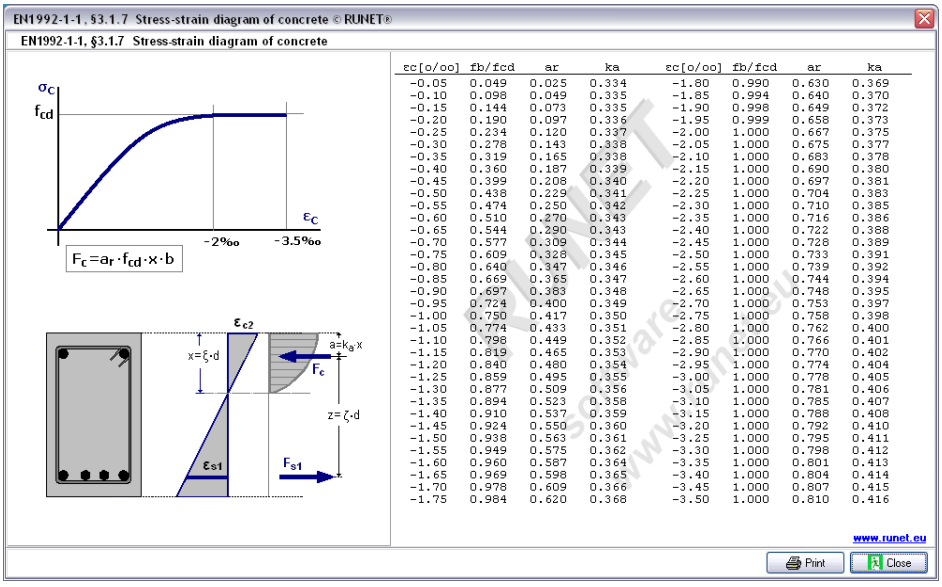
The results are tabulated values and graphs for the failure surface, Pn-Mn values for the uniaxial loading and Pn-Mx-My for the biaxial bending.

5.5 Eurocode 2, design charts

5.5.1 Stress-strain diagram of concrete

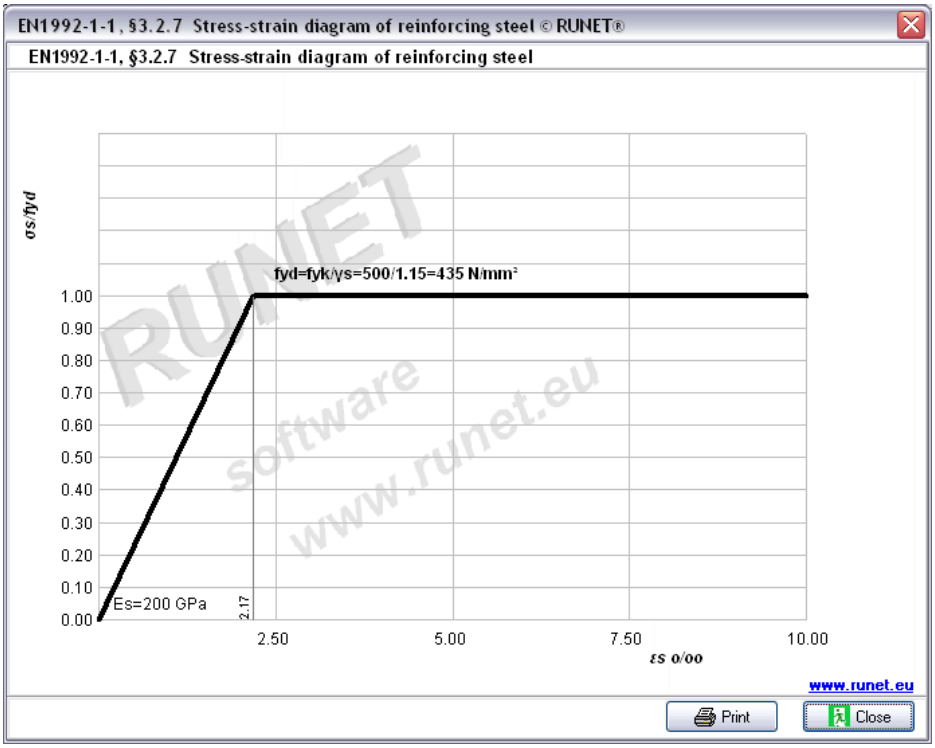


5.5.2 Parabolic diagram for concrete under compression

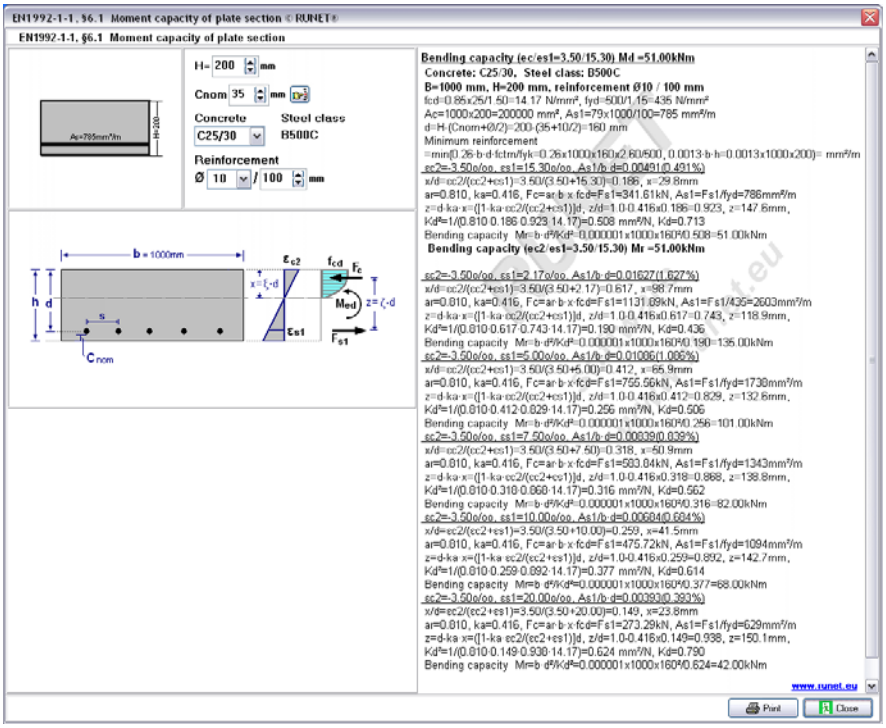


εc[o/oo]	fb/fcd	ar	ka	εc[o/oo]	fb/fcd	ar	ka
-0.05	0.049	0.025	0.334	-1.80	0.990	0.630	0.369
-0.10	0.098	0.049	0.335	-1.85	0.994	0.640	0.370
-0.15	0.144	0.073	0.335	-1.90	0.998	0.649	0.372
-0.20	0.190	0.097	0.336	-1.95	0.999	0.658	0.373
-0.25	0.234	0.120	0.337	-2.00	1.000	0.667	0.375
-0.30	0.278	0.143	0.338	-2.05	1.000	0.675	0.377
-0.35	0.319	0.165	0.338	-2.10	1.000	0.683	0.378
-0.40	0.360	0.187	0.339	-2.15	1.000	0.690	0.380
-0.45	0.399	0.208	0.340	-2.20	1.000	0.697	0.381
-0.50	0.438	0.229	0.341	-2.25	1.000	0.704	0.383
-0.55	0.474	0.250	0.342	-2.30	1.000	0.710	0.385
-0.60	0.510	0.270	0.343	-2.35	1.000	0.716	0.386
-0.65	0.544	0.290	0.343	-2.40	1.000	0.722	0.388
-0.70	0.577	0.309	0.344	-2.45	1.000	0.728	0.389
-0.75	0.609	0.328	0.345	-2.50	1.000	0.733	0.391
-0.80	0.640	0.347	0.346	-2.55	1.000	0.739	0.392
-0.85	0.669	0.365	0.347	-2.60	1.000	0.744	0.394
-0.90	0.697	0.383	0.348	-2.65	1.000	0.748	0.395
-0.95	0.724	0.400	0.349	-2.70	1.000	0.753	0.397
-1.00	0.750	0.417	0.350	-2.75	1.000	0.758	0.398
-1.05	0.774	0.433	0.351	-2.80	1.000	0.762	0.400
-1.10	0.798	0.449	0.352	-2.85	1.000	0.766	0.401
-1.15	0.819	0.465	0.353	-2.90	1.000	0.770	0.402
-1.20	0.840	0.480	0.354	-2.95	1.000	0.774	0.404
-1.25	0.859	0.495	0.355	-3.00	1.000	0.778	0.405
-1.30	0.877	0.509	0.356	-3.05	1.000	0.781	0.406
-1.35	0.894	0.523	0.358	-3.10	1.000	0.785	0.407
-1.40	0.910	0.537	0.359	-3.15	1.000	0.788	0.408
-1.45	0.924	0.550	0.360	-3.20	1.000	0.792	0.410
-1.50	0.938	0.563	0.361	-3.25	1.000	0.795	0.411
-1.55	0.949	0.575	0.362	-3.30	1.000	0.798	0.412
-1.60	0.960	0.587	0.364	-3.35	1.000	0.801	0.413
-1.65	0.969	0.598	0.365	-3.40	1.000	0.804	0.414
-1.70	0.978	0.609	0.366	-3.45	1.000	0.807	0.415
-1.75	0.984	0.620	0.368	-3.50	1.000	0.810	0.416

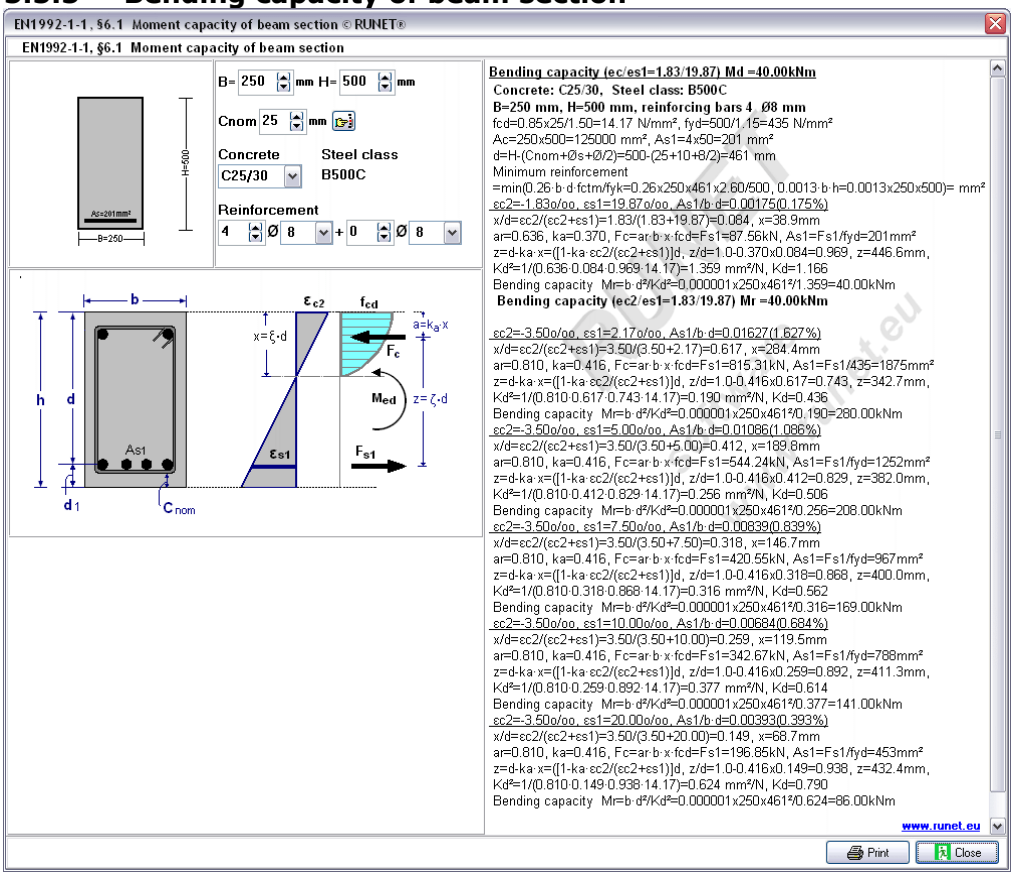
5.5.3 Stress-strain diagram of reinforcing steel



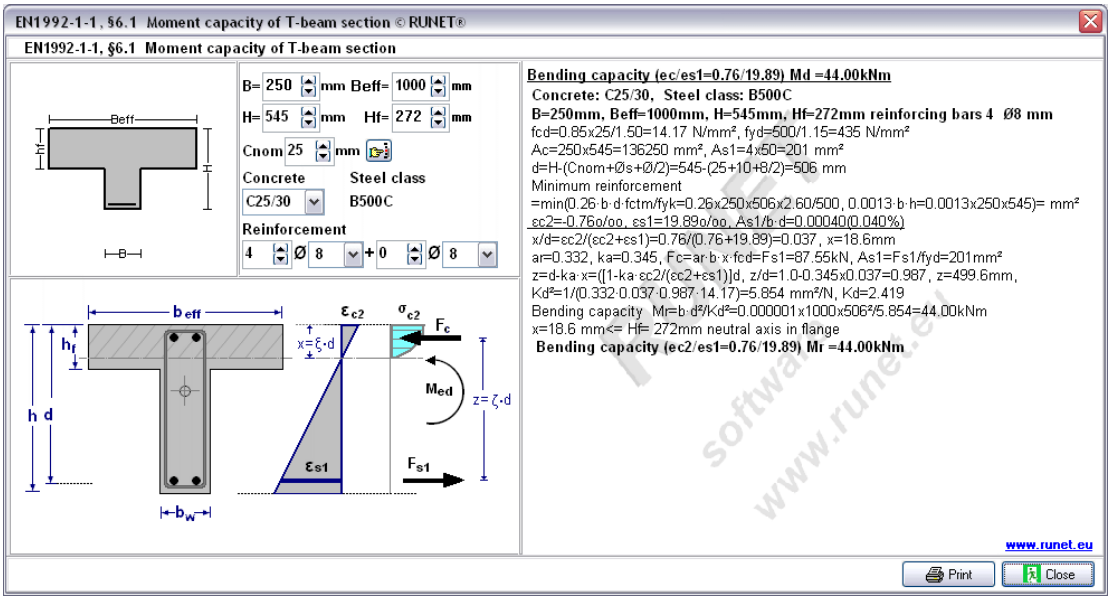
5.5.4 Bending capacity of plate section



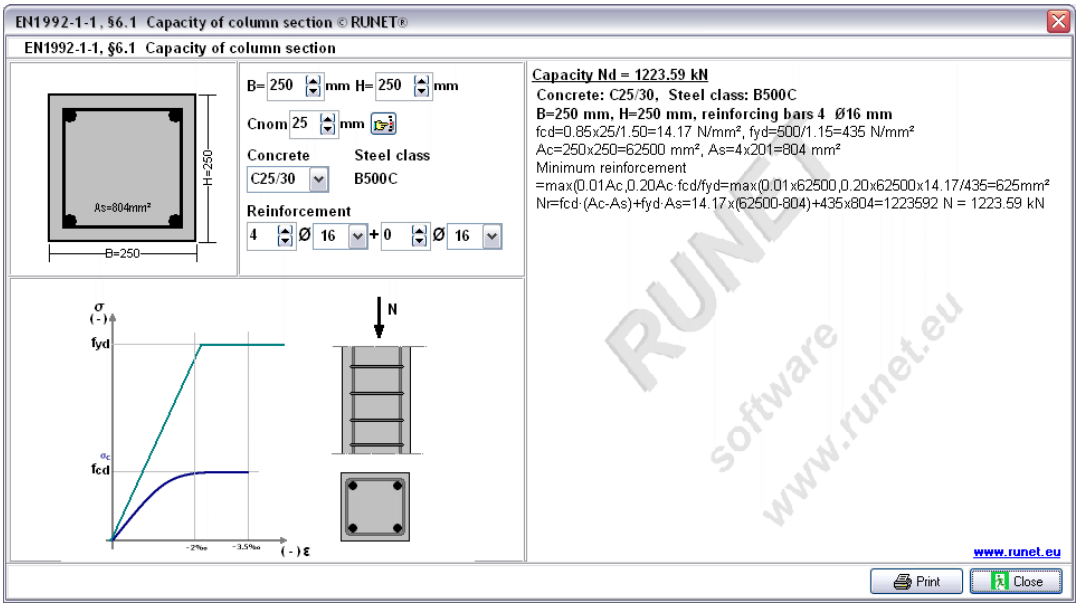
5.5.5 Bending capacity of beam section



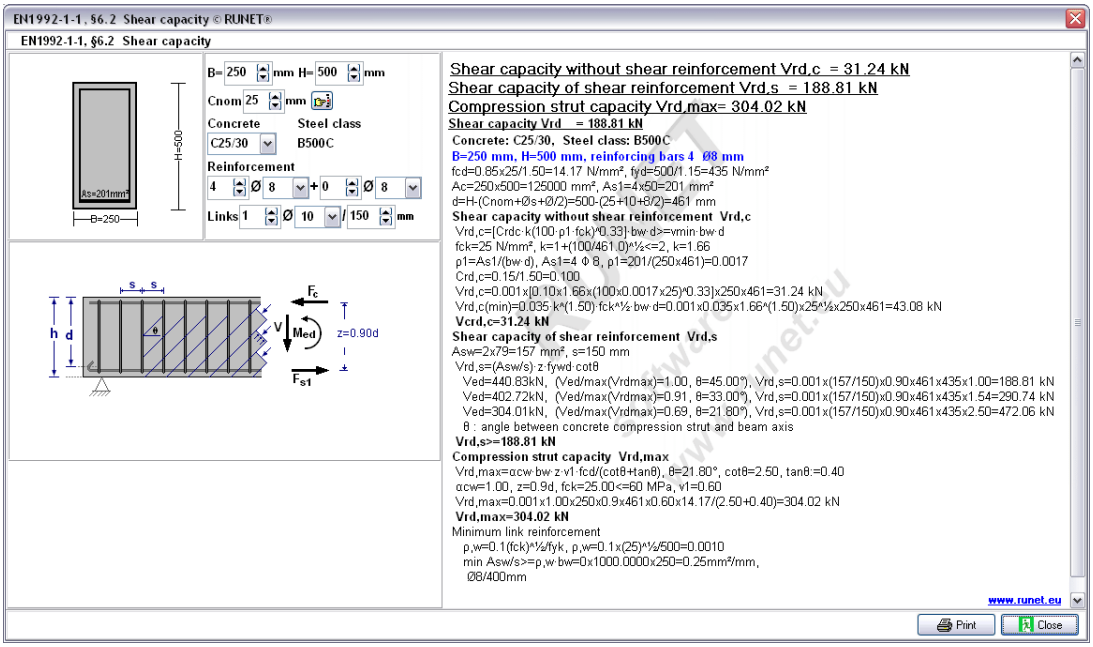
5.5.6 Bending capacity of T-beam section



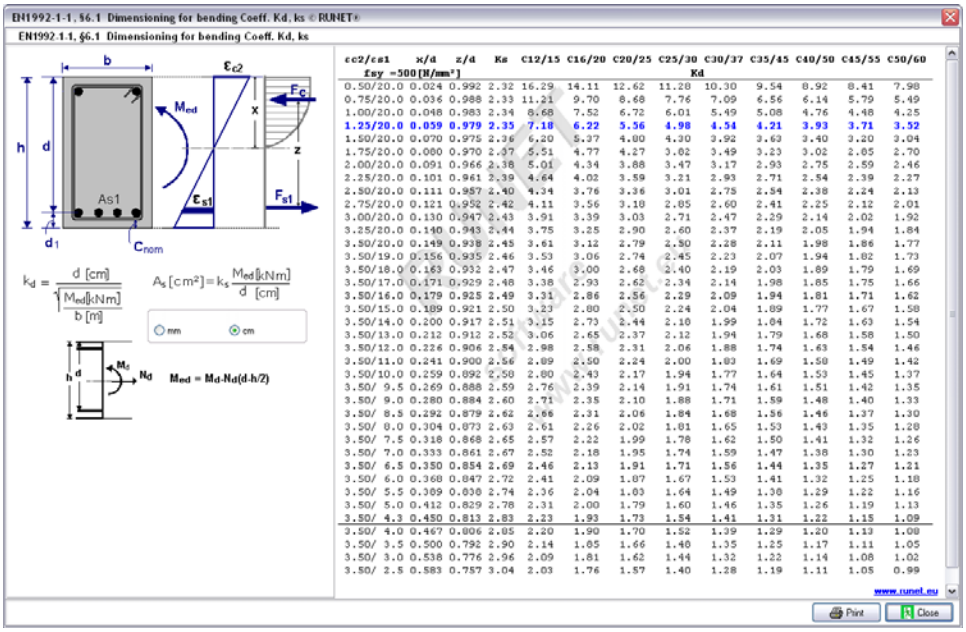
5.5.7 Capacity of rectangular columns



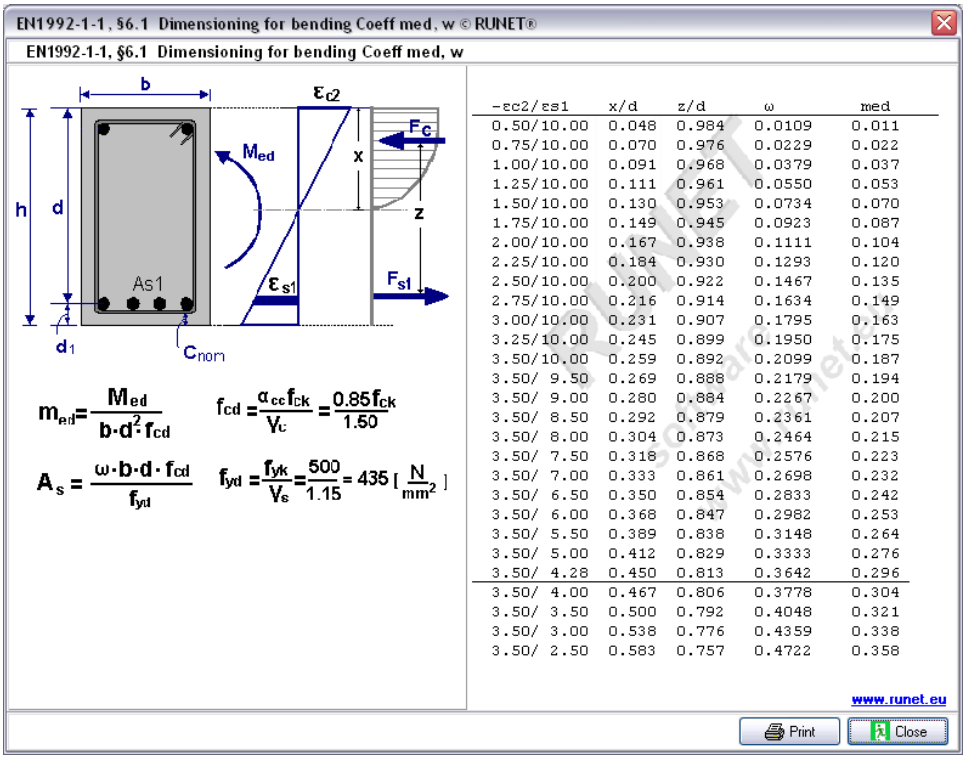
5.5.8 Shear capacity



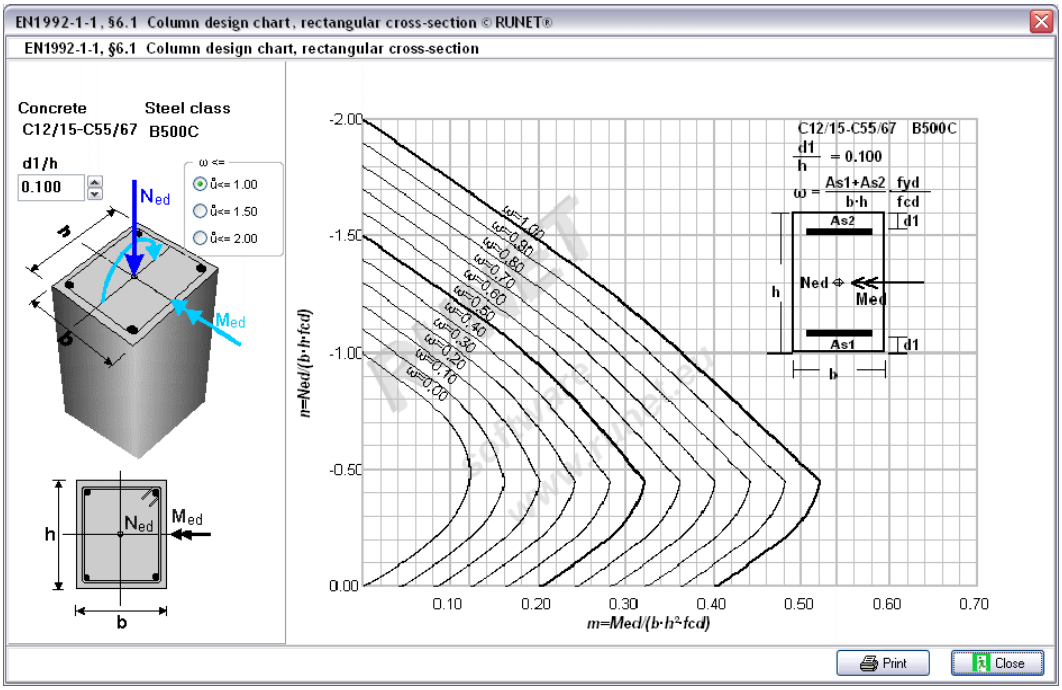
5.5.9 Dimensioning for bending Coeff. Kd, ks



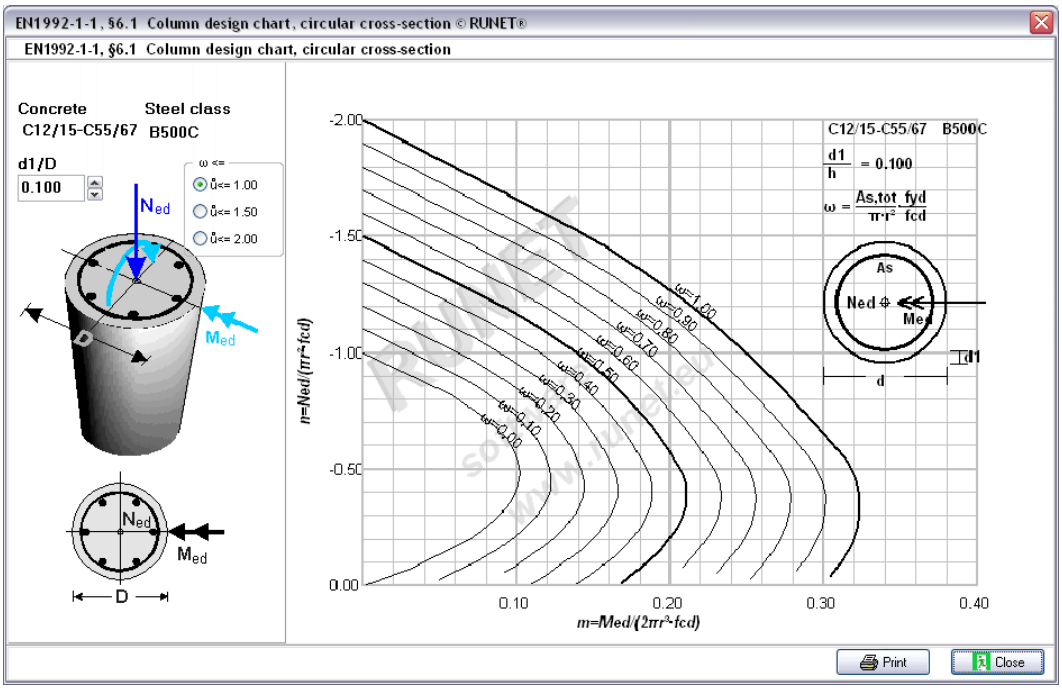
5.5.10 Dimensioning for bending Coeff med, w



