USER'S Manual

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Table of Contents

1 General about BETONexpress

BETONexpress is a software that covers the design and analysis of structural concrete elements according to Eurocode 2. In a unified environment you design concrete elements in a simple way. The calculations of concrete components performed by BETONexpress cover all the needs of a structural design firm. It simplifies all the repetitive and time-consuming every day calculations for concrete elements.

In a graphical added environment you specify the necessary dimensions, loads and design code parameters of concrete components, and the design is immediately performed. Default values and checks for erroneous input values, facilitate the input data process. The detailed calculations can be viewed immediately.

The report, which is created simultaneously, shows in detail all the calculations and the design steps with references to the corresponding design code paragraphs. In case of inadequate design warnings in red color appear in the report. Reinforcing bar schedule is also produced. With a special editor you can add or edit reinforcing bars. The report quality is high with sketches, graphs and formulas, and with user specified title block, logos and fonts.

In one project you can create as many structural elements (design objects) as you desire. All the data are stored automatically in one file. A dedicated window helps you working with the design objects in a project. Each structural element is well marked with a name and an icon. You can edit, copy or delete design objects in a project with a click of the mouse.

You can select the design objects to be included in the final project report, and the reinforcing bar schedule.

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 export file, or drawing.

A context-sensitive Help system, guides you through the use of the program and the Eurocode provisions. On-line user's manual and frequently asked questions (F.A.Q.) are included in the program.

You can adjust the material properties and the design code parameters according to the requirements of the National application document.

Eurocode2 is used for the concrete design, Eurocode 7 for the geotechnical design, Eurocode 8 for the seismic design, and Eurocode 6 for gravity wall design. In addition in the design of footings and gravity retaining walls, the allowable stress method may be used.

The concrete components you can design are:
Solid and ribbed slabs

- slab sections
- one-way continuous slabs
- two-way slabs
- cantilever slabs
- section capacity
- section capacity with FRP strengthening

Beams of rectangular or T section

- beam sections in bending shear and torsion
- one span in composite loading
- continuous beams in uniformly distributed loading
- section capacity
- section capacity with FRP strengthening

Columns

- column sections in biaxial bending
- isolated columns
- section capacity
- section capacity with FRP strengthening

Spread footings

- flat or sloped footings
- centrically or eccentrically loaded
- eccentric footings

Retaining walls

- gravity type backwards inclined or not
- cantilever walls

Corbels-brackets
Deep beams

Light Wight Aggregate concrete (LWAC) Solid and ribbed slabs
slab sections
one-way continuous slabs

- two-way slabs
- cantilever slabs
- Light Wight Aggregate concrete (LWAC) Beams of rectangular or T section
- beam sections in bending shear and torsion
- one span in composite loading
- continuous beams in uniformly distributed loading

Design charts Tables and graphs:

Tables and Design charts with Eurocode 2 as: Kd , med ω, effective length.

Tools with charts and computational material to understand and use Eurocode 2.

Ultimate strength interaction diagrams, biaxial bending and compression charts.

In addition, various engineering tools are included: unit conversion, section properties, area computations, reinforcing bar properties, lateral earth pressure coefficients.

From the parameters menu you can adjust the default dimensions, code parameters and material properties, according to the needs of your region and the Eurocode National application document of your country.

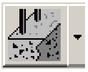
2 After program installation

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 necessry you may also adjust various parameters such as material constants, safety factors, default values, and minimum requirements for reinforcement.

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**:

Design rules. You can select the design code you want to use. (select Eurocode or native code for concrete design, Eurocode 7 or allowable stresses for foundation design, seismic design)

Concrete and steel class. You can select the default concrete class and reinforcing steel class.

Eurocode and National Annexes, select the National Annex to apply in the design.

Concrete properties, Reinforcing steel properties, Soil properties, Fiber Reinforced Polymer materials. You can adjust the characteristic material properties. It is advisable to consult the National Application Document of the Eurocodes 0,1, 2, 6, 7, 8.

Parameters of reinforced concrete, **Parameters of geotechnical design**, **Parameters of retaining walls**. You can set the default values for the various design parameters.

 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 check the right appearance of Greek mathematical symbols in the report. If you do not get the right appearance of Greek characters, then from [**Setup/Greek character support**], you can select the Greek characters to appear explicitly with English characters.

According to the notation used in the Eurocodes the report contains many Greek mathematical symbols. Depending on the Window installation the Greek mathematical symbols may or may not appear right. If you have Windows XP or 2000 you may add Greek language support in your Windows. Go to [Settings/Control Panel/Regional and Language Options/Advanced].

If your Windows do not support Greek mathematical symbols, then from [Setup/Greek character support] select NO. The Greek characters will appear as alpha, beta etc., in the report.

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.

3 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 concrete parts of a structure such as: slabs, beams, columns, footings, retaining walls, corbels, deep beams. 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 and reinforcing bar schedule is created. You can select the concrete objects that you want to include in the report and the rebar schedules. 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 at the top of the main program window.

Each design object, with a name you specified, 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 and reinforcing bar schedule.

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 reinforcement lay out, and you can preview or print the report of that particular design object.

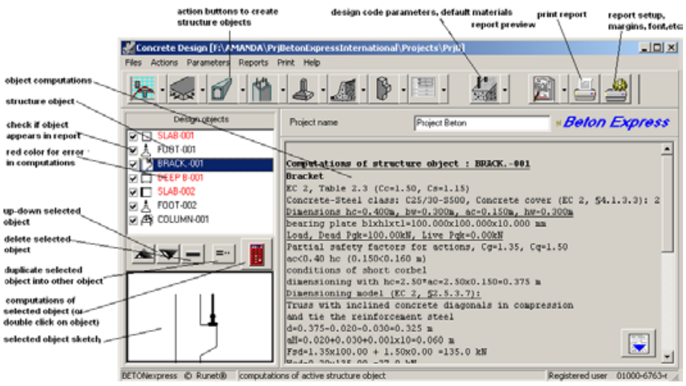
Check the objects you would like to appear in the report, and adjust their order of appearance in the [Design objects] window.

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.



4 Design objects

The design objects can be a variety of concrete parts of a structure such as : slabs, beams, columns, footings, retaining walls, corbels, deep beams.

We refer to these calculations as design objects or structural concrete elements .

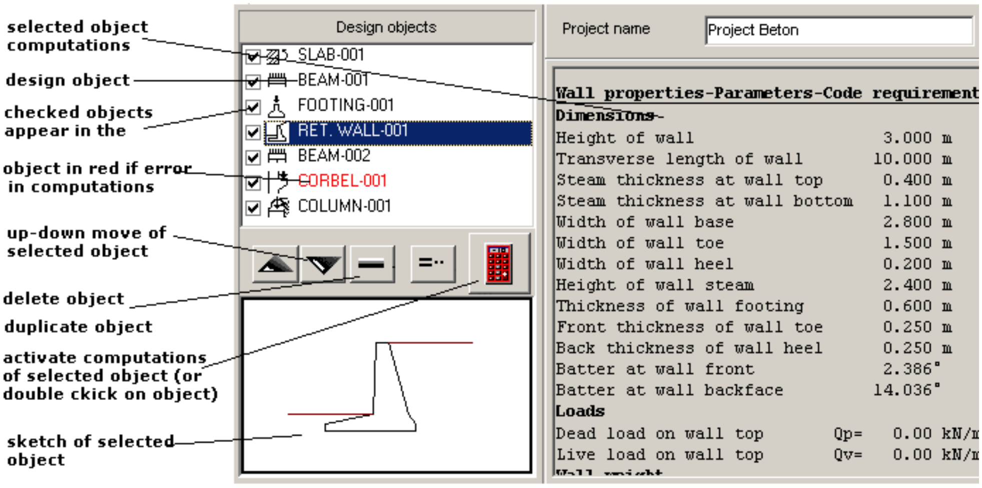
You create the design objects with the action buttons on the top. In a project you may create as many design objects, as you want. Automatically the program gives a default name to each object, (which you may change), and assigns a small characteristic icon in front to recognize the type of the design object.

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. The 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, and the reinforcing bar schedules. A common report and reinforcing bar schedule 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 =·· .



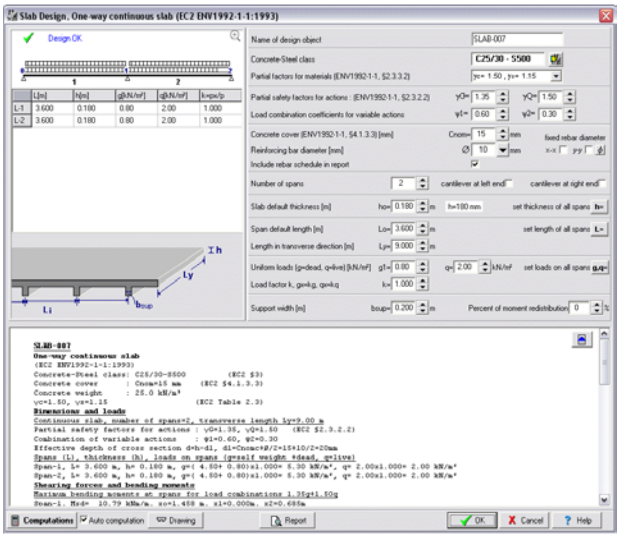
5 Calculation Window

A calculation window has a typical sketch of the concrete 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.

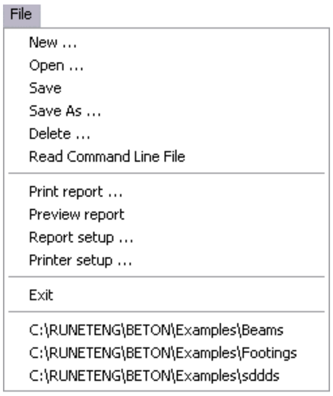
You can enter a CAD drawing of the concrete component by clicking [Drawing], or by double clicking at the centre of the sketch of the concrete object. The size of the letters in the object graph can be adjusted from Report Setup.

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. By clicking at Drawing a detailed drawing appears. With Preview and Print the full report of that object may be previewed or printed. From this preview you can export the report to PDF or Word file.



6 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 [BetonExpressData]. When you specify a new file name you don't have to type in the extension.



7 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:

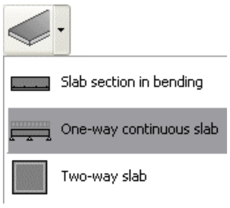
length [m] .
forces [kN]
moments [kNm]
stresses [N/mm²] = [GPa]
concentrated loads [kN]
distributed loads [kN/m²]
line loads [kN/m]

reinforcing bar diameter [mm]
concrete cover [mm]

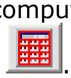
You can select the units for the reinforcement in the report from [Setup/Units in report]

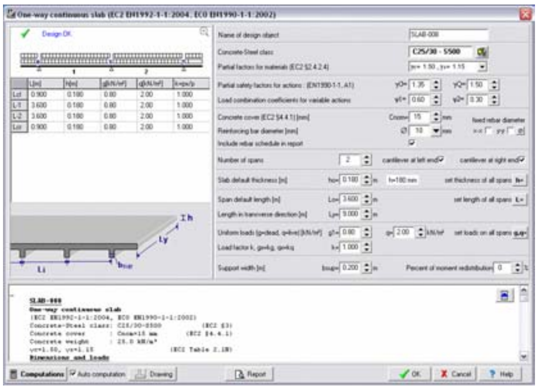
8 Step by step, program use

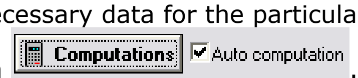
Open a Project File. Use New for new project and Open for an existing project file. All the data are saved in the same file. The data are saved automatically.



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. Footing-001, or by clicking at .



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

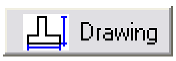
When the Auto-computation is checked, the calculations are performed automatically when you change the data.

 Click to see more of calculations.

All the computations for the design object are performed.

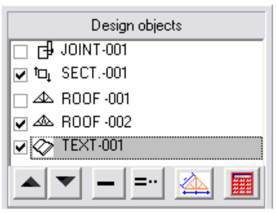
A message appears if design is OK, the computations and the dimensions are adequate.

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.

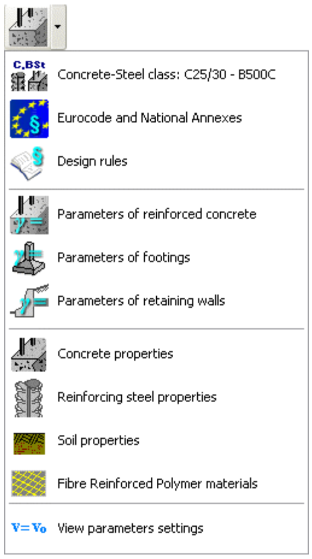


Select (check) the objects you want to include in the report. With the arrows you can adjust their order of appearance in the report. In the report only the objects checked in front will appear.

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

9 Parameters

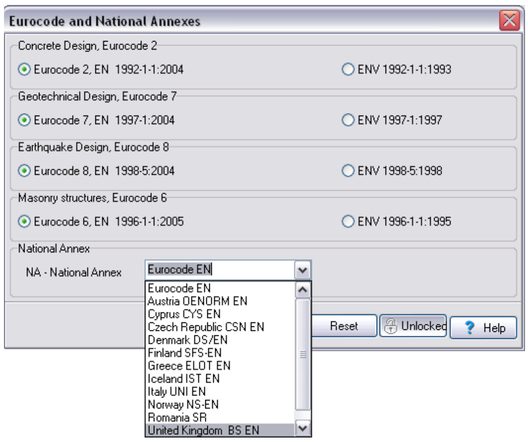


The program is based on the structural Eurocodes. The application as well as the parameters of Eurocodes may differ from country to country.

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 necessry you may also adjust various parameters such as material constants, safety factors, default values, and minimum requirements for reinforcement.

From the Parameters set:
Concrete and Steel class, default values for concrete and steel class.
Eurocode and National Annexes, select the National Annex to apply in the design.
Design Rules, select the design code you want to use, Eurocode 2 or native code for concrete design, Eurocode 7 or allowable stresses for foundation design, Eurocode 6 or allowable stresses for gravity wall design, seismic design or not.
Parameters of reinforced concrete, you adjust the load factors and you set the default values for concrete cover, default rebar diameters, minimum and maximum rebar requirements for slabs, beams, columns, footings and retaining walls.
Parameters of footing design, you adjust the partial safety factors for Eurocode 7, and the coefficients for the foundation analysis with allowable stresses.
Parameters of retaining walls, you adjust the partial safety factors for Eurocode 7, and the coefficients for the wall stability analysis with allowable stresses, participation factor of passive earth pressure, etc.
Concrete properties, **Reinforcing steel properties**, **Soil properties**, **Fibre Reinforced Polymer (FRP) materials**, you adjust the characteristic properties according to the requirements of your region. For this it is advisable to consult the National Application Document of the Eurocodes 2, 7 and 1. You select also the default properties for concrete, reinforcing steel and soil to be used in the program.

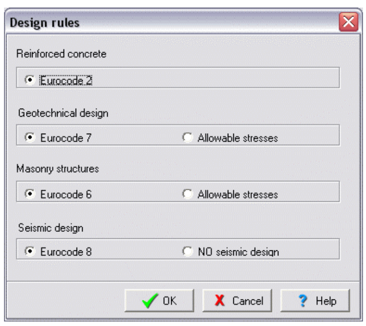


In order to edit the material properties or other design parameters, first you have to click [Locked], to unlock the edit procedures.

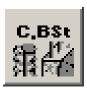
9.1 Eurocode and National Annex

Select the Eurocode and National Annex to apply in the design. The Eurocode parameters are set according to the National standards you choose. From the menu paramers, you can view the parameters.

If you select as National Annex - NA, the first option, Eurocode EN, then also ENV (prestandard versions of Eurocodes) are activated. These preversions of Eurocodes are expired, but are kept as an option in the program if someone wants to calculate with old standards for comparison.



9.2 Concrete and steel class



Select the default values for concrete class and reinforcing steel class.

9.3 Design rules

Options:

Reinforced Concrete Design

- According to Eurocode 2
- Native Concrete Design Code (if available)

Geotechnical design for footings and retaining walls

- Ultimate Limit State Design, according to Eurocode 7.
- Working Stress Design (allowable stresses)

Design of gravity type retaining walls

- Ultimate Limit State Design, according to Eurocode 6
- Working Stress Design (allowable stresses)

Seismic design

- Seismic design, (in footings, and in retaining walls), according to Eurocode 8
- No seismic design.

9.4 Parameters of reinforced concrete

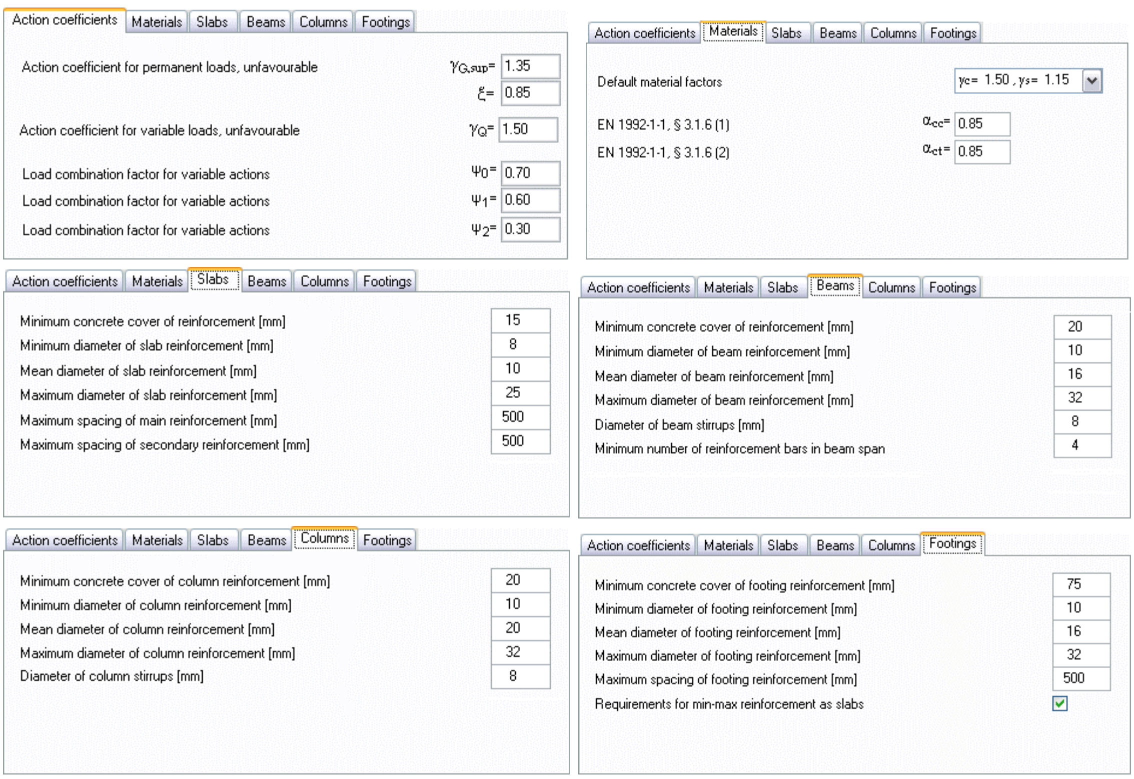
Default values for parameters of the reinforced concrete design

Default values for action coefficients for permanent and variable actions and load combination coefficients for variable actions, Eurocode 0, EN 1990:2002.

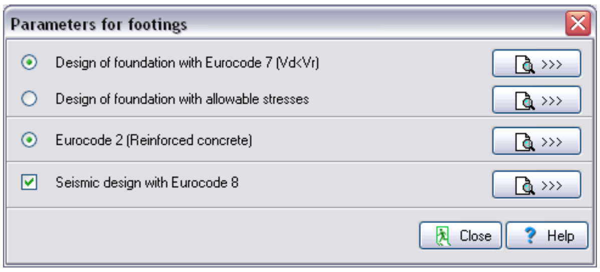
Default values for concrete cover, minimum mean and maximum steel bar diameters and spacing for slabs beams columns and footings

These parameters may be adjusted according to the design code requirements and National Application Document for Eurocode 2.

In the design of a concrete member the mean reinforcing steel diameter is used as a default value. The minimum and maximum values for the steel bar diameters are the low and upper limits of the bar diameters which are used in the design.



9.5 Parameters for footings

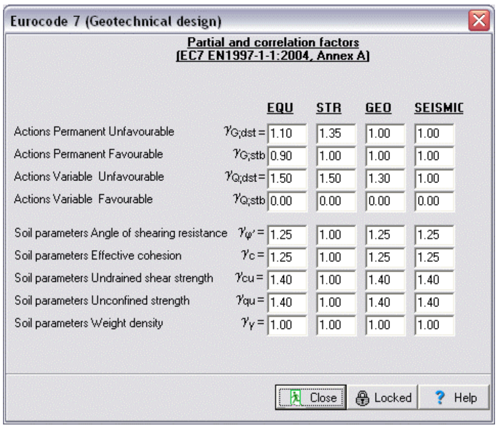


These parameters may be adjusted according to the design code requirements and National Application Document for Eurocode 7.

In order to edit the material properties or other design parameters, first you have to click 

, to unlock the edit procedures.

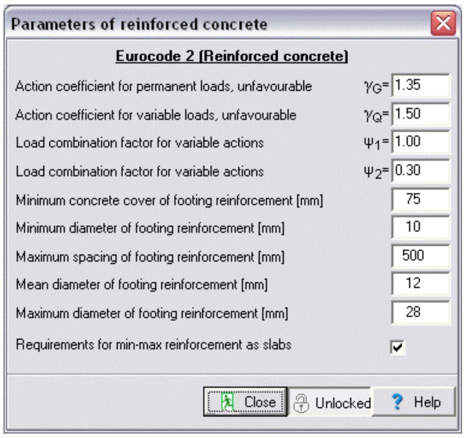
9.5.1 Design according to Eurocode 7



Partial safety factors as defined in Eurocode 7 Annex A, for EQU, STR and GEO limit cases. You can adjust them according to the requirement of National Application Document.

9.6 Design with allowable stresses

When you design with allowable stresses and seismic loading, a part only of the live loads must be considered. This part is defined by a factor specified in these parameters.



9.6.1 Reinforced concrete design

Default values for action coefficients for permanent and variable actions, and load combination coefficients for variable actions. Default values for concrete cover, and minimum mean and maximum steel bar diameters and maximum spacing for reinforcement.

In the design of footings the mean reinforcing steel diameter is used as a default value. The minimum and maximum values for the steel bar diameters are the low and upper limits of the bar diameters which are used in the design. The spacing of the reinforcing bars in the design of footings will not exceed the maximum spacing specified in these parameters.

Requirements for min-max reinforcement as slabs. If checked the minimum and maximum steel percentages are computed according to Eurocode 2 §9.3.1. (Eurocode 2 does not mention anything about the min-max steel percentages for footings).

9.6.2 Seismic design

The seismic design for footings is according to Eurocode 8 Part 5. Some factors although for the seismic design must be adjusted according to the National Application Document of Eurocode 8, or the native design code for earthquake resistance of structures.

Seismic design. You specify the default option for designing or not for seismic loading.

Design ground acceleration. You specify the default design ground acceleration ratio α. The horizontal seismic acceleration is taken as **ah=**α**xg** (where g is the acceleration of gravity).

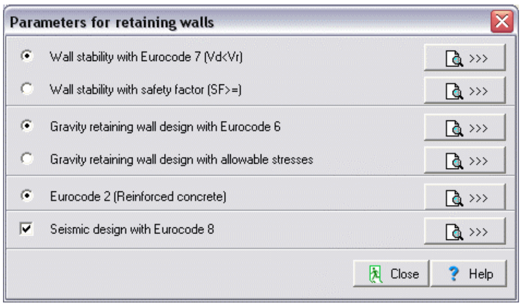
Additional factors according to Eurocode 8.

The vertical seismic coefficients is taken according to Eurocode 8 Part 5,§ 7.3.2.2 as: **kv=cxkh**. The usual value for coefficient **c** (Eurocode 8 Part 5,§ 7.3.2) is **c=0.50**.

In seismic design, you can specify a limit for the load eccentricity on the footing. Specifying a limit value for the effective footing area, it sets an upper limit to the eccentricity of the load. The upper limit for the ratio of the (effective footing area)/(footing area) can be specified. (effective footing area is considered the contact area of footing and soil). This coefficient has a usual value 0.50, which corresponds to load eccentricity ratio 0.33.

Increase of allowable soil bearing pressure. In seismic design, when you design with allowable stresses, you can increase the allowable soil pressure by a factor. In many design codes this factor is about 1.20 to 1.30.

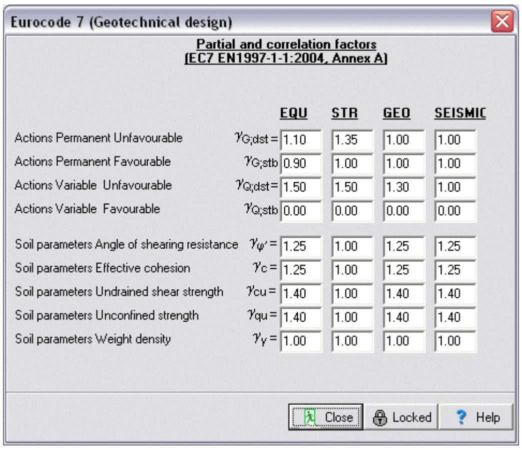
9.7 Parameters of retaining walls



Default values for parameters of the design of retaining walls.

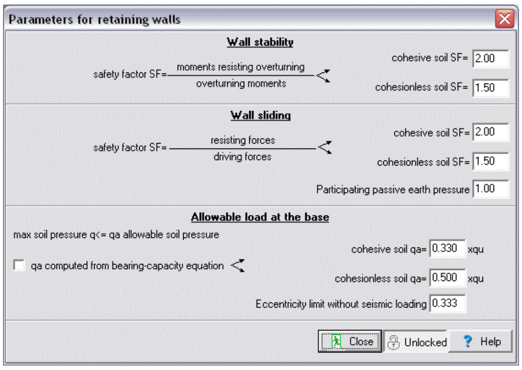
These parameters may be adjusted according to the design code requirements and National Application Document for Eurocode 2, 7 and 8.

9.7.1 Wall stability according to EC 7



Partial safety factors as defined in Eurocode 7 Annex A, for EQU STR and GEO limit cases. You can adjust them according to the requirement of National Application document.

9.7.2 Wall stability with allowable stresses



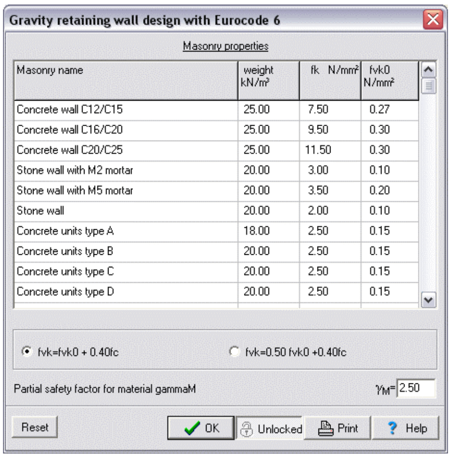
Safety factors. Safety factors for wall stability (overturning), and sliding. Usual values for these safety factors are 1.50.

Participationfactor for passive earth pressure. In designing with allowable stresses you can reduce the favourable effects of the passive earth pressure by the reduction factor, which you specify in this set of parameters.

Eccentricity limit. A limit in the eccentricity ratio (e/B e=load eccentricity, B= footing width) is imposed for the loading on the wall foundation.

9.7.3 Gravity retaining walls, (design according to Eurocode 6)

Properties of masonry wall materials.



fk [N/mm²] characteristic compressive strength of the masonry (Eurocode 6, §3.6.2)

fvk0 [N/mm²] characteristic shear strength (Eurocode 6, §4.5.3)

9.7.4 Gravity retaining walls (design with allowable stresses)

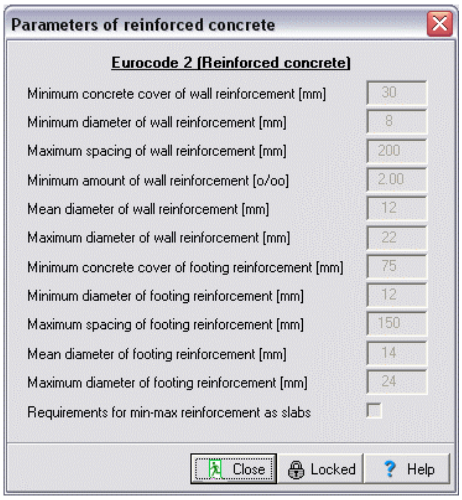
Properties of masonry wall materials.

fc [N/mm²] allowable compressive stress.

ft [N/mm²] allowable tensile stress.

fv [N/mm²] allowable shearing stress.

