



Проектсофт - Column Expert v 1.0/2009

Оразмеряване и изчертаване на стоманобетонни колони

Геометрични размери

| Етаж | Колона | K1 | K2 | K3 | K4 |
|-------------|-----------|-----|-----|-----|-----|
| Ет. 3 | h ет [cm] | 280 | 280 | 280 | 280 |
| | h пл [cm] | 20 | 20 | 20 | 20 |
| | h гр [cm] | | | | |
| Ет. 2 | h ет [cm] | 280 | 280 | 280 | 280 |
| | h пл [cm] | 20 | 20 | 20 | 20 |
| | h гр [cm] | | | | |
| Ет. 1 | h ет [cm] | 280 | 280 | 280 | 280 |
| | h пл [cm] | 20 | 20 | 20 | 20 |
| | h гр [cm] | | | | |
| к.г.р.ф.[m] | | | | | |

Материали

Бетон клас B20 с изчислително съпротивление на натиск R_b = 11,5 MPa

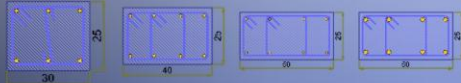
Стомана за надлъжна армировка клас AIII с изчислително съпротивление на натиск R_{sc} = 375 MPa

Стомана за напречна армировка клас AI с изчислително съпротивление на натиск R_{sw} = 180 MPa

Коэффициенти за условие на работа: $\gamma_b = 0.85$; $\gamma_s = 1.00$

Напречни сечения

№ 1 - 25x30-6N16 № 2 - 25x40-8N16 № 3 - 25x50-8N16 № 4 - 25x50-8N25



| | | | |
|--|---|---|---|
| Ab = 750 cm ² As = 12.1 cm ² mu = 1.6 % N = 1186 kN | Ab = 1000 cm ² As = 16.1 cm ² mu = 1.6 % N = 1581 kN | Ab = 1250 cm ² As = 16.1 cm ² mu = 1.3 % N = 1825 kN | Ab = 1250 cm ² As = 39.3 cm ² mu = 3.1 % N = 2694 kN |
|--|---|---|---|