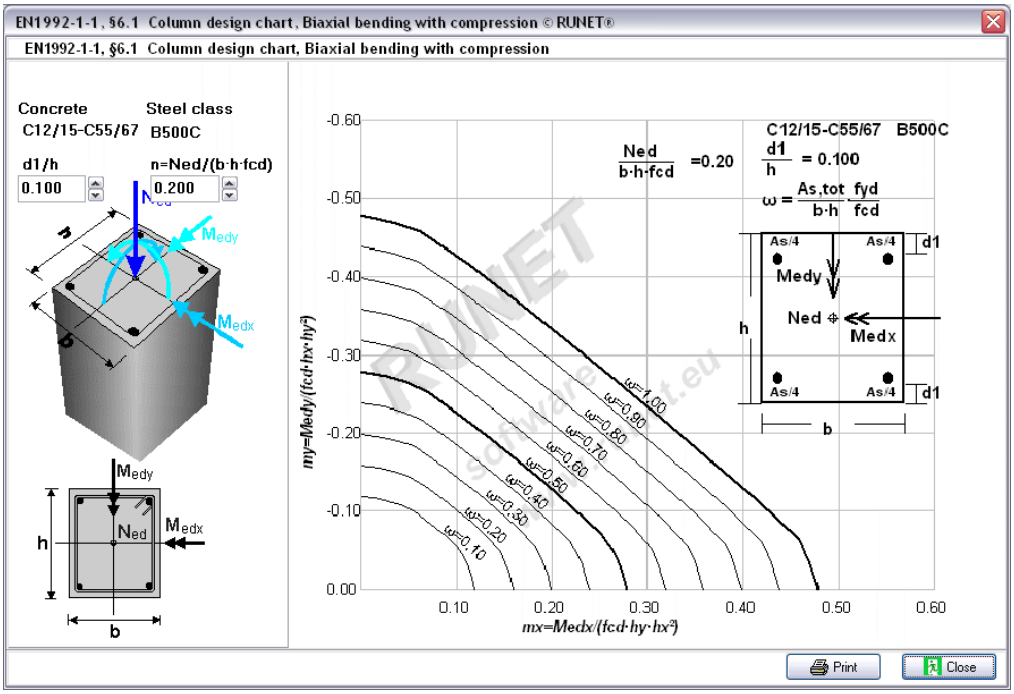
5.5.11 Column design chart, rectangular cross-section



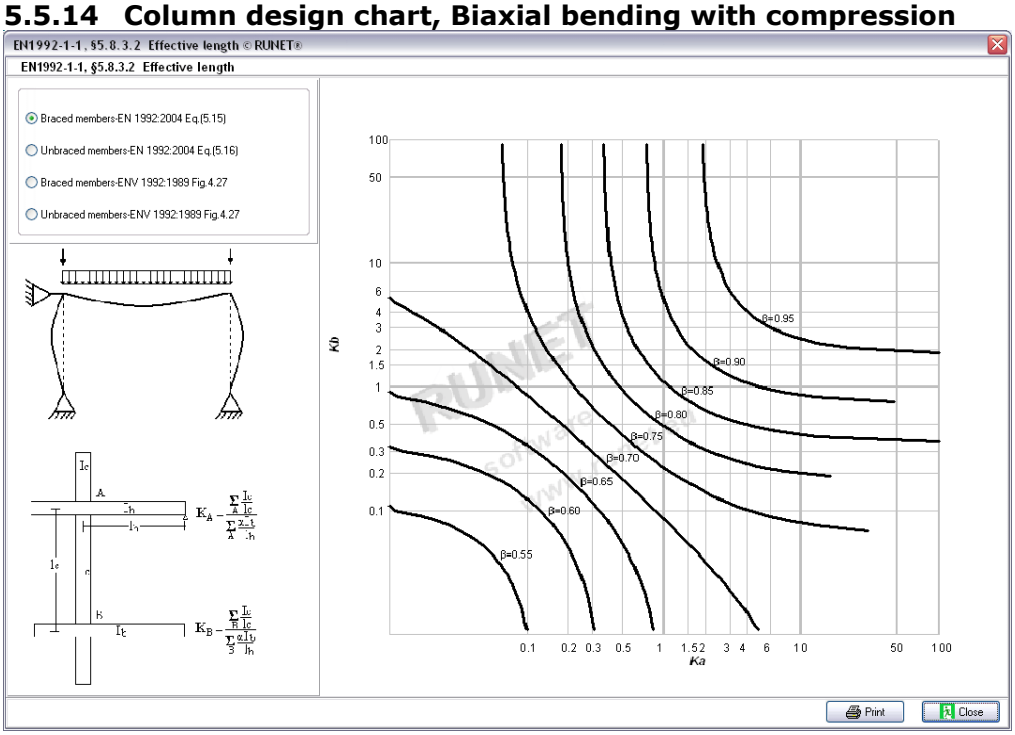
5.5.12 Column design chart, circular cross-section



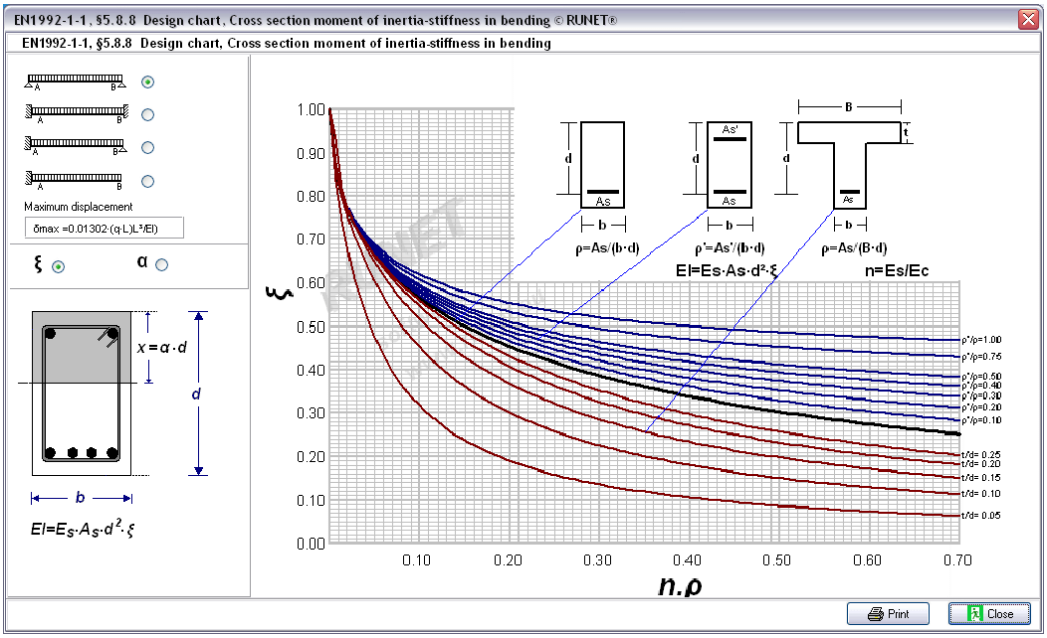
5.5.13 Column design chart, Biaxial bending with compression



5.5.14 Column design chart, Biaxial bending with compression

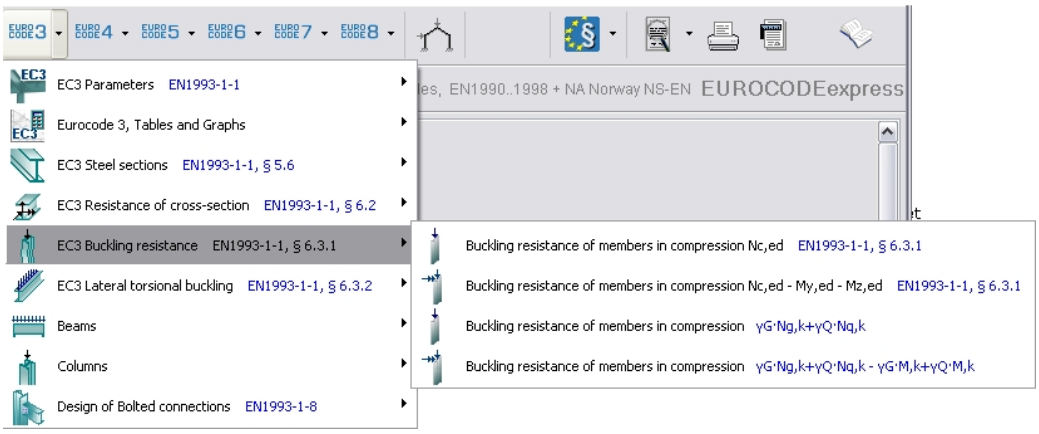


5.5.15 Column design chart, Cross section moment of inertia-stiffness in bending



6 Design of steel structures

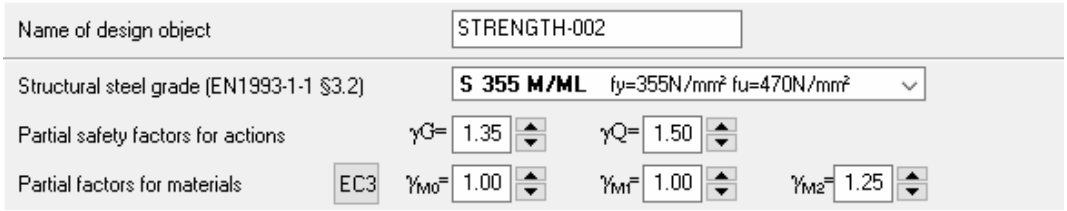
EN 1993-1-1:2005/AC:2009



6.1 General input data for steelwork components

Most of the steelwork design objects have some basic common data as follows:

- Name of design object
- Structural steel grade
- Partial safety factors for actions
- Partial factors for materials
- Actions
- Steel section

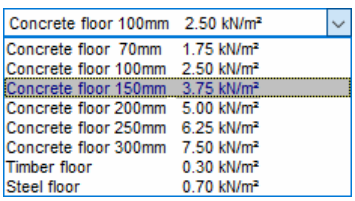


6.1.1 Name of design object

Every design object has a name, which appears in the report. In the creation of each object the program assigns a default name e.g. Beam-001, Beam-002 etc. which may be changed any time. (names up to 16 characters long). Names of structural design objects must be unique. Two design objects cannot have the same name.

6.1.2 Structural steel grade

Select the steel grade from the steel materials available. Most of the used steel grades are included in the program, and are loaded according to the national Annex you select. You can add steel grades, or change properties for steel grades in the menu Parameters/materials/Structural Steel. The program automatically sets the respective steel properties (fyk, fuk, Es etc.).



Steel grades included in the program

S 235 EN 10025-2 fy40:235;fu40:360	S 220GD+Z EN 10147 fy40:220;fu40:300
S 275 EN 10025-2 fy40:275;fu40:430	S 250GD+Z EN 10147 fy40:250;fu40:330
S 355 EN 10025-2 fy40:355;fu40:510	S 280GD+Z EN 10147 fy40:280;fu40:360
S 450 EN 10025-2 fy40:440;fu40:550	S 320GD+Z EN 10147 fy40:320;fu40:390
S 275 N/NL EN 10025-3 fy40:275;fu40:390	S 350GD+Z EN 10147 fy40:350;fu40:420
S 355 N/NL EN 10025-3 fy40:355;fu40:490	H240LA EN 10268 fy40:240;fu40:340
S 420 N/NL EN 10025-3 fy40:420;fu40:520	H280LA EN 10268 fy40:280;fu40:370
S 460 N/NL EN 10025-3 fy40:460;fu40:540	H320LA EN 10268 fy40:320;fu40:400
S 275 M/ML EN 10025-4 fy40:275;fu40:370	H360LA EN 10268 fy40:360;fu40:430
S 355 M/ML EN 10025-4 fy40:355;fu40:470	H400LA EN 10268 fy40:400;fu40:460
S 420 M/ML EN 10025-4 fy40:420;fu40:520	H260LAD EN 10292 fy40:240;fu40:340
S 460 M/ML' EN 10025-4 fy40:460;fu40:540	H300LAD EN 10292 fy40:280;fu40:370
S 235 W EN 10025-5 fy40:235;fu40:360	H340LAD EN 10292 fy40:320;fu40:400
S 355 W EN 10025-5 fy40:355;fu40:510	H380LAD EN 10292 fy40:360;fu40:430
S 460 Q/QL EN 10025-6 fy40:460;fu40:570	H420LAD EN 10292 fy40:400;fu40:460
S 235 H EN 10210-1 fy40:235;fu40:360	220GD+ZA EN 10214 fy40:220;fu40:300
S 275 H EN 10210-1 fy40:275;fu40:430	250GD+ZA EN 10214 fy40:250;fu40:330
S 355 H EN 10210-1 fy40:355;fu40:510	280GD+ZA EN 10214 fy40:280;fu40:360
S 275 NH/NLH EN 10210-1 fy40:275;fu40:390	320GD+ZA EN 10214 fy40:320;fu40:390
S 355 NH/NLH EN 10210-1 fy40:355;fu40:490	350GD+ZA EN 10214 fy40:350;fu40:420
S 420 NH/NLH EN 10210-1 fy40:420;fu40:540	
S 460 NH/NLH EN 10210-1 fy40:460;fu40:560	
S 460 NH/NLH EN 10210-1 fy40:460;fu40:560	
S 460 NH/NLH EN 10210-1 fy40:460;fu40:560	
S 460 NH/NLH EN 10210-1 fy40:460;fu40:560	

The steel grades for cold formed steel C Z and U sections are included.

6.1.3 Partial safety factors for actions

The partial safety γG, γG.sup (permanent loads unfavourable), γG.inf (permanent loads unfavourable), γQ (variable loads), and coefficients ψo, ψ1, ψ2 for combining actions, are set according to the national Annex selected. They can be changed from the menu Parameters/Design parameters/Action coefficients. And Parameters/Design parameters/Load combination factors. Common values γG=1.35, γG.inf:=1.00, γQ:=1.50, ψo:=0.70.

6.1.4 Partial factors for materials

The material partial factors γM0 γM1, γM2, are set according to the national Annex selected. They can be changed from the menu Parameters/Design parameters/Material factors

6.1.5 Actions

In some cases (as the cases of evaluating the resistance of cross-section) you specify the design value for actions Ned (axial force), Medy, Medz (bending moments), etc.. that is the result of combining permanent and variable actions.

$$Ned = \gamma G \cdot Ng + \gamma Q \cdot Nq1 + \gamma Q \cdot \psi o \cdot Nq2 \quad \text{(Eq.6.10)}$$
$$Med = \gamma G \cdot Mq + \gamma Q \cdot Mq1 + \gamma Q \cdot \psi o \cdot Mq2$$

In most cases you specify the permanent and variable actions and the program evaluates the design actions.

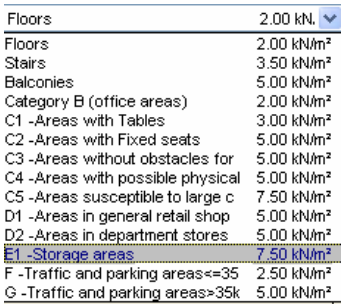
In cases of designing structural parts as floors, or roofs you specify the environmental loads permanent and variable on the structure.

Permanent loads on floors

Weight of floor finishing, the weight of the floor finishing (tiles etc.)
Weight of floor structure then weight of the floor structure If you select thin concrete slab (70mm) or timber floor The floor beams are checked as unrestrained. For thicker concrete slab are checked restrained, and for steel floor (steel plates etc) are checked later restrained at one middle point. The lateral restraining selection can be altered afterwards

Variable loads on floors

You can select from the table of EN1991-1-1 6.3).



Permanent loads on roofs

- Load of roof covering [kN/m²] It includes the weight of the sheeting, purlins and insulation materials.
- Load of ceiling under the roof [kN/m²]
- self weight of frame elements, calculated by the program from the element cross sections with Unit mass ρ= 7850 Kg/m³

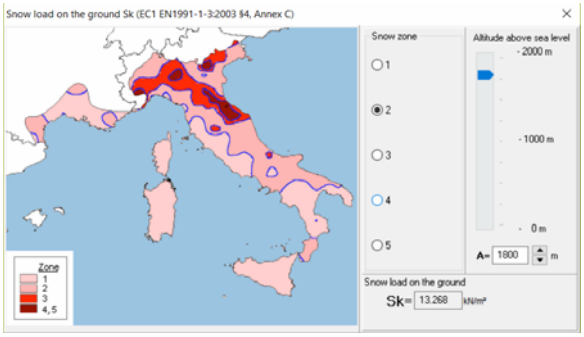
Variable loads on roofs

- Imposed load according to EN1990-1-1 Tab 6.1, calculated by the program according to the selected National Annex

- Snow load according to Eurocode 1-3:2004

The characteristic snow load on the ground sk is specified in kN/m2.

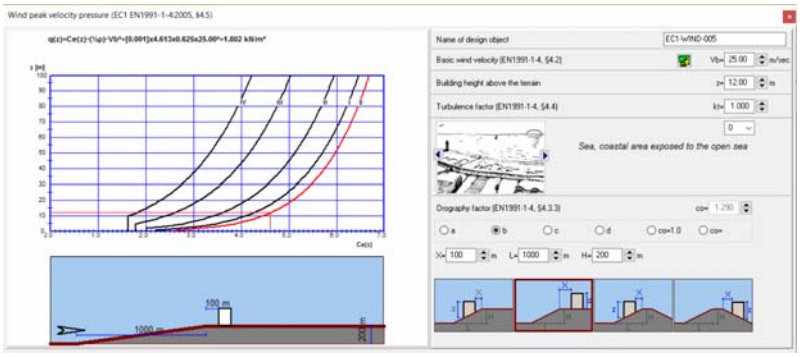
Click , and a special dialog window appear. In this window you set the snow zone and the height above the sea level. The characteristic snow load on the ground is computed according to Eurocode 1-3:2004, and the National Annex. The snow region can be selected from Parameters/snow load on the ground. The snow load on the roof is computed according to Eurocode 1-3:2003.



- Wind load, according to Eurocode 1-4:2005

The wind pressure on vertical surface is specified in kN/m2.

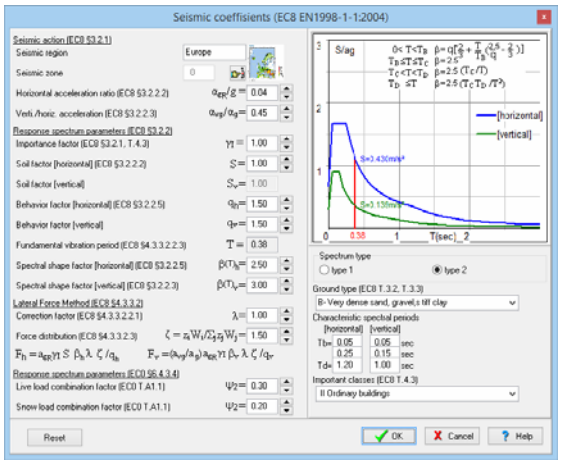
Click and in this window you compute the wind pressure from the wind velocity and the topography of the region according to Eurocode 1-4:2005.



The wind load is computed for various places at the roof and the vertical walls according to Eurocode 1-4:2005 §7.2.5 and Tab 7.4a and Tab. 7.1.
The wind region, which specifies the wind velocity, is selected from Parameters/Basic wind velocity. Wind internal pressure wi in kN/m2. This is internal pressure and it acts from inside outwards on the walls and roof. It is subtracted directly (without further multiplication by pressure coefficients) from any uplift wind pressure on the outside surfaces.

Seismic load Eurocode 8-1:2004

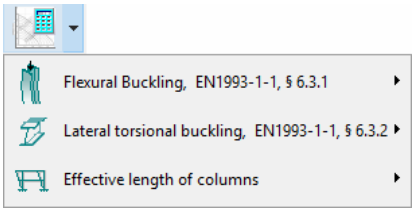
The program performs a verification of the structure under seismic loading, using both Lateral force method, and Modal superposition spectrum analysis. $\alpha = a_{gR}/g$ 0.160 .
Basic value used in the seismic design is the ratio of horizontal seismic acceleration. Click and a special dialog window appears where you may in detail specify all the necessary seismic parameters (soil factors, spectra periods, behaviour factors, etc..) for the design spectrum, according to Eurocode 8-1:2004.

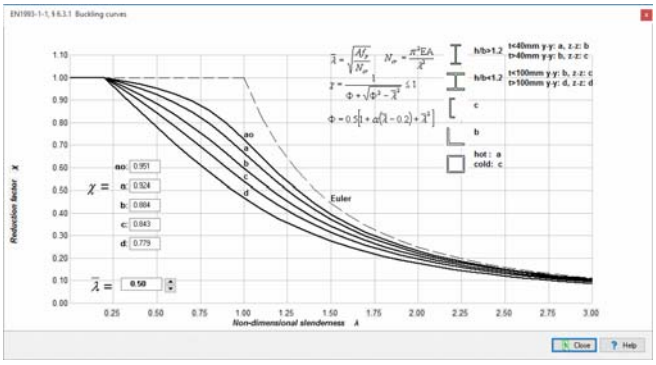


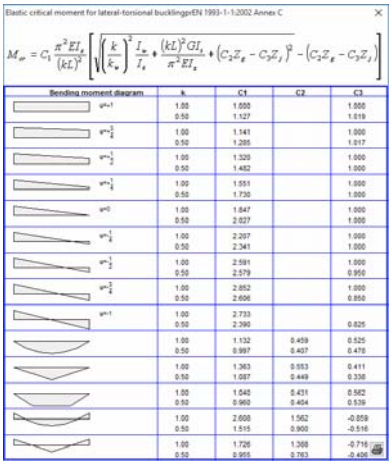
6.2 Eurocode 3, Tables and charts

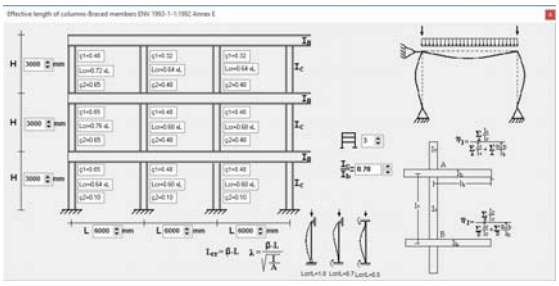
From the menu you can see various helpful charts and tables of Eurocode 3.

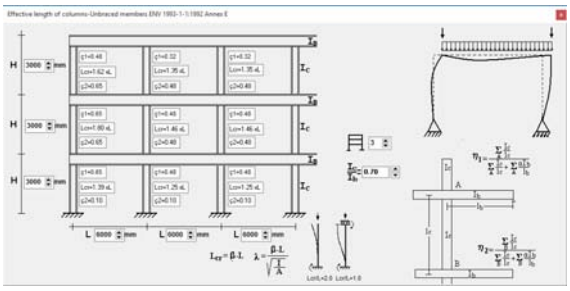
- Flexural buckling
- Lateral torsional buckling
- Effective length of columns in braced and unbraced frames.



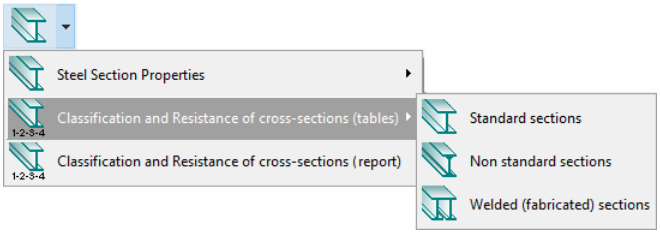








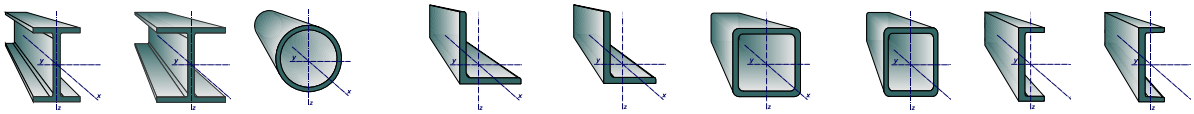
6.3 Design tables for Structural Steel Sections, Eurocode 3, EN1993-1-1:2005 § 5.5



Tables with steel sections, with their **dimensions**, **properties**, **classification**, **resistance and buckling resistance values** according to Eurocode 3

Three (3) groups of sections are included in the program.

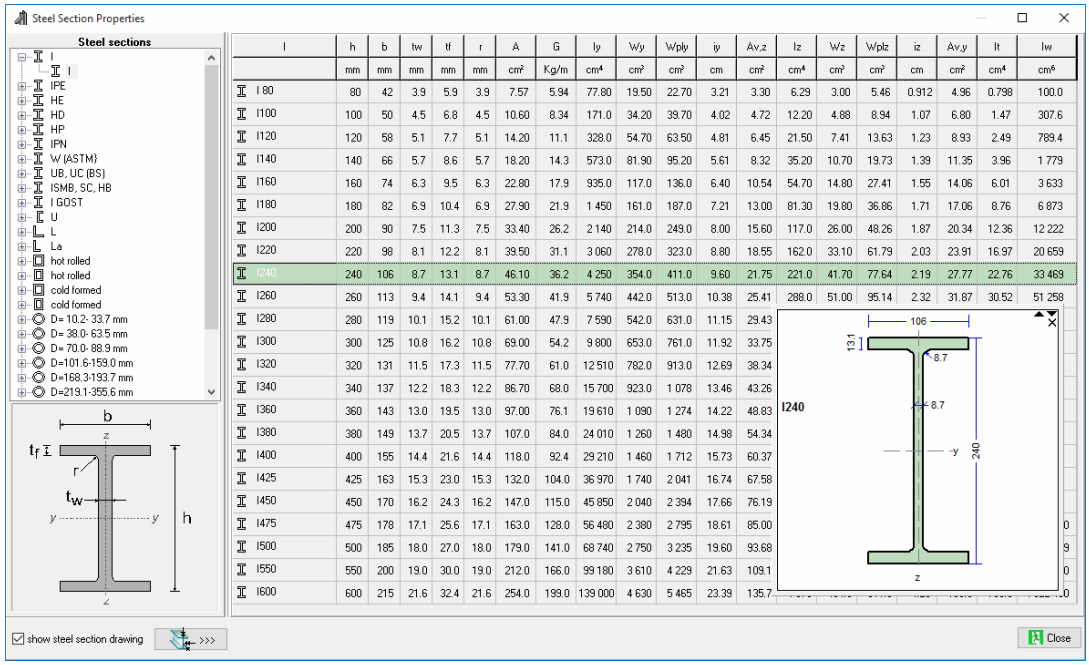
- Standard sections. All international section profiles.
- Non standard sections. Sections with dimensions given by the user.
- Welded sections. Welded sections made from rectangular steel plates, with dimensions given by the user.



6.3.1 Tables with dimensions and properties of standard steel sections

From the left tree you select the section type e.g. IPE, HE etc. On the right the table shows all the standard sections for this group and their dimensions and properties. Moving up and down the table on the right the section drawing is shown in scale (you can grab and move the section drawing around the window and you can make it small or bigger with the arrows).

Click or double click on a section and you obtain analytical report for the classification, resistance values and buckling resistance of the selected section.



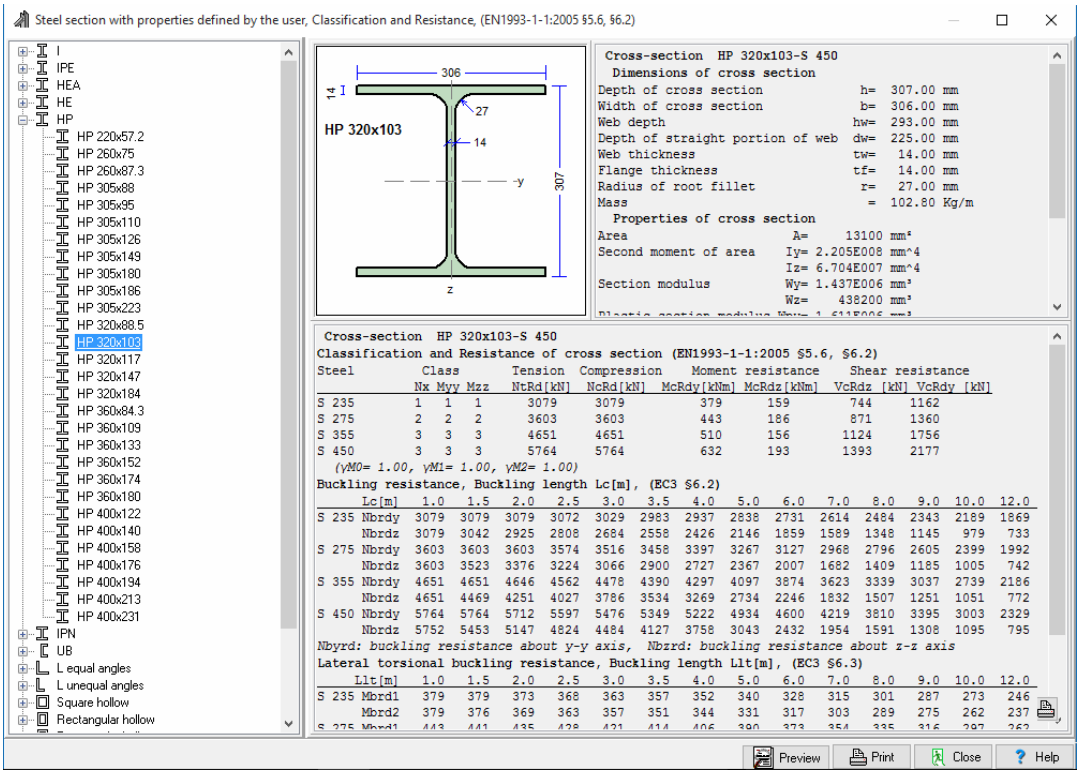
6.3.2 Classification and resistance of standard steel sections

Classification of cross section according to EN1993-1-1:2005 §5.5.
Resistance values of cross section according to EN1993-1-1:2005 §6.2.
Buckling resistance and lateral buckling resistance according to EN1993-1-1:2005 §6.3

From the tree on the left you select the section with its designation. On the right, a drawing of the section profile is displayed together with the section dimensions and properties.