9.7.5 Reinforced concrete design



Default values for concrete cover, minimum, mean, and maximum steel bar diameters, and maximum spacing for reinforcement for the retaining wall stem and the footing.

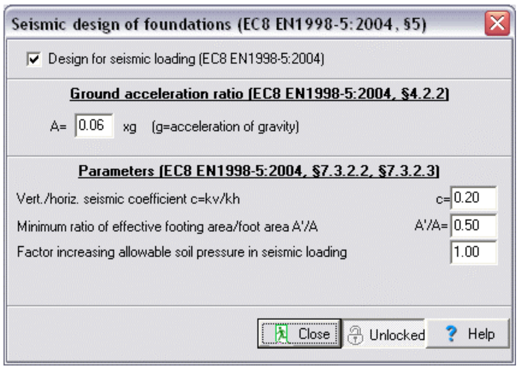
In the design of the wall stem and the footing the mean reinforcing steel diameter is used as a default value.

The minimum and maximum values for the steel bar diameters are the low and upper limits of the bar diameters which are used in the design.

The spacing of the bars in the steam and the footing, which is used in the design will not exceed the maximum spacing specified in these parameters.

Requirements for min-max reinforcement as slabs. If checked the minimum and maximum steel percentages for the wall footing are computed according to Eurocode 2 §9.3.1. (Eurocode 2 does not include anything about the min-max steel percentages for footings).

9.7.6 Seismic design



The seismic design is according to Eurocode 8. Some factors although for the seismic design must be adjusted according to the National Application Document of Eurocode 8 Part 5, or the native design code for earthquake resistance of structures.

Seismic design. You specify the default option for designing or not for seismic loading.

Design ground acceleration. You specify the default design ground acceleration ratio α. The horizontal seismic acceleration is taken as **ah=αxg** (where g is the acceleration of gravity).

Safety factors. In seismic design, when you design with allowable stresses, the safety factors against sliding and overturning maybe reduced towards 1.00.

Increase of allowable soil bearing pressure. In seismic design, when you design with allowable stresses, you can increase the allowable soil pressure by a factor. In some design codes this factor is about 1.20 to 1.30.

Additional factors according to Eurocode 8, Part 5.

The horizontal and vertical seismic coefficients affecting all the masses are taken according to Eurocode 8 Part 5,§ 7.3.2.2 as: **$kh=\alpha/r$**, and **$kv=cxkh$**. The usual value for coefficient **r** according to Eurocode 8 Part 5, Table 7.1, for walls with possibility of small sliding is **r=2.00** to **1.50**. The usual value for the coefficient **c** according to Eurocode 8 Part 5, § 7.3.2.2 is **c=0.50**.

In seismic design, you can specify a limit for the load eccentricity on the wall footing. Specifying a limit value for the effective footing area, it sets an upper limit to the eccentricity of the load. The upper limit for the ratio of the (effective footing area)/(footing area) can be specified. (effective footing area is considered the contact area of footing and soil). This coefficient has an usual value 0.50, which corresponds to load eccentricity ratio 0.33.

According to Eurocode 8 Part 5, § 7.3.2 3 (6) the shearing resistance between soil and wall is restricted to be less than a ratio (2/3=0.67) of the soil shearing resistance.

In the seismic loadings, a reduction factor can be applied on the favourable effects of passive earth force. This factor has a usual value 0.50.

9.8 Soil properties

You can edit the values of the soil properties, from [Parameters/Soil properties].

insert and delete buttons.

γ_d**: dry unit weight ,** γ_s**: saturated unit weight**

$\phi°$**: angle of internal friction,** c**: cohesion**

q_a: allowable bearing pressure, q_u: bearing capacity,

Es**: modulus of elasticity,** μ**: Poisson ratio,**

Ks: modulus of subgrade reaction.

Soil type	γ_d [kN/m³]	γ_s [kN/m³]	φ°	c [N/mm²]	qa [N/mm²]	qu [N/mm²]	Es [MPa]	μ	Ks [kN/m³]
Large gravel	16.00	20.00	45.00	0.00	0.30	0.50	80.00	0.15	200000
Mean gravel	16.00	20.00	40.00	0.00	0.30	0.40	70.00	0.15	140000
Thin gravel	16.00	20.00	35.00	0.00	0.30	0.40	60.00	0.15	100000
Dense sand	17.00	20.00	35.00	0.01	0.25	0.30	50.00	0.20	125000
Sand	15.00	19.00	30.00	0.00	0.25	0.30	25.00	0.20	90000
Loose sand	14.00	18.00	25.00	0.00	0.20	0.25	15.00	0.20	30000
Silty sand	21.00	23.00	25.00	0.00	0.15	0.15	10.00	0.25	80000
Clay	20.00	21.00	20.00	0.02	0.15	0.15	5.00	0.30	50000
Silt	16.00	20.00	20.00	0.00	0.10	0.10	2.00	0.25	50000

9.9 FRP Fibre Reinforced Polymer Materials

Fibre Reinforced Polymer materials (F.R.P.), are used as coatings to strengthen reinforced concrete components. Materials made from carbon (CFRP), glass (GFRP), or aramid (AFRP), bonded together with a polymeric matrix, such as epoxy, polyester or vinylester. These materials have high strength and stiffness in the direction of the fibres, low weight and they resist corrosion.

In order to edit the FRP material properties:

Locked in order to unlock the edit procedures

insert and delete buttons.

Ef characteristic elastic tensile modulus [Gpa]

ftk characteristic tensile strength [Mpa]

Material	Modulus of elasticity Ef [GPa]	Tensile strength ftk [Mpa]
CFRP Carbon fiber-epoxy	140	2000
GFRP Glass fiber-epoxy	35	800
Polyester fiber-epoxy	5	1000
AFRP Aramid fiber-epoxy	50	2000
FRP Fiber - epoxy	10	1000

9.10 Reset all parameters

From the menu [Setup/ Show all parameters] setting you can see the default values you have chosen for your designs. You can any time change the parameters from inside the calculation window.

If you want to reset all your parameters to the original values of the program, press the button

Reset to original program values

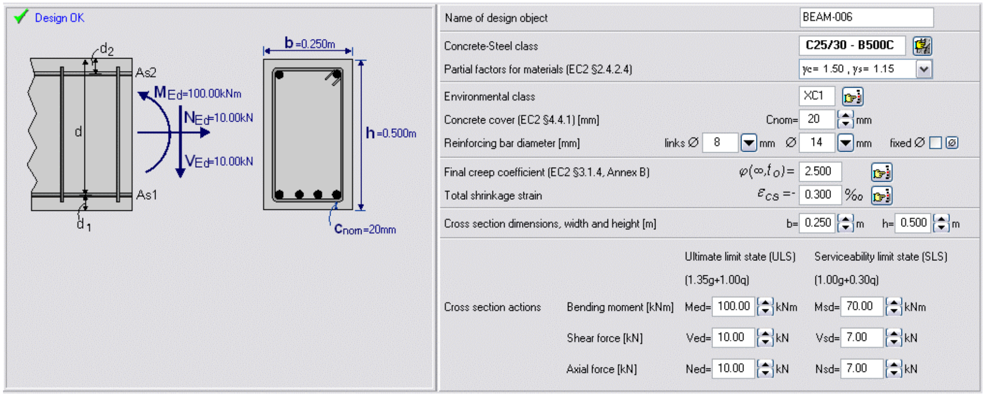
If you reset all parameters ALL your user defined values will be LOST.

Program will close down and you must restart the program.

10 General input data for concrete components

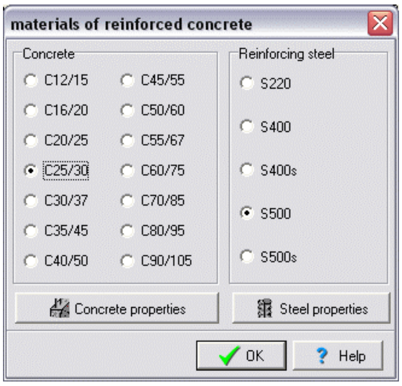
Most of the concrete design objects have some basic common data as follows:

- 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



10.1.1 Name of design object

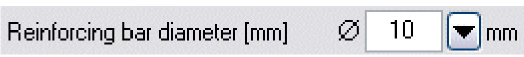
Every design object has a name, which appears in the report. In the creation of each object the program assigns a default name e.g. slab-001, Beam-002 etc. which may be changed any time. (names up to 16 characters long)



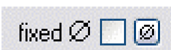
10.1.2 Concrete-Steel Class

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].

10.1.3 Reinforcing bar diameter



You specify the reinforcing bar diameter, which is 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.

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

Factors for the combination of permanent and variable actions, Eurocode 0 Annex A 1.

The values defined in Eurocodes for these factors are **γG=1.35**, and **γQ=1.50**

The design values for actions are combined as:

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

10.1.5 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

10.1.6 Concrete cover (Eurocode 2 §4.4.1.2)

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

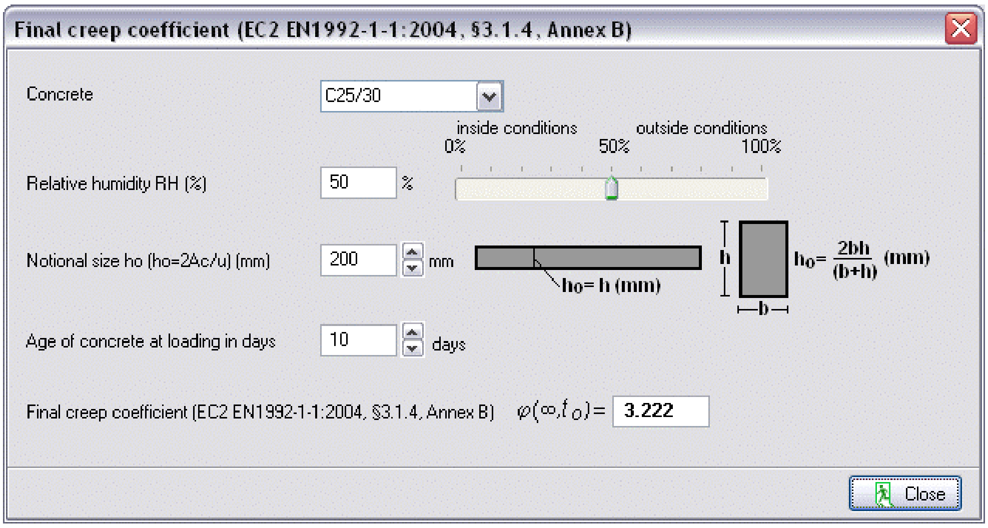
$C_{nom} = C_{min} + \Delta C_{dev}$ ΔC_{dev}=10 mm EC2 §4.4.1

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, for interior and exterior concrete components the minimum cover is 40 mm.

10.1.7 Creep and shrinkage coefficient

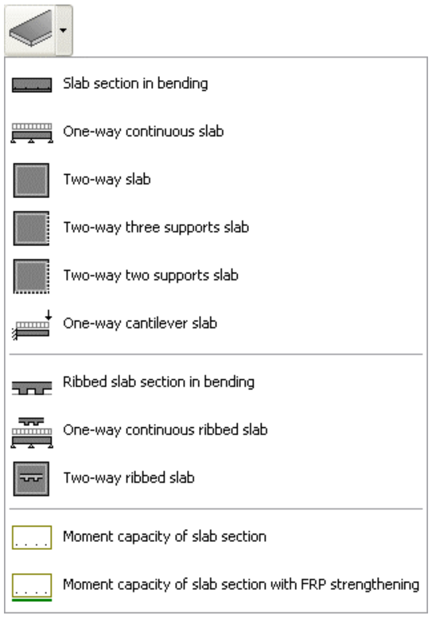
The final creep coefficient is used in the calculations of deflections and crack control in Serviceability limit states (SLS). You can compute the creep coefficient from the enviromental parameters and the sizes of the cross sectionsaccordind to EN 1992-1-1:2004, par 3.1.4. and Annex B.



10.1.8 Include rebar schedule in report.

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

11 Concrete slabs



Dimensioning of concrete slabs of **solid** or **ribbed** cross section. You can design two-way slabs, or one-way multiple span concrete slabs, and compute the ultimate capacity of slabs sections and slabs with FRP (Fibre Reinforced Polymers) jackets. 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.

Two-way slabs. Three categories of two-way slabs are considered. Slabs supported on all four edges, slab supported on three edges and having one edge free, and slabs supported on two adjacent edges and having the other two free. 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.

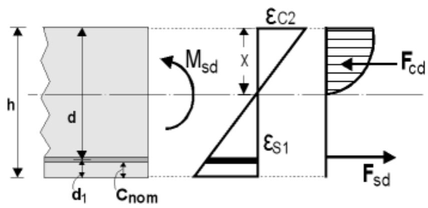
One-way multiple span slab. Design of one-way continuous slabs up to 8 spans with optional end cantilevers, and uniform load with dead and live components on the spans. The lengths, the slab height and the loading may be specified for every span. The static solution is performed with finite element analysis 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.

Section capacity. Ultimate moment capacity of slab section with given reinforcement.

Section capacity with FRP jacket. Ultimate moment capacity of slab section with given reinforcement and strengthened with FRP (Fibre Reinforced Polymer) jacket.

11.1 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.

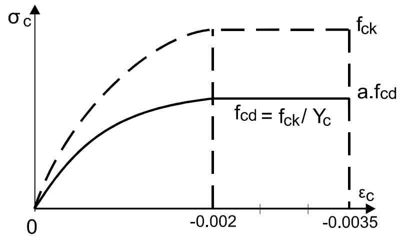
Basic principles.

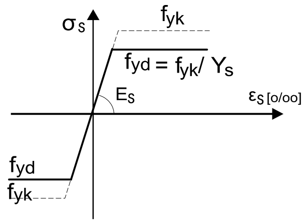
Plane sections remain plain

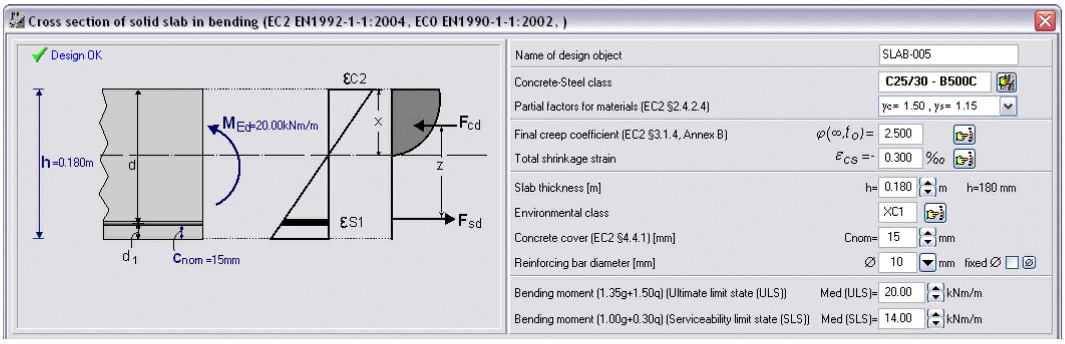
The strain in bonded reinforcement is the same as the surrounding concrete.

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.

11.2 One-way multiple span slabs (up to 8 spans)

Design of one-way continuous slabs up to 8 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].

11.2.1 Number of spans

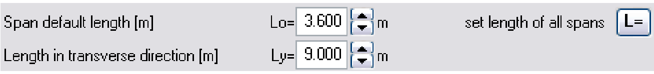
You specify the number of spans of the continuous slab. By checking cantilever at left or cantilever at right, you specify the existence of cantilevers at the left or the right end.

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.

11.2.2 Slab thickness

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

11.2.3 Span length



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

11.2.4 Loads

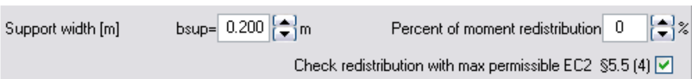
Default loads in [kN/m²], **g1** for the dead load of the slab finishing, and q for the live load on the slab. From the left window under the slab sketch, you may change these default values for every span. The total dead load is computed by the program as g=(g1+self weight).

By clicking at **g,q=** you set the values for the loads at all the spans to the default values.

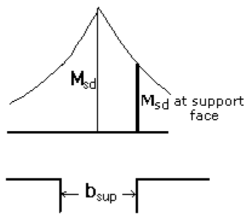
The loads are multiply by a load factor k (default value 1.00), when two dimensional in plane solution of a slab system is performed. The design actions are obtained with combination of permanent and variable actions as in Eurocode EN 1990:2002, **γG Gk +γQ Qk).**

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.

11.2.5 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 (%).



11.2.6 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.

11.3 Two-way slabs

Three categories of two-way slabs are considered.

Slabs supported on all four sides.

Slabs supported on three sides and with one side free.

Slabs supported on two adjacent sides and with the other two sides free.

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 $mx=q.Lx^2/TV$ $mx=q.Lx^2/TV$

for shear forces are $vx:=\pm q.Lx/TV$ $vx:=\pm q.Lx/TV$

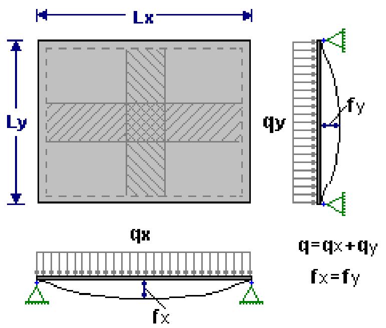
TV are coefficients obtained from tables for various Lx/Ly ratios and support conditions.

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 $mx=q.Lx^2.TV$, $my=q.Ly^2.TV$

for shear forces are $vx:=\pm q.Lx.TV$ $vx:=\pm q.Lx.TV$

TV are coefficients obtained from tables for various Lx/Ly ratios and support conditions



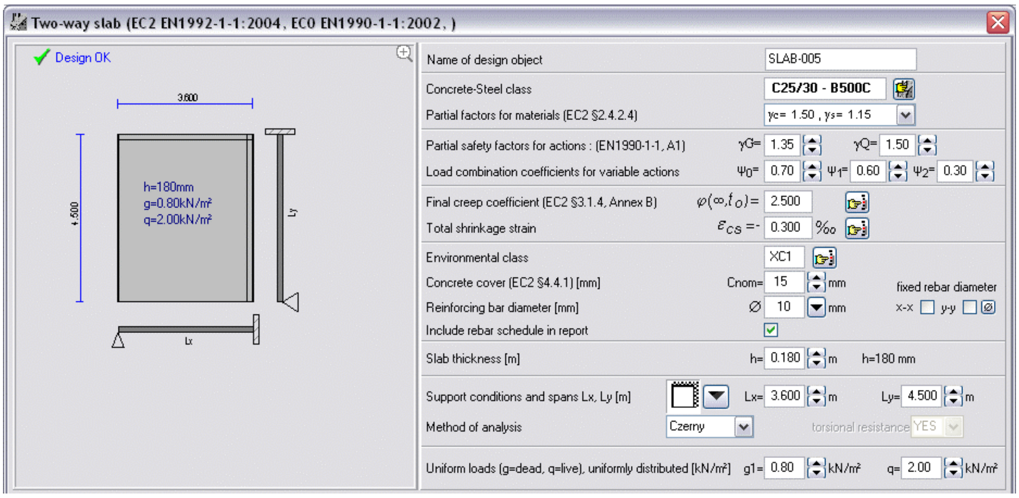
Marcus method of analysis. Marcus H., "*Die vereinfachte Barechnung biegsamer Platten*", 2nd ed., Springer-verlag, Berlin, 1929.

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.

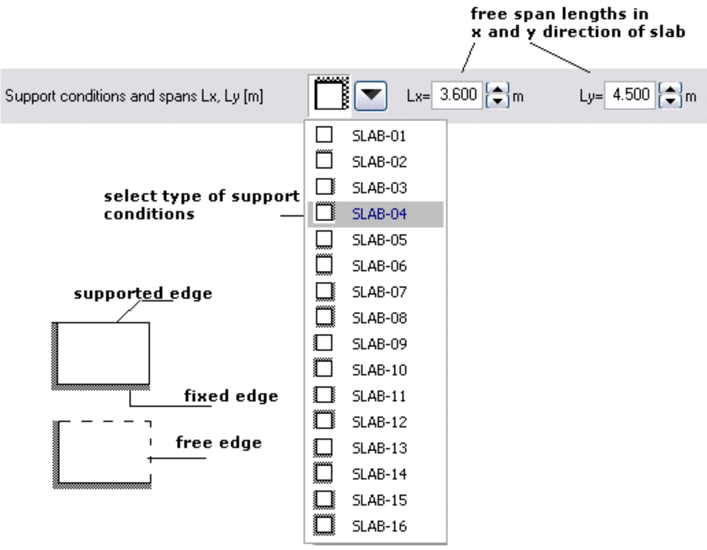
The two directions x-x and y-y of the slab are designed separately. The direction with the maximum bending moment defines the lower reinforcement layer. Full code check, according to Eurocode 2, is performed. The reinforcing bars are automatically placed in the reinforcing bar schedules. The design actions 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.

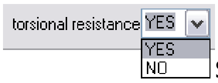
You specify the desired diameter for flexural reinforcement, and the spacing and number of reinforcing bars is obtained. You can check to use specific reinforcement diameter or the program optimise the reinforcement around the desired diameter. The reinforcing bars are automatically placed in the reinforcing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



11.3.1 Support conditions

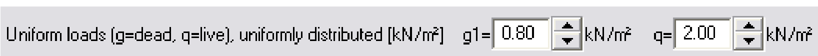


11.3.2 Torsional resistance



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.

11.3.3 Loads

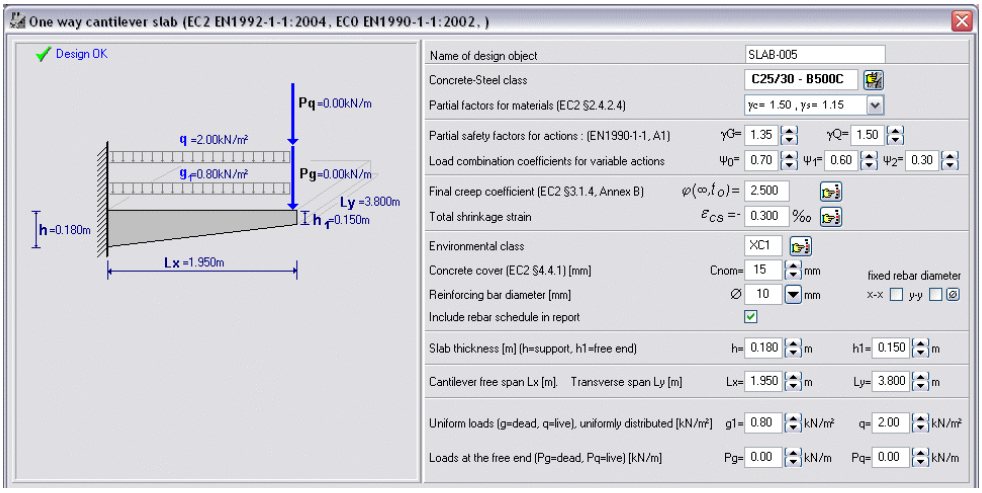


Loads in [kN/m²]. g1 for the dead load of the slab finishing, and q for the live load on the slab.

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).

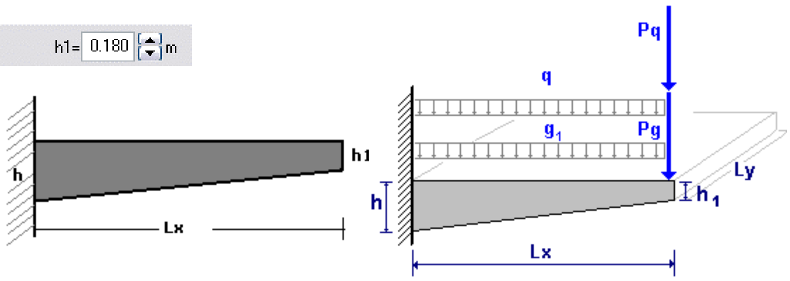
11.4 Cantilever slabs

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, (γ**G Gk +**γ**Q 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.

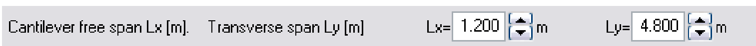


11.4.1 Slab thickness

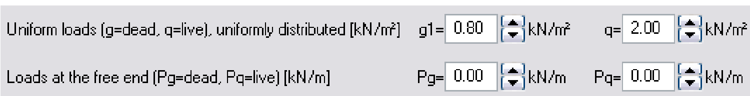
Slab thickness h at fixed end and h1 at free end in meters (m).



11.4.2 Free span



11.4.3 Loads

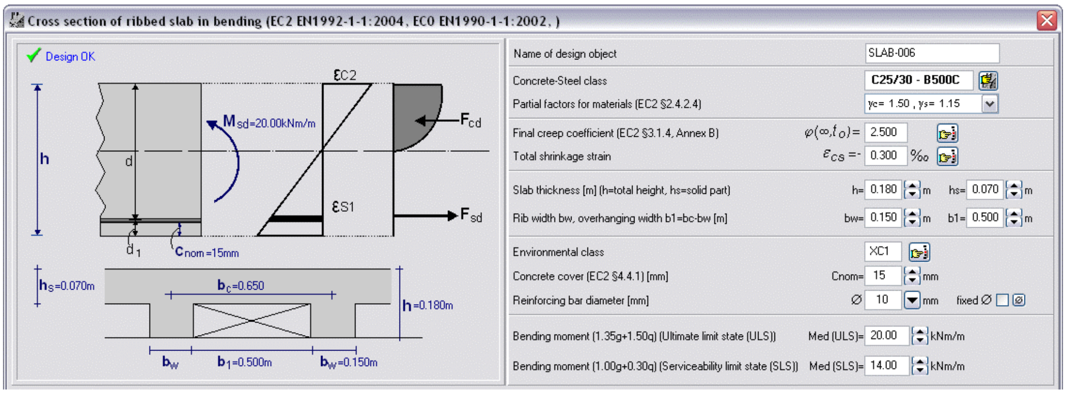


Uniformly distributed loads in [kN/m²], g1 for the dead load of the slab finishing, and q for the live load on the slab. Pg [kN/m] is the dead concentrated load at the free end and Pq [kN/m] the live concentrated load at the free end.

The design actions are obtained with combination of permanent and variable actions as in Eurocode EN 1990:2002 (γ**G Gk +**γ**Q Qk).**

11.5 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. In the case of two-way ribbed slabs the torsional resistance is not taken into account. 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)



11.6 Slab section, moment capacity

Evaluation of the ultimate moment capacity, of a slab section with a given reinforcement.

The ultimate bending capacity of the cross section is computed, by numerical integration of the internal forces acting on the section. The 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.

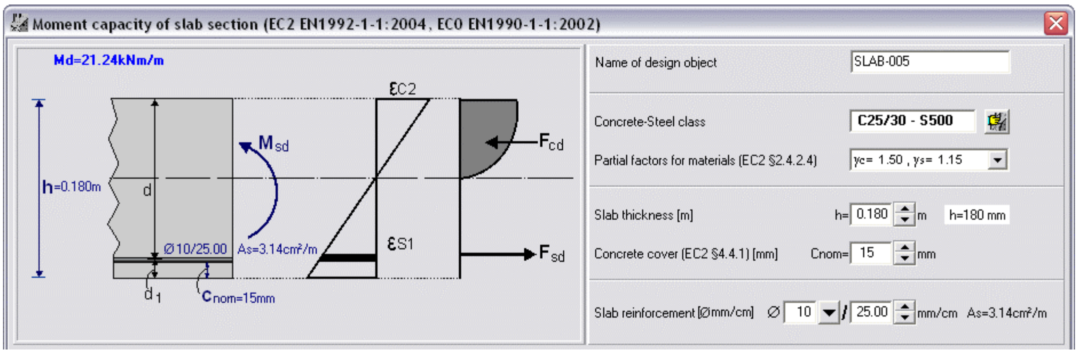
The following assumptions are used:

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.



11.7 Slab section strenghtened with FRP jacket (moment capacity)

Evaluation of the ultimate moment capacity of slab section, with a given reinforcement and strengthened with jacket from Fibre Reinforced Polymer (FRP) material.