Software Package

Design Expert version 2.0

Column Expert

Design and detailing of reinforced concrete columns

User Manual

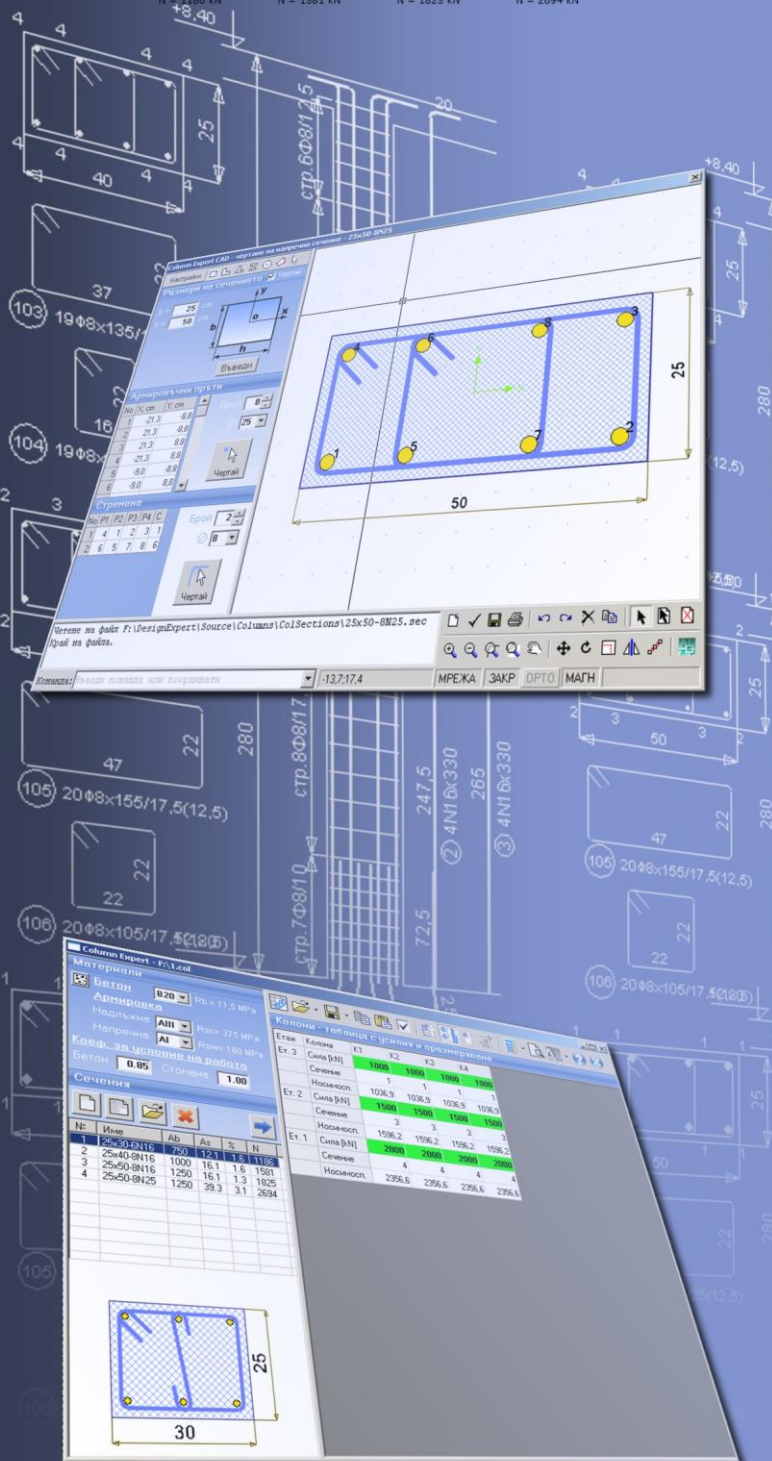


TABLE OF CONTENTS

| | |
|---|-------------------------------------|
| ABOUT THE PROGRAM..... | 4 |
| FILES | 4 |
| Open a file | 4 |
| Save a file | 4 |
| INPUT DATA..... | 4 |
| Working with tables | Error! Bookmark not defined. |
| Number of floors and columns | 4 |
| Geometrical data | 5 |
| Materials data | 5 |
| Material tables..... | 5 |
| Loads and sections..... | 5 |
| CROSS SECTIONS..... | 6 |
| LOAD SECTIONS IN CURRENT PROJECT | 6 |
| Assign sections to columns | 6 |
| Библиотека напречни сечения..... | Error! Bookmark not defined. |
| RC Sections Library | 7 |
| Import and remove sections | 7 |
| Add a new section | 8 |
| Modify existing section..... | 8 |
| Delete a section | 8 |
| Filter | 8 |
| Draw sections..... | 9 |
| Settings | 9 |
| Section shape and dimensions | 10 |
| Main bars..... | 10 |
| Shear links..... | 10 |
| Section check | 10 |
| Detailing requirements to Bulgarian code NPBStBK..... | 11 |
| Detailing requirements to Eurocode 2 и Eurocode 8 | 12 |
| Save..... | 12 |
| OUTPUT | ERROR! BOOKMARK NOT DEFINED. |
| Design checks | 13 |
| Design to Bulgarian code NPBStBK | 13 |
| Design to Bulgarian code Eurocode 2 | 14 |
| Check current sections..... | 14 |
| Automatically select reinforcement..... | 14 |
| Automatically select sections | 14 |
| View columns elevations and allign columns in height..... | 14 |
| Detailing settings..... | 15 |
| Seismic factor..... | 15 |
| Concrete cover | 15 |
| Detailing | 15 |
| Drawing | 16 |
| Bill of Materials | 16 |
| Drawing scale | 16 |
| Generation of reinforcement drawing | 16 |
| Export to ZWCAD (AutoCAD) and other applications..... | 17 |
| WORKING WITH DESIGN EXPERT CAD GRAPHIC ENVIRONMENT | 17 |
| Commands | 17 |
| Screen view management..... | Error! Bookmark not defined. |
| Zoom In..... | Error! Bookmark not defined. |
| Zoom Out | Error! Bookmark not defined. |