On the right window are also displayed:

- **Classification** (1,2,3,4) according to EN1993-1-1:2005 §5.5 for axial loading and loading with bending moments.
- **Resistances** of the section in compression, bending in y-y and z-z axis, and shear according to EN1993-1-1:2005 §6.2
- **Buckling resistance** for various buckling lengths (Lc) according to EN1993-1-1:2005 §6.3.1
- **Lateral torsional buckling resistance** for various lateral buckling lengths (L_{lt}) according to EN1993-1-1:2005 §6.3.2



Symbols

	NtRd [kN]:	Tension resistance EN1993-1-1:2005 §6.2.3
	NcRd [kN]:	Compression resistance EN1993-1-1:2005 §6.2.4
	Mcrdy [kNm]:	Bending resistance about the strong y-y axis EN1993-1-1:2005 §6.2.5
	Mcrdz [kNm]:	Bending resistance about the weak z-z axis EN1993-1-1:2005 §6.2.5
	Vcrdz [kN]:	Shear resistance in the axis z-z parallel to web EN1993-1-1 §6.2.6
	Vcrdy [kN]:	Shear resistance in the axis y-y axis parallel to flanges EN1993-1-1:2005 §6.2.6
	Nbrdy [kN]: **Nbrdz [kN]:**	Buckling resistance in compression about the strong y-y or weak z-z axis, for various buckling lengths Lc (1.00,1.50…15 m) EN1993-1-1:2005 §6.3.1

Mbrd1 [kNm]: Lateral torsional buckling resistance for various lengths between constrains Llt
Mbrd2 [kNm]: (1.00,1.50 ….15 m) EN1993-1-1:2005 §6.3.2
Mbrd1: Lateral torsional buckling resistance for constant (uniform) bending moment diagram along the beam
Mbrd2: Lateral torsional buckling resistance for parabolic bending moment diagram along the beam

h [mm]: Depth of cross section
b [mm]: Width of cross section
hw [mm]: Web depth
dw [mm]: Depth of straight portion of web
tw [mm]: Web thickness
tf [mm]: Flange thickness
r [mm]: Radius of root fillet
G [Kg/m]: Mass
A [cm²]: Area
Iy [cm^4]: Moment of area about axis y-y
Iz [cm^4]: Second moment of area about axis z-z
Wy [cm^3]: Section modulus about axis y-y
Wz [cm^3]: Section modulus about axis z-z
Wpy [cm]: Plastic section modulus about axis y-y
Wpz [cm^3]: Plastic section modulus about axis z-z
iy [cm]: Radius of gyration about y-y axis
iz [cm]: Radius of gyration about z-z axis
Avz [cm²]: Shear area parallel to web
Avy [cm²]: Shear area parallel to flanges
It [cm^4]: Torsional constant
Iw [cm^6]: Warping constant

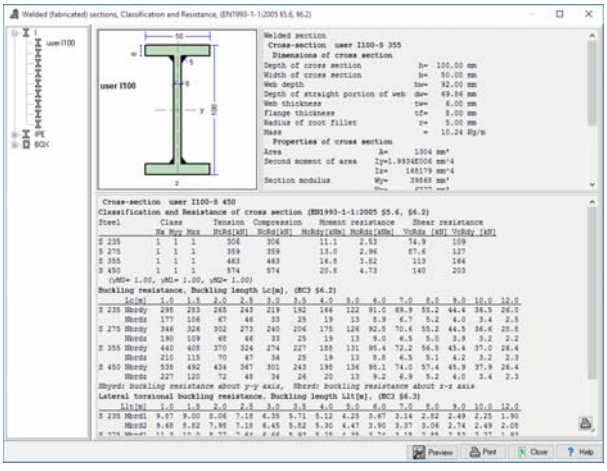
6.3.3 Tables of non standard steel sections

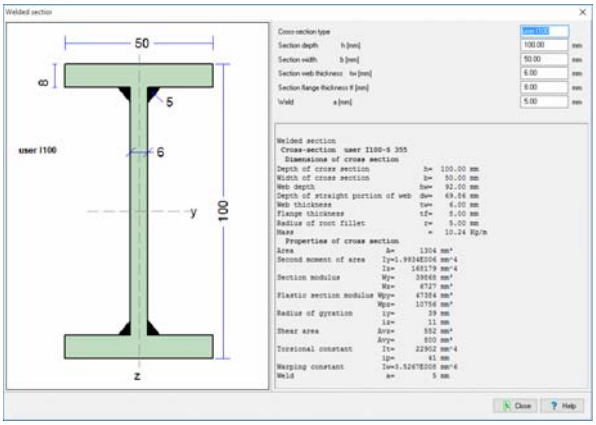
Tables with steel sections organized as the standard sections, but the user can change the basic dimensions. Changes are activated with the [Edit]. As you change the dimensions the new geometric and strength properties are evaluated. These sections can be used as standard sections.

6.3.4 Tables of user defined welded steel sections

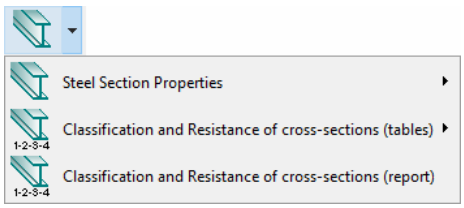
Click [Edit] and you enter the window where you can enter the basic dimensions of a welded steel section. The strength properties of the section are listed at the same time.

For adding new section or deleting existing click . Click [Stop edit] to stop editing.



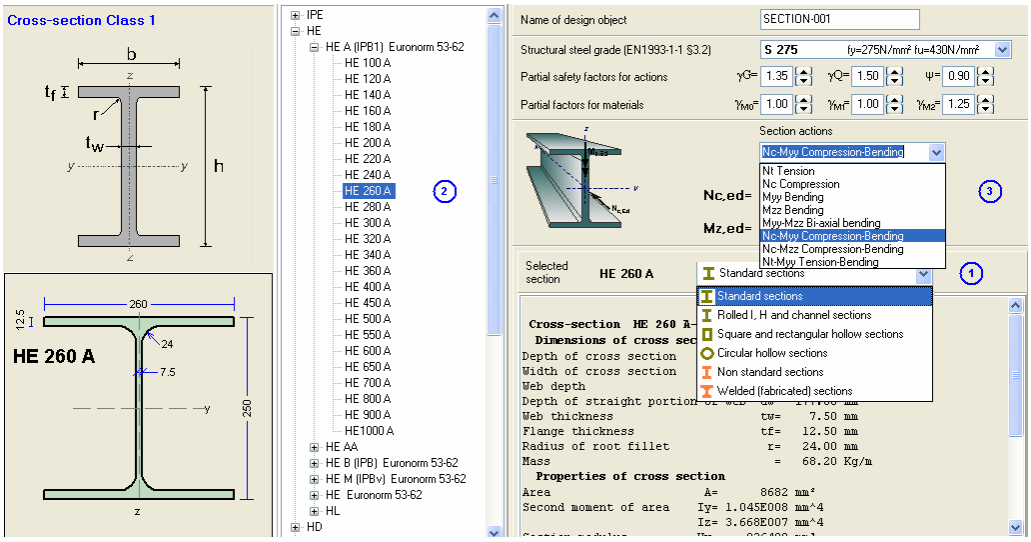


Classification and resistance of steel sections (detailed report):



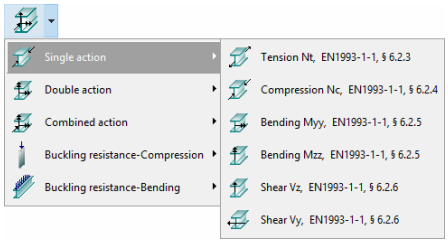
1. Select section group (standard, non standard, welded)
2. From the tree on the left select the section.
3. Select the combination of actions on the cross-section. If it is combination with axial force and bending moments specify the actions.

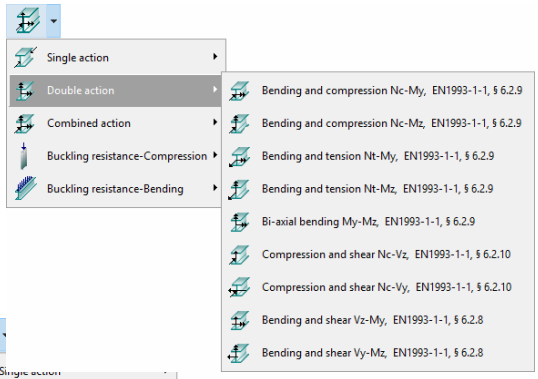
You obtain a detailed report of the section classification according to EN1993-1-1:2005 §5.5.
You can adjust also the steel grade and the partial safety factors.

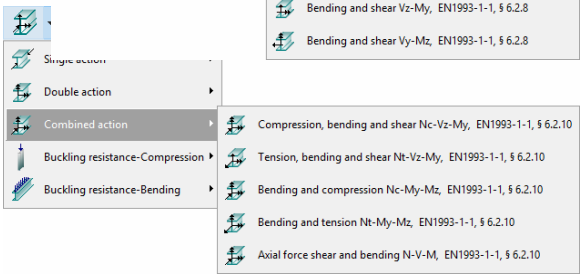


6.4 Resistance of cross-sections (Eurocode 3, EN1993-1-1:2005 § 6.2)

Design of cross-section in Ultimate limit state, for various combinations of actions





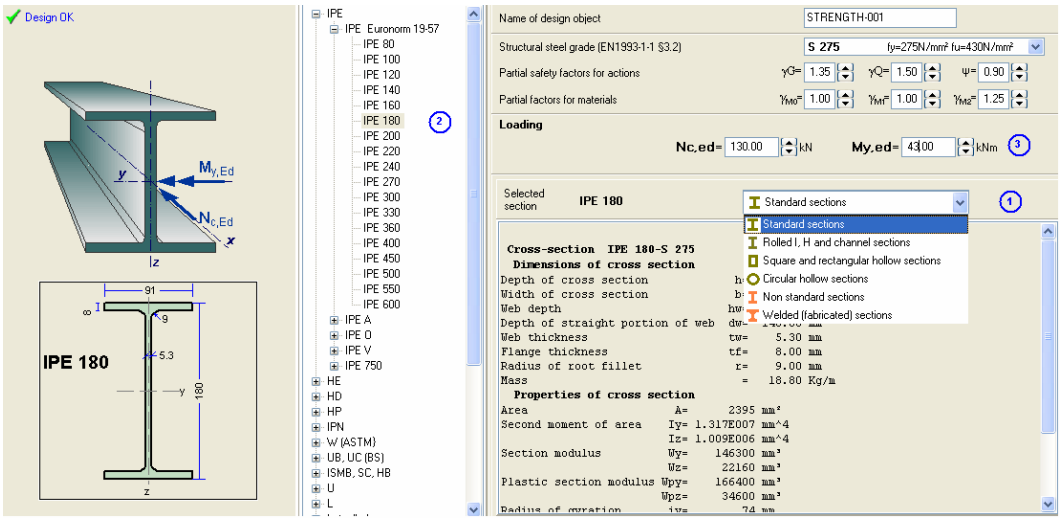


Design load combinations

- **Single actions**
  - Tension Nt
  - Compression Nc
  - Bending Myy
  - Bending Mzz
  - Shear Vz
  - Shear Vy
- **Double actions**
  - Bending and compression Nc-Myy
  - Bending and compression Nc-Mzz
  - Biaxial bending Myy-Mzz
  - Compression and shear Nc-Vz
  - Compression and shear Nc-Vy
- **Combined actions**
  - Compression, bending and shear Nc-Vz-My
  - Tension, bending and shear Nt-Vz-My
  - Bending and compression Nc-Myy-Mzz
  - Bending and tension Nt-Myy-Mzz
  - Axial force shear and bending N-V-M

1. Select section group (standard, non standard, welded)
2. From the tree on the left select the section.
3. Specify the design actions on the cross-section.

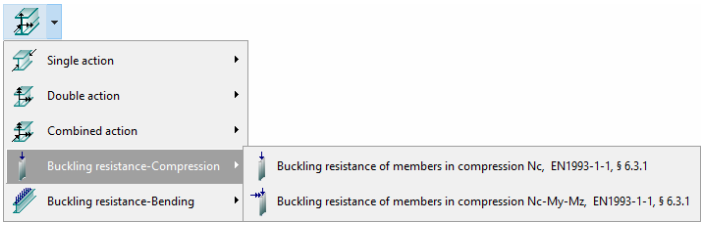
Detail report is obtained for the design of the selected cross-section under the specified loading. If the cross-section is not appropriate to resist the loading, error messages are displayed.



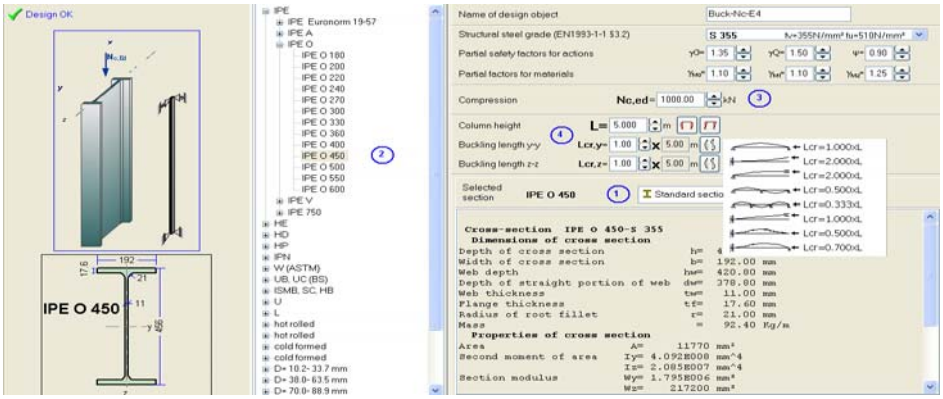
6.5 Buckling resistance of members (Eurocode 3, EN1993-1-1:2005 § 6.3)

6.5.1 Uniform members in compression EN1993-1-1:2005 § 6.3.1

Columns with axial load only

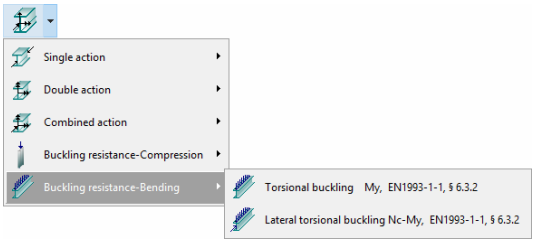


1. Select section group
2. From the tree on the left select the section.
3. Specify the design actions. Axial load Nc,ed [kN].
4. Specify the member length L in meters, and the buckling lengths in y-y and z-z direction. The buckling lengths are specified by the ratios to the member length. The ratios may be selected from the standard buckling lengths by click at or from the buckling lengths of frame columns by clicking at for braced or unbraced frames according to Eurocode 3.

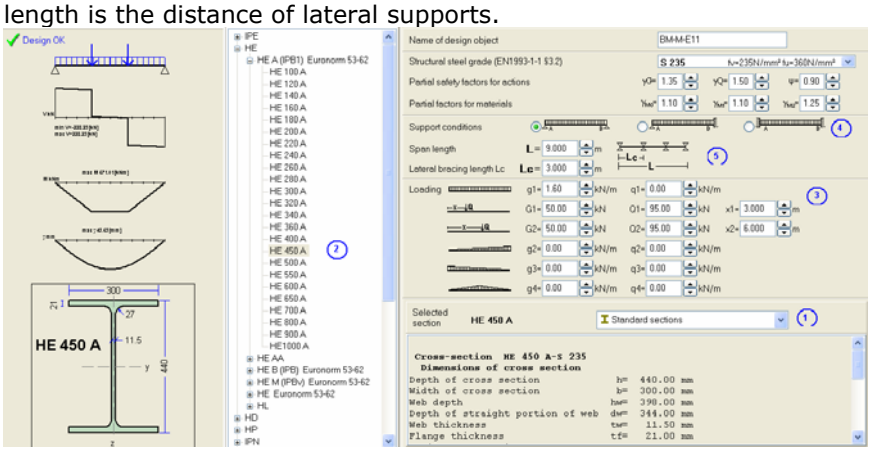


6.5.2 Uniform members in bending EN1993-1-1:2005 § 6.3.2

Beams with vertical load only



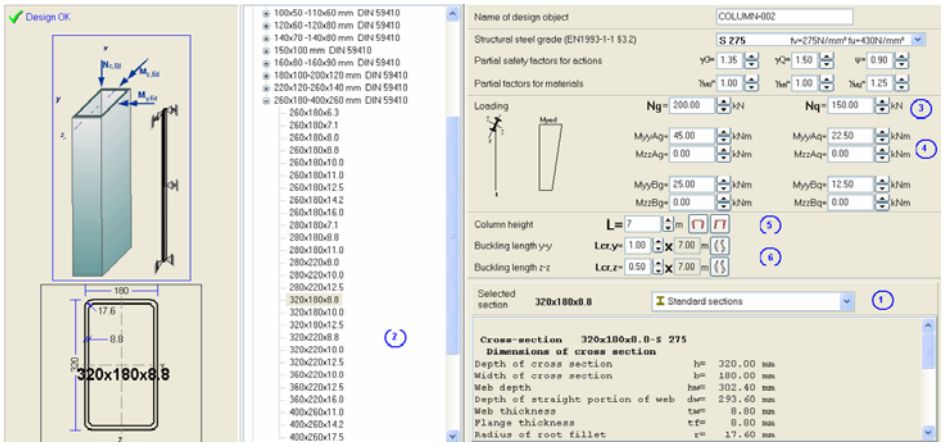
1. Select section group
2. From the tree on the left select the section.
3. Specify the beam loading as a combination of uniform [kN/m] and concentrated [kN] loads. For concentrated loads specify the distance x [m] from left support. The loads are for permanent and live loading conditions.
4. Specify the end support conditions of the beam (simply supported, fixed at one end or fixed at both ends).
5. Specify the member length L in meters, and the lateral buckling length Lc [m]. The lateral buckling length is the distance of lateral supports.



6.5.3 Uniform members in bending and axial compression, EN1993-1-1:2005 § 6.3.3

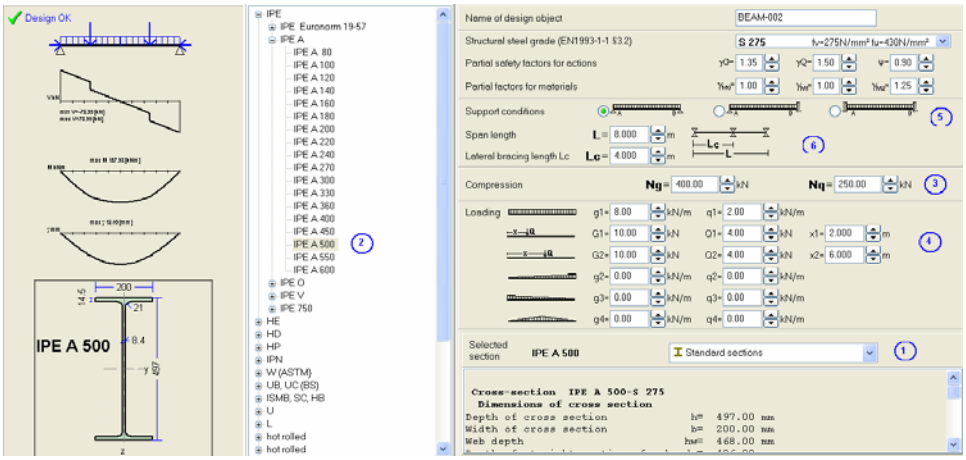
Columns with axial compression and end moments

1. Select section group
2. From the tree on the left select the section.
3. Specify the column axial load Ng [kN] (permanent) and Nq [kN] (live).
4. Specify the column end moments at top point A and bottom point B. Moments Myy [kNm] for the bending around the main axis and Mzz [kNm] for bending around the secondary axis. Moments MyyAg, MzzAg, MyyBg, MzzBg for permanent loading and MyyAq, MzzAq, MyyBq, MzzBq for live loading.
5. Specify the member length L in meters,
6. Specify the buckling lengths in y-y and z-z direction. The buckling lengths are specified by the ratios to the member length. This ratios may be selected from the standard buckling lengths by click at or from the buckling lengths of frame columns by clicking at for braced or unbraced frames according to Eurocode 3.



Beams with vertical load and axial compression

1. Select section group
2. From the tree on the left select the section.
3. Specify the axial load of the beam Ng[kN] permanent, Nq[kN] live load.
4. Specify the beam loading as a combination of uniform [kN/m] and concentrated [kN] loads. For concentrated loads specify the distance x [m] from left support. The loads are for permanent and live loading conditions.
5. Specify the end support conditions of the beam.
6. Specify the member length L in meters, and the lateral buckling length Lc [m]. The lateral buckling length is the distance of lateral supports.



6.6 Connections EN1993-1-8:2005

Design of various connections. For most types of connections there is

1. Connection design, Specify the connection loading and the program selects optimum connection geometry and bolt arrangement to satisfy the design of the connection.
2. Connection capacity, you specify the connection geometry and the bolt arrangement, and the capacity of the connection is evaluated

6.6.1 Connection types

Tension connections (design and capacity)

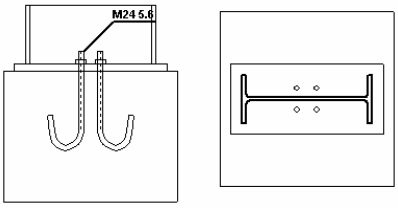
- double shear joint

Beam to beam connections (design and capacity)

- Beam-on-beam connection with web cleats

Beam to column connections

- Beam on column connection with end plates



- **Simple column base connection**

The connection has a base plate connected to the column by fillet welds. Holding down anchoring bolts are designed. The bolts are anchored in the concrete foundation with hooks or washer plates. If the connection is simple connection then the connection is not designed to carry bending moment. (pin connection). In the case of pin connection the bolts are located in the middle of the column. If the connection is designed to carry bending moment (fixed connection), the bolts are located outside and close to the peripheral of the column.

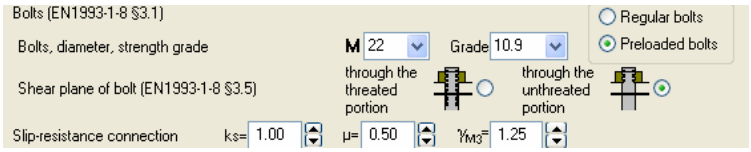
6.6.2 Connection data

Connection loading

Design forces and moments on the connected members as the drawing shows.

Connection bolts EN1993-1-8 §3.1

- Diameter of bolts in mm M (from 8 to 30 mm)
- Grade of bolts. (From 4.6 to 10.9) according to EN1993-1-8 Tab3.1.
- Regular or preloaded bolts (only for bolts of grades 8.8 and 10.9) EN1993-1-8 §3.1.2. In case of preloaded bolts give the values of Ks, μ ,γM3 according to EN1993-1-8 §3.9.1
- Shear plane through the treated part or not. EN1993-1-8 Tab 3.4.

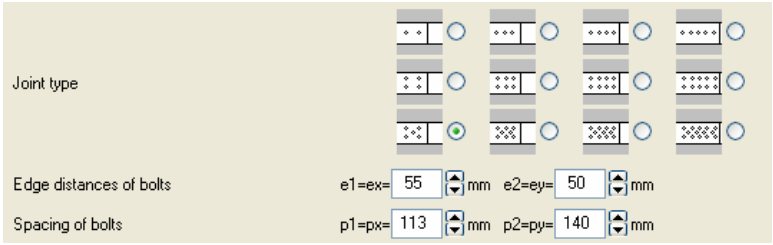


Connection plates

Dimensions of the connection plates are given in mm.

Joint geometry

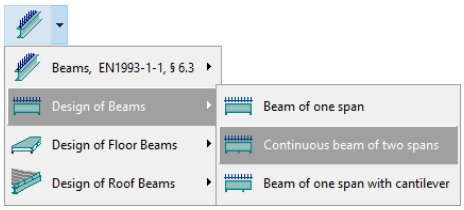
In case of evaluating the capacity of a joint, the number and positioning of the bolts has to be chosen. The basic distances between the bolts have to be specified.
In the case of designing a connection for a given load, the program selects the optimum geometry and the necessary number of bolts.
The distances from the edges and between the bolts are according to EN1993-1-8 Tab 3.3 and Fig. 3.1



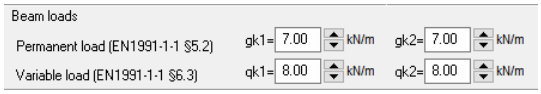
6.7 Design of Steel Beams

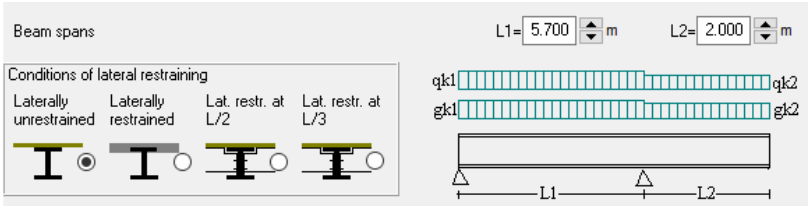
Beams in Uniform load

- Beams of One span,
- Two spans or one span
- Beam with one span and cantilever.



Beam loads
Uniformly distributed permanent and variable load in Kn/m. The program adds the beam self weight.

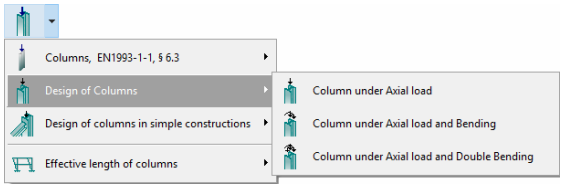




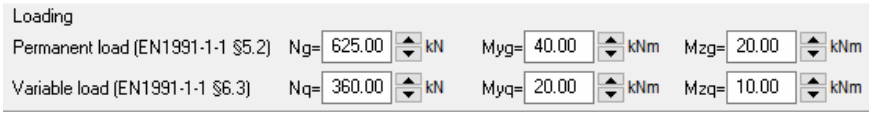
Beam span and lateral restrains
Beam span L in Meters
Conditions of lateral restrains, laterally unrestrained, laterally totally restrained, and laterally restrained in middle span or at one third span.

6.8 Design of Steel Columns

- Columns in axial load
- Columns in Axial load and simple bending
- Columns in Axial load and double bending

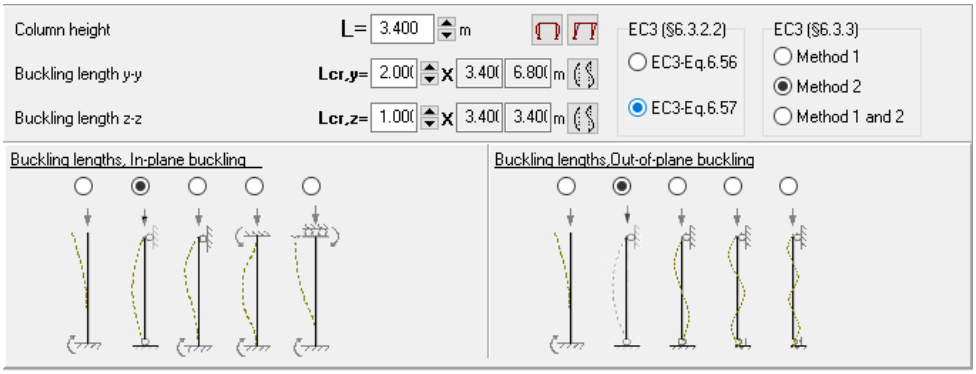


Loading



Axial load in (kN) and bending moments in (kNm) in the two bending directions. Y-y is the main bending direction, z-z is the secondary bending direction. Permanent and variable load.

Column height and buckling lengths



Column height and buckling lengths in the two bending directions, y-y and z-z n. The buckling lengths are specified by the ratios to the column length. The ratios may be selected from the standard buckling lengths by click at or from the buckling lengths of frame columns by clicking at for braced or unbraced frames according to Eurocode 3.

Eurocode 3 options

You can select the lateral buckling curves of Eq 6.56 or Eq. 6.57.
You can select the method (1 or 2 or both) for computing the interaction factors Kyy,kyz,kzy and kzz.

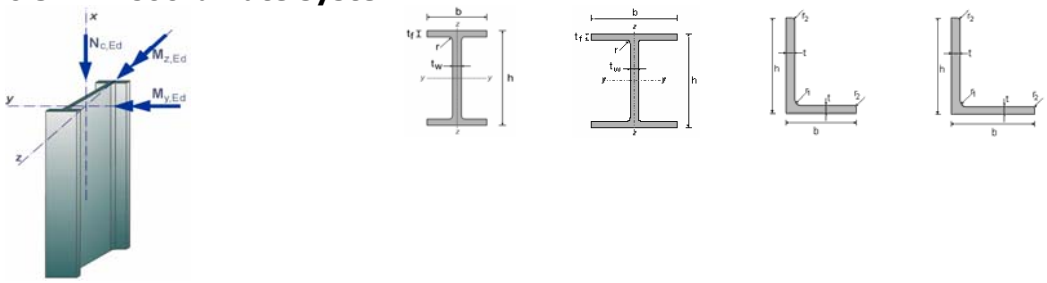
6.9 Short theoretical overview of steel structures

6.9.1 Units

The units used in the program are **SI (**System International Metric) units. The unit of any input value is marked next to the place you enter the data. The unit of every value in the report is also marked.