For the cross section you specify:

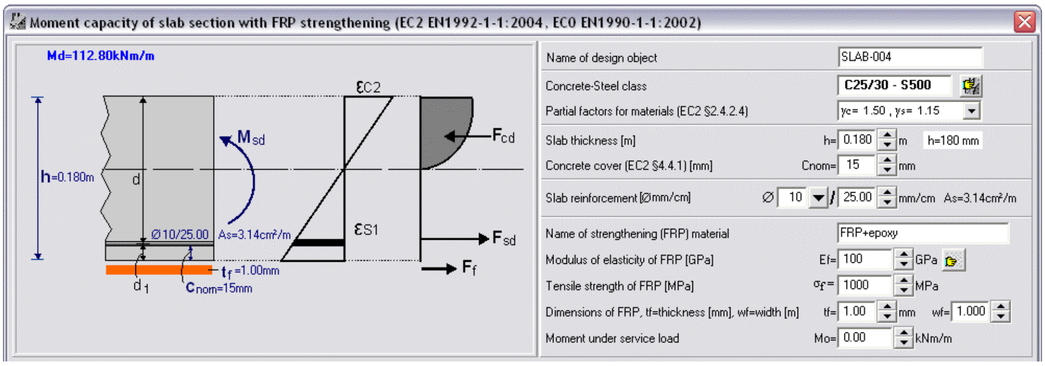
- The concrete and steel class.
- The dimensions and the reinforcement.
- The characteristic properties (Modulus of Elasticity, Tensile strength) of the FRP material
- The dimensions (width, and thickness) of the FRP material
- The bending moment under service load without FRP jacket.

By clicking at  you select FRP material from the table of FRP materials. You can edit and update the table of FRP materials from the menu [Parameters/FRP materials].

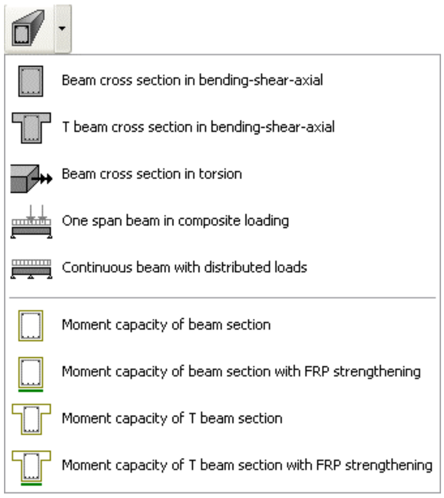
The ultimate bending capacity of the cross section is computed by numerical integration of the internal forces acting on the section. The internal forces are the forces due to compression of the concrete, due to tension and compression of the steel at the positions of the reinforcing bars, and due to compression and tension of the FRP jacket. The initial deformations under service load, (bending moment without FRP jacket) are taken into account in the evaluation of the stresses in the FRP jacket.

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.
- Linear stress-strain relationship for the FRP material.



12 Beams



Dimensioning of concrete beams, of rectangular or T cross-section. You can design single or multiple span continuous beams, and compute the ultimate capacity of beam sections and beams strengthened with FRP (Fibre Reinforced Polymer) jackets. 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 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.

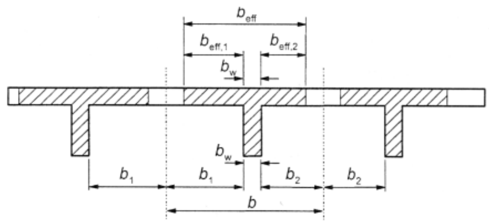
Single span beam in composite loading. Dimensioning of single span beam under composite loading. The beam cross section can be rectangular, T section, or edge beam. The effective flange width is evaluated according to Eurocode 2 §5.3.2.1. The left or right end support conditions of the beam may be specified 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 8 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.

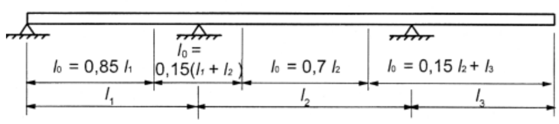
Moment capacity. Evaluation of the ultimate capacity of a beam section with given reinforcement.

Moment capacity with FRP jacket. Evaluation of ultimate capacity of a beam section with given reinforcement, and strengthened with Fiber Reinforced Polymer (FRP) jacket.

12.1 Effective flange width

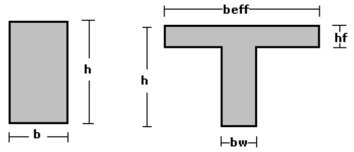


The effective flange width for symmetrical T beams may be taken as beff=bw+(1/5)Lo<b and for beams with flange at one side only as beff=bw+(1/10)Lo<b1+bw. Eurocode 2 §5.3.2.1(3).



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).

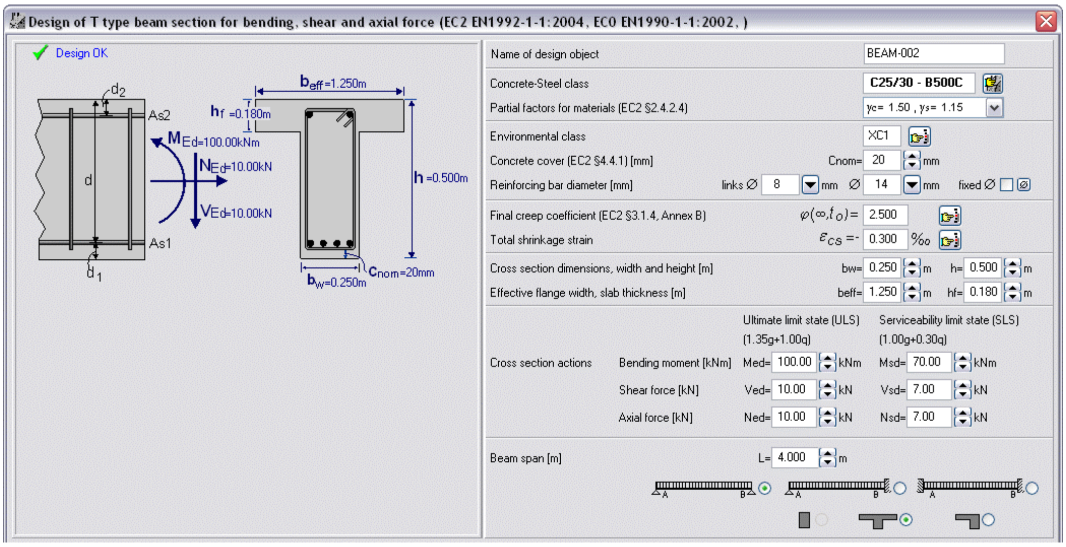
12.2 Beam cross section data



All dimensions in meters (m).

12.3 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.

12.4 One span beam under composite loading

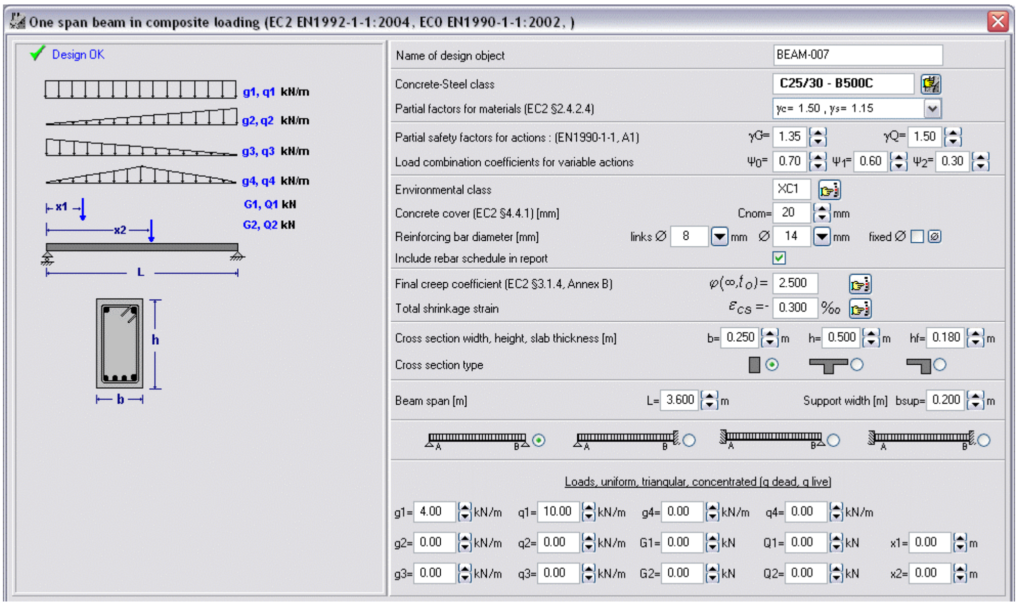
Dimensioning of one span beam under composite loading. The beam cross section can be rectangular, T section, or edge beam. The effective flange width is evaluated according to Eurocode 2 §5.3.2.1. The end support conditions of the beam may be specified as simply supported or fixed. The loading is the 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].



12.4.1 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.

12.4.2 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**).

12.5 Multiple span continuous beams

Design of continuous beams up to 8 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

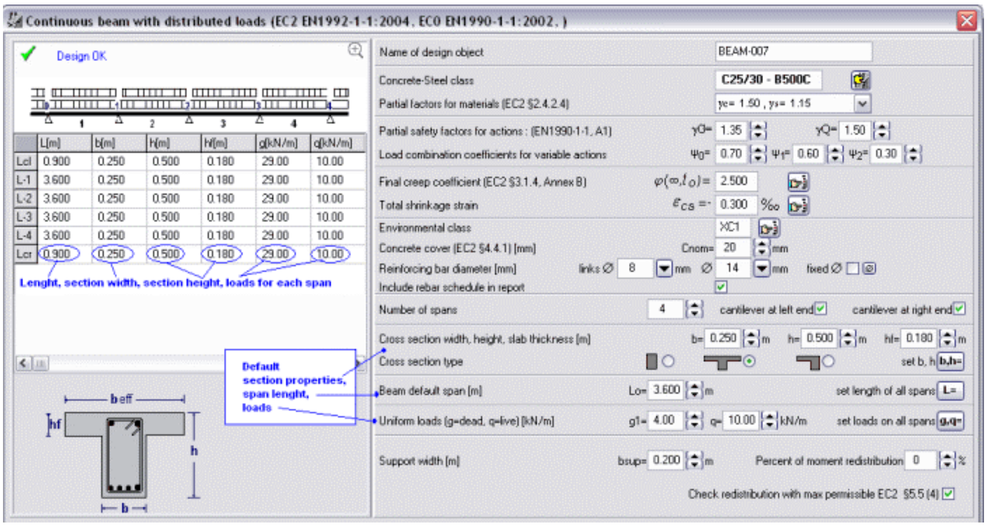
The design actions are obtained with combination of permanent and variable actions as in Eurocode 0 1990:2002 (**γG Gk +γQ Qk**). The static solution is performed with finite element analysis taking into account the most unfavourable live load placing on the spans to obtain the maximum or minimum design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



	L[m]	b[m]	H[m]	hf[m]	g[kN/m]	q[kN/m]
Lcl	0.900	0.250	0.500	0.180	29.00	10.00
L-1	3.600	0.250	0.500	0.180	29.00	10.00
L-2	3.600	0.250	0.500	0.180	29.00	10.00
L-3	3.600	0.250	0.500	0.180	29.00	10.00
L-4	3.600	0.250	0.500	0.180	29.00	10.00
Lcr	0.900	0.250	0.500	0.180	29.00	10.00

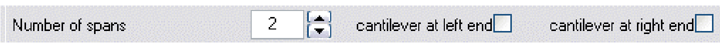
12.5.1 Beam cross-section

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.

12.5.2 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.

12.5.3 Number of spans

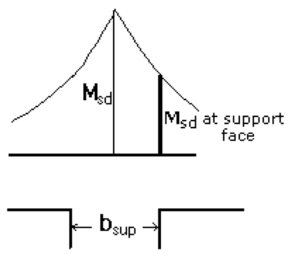


You specify the number of spans of the continuous beam. By checking <u>cantilever at left</u> or <u>cantilever at right</u>, you specify the existence of cantilevers at the left or the right end.

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.

12.5.4 Loads

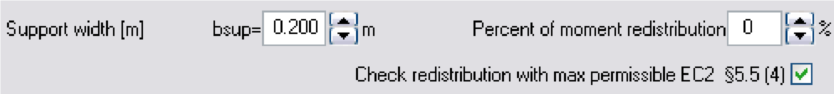
Default loads in [kN/m], g1 for the dead load on the beam, and q for the live load on the beam. From the left window under the beam sketch, you may change these default values for every span. (The total dead load is g=self weight + g1, the self weight is computed by the program)



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**).

12.5.5 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 (%).

12.5.6 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.

12.6 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,

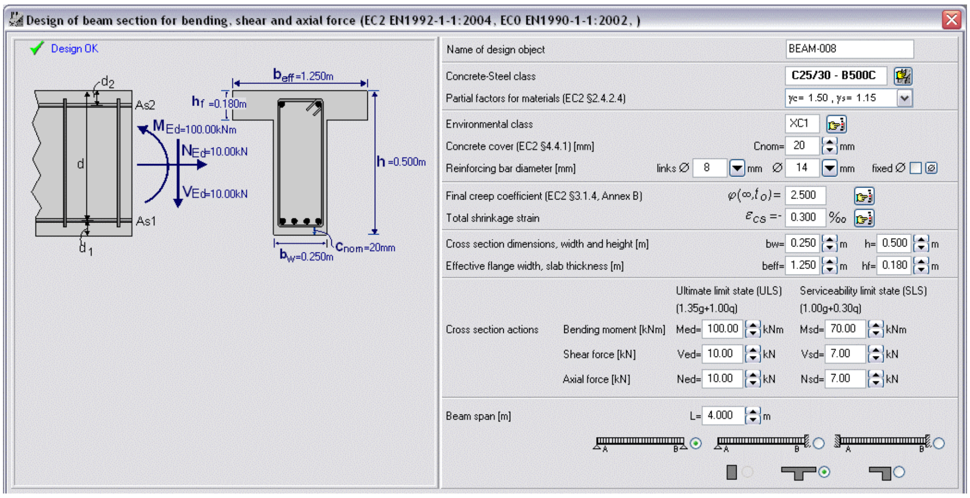
$$\left(\frac{T_{Ed}}{T_{Rd,max}}\right)+\left(\frac{V_{Ed}}{V_{Rd,max}}\right)\le 1$$

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.,

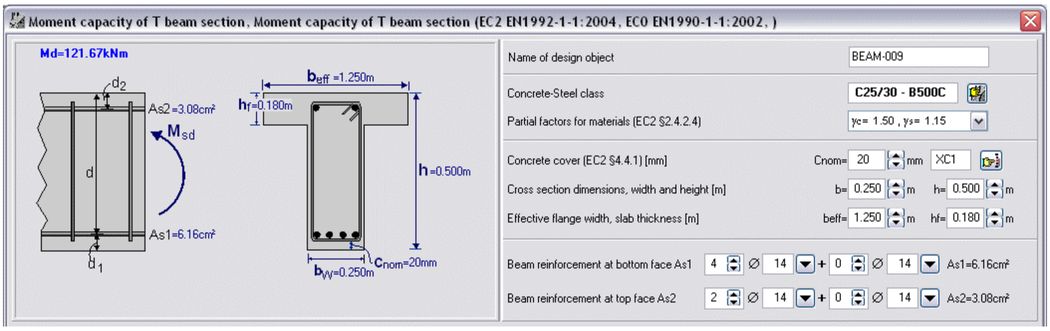
The calculation for necessary stirrups in torsion and shear are made separately.

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].



12.7 Moment capacity of beam section

Evaluation of the ultimate moment capacity of rectangular or T shape beam section, with a given reinforcement.
The ultimate bending capacity of the cross section is computed by numerical integration of the internal forces acting on the section. 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.



12.8 Beam section strengthened with FRP jacket (moment capacity)

Evaluation of the ultimate moment capacity of rectangular or T shape beam section, with a given reinforcement and strengthened with a jacket from Fibre Reinforced Polymer (FRP) material.

For the cross section you specify:

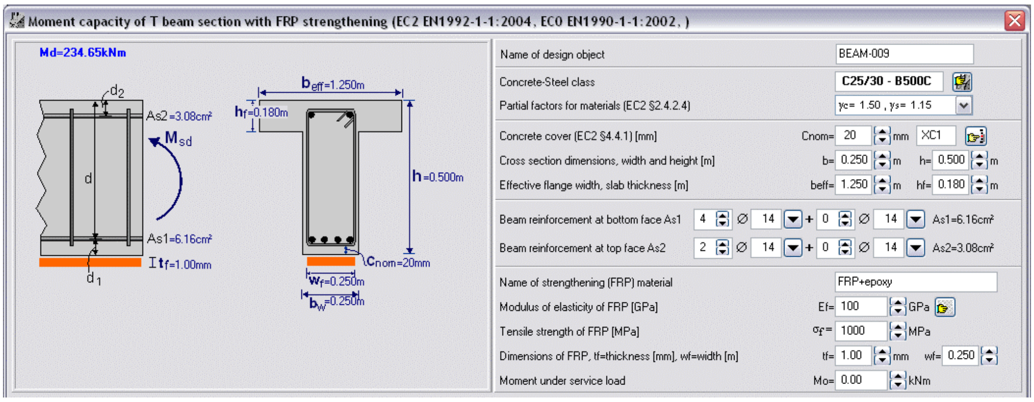
- The concrete and steel class.
- The dimensions and the reinforcement.
- The characteristic properties (Modulus of Elasticity, Tensile strength) of the FRP material
- The dimensions (width, and thickness) of the jacket from FRP material
- The bending moment under service load without FRP jacket.

By clicking at  you select FRP material from the table of FRP materials. You can edit and update the table of FRP materials from the menu [Parameters/FRP materials].

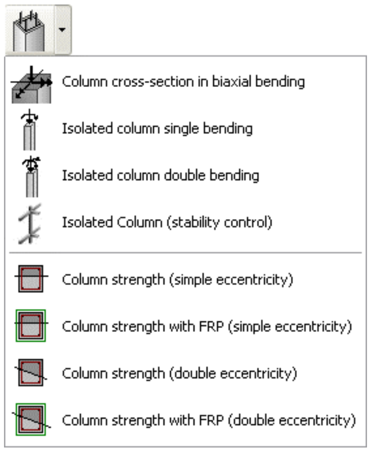
The ultimate bending capacity of the cross section is computed, by numerical integration of the internal forces acting on the section. These internal forces are the forces due to compression of the concrete, due to tension and compression of the steel at the positions of the reinforcing bars, and due to compression and tension of the FRP jacket. The initial deformations under service load, (bending moment without FRP jacket) is taken into account in the evaluation of stresses in the FRP jacket.

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.
- Linear stress-strain relationship for the FRP material.



13 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 §5.8.3.2The 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.

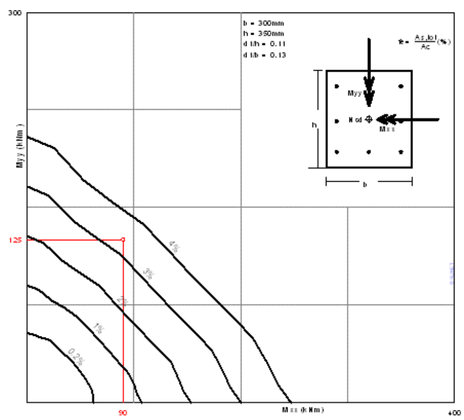
Slender columns in double bending. The design is according to Eurocode 2 §5.8. The slenderness effects and second order effects are considered in the design. For the end restrain conditions you specify the end support conditions in both x and y directions (fixed, pin or free end). In the case of column, which is part of a building frame, elastically restrained ends can be specified. The applied loads are axial loads and bending moments in x-x and y-y directions at the top and bottom. 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.

Section capacity of rectangular or circular columns with FRP (fibre reinforced polymer) jacket subjected to compression and uniaxial or biaxial bending moments. The ultimate capacity of a column cross section , with given dimensions, reinforcement and FRP jacket, 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), the forces of the steel (elasto-plastic stress-strain diagram), and the forces of the FRP jacket (linear stress-strain diagram). 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.

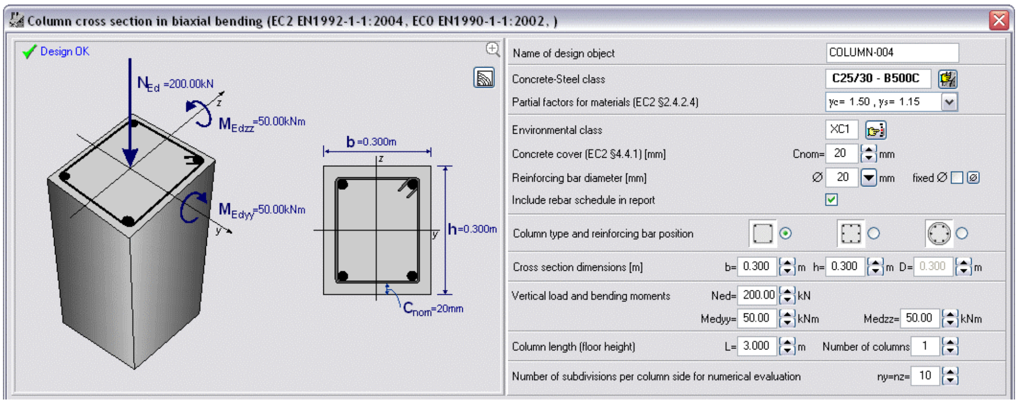
13.1 Design of column section in double bending

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.

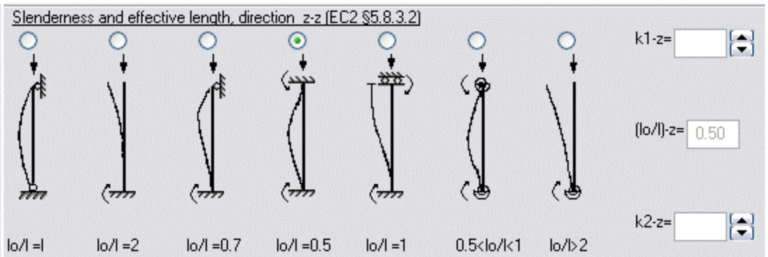
The axial force in [kN], positive for compression and the bending moments in [kNm]. You specify if the reinforcement is placed in the four corners of the cross section or if it is distributed around the perimeter of the section. The position of the reinforcement plays roll in the evaluation of the equilibrium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



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

13.2 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

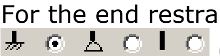


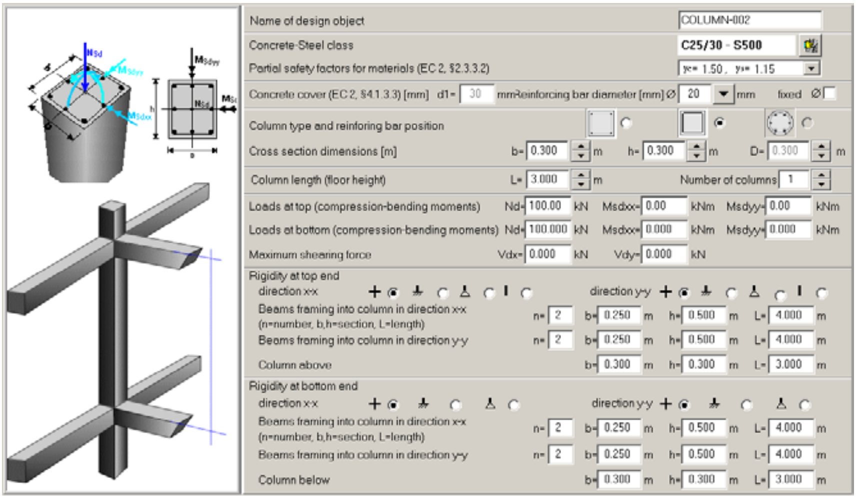
The analysis method is according to §5.8.7.3.Moment magnification factor. The applied loads are axial loads and bending moments in x-x and y-y directions . The reinforcing bars are automatically placed in the reinforcing bar.

13.3 Slender columns (second order effects)

Design of slender columns in double bending. The design is according to Eurocode 2, §5.8. The slenderness effect and second order effects are considered in the design.

Axial loads and bending moments in x-x and y-y directions, can be applied at the top and bottom of the column.

For the end restrain conditions you specify the end support conditions in both x and y directions  (fixed, pin or free end). In case of column, which is part of a building frame, elastically restrained ends are assumed in non-sway structure. In this case select  , and underneath specify the number of beams (n) at the column end in the x-x or y-y direction, and the beam dimensions (b=cross section width, h=cross section height, L=beam length). You specify also the dimensions (b=cross section width, h=cross section height, L=column length), for the columns above and below. The rigidity of restraint at the column ends is evaluated according to Eurocode 2, §5.8.

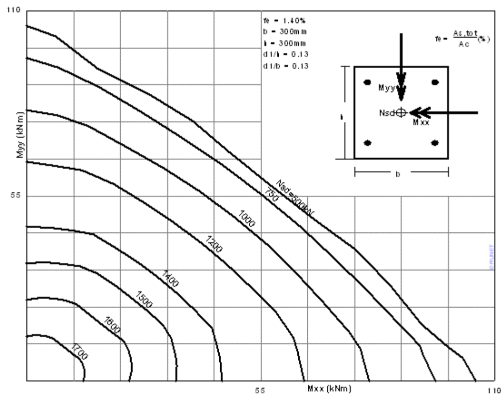


13.4 Column section capacity

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.

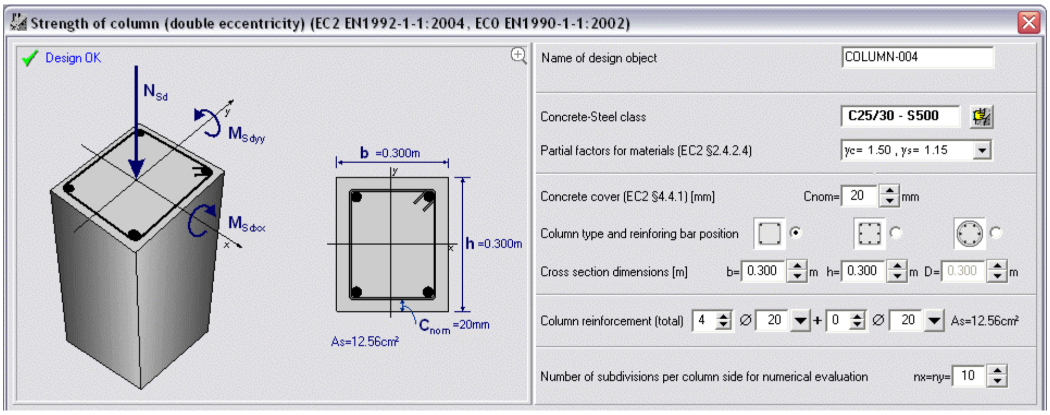
The following assumptions are used:

- 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.



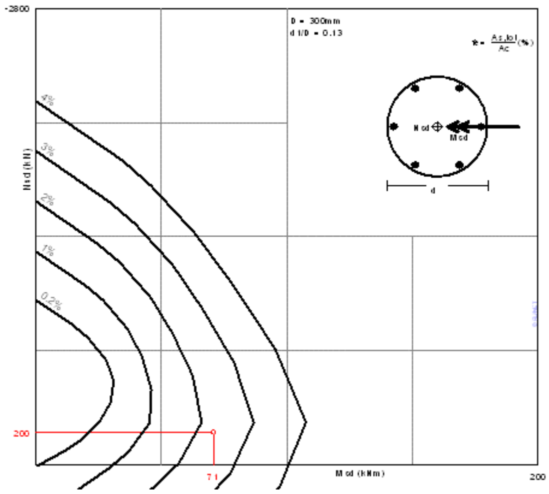
13.5 Column section strengthened with FRP jacket

Section capacity of rectangular or circular column strengthened with FRP (Fibre reinforced polymer) jacket, and subjected to compression with uniaxial or biaxial bending moments.

For the column cross section you specify:

- The concrete and steel class.
- The dimensions, concrete cover and the reinforcement.
- The characteristic properties (Modulus of Elasticity, Tensile strength) of the FRP material
- The dimensions (width, and thickness) of the FRP jacket.
- The axial load under service load without FRP jacket.

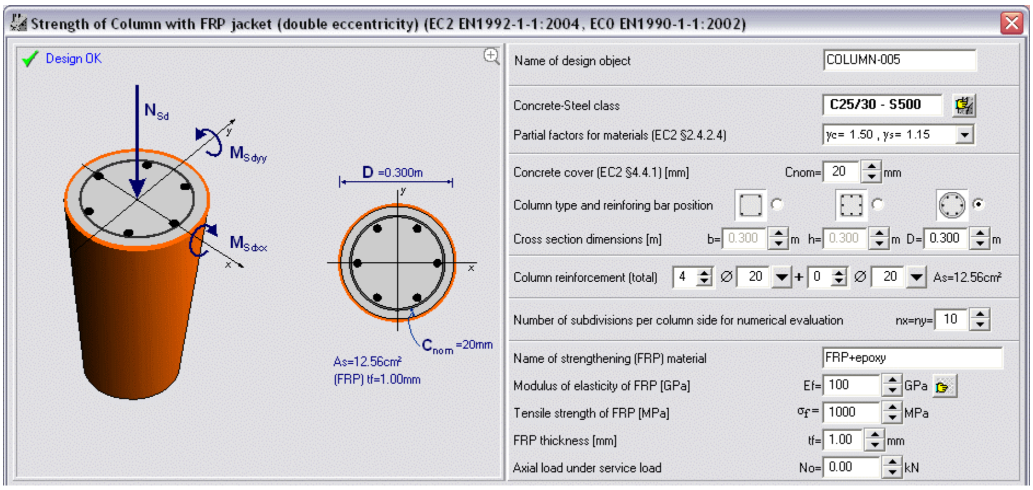
The ultimate capacity of the cross section is computed, by numerical integration of the internal forces on the cross section at equilibrium. These internal forces are the forces due to compression of the concrete, due to tension and compression of the steel at the positions of the reinforcing bars, and due to compression and tension of the FRP jacket.