| | |
|--|-------------------------------------|
| Zoom Window | Error! Bookmark not defined. |
| Zoom All | Error! Bookmark not defined. |
| Pan | Error! Bookmark not defined. |
| Using a three button mouse | Error! Bookmark not defined. |
| Coordinate input | Error! Bookmark not defined. |
| Select and deselect objects | Error! Bookmark not defined. |
| Single..... | Error! Bookmark not defined. |
| Group..... | Error! Bookmark not defined. |
| All | Error! Bookmark not defined. |
| Deselect..... | Error! Bookmark not defined. |
| Modify objects | Error! Bookmark not defined. |
| Delete | Error! Bookmark not defined. |
| Move | Error! Bookmark not defined. |
| Rotate | Error! Bookmark not defined. |
| Scale | Error! Bookmark not defined. |
| Mirror | Error! Bookmark not defined. |
| Stretch | Error! Bookmark not defined. |
| Copy | Error! Bookmark not defined. |
| Method of transformation..... | Error! Bookmark not defined. |
| Number of repetitions..... | Error! Bookmark not defined. |
| Pick points | Error! Bookmark not defined. |
| Printing graphics..... | Error! Bookmark not defined. |
| Copy graphics to other applications..... | 22 |



About the program


Column Expert is created for design and detailing of reinforced concrete columns of buildings. Storey heights, thickness of slabs and heights of beams (if any) are filled in tabular form. Column loads and cross sections are entered as well. Cross sections are stored in library and can be inserted readymade. New sections can be added easily by drawing them in the embeded CAD environment. Design checks of columns are performed for axial load with nominal eccentricity. Detailed drawing of all columns with views and sections is generated automatically. Drawing is created in Design Expert own embeded CAD environment and can be saved as ZWCAD (AutoCAD) command file (script) or directly transferred to ZWCAD (AutoCAD).

Files



Input data for each project is saved in a file with extension ***.col**. Design output is written to a ***.col.html** file in HTML format.

Open a file

Opening of a ***.col** file is performed by the  button or by  ▾ "**Column Expert (*.col)**" submenu. A standard dialog is displayed. Select or write down file name and path and click "**Open**".

You can also import output files from static and dynamic analysis program Stadybs, version 6.4 or newer. Select  ▾ submenu "**Stadybs (*.k)**". A standard dialog window is displayed, where you should enter file path and name. Next you will be prompted to enter slab thickness in cm. Floor heights, column names and vertical loads, calculated by Stadybs are read from the file.

Save a file

Saving a file to disc is performed by the  button. A standard dialog appears where you should enter file path and name. If file already exists, you can overwrite it or specify different name. To save a file with different name select  ▾ "**Save As...**" submenu.

Input data


Working with tables

Most of the input data is filled in tables. The following commands are used with tables:


- add a row – press the **Ins** key or the **Up▲** button or when you go to the last column press **Enter** to open a new row;
- delete a row – press **Backspace** or **Down▼** button. Some tables have a fixed size and you cannot add or delete rows;
- move the focus with a single cell – use keyboard arrows **←, ↑, ↓, →**;
- move the focus to the first or last row – press **Page Up, Page Down, Home, End**;
- edit cell contents – press **F2** or just start writing – an input box is opened in the current cell
- end of cell edit – press Enter or arrow – the new data is saved to the cell;
- cancel of cell edit – press Esc – existing data remains in the cell;

- delete cell contents – select single or multiple cells and press **Del**;
 - area selection - use **Shift+arrows (Page Up, Page Down, Home, End)** or press left mouse button over the first corner, drag to the opposite corner and release the button. You can also click the first corner, hold shift key and click the second corner;
 - copy multiple cells – select an area and press **Ctrl+C**;
 - paste multiple cells - select an area or top-left cell and press **Ctrl+V**;
- You can copy to and from external programs like Word, Excel etc.