Units used in the program:
length [m] . and [mm]
forces [kN]
moments [kNm]
stresses [N/mm²] = [GPa]
concentrated loads [kN]
distributed loads [kN/m²]
line loads [kN/m]

6.9.2 Coordinate system



6.9.3 Materials EN 1993-1-1:2005 § 3.2

The steel grades listed in Eurocode EN 1993-1-1 Table 3.1 and EN 1993-1-3 are included in the program.
The steel properties (yield strength f_y and ultimate strength f_u) can be changed from Parameters/Material.
Design values for: Modulus of elasticity E=210000 N/mm², Poisson ratio v=0.30, Unit mass ρ= 7850 Kg/m³

6.9.4 Steel grades included in the program

S 235 EN 10025-2 fy40:235;fu40:360
S 275 EN 10025-2 fy40:275;fu40:430
S 355 EN 10025-2 fy40:355;fu40:510
S 450 EN 10025-2 fy40:440;fu40:550
S 275 N/NL EN 10025-3 fy40:275;fu40:390
S 355 N/NL EN 10025-3 fy40:355;fu40:490
S 420 N/NL EN 10025-3 fy40:420;fu40:520
S 460 N/NL EN 10025-3 fy40:460;fu40:540
S 275 M/ML EN 10025-4 fy40:275;fu40:370

S 355 M/ML EN 10025-4 fy40:355;fu40:470
S 420 M/ML EN 10025-4 fy40:420;fu40:520
S 460 M/ML' EN 10025-4 fy40:460;fu40:540
S 235 W EN 10025-5 fy40:235;fu40:360
S 355 W EN 10025-5 fy40:355;fu40:510
S 460 Q/QL EN 10025-6 fy40:460;fu40:570
S 235 H EN 10210-1 fy40:235;fu40:360
S 275 H EN 10210-1 fy40:275;fu40:430
S 355 H EN 10210-1 fy40:355;fu40:510
S 275 NH/NLH EN 10210-1 fy40:275;fu40:390
S 355 NH/NLH EN 10210-1 fy40:355;fu40:490
S 420 NH/NLH EN 10210-1 fy40:420;fu40:540
S 460 NH/NLH EN 10210-1 fy40:460;fu40:560
S 460 NH/NLH EN 10210-1 fy40:460;fu40:560
S 460 NH/NLH EN 10210-1 fy40:460;fu40:560
S 460 NH/NLH EN 10210-1 fy40:460;fu40:560

S 220GD+Z EN 10147 fy40:220;fu40:300
S 250GD+Z EN 10147 fy40:250;fu40:330
S 280GD+Z EN 10147 fy40:280;fu40:360
S 320GD+Z EN 10147 fy40:320;fu40:390
S 350GD+Z EN 10147 fy40:350;fu40:420
H240LA EN 10268 fy40:240;fu40:340
H280LA EN 10268 fy40:280;fu40:370
H320LA EN 10268 fy40:320;fu40:400
H360LA EN 10268 fy40:360;fu40:430
H400LA EN 10268 fy40:400;fu40:460
H260LAD EN 10292 fy40:240;fu40:340
H300LAD EN 10292 fy40:280;fu40:370
H340LAD EN 10292 fy40:320;fu40:400
H380LAD EN 10292 fy40:360;fu40:430
H420LAD EN 10292 fy40:400;fu40:460
220GD+ZA EN 10214 fy40:220;fu40:300
250GD+ZA EN 10214 fy40:250;fu40:330
280GD+ZA EN 10214 fy40:280;fu40:360
320GD+ZA EN 10214 fy40:320;fu40:390
350GD+ZA EN 10214 fy40:350;fu40:420

The steel grades for cold formed steel C Z and U sections are included.

6.9.5 Partial factors EN 1993-1-1:2005 § 6.1

The partial factors γ_M are applied to various characteristics resistance values. The partial factors are defined in the program from the selected National Annex., and can be overwritten in Parameters/National Annex parameters.
Usual values for steel structures
$\gamma_{M0} = 1.00$
$\gamma_{M1} = 1.00$
$\gamma_{M2} = 1.25$
Usual values for concrete structures (EN1992-1-1 Tab. 2.1N)
$\gamma_c = 1.50$ (concrete)
$\gamma_s = 1.15$ (reinforcing steel)

6.9.6 Second order effects EN1993-1-1 §5.2.1

The material behaviour is considered linear elastic. The second order effects are geometrical (P-Δ and P-δ) effects. The practical consequence of (P-Δ)-effects is to reduce the stiffness of the frame, with a result the increase of the deflections and the internal forces beyond the ones calculated from first-order analysis.
The effects of the deformed geometry are quantified using the factor a_{cr} EN1993-1-1 §5.2.1

acr=Fcr/Fed EN1993-1-1 Eq. (5.1)

Fed: is the design loading of the structure
Fcr : is the elastic critical buckling load for global instability mode based on initial elastic stiffness.
The frame is considered sufficiently stiff and second order effects may be ignored in a first order analysis if $a_{cr} \geq 10$
For portal frames with shallow slopes according to EN1993-1-1 §5.2.1 (4) a_{cr} can be estimated as

$$\alpha_{cr} = \left(\frac{H_{Ed}}{V_{Ed}}\right)\left(\frac{h}{\delta_{H,Ed}}\right)$$ EN1993-1-1 Eq (5.2)

Hed : total design the total design horizontal load
Ved : total design vertical load
δ_{hed} : is the horizontal displacement at the top of the columns
h : is the column height

Axial force in the rafters may be assumed to be significant if

$$\bar{\lambda} < 0.5\sqrt{\frac{Af_y}{N_{Ed}}}$$ EN1993-1-1 Eq (5.3)

According to EN1993-1-1 §5.2.2 (5), single story portal frames designed based on elastic analysis the global analysis second order effects due to vertical load may be calculated by increasing the horizontal loads Hed by equivalent loads φ Ved due to imperfections and other possible sway effects according to the first order theory by an amplification factor

$$\frac{1}{1-1/\alpha_{cr}}$$ provided that $a_{cr} \geq 3$ EN1993-1-1 Eq (5.4)

If $\alpha_{cr} < 3$, second order analysis is necessary

6.9.7 Imperfections EN1993-1-1 §5.3.1

Global initial sway imperfection: $\varphi = \varphi_0 \bullet \alpha_h \bullet \varphi_m$
φ_0: Initial value =1/200
α_h: Reduction factor for column height = $2/\sqrt{h}$ ($2/3 \leq \alpha_h \leq 1$) (h: structure height)
φ_m: Reduction factor for number of columns in a row $\alpha_m = \sqrt{0.5\left(1+\frac{1}{m}\right)}$

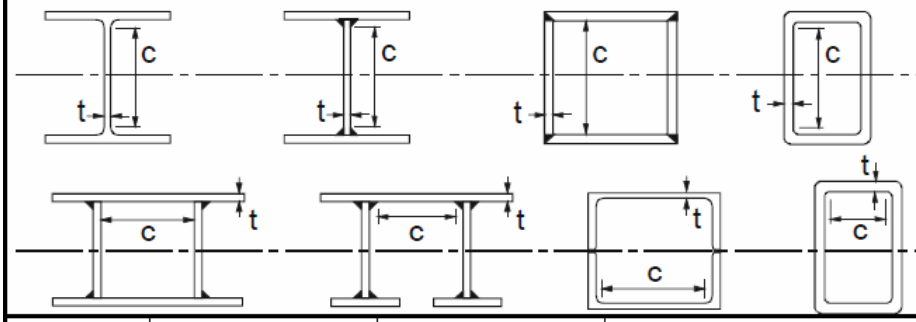
6.9.8 Steel section types included in the program

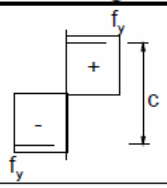
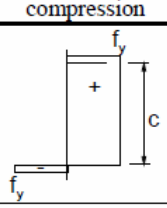
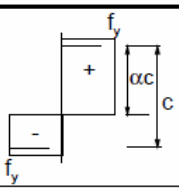
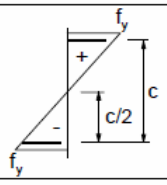
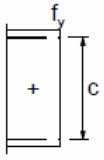
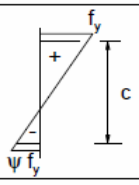
IPE	European I-beams	IPE 80-600 IPE A 80-600 IPE O 180-600 IPE V 400-600 IPE 750
IPE Euronorm 19-57		
IPE A		
IPE O		
IPE V		
IPE 750		
HE	European wide flange beams	HE A 100-1000 HE AA 100-1000 HE B 100-1000 HEM 100-1000 HE 400-1000 HL 1000/1100
HE A (IPB1) Euronorm 53-62		
HE AA		
HE B (IPB) Euronorm 53-62		
HE M (IPBv) Euronorm 53-62		
HE Euronorm 53-62		
HL		
HD	Beams with very wide flanges	HD 260x54.1 – 400x1086
HD-1		
HD-2 ASTM A6/A 6M		
HP	Wide flange columns	HP 200x57.2 – 400x231
HP		
IPN	Wide flange bearing piles	IPN 80-550
IPN		
W (ASTM)	European standard beams	W 360x370x134 W 1100x400x499
W-1 ASTM A6/A 6M		
W-2 ASTM A6/A 6M		
W-3 ASTM A6/A 6M		
UB, UC (BS)	American wide flange beams	UB 178x102x19 UB 914x419x388
UB-1 BS 4 part 1-1993		
UB-2 BS 4 part 1-1993	British universal beams	UC 152x152x23 UC 356x406x634
UC BS 4 part 1-1993		
ISMB, SC, HB		
ISMB Indian Standard		
ISSC Indian Standard		
ISHB Indian Standard		
U	British universal columns	UPN 30-65 UPN 80-400
UPN		
UAP NF A 45-255	European standard channels	UAP 80-300 UPE 80-400
UPE		
L	Channels with parallel flanges	L 20x20x3 L 250x250x28
L20x20x3..80x80x8 Euronorm 56-77		
L100x100x8..160x160x19 Euronorm 56-77	Equal angels	L 30x20x3 L 250x90x16
L180x180x16..250x250x28 Euronorm 56-77		
L30x20x3..80x40x8 Euronorm 57-78		
L90x60x6..130x40x12 Euronorm 57-78	Unequal angels	Ø 10.2x1.0 Ø 1016x400
L150x75x9..250x90x16 Euronorm 57-78		
θερμής έλασης	Circular hollow sections	20x20x1.6 400x400x12.5
θερμής έλασης		
ψυχρής έλασης	Square hollow sections cold formed	40x40x2.6 400x400x20.0
ψυχρής έλασης		
D= 10.2- 33.7 mm	Square hollow sections hot rolled	30x20x1.5 500x300x12.5
D= 38.0- 63.5 mm		
D= 70.0- 88.9 mm	Rectangular hollow sections cold formed	50x30x2.6 400x260x17.5
D=101.6-159.0 mm		
D=168.3-193.7 mm	Rectangular hollow sections hot rolled	
D=219.1-355.6 mm		
D=406.4-508.0 mm		
D=559.0-660.0 mm		
D=771.0-1016 mm		

6.9.9 Classification of cross sections EN 1993-1-1:2005 § 5.5

The design of steel elements can be done with elastic or plastic analysis depending on the class of the cross section.
The design of sections of classes 1 and 2 is based on the plastic resistance, the design of cross-sections of class 3 is based on elastic resistance, and the design of cross-sections of class 4 is based on elastic resistance and effective cross section properties.
The classification of cross sections in 1, 2, 3 and 4 classes depends on the ratios of thickness to width of the parts of the cross-section which are in compression according to tables 5.2 of EN 1993-1-1:2005.

Table 5.2 EN 1993-1-1:2005 – Internal compression parts

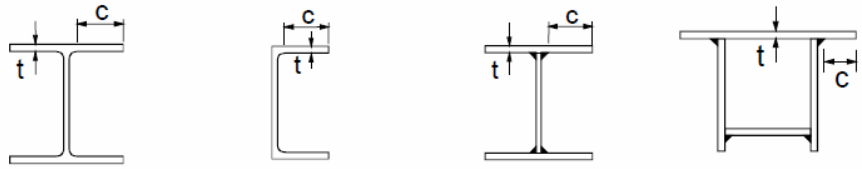


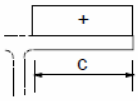
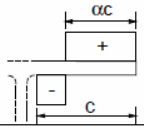
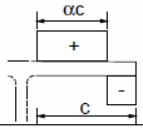
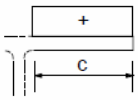
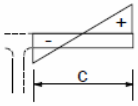
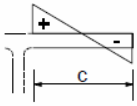
Class	Part subject to bending	Part subject to compression	Part subject to bending and compression
Stress distribution in parts (compression positive)			
1	$c/t \le 72\varepsilon$	$c/t \le 33\varepsilon$	when $\alpha > 0{,}5$: $c/t \le \frac{396\varepsilon}{13\alpha - 1}$ when $\alpha \le 0{,}5$: $c/t \le \frac{36\varepsilon}{\alpha}$
2	$c/t \le 83\varepsilon$	$c/t \le 38\varepsilon$	when $\alpha > 0{,}5$: $c/t \le \frac{456\varepsilon}{13\alpha - 1}$ when $\alpha \le 0{,}5$: $c/t \le \frac{41{,}5\varepsilon}{\alpha}$
Stress distribution in parts (compression positive)			
3	$c/t \le 124\varepsilon$	$c/t \le 42\varepsilon$	when $\psi > -1$: $c/t \le \frac{42\varepsilon}{0{,}67 + 0{,}33\psi}$ when $\psi \le -1$ [*)] : $c/t \le 62\varepsilon(1-\psi)\sqrt{(-\psi)}$

$\varepsilon = \sqrt{235/f_y}$	f_y	235	275	355	420	460
	ε	1,00	0,92	0,81	0,75	0,71

Table 5.2 EN 1993-1-1:2005 – Outstanding flanges

Outstand flanges

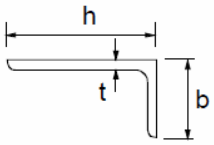


Class	Part subject to compression	Part subject to bending and compression	
		Tip in compression	Tip in tension
Stress distribution in parts (compression positive)			
1	$c/t \le 9\varepsilon$	$c/t \le \frac{9\varepsilon}{\alpha}$	$c/t \le \frac{9\varepsilon}{\alpha\sqrt{\alpha}}$
2	$c/t \le 10\varepsilon$	$c/t \le \frac{10\varepsilon}{\alpha}$	$c/t \le \frac{10\varepsilon}{\alpha\sqrt{\alpha}}$
Stress distribution in parts (compression positive)			
3	$c/t \le 14\varepsilon$	$c/t \le 21\varepsilon\sqrt{k_\sigma}$ For k_σ see EN 1993-1-5	

$\varepsilon = \sqrt{235/f_y}$	f_y	235	275	355	420	460
	ε	1,00	0,92	0,81	0,75	0,71

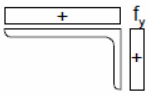
Table 5.2 EN 1993-1-1:2005 - Angles

Angles

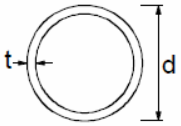


Refer also to "Outstand flanges" (see sheet 2 of 3)

Does not apply to angles in continuous contact with other components

Class	Section in compression
Stress distribution across section (compression positive)	
3	$h/t \le 15\varepsilon : \frac{b+h}{2t} \le 11{,}5\varepsilon$

Tubular sections



Class	Section in bending and/or compression
1	$d/t \le 50\varepsilon^2$
2	$d/t \le 70\varepsilon^2$
3	$d/t \le 90\varepsilon^2$ **NOTE** For $d/t > 90\varepsilon^2$ see EN 1993-1-6.

$\varepsilon = \sqrt{235/f_y}$	f_y	235	275	355	420	460
	ε	1,00	0,92	0,81	0,75	0,71
	ε^2	1,00	0,85	0,66	0,56	0,51

6.9.10 Ultimate limit states, EN 1993-1-1:2005 § 6.2

Tension EN 1993-1-1:2005 § 6.2.3

$$\frac{N_{Ed}}{N_{t,Rd}} \le 1 \qquad \text{(EN 1993-1-1, 6.5)}$$

Design plastic resistance of the cross-section.

$$N_{pl,Rd} = \frac{A \cdot f_y}{\gamma_{M0}} \qquad \text{(EN 1993-1-1, 6.6)}$$

Design ultimate resistance of net cross-section at holes for fasteners.

$$N_{u,Rd} = \frac{0.9 A_{net} \cdot f_u}{\gamma_{M2}} \qquad \text{(EN 1993-1-1, 6.7)}$$

A *area of cross-section*
A_{net} *area of net cross-section (minus holes)*
f_y *yield strength of steel*
f_u *ultimate strength of steel*
γ_{M0} , γ_{M2} *partial factors for material*

Compression EN 1993-1-1:2005 § 6.2.4

$$\frac{N_{Ed}}{N_{c,Rd}} \le 1 \qquad \text{(EN 1993-1-1, 6.9)}$$

$$N_{c,Rd} = \frac{A \cdot fy}{\gamma_{M0}} \quad \text{for class 1, 2, 3 cross-sections} \qquad \text{(EN 1993-1-1, 6.10)}$$

$$N_{c,Rd} = \frac{A_{eff} \cdot fy}{\gamma_{M0}} \quad \text{for class 4 cross-sections} \qquad \text{(EN 1993-1-1, 6.11)}$$

A *area of cross-section*
A_{eff} *effective area of cross-section*
fy *yield strength of steel*
γ_{M0} *partial factors for material*

In case the design value of shear is $V_{Ed} > 0.50 V_{pl,Rd}$ the reduced yield strength is used.

$(1-\rho)fy$, where ρ = $\left(\frac{2V_{Ed}}{V_{pl,Rd}} - 1\right)^2$ (EN 1993-1-1, 6.29)

Bending moment EN 1993-1-1:2005 § 6.2.5

$$\frac{M_{Ed}}{M_{c,Rd}} \le 1 \qquad \text{(EN 1993-1-1, 6.12)}$$

Design resistance of cross section for bending about the principal (y-y) or secondary (z-z) axis.

$$M_{y,Rd} = M_{pl,y,Rd} = \frac{W_{pl,y} \cdot fy}{\gamma_{M0}} \quad \text{for class 1, 2 cross-sections} \qquad \text{(EN 1993-1-1, 6.13)}$$

$$M_{z,Rd} = M_{pl,z,Rd} = \frac{W_{pl,z} \cdot fy}{\gamma_{M0}} \quad \text{for class 1, 2 cross-sections}$$

$$M_{y,Rd} = M_{el,y,Rd} = \frac{W_{el,y} \cdot fy}{\gamma_{M0}} \quad \text{for class 3 cross-sections} \qquad \text{(EN 1993-1-1, 6.14)}$$

$$M_{z,Rd} = M_{el,z,Rd} = \frac{W_{el,z} \cdot fy}{\gamma_{M0}} \quad \text{for class 3 cross-sections}$$

$$M_{y,Rd} = M_{c,y,Rd} = \frac{W_{eff,y} \cdot fy}{\gamma_{M0}} \quad \text{for class 4 cross-sections} \qquad \text{(EN 1993-1-1, 6.15)}$$

$$M_{z,Rd} = M_{c,z,Rd} = \frac{W_{eff,z} \cdot fy}{\gamma_{M0}} \quad \text{for class 4 cross-sections}$$

$W_{pl,y}$ $W_{pl,z}$ *plastic section modulus about principal and secondary axis,*

$W_{el,y}$ $W_{el,z}$ *elastic section modulus about principal and secondary axis,*

$W_{eff,y}$ $W_{eff,z}$ *effective section modulus about principal and secondary axis,*

fy *yield strength of steel*

γ_{M0} *partial factors for material*

When bending moment acts together with axial force design check is performed according to :

$$\frac{M_{Ed}}{M_{N,Rd}} \le 1 \qquad \text{(EN 1993-1-1, 6.31)}$$

$$M_{N,Rd} = M_{pl,Rd}\left[1 - \left(\frac{N_{Ed}}{N_{pl,Rd}}\right)^2\right] \qquad \text{(EN 1993-1-1, 6.32)}$$

In case the design value of shear is $V_{Ed} > 0.50 V_{pl,Rd}$ the reduced yield strength is used.

$(1-\rho)fy$, where ρ = $\left(\frac{2V_{Ed}}{V_{pl,Rd}} - 1\right)^2$ (EN 1993-1-1, 6.29)

Bi-axial bending EN 1993-1-1:2005 § 6.2.9

$$\left(\frac{M_{y,Ed}}{M_{y,Rd}}\right)^{\alpha}+\left(\frac{M_{z,Ed}}{M_{zRd}}\right)^{\beta}\le 1 \qquad \text{(EN 1993-1-1, 6.41)}$$

For I and H sections: α=2, β=5n, β≥1 ($n=N_{Ed}/N_{pl,Rd}$)
For circular hollow sections: α=2, β=2
For rectangular hollow sections $\alpha=\beta=1.66/(1-1.13\,n^2)$

Shear EN 1993-1-1:2005 § 6.2.6

$$\frac{V_{Ed}}{V_{c,Rd}}\le 1 \qquad \text{(EN 1993-1-1, 6.17)}$$

Plastic shear resistance parallel to the cross-section web.

$$V_{z,Rd}=V_{pl,z,Rd}=\frac{A_{vz}\cdot f_y}{\sqrt{3}\gamma_{M0}} \qquad \text{(EN 1993-1-1, 6.18)}$$

Plastic shear resistance parallel to the cross-section flanges.

$$V_{y,Rd}=V_{pl,y,Rd}=\frac{A_{vy}\cdot f_y}{\sqrt{3}\gamma_{M0}} \qquad \text{(EN 1993-1-1, 6.18)}$$

A_{vy} A_{vz} *shear areas parallel to the cross-section web or flanges,*
fy *yield strength of steel*
γ_{M0} *partial factors for material*

6.9.11 Buckling resistance of uniform members in compression

EN 1993-1-1:2005 § 6.3.1

Buckling resistance due to compression.

$$\frac{N_{Ed}}{N_{b,Rd}} \le 1 \qquad \text{(EN 1993-1-1, 6.46)}$$

$$N_{b,Rd} = \frac{\chi A f_y}{\gamma_{M1}} \quad \text{for class 1, 2, 3 cross-sections} \qquad \text{(EN 1993-1-1, 6.47)}$$

$$N_{b,Rd} = \frac{\chi A_{eff}\, f_y}{\gamma_{M1}} \quad \text{for class 4 cross-sections} \qquad \text{(EN 1993-1-1, 6.48)}$$

The reduction factor χ is determined from the non-dimensional slenderness $\overline{\lambda}$

$$\chi = \frac{1}{\Phi + \sqrt{\Phi^2 - \overline{\lambda}^2}} \le 1 \qquad \text{(EN 1993-1-1, 6.49)}$$

$$\Phi = 0.5\left[1 + \alpha\left(\overline{\lambda} - 0.2\right) + \overline{\lambda}^2\right]$$

$$\overline{\lambda} = \sqrt{\frac{Af_y}{N_{cr}}};\ N_{cr} = \frac{\pi^2 \mathrm{EA}}{\lambda^2};\ \lambda = \frac{l_{eff}}{i};\ i = \sqrt{\frac{I}{A}}$$

$\overline{\lambda}$ *non-dimensional slenderness,*
N_{cr} *elastic critical buckling load,*
Lcr equivalent buckling length,
λ slenderness,
i radius of gyration.

The imperfection factor α that corresponds to the appropriate buckling curve ao,a,b,c,d should be obtained from Table 6.2 of Eurocode 3, EN 1993-1-1:2005:

Buckling curve	a_o	a	b	C	d
Imperfection factor α	0.13	0.21	0.34	0.49	0.76

Equivalent buckling lengths Lcr/L

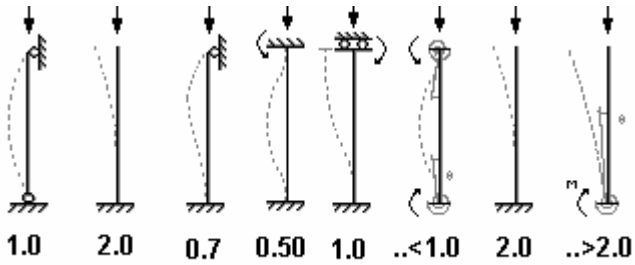
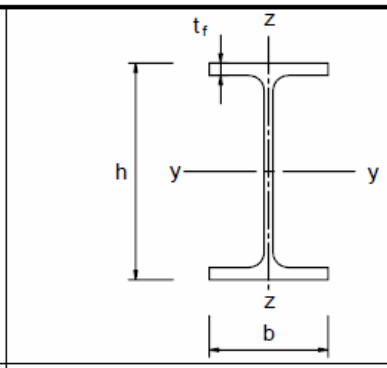
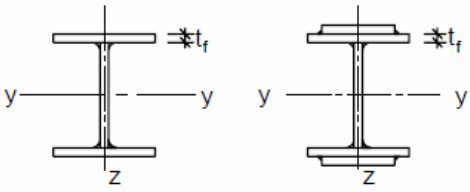
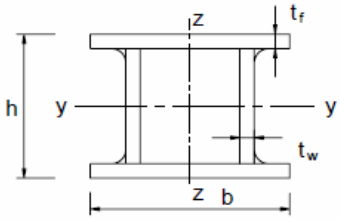
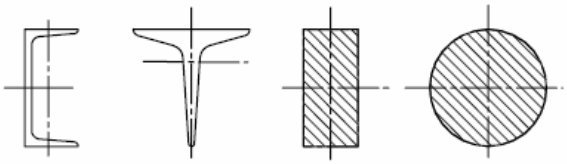
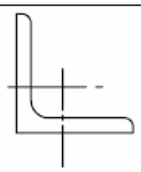


Table 6.2 EN 1993-1-1:2005 Selection of buckling curve of a cross-section

Cross section		Limits		Buckling about axis	Buckling curve: S 235 S 275 S 355 S 420	Buckling curve: S 460
Rolled sections		h/b > 1,2	$t_f \le 40$ mm	y – y z – z	a b	a_0 a_0
			40 mm < $t_f \le 100$	y – y z – z	b c	a a
		h/b ≤ 1,2	$t_f \le 100$ mm	y – y z – z	b c	a a
			$t_f > 100$ mm	y – y z – z	d d	c c
Welded I-sections		$t_f \le 40$ mm		y – y z – z	b c	b c
		$t_f > 40$ mm		y – y z – z	c d	c d
Hollow sections		hot finished		any	a	a_0
		cold formed		any	c	c
Welded box sections		generally (except as below)		any	b	b
		thick welds: a > 0,5t_f b/t_f < 30 h/t_w <30		any	c	c
U-, T- and solid sections				any	c	c
L-sections				any	b	b

6.9.12 Lateral torsional buckling for uniform members EN 1993-1-1:2005 § 6.3.2

Lateral torsional buckling of uniform members in bending.

$$\frac{M_{Ed}}{M_{b,Rd}} \le 1 \qquad \text{(EN 1993-1-1, 6.54)}$$

$$M_{b,Rd} = \frac{\chi_{LT} W_y f_y}{\gamma_{M1}} \qquad \text{(EN 1993-1-1, 6.55)}$$

$W_y = W_{pl,y}$ for class 1, 2 cross-sections,

$W_y = W_{el,y}$ for class 3 cross-sections,

$W_y = W_{eff,y}$ for class 4 cross-sections.