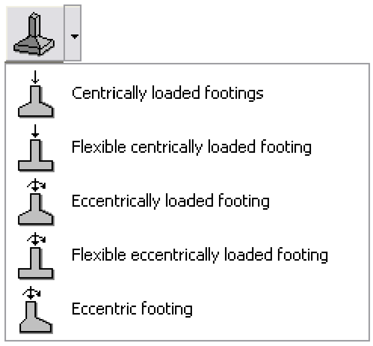
The following assumptions are used:

- 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.
- Linear stress-strain relationship for the FRP material.

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.

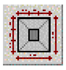


14 Spread footings



Design of square or rectangular spread footings, subject to vertical load and biaxial overturning moments. The footings can be flat or sloped, centric or eccentric.

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. In the case of eccentric footing the eccentricity of the column in respect to the footing center must be specified. All the dimensions are in meters.

 **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

γ_G, and γ_Q 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.
You specify :
the soil bearing capacity in [N/mm²] (GPa) when the geotechnical design is according to Eurocode 7.
the soil bearing pressure in [N/mm²] (GPa) when the geotechnical design is with allowable stresses.

By clicking at  you can select a soil from the table with soil properties.

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 can be 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.

According to allowable pressure theory. The maximum pressure under the footing, as calculated from the exact pressure distribution, is less than the soil bearing pressure qu.

From [Parameters/Design rules], you can choose to work with Eurocode 7 or allowable stresses for the geotechnical design.

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

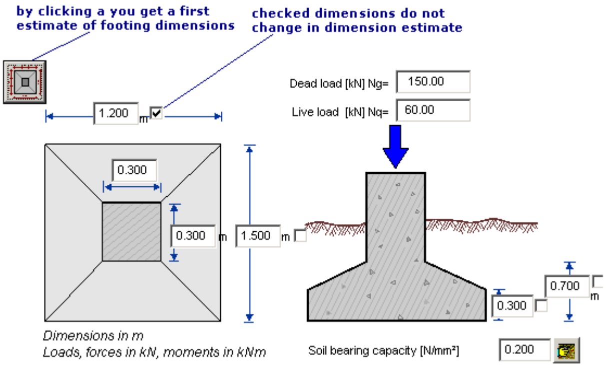
specific reinforcement diameter or the program optimise the reinforcement around the desired diameter. The reinforcing bars are automatically placed in the reinforcing bar schedules. In [Parameters/Parameters for reinforced concrete/Footings] you specify the limits for reinforcing bar diameter and reinforcement 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.

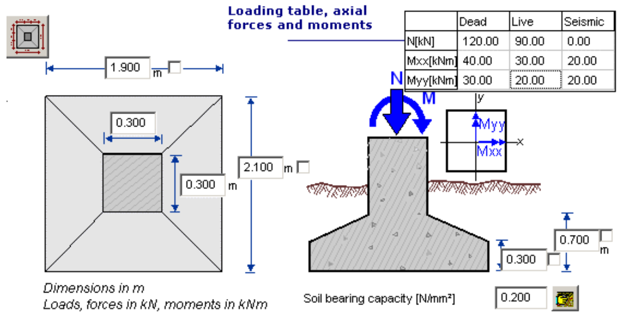
Report. The report shows in detail all the calculations of soil pressures, load combinations, internal force evaluation, stability controls and strength design. The report has references to relative paragraphs of the Eurocodes, and sketches aside of the text, which explain the notation, and show the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

14.1 Dimensions and loading

centrically loaded footing



eccentrically loaded footing



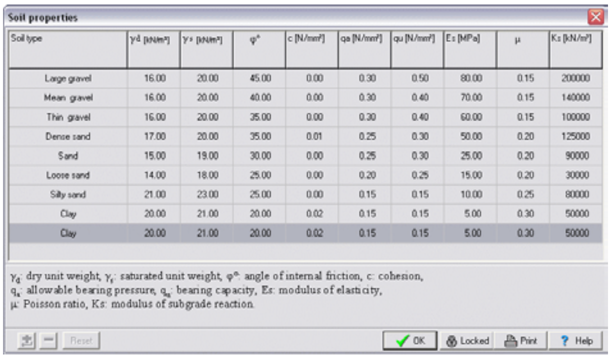
14.2 Soil properties

You specify :

- the soil bearing capacity in [N/mm²] (GPa) when the geotechnical design is according to Eurocode 7.
- the soil bearing pressure in [N/mm²] (GPa) when the geotechnical design is with allowable stresses.

From [Parameters/Design rules] you can choose to work either with Eurocode 7 or with allowable stresses, for the geotechnical design.

By clicking at  you can select a soil from the table with soil properties.



Soil properties

Soil type	γ_d [kN/m³]	γ_s [kN/m³]	φ°	c [N/mm²]	qa [N/mm²]	qu [N/mm²]	Es [MPa]	μ	Ks [kN/m³]
Large gravel	16.00	20.00	45.00	0.00	0.30	0.50	80.00	0.15	200000
Mean gravel	16.00	20.00	40.00	0.00	0.30	0.40	70.00	0.15	140000
Thin gravel	16.00	20.00	35.00	0.00	0.30	0.40	60.00	0.15	100000
Dense sand	17.00	20.00	35.00	0.01	0.25	0.30	50.00	0.20	125000
Sand	15.00	19.00	30.00	0.00	0.25	0.30	25.00	0.20	90000
Loose sand	14.00	18.00	25.00	0.00	0.20	0.25	15.00	0.20	30000
Silty sand	21.00	23.00	25.00	0.00	0.15	0.15	10.00	0.25	80000
Clay	20.00	21.00	20.00	0.02	0.15	0.15	5.00	0.30	50000
Clay	20.00	21.00	20.00	0.02	0.15	0.15	5.00	0.30	50000

γ_d: dry unit weight, γ_s: saturated unit weight, φ°: angle of internal friction, c: cohesion,
q_a: allowable bearing pressure, q_u: bearing capacity, Es: modulus of elasticity,
μ: Poisson ratio, Ks: modulus of subgrade reaction

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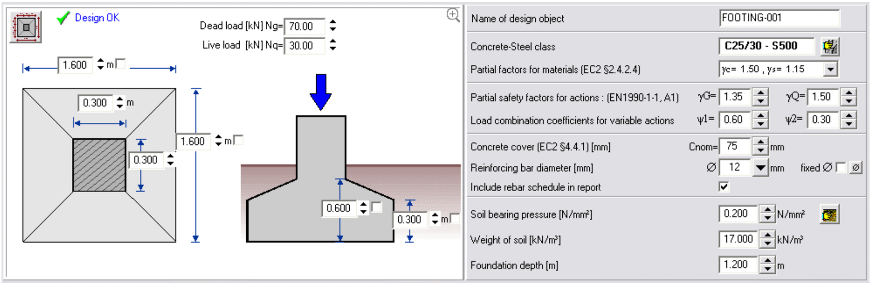
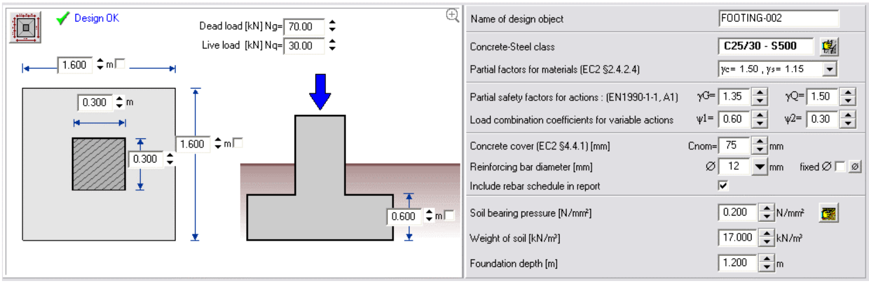
From [Parameters/Soil properties] you can edit (change properties, or add new) the table with the soil properties.
The foundation depth can be specified so the extra weight of the soil above the footing is taken into the account in the design. This is very useful in the case of vertical upwards loading of the footing.

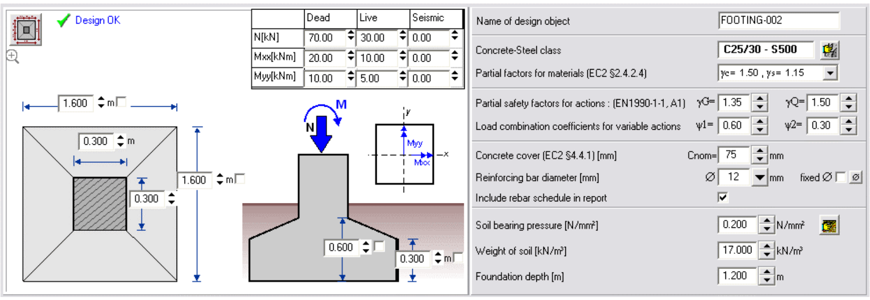
The foundation depth can be specified so the extra weight of the soil above the footing is taken into the account in the design. This is very useful in the case of vertical upwards loading of the footing.

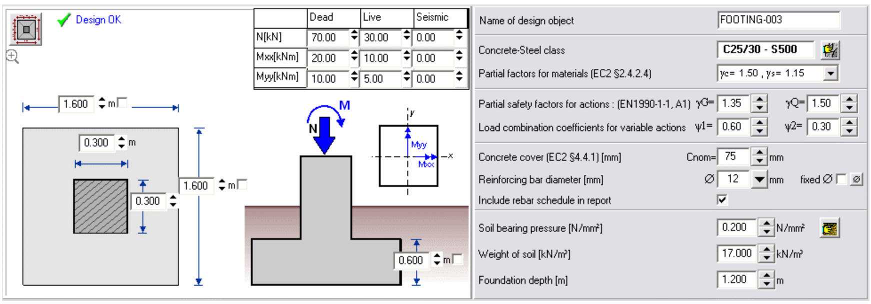
14.3 Spread footings, centrically loaded



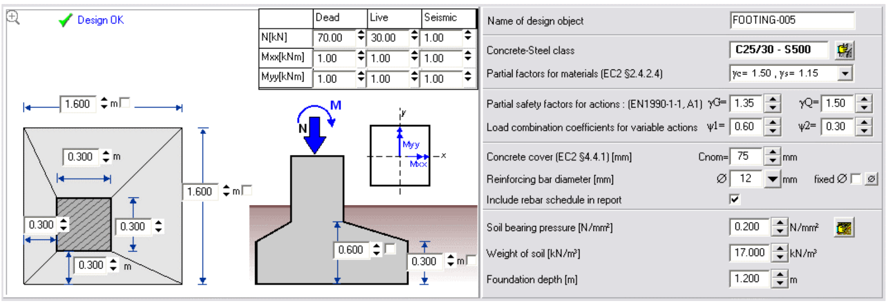


14.4 Spread footings eccentrically loaded

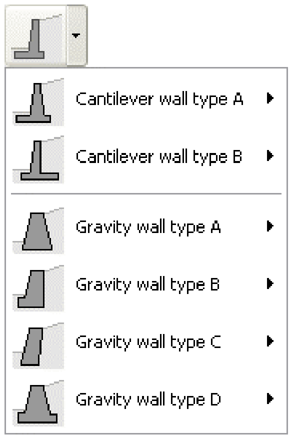




14.5 Spread footings, eccentric (unsymmetrical) footing



15 Retaining walls



Basic types of retaining walls, which you can design with the program are:

Gravity walls. Their stability depends entirely upon the weight of the masonry and any soil resting on the wall. Gravity walls must have sufficient thickness to resist the forces upon them without developing tensile stresses. Four types of gravity walls (backwards inclined or not), which cover most of the gravity wall shapes encountered in practice, are included in the program.

Cantilever walls. They 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 short heel and the other with large heel.

Dimensions and materials. For each type of wall the required input data, wall dimensions, backfill slope, wall material properties, backfill soil properties, foundation soil properties, are shown graphically at the corresponding places of the wall section. You can specify up to two different soil layers of backfill materials, each one with different properties, and you can specify if one or both of these soil layers are under the water table. A different soil layer can be specified in the front of the wall. Surcharge load with dead or live components, can be applied on the free surface of the backfill. On the top of the wall concentrated line load with dead or live components may be applied. This is useful in the design of bridge abutments. The properties of the soils are defined in [Parameters/Soil properties]

Earth forces. The computation of the active and passive earth forces is done using Coulomb's or Rankine's theory. For gravity walls and for cantilever walls without, or with very small back heel, the active earth pressure is computed at the back face of the wall using Coulomb's theory. For cantilever walls with back heel the active earth pressure is computed at a vertical passing from the end of the heel using Rankine's theory. The additional seismic forces, due to earth pressure, are computed using the theory by Mononobe-Okabe. (Eurocode 8-Part 5).

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.

Strength design.

The design of <u>gravity</u> type walls from masonry or concrete is based either on Ultimate Limit State Design according to Eurocode 6, or on Working Stress Design method. The properties of the wall materials are defined in [Parameters/Parameters of retaining walls].

The design of <u>cantilever</u> 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.

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..

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
- allowable stresses limits

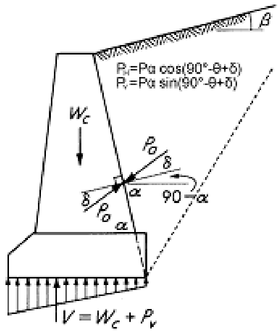
- safety factors (overturning and sliding)
- participation coefficients for passive earth force with or without seismic loading
- eccentricity limits with or without seismic loading
- minimum rebar requirements
- seismic coefficients.

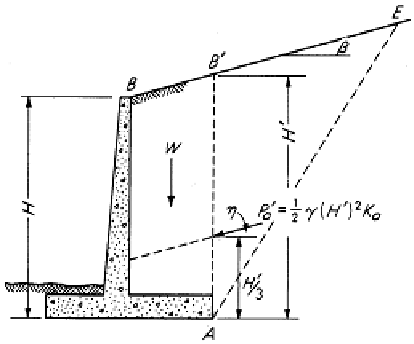
From [Parameters/Soil properties] the material properties for the soil types included in the program can be defined.

Report. The report is showing in detail all the calculations of earth forces, seismic forces load combinations, internal force evaluation, stability controls and strength design. It shows detail rebar design. The report shows references to relative paragraphs of the Eurocodes, and includes with the text sketches which explain the notation, show the stress distributions and rebar position.

15.1 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)..





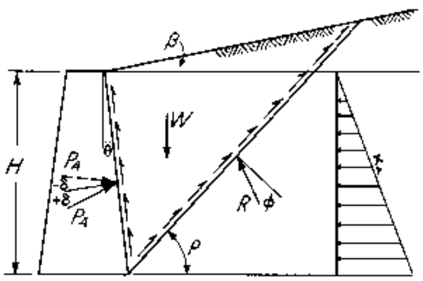
15.2 Lateral earth pressure

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

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

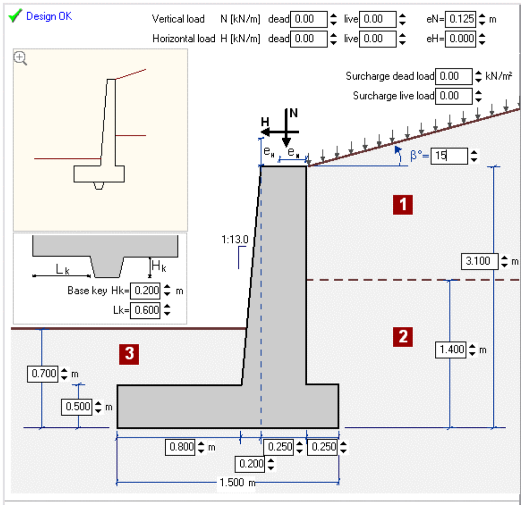
passive earth pressure $P_p = \frac{\gamma H^2}{2} K_p$

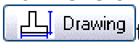
$$K_p = \frac{\cos^2(\varphi + \theta)}{\cos^2\theta \cos(\theta-\delta)\left[1-\sqrt{\frac{\sin(\varphi+\delta)\sin(\varphi+\beta)}{\cos(\theta-\delta)\cos(\theta-\beta)}}\right]^2}$$

φ angle of internal friction of soil

δ angle of wall friction

15.3 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.

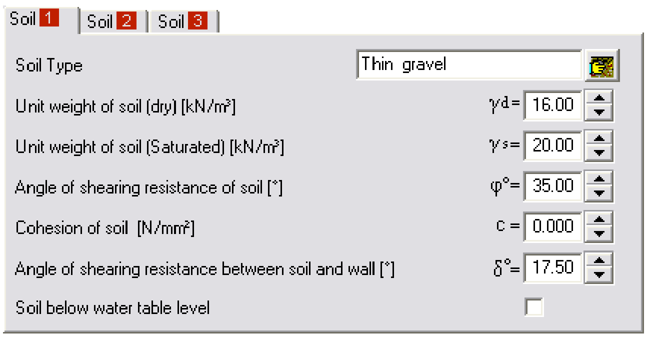
You can supply up to 3 soil layers, marked with numbers on the wall drawing. Two soil layers (1 and 2) are behind the wall and one soil layer (3) in front. The soil layers 2 and 3 exist if their heights are >0. If you have high water table level behind the wall, then use two soils. In that case the height 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.

15.4 Soil properties

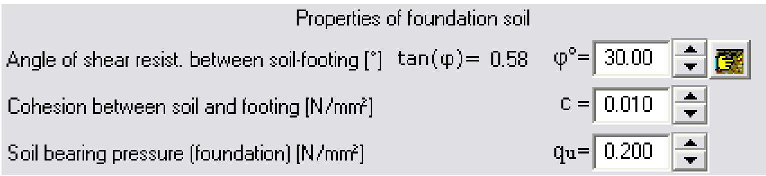
15.4.1 Properties of soil layers for lateral earth forces



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 behind the wall you have high water table level then 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].

15.4.2 Foundation soil



The properties of the foundation soil are defined under the sketch of the wall. By clicking 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, or the allowable bearing pressure when the geotechnical design is with allowable stresses. You choose to work with Eurocode 7, or allowable stresses, for the geotechnical design, from the menu [Parameters/Design rules].

15.5 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.

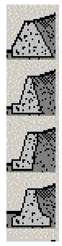
15.5.1 Stability checks using Working Stresses Design

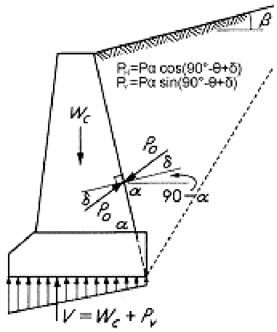
Stability against overturning
(sum of moments resisting overturning)/(sum of overturning moments)>=Cf overturning.
The coefficients Cf for overturning is usually=1.50, but it can be set from [Parameters/Parameters of retaining walls/Check wall stability with safety factors]. In seismic design this coefficient is usually 1.00 and can be set from the menu [Parameters/Parameters of retaining walls/Seismic design].
Stability against sliding
(Sum of resisting forces)/(sum of driving forces)>=Cf sliding
The coefficients Cf for sliding is usually=1.50, but it can be set from [Parameters/Parameters of retaining walls/Check wall stability with safety factors]. In seismic design this coefficient is usually 1.00 and can be set from the menu [Parameters/Parameters of retaining walls/Seismic design]. From [Parameters/Parameters of retaining walls] you can set the participation coefficient of passive earth forces (coefficient which multiplies the passive earth force, default=0.50).
Soil allowable bearing capacity
The maximum soil pressure under the footing must not exceed the allowable soil bearing pressure.
Load eccentricity in the foundation.
The eccentricity limits are defined in [Parameters/Parameters of retaining walls/Check wall stability with safety factors], and for seismic design in [Parameters/Parameters of retaining walls/Seismic design].

15.6 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).

15.7 Gravity type retaining walls





You can design four different types of gravity walls, backwards inclined or not. The computation of the passive and active earth forces is done using Coulomb's theory. The active earth pressure is computed at the back face of the wall. The design of gravity type walls from masonry or concrete is based either on Ultimate Limit State Design according to Eurocode 6, or on Working Stress Design method. The properties of the wall materials are defined in [Parameters/Parameters of retaining walls].

15.7.1 Design method

The design according to Eurocode 6 is based on the following checks:

Check for failure against normal vertical load **Nsd<Nrd**, (Eurocode 6 §4.4.1).

Nrd =design vertical load resistance, Nsd vertical design load.

Nrd=Φi,m t fk/γM

Φi,m is the capacity reduction factor, which takes into account the effects of slenderness and eccentricity of the loading at each wall section, according to Eurocode 6 §4.4.3.

t : is the wall thickness

fk : is the characteristic compressive strength of the masonry according to Eurocode 6, §3.6.2

γM : is the partial safety factor for the material and is obtained according to Eurocode 6 table 2.3.

Check for failure against shear, **Vsd<Vrd.** Eurocode 6, §4.5.3

Vrd=fvk t Lc/γM

Vsd is the applied shear load, which is computed as horizontal force per unit length at each wall section. .

fvk is the characteristic shear strength

The design using allowable stresses is based on the following checks:

σnsd<**σn(allowable**) The normal stress in the cross section wall must be less than the allowable . The normal stress **σnsd** is computed taking into account the eccentricity of the loading at each wall section, and without permitting any tensile stress.

τsd<**τ(allowable)** The shear stresses at each cross section **τsd=Vsd/bxL**, where **b** is the wall cross section width, and **L** is the length (L=1.00m)

The choice to design the gravity wall according to Eurocode 6 or using allowable stresses, is selected from [**Parameters/Design rules]**

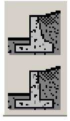
The material properties are defined in [**Parameters/Parameters of retaining walls]** .

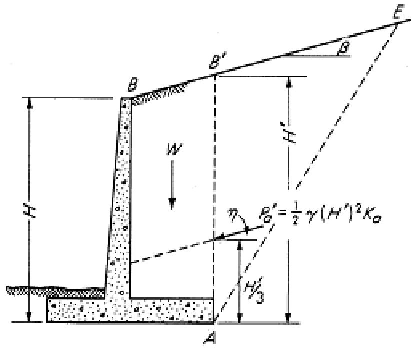
15.7.2 Wall materials

Specify the material properties. By clicking at  you can choose from the list of wall materials. You edit and update the list of wall materials from [Parameters/Parameters of retaining walls].

You select to perform the wall strength design according to Eurocode 6, then for the wall material properties you specify the self weight in [kN/m³], the compressive strength and the shear strength in [kN/m²].
If you select to perform the wall strength design using allowable stresses, then for the wall material properties you specify the self weight in [kN/m³], the allowable compressive stress and allowable shear stress in [kN/m²].

15.8 Retaining walls of cantilever type

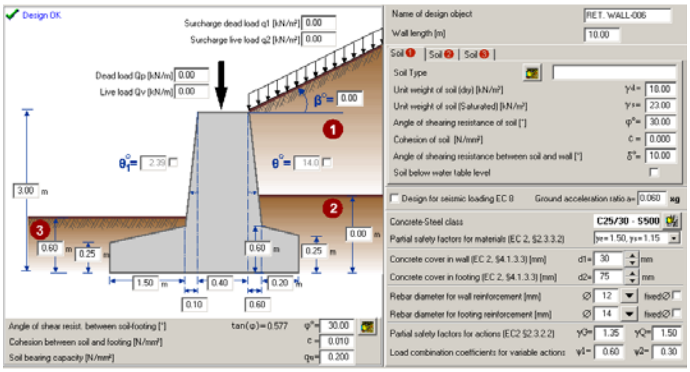




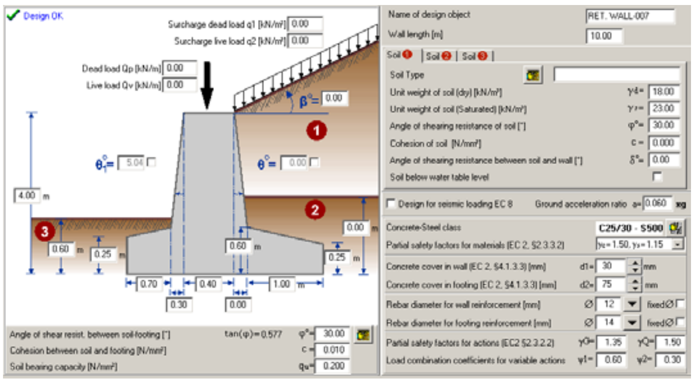
You can design two different types of cantilever walls. The difference between these two is the size of the heel at the back-side of the wall. The computation of the passive and active earth forces is done using Coulomb's theory.

For walls with small back heel the active earth pressure is computed at the back face of the wall and for walls with back heel the active earth pressure is computed at a vertical surface at the end of the heel.

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. The reinforcement of the stem is optimised, and depending on the stem height the reinforcement is reduced toward the top of the wall. The reinforcing bars are automatically placed in the reinforcing bar schedules.

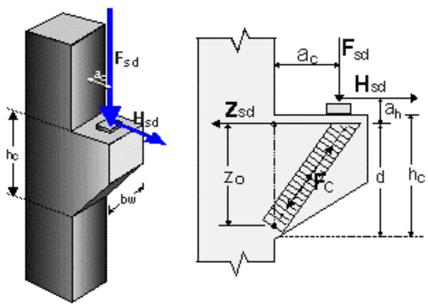


Wall with small heel at the back-side.



Wall with large heel at the back-side.

16 Corbels / Brackets



Corbels and brackets are used to support beams and girders. They are short cantilevers projecting from column faces. When ac/hc<=1 then they should be design with deep beam theory rather than flexural theory. Corbels and brackets are designed for vertical and horizontal dead and live point loading, according to Eurocode 2 §5.6.4,§6.5, based on a strut and tie model.

Corbels and brackets are designed according to Eurocode 2 §5.6.4,§6.5. and Annex j.

Corbels with **0.40<=ac/hc<=1** are designed using a simple strut and tie model

Corbels with **ac/hc<0.40** are designed using hc=2ac.

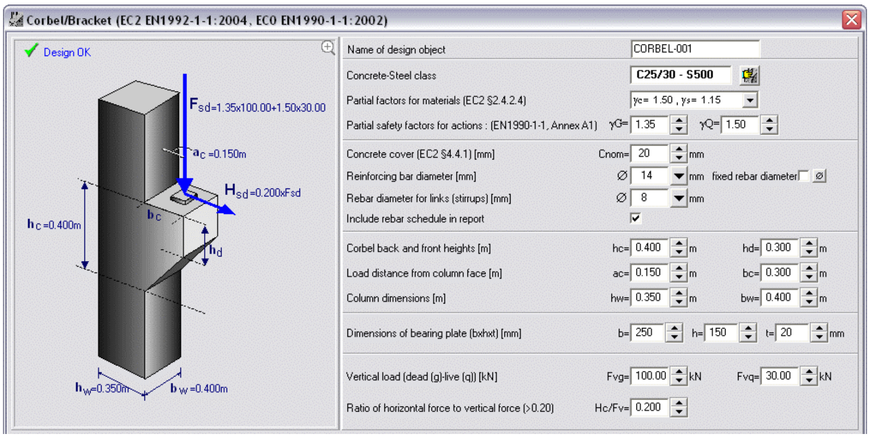
Corbels with **ac/hc>1** are designed using flexural theory, as cantilever beams.
The concrete bearing pressure under bearing plate is also checked.

16.1 Loading

The concentrated vertical load on the bracket, permanent (dead) load Fgk and variable (live) load Fqk, in [kN].

The design vertical load is taken as: **Fsd=γGxFgk+γQxFqk**

You have to specify also the ratio of the horizontal to the vertical force. **Hsd/Fsd**. According to Eurocode 2 Annex J , the corbel should be designed for horizontal force at least **Hsd>0.20 Hsd**.

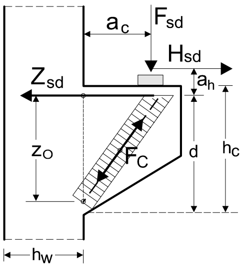


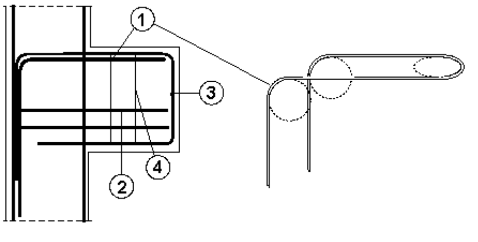
16.2 Bearing capacity at load point

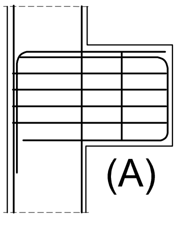
The concrete bearing pressure, under bearing plate, is checked so to not exceed **0.60ν.fcd** Eurocode 2 §6.5.4.b. The area of the bearing plate must be adequate so the bearing capacity of concrete check is satisfied.