Number of floors and columns

Click the  button. A dialog is opened, where you should enter the number of floors and columns in the respective fields. When you click "**Save**" tables are automatically resized to the specified number of rows and columns.

Geometrical data

Geometrical data table can be opened with the  button. Column numbers are filled in the first row (C1, C2 etc.). Then you need to enter the following data for each column and storey:

- **h_{st}** – storey height from top of lower slab to top of upper slab [cm];
- **h_{pl}** – slab thickness [cm];
- **h_{bm}** – beam height [cm]. If there are several beams crossing the column, the highest is used. If there are no beams leave the cell empty or enter "**0**".




You can also specify top of concrete (T.O.C.) and height of foundation for each column. Starter bars will be added automatically by the program. If you have equal columns you can enter their number in the last row.

You can easily copy data for a column or storey to other cells.


Materials data

Select concrete grade and steel grades for bars and shear links. Strength reduction factors such as α_{cc} to EC2 can be entered for concrete and steel. Material properties for different concrete and steel grades are defined in „**Material Tables**“.

Material tables


Material tables can be opened by clicking the  button in the main window. A dialog is displayed with two separate tables for concrete and steel. You can add new rows with the „+“ button and fill in new materials, remove rows with „-“ or edit values. Elastic module and strengths are entered in MPa. With the  „**Save**“ button you can save your changes. With the  „**Exit**“ button you can close the materials dialog and return to the main window.

Loads and sections

Loads and sections table is displayed by clicking the  button. Column numbers are entered in the first row (C1, C2 etc.). Then two cells are entered for each column and floor:

- **Load** – ultimate force in the column for the respective storey in kN;
- **Section** – section number from the section list - see "**Cross sections**".

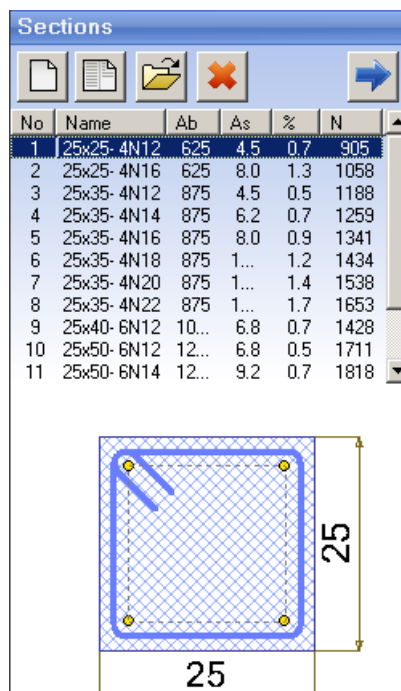


When design checks  are started, the program calculates column capacities and fills them into the table. See "Design".

You can easily copy data for a column or storey to other cells.





Cross Sections

Load sections in current project



| No | Name | Ab | As | % | N |
|----|------------|-------|------|-----|------|
| 1 | 25x25-4N12 | 625 | 4.5 | 0.7 | 905 |
| 2 | 25x25-4N16 | 625 | 8.0 | 1.3 | 1058 |
| 3 | 25x35-4N12 | 875 | 4.5 | 0.5 | 1188 |
| 4 | 25x35-4N14 | 875 | 6.2 | 0.7 | 1259 |
| 5 | 25x35-4N16 | 875 | 8.0 | 0.9 | 1341 |
| 6 | 25x35-4N18 | 875 | 1... | 1.2 | 1434 |
| 7 | 25x35-4N20 | 875 | 1... | 1.4 | 1538 |
| 8 | 25x35-4N22 | 875 | 1... | 1.7 | 1653 |
| 9 | 25x40-6N12 | 10... | 6.8 | 0.7 | 1428 |
| 10 | 25x50-6N12 | 12... | 6.8 | 0.5 | 1711 |
| 11 | 25x50-6N14 | 12... | 9.2 | 0.7 | 1818 |

Before you draw the columns, you need to load or draw the cross sections you will be working with. You should also assign a section number to each column on each floor.