The reduction factor χ_{LT} is determined from the non-dimensional slenderness $\overline{\lambda}_{LT}$

$$\chi_{LT} = \frac{1}{\Phi_{LT} + \sqrt{\Phi_{LT}^2 - \overline{\lambda}_{LT}^2}} \le 1 \qquad \text{(EN 1993-1-1, 6.56)}$$

$$\Phi_{LT} = 0.5\left[1 + \alpha_{LT}\left(\overline{\lambda}_{LT} - 0.2\right) + \overline{\lambda}_{LT}^2\right]$$

$$\overline{\lambda}_{LT} = \sqrt{\frac{W_y f_y}{M_{cr}}}$$

The imperfection factor α which corresponds to the appropriate buckling curve a,b,c,d:

Buckling curve	a	b	C	d
Imperfection factor α_{LT}	0.21	0.34	0.49	0.76

Recommended values for torsional buckling curves:
Rolled Sections h/b<2 buckling curve a, h/b>2 buckling curve b
Welded sections h/b<2 buckling curve c, h/b>2 buckling curve d

The critical elastic moment for lateral torsional buckling is computed according to Annex F of Eurocode 3-1-1 (1992).

$$M_{cr} = C_1 \frac{\pi^2 EI_z}{(kL)^2}\left[\sqrt{\left(\frac{k}{k_w}\right)^2 \frac{I_w}{I_z} + \frac{(kL)^2 GI_t}{\pi^2 EI_z} + \left(C_2 Z_g - C_3 Z_j\right)^2} - \left(C_2 Z_g - C_3 Z_j\right)\right]$$

C1, C2, C3, coefficients depending on the loading conditions and support conditions,
for a beam with uniform bending moment diagram C1=1.000, C2=0.000, C3=1.000
for a beam with parabolic bending moment diagram C1=1.132, C2=0.459, C3=0.525

I_t *St. Venant torsional constant,*

I_w *warping constant,*

I_z *second moment of inertia about the weak axis,*

L *beam length between the support points,*

k , k_w *coefficients depending on the support conditions,*

Z_g *distance of shear center from point of load application*

6.9.13 Uniform members in bending and compression EN 1993-1-1:2005 § 6.3.4

$$\frac{N_{Ed}}{x_y N_{Rk}/\gamma_{M1}} + k_{yy}\frac{M_{Y,Ed}}{\chi_{LT} M_{y,Rk}/\gamma_{M1}} + k_{yz}\frac{M_{z,Ed}}{M_{z,Rk}/\gamma_{M1}} \le 1 \qquad \text{(EN 1993-1-1, 6.61)}$$

$$\frac{N_{Ed}}{x_z N_{Rk}/\gamma_{M1}} + k_{zy}\frac{M_{Y,Ed}}{\chi_{LT} M_{y,Rk}/\gamma_{M1}} + k_{zz}\frac{M_{z,Ed}}{M_{z,Rk}/\gamma_{M1}} \le 1 \qquad \text{(EN 1993-1-1, 6.62)}$$

$N_{Rk} = Af_y$

$M_{y,Rk} = W_{pl,y} f_y$ for class 1, 2 cross-sections
$M_{y,Rk} = W_{el,y} f_y$ for class 3 cross-sections,
$M_{y,Rk} = W_{eff,y} f_y$ for class 4 cross-sections,
$M_{z,Rk} = W_{pl,z} f_y$ for class 1, 2 cross-sections
$M_{z,Rk} = W_{el,z} f_y$ for class 3 cross-sections,
$M_{z,Rk} = W_{eff,z} f_y$ for class 4 cross-sections.

The interaction coefficients $k_{yy}, k_{yz}, k_{zy}, k_{zz}$ are determined from tables B.1 and B.2

Table B.1 interaction coefficients $k_{yy}, k_{yz}, k_{zy}, k_{zz}$

Interaction factors	Type of sections	Design assumption	
		elastic cross-sectional properties class 3, class 4	plastic cross-sectional properties class 1, class 2
k_{yy}	I-sections RHS-sections	$C_{my}\left(1+0{,}6\bar{\lambda}_y\frac{N_{Ed}}{\chi_y N_{Rk}/\gamma_{M1}}\right) \le C_{my}\left(1+0{,}6\frac{N_{Ed}}{\chi_y N_{Rk}/\gamma_{M1}}\right)$	$C_{my}\left(1+(\bar{\lambda}_y-0{,}2)\frac{N_{Ed}}{\chi_y N_{Rk}/\gamma_{M1}}\right) \le C_{my}\left(1+0{,}8\frac{N_{Ed}}{\chi_y N_{Rk}/\gamma_{M1}}\right)$
k_{yz}	I-sections RHS-sections	k_{zz}	$0{,}6\,k_{zz}$
k_{zy}	I-sections RHS-sections	$0{,}8\,k_{yy}$	$0{,}6\,k_{yy}$
k_{zz}	I-sections	$C_{mz}\left(1+0{,}6\bar{\lambda}_z\frac{N_{Ed}}{\chi_z N_{Rk}/\gamma_{M1}}\right) \le C_{mz}\left(1+0{,}6\frac{N_{Ed}}{\chi_z N_{Rk}/\gamma_{M1}}\right)$	$C_{mz}\left(1+(2\bar{\lambda}_z-0{,}6)\frac{N_{Ed}}{\chi_z N_{Rk}/\gamma_{M1}}\right) \le C_{mz}\left(1+1{,}4\frac{N_{Ed}}{\chi_z N_{Rk}/\gamma_{M1}}\right)$
	RHS-sections		$C_{mz}\left(1+(\bar{\lambda}_z-0{,}2)\frac{N_{Ed}}{\chi_z N_{Rk}/\gamma_{M1}}\right) \le C_{mz}\left(1+0{,}8\frac{N_{Ed}}{\chi_z N_{Rk}/\gamma_{M1}}\right)$
For I- and H-sections and rectangular hollow sections under axial compression and uniaxial bending $M_{y,Ed}$ the coefficient k_{zy} may be $k_{zy} = 0$.			

Table B.2

Interaction factors	Design assumptions	
	elastic cross-sectional properties class 3, class 4	plastic cross-sectional properties class 1, class 2
k_{yy}	k_{yy} from Table B.1	k_{yy} from Table B.1
k_{yz}	k_{yz} from Table B.1	k_{yz} from Table B.1
k_{zy}	$\left[1-\frac{0,05\bar{\lambda}_z}{(C_{mLT}-0,25)}\frac{N_{Ed}}{\chi_z N_{Rk}/\gamma_{M1}}\right]$ $\geq\left[1-\frac{0,05}{(C_{mLT}-0,25)}\frac{N_{Ed}}{\chi_z N_{Rk}/\gamma_{M1}}\right]$	$\left[1-\frac{0,1\bar{\lambda}_z}{(C_{mLT}-0,25)}\frac{N_{Ed}}{\chi_z N_{Rk}/\gamma_{M1}}\right]$ $\geq\left[1-\frac{0,1}{(C_{mLT}-0,25)}\frac{N_{Ed}}{\chi_z N_{Rk}/\gamma_{M1}}\right]$ for $\bar{\lambda}_z < 0,4$: $k_{zy}=0,6+\bar{\lambda}_z \leq 1-\frac{0,1\bar{\lambda}_z}{(C_{mLT}-0,25)}\frac{N_{Ed}}{\chi_z N_{Rk}/\gamma_{M1}}$
k_{zz}	k_{zz} from Table B.1	k_{zz} from Table B.1

Factor	Bending axis	Points braced in direction
Cmy	y-y	z-z
Cmz	z-z	y-y
CmLT	y-y	y-y

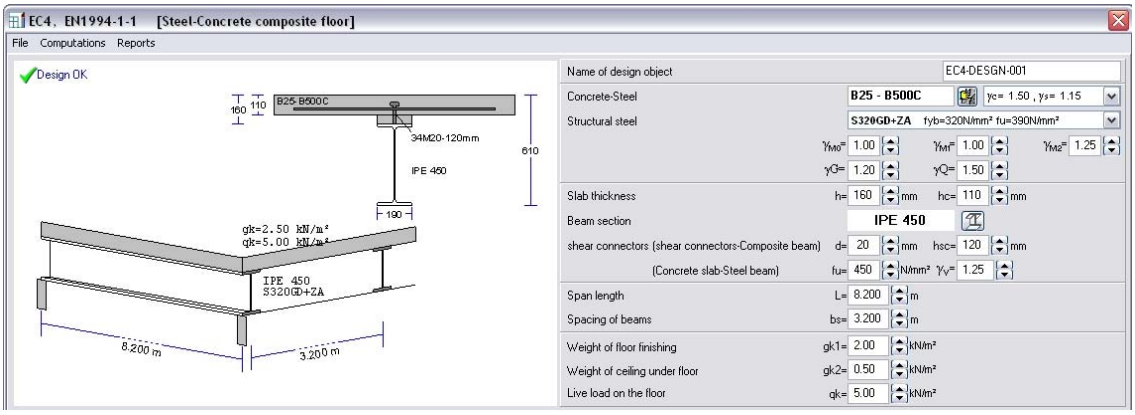
Table B.3

Moment Diagram	Range		C_{my}, C_{mz} и C_{mLT} under loading	
			Distributed	Concentrated
M ψM	$-1 \leq \psi \leq 1$		$0,6 + 0.4\,\psi \geq 0,4$	
(–) M_h ψM_h (+) M_s $\alpha_s = M_s/M_h$	$0 \leq \alpha_s \leq 1$	$-1 \leq \psi \leq 1$	$0,2 + 0.8\,\alpha_s \geq 0,4$	$0,2 + 0.8\alpha_s \geq 0,4$
	$-1 \leq \alpha_s < 0$	$0 \leq \psi \leq 1$	$0,1 - 0.8\,\alpha_s \geq 0,4$	$-0.8\alpha_s \geq 0,4$
		$-1 \leq \psi < 0$	$0,1(1-\psi) - 0.8\,\alpha_s \geq 0,4$	$0,2(-\psi) - 0.8\,\alpha_s \geq 0,4$
(+) M_s (+) M_h ψM_h $\alpha_h = M_h/M_s$	$0 \leq \alpha_h \leq 1$	$-1 \leq \psi \leq 1$	$0,95 + 0,05\,\alpha_h$	$0,90 + 0,10\,\alpha_h$
	$-1 \leq \alpha_h < 0$	$0 \leq \psi \leq 1$	$0,95 + 0,05\,\alpha_h$	$0,90 + 0,10\,\alpha_h$
		$-1 \leq \psi < 0$	$0,95 + 0,05\,\alpha_h(1+2\psi)$	$0,90 - 0,10\,\alpha_h(1+2\psi)$

7 Eurocode 4 , EN 1994

7.1 Steel-Concrete composite floor (EN 1994-1-1 §6.2)

Simply supported composite beams. He web of the steel section is encased by reinforced concrete and shear connectors are provided between the concrete slab and the steel beam. The concrete works in compression and the steel section works in tension. Action effects are calculated by elastic global analysis. The bending resistance of the composite cross-section is based on plastic model. When sufficient shear connection exist to develop the full plastic resistance of the section the connection is consider "full shear connection". When the resistance moment of the section increases with the number of shear connectors, the shear connection is "partial shear connection".



7.1.1 Basic input data Steel-Concrete composite floor

Partial factors for actions: permanent action γ_G, live action γ_Q. Design action $Q_{ed} = \gamma_G \cdot G + \gamma_Q \cdot Q$

Concrete slab
- Concrete and steel classes.
- Material factors γc and γs
- h (mm): Total slab height above the steel section
- hc(mm): Slab thickness, solid part of slab.

Steel Beams
- Steel strength classes
- Material factors γMo, γM1 γM2.
- Steel beam profile

Shear connectors, ductile headed studs
- Diameter of the shank of the stud connector d (mm)
- Overall nominal height of stud connector hsc (mm)
- Ultimate tensile strength of headed studs fu (N/mm^2)
- Partial factor for design shear resistance of a headed stud γ_v,

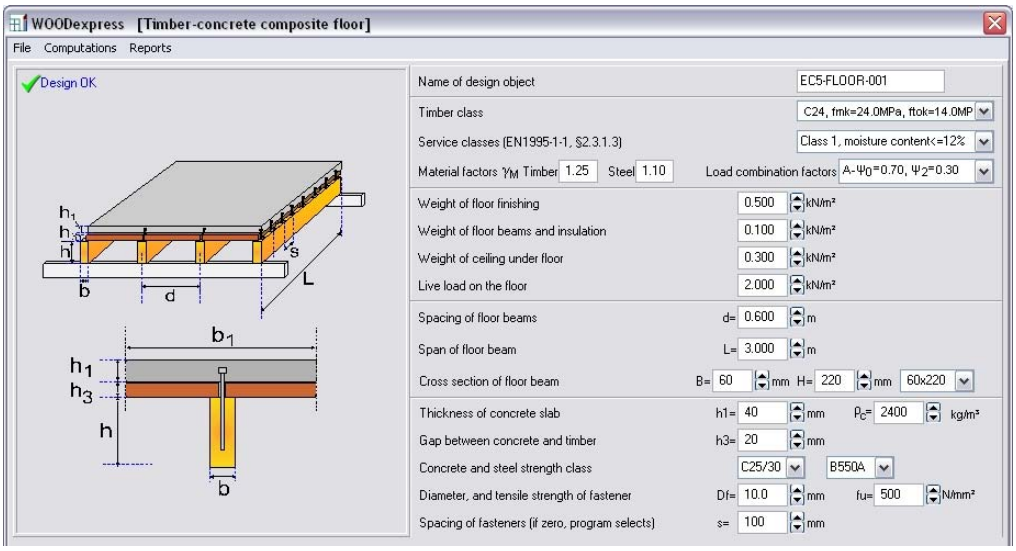
Beam dimensions
- Clear span length L (m)
- Beam spacing in transverse direction bs (m)

Floor Loading
- Weight of floor finishing gk1 (kN/m^2)
- Weight of ceiling underneath (if any) gk2 (kN/m^2)
- Live load on the floor qk (kN/m^2)

Design load of the floor qed= $\gamma_G \cdot (gk1+gk2+gk3+gk4)+ \gamma_Q \cdot qk$
(gk3 is weight of concrete slab, gk4 weight of steel beam, both evaluated by the program)

7.2 Timber-concrete composite floor (EN 1995-1-1:Annex B)

In this type of composite floors the concrete is only in compression, and timber is used in tension. The load carrying capacity and the out of plane rigidity of the floor is increased compared to a timber floor. The design of the composite cross section is based on EN 1995-1-1:Annex B.
In addition to the data supplied as in one span floors the data for the concrete/steel material, and slab thickness must be supplied, and the size, spacing and strength of the metal fasteners. If the spacing of the metal fasteners is set to zero (0) then the program selects an optimum value.
If the concrete slab is quite thick then the neutral axis is inside the slab and a design failure message appears for the concrete slab. In this case you may reduce the thickness of the concrete slab or increase the gap between concrete and timber h3, so to have the concrete in compression only.

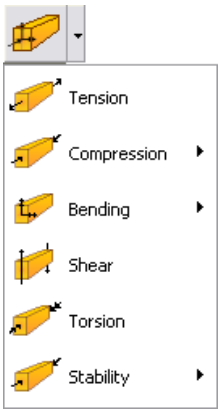


7.2.1 Basic input data Timber-concrete composite floor

Timber class and service class
Material factors γM for timber and steel (fasteners).
Concrete slab
Concrete and steel classes.
Concrete weight ρc (kg/m^3)
h1(mm): Slab thickness, solid part of slab.
h2(mm): Gap between concrete slab and timber beam.
Shear connectors,
Diameter of the shank of the stud connector d (mm)
Ultimate tensile strength of headed studs fu (N/mm^2)
Spacing s (mm) of shear connectors. If s set to zero (0) the program selects an optimum spacing.
Floor Loading
Weight of floor finishing gk1 (kN/m^2)
Weight of beams and insulation gk2 (kN/m^2)
Weight of ceiling underneath (if any) gk3 (kN/m^2)
Live load on the floor qk (kN/m^2)
Design load of the floor qed= $\gamma_G \cdot (gk1+gk2+gk3)+ \gamma_Q \cdot qk$

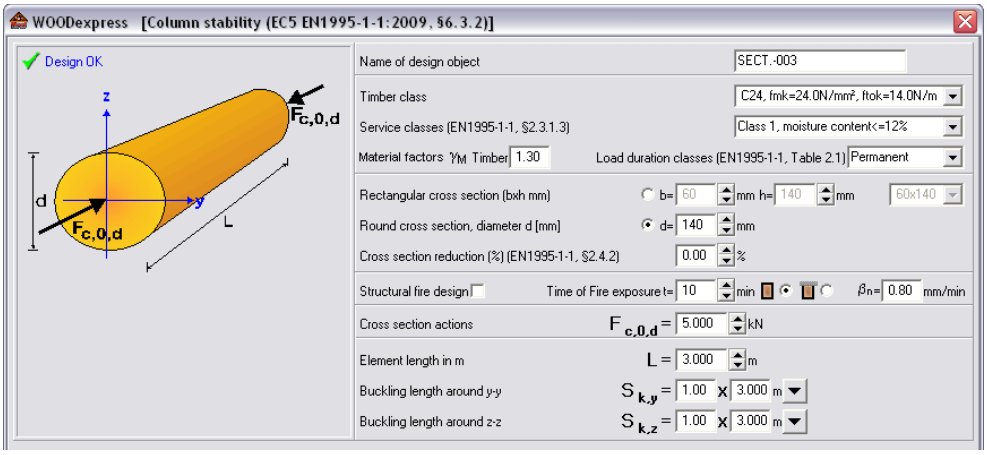
8 Eurocode 5, EN 1995-1-1:2003 Design of timber structures

8.1 Ultimate limit states



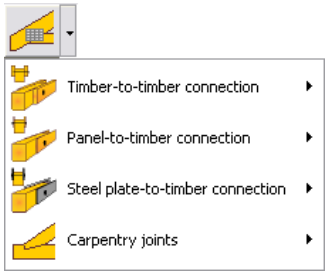
Design of various cases of single or combined action according to Eurocode 5, EN 1995-1-1:2004 §6. You specify the timber cross-section dimensions, the timber properties, the cross-section loads, and the design check is performed according to Eurocode 5.

- Tension
- Compression
- Bending
- Shear
- Torsion
- Stability



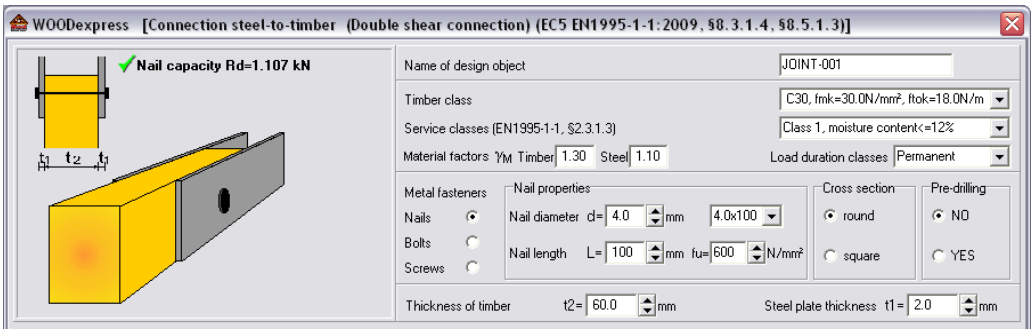
Many Ultimate limit cases can run automatically using the actions and section properties from other programs, using the Command language, Appendix 1.

8.2 Connections

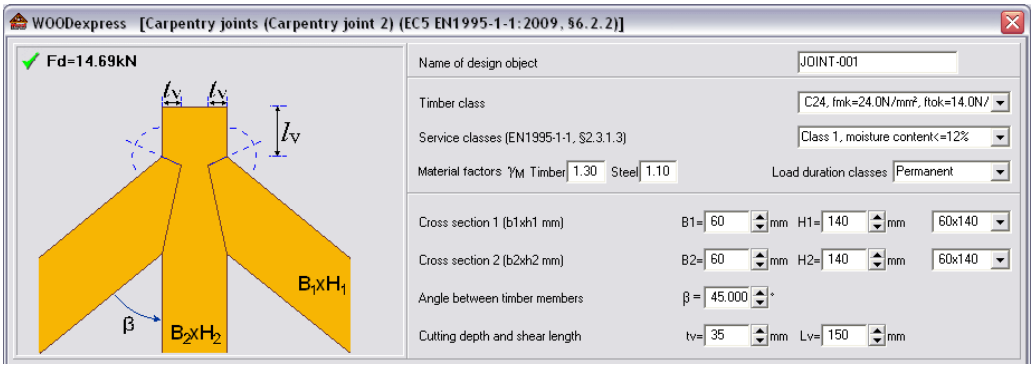


Design of nailed connections of various types. You specify the properties of the nails, (nail dimensions, round or square cross section), and the properties of the connection wood or metal plate. The Nail Capacity **Rd** is computed according to Eurocode 5, EN 1995-1-1:2004 §8.

- Timber to timber connection
- Panel to timber connection
- Steel plate to timber connection
- Carpentry joints



Example of Steel plate to timber connection

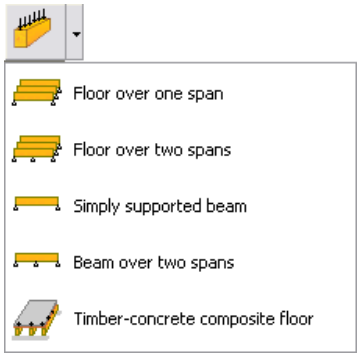


Example of Carpentry joint

8.3 Beams and Floors

In this session of the program you can design:

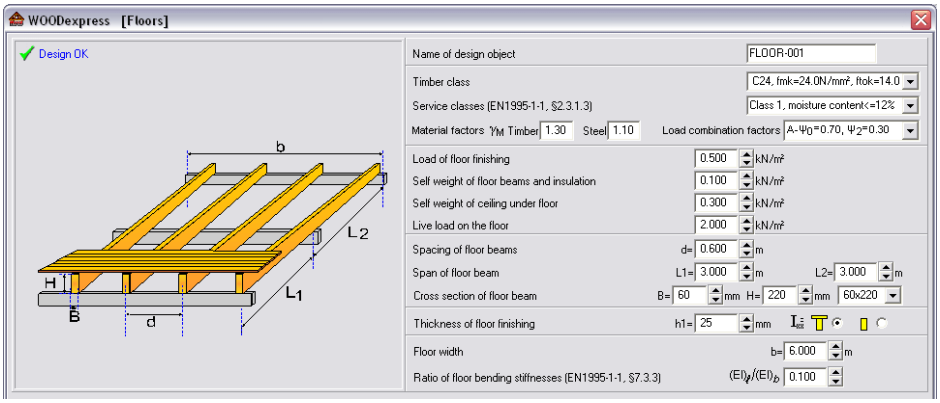
- Floor over one span
- Floor over two spans
- Simply supported beams
- Beam over two spans
- Timber-concrete composite floors



8.3.1 Floors over one or two spans

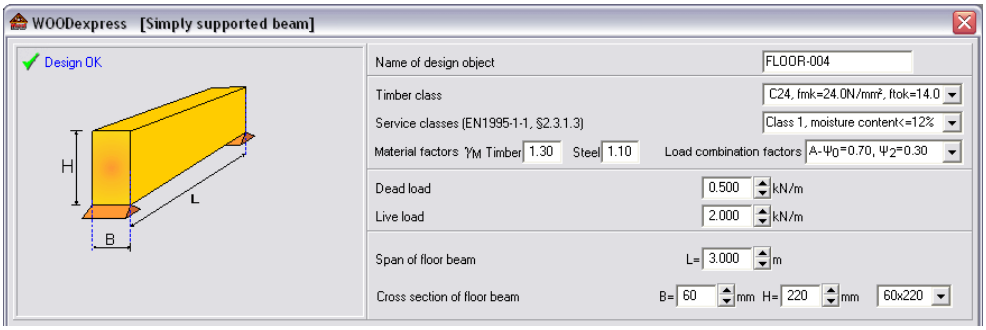
The internal forces are computed at the ends and the midspan of the floor beam, and the elastic bending deformations at midspan, for all the load combinations according to Eurocode 0,1 and 5. All the checks of Eurocode 5 are performed in ultimate limit state. The deformations are checked in serviceability limit state according to EN 1995-1-1:2004 §7.2. The Eurocode 5, EN 1995-1-1:2004 §7.3.3 considerations are taken into account for the check of floor vibrations.

The user has the option to select the way the moment of inertia of the floor beams is evaluated for the computation of deformations and vibrations.
a. as T cross/section with flange the floor finishing.
b as rectangular cross section.



8.3.2 Simply supported beams and beam over two spans

Simply supported beams under line load. As in one span floors the internal forces are computed at the ends and the midspan of the floor beam, and the elastic bending deformations at midspan, for all the load combinations according to Eurocode 0,1 and 5.



8.4 Timer roofs

From the programs main menu you can choose from various roof structures. Select the one you prefer, and perform a full design according to Eurocode 5. The loadings are evaluated according to Eurocode 1. The roof finishing (rafter), the purlins and the truss members are design for all the load combinations prescribed in Eurocode 1 and Eurocode 5. The internal forces of the trusses are computed with finite element analysis of the truss structure. The user can select the degree of stiffness of the connections (stiff or flexible joint connections). The truss is considered as a two dimensional frame structure, and the stiffness of the connections is adjusted according to the selected degree of stiffness.

In order to compute the design values for internal forces in various loading conditions, the internal forces are computed for unit loading, and from their combination the internal forces in various loading conditions are obtained.

All the load combinations according to Eurocode 0 and Eurocode 5 are taken into account and the checks are performed in the most unfavourable loading conditions, for combined action in ultimate limit state of design, according to EC 5 §6.

The deformations are checked in serviceability limit condition, according to EC 5 §4. The truss deflections are checked in **serviceability limit condition**, according to EN 1995-1-1:2004 §7.2.

The maximum deflection for finishing or purlins are computed as:
1: Beams fixed at one end, when the span of finishing (distance of purlins) or the span of purlins (distance between trusses) is less than the half of the timber length defined in parameters and assumptions,
2: Simply supported beam when the span is larger than half of the timber length.

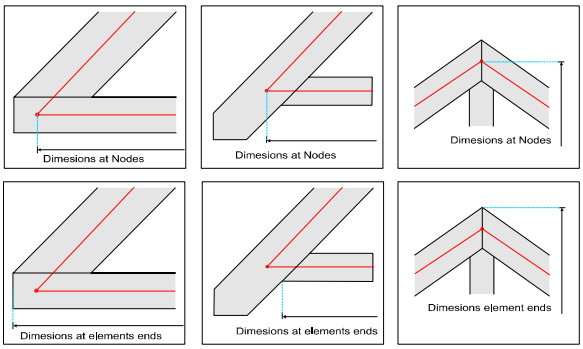
In EN the coefficients for checking the limit of allowable deflections are specified in the program as parameters. are defined in Table 7.2, as regions L/300~L/500, L/250~L350, L150~L/300. In the program in menu [Parameters/Parameters and assumptions] you can define the values you want. Default values (L/300, L/250 and L/150). The limits for cantilevering beams are taken as half of the above.

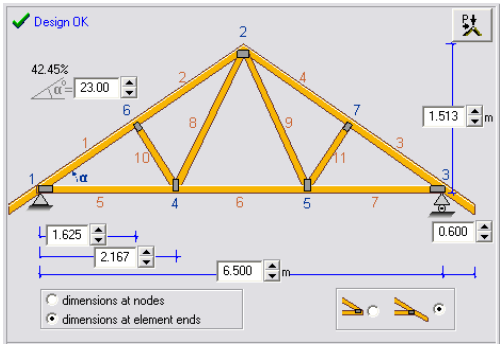
The natural frequencies of the roof trusses are also computed after a dynamic analysis.

The connections can be nailed, screwed or bolted joints with metal plates and they are dimensioned according to EN 1995-1-1:2004 §8.
A detailed report is produced, and shows analytically all the computations, design steps, design assumptions and references to the corresponding design code paragraphs. Automatic generation of truss drawings that can be manipulated with the CAD modulus. Warnings in red appear in the report in cases of inadequate design.

8.4.1 Roof dimensions

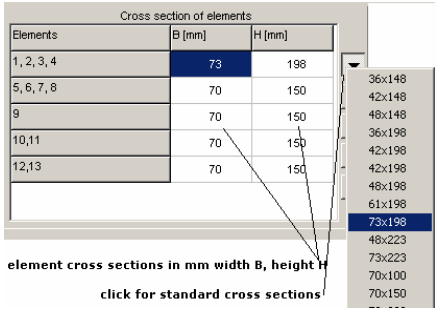
In the calculation window there is a sketch of the object. Specify the basic roof dimensions in meters [m], according to the roof truss drawing. The roof pitch (angle with the horizontal) may be specified. If you give the roof height the roof pitch is obtained, otherwise, if you give the roof pitch the roof height is obtained.
You can specify dimensions at the nodal points (intersection of element axis) or the total dimensions. Select what dimensions you are giving.
You can also choose if you want the truss to be extended at left and right ends with cantilever elements or if you want an asymmetric roof..





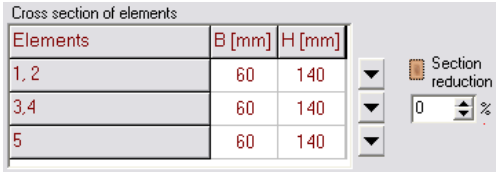
8.4.2 Element cross sections

For the elements of the truss you specify the cross section dimensions. The elements of the same cross section are grouped according to the most common sizes in different countries, EN1313-1. The cross section is rectangular with width B and height H. The dimensions of the cross section are in [mm].
In the program there are included user defined groups of timber sections for the truss elements and the purlins. The user can define two(2) groups for timber sections for truss elements and two (2) groups for purlins. From [parameters/timber sections] you can select the group of timber sections you want to appear in the design of roofs.



8.4.3 Reduction of timber sections

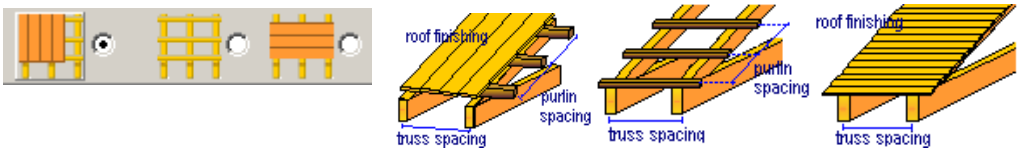
Specify the cross sections of the elements used in the truss. If the timber of the trusses are old, damaged or suffered from deterioration, you can specify a reduction of cross section in %.