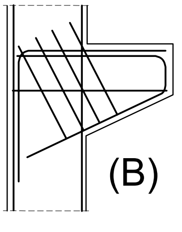
16.3 Reinforcement

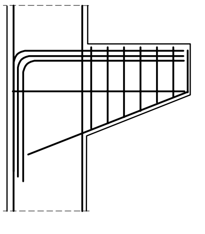
Eurocode 2 § 5.4.4 .The main tension reinforcement should be anchored beyond the bearing plate using U loops. The minimum-bending diameter of the loop is computed according to Table 8.1.N of Eurocode 2.









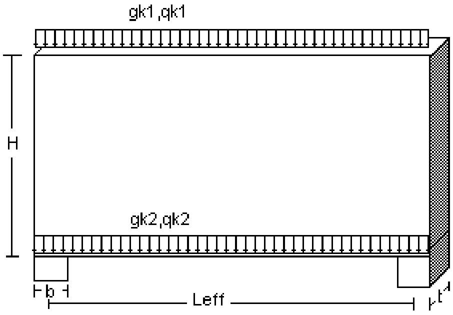


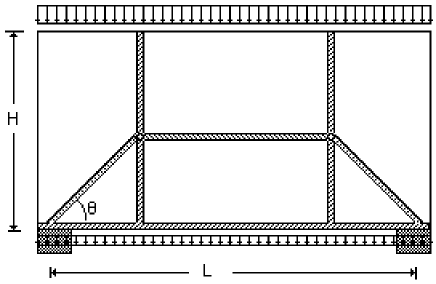
In deep corbels, with **ac/hc**<=0.50, horizontal or inclined closed stirrups are distributed over the effective depth to take the splitting stresses in the concrete strut, with total area Asw>=0.25 As, Annex J.3

In shallow corbels, with **ac/hc**>0.50, vertical stirrups are distributed over the width of the corbel with total area Asw>=0.50 Fsd/fyd, Annex J.3.

17 Deep beams

When **Leff/H<2** then the strain distribution is no longer linear and the shear deformation becomes significant. The usual flexural theory cannot be used. In this case the design of the beam is done according to Eurocode 2 §5.6.4,§6.5, using a simple strut and tie model. You can design deep beams subjected to uniformly distributed dead and live load at the top and bottom face.





17.1 Design method

Beams with **Leff/H<2**. The design method is based on elasto-plastic material behaviour. The design model, is a simple truss model, combining strut and tie action (Eurocode 2, §5.6.4,§6.5). [Schlaich,J Schafer,K, Konstruieren im Stahlbetonnbau, Betonkalender 82,1993 Teil 2,313-458, Berlin, Ernst&Son,1993.]

The lever arm Zf of internal forces is taken as :

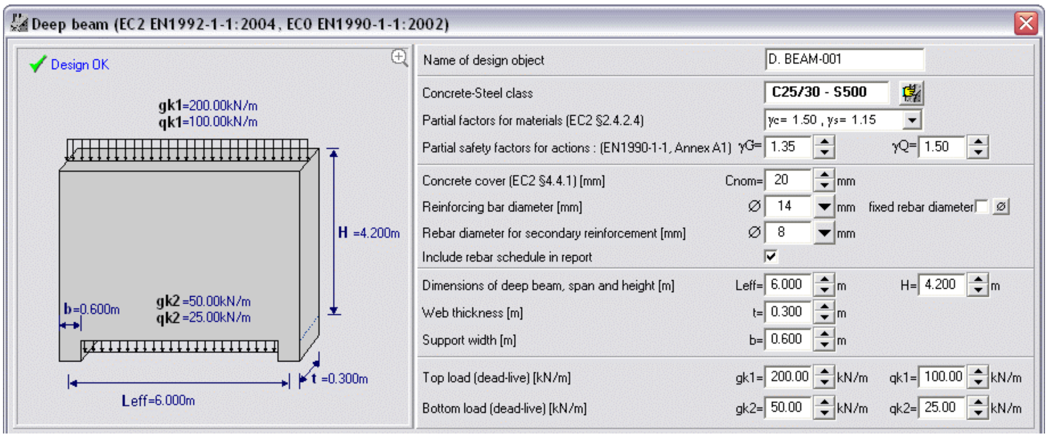
Zf=0.30H(3-H/Leff), when 0.5<H/Leff<=1.0

Zf:=0.60H, when H/Leff>1.0

From the tension in the tie, the horizontal bottom reinforcement is computed. This reinforcement should be fully anchored by bending up the bars, or by using U loops. The concrete compressive stress in the struts must not exceed 0.60.fcd, according to Eurocode 2, §6.5.

Horizontal reinforcement must be distributed over the height Zf, to take the splitting stresses in the concrete struts.

Reinforcement mats must be placed on both faces of the deep beam, in both directions according to Eurocode 2, Annex J.

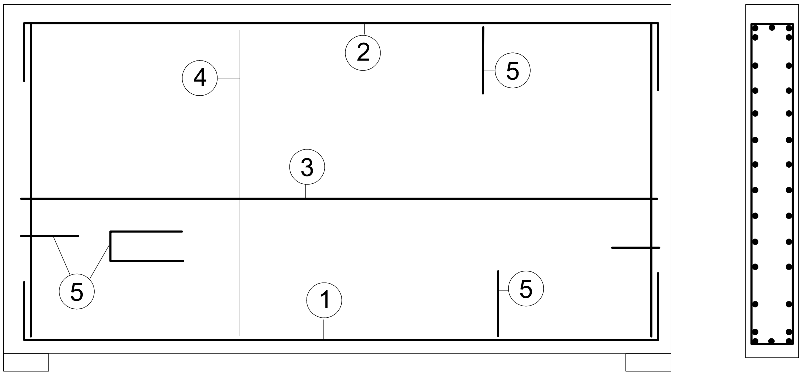


17.2 Reinforcement

The main tension reinforcement at the bottom of the beam, should be fully anchored by bending up the bars, or by using U loops.

Horizontal reinforcement must be distributed over the height Zf, to take the splitting stresses in the concrete struts.

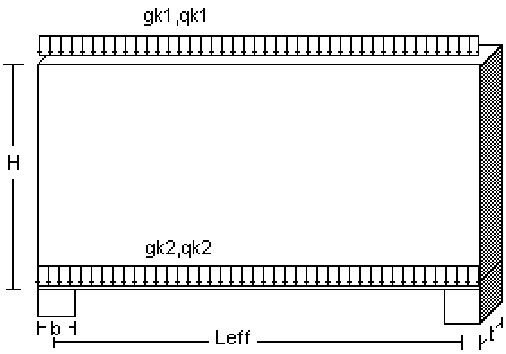
Reinforcement mats must be placed on both faces of the deep beam, in both directions according to Eurocode 2, Annex J.



17.3 Dimensions

Dimensions of deep beam, span and height [m]	Leff=	2.00	[m]	H=	3.00	[m]
Web thickness [m]	t=	0.200	[m]			
Support width [m]	b=	0.500	[m]			

You give the dimensions in meters [m] according to the drawing below.



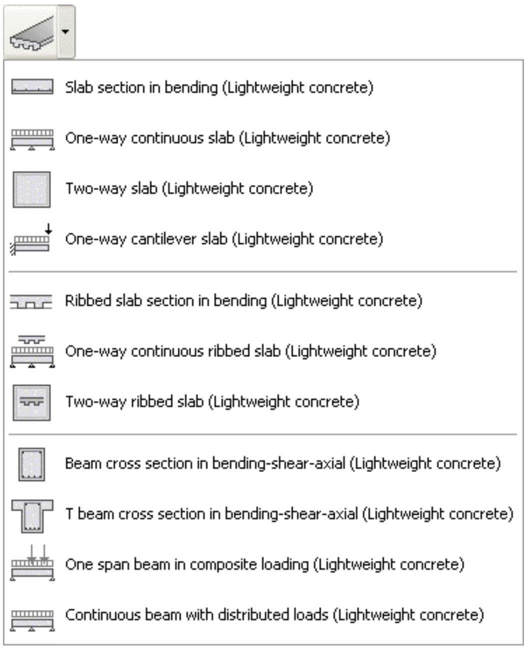
17.4 Loading

Top load (dead-live) [kN/m]	gk1=	200.00	[kN/m]	qk1=	100.00	[kN/m]
Bottom load (dead-live) [kN/m]	gk2=	50.00	[kN/m]	qk2=	25.00	[kN/m]

Give the vertical loading a the top and the bottom face of the deep beam, permanent (dead) load gk1 and gk2 and variable (live) load qk1 and qk2, in [kN/m].

The design vertical load is taken as: **Fsd=γGxgk+γQxqk**

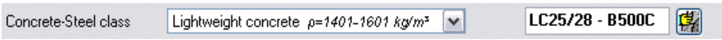
18 Leight weight aggregate concrete (LWAC)



Design of plates and beams made from light weight aggregate concrete (LWAC).

The properties of light weight aggregate concrete are computed according to EC 2 § 11.3. using the density class. The density(weight) of the concrete is specified by the user.

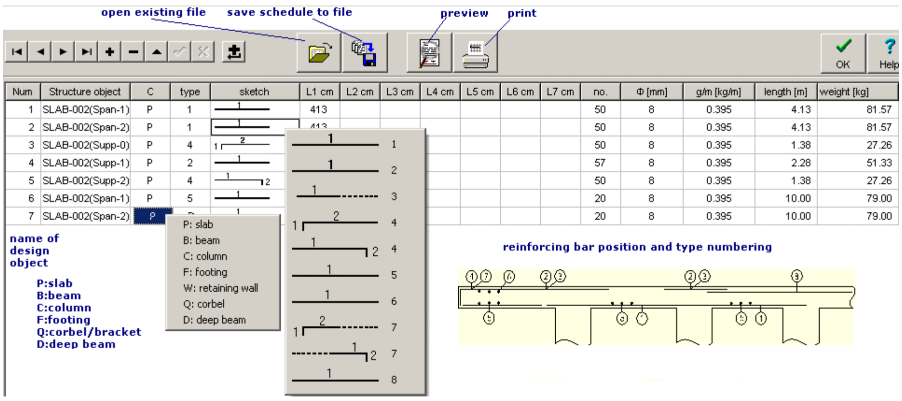
All the other data are the same as in normal concrete.



19 Reinforcement schedule

A detailed reinforcement schedule is produced. The design objects that participate in the bar schedule are the ones checked in the Design objects window, and their order of appearance can be changed from the Design objects window. For the supports of the two way plates you can select the way the reinforcing bars are shown in the reinforcement schedule from the menu [Edit reinforcement schedule]. They can show in double length symmetrical over the support center or half length.

You can edit the reinforcing bar schedule. You have to notice that if you make changes you must save the schedule in a file. By clicking at column C the type (plate, beam, etc..) of the concrete object can be selected. By clicking at [sketch], you can select the rebar type.



Reinforcing bar schedule

Num	Structure object	type	reinforcing bar [cm]	no.	Φ [mm]	g/m [kg/m]	length [m]	weight [kg]
1	SLAB-002(Span-1)	P1	413	50	8	0.395	4.13	81.57
2	SLAB-002(Span-2)	P1	413	50	8	0.395	4.13	81.57
3	SLAB-002(Supp-0)	P4	10 128	50	8	0.395	1.38	27.26
4	SLAB-002(Supp-1)	P2	228	57	8	0.395	2.28	51.33
5	SLAB-002(Supp-2)	P4	128 10	50	8	0.395	1.38	27.26
6	SLAB-002(Span-1)	P5	1000	20	8	0.395	10.00	79.00
7	SLAB-002(Span-2)	P5	1000	20	8	0.395	10.00	79.00
			Total weight [kg]					426.99

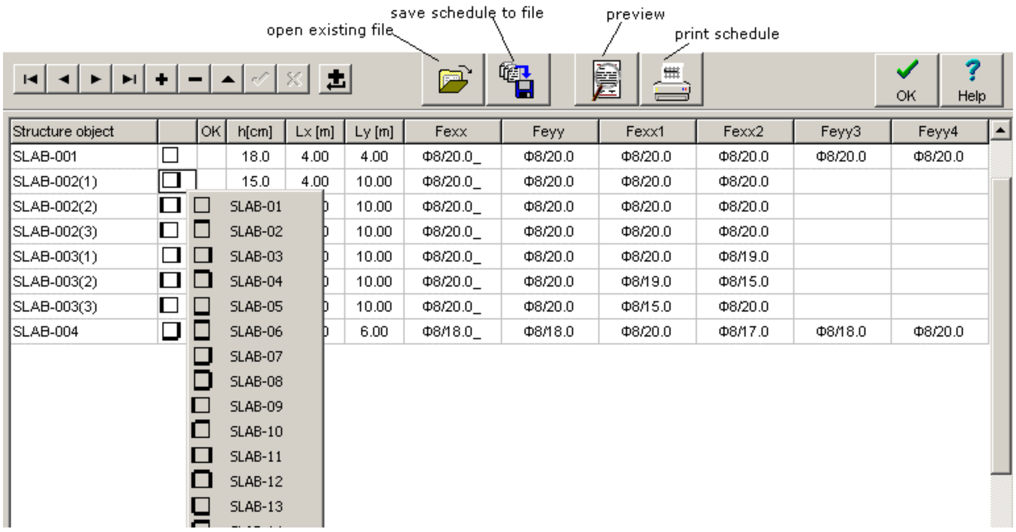
19.1 Reinforcement schedule for plates

Project Beton **Slab schedule** Pg. 1

slab name		h [cm]	Lx [m]	Ly [m]	span reinforcement x-x	span reinforcement y-y	support reinforcement			
SLAB-001		18.0	4.00	4.00	Φ8/20.0_	Φ8/20.0	Φ8/20.0	Φ8/20.0	Φ8/20.0	Φ8/20.0
SLAB-002(1)		15.0	4.00	10.00	Φ8/20.0_	Φ8/20.0	Φ8/20.0	Φ8/20.0		
SLAB-002(2)		15.0	4.00	10.00	Φ8/20.0_	Φ8/20.0	Φ8/20.0	Φ8/20.0		
SLAB-002(3)		15.0	4.00	10.00	Φ8/20.0_	Φ8/20.0	Φ8/20.0	Φ8/20.0		
SLAB-003(1)		15.0	3.00	10.00	Φ8/20.0_	Φ8/20.0	Φ8/20.0	Φ8/19.0		
SLAB-003(2)		17.0	5.00	10.00	Φ8/20.0_	Φ8/20.0	Φ8/19.0	Φ8/15.0		
SLAB-003(3)		15.0	4.00	10.00	Φ8/20.0_	Φ8/20.0	Φ8/15.0	Φ8/20.0		
SLAB-004		20.0	5.00	6.00	Φ8/18.0_	Φ8/18.0	Φ8/20.0	Φ8/17.0	Φ8/18.0	Φ8/20.0

(_=bottom layer of reinforcement, ^=span reinforcement at top,:=reinforcement at top and

You can edit the reinforcing bar schedule for the slabs. You have to notice although that if you make changes you have to save the schedule in a file. The design objects that participate in the bar schedule are the ones checked in the Design objects window, and their order of appearance can be changed from the Design objects window.



19.2 Reinforcement schedule for beams

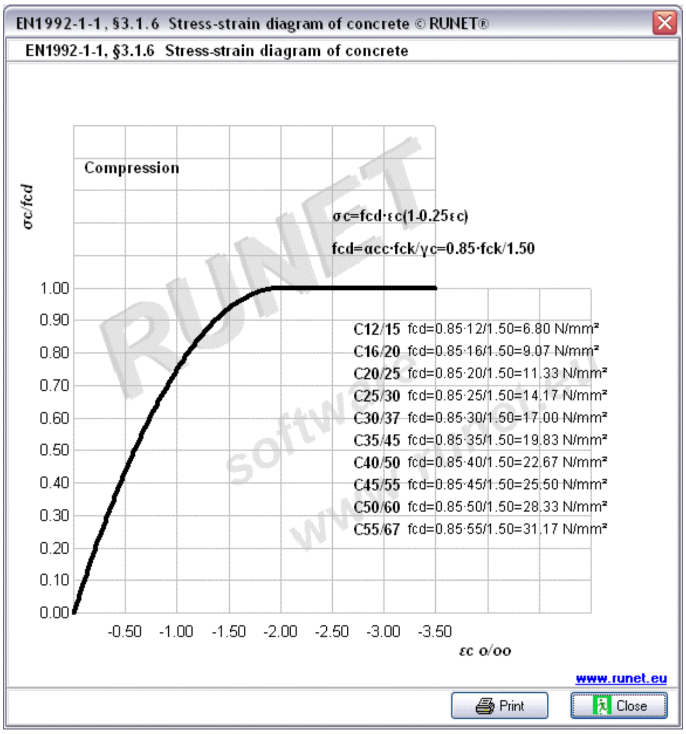
Project Beton **Beam schedule** Pg. 1

beam name	Span bottom	Span top	Support-A top	Support-A bottom	Support-B top	Support-B bottom	Stirrups
BEAM-001 Span -1 L=4.00[m] B=0.25m h=0.50m	3Φ14 1Φ16	2Φ12			4Φ14 1Φ16		Φ8/16.0
BEAM-001 Span -2 L=4.00[m] B=0.25m h=0.50m	3Φ14 1Φ16	2Φ12	4Φ14 1Φ16				Φ8/16.0
BEAM-002 Span -1 L=5.00[m] B=0.25m h=0.50m	6Φ18 1Φ12	2Φ14					Φ8/17.0
BEAM-003 Span -1 L=4.00[m] B=0.25m h=0.50m	3Φ14 1Φ18	2Φ12			3Φ14 1Φ18		Φ8/17.0
BEAM-003 Span -2 L=4.00[m] B=0.25m h=0.50m	4Φ12	2Φ12	3Φ14 1Φ18		2Φ14 1Φ16		Φ8/20.5
BEAM-003 Span -3 L=4.00[m] B=0.25m h=0.50m	3Φ12 1Φ14	2Φ12	2Φ14 1Φ16		4Φ14		Φ8/22.0
BEAM-003 Span -4 L=4.00[m] B=0.25m h=0.50m	3Φ12 1Φ14	2Φ12	4Φ14		2Φ14 1Φ16		Φ8/22.0
BEAM-003 Span -5 L=4.00[m] B=0.25m h=0.50m	4Φ12	2Φ12	2Φ14 1Φ16		3Φ14 1Φ18		Φ8/20.5
BEAM-003 Span -6 L=4.00[m] B=0.25m h=0.50m	3Φ14 1Φ18	2Φ12	3Φ14 1Φ18				Φ8/17.0

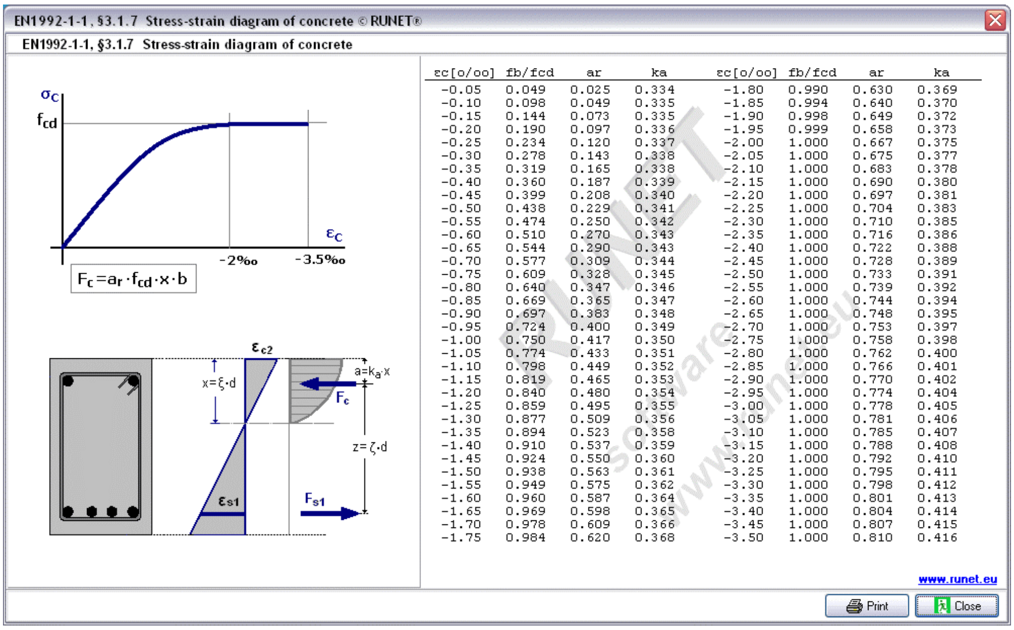
20 Eurocode 2, design charts

20.1 Concrete-Steel

20.1.1 Stress-strain diagram of concrete

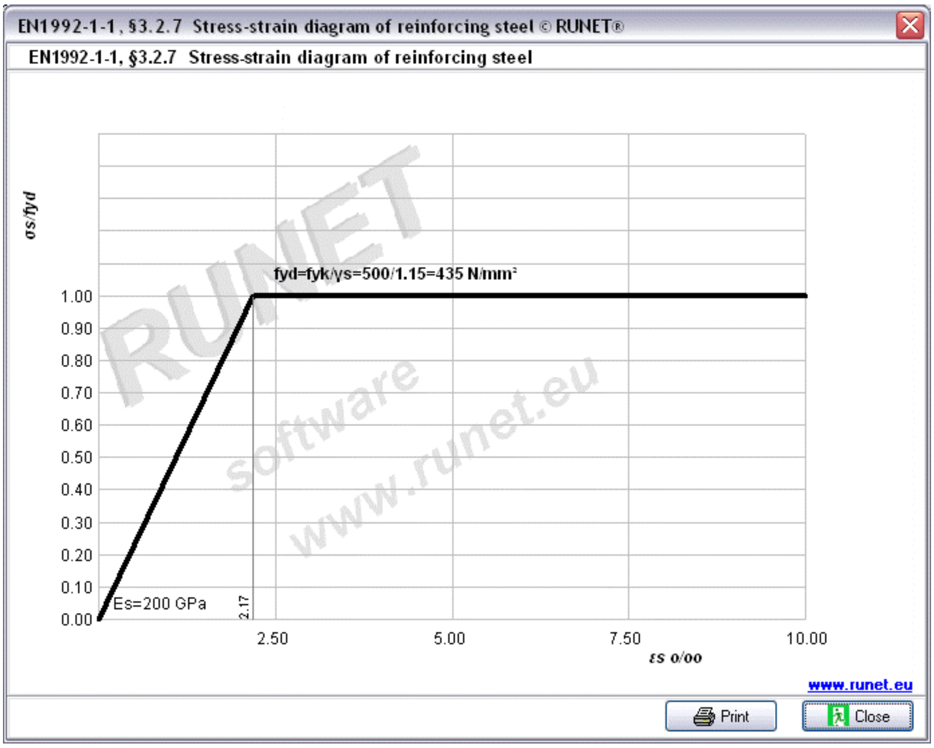


20.1.2 Parabolic diagram for concrete under compression



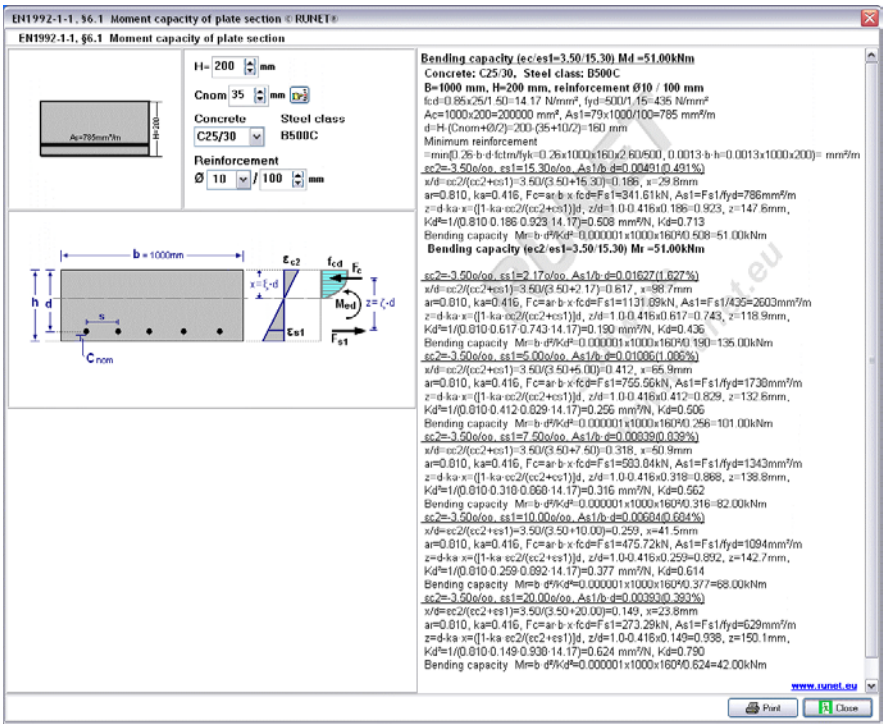
εc[o/oo]	fb/fcd	ar	ka	εc[o/oo]	fb/fcd	ar	ka
-0.05	0.049	0.025	0.334	-1.80	0.990	0.630	0.369
-0.10	0.098	0.049	0.335	-1.85	0.994	0.640	0.370
-0.15	0.144	0.073	0.335	-1.90	0.998	0.649	0.372
-0.20	0.190	0.097	0.336	-1.95	0.999	0.658	0.373
-0.25	0.234	0.120	0.337	-2.00	1.000	0.667	0.375
-0.30	0.278	0.143	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

20.1.3 Stress-strain diagram of reinforcing steel

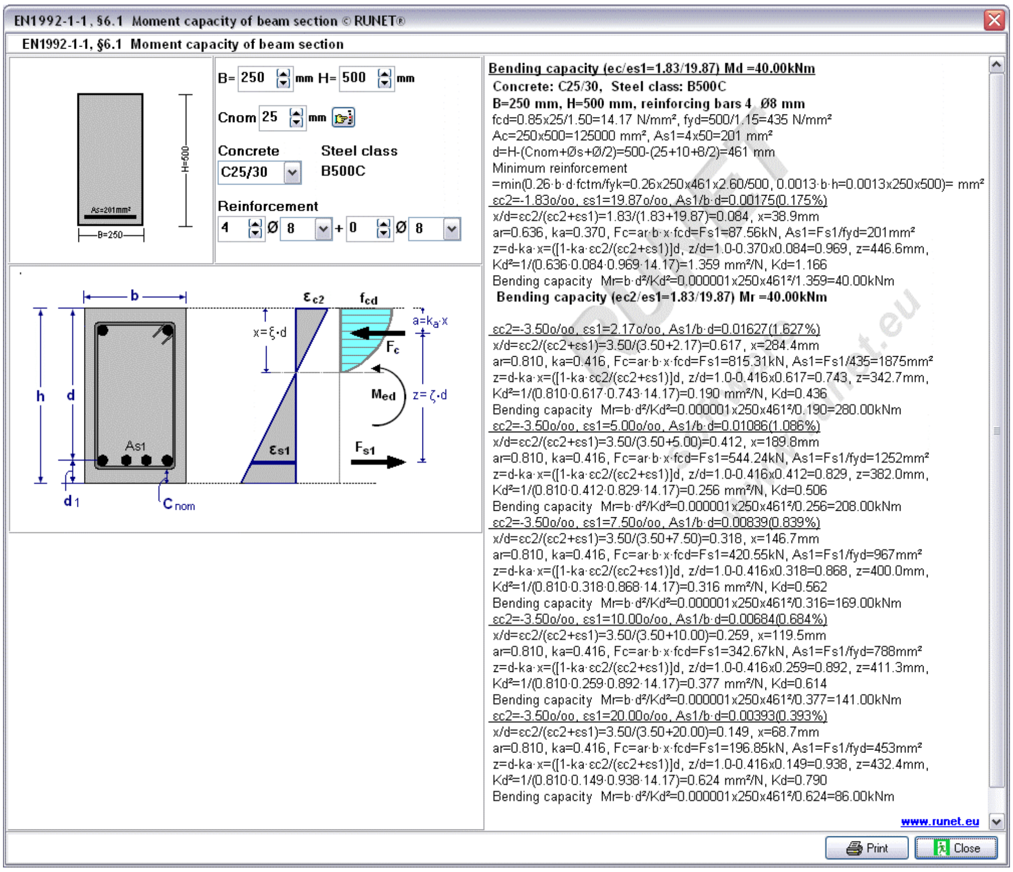


20.2 Capacity of cross-sections

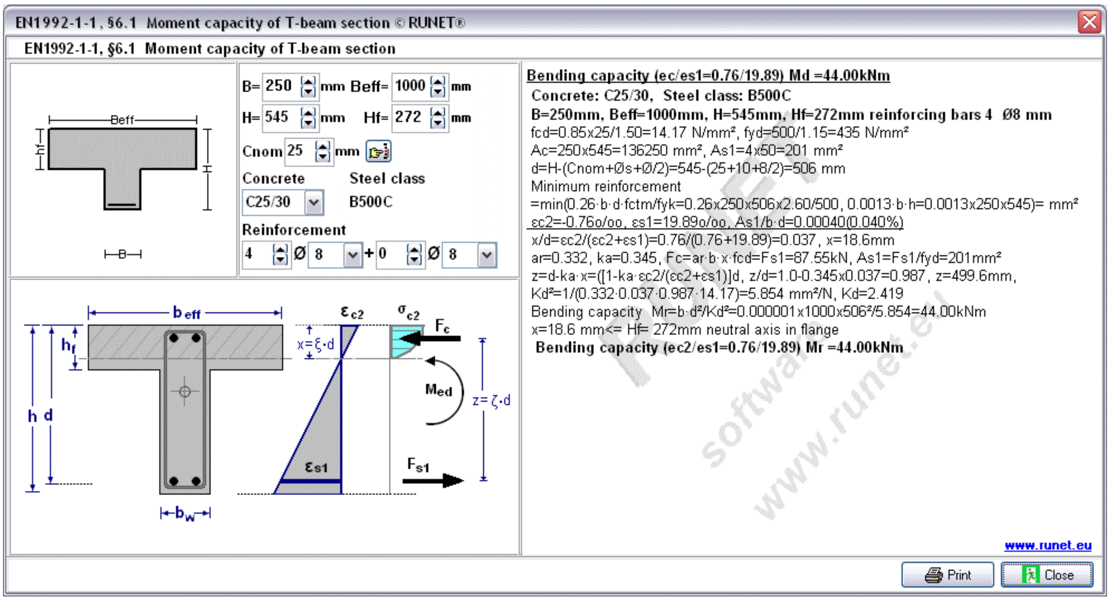
20.2.1 Bending capacity of plate section