Sections are load in the „Sections“ list in the left panel of the main window by clicking the  button. It opens the „**RC Sections Library**“. If a section cannot be found in the library, click the  button. A dialog will open where you can draw a new section. You need to save the section to a file in order to add it to the list. The  button opens the selected section from the list for editing. The  button removes selected sections from the list, but does not delete them from the library. Numbers of deleted sections are removed from columns table and higher section numbers are automatically decreased.


You can select sections in the list by clicking the left mouse button or by using arrows keys. Hold **Shift** or **Ctrl** key to select more than one section. Scheme of the current section is displayed below the list. Each section receives a number. The following data is also displayed for information:

- A_b – concrete area [cm²];
- A_s – main reinforcement area [cm²];
- % – reinforcement ratio
- N – section capacity for compression $N = A_b \cdot R_b + A_s \cdot R_{sc}$ [kN].

Section capacity is provided for information only and is greater than column capacity with the same section, because second order effects and initial imperfections are still not included. Column capacity is calculated during the design when all data is entered.

Assign sections to columns

Sections are assigned in „**Column Loads and Sections**“ table, which is displayed with the  button. Section number from list on the left should be entered in the corresponding cell in table on the right. You can assign a section to multiple columns and storeys as follows:

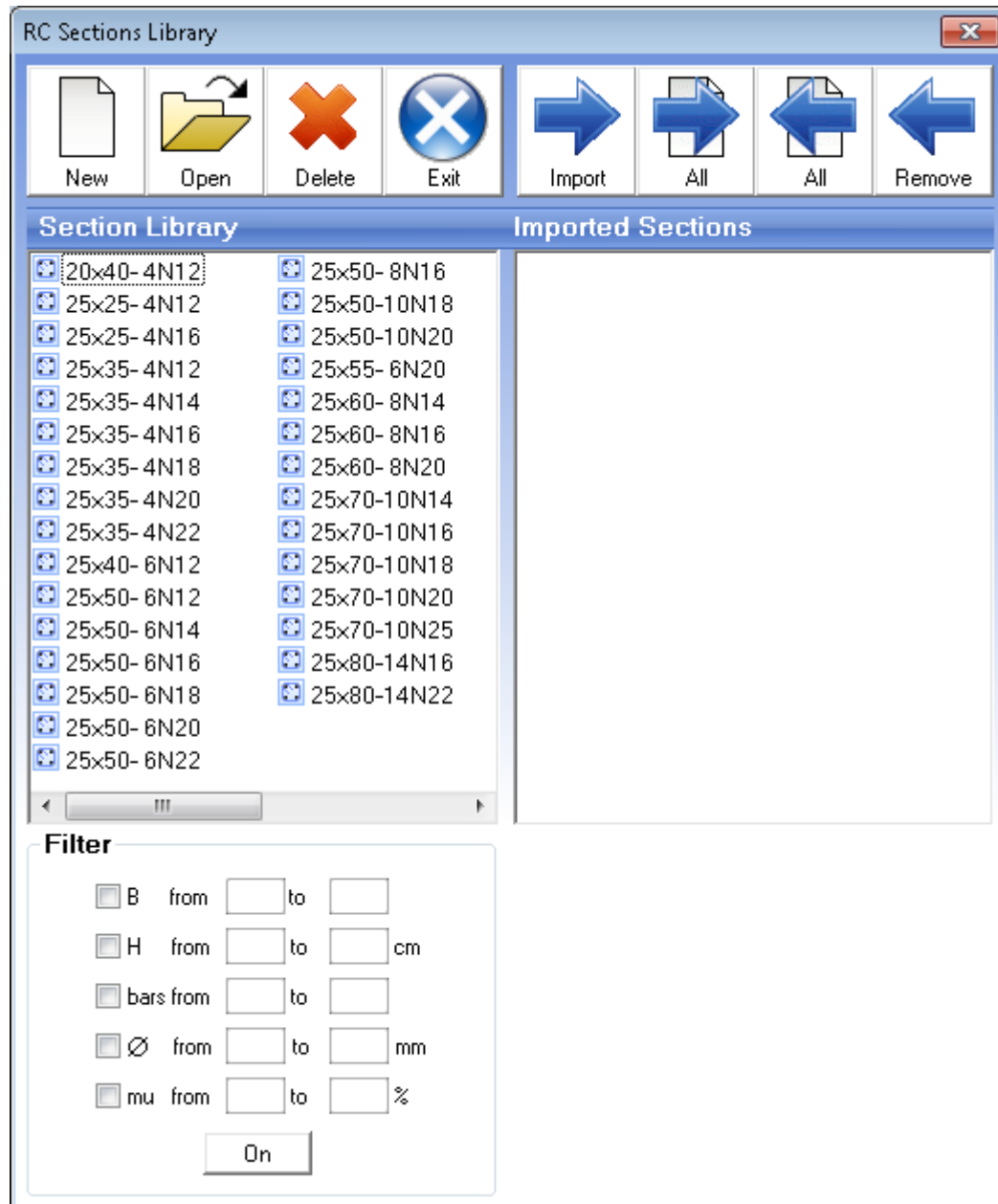
1. Select a range of cells in the table.
2. Select a section in the list.
3. Click the  button.