8.4.4 Roof secondary structure

You can select between three types of roofing.

- Roof consisting of purlins and timber finishing on top. The finishing may be rafters laid on top of the purlins. The tiles are laid on top of the finishing.
- Roof consisting of purlins and no rafters on top. The tiles are laid on top of the purlins.
- Roof with the timber finishing (rafters) nailed directly on the roof truss.

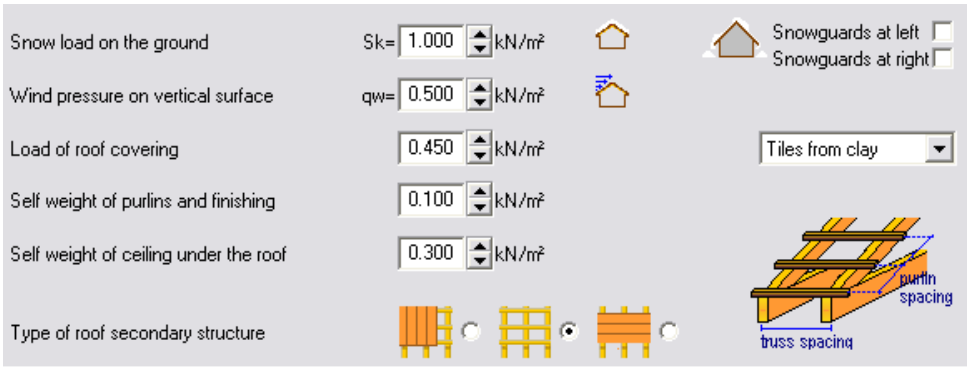


8.4.5 Roof loads

You specify the loads:

- dead load of the roof covering materials [kN/m^2],
- snow load on the ground [kN/m^2]
- wind load as wind pressure on a vertical surface in [kN/m^2] .
- self weight of purlins and roof finishing materials (insulation, water proofing) in [kN/m$^{2]}$
- dead load of the ceiling under the roof in [kN/m$^{2]}$
- dead and live loads on the attic floor in [kN/m^2]

The default values for these loads are set in the menu [Parameters].



8.4.6 Concentrated loads

Enter the nodal loads in [kN]. Node (first column) is the nodal point where the concentrated force is applied. Fy, vertical nodal force positive downwards. Fx horizontal nodal force positive towards the right side. #Load in the last column is the load case for the nodal loads.

Nodal loads

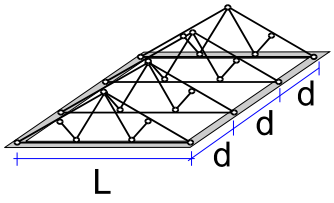
Node	Fy kN	Fx kN	#Load
2	5.2	0	0
2	2	0	1
2	3.2	1.2	5

Permanent loads,	Load case =0
Snow loads	Load cases 1 to 4 (see fig pg. 10)
Wind loads	Load cases 5 and 6 (pg. 11)

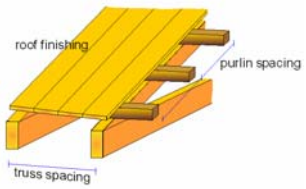
8.4.7 Snow and wind loading

For the snow load you specify the characteristic snow load on the ground in kN/m^2. The snow loading on the structure is computed according to Eurocode 1, EN 1991-1-3:2003. For the wind loading you specify the wind pressure on a vertical surface in kN/m^2.
The wind loading on the structure is computed according to Eurocode 1, prEN 1991-1-4:2004.

8.4.8 Spacing of trusses



Spacing of purlins



8.4.9 Truss connections

The connections are considered as bolted, nailed or screwed joints with single or double steel plate and they are dimensioned according to Eurocode 5, EN 1995-1-1:2004 §8.

- The user can select or specify :
- The type of connection, nailed, bolted or screwed connections.
- The diameter of the nails, bolts or screws, as well as the type of nails (round or square). The tensile strength of the steel for the nails, screws or bolts can be specified.
- The plate arrangement. Double plates on both sides of the truss surface or inside the truss member, single plate on the outside surface or inside the truss member.
- The thickness of connection plates.
- The yielding stress of plate steel.
- The degree of stiffness of the connection to perform the truss analysis.
- Multiple or single plates for each joint. Selecting multiple plates reduces the plate size in connections with more than two members.

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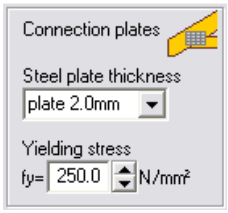
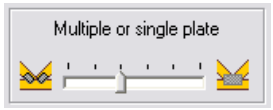
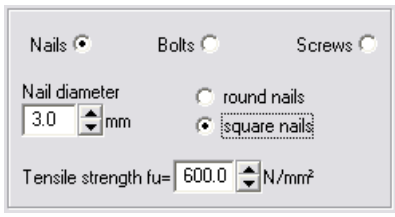
Truss connections, Steel plates



Select the thickness of plates in mm. In the case of nailed joints you can select standard plates as (BMF plates 1.50 or 2.00 mm). When you choose BMF plates the program selects the optimal plate size from the available BMF plates, and marks it in the drawings details of the connection. If the BMP plate is getting too large, or no reasonable dimensions for BMF plates are available, the program will choose ordinary steel plates and this will also show in the drawing and reports.
You specify also the characteristic value of yielding stress of the connection plates fy in kN/mm². The default value is defined in parameters and assumptions
When the steel plates are getting very large, try multiple plates.

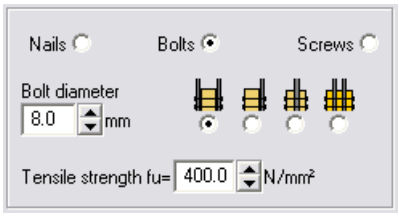


Truss connections, Nails



Specify the nail diameter (in mm), as well as the type of nails (round or square). In case of selecting BMF plates automatically the nails are set to 4mm shank nails. Specify also the tensile strength of the nails fu kN/mm², (EN1995-1-1:2004, Eq. 8.14). The default value of the tensile strength of nails is specified in parameters and assumptions.
The minimum nail length will be specified automatically by the program according to EN1995-1-1 §8, and shown in the report and drawings.

Truss connections, Bolts

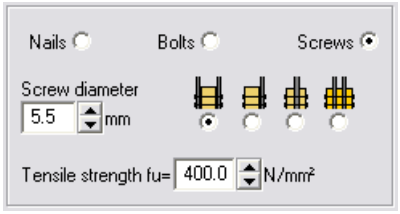


When you are using bolts in connections, specify the following:
The diameter of the bolts in mm.
The position of the connection plates:

- double plate on both faces of the timber members.
- single plate on one face of the timber members.
- single plate in the middle of the timber members.
- double plate inside the timber members.

The tensile strength of the bolts, fu in kN/mm², (EN1995-1-1:2004, Eq. 8.30). The default value of the tensile strength of bolts is specified in parameters and assumptions
The steel plate thickness t in mm .
The yielding stress of the steel of the connection plate, fy in kN/mm². The default value of yielding stress of the connection plates is defined in parameters and assumptions.

Truss connections, Screws



When you are using screws in connections, specify the following:
The diameter of the screws in mm.
The position of the connection plates:

- double plate on both faces of the timber members.
- single plate on one face of the timber members.
- single plate in the middle of the timber members.
- double plate inside the timber members.

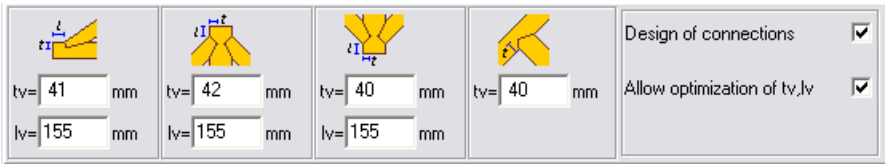
The tensile strength of the screws, fu in kN/mm², (EN1995-1-1:2004, Eq. 8.30). The default value of the tensile strength of screws is specified in parameters and assumptions
The plate thickness t in mm.
The yielding stress of the steel of the connection plate, fy in kN/mm². The default value of yielding stress of the connection plates is defined in parameters and assumptions

The minimum screw length will be specified automatically by the program according to EN1995-1-1 §8, and shown in the report and drawings.

Carpentry joints

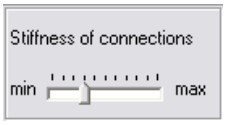
In carpentry joints you specify the cutting depth (tv) and shear surface length (Lv) for each joint. When you select timber section dimensions tv and Lv are set to the default values which are tv=h/4 and lv= h. The minimum value if Lv is 150 mm.
When the [Alllow optimisation] is checked, the values the user is specifying for *tv* and *lv*, may change if from the solution comes out that larger values are needed. If this option is unchecked then

tv and lv are kept and if the joint is inadequate an error message shows. By pressing the reset values *t*v and *l*v are reset to the default values (h/h and h or 150 mm)



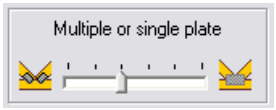
Stiffness of connections

You select the stiffness of connections. By moving the bar at left the truss is solved with very flexible (almost pin) connections. By moving the bar to the right the truss is solved with very stiff connections. The connections are considered as bolted, screwed or nailed joints with single or double steel plate and they are dimensioned according to EN 1995-1-1:2004 § 8.



Truss connections, Plate arrangement

The user can select the connection plates to be multiple plates instead of single plate in order to reduce the plate sizes. If the pointer is moved to the left the program selects multiple plates in the connections. If the pointer moves to the right the program selects single plates in the connections. If the pointer is placed between the program depending on the size of the plate selects multiple or single plate automatically depending on the connection type and the angle of the connected members.



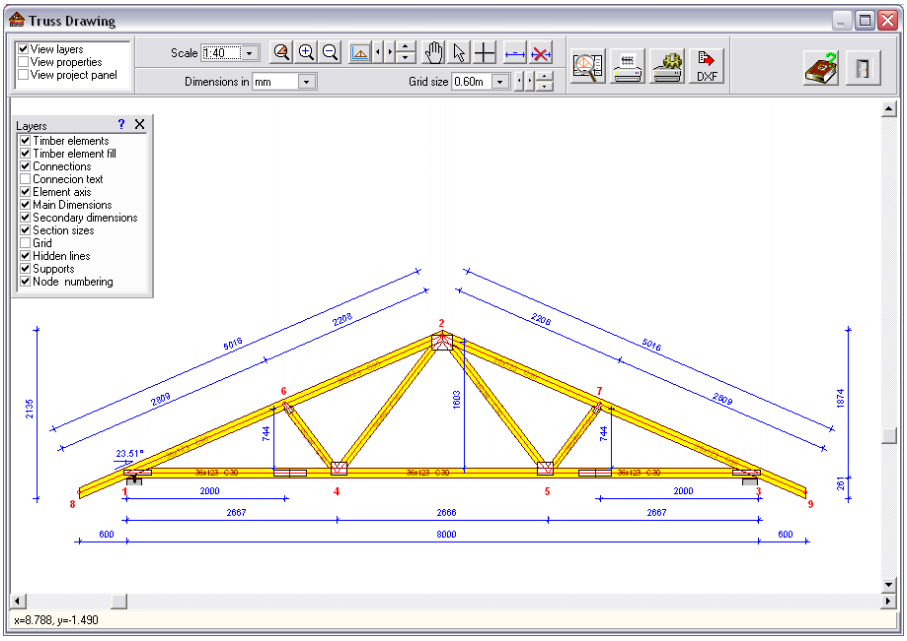
The user is advised to perform a solution with single (right position) and with multiple (left position), and select the preferable configuration.

8.4.10 Asymmetric roofs

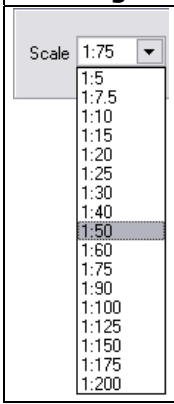
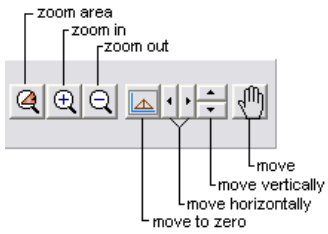
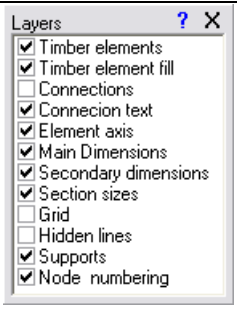
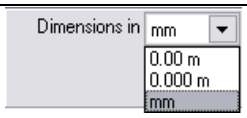
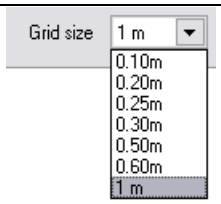
In design window, choose asymmetric and adjust the dimensions.

8.4.11 CAD drawing of roof trusses

The CAD modulus of the program automatically creates a detailed truss drawing. You can adjust the scale of the drawing, and you can choose the visible layers. The properties of the drawing components, (line thickness, colour, text size) can also be adjusted. You can also specify the dimension units that are shown on the graph.
Before previewing or printing the drawing you can select the printing paper size, and move the drawing to the desired position on the paper.



CAD Features

Scale of Drawing	Zoom	Layers	Dimension units	Grid
				

Scale/Move/Zoom If you cannot see all or parts of the truss on the screen, you can scale or move your drawing. You activate/deactivate the move command (hand) by double clicking on the drawing. By right click you can change cursor.

Layers Choose the layers you want to be visible and printed. The properties of the layers are defined of the Properties of drawing components.

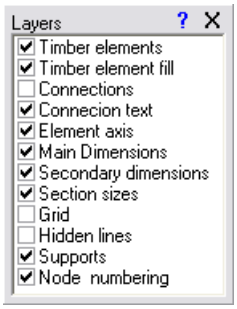
Dimension units

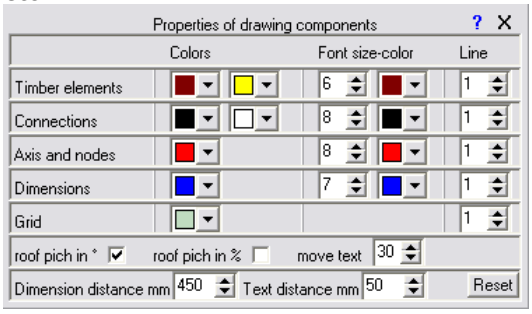
Choose unit for dimensions appearing on the truss drawing. This will be the default unit until you change it.

Grid If you want the grid to appear, from the layers panel, check the grid and choose the size from the pull down menu. By clicking on the small arrows on the right, you move the grid in relation to the drawing.

Line thickness, colour and font sizes

By using this panel you can adjust the appearance of the truss drawing.
Turn on or off the layers from the panel with Layers.
For the line type of **Axis and nodes**, choose line thickness **1 for dashed line**, line thickness 2 for the thinner solid line etc.





There are three levels of dimensioning. By adjusting the dimension distance you move the dimension lines further or closer to the truss element.
By adjusting the Text distance you move the connection text further or closer to the truss connections.
The values you are setting are maintained automatically. By clicking at Reset you restore the original default values of the program.

Add extra dimensions

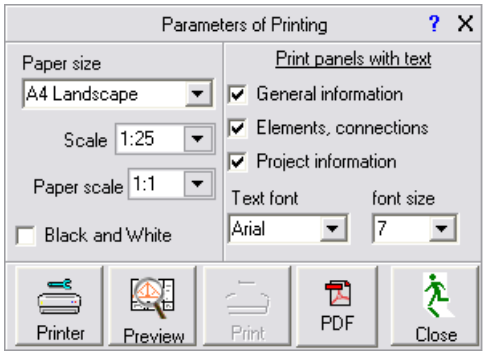
If you want to add extra dimensions on the drawing, use the . Click on the point at beginning and the end of the distance you want to insert. Stop the process by right click.

If you want to remove all the extra dimensions added, use the .
For the standard dimensions, use the layer function to turn the dimension on or off.

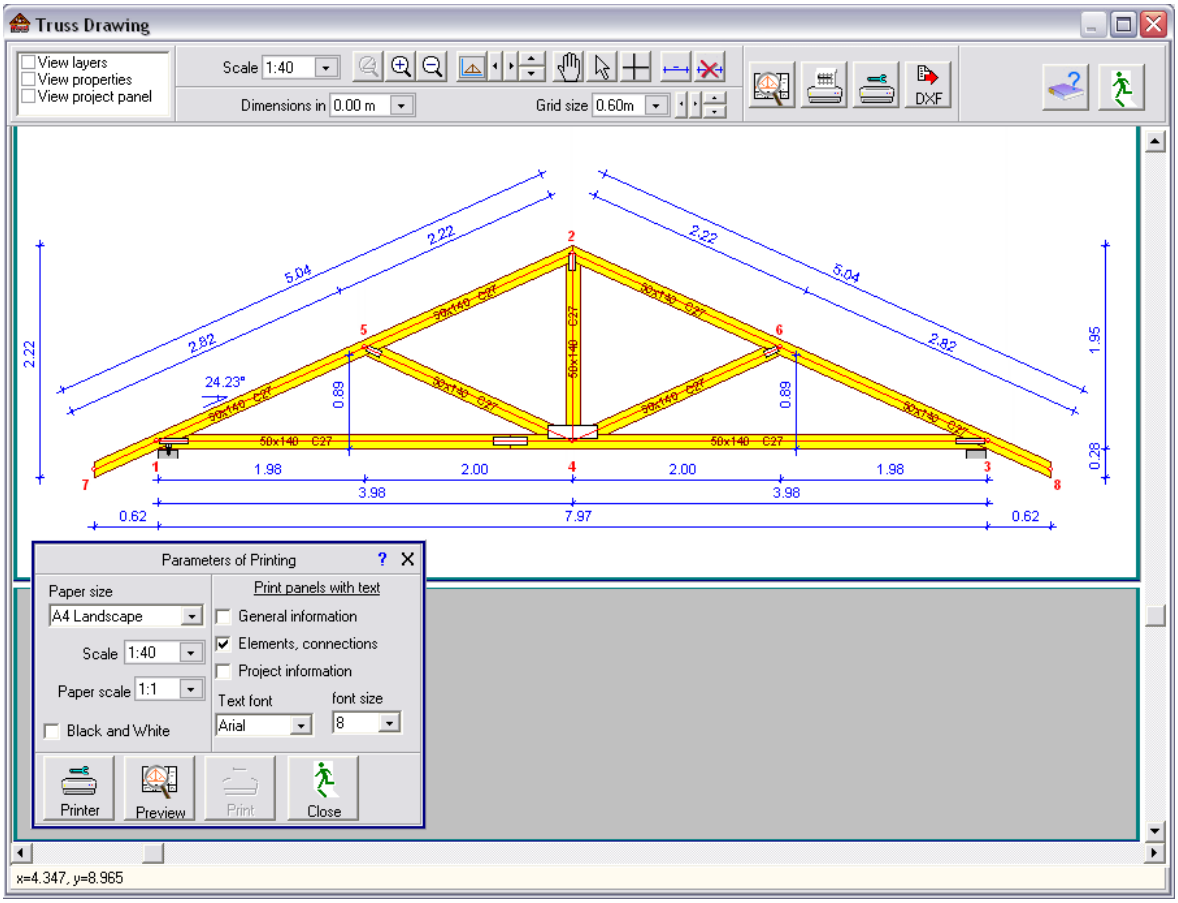
The extra dimensions added are not maintained in the data file.

Print - preview drawing

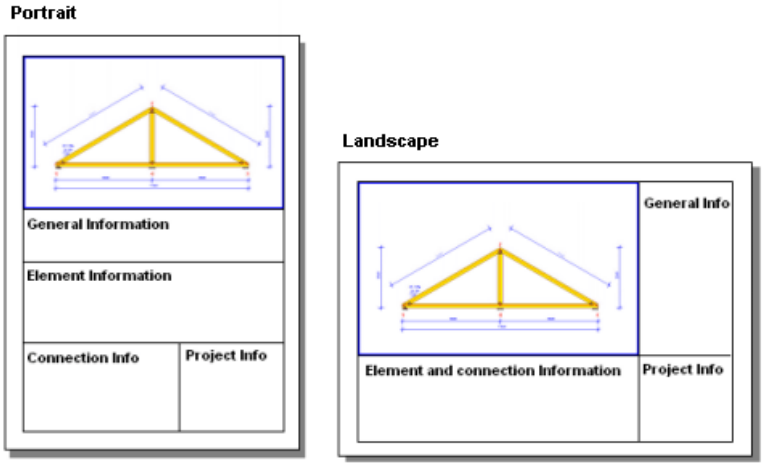
Before you print your drawing it is advisable to preview the contents of you drawing first.



Click on the Preview Button and set the parameters of printing.
Choose Paper size and orientation, Scale and check for Black and White **according to your printer.**
You move (click on the drawing and move the mouse) the drawing to place it at the desired position inside the drawing paper.
In case your screen size does not allow you to see all the drawing paper by choosing another Paper scale you scale down the screen image.
Choose the text panels you want included in your drawing.
When you check/uncheck a text panel you can see the area available for the truss drawing is changing.
You can change text font and size. Be aware if you increase the text size in A4 paper. The text may become too large for the text area.



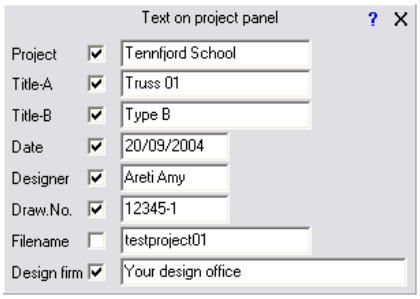
Print preview drawing.



Page orientation for drawings.

Project panel

To edit appearance of the text panel for the drawings check the fields you want to be included and type the wanted text.



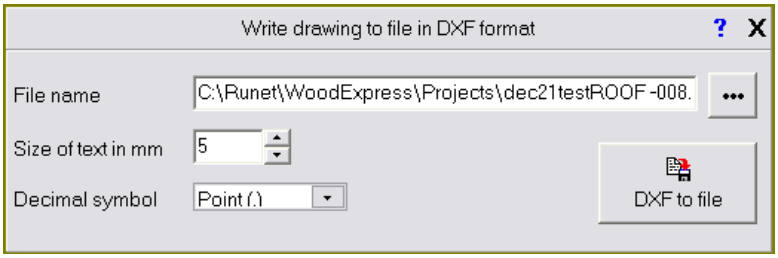
The project title is automatically taken from the name of the project.
The title A is automatically taken from the name of the design object.
The Design Firm title is automatically taken from the settings of the report parameters, see pg. 28, report page footer.

Export drawing to PDF format

From the CAD modulus of the program you can save you truss drawing in PDF format

Export drawing to dxf format

From the CAD modulus of the program you can save you truss drawing in .dxf format. This file can be read from Autocad In the window that appears specify the file name and adjust the text size and decimal symbol in the new file.



9 Eurocode 6, EN 1996 Design of masonry structures

9.1 Characteristic strength of masonry

Characteristic compressive strength of masonry EN 1996-1-1 § 3.6.1
Characteristic shear strength of masonry EN 1996-1-1 § 3.6.2
Characteristic flexural strength of masonry EN 1996-1-1 § 3.6.3

The characteristic strength is computed from the properties of the masonry units, mortar and the construction type of the masonry.

9.2 Basic input data masonry

Masonry construction type
General classification
Unreinforced
Confined
Reinforced masonry
Construction type
Masonry with filled head joints
Masonry with unfilled head joints
Shell bended masonry g/t=0.3
Shell bended masonry g/t=0.4
Shell bended masonry g/t=0.5
for shell bended masonry g: is the total width of the mortar strips, t is the thickness of the wall.
Execution control §2.4.3
Classes 1 to 5 . Selecting the class of execution control the material factor is set according to the table in §2.4.3
Masonry units. §3.1
Select the type of masonry unit according to §3.1.1 (1) and specify the additional data category, group weight, compressive strength fb, and final creep coefficient.
Mortar §3.2

Mortar type M2 general
M5 general
Etc…
By selecting mortar type by name the remaining properties are set to match the mortar properties.

Method of specification
Designed
Prescribed
Any mortar
Method of application
General purpose
Thin layer
Lightweight
Method of production
Factory made
Semi-finished factory made (pre-mixed)
Side made mortar
Compressive strength fm (N/mm2)

9.3 Masonry wall design

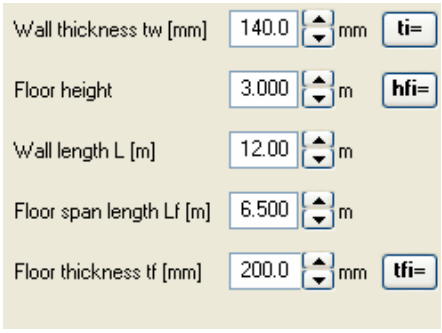
Masonry design for vertical loading
Masonry design for shear loading
Masonry design for lateral loading

In addition to the masonry units and mortar data as above you specify the wall dimensions, the support conditions on top and bottom, and the design loads on the wall top.

9.4 Design of Wall in one, two or three floor building

Masonry units and mortar
As above.

General wall dimensions.

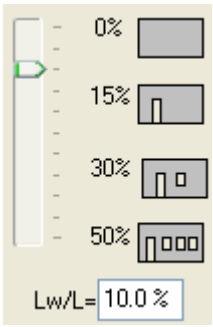


Wall thickness, floor height, and floor thickness.

Values in meters. By click at the ti=, hfi=, tfi= the values are set for all floors. Then you may change every individual floor from the left boxes on the drawing of the wall, values in millimeters.

Wall length (L) is the length of the wall face.
Floor span length (Lf) is the span in transverse direction of the wall, and is used to compute the load eccentricities according to Annex C of Eurocode 6.

Wall solid parts and openings



A wall generally, is not solid. It includes windows and doors. To take this into account in the design, the percentage of wall openings of the wall have to be specified. The ratio Lw/L shows the ratio of the openings length in respect to the wall length.

Wall loads

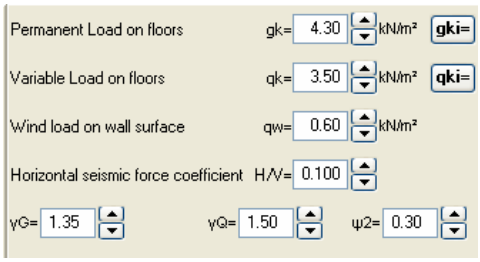
Permanent gk, and variable qk, loads in kN/m2 on the floors.

By clicking at the gki=, qki= the values are set for all floors. Then you may change every individual floor from the left boxes on the drawing of the wall, values in kN/m2.

Wind load qw on the wall surface in kN/m2.
The loads on the wall top are computed as

$$Qk=(\gamma k \cdot gk + \gamma k \cdot gk) \cdot Lf/2$$

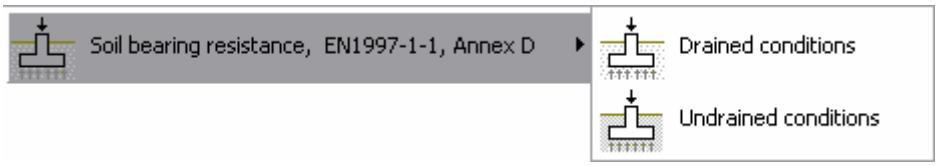
In case you want to design for seismic loading, specify the horizontal seismic force coefficient. The Horizontal seismic force will be evaluated as the (total vertical force) x(seismic coefficient). The distribution of this force will be triangular along the height of the building according to Eurocode 8.



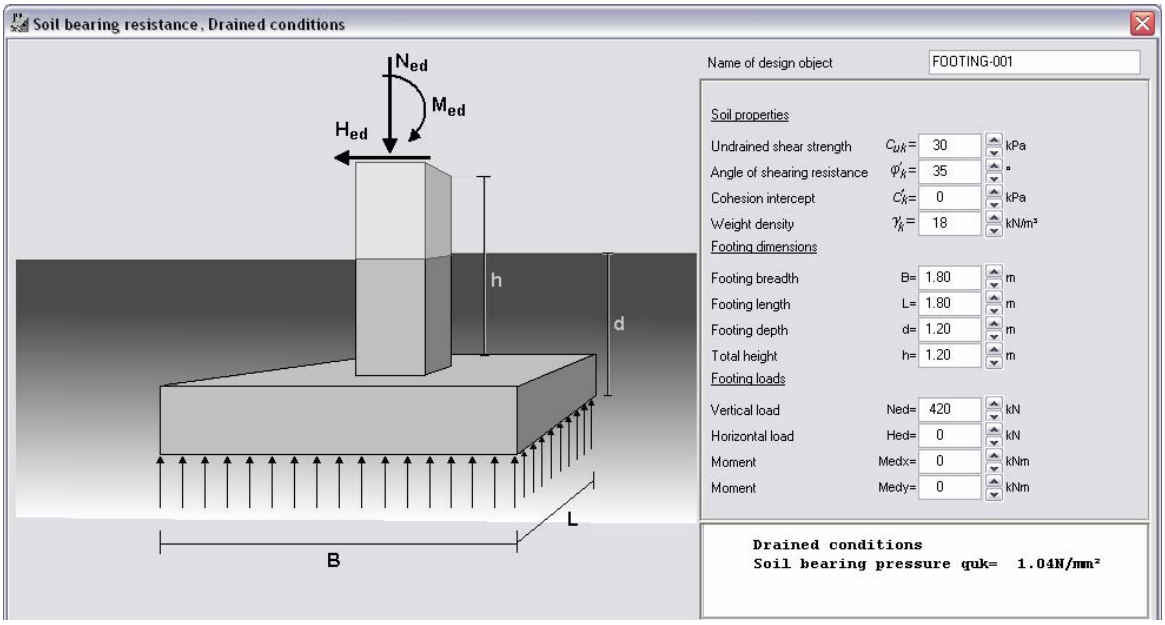
9.4.1
Modulus of elasticity of wall and floor material. For wall material usual value is the same as the characteristic compressive strength of the wall material in GPa according to Eurocode 6, 3.7.2.