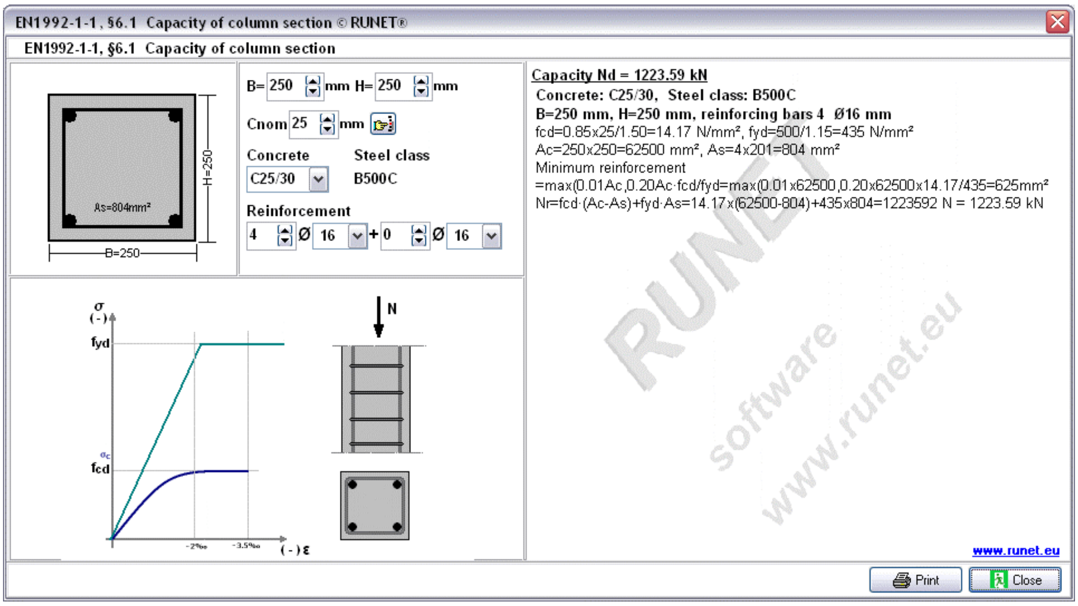
20.2.2 Bending capacity of beam section



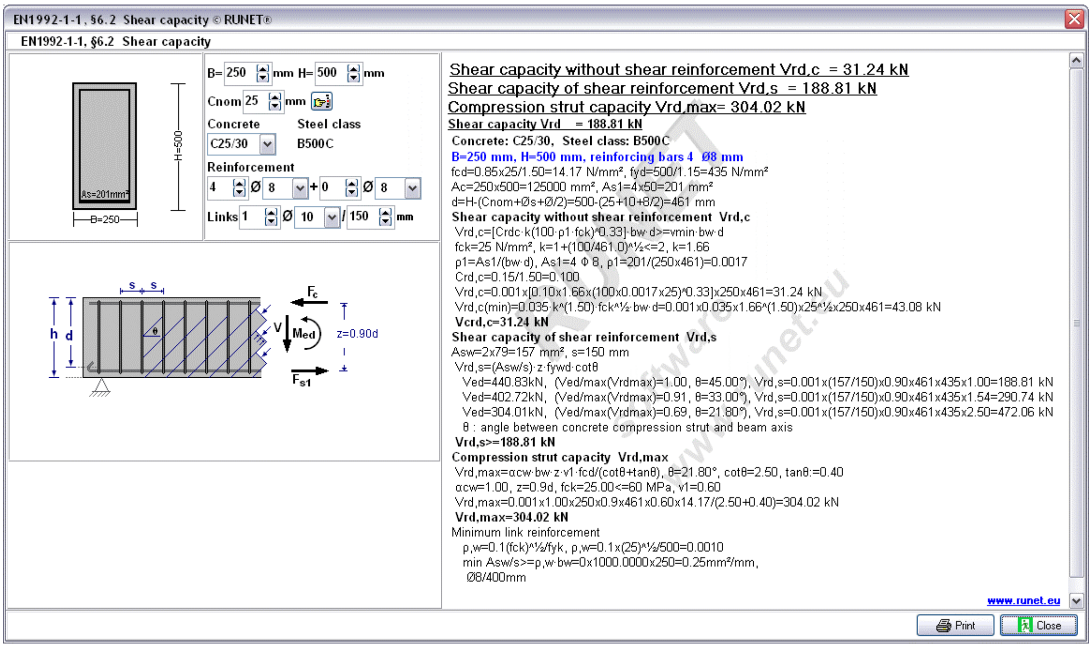
20.2.3 Bending capacity of T-beam section



20.2.4 Capacity of rectangular columns



20.2.5 Shear capacity

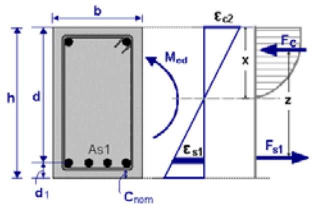


20.3 Design charts, Bending

20.3.1 Dimensioning for bending Coeff. Kd, ks

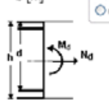
EN1992-1-1, §6.1 Dimensioning for bending Coeff. Kd, ks © RUNET®

EN1992-1-1, §6.1 Dimensioning for bending Coeff. Kd, ks



$$k_d = \frac{d\,[cm]}{\sqrt{\frac{M_{ed}[kNm]}{b\,[m]}}} \qquad A_s[cm^2] = k_s \frac{M_{ed}[kNm]}{d\,[cm]}$$

mm cm



$$M_{ed} = M_d - N_d(d-h/2)$$

εc2/εs1	x/d	z/d	Ks	C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
fsy =500 [N/mm²]							Kd					
0.50/20.0	0.024	0.992	2.32	16.29	14.11	12.62	11.28	10.30	9.54	8.92	8.41	7.98
0.75/20.0	0.036	0.988	2.33	11.21	9.70	8.68	7.76	7.09	6.56	6.14	5.79	5.49
1.00/20.0	0.048	0.983	2.34	8.68	7.52	6.72	6.01	5.49	5.08	4.76	4.48	4.25
1.25/20.0	**0.059**	**0.979**	**2.35**	**7.18**	**6.22**	**5.56**	**4.98**	**4.54**	**4.21**	**3.93**	**3.71**	**3.52**
1.50/20.0	0.070	0.975	2.36	6.20	5.37	4.80	4.30	3.92	3.63	3.40	3.20	3.04
1.75/20.0	0.080	0.970	2.37	5.51	4.77	4.27	3.82	3.49	3.23	3.02	2.85	2.70
2.00/20.0	0.091	0.966	2.38	5.01	4.34	3.88	3.47	3.17	2.93	2.75	2.59	2.46
2.25/20.0	0.101	0.961	2.39	4.64	4.02	3.59	3.21	2.93	2.71	2.54	2.39	2.27
2.50/20.0	0.111	0.957	2.40	4.34	3.76	3.36	3.01	2.75	2.54	2.38	2.24	2.13
2.75/20.0	0.121	0.952	2.42	4.11	3.56	3.18	2.85	2.60	2.41	2.25	2.12	2.01
3.00/20.0	0.130	0.947	2.43	3.91	3.39	3.03	2.71	2.47	2.29	2.14	2.02	1.92
3.25/20.0	0.140	0.943	2.44	3.75	3.25	2.90	2.60	2.37	2.19	2.05	1.94	1.84
3.50/20.0	0.149	0.938	2.45	3.61	3.12	2.79	2.50	2.28	2.11	1.98	1.86	1.77
3.50/19.0	0.156	0.935	2.46	3.53	3.06	2.74	2.45	2.23	2.07	1.94	1.82	1.73
3.50/18.0	0.163	0.932	2.47	3.46	3.00	2.68	2.40	2.19	2.03	1.89	1.79	1.69
3.50/17.0	0.171	0.929	2.48	3.38	2.93	2.62	2.34	2.14	1.98	1.85	1.75	1.66
3.50/16.0	0.179	0.925	2.49	3.31	2.86	2.56	2.29	2.09	1.94	1.81	1.71	1.62
3.50/15.0	0.189	0.921	2.50	3.23	2.80	2.50	2.24	2.04	1.89	1.77	1.67	1.58
3.50/14.0	0.200	0.917	2.51	3.15	2.73	2.44	2.18	1.99	1.84	1.72	1.63	1.54
3.50/13.0	0.212	0.912	2.52	3.06	2.65	2.37	2.12	1.94	1.79	1.68	1.58	1.50
3.50/12.0	0.226	0.906	2.54	2.98	2.58	2.31	2.06	1.88	1.74	1.63	1.54	1.46
3.50/11.0	0.241	0.900	2.56	2.89	2.50	2.24	2.00	1.83	1.69	1.58	1.49	1.42
3.50/10.0	0.259	0.892	2.58	2.80	2.43	2.17	1.94	1.77	1.64	1.53	1.45	1.37
3.50/ 9.5	0.269	0.888	2.59	2.76	2.39	2.14	1.91	1.74	1.61	1.51	1.42	1.35
3.50/ 9.0	0.280	0.884	2.60	2.71	2.35	2.10	1.88	1.71	1.59	1.48	1.40	1.33
3.50/ 8.5	0.292	0.879	2.62	2.66	2.31	2.06	1.84	1.68	1.56	1.46	1.37	1.30
3.50/ 8.0	0.304	0.873	2.63	2.61	2.26	2.02	1.81	1.65	1.53	1.43	1.35	1.28
3.50/ 7.5	0.318	0.868	2.65	2.57	2.22	1.99	1.78	1.62	1.50	1.41	1.32	1.26
3.50/ 7.0	0.333	0.861	2.67	2.52	2.18	1.95	1.74	1.59	1.47	1.38	1.30	1.23
3.50/ 6.5	0.350	0.854	2.69	2.46	2.13	1.91	1.71	1.56	1.44	1.35	1.27	1.21
3.50/ 6.0	0.368	0.847	2.72	2.41	2.09	1.87	1.67	1.53	1.41	1.32	1.25	1.18
3.50/ 5.5	0.389	0.838	2.74	2.36	2.04	1.83	1.64	1.49	1.38	1.29	1.22	1.16
3.50/ 5.0	0.412	0.829	2.78	2.31	2.00	1.79	1.60	1.46	1.35	1.26	1.19	1.13
3.50/ 4.3	0.450	0.813	2.83	2.23	1.93	1.73	1.54	1.41	1.31	1.22	1.15	1.09
3.50/ 4.0	0.467	0.806	2.85	2.20	1.90	1.70	1.52	1.39	1.29	1.20	1.13	1.08
3.50/ 3.5	0.500	0.792	2.90	2.14	1.85	1.66	1.48	1.35	1.25	1.17	1.11	1.05
3.50/ 3.0	0.538	0.776	2.96	2.09	1.81	1.62	1.44	1.32	1.22	1.14	1.08	1.02
3.50/ 2.5	0.583	0.757	3.04	2.03	1.76	1.57	1.40	1.28	1.19	1.11	1.05	0.99

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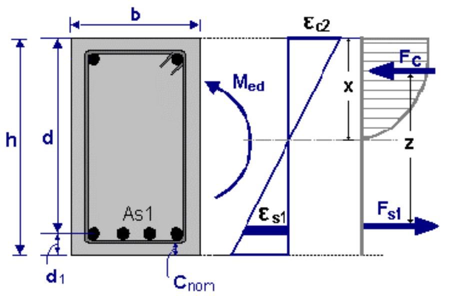
Print Close

20.3.2 Dimensioning for bending Coeff med, w

EN1992-1-1, §6.1 Dimensioning for bending Coeff med, w © RUNET®

EN1992-1-1, §6.1 Dimensioning for bending Coeff med, w



$$m_{ed} = \frac{M_{ed}}{b \cdot d^2 \cdot f_{cd}} \qquad f_{cd} = \frac{\alpha_{cc} f_{ck}}{\gamma_c} = \frac{0.85 f_{ck}}{1.50}$$

$$A_s = \frac{\omega \cdot b \cdot d \cdot f_{cd}}{f_{yd}} \qquad f_{yd} = \frac{f_{yk}}{\gamma_s} = \frac{500}{1.15} = 435\,[\frac{N}{mm^2}]$$

-εc2/εs1	x/d	z/d	ω	med
0.50/10.00	0.048	0.984	0.0109	0.011
0.75/10.00	0.070	0.976	0.0229	0.022
1.00/10.00	0.091	0.968	0.0379	0.037
1.25/10.00	0.111	0.961	0.0550	0.053
1.50/10.00	0.130	0.953	0.0734	0.070
1.75/10.00	0.149	0.945	0.0923	0.087
2.00/10.00	0.167	0.938	0.1111	0.104
2.25/10.00	0.184	0.930	0.1293	0.120
2.50/10.00	0.200	0.922	0.1467	0.135
2.75/10.00	0.216	0.914	0.1634	0.149
3.00/10.00	0.231	0.907	0.1795	0.163
3.25/10.00	0.245	0.899	0.1950	0.175
3.50/10.00	0.259	0.892	0.2099	0.187
3.50/ 9.50	0.269	0.888	0.2179	0.194
3.50/ 9.00	0.280	0.884	0.2267	0.200
3.50/ 8.50	0.292	0.879	0.2361	0.207
3.50/ 8.00	0.304	0.873	0.2464	0.215
3.50/ 7.50	0.318	0.868	0.2576	0.223
3.50/ 7.00	0.333	0.861	0.2698	0.232
3.50/ 6.50	0.350	0.854	0.2833	0.242
3.50/ 6.00	0.368	0.847	0.2982	0.253
3.50/ 5.50	0.389	0.838	0.3148	0.264
3.50/ 5.00	0.412	0.829	0.3333	0.276
3.50/ 4.28	0.450	0.813	0.3642	0.296
3.50/ 4.00	0.467	0.806	0.3778	0.304
3.50/ 3.50	0.500	0.792	0.4048	0.321
3.50/ 3.00	0.538	0.776	0.4359	0.338
3.50/ 2.50	0.583	0.757	0.4722	0.358

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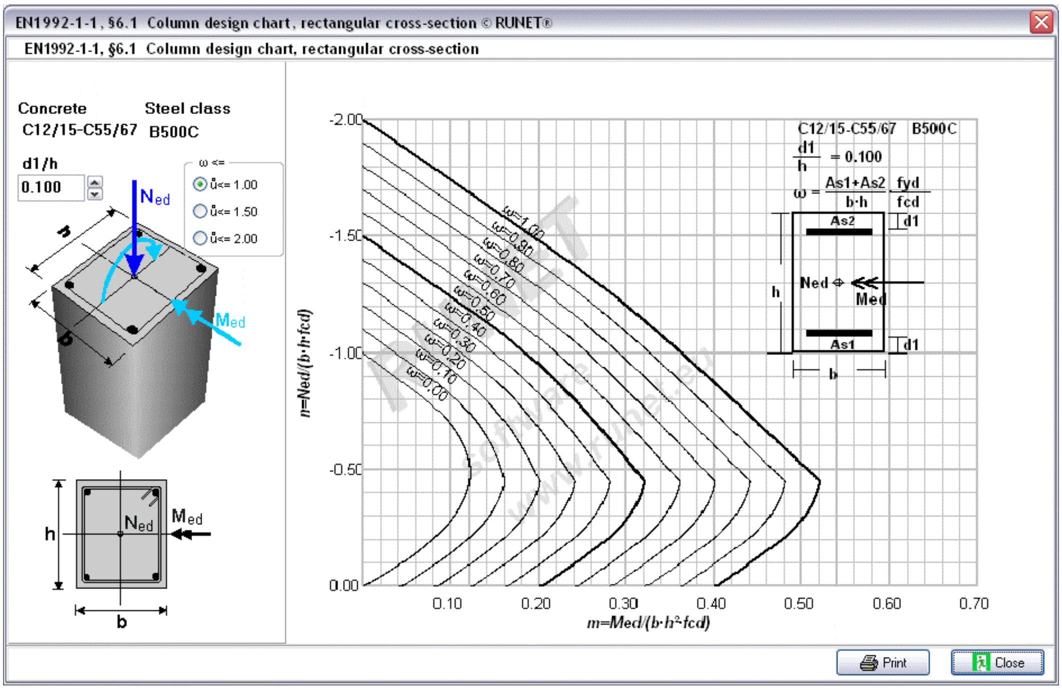
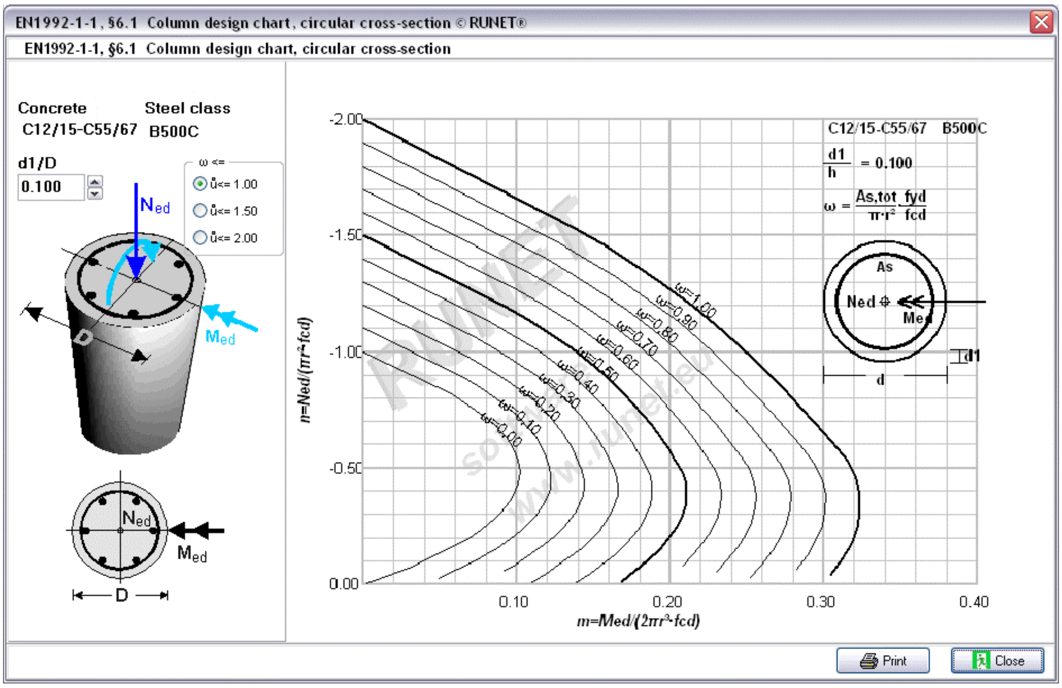
Print Close

20.4 Design charts, Columns

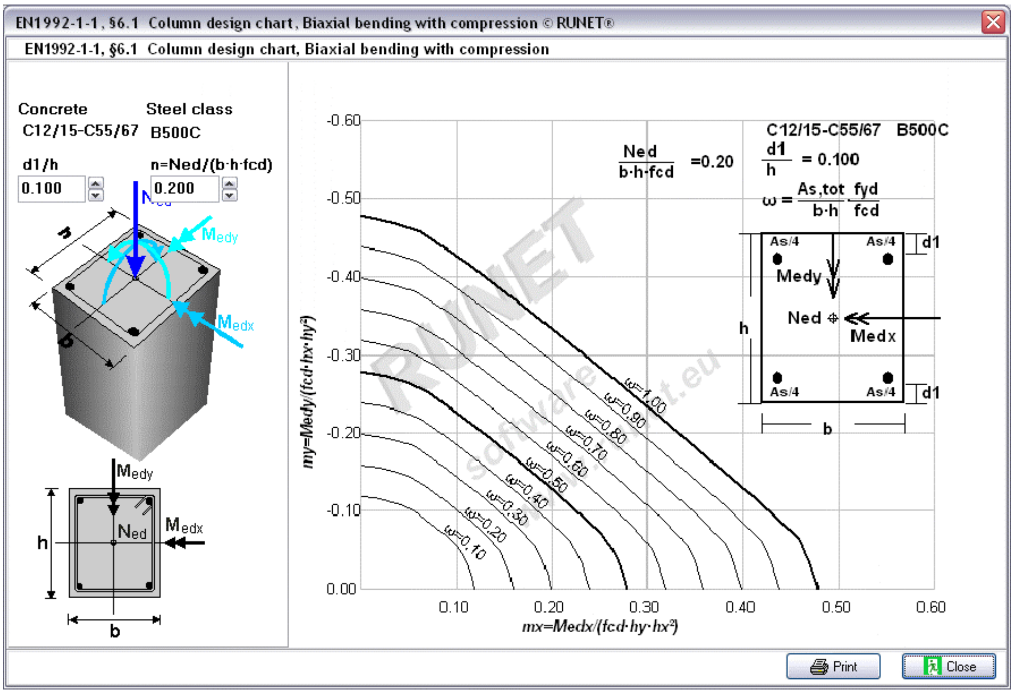
20.4.1 Column design chart, rectangular cross-section



20.4.2 Column design chart, circular cross-section

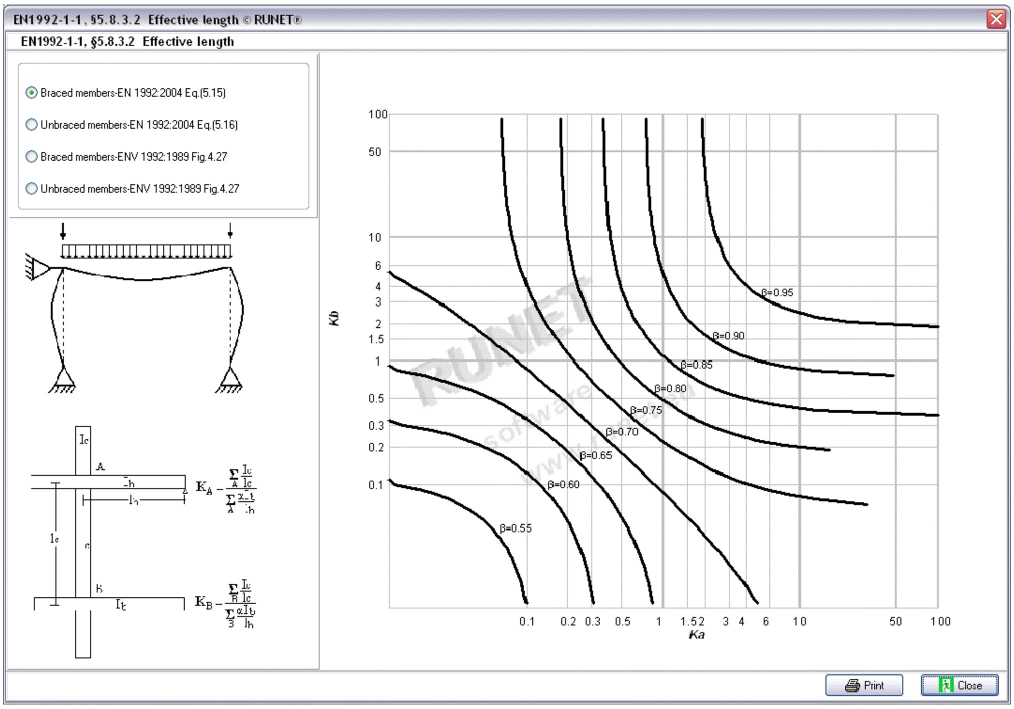


20.4.3 Column design chart, Biaxial bending with compression



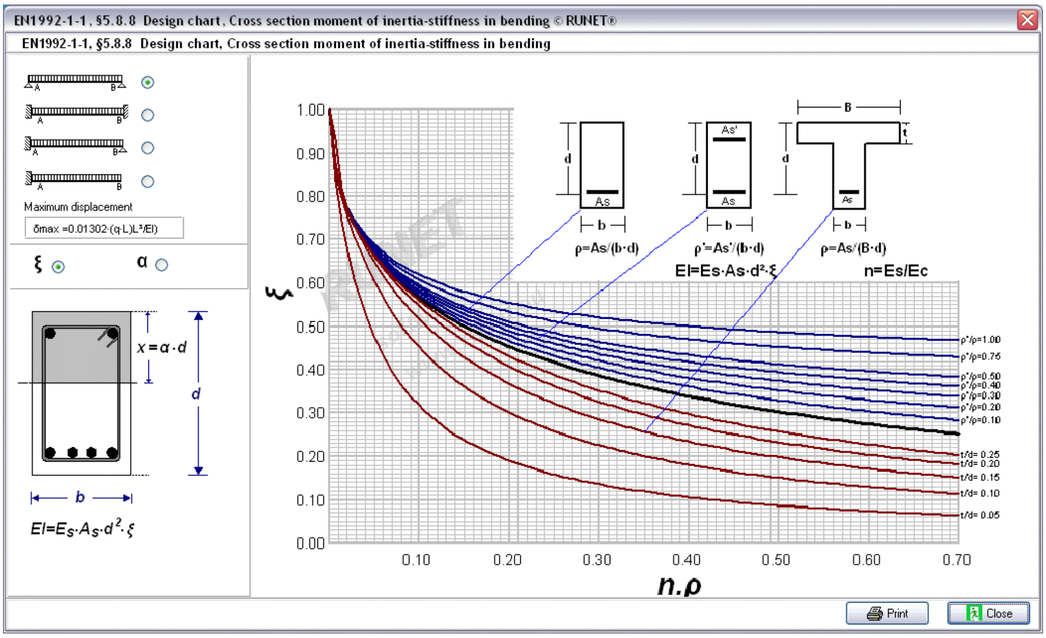
20.5 Design charts, Slenderness and effective length of columns

20.5.1 Column design chart, Biaxial bending with compression



20.6 Design chart, Deflection control

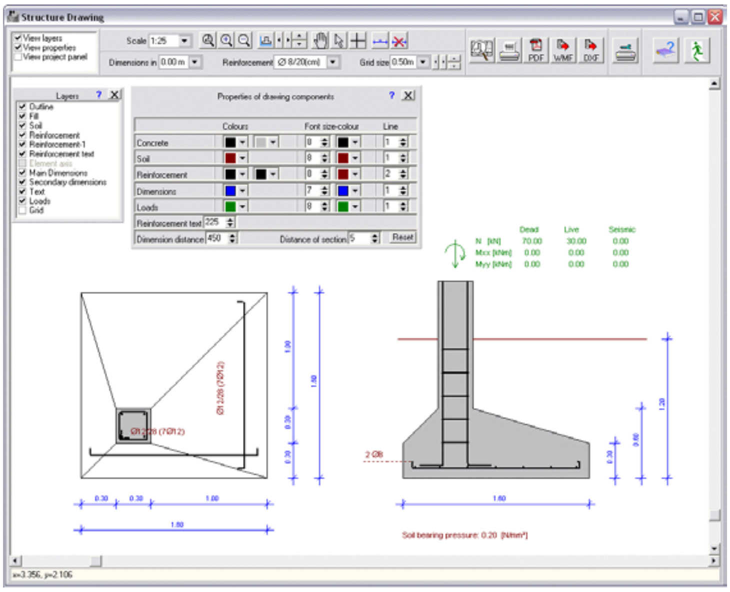
20.6.1 Column design chart, Cross section moment of inertia-stiffness in bending



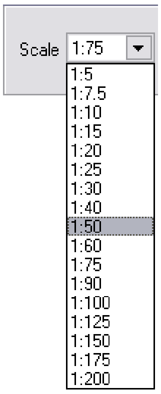
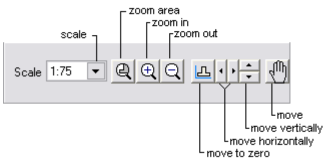
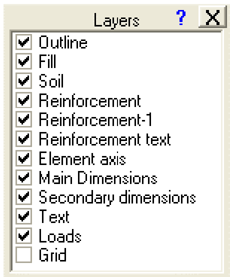
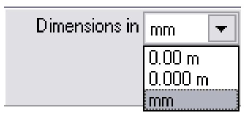
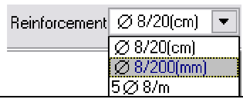
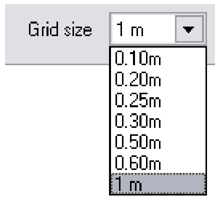
21 CAD drawing of concrete elements

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.