You can double click on the section instead 2 and 3.

RC Sections Library

With this program you can build a library, containing detailed drawings of cross sections with different dimensions and reinforcements, which can be used later on. When you design new sections they are saved in the library and can be used multiple times in the future.



You can open the library by clicking the  button above the section list in the main window.





All sections in library are loaded into the left panel. Selected sections in the current project are listed in the right panel. If you click a section with the mouse you will see a picture of it.

Import and remove sections


You can select only those sections that you need for the particular project. This will make your further work easier handling smaller amount of data. You should select the required sections in the left panel "**Section Library**" and transfer them to the right panel "**Imported Sections**".

You can either drag them with the left mouse button or click the  „**Import**” button. You can import all sections in once by using the  „**All**” button.


You can remove all unnecessary section from the imported list by transferring them back from right to left panel with the mouse or by  „**Remove**” and  „**All**” buttons.

You can use the filter option to find sections more easily. Select criteria and set “from” and “to” margins. Press “On”. Only sections that satisfy all criteria will remain in the list

Add a new section

Press the  „**New**” button. The „**Design Expert CAD**” window is displayed, where you can input or draw section dimensions and reinforcement. When you finish you should save the section to a file in order to add it to the library.

Modify existing section

Select a section to be modified and click the  „**Open**” button. Selected section is opened in the „**Design Expert CAD**” window, where you can modify section dimensions and reinforcement and save it.

Delete a section

Select sections to be deleted and click the  „**Delete**” button. You will be prompted to confirm and then sections will be permanently deleted from the hard disc.