10 Eurocode 7, EN 1997-1:2004 Geotechnical design

10.1 Soil Bearing resistance



The basis for the design of foundations is the bearing resistance of the soil.
The design bearing resistance can be calculated using analytical or semi-empirical methods. Annex D of Eurocode 7, EN1997:2004 describes a method of obtaining the design bearing strength of the soil.



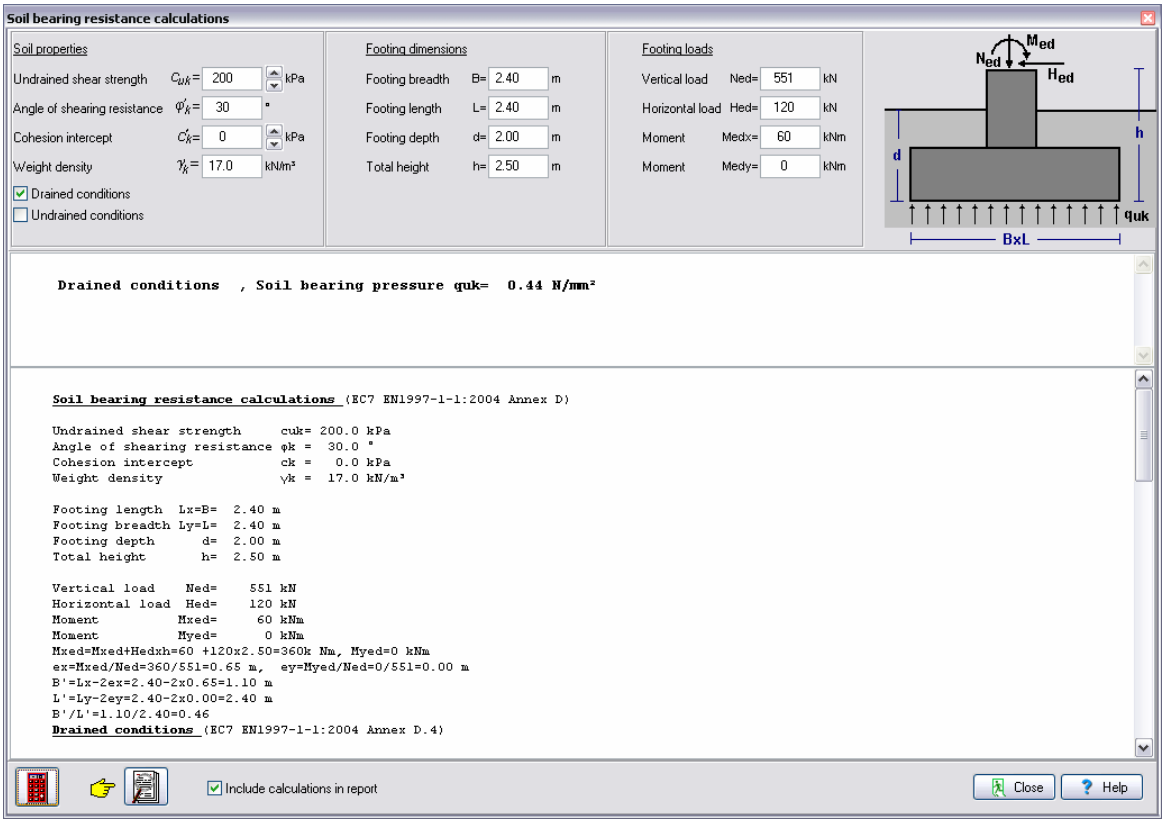
The methods of Annex D Eurocode 7, EN1997:2004 for drained and undrained conditions are implemented in the program.
The design bearing strength of the soil is estimated for EQU, STR and GEO conditions.
The computation of design bearing strength is for drained and undrained soil conditions.

For drained soil conditions the important soil property is the angle of shearing resistance φ_k [°] and the cohesion intercept c[kPA].
For undrained soil conditions the important soil property is the undrained strength c_u [kPa].

For the computation of design bearing strength other parameters are the dimensions and depth of the footing, as well as the loading and the load eccentricities.

In the program's foundation design for the soil strength we use the soil bearing pressure q_{uk} (N/mm^2). This is corresponding soil strength to the soil allowable pressure. In the foundation design we use as design bearing soil pressure $q_{ud}=q_{uk}/\gamma_{qu}$, where γ_{qu} is the partial factor for unconfined strength (Eurocode 7, Annex A).
To be consistent in order to convert the design strength estimated from Annex D of Eurocode 7 to the soil bearing pressure used in the program, the design value has to be multiplied by γ_{qu}, $q_{uk} = q_{ud}. \gamma_{qu}. \gamma_{qu}$ =1.40 for EQU and 1.00 and 1.4 for STR-GEO.

In all the designs of footings and retaining walls the utility has been added.
Click the button and the design of fundaments or in the design of retaining walls and you get into a calculation window for design bearing resistance.

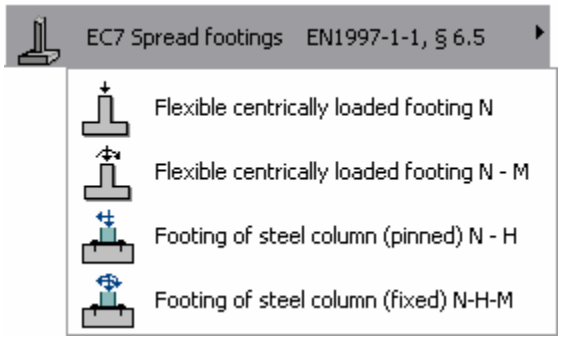


In this window you have an estimate of the soil bearing resistance q_{uk} from the soil and fundament parameters. This bearing resistance q_{uk} is the value you may use in the program.
If you check to include the calculations in the report, then the design bearing resistance will be set to the minimum estimated and the calculations will be included in the report of the footing design (remember that if you alter the dimensions or loading you have to re-evaluate q_{uk}).

10.2 Spread footings

Design of square or rectangular spread footings, subject to vertical load and biaxial overturning moments.
Dimensions. The footing dimensions you specify are: the length and the width of the footing, the thickness of footing and the size of column sides

Pre-dimensioning. After you give the loads by clicking at this button, you get a first estimate of the footing dimensions. In this predimensioning the dimensions that are checked, remain unchanged.



Loading. The loading is on the top of the footing. The vertical load, that you specify, does not include the self weight of the footing. In the case of centrically loaded footings the loading is the vertical dead and live load in [kN]. The vertical load is positive downwards. You can specify negative vertical loading (dead or live) if the load is upwards. In the case of eccentrically loaded footings in addition you supply the moments Mxx and Myy in [kNm] for the dead, the live and seismic components of the loading on the top of the footing.
The design load combinations are according to EN 1990:2002, and Eurocode 7,Annex A.

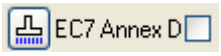
Loading-1 **γGxDead** + **γQxLive**,
Loading-2 Dead + ψ2xLive + Seismic x-x,
Loading-3 Dead + ψ2xLive + Seismic y-y

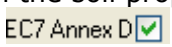
γG, and γQ are according to EN 1990:2002 and Eurocode 7, Annex A, for unfavourable and favourable permanent and variable actions for EQU, STR and GEO limit states
The design for earthquake loading is activated/deactivated from [Parameters/Design rules]

Soil properties.

Soil bearing capacity in [N/mm²] (GPa) .

You can select capacity by Clicking at and choose soil from the table with soil properties.

Click at 

you get the soil bearing capacity from the soil properties and the footing dimensions, according to Eurocode 7 Annex D. Having 

checked the soil bearing capacity is obtained automatically from the computations according to Annex D of Eurocode 7, when you alter any dimensions of the footing.

From [Parameters/Soil properties] you can edit (change properties, or add new) the table with the soil properties.

Geotechnical design. The program determines the exact pressure distribution under the footing using numerical integration, even when only a part of the footing is in contact with the soil.
The geotechnical design i performed: According to Eurocode 7 §6.5.2. The bearing resistance of the footing Rd is greater than the design load Vd, Rd>Vd. The bearing resistance Rd=quxA'/γq, where qu is bearing capacity of soil and the A' is the effective design area of footing as is defined in Annex B of Eurocode 7. The partial factors for soil properties γM are used for the design values of geotechnical parameters according to Eurocode 7 Annex A. EQU, STR and GEO limit states.

Concrete design. The flexural reinforcement is computed according to Eurocode 2 § 6.1, in ultimate limit sate for bending. The shear strength is checked according to Eurocode 2 §6.2 2. The punching shear is checked according to Eurocode 2 §6.4.3. You specify the desired diameter for flexural reinforcement, and the spacing and number of reinforcing bars is obtained. You may check to use specific reinforcement diameter or the program optimise the reinforcement around the desired diameter. The reinforcing bars are automatically placed in the reinforcing bar schedules. In [Parameters/Parameters for reinforced concrete/Footings] you specify the limits for reinforcing bar diameter and reinforcement spacing that are applied in the design.
In [Parameters/Parameters for reinforced concrete/Footings] you can specify if you want for the min and maximum reinforcing steel areas to apply the requirements for plates §9.3.1. Eurocode 2 is not clear on this subject.

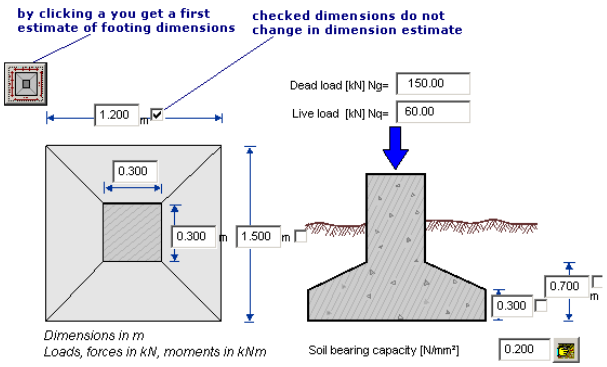
Design parameters. From [Parameters/Parameters of footings] you can adjust the various design code factors, as partial safety factors, allowable limits, safety factors, eccentricity limits with or without seismic loading, minimum rebar requirements, seismic coefficients etc..

From [Parameters/Soil properties] you can edit and update the data base with soil materials which are used in the program.

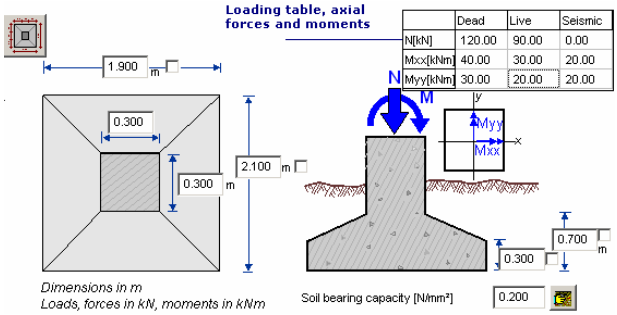
Report. The report shows in detail all the calculations of soil pressures, load combinations, internal force evaluation, stability controls and strength design. The report has references to relative paragraphs of the Eurocodes, and sketches aside of the text, which explain the notation, and show the stress distributions, and rebar position.

Dimensions and loading

centrically loaded footing

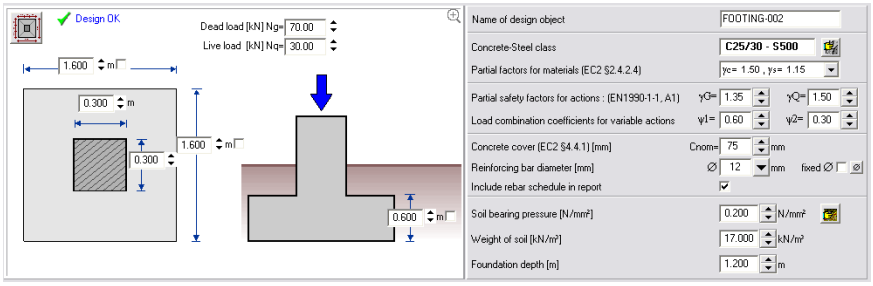


eccentrically loaded footing

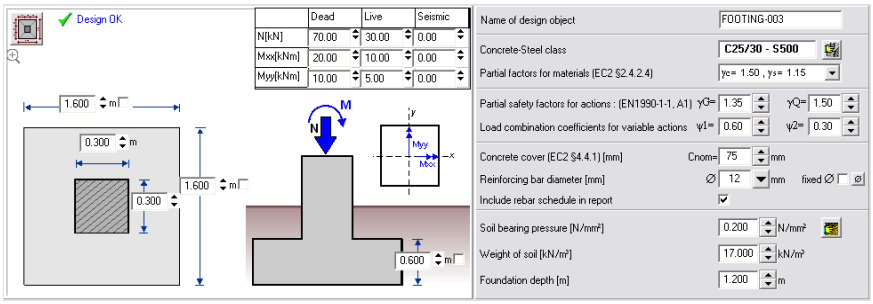


The foundation depth can be specified so the extra weight of the soil above the footing is taken into the account in the design. This is very useful in the case of vertical upwards loading of the footing.

10.3 Spread footings, centrically loaded

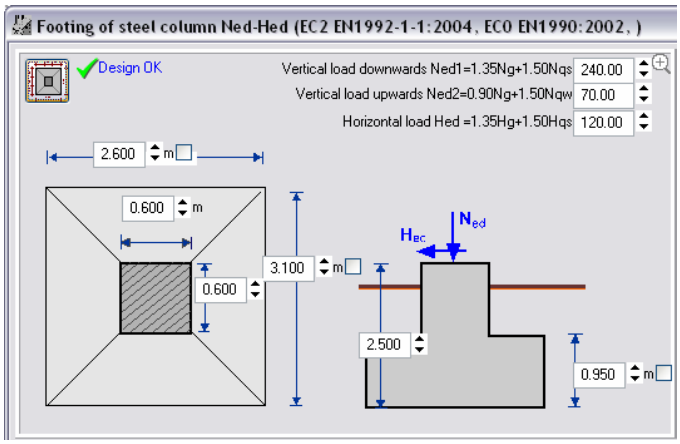


10.4 Spread footings eccentrically loaded



10.5 Fundaments of Steel columns

The concrete footing of steel structures has to be designed to resist soil pressure for maximum vertical load and it must have enough weight to resist uplift (from wind or seismic forces). You can design a pin (N and H forces) or a fixed (N H forces and Moment) base connection.



Loading on the fundament

The final actions after multiplication with safety factors (γ_G and γ_Q) Eurocode-1990-1-1, Table A1.2

For downwards loading usual values are:
γ_G =1.35 (unfavourable), γ_Q=1.50.

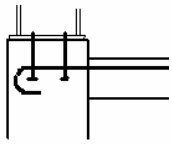
For upwards (uplift) loading usual values are:
γ_G =0.90 (favourable), γ_Q=0.00.

The height of the load application over the foundation must be specified.

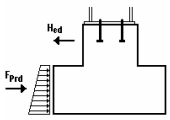
Steel Tie and Passive earth pressure

The high horizontal forces acting at the base are acting outwards as a result of bending in the columns due to vertical loading on the roof.
This is resisted in two ways.

- ***Steel tie at column base.***
  A tie cast into the floor slab connected to the base of the columns. This should be considered more safe method to resist the horizontal forces at the base of the columns.

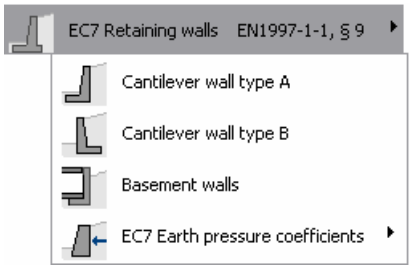


- ***Passive earth pressure on the side of the foundation.***
  In this case the earth filling and compacting on the side of the foundation must be performed carefully, so that the passive earth pressure is not reduced. The fundament transverse width By and the height Bh are used to compute the active area for passive earth pressure.



10.6 Retaining walls

Basic types of retaining walls are:



Cantilever walls

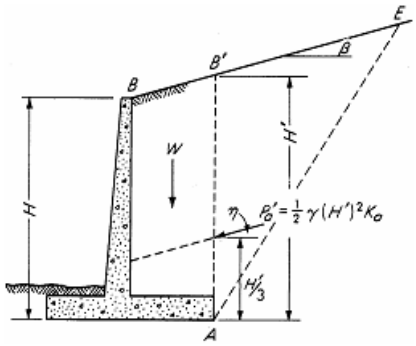
The walls consist of a steam on a base slab, both fully reinforced to resist the bending moments and shear forces which are subjected. Major part for their stability is the weight of the soil acting on the heel of the wall, and the large dimensions of the basement. Two types of cantilever walls are included in the program. One with no heel and the other with large heel.

Basement walls

Walls with restricted horizontal movement at the top. Earth pressure at rest (Jaky 1944)

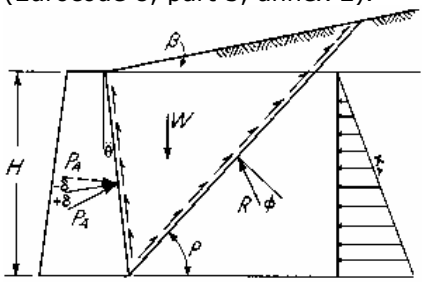
10.6.1 Earth pressure

The computation of the passive and active earth forces is done using Coulomb's theory. For gravity walls and for cantilever walls with small back heel (Type A) the active earth pressure is computed at the back face of the wall using Coulomb's theory. For cantilever walls with back heel (Type B) the active earth pressure is computed at a vertical surface at the end of the heel, (see drawings below) using Rankine's theory.. The additional seismic forces, due to earth pressure, are computed using the theory by Mononobe-Okabe (Eurocode 8, Part 5, Annex E)..



Lateral earth pressure

Active earth pressure is the force which is developed on some surface by a granular material, when the latter moves over a very small distance away from the granular material..
Passive earth pressure is the resultant pressure developed by a granular material against some surface, when the latter shifts over a small distance towards the material.
The basic assumptions for lateral earth-pressure, using a simplified wedge theory are set by Coulomb (1736-1806).
Additional seismic forces due to earth pressure according to theory by Mononobe-Okabe [ref], (Eurocode 8, part 5, annex E).



active earth pressure $P_A = \frac{\gamma H^2}{2} K_A$

$$K_A = \frac{\cos^2(\varphi - \theta)}{\cos^2\theta \cos(\theta+\delta)\left[1+\sqrt{\frac{\sin(\varphi+\delta)\sin(\varphi-\beta)}{\cos(\theta+\delta)\cos(\theta-\beta)}}\right]^2}$$

passive earth pressure $P_p = \frac{\gamma H^2}{2} K_p$

$$K_p = \frac{\cos^2(\varphi + \theta)}{\cos^2\theta \cos(\theta-\delta)\left[1-\sqrt{\frac{\sin(\varphi+\delta)\sin(\varphi+\beta)}{\cos(\theta-\delta)\cos(\theta-\beta)}}\right]^2}$$

φ angle of internal friction of soil
δ angle of wall friction

10.6.2 Stability controls

are performed based either on Ultimate Limit State Design according to Eurocode 7, Annex A for EQU, STR and GEO limit states or on Working Stress Design method. The user selects the method of analysis. The partial safety factors and load combination factors have values as defined in Eurocode 7 Annex A for EQU, STR and GEO limit states, but they can be adjusted by the user from [Parameters\Retaining walls]. In the case of working stress design method, the safety factors for overturning and sliding, (default values 2.00 and 1.50), can be defined by the user. The safety factors may have different values in seismic loading. The participation of passive earth force is taken into account as defined in Eurocode 7. In the case of working stress design method, and in the seismic analysis, the effect of passive earth force is taken into account by a factor, which can be defined by the user.

10.6.3 Strength design

The design of cantilever type walls is based on Ultimate Limit State Design of concrete according to Eurocode 2.
The design checks are performed at each tenth of the stem height and for cantilever walls the reinforcement of the stem is optimised. The reinforcing bars are automatically placed in the reinforcing bar schedules.

10.6.4 Seismic design

The seismic forces due to earth pressure are computed using the theory by Mononobe-Okabe. (Eurocode 8, part-5). Additional seismic loads are horizontal and vertical seismic forces due to the mass of the structure according to Eurocode 8 part 5..

10.6.5 Design parameters

From [Parameters/Parameters of retaining walls], and [Parameters/Parameters for reinforced concrete/Retaining walls], you can adjust the various code parameters, as:

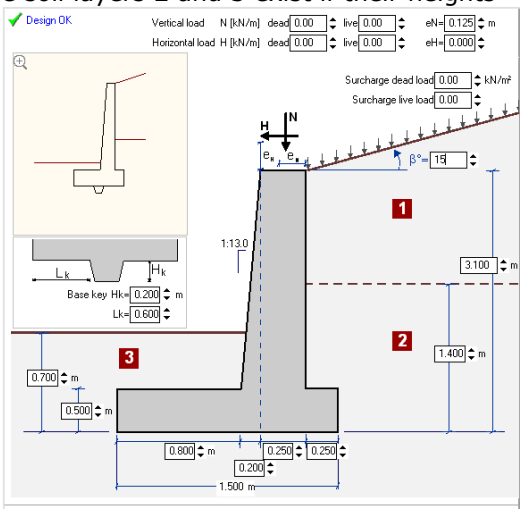
- partial safety factors
- safety factors (overturning and sliding)
- participation coefficients for passive earth force with or without seismic loading
- eccentricity limits with or without seismic loading
- minimum rebar requirements
- seismic coefficients.

From [Parameters/Soil properties] the material properties for the soil types included in the program can be defined.

10.6.6 Dimensions

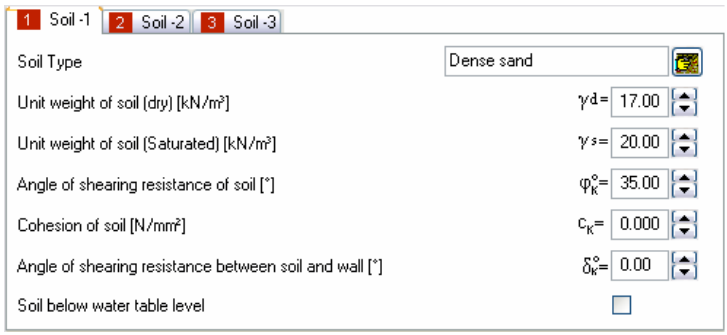
Give the basic wall dimensions according to the drawing. Click at

to enter drawing.
All the dimensions are in meters [m], and the angles (soil surface slope, wall batter) in degrees.
In order to give the batter of the front or the back face of the wall you have to check next to the angle to activate it, otherwise you can give the horizontal projection of the wall face and the batter is computed.
You can supply up to 3 soil layers, marked with numbers on the wall drawing. Two soil layers (1 and 2) are behind the wall and one soil layer (3) in front. The soil layers 2 and 3 exist if their heights are >0. If you have high water table level behind the wall, then use two soils. In that case the height of soil 2 is the height of the water table level, and in the soil properties of soil 2 checked to be under the water table level.
Together with the wall dimensions you give (if they exist) the surcharge distributed (dead and live) loads in [kN/m²]. The surcharge is assumed to act all over the top ground surface.
In addition you can specify, as in the case of bridge abutments, line load (vertical or horizontal, dead and live), acting on the top of the wall. To improve the wall behaviour in sliding, a base key can be specified. Specify the height of the key and its distance from the front toe.



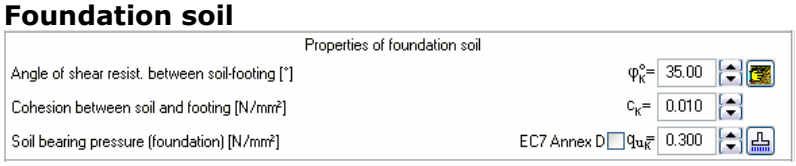
10.6.7 Soil properties
Properties of soil layers for lateral earth forces

You specify the soil properties for the three soil layers as shown in the wall sketch. The two soil layers 1 and 2 are behind the wall, and soil layer 3 is in front of the wall. The soil layers 2 and 3 exist if their height is specified >0. If you have high water behind the wall table level, use two soil layers. In that case the height of soil layer 2 is the height of the water table level, and in the soil properties of soil layer 2 check [Soil below water table level].

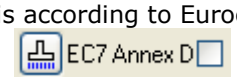
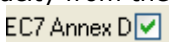


By clicking at the table with soil types appears from which you can select a soil type and its properties are loaded.
The table of soil types can be edited (change values, add new soil types) from the menu [Parameters/Soil properties].

Foundation soil



The properties of the foundation soil are defined under the sketch of the wall. Click at the table with soil types appears and you can select a soil type. For the shear resistance between wall and soil, you specify the angle of friction in degrees, and the friction coefficient (shear resistance) is computed as the tangent of this angle. You specify the soil bearing capacity when the geotechnical design is according to Eurocode 7,

Click at  you get the soil bearing capacity from the soil properties and the footing dimensions, according to Eurocode 7 Anndx D. Having  checked the soil bearing capacity is obtained automatically from the computations according to Annex D of Eurocode 7, when you alter any dimensions of the footing.

10.6.8 Stability design

The design of retaining walls is based either on Ultimate Strength Design method according to Eurocode 7, or on Working Stress Design method. Form [Parameters/Design rules] you select which of the two methods you want to use.

Stability checks using Ultimate Limit State Design, Eurocode 7, §6.5 and §9.7
Stability against overturning **Msd<Mrd**,
Msd are all the overturning moments (active earth pressure, seismic forces).
Mrd are the moments resisting overturning (self weight, backfill weight).
Overturning moments are computed in respect to the wall toe.
Stability against sliding **Hd<=Sd+Epd**
Hd is the horizontal component of the driving forces (active earth pressure, seismic forces).
Sd is the design shear resistance between the foundation and the soil. Sd=Vd tanϕd+A' Cu, where Vd is the design vertical load on the foundation surface, ϕd is the design shear resistance between foundation and soil. A' is the effective footing area (EC7 Annex B). Cu is the cohesion between foundation and soil.
Epd is the passive earth force.
Stability against soil bearing capacity failure **Vd<Rd**
Vd is the design load at the wall base (self weight, backfill weight, earth pressure, surcharge load).
Rd is the bearing capacity of the foundation Rd=A' qu. where A' is the effective footing area (EC7 Annex D), and qu is the soil bearing capacity (EC7 Annex C).
Load eccentricity in the foundation according to EC7 §6.5.4.

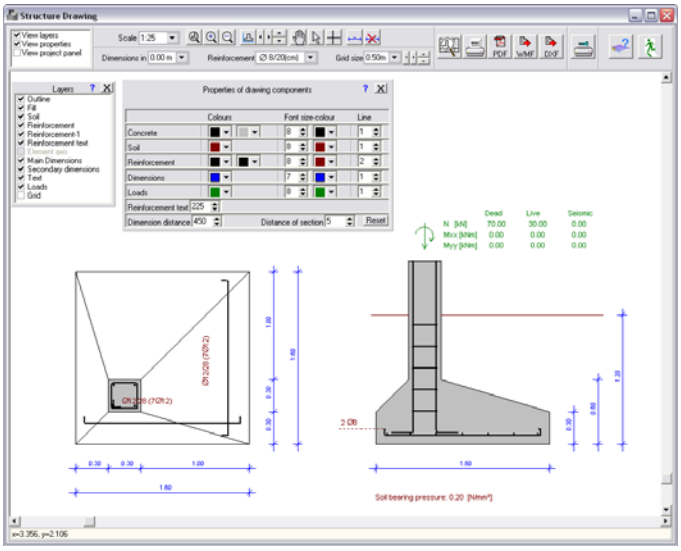
The actions are multiplied with the partial load factors given in Eurocode 7, Annex A. These factors are for unfavourable (overturning moments, sliding forces), or favourable (moments resisting overturning, foundation shear resistance, passive earth pressure) loading conditions. The load factors for favourable or unfavourable loadings can be set from [Parameters/Retaining Walls/Check wall stability with Eurocode 7]. The soil parameters are divided by the partial factors for soil parameters given in Eurocode 7 Annex A.
The limit states EQU (equilibrium), STR (structural) and GEO (geotechnical) are considered.