21.1 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.

21.1.1 Dimension units

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

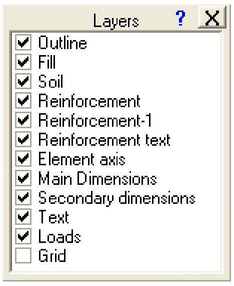
Grid. If you want the grid to appear, from the layers panel, check the grid and choose the size from the pull down menu. By clicking on the small arrows on the right, you move the grid in relation to the drawing.

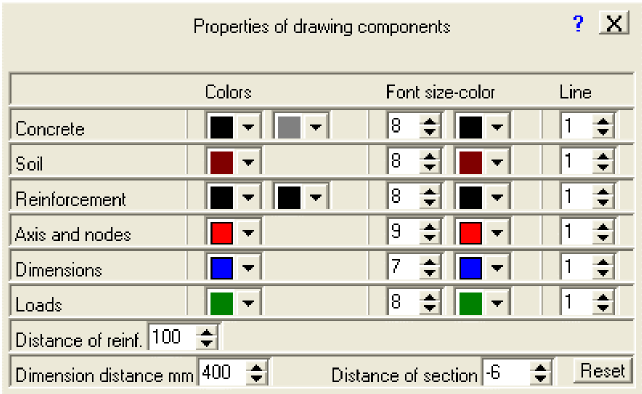
21.1.2 Line thickness, colour and font sizes

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.



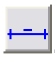


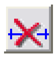
There are three levels of dimensioning. By adjusting the dimension distance you move the dimension lines further or closer to the design object.

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.

21.1.3 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.

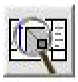
If you want to remove all the extra dimensions added, use the  .

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.

21.2 Print - preview drawing

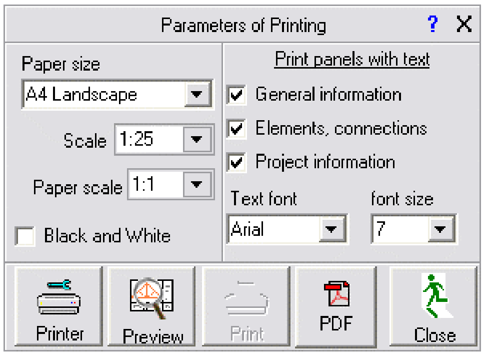
Before you print your drawing it is advisable to preview the contents of you drawing first.



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.

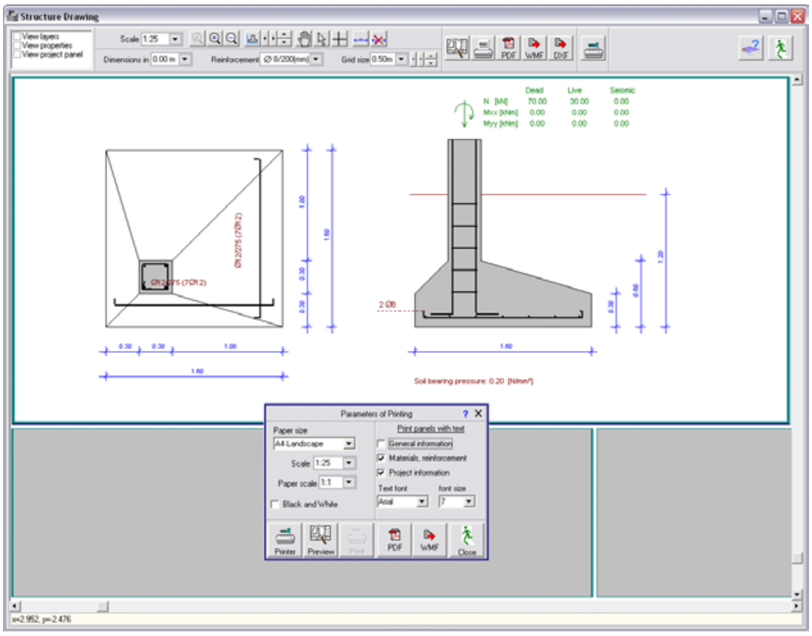


In case your screen size does not allow you to see all the drawing paper by choosing another Paper scale you scale down the screen image.

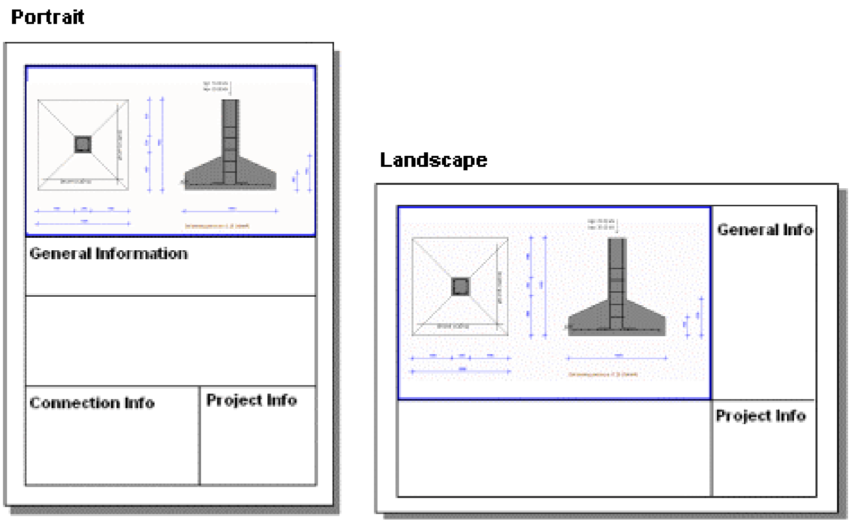
Choose the text panels you want included in your drawing.

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.



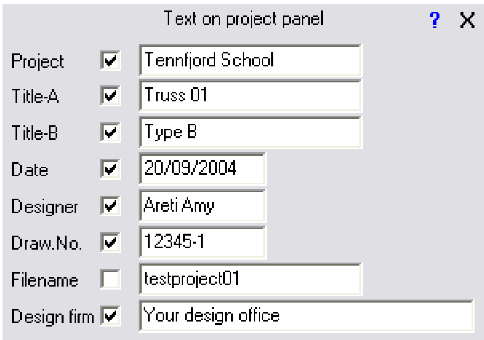
Print preview drawing.



Page orientation for drawings.

21.3 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.

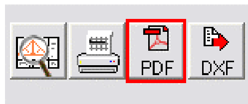


The project title is automatically taken from the name of the project.

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

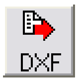
The Design Firm title is automatically taken from the settings of the report parameters, see pg. 28, report page footer.

21.4 Export drawing to PDF format

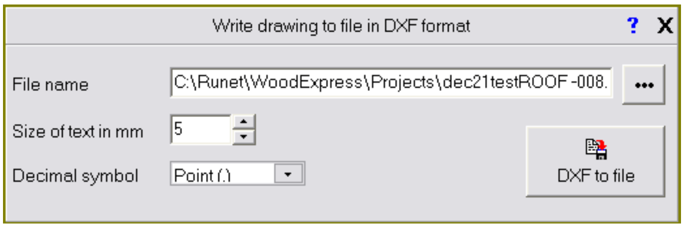


From the CAD modulus of the program you can save your drawing in PDF format

21.5 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.



22 Program settings

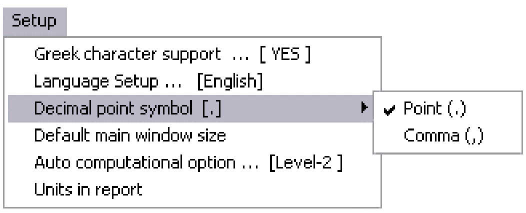
22.1 Greek character setup

According to the notation used in the Eurocodes the report contains many Greek mathematical symbols. Depending on the Window installation the Greek mathematical symbols may or may not appear right. If you have Windows XP or 2000 you can add Greek language support in your Windows. Go to [Settings/Control Panel/Regional and Language Options/Advanced].

If your Windows do not support Greek mathematical symbols, then from [Setup/Greek character support] select NO . The Greek characters will appear as: alpha, beta etc. , in the report.

22.2 Language Set Up

The program interface and reports are in various languages. You can choose the language of the program from the menu [Setup/Language Set-Up]. Choosing the language the program will close and when it will be opened again is going to be in the new language.



22.3 Decimal point symbol

You specify (.) or (,) for the decimal point appearing in the input data and the reports.

22.4 Screen sizes

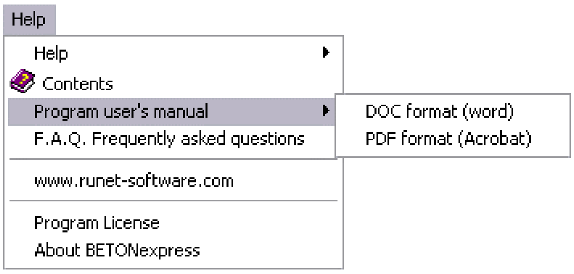
The size of each window bas been optimised.

You can resize the main screen, and its size is maintained. The size of the main screen is automatically set to the size the last time you opened the program. You can reset the main screen to the default size by clicking at [Setup/Default screen size].

The calculation window takes a height almost equal to the height of the main program window.

22.5 User's guide

You can preview, or print the program user's manual. You select to view it as a Word (doc) or as an Acrobat (pdf) document.



23 Reports

After designing the desired concrete objects they can be printed into a high quality report. The report will contain all the objects that are checked in the [design objects] window. The order of which the objects will appear in the report can be adjusted with the two arrows at the bottom of the design objects window. Adjustments for the report, font, margins, logo of caption or footnote, etc. can be done from [Report Setup].

23.1 Preview report

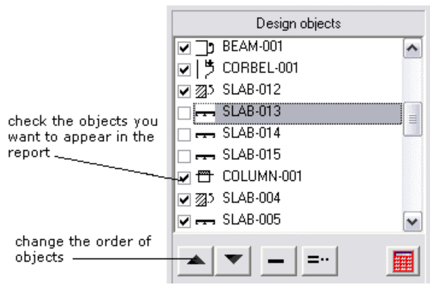
The report preview contains all the objects that are checked in the [design objects] window. You can adjust the order in which the object appears in the report by using the two arrows at the bottom of the [design objects] window.

In order to preview the report you must have a valid printer installed in your system. If you work in a network there must be installed a network printer. Otherwise the system will report – invalid printer. In this case simply connect/add a printer, or select another printer as default.

From the [Report Setup] you can adjust the looks of your report such as font, margins, logo of caption or footnote, etc. In [Report Setup/Various/Change page for each chapter], you can choose to start each design object in a new page.

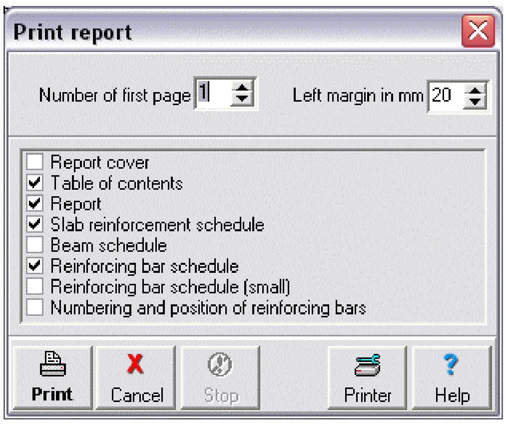
23.2 Printing report

The report contains all the objects that are checked in the [design objects] window. The order of the objects appearing in the preview can be adjusted with the two arrows at the bottom of the design objects window.



In order to print a report you must have a valid printer installed in your system. If you work in a network there must be installed a network printer. Otherwise the system will report – invalid printer. In this case simply connect/add a printer, or select another printer as default.

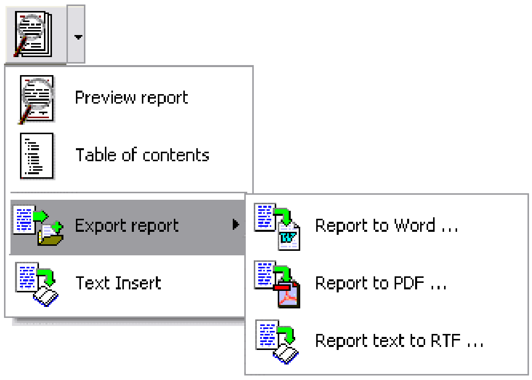
Adjustments for the report, font, margins, logo of caption or footnote, etc. can be done from Report Setup. In [Report Setup/Various/Change page for each chapter], you can choose to start each design object in a new page.



From the printing dialog you can adjust the page number of the first page and the left margin in mm. More adjustments for the report, font, margins, logo of caption or footnote, etc. can be done from Report Setup.

In [Report Setup/Various/Change page for each chapter], you can choose to start each design object in a new page.

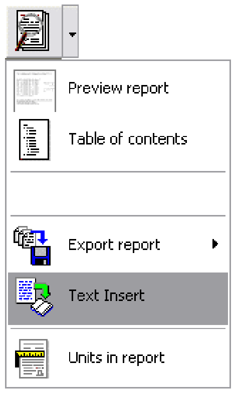
23.3 Report to file



You can transfer the report (text only) to a RTF file, which can be opened by Microsoft's Word. In order for the report to appear right in the Word, select all the text, expand the margins and set font to courier new and the font size to10.

If your windows do not support Greek character set, the Greek mathematical symbols will not appear right. Depending on the Window installation the Greek mathematical symbols may not appear right. If you have Windows XP or 2000 you can add Greek language support in your Windows, from Windows [Settings/Control Panel/Regional and Language Options/Advanced].

If your windows do not support Greek mathematical symbols, then from [Setup/Greek character support] select the language without the support of Greek mathematical symbols. Thus the Greek characters will appear as alpha, beta etc.



23.4 Text insert

You can insert your own text in the report, with the [Preview/Text Insert] command.

In the window which opens, write the text or read it from a ***.rtf** file. This text object can be treated like all the other objects of the program.

23.5 Report editing

To edit the report, save the file to word or rtf format and do the changes from the new document.

23.6 Printer Setup

Select printer, and adjust printer properties. Standard Windows dialog.

23.7 Troubleshooting

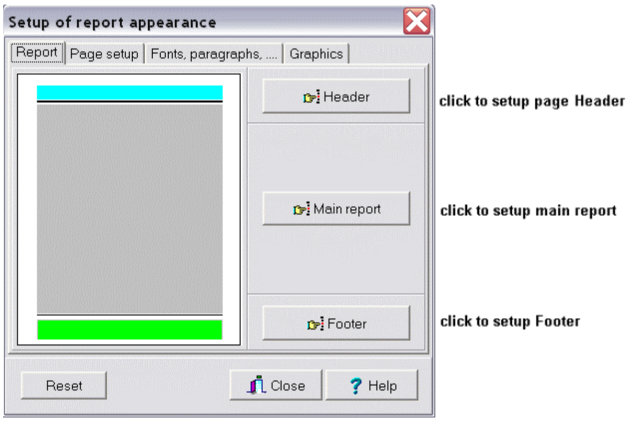
Greek Mathematical symbols

According to the notation used in the Eurocodes the report contains many Greek mathematical symbols. Depending on the window installation the Greek mathematical symbols may not appear right. In case you still have windows XP or 2000 you may add Greek language support in your windows, from windows [Settings/Control Panel/Regional and Language Options/Advanced].

In case your windows do not support Greek mathematical symbols, then from [Setup/Language Set-Up] select the language without the support of Greek mathematical symbols. In this case the Greek characters appear explicit e.g. alpha, beta etc.

24 Report parameters

From the main menu you can adjust the appearance and the printout of the reports by using the [report parameters setup].

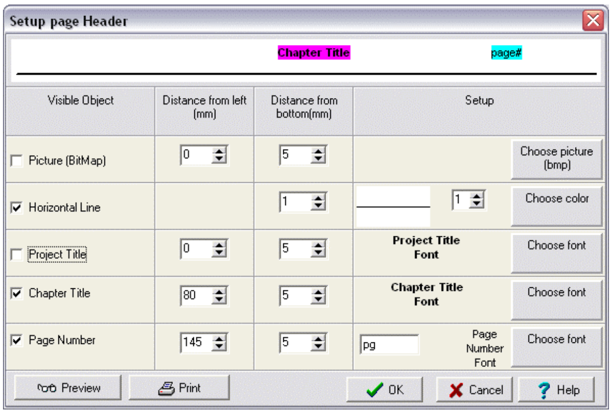


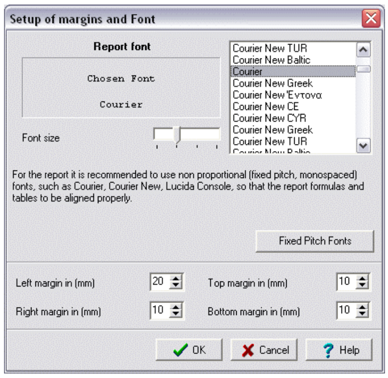
24.1 Report –setup

Header, page footer, paper size, orientation, line distance, margins etc.

24.1.1 Report Page Header

On the page's header it can appear, a small picture (bitmap), at the project title, the chapter title, the page number and an horizontal line underneath. By checking the corresponding boxes you can choose which of the above objects you want to appear on the caption. The position of these objects is regulated from the numbers in mm you specify in the boxes in columns 2 and 3. In the last column you can set the font, or select a bitmap for the icon, or the thickness and colour of the line. At the page place you can specify the letters you want to appear before the page number e.g. Pg. With the buttons at the bottom you can preview or print a sample of the header.

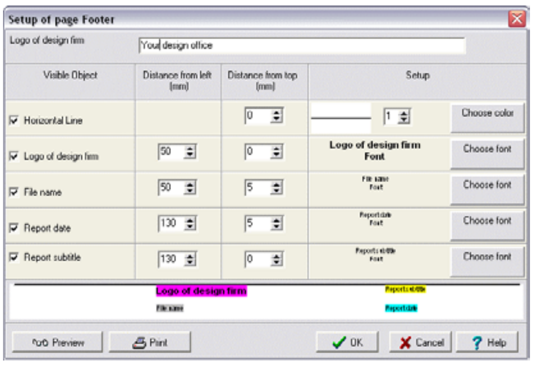




24.1.2 Main report

You select the font type, as well as the size of the font. For the font type it is **wise to select non proportional fonts, such as Courier, Courier new, Lucida Console, so that the report formulas and tables to be aligned properly**.

You can also specify the page margins (left, right, top, bottom) in millimetres (mm).

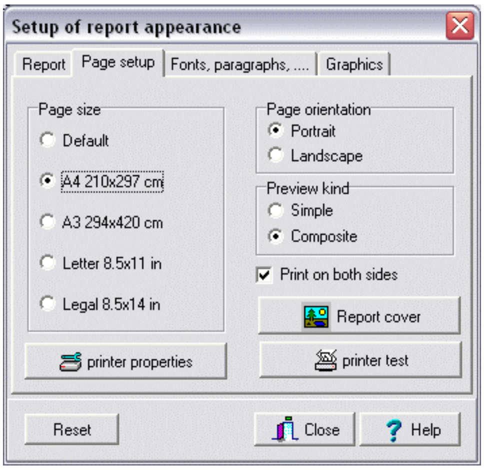


24.1.3 Report page footer

On the page's footer it can appear, the logo of the design firm, the file name of the project, the report subtitle or chapter title, the report date, and an horizontal line on top. By checking the corresponding boxes you can choose which of the above objects you want to appear on the caption. The position of these objects is regulated from the numbers in mm you specify in the boxes in columns 2 and 3. In the last column you can set the font, or the thickness and colour of the line.

With the buttons at the bottom you can preview or print a sample of the page footer.

24.2 Page setup



24.2.1 Report cover

You can design your own front page of the report. From [Report Setup/Page Preview/Report Cover]

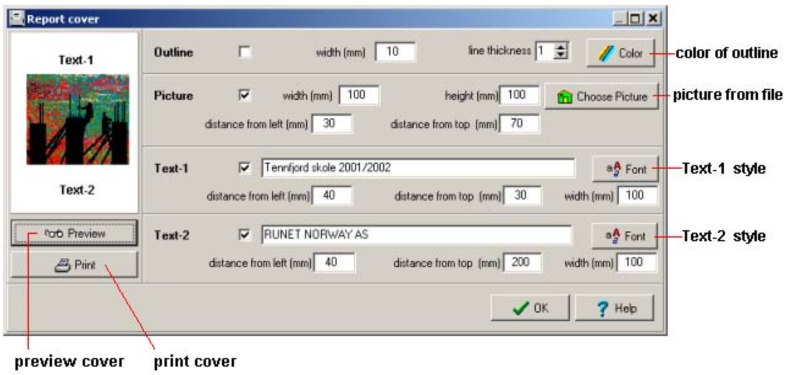
you can edit the features on the cover of the report. The cover can be displayed with an outline, a picture (from bitmap file) and two text lines. You can adjust the contents with the checkboxes.

The outline's colour and thickness be changed.

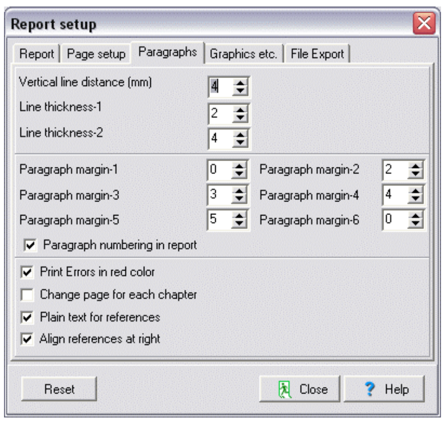
If you wish a picture on the cover, you can choose from the examples or choose your own bitmap.

The style of text in the two text lines from the font style editor box.

You can Preview your new report cover and also do test print.



24.2.2 Report setup, Various



Report paragraphs etc.

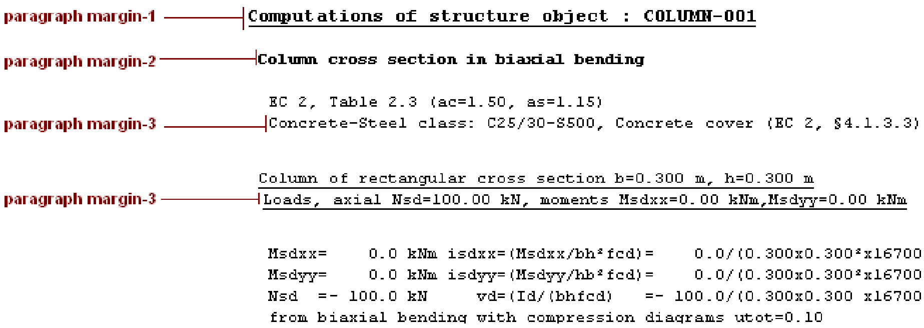
If you check, [**Change page for each chapter**], The computations of every design objects will start on a new page.

If you check, [**Print Errors in red colour**], warnings will be printed in red when computations are not satisfying the codes or standards.

You can adjust the line distance in mm and the paragraph left margin in characters.

The indentation of paragraphs can be adjusted from the margin already set in [Report setup/Page-setup/main report]. The indentation can be adjusted in characters (not mm).

margins are according to the figure.



25 Program settings

25.1.1 Greek character support

According to the notation used in the Eurocodes the report contains many Greek mathematical symbols. Depending on the Window installation the Greek mathematical symbols may or may not appear right. If you have Windows XP or 2000 you can add Greek language support in your Windows. Go to [Settings/Control Panel/Regional and Language Options/Advanced].

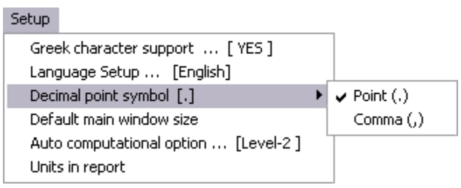
If your Windows do not support Greek mathematical symbols, then from [Setup/Greek character support] select NO. The Greek characters will appear as: alpha, beta etc. , in the report.

25.1.2 Language Set Up

You can choose the language of the program from the menu Setup/Language Setup]. By changing the language and confirm it by [apply] program will close down. When you reopen, the program will appear with the selected language.

25.1.3 Decimal point symbol

You specify (.) or (,) for the decimal point appearing in the input data and the reports.



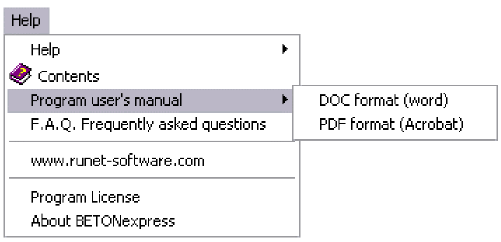
25.1.4 Screen dimensions

You can resize the main screen, and its size is maintained.
The size of the main screen is automatically set to the size the last time you opened the program. You can reset the main screen to the default size by clicking at [Setup/Default screen size].

The windows which are opened inside the main window have a height limited by the height of the main screen. If you want to have these windows larger, simply open the main screen. .

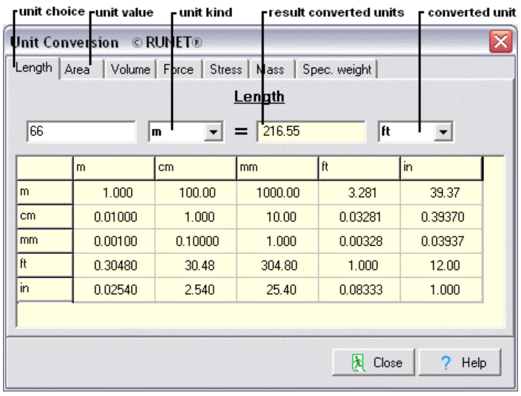
25.1.5 User's guide

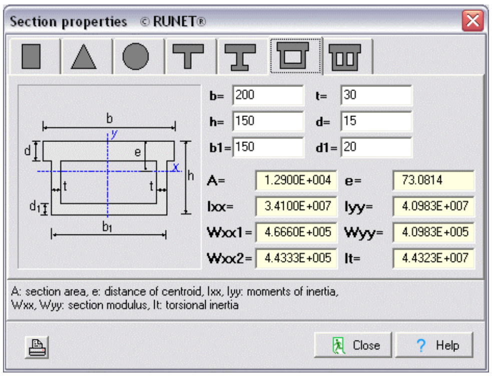
You can preview, or print the program user's manual. You select to view it as a Word(doc) or as an Acrobat (pdf) document.



26 Engineering tools

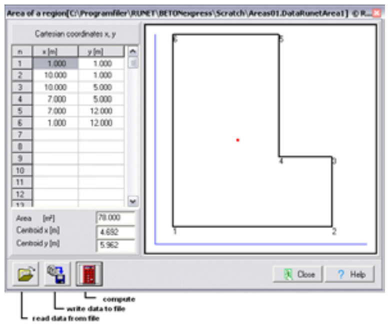
26.1.1 Unit conversion Cross sections





Cross section properties. Give the cross section dimensions b,h,...etc, and the cross section properties (area, moments of inertia, and section modulus), are computed.

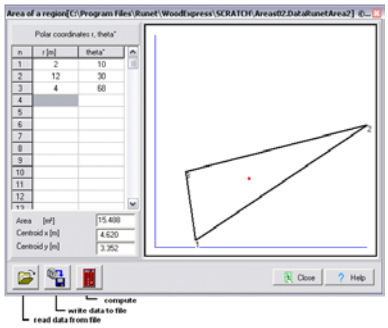
26.1.2 Areas (x,y coordinates)



To find the area of a more or less complicated shapes you can use the area of the region .