10.6.9 Seismic loading

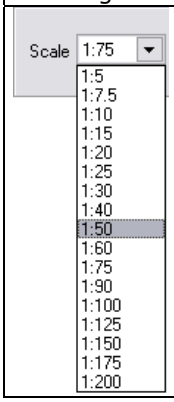
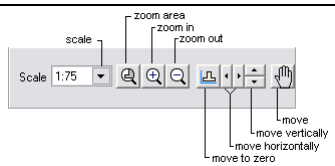
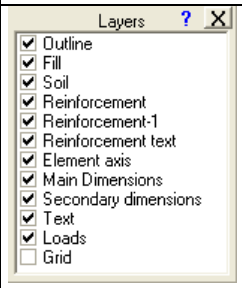
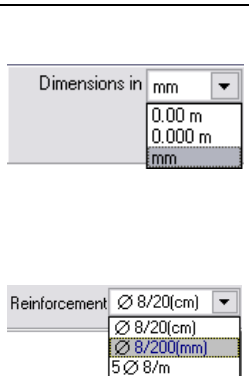
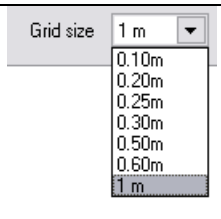
Check to perform or not the design for earthquake loading, and you specify the design ground acceleration ratio (Eurocode 8, part-1, §4.2.2). The seismic forces, due to active earth pressure, are computed according to Mononobe-Okabe (Eurocode 8, part-5, Annex E).

10.7 CAD drawing of concrete footings and retaining walls

The CAD modulus of the program automatically creates detailed drawings of spread footings, retaining walls, corbels and deep beams. You can adjust the scale of the drawing, and you can choose the visible layers. The properties of the drawing components, (line thickness, colour, text size) can also be adjusted. You can also specify the dimension units that are used.
Before previewing or printing the drawing you can select printing paper size, and move the drawing to the desired position on the paper.



10.7.1 CAD Features

Scale of Drawing	Zoom	Layers	Dimension units/ Reinforcement	Grid
				

Scale/Move/Zoom If you cannot see all or parts of the object on the screen, you can scale or move your drawing. You activate/deactivate the move command (hand) by double clicking on the drawing. By right click you can change cursor.
Layers Choose the layers you want to be visible and printed. The properties of the layers are defined of the Properties of drawing components.

Dimension units

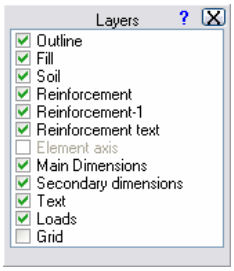
Choose unit for dimensions appearing on the drawing. This will be the default unit until you change it.

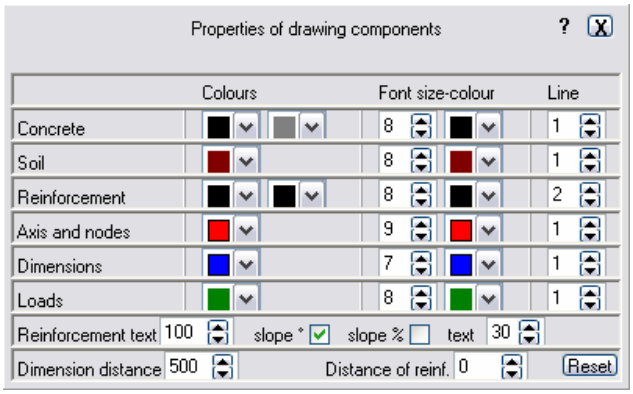
Grid

If you want the grid to appear, from the layers panel, check the grid and choose the size from the pull down menu. By clicking on the small arrows on the right, you move the grid in relation to the drawing.

Line thickness, colour and font sizes

By using this panel you can adjust the appearance of the drawing.
Turn on or off the layers from the panel with Layers.
For the line type of **Axis and nodes**, choose line thickness **1 for dashed line**, line thickness 2 for the thinner solid line etc.





There are three levels of dimensioning. By adjusting the dimension distance you move the dimension lines further or closer to the design object.
By adjusting the Text distance you move the text further or closer to the design object.
The values you are setting are maintained automatically. By clicking at Reset you restore the original default values of the program.

Add extra dimensions

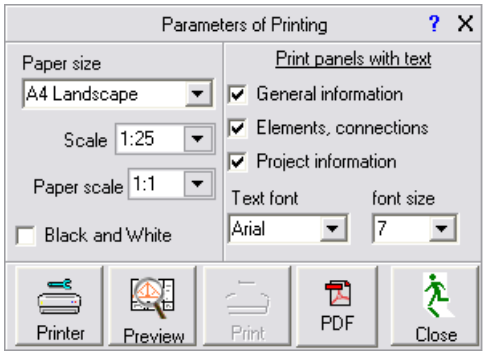
If you want to add extra dimensions on the drawing, use the . Click on the point at beginning and the end of the distance you want to insert. Stop the process by right click.

If you want to remove all the extra dimensions added, use the .
For the standard dimensions, use the layer function to turn the dimension on or off.
The extra dimensions added are not maintained in the data file.

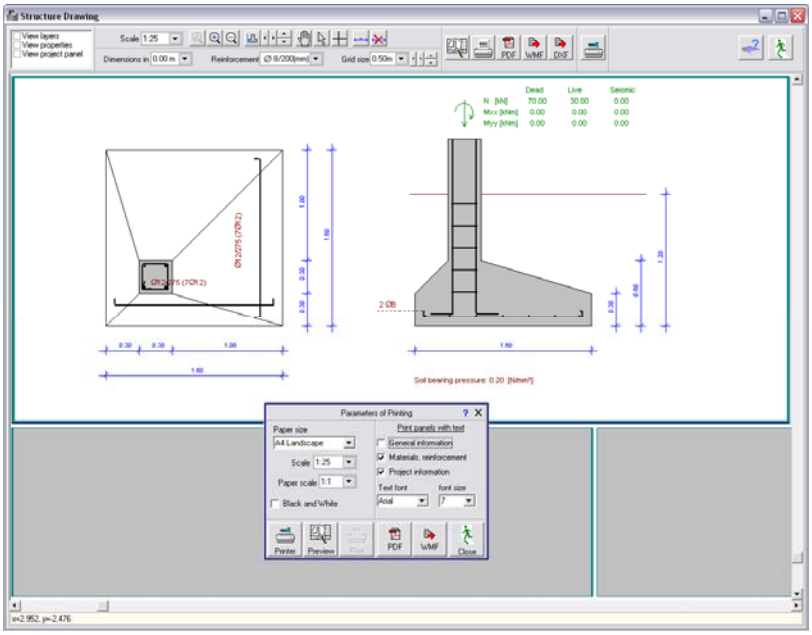
10.7.2 Print - preview drawing

Before you print your drawing it is advisable to preview the contents of you drawing first.

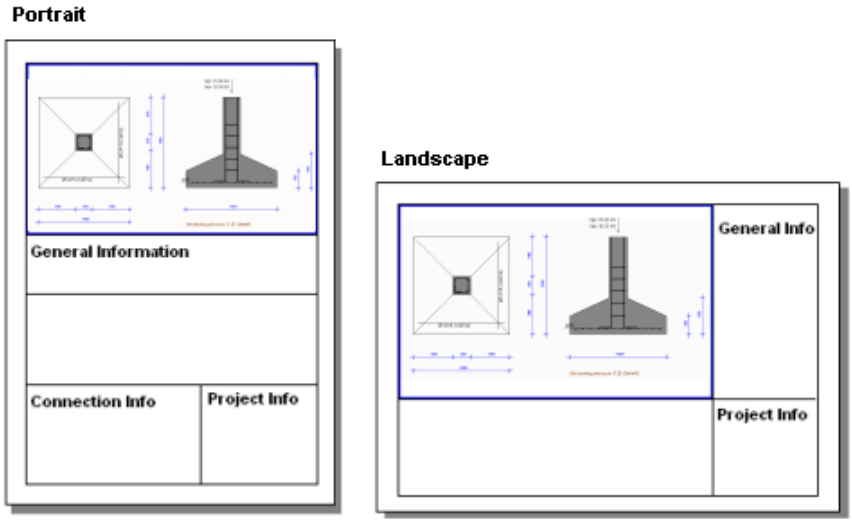
Click on the Preview Button and set the parameters of printing.
Choose Paper size and orientation, Scale and check for Black and White **according to your printer.**
You move (click on the drawing and move the mouse) the drawing to place it at the desired position inside the drawing paper.



In case your screen size does not allow you to see all the drawing paper by choosing another Paper scale you scale down the screen image.
Choose the text panels you want included in your drawing.
When you check/uncheck a text panel you can see the area available for drawing is changing.
You can change text font and size. Be aware if you increase the text size in A4 paper. The text can become too large for the text area.



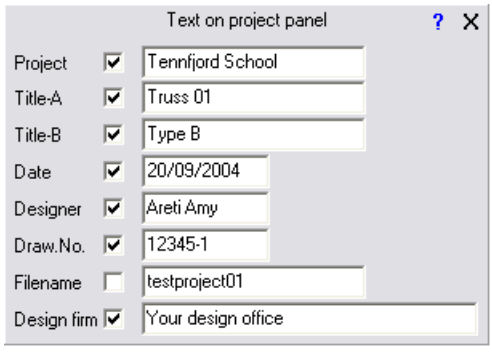
Print preview drawing.



Page orientation for drawings.

10.7.3 Project panel

To edit appearance of the text panel for the drawings check the fields you want to be included and type the wanted text.



The project title is automatically taken from the name of the project.
The title A is automatically taken from the name of the design object.

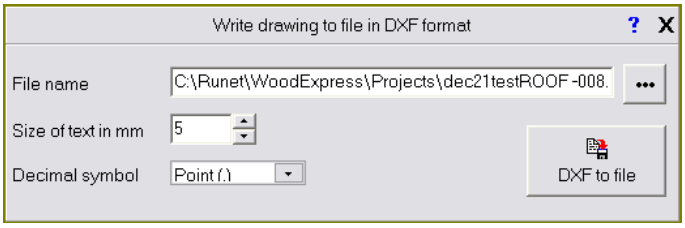
The Design Firm title is automatically taken from the settings of the report parameters, see pg. 28, report page footer.

10.7.4 Export drawing to PDF format

From the CAD modulus of the program you can save your drawing in PDF format

10.7.5 Export drawing to dxf format

From the CAD modulus of the program you can save your drawing in .dxf format. This file can be read from Autocad In the window that appears specify the file name and adjust the text size and decimal symbol in the new file.

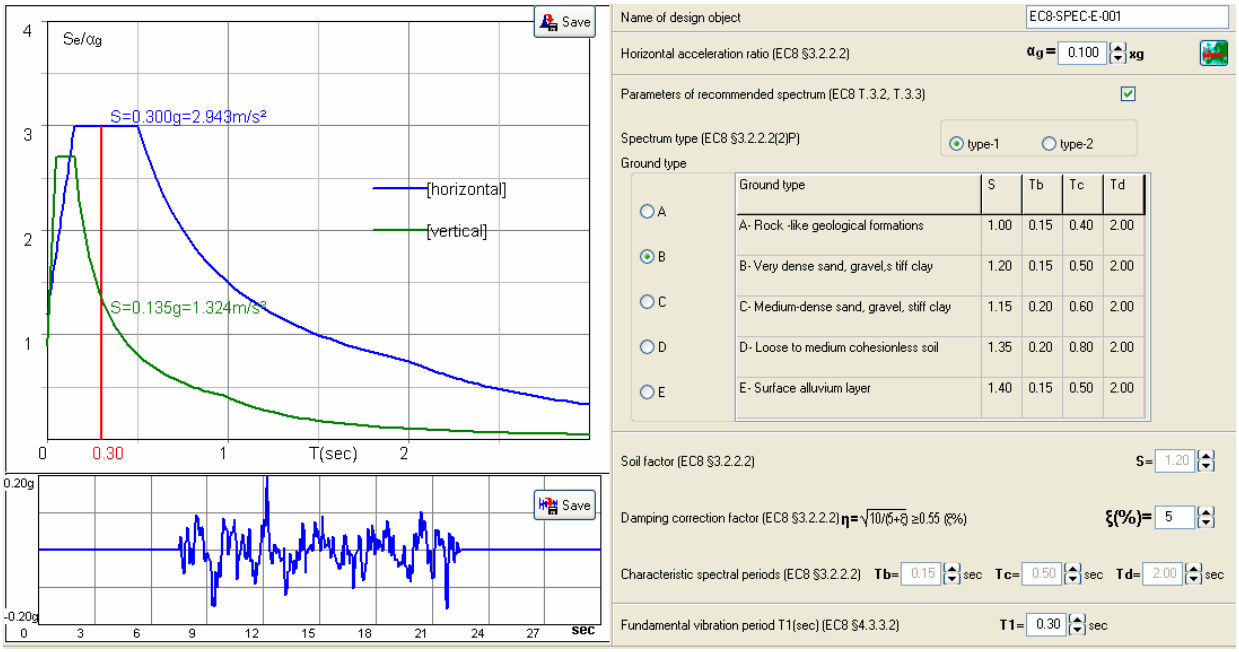


11 Eurocode 8

EN 1998-1:2004 Design of structures for earthquake resistance

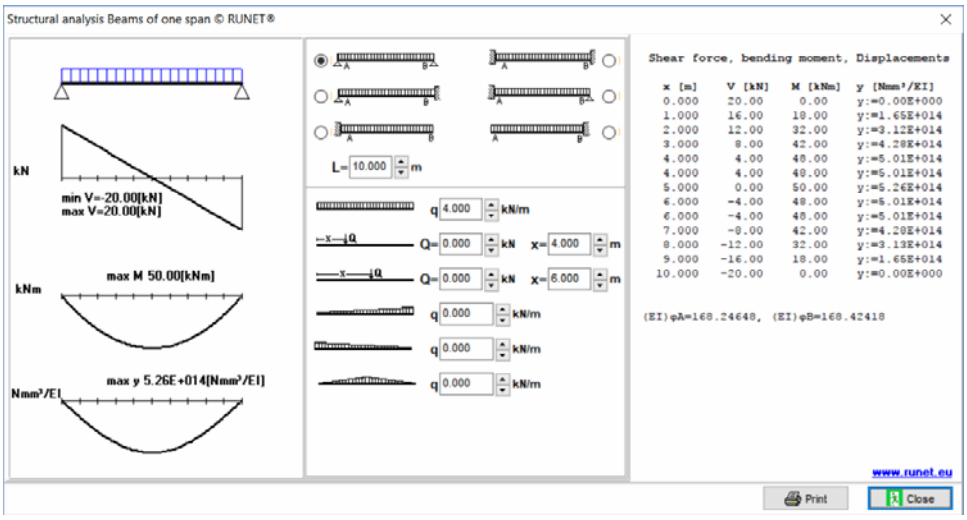
11.1 Seismic spectra

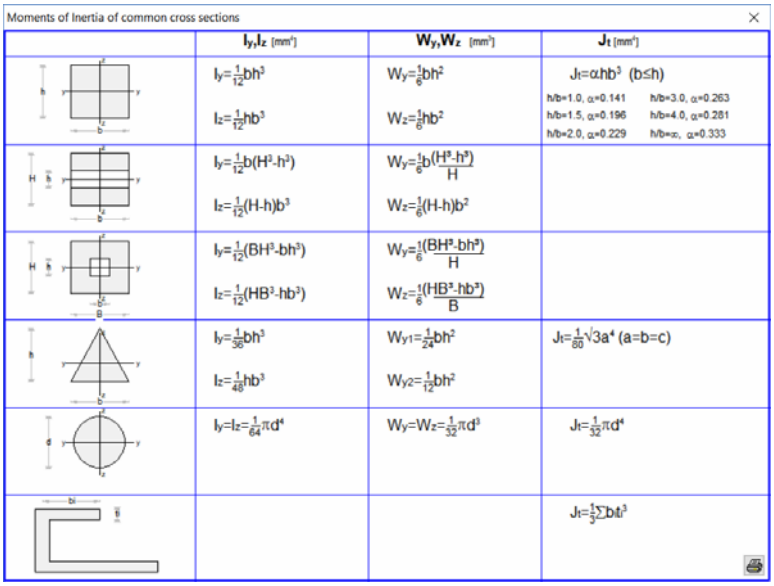
Elastic and Design seismic spectral for Horizontal and vertical seismic activity.
Select ground types according to Eurocode 8 3.2.2.2.2,. You can alter all the basic spectra parameters.
Sample seismic time series simulated from the spectrum, is shown under the spectum.

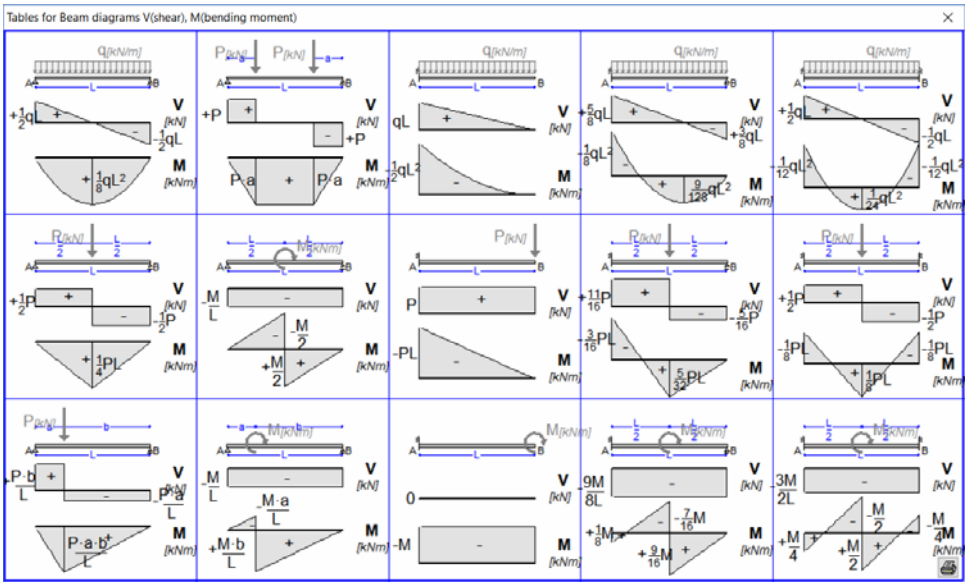


If Parameters of recommended spectrum is checked, then all the spectra parameters, periods and soil factor, except the damping ratio ξ and ratio a_{vg}/a_g , are taken as recommended in Eurocode 8 3.2.2.2.2 and 3.2.2.2.3 and the national Annex, for spectral of type 1 or 2.
If Parameters of recommended spectrum is NOT checked, then the spectrum parameters, periods and soil factor and ratio a_{vg}/a_g, can be defined by the user.
The value of fundamental vibration period, is the value of the fundamental vibration period of the structure. In the graph is shown the spectral amplitude for horizontal and vertical movement for this eigenperiod.

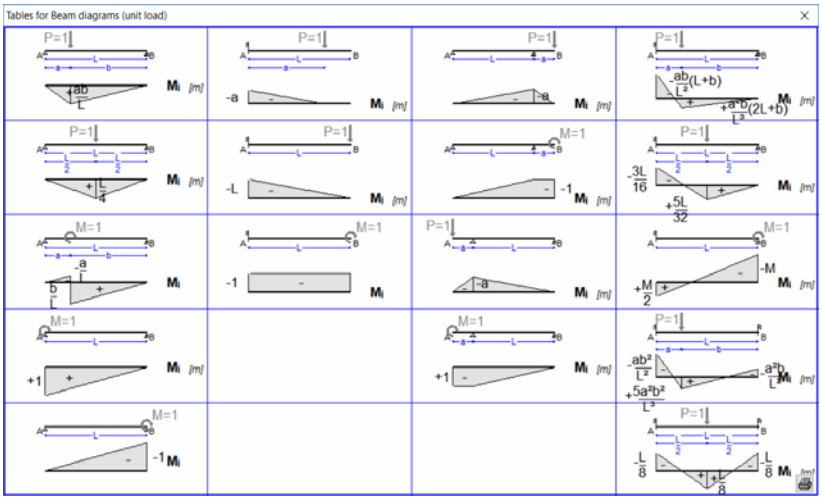
12 Tables of structural analysis



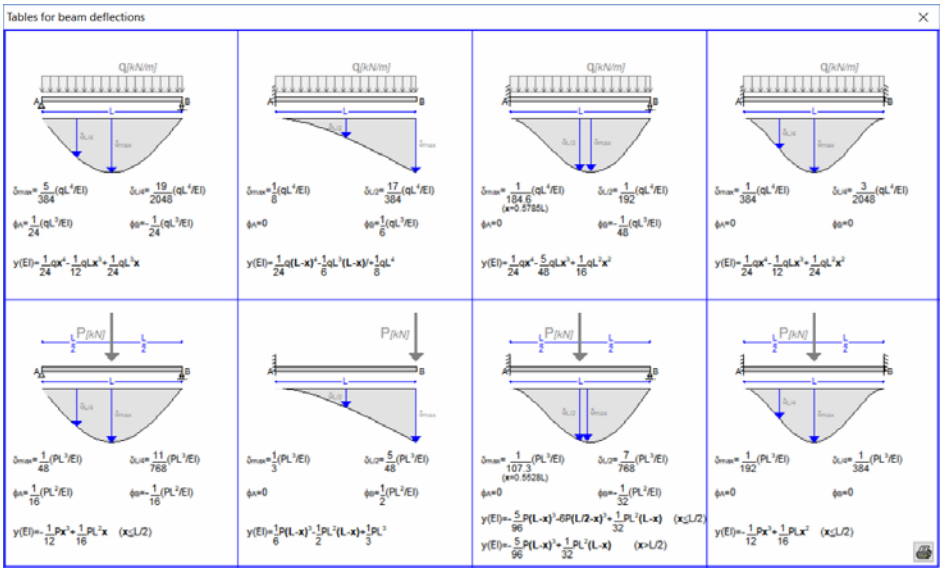




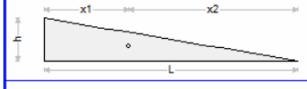
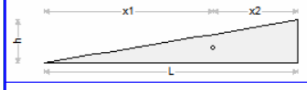
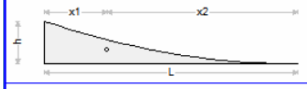
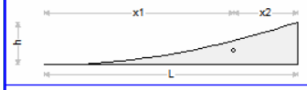
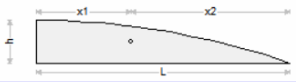
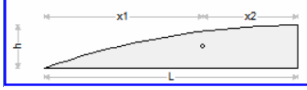
Tables for Beam diagrams (unit load)



Tables for beam deflections



Tables for areas and centroids of diagrams

Shape of graph	Area	x1	x2
	h·L	$\frac{1}{2}$ L	$\frac{1}{2}$ L
	$\frac{1}{2}$ h·L	$\frac{1}{3}$ L	$\frac{2}{3}$ L
	$\frac{1}{2}$ h·L	$\frac{2}{3}$ L	$\frac{1}{3}$ L
	$\frac{1}{3}$ h·L	$\frac{1}{4}$ L	$\frac{3}{4}$ L
	$\frac{1}{3}$ h·L	$\frac{3}{4}$ L	$\frac{1}{4}$ L
	$\frac{2}{3}$ h·L	$\frac{3}{8}$ L	$\frac{5}{8}$ L
	$\frac{2}{3}$ h·L	$\frac{5}{8}$ L	$\frac{3}{8}$ L

13 FRAME2D design

Finite element Design of 2-D structures and dimensioning of members for Reinforced concrete, structural steel and timber according to Eurocodes.

FRAME2D design user's manual

14 Standards and Bibliography

EN 1990:2002/A1:2005/AC:2010 Eurocode - Basis of structural design

***
EN 1991-1-1:2002/AC:2009
Eurocode 1: Actions on structures - Part 1-1: General actions - Densities, self-weight, imposed loads for buildings
EN 1991-1-2:2002/AC:2013
Eurocode 1: Actions on structures - Part 1-2: General actions - Actions on structures exposed to fire

EN 1991-1-3:2003/AC:2009
Eurocode 1 - Actions on structures - Part 1-3: General actions - Snow loads
EN 1991-1-4:2005/A1:2010
Eurocode 1: Actions on structures - Part 1-4: General actions - Wind actions
EN 1991-1-4:2005/AC:2010
Eurocode 1: Actions on structures - Part 1-4: General actions - Wind actions
EN 1991-1-5:2003/AC:2009
Eurocode 1: Actions on structures - Part 1-5: General actions - Thermal actions
EN 1991-1-6:2005/AC:2013
Eurocode 1 - Actions on structures Part 1-6: General actions - Actions during execution
EN 1991-1-7:2006/AC:2010
Eurocode 1 - Actions on structures - Part 1-7: General actions - Accidental actions
EN 1991-2:2003/AC:2010
Eurocode 1: Actions on structures - Part 2: Traffic loads on bridges
EN 1991-3:2006/AC:2012
Eurocode 1 - Actions on structures - Part 3: Actions induced by cranes and machinery
EN 1991-4:2006/AC:2012
Eurocode 1 - Actions on structures - Part 4: Silos and tanks

***
EN 1992-1-1:2004
Eurocode 2: Design of concrete structures - Part 1-1: General rules and rules for buildings
EN 1992-1-1:2004/AC:2010
Eurocode 2: Design of concrete structures - Part 1-1: General rules and rules for buildings
EN 1992-1-2:2004/AC:2008
Eurocode 2: Design of concrete structures - Part 1-2: General rules - Structural fire design
EN 1992-2:2005/AC:2008
Eurocode 2 - Design of concrete structures - Concrete bridges - Design and detailing rules
EN 1992-3:2006
Eurocode 2 - Design of concrete structures - Part 3: Liquid retaining and containment structures

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EN 1993-1-1:2005/AC:2009
Eurocode 3: Design of steel structures - Part 1-1: General rules and rules for buildings
EN 1993-1-2:2005/AC:2009
Eurocode 3: Design of steel structures - Part 1-2: General rules - Structural fire design
EN 1993-1-3:2006/AC:2009
Eurocode 3 - Design of steel structures - Part 1-3: General rules - Supplementary rules for cold-formed members and sheeting
EN 1993-1-4:2006
Eurocode 3 - Design of steel structures - Part 1-4: General rules - Supplementary rules for stainless steels
EN 1993-1-5:2006/AC:2009
Eurocode 3 - Design of steel structures - Part 1-5: Plated structural elements
EN 1993-1-6:2007/AC:2009
Eurocode 3 - Design of steel structures - Part 1-6: Strength and Stability of Shell Structures

EN 1993-1-7:2007/AC:2009
Eurocode 3 - Design of steel structures - Part 1-7: Plated structures subject to out of plane loading

EN 1993-1-8:2005/AC:2009
Eurocode 3: Design of steel structures - Part 1-8: Design of joints
EN 1993-1-9:2005/AC:2009
Eurocode 3: Design of steel structures - Part 1-9: Fatigue
EN 1993-1-10:2005/AC:2009
Eurocode 3: Design of steel structures - Part 1-10: Material toughness and through-thickness properties
EN 1993-1-11:2006/AC:2009
Eurocode 3 - Design of steel structures - Part 1-11: Design of structures with tension components

EN 1993-1-12:2007/AC:2009
Eurocode 3 - Design of steel structures - Part 1-12: Additional rules for the extension of EN 1993 up to steel grades S 700

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EN 1997-1:2004/AC:2009
Eurocode 7: Geotechnical design - Part 1: General rules
EN 1997-2:2007/AC:2010
Eurocode 7 - Geotechnical design - Part 2: Ground investigation and testing
EN 1998-1:2004/A1:2013
Eurocode 8: Design of structures for earthquake resistance - Part 1: General rules, seismic actions and rules for buildings
EN 1998-1:2004/AC:2009
Eurocode 8: Design of structures for earthquake resistance - Part 1: General rules, seismic actions and rules for buildings.
EN 1998-2:2005/A1:2009
Eurocode 8: Design of structures for earthquake resistance - Part 2: Bridges
EN 1998-2:2005/A2:2011
Eurocode 8: Design of structures for earthquake resistance - Part 2: Bridges
EN 1998-2:2005/AC:2010
Eurocode 8 - Design of structures for earthquake resistance - Part 2: Bridges
EN 1998-3:2005/AC:2013
Eurocode 8: Design of structures for earthquake resistance - Part 3: Assessment and retrofitting of buildings
EN 1998-4:2006
Eurocode 8 - Design of structures for earthquake resistance - Part 4: Silos, tanks and pipelines
EN 1998-5:2004
Eurocode 8: Design of structures for earthquake resistance Part 5: Foundations, retaining structures and geotechnical aspects
EN 1998-6:2005
Eurocode 8: Design of structures for earthquake resistance - Part 6: Towers, masts and chimneys

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CEN/TS 1992-4-1:2009
Design of fastenings for use in concrete - Part 4-1: General
CEN/TS 1992-4-2:2009
Design of fastenings for use in concrete - Part 4-2: Headed Fasteners
CEN/TS 1992-4-3:2009
Design of fastenings for use in concrete - Part 4-3: Anchor channels
CEN/TS 1992-4-4:2009
Design of fastenings for use in concrete - Part 4-4: Post-installed fasteners - Mechanical systems

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Design of fastenings for use in concrete - Part 4-5: Post-installed fasteners - Chemical systems
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