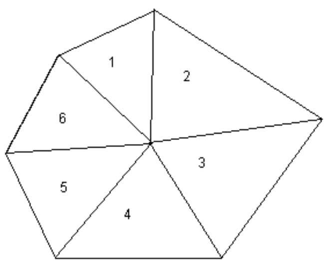
Give the points of the border line of an area, in polar (r , theta) coordinate. The area and the centroid of the region are computed. On the right of the window appears a sketch of the region, and the centroid is marked in red. with the buttons at the bottom left you can save the data in a file and read them back again later.

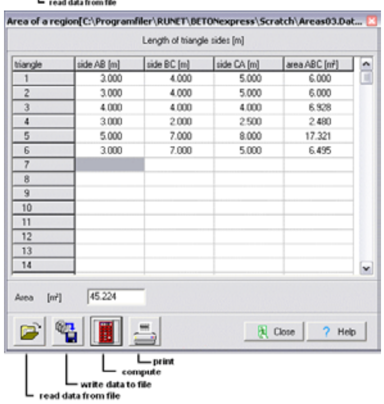
26.1.3 Area (polar coordinates)



Give the points of the border line of an area, in polar (r , theta) coordinate. The area and the centroid of the region are computed. On the right of the window appears a sketch of the region, and the centroid is marked in red. with the buttons at the bottom left you can save the data in a file and read them back again later.

26.1.4 Areas (sum of triangles)





27 Eurocodes

Group of standards for the structural and geotechnical design of buildings and civil engineering works. These standards is a set harmonized technical rules for civil engineering works, in the members of the European Community. National Application Documents are national standard for adapting the Eurocode to native requirements.

The structural Eurocodes are:

Eurocode 0	1990:2002	Basis of structural design
Eurocode 1	EN 1991-1-1:2002	Actions on structures – general actions – Densities, self-weight and imposed loads.
	EN 1991-1-2:2002	Actions on structures – general actions – Actions on structures exposed to fire
	EN 1991-1-3:2003	Actions on structures – general actions – Snow loads
	EN 1991-1-4:2005	Actions on structures – general actions – Wind actions
	EN 1991-1-5:2003	Actions on structures – general actions – Thermal actions
	EN 1991-1-6:2005	Actions on structures – general actions – Actions during execution
	EN 1991-1-7:2005	Actions on structures – general actions – Accidental Actions
Eurocode 2	EN 1992-1-1:2004	Design of concrete structures, General rules and rules for buildings
	EN 1992-1-2:2004	Design of concrete structures, General rules -Structural fire design
Eurocode 3	EN 1993-1-1:2005	Design of steel structures
Eurocode 4	EN 1994-1-1:2004	Design of composite steel and concrete structures, General rules and rules for buildings
Eurocode 5	EN 1995-1-1:2004	Design of timber structures – General – Common rules and rules for buildings
	EN 1995-1-2:2004	Design of timber structures – General – Structural fire design
Eurocode 6	EN 1996-1-1:2005	Design of masonry structures, General rules for reinforced and unreinforced masonry structures
	EN 1996-1-2:2005	Design of masonry structures, General rules - Structural fire design
Eurocode 7	EN 1997-1:2004	Geotechnical design – General rules
Eurocode 8	EN 1998-1:2004	Design of structures for earthquake resistance, General rules, seismic actions and rules for buildings
	EN 1998-5:2004	Design of structures for earthquake resistance, Foundations, retaining structures and geotechnical aspects
Eurocode 9	EN 1999-1-1	Design of Aluminium structures, General rules

27.1 Eurocode 0 EN 1990:2002, Load combination

According to Eurocode EN 1990:2002 the design values for actions should be combined as

$\Sigma\gamma G,j\ Gk,j + \gamma Q,1\ Qk,1 + \Sigma\gamma Q,i\ \psi Q,i\ Qki$

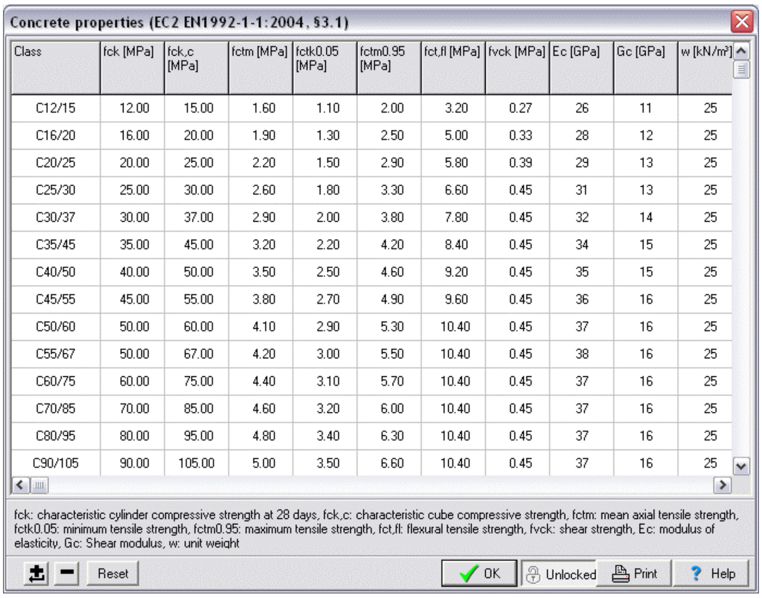
Factors for combining permanent and variable actions, Eurocode 0 Annex A1.

Usual values for these factors are **γG=1.35**, and **γQ=1.50**.

27.2 Eurocode 2, concrete design

27.2.1 Concrete (Eurocode 2 §3.1)

The strength class of concrete is classified by the cylinder strength or the cube strength Eurocode 2 §3.1.2.4



Concrete properties (EC2 EN1992-1-1:2004, §3.1)

Class	fck [MPa]	fck,c [MPa]	fctm [MPa]	fctk0.05 [MPa]	fctm0.95 [MPa]	fct,fl [MPa]	fvck [MPa]	Ec [GPa]	Gc [GPa]	w [kN/m³]
C12/15	12.00	15.00	1.60	1.10	2.00	3.20	0.27	26	11	25
C16/20	16.00	20.00	1.90	1.30	2.50	5.00	0.33	28	12	25
C20/25	20.00	25.00	2.20	1.50	2.90	5.80	0.39	29	13	25
C25/30	25.00	30.00	2.60	1.80	3.30	6.60	0.45	31	13	25
C30/37	30.00	37.00	2.90	2.00	3.80	7.80	0.45	32	14	25
C35/45	35.00	45.00	3.20	2.20	4.20	8.40	0.45	34	15	25
C40/50	40.00	50.00	3.50	2.50	4.60	9.20	0.45	35	15	25
C45/55	45.00	55.00	3.80	2.70	4.90	9.60	0.45	36	16	25
C50/60	50.00	60.00	4.10	2.90	5.30	10.40	0.45	37	16	25
C55/67	50.00	67.00	4.20	3.00	5.50	10.40	0.45	38	16	25
C60/75	60.00	75.00	4.40	3.10	5.70	10.40	0.45	37	16	25
C70/85	70.00	85.00	4.60	3.20	6.00	10.40	0.45	37	16	25
C80/95	80.00	95.00	4.80	3.40	6.30	10.40	0.45	37	16	25
C90/105	90.00	105.00	5.00	3.50	6.60	10.40	0.45	37	16	25

fck: characteristic cylinder compressive strength at 28 days, fck,c: characteristic cube compressive strength, fctm: mean axial tensile strength, fctk0.05: minimum tensile strength, fctm0.95: maximum tensile strength, fct,fl: flexural tensile strength, fvck: shear strength, Ec: modulus of elasticity, Gc: Shear modulus, w: unit weight

fck: characteristic compressive cylinder strength at 28 days

fck,c: characteristic compressive cube strength

fctm: mean axial tensile strength

fctk0.05: minimum tensile strength

fctm0.95: maximum tensile strength

fct,fl: flexural tensile strength

fvck: shear strength

Ec: modulus of elasticity

Gc: Shear modulus

w: unit weight

Poissons ration can be taken 0.20

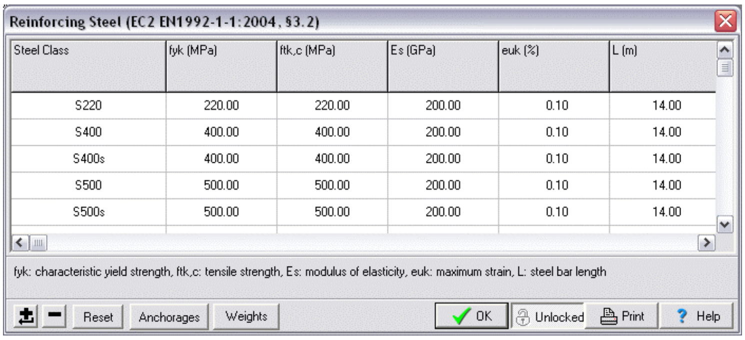
Coefficient of thermal expansion 0.00001 /°C

Creep and shrinkage of concrete

Density for normal weight concrete between 2000 and 2888 kg/m³ (usual value 2400 kg/m³)

27.2.2 Reinforcing steel Eurocode 2, §3.2

The reinforcing steel is classified according to the characteristic yield stress **fyk**



Reinforcing Steel (EC2 EN1992-1-1:2004, §3.2)

Steel Class	fyk (MPa)	ftk,c (MPa)	Es (GPa)	euk (%)	L (m)
S220	220.00	220.00	200.00	0.10	14.00
S400	400.00	400.00	200.00	0.10	14.00
S400s	400.00	400.00	200.00	0.10	14.00
S500	500.00	500.00	200.00	0.10	14.00
S500s	500.00	500.00	200.00	0.10	14.00

fyk: characteristic yield strength, ftk,c: tensile strength, Es: modulus of elasticity, euk: maximum strain, L: steel bar length

fyk: characteristic yield strength

ftk,c: tensile strength

Es: modulus of elasticity

euk: elongation at maximum load.

L: steel bar length

Mean value for density 7885 kg/m³

Coefficient of thermal expansion 0.00001 /°C

Ductility characteristics

Height ductility euk>5% value of (ft/fy)k>1.08

Normal ductility euk>2.5%, value of (ft/fy)k>1.05

27.2.3 Concrete cover, Eurocode 2 §2.4.1.3.3

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

Environmental class XC1

Concrete cover [EC2 §4.4.1] [mm] Cnom= 15 mm

$C_{nom} = C_{min} + \Delta C_{dev}$ ΔC_{dev}=10 mm EC2 §4.4.1

Concrete cover 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, for interior and exterior concrete components the minimum cover is 40 mm.

EN1992-1-1, §4.4.1 Minimum cover of reinforcement Cmin,

Environmental class	50 years design working life	100 years design working life
XC0: Corrosion induced by carbonation. Very dry environment	Cmin = 10 mm	Cmin = 10 mm
XC1: Corrosion induced by carbonation. Dry or permanently wet	Cmin = 15 mm	Cmin = 25 mm
XC2: Corrosion induced by carbonation. Wet, rarely dry	Cmin = 25 mm	Cmin = 35 mm
XC3: Corrosion induced by carbonation. Moderate humidity	Cmin = 25 mm	Cmin = 35 mm
XC4: Corrosion induced by carbonation. Cyclic wet and dry	Cmin = 25 mm	Cmin = 35 mm
XD1: Corrosion induced by chlorides. Moderate humidity	Cmin = 40 mm	Cmin = 50 mm
XD2: Corrosion induced by chlorides. Wet, rarely dry	Cmin = 40 mm	Cmin = 50 mm
XD3: Corrosion induced by chlorides. Cyclic wet and dry	Cmin = 40 mm	Cmin = 50 mm
XS1: Corrosion induced by chlorides from sea water. Moderate humidity	Cmin = 40 mm	Cmin = 50 mm
XS2: Corrosion induced by chlorides from sea water. Permanently submerged	Cmin = 40 mm	Cmin = 50 mm
XS3: Corrosion induced by chlorides from sea water. Tidal, splash and spray zone:	Cmin = 50 mm	Cmin = 60 mm

$C_{min} = \max\{C_{min,b}, C_{min,dur}, 10mm\}$ $C_{min,b} = Ø$

$C_{nom} = C_{min} + \Delta C_{dev}$ ΔC_{dev}=10 mm EC2 §4.4.1

OK Close

Other references:

Ultimate limit state for bending Eurocode 2 § 6.1

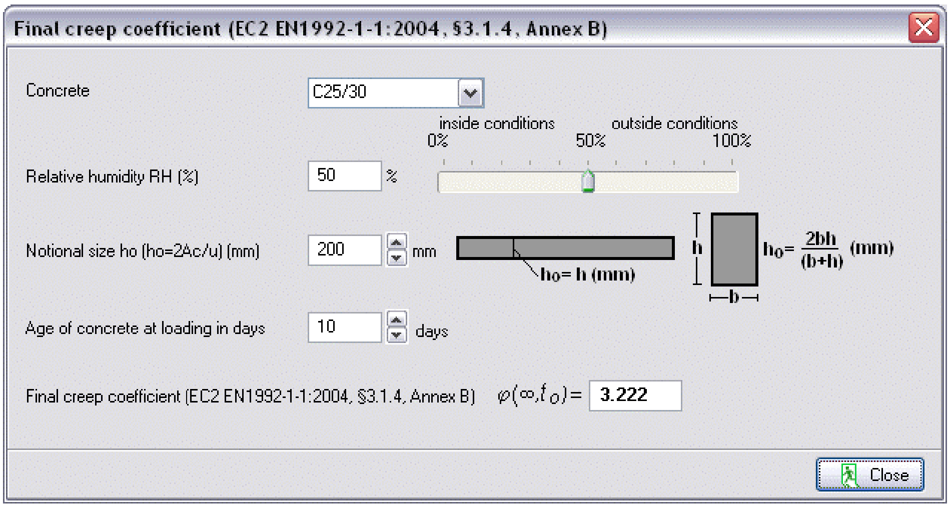
Shear Eurocode 2 § 6.2

Punching, Eurocode 2 § 6.4

Torsion Eurocode 2 § 6.3.

27.3 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 enviromental parameters and the sizes of the cross sections according to EN 1992-1-1:2004, par 3.1.4. and Annex B.



27.4 Eurocode 7, Geotechnical design

Eurocode 7, EN 1997-1:2004, Geotechnical design – General rules, Annex A, for EQU STR and GEO limit cases

A. 2. Partial factors for equilibrium limit state (EQU) verification.

Table A.1
Partial factors on actions (γF)

Action	Symbol	Value
Permanent		
Unfavourable[a]	$\gamma_{G;dst}$	1,1
Favourable[b]	$\gamma_{G;stb}$	0,9
Variable		
Unfavourable[a]	$\gamma_{Q;dst}$	1,5
Favourable[b]	$\gamma_{Q;stb}$	0
[a] Destabilising [b] Stabilising		

Table A.2
Partial factors for soil parametrers (γM)

Soil parametrers	Symbol	Value
Angle of shearing resistance[a]	$\gamma_{\varphi'}$	1,25
Effective cohesion	$\gamma_{c'}$	1,25
Undrained shear strength	γ_{cu}	1,4
Unconfined strength	γ_{qu}	1,4
Weight density	γ_{γ}	1,0
[a] This factor is applied to tan φ'		

A.3. Partial factors for structural (STR) and geotechnical (GEO) limit states verification.

Table A.3.
Partial factors on actions (γ_F) or the effects of actions (γ_E)

Action		Symbol	Set	
			A1 (STR)	*A2* (GEO)
Permanent	Unfavourable	γ_G	1,35	1,0
	Favourable		1,0	1,0
Variable	Unfavourable	γ_Q	1,5	1,3
	Favourable		0	0

Table A.4.
Partial factors for soil parameters (γ_M)

Soil parametrers	Symbol	Set	
		M1 (STR)	*M2* (GEO)
Angle of shearing resistance[a]	$\gamma_{\varphi'}$	1,0	1,25
Effective cohesion	$\gamma_{c'}$	1,0	1,25
Undrained shear strength	γ_{cu}	1,0	1,4
Unconfined strength	γ_{qu}	1,0	1,4
Weight density	γ_{γ}	1,0	1,0
[a] This factor is applied to tan φ'			

27.5 Eurocode 8, Seismic design

Seismic design is included in the footings, and in retaining walls Eurocode 8 Part 5

In footings
You specify the additional vertical loading and moments Mxx and Myy on the top of the footing due to earthquake.

Two additional design load combinations are treated according to Eurocode 8.

Loading-2 Dead + ψ2xLive + Seismic x-x,

<u>Loading-3</u> Dead + ψ2xLive + Seismic y-y

A restriction in seismic design is for the ratio of the (effective footing area)/(footing area)< coefficient, defined in [Parameters/Retaining walls]. This coefficient has a default value 0.50.

In retaining walls

You specify the design ground acceleration ratio α. The horizontal seismic acceleration is taken as **ah=αxg** (where g is the acceleration of gravity).

The final horizontal and vertical seismic coefficients affecting all the masses are taken according to Eurocode 8 Part 5,§ 7.3.2as: **kh=α/r**, and **kv=cxkh**. The coefficients **r** and **c** are defined in the [Parameters/Retaining walls], and usually values are **r=1.50**, **c=0.50**.

In the seismic loadings the effect of passive earth force is taken into account with a reduced factor defined in [Parameters/Retaining walls] and has an usual value 0.50.

A restriction in seismic design is for the ratio of the (effective footing area)/(footing area)< coefficient, defined in [Parameters/Retaining walls]. This coefficient has an usual value 0.50.

An additional restriction is according to Eurocode 8 Part 5,§ 7.3.2 3 (6) for the shearing resistance between soil and wall to be les than a ratio (usually 2/3=0.67) o the soil shearing resistance. This ratio is defined in [Parameters/Retaining walls].

The additional seismic forces, due to active earth pressure, are computed according to Eurocode 8 Part 5, Annex E, using the formula of Mononobe-Okabe [ref]. Thus the increased active earth pressure with seismic loading is computed as

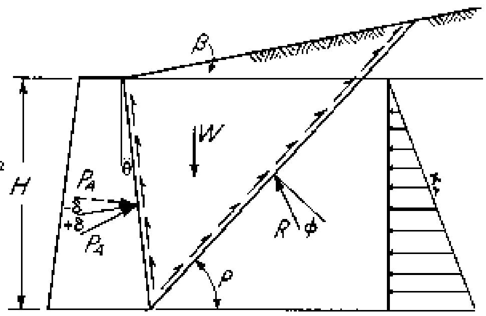
active earth pressure $P_A = \frac{\gamma H^2}{2} K_E$

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

φ angle of internal friction of soil

δ angle of wall friction

$\omega = \arctan\left(\frac{a_h}{1-a_v}\right)$ a_h, a_v horizontal and vertical seismic coefficient



In addition horizontal and vertical forces are acting at the center of gravity of the wall due to the wall mass. These forces are equal to **Fh=kh.W** and **Fv=kv.W**. Where **kh** and **kv** the horizontal and vertical seismic coefficients.

28 References

Eurocode 0	1990:2002	Basis of structural design
Eurocode 1	EN 1991-1-1:2002	Actions on structures – general actions – Densities, self-weight and imposed loads.
	EN 1991-1-2:2002	Actions on structures – general actions – Actions on structures exposed to fire
	EN 1991-1-3:2003	Actions on structures – general actions – Snow loads
	EN 1991-1-4:2005	Actions on structures – general actions – Wind actions
	EN 1991-1-5:2003	Actions on structures – general actions – Thermal actions
	EN 1991-1-6:2005	Actions on structures – general actions – Actions during execution
		Actions on structures – general actions – Accidental Actions
Eurocode 2	EN 1992-1-1:2004	Design of concrete structures, General rules and rules for buildings
	EN 1992-1-2:2004	Design of concrete structures, General rules -Structural fire design
Eurocode 3	EN 1993-1-1:2005	Design of steel structures
Eurocode 4	EN 1994-1-1:2004	Design of composite steel and concrete structures, General rules and rules for buildings
Eurocode 5	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
Eurocode 6	EN 1996-1-1:2005	Design of masonry structures, General rules for reinforced and unreinforced masonry structures
	EN 1996-1-2:2005	Design of masonry structures, General rules - Structural fire design
Eurocode 7	EN 1997-1:2004	Geotechnical design – General rules
Eurocode 8	EN 1998-1:2004	Design of structures for earthquake resistance, General rules, seismic actions and rules for buildings
	EN 1998-5:2004	Design of structures for earthquake resistance, Foundations, retaining structures and geotechnical aspects
Eurocode 9	EN 1999-1-1	Design of Aluminium structures, General rules

Eurocode 1 (EC1) ENV 1991 Basis of design and actions on structures

Eurocode 2 (EC2) ENV 1992 Design of concrete structures.

Eurocode 6 (EC6) ENV 1996 Design of masonry structures.

Eurocode 7 (EC7) ENV 1997 Geotechnical design.

Eurocode 8 (EC8) "Structures in seismic regions, Part 5, Foundations, Retaining Structures, Geotechnical Aspects" Draft, January 1991.

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29 Annex 1

30 BETONexpress Command Line

BETONexpress can also run as a post processor of various Finite Element Programs (ANSYS, SAP2000,) to perform the concrete element design. The communication of BETONexpress with other programs can be done with a command file in simple text format. Each line of this Command line file describes an object that is going to be created in BETONexpress. Commands and data can be read in BETONexpress and the design objects are automatically created. The format of the command text file is given below.

30.1 How to import the command file

Click at menu File/ Read Command Line File
Browse and [Open] the file with the command lines (.TXT)
Enter the name of the new project file as .BetonExpress data.
… and the Design objects are created from the commands and the data of the text file.

30.2 Example of command text file

MATER BI=4, SI=5, gG=1.35, gQ=1.50

PLATE-1 NM=Slab-1, H=0.20, Cb=15, D=10, Mb=12.10
PLATE-1 NM=Slab-2, H=0.25, Cb=15, D=10.1, Mb=12.30

PLATE-2 NM=Slab-7, TP=0011, H=0.20, Cb=15, D=10, Lx=3.60, Ly=4.00, G=0.80, Q=2.00
PLATE-2 NM=Slab-8, TP=1010, H=0.20, Cb=15, D=10, Lx=3.90, Ly=4.50, G=0.80, Q=2.00

BEAM-1 NM=BeamA-1, BW=0.20, H=0.50, Cb=25, D=14, Mb=48.65, Vs=56.80, Na=12.56
BEAM-1 NM=BeamA-2, BW=0.20, H=0.60, Cb=25, D=14.1, Mb=58.65, Vs=66.80, Na=22.56

BEAM-2 NM=BeamT-5, TP=1, BW=0.20, Bf=1.25, H=0.50, Hf=0.07, Cb=25, D=14, Mb=48.65, Vs=56.80, Na=12.56, L=6.47, SP=0
BEAM-2 NM=BeamT-6, TP=2, BW=0.20, Bf=1.25, H=0.60, Hf=0.07, Cb=25, D=14.1, Mb=58.65, Vs=66.80, Na=22.56, L=7.47, SP=1

MATER BI=5, SI=5, gG=1.35, gQ=1.50

COLUMN-1 NM=Column-1, TP=0, Bx=0.35, By=0.35, Cb=25, D=20, Mx=48.65, My=56.70, Na=-812.16, H=3.50
COLUMN-1 NM=Column-2, TP=1, Bx=0.36, By=0.36, Cb=26, D=22.1, Mx=48.75, My=56.80, Na=-812.26, H=3.60

FOOT-1 NM=Foot-1, Lx=1.50, Ly=1.40, Cx=0.30, Cy=0.40, H=0.70, H1=0.40, Cb=30, D=12, Ng=148.61, Nq=156.71, Qu=0.21, Ws=1.91, Hs=2.1
FOOT-1 NM=Foot21, Lx=1.60, Ly=1.50, Cx=0.40, Cy=0.50, H=0.70, H1=0.40, Cb=30, D=12.1, Ng=128.62, Nq=186.72, Qu=0.22, Ws=1.92, Hs=2.2

30.2.1 Command Line explanations

Every part of a command must separated with comma (,)
Code words (first word and words with =) must be exactly the same
Capital and small letters are the same

MATER	**Materials and partial safety factors**
BS=C16/20	Concrete class
SS=S500	Steel class
gG=1.35	γ_G Partial factor for permanent loads
gQ=1.50	γ_Q Partial factor for variable loads

If Material Command is omitted, then the default values that are set in the program the moment you read the command file are taken.

Many material cards may be included. Each one affects the set of following commands.

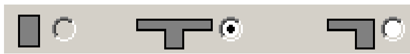
PLATE-1	Cross section of Plate
NM=SLAB-1	Name of slab object (any name up to 16 characters)
	*** NOTE object names are unique and must not repeated *****
H=0.20	Slab thickness in [m].
Cb=15	Concrete cover in [mm]
D=10	Rebar diameter (optimum). The program uses a optimum diameter around this.
	If you use D=10.1 then only10 mm rebar diameter will be used
Mb=12.10	Bending moment in [kNm/m] for the slab cross section.

PLATE-2	Two way slab
NM=SLAB-1	Name of slab object (up to 16 characters)
H=0.20	Slab thickness in [m].
Cb=15	Concrete cover in [mm]
D=10	Rebar diameter (optimum). The program uses an optimum diameter around this.
	If you use D=10.1 then only 10 mm rebar diameter will be used
TP=0011	Support conditions.
	0=support
	1=fixed
	Numbers in order Left, Bottom, Right, Top supports
Lx=3.60	Span x in [m]
Ly=4.00	Span y in [m]
g=0.80	Uniformly distributed permanent load in addition to self weight in [kn/m^2]
q=2.00	Uniformly distributed variable load in [kn/m^2]

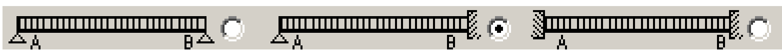
BEAM-1	Beam section of orthogonal cross section
NM=BEAMA-1	Name of slab object (any name up to 16 characters).

Cb=25	Concrete cover in [mm]
D=14	Rebar diameter (optimum). The program uses a optimum diameter around this.
	If you use D=14.1 then only 14 mm rebar diameter will be used
BW=0.20	Beam width in [m]
H=0.50	Beam height in [m]
Mb=48.65	Beam bending moment in [kNm]
Vs=56.80	Beam shear force in [kN]
Na=12.56	Beam axial force in [kN]

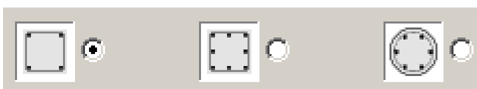
BEAM-2	Beam section of T cross section
NM=BEAMT-5	Name of slab object (up to 16 characters).
Cb=25	Concrete cover in [mm]
D=14	Rebar diameter (optimum). The program uses a optimum diameter around this.
	If you use D=14.1 then only14 mm rebar diameter will be used
TP=1	Beam type
	0=orthogonal cross section
	1=T beam
	2=L beam



BW=0.20	Beam width in [m]
Bf=1.25	Effective beam width in [m]
H=0.50	Beam height in [m]
Hf=0.07	Beam flange thickness in [m]
Mb=48.65	Beam bending moment in [kNm]
Vs=56.80	Beam shear force in [kN]
Na=12.56	Beam axial force in [kN]
L=6.47	Beam span length
SP=1	Span type
	0 simply supported
	1 simply supported-fixed
	2 fixed-fixed



COLUMN-1	Short column cross section
NM=Column-1	Name of slab object (up to 16 characters).
Cb=25	Concrete cover in [mm]
D=20	Rebar diameter (optimum). The program uses a optimum diameter around this.
	If you use D=20.1 then 20 mm rebar diameter will be used only
TP=0	Section type
	0, 1 for square section
	2 for round cross section (in this case Bx=By=D)



Bx=0.35	x column side in [m]
By=0.35	y column side in [m]

Mx=48.65	Bending moment Mxx in [kNm]
My=56.70	Bending moment Myy in [kNm]
Na=-812.16	Axial load in [kN]
H=3.50	Column height in [m]

FOOT-1	Short column cross section
NM=Foot-1	Name of slab object (up to 16 characters).
Cb=25	Concrete cover in [mm]
D=12	Rebar diameter (optimum). The program uses a optimum diameter around this. If you use D=12.1 then 12 mm rebar diameter will be used only
Lx=1.50	Footing x dimension in [m]
Ly=1.40	Footing y dimension in [m]
Cx=0.30	Column x dimension in [m]
Cy=0.40	Column y dimension in [m]
H=0.70	Footing total height in [m]
H1=0.40	Footing base height in [m]
Ng=148.61	Permanent vertical load on top in [kN]
Nq=156.71	Variable vertical load on top in [kN]
Qu=0.21	Soil bearing pressure in [N/mm^2]
Ws=1.91	Soil unit weight in [kN/m^3]
Hs=2.1	Foundation depth in [m]