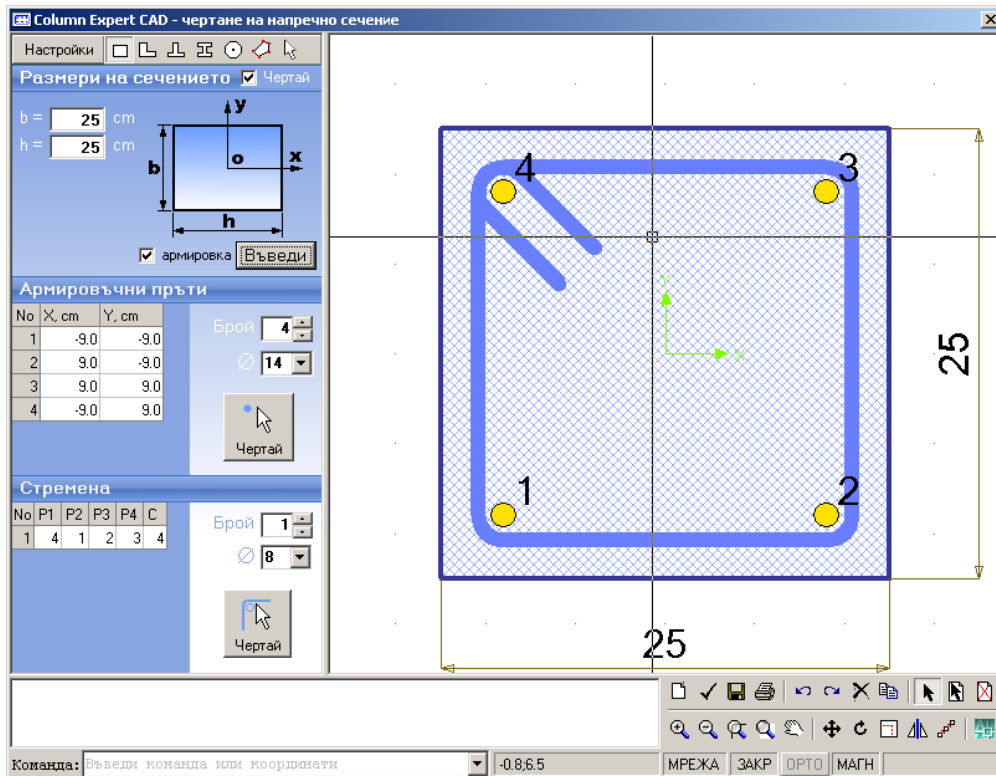
Filter

With the filter option you can view only those sections that satisfy selected criteria:

- **B** – section width [cm];
- **H** – section height[cm];
- **bars** – count of bars;
- **Ø** – diameter of bars [mm];
- **mu** – reinforcement ratio [%].

You should set bottom and top margins for each criterion and press “On” to apply the filter. If you want to change the criteria press “Off”, make your changes and then press back “On”. Press “Off” to deactivate the filter.

Draw sections









Settings

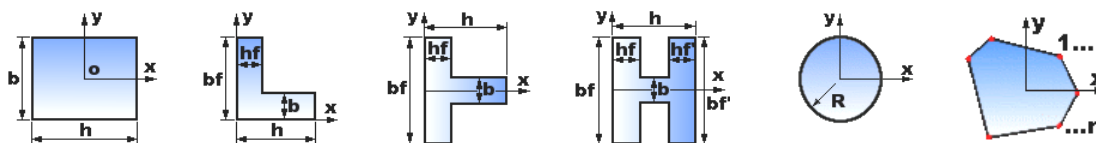
With the "**Settings**" button you can open a dialog where you can enter the seismic factor and concrete cover to main (bars) and shear reinforcement (links). Requirements of design codes are built into the program. If seismic factor is ≤ 0.05 non-seismic code requirements are applied (Eurocode 2). If value is > 0.05 seismic code requirements are applied (Eurocode 8). Concrete cover applies to current and future sections only. Existing sections are not affected.






Section shape and dimensions


Select section shape by the toolbar (, , , ,  or  - general), enter dimensions as shown on the respective picture and click the "Enter" button. Dimensions for different shapes are displayed below:



General sections can be entered in two ways – tabular or graphical.

Tabular – enter coordinates for outline points and click the "Enter" button. If the "automatic" option is checked main bars and shear links are automatically created as well.


Graphical – click the  button and draw the section by pointing with the mouse. (see "Working with graphical environment..."). Click with the right mouse button to finish.

You can also import a section directly from a ZWCAD or AutoCAD drawing by using the  button. Section should be drawn as closed polyline. You will be prompted to click the section in the current drawing in ZWCAD (AutoCAD).

Main bars

Enter diameter and coordinates of bars centers. All bars in a section have the same diameter. There are two ways to enter bars data:


Tabular – select bars count and enter coordinates into the table. When you change the count, bars are automatically arranged uniformly along the perimeter for rectangular and circular sections.

Graphical – click the  "Draw" button. Enter positions of bars by clicking with left mouse button in the drawing and click with the right button to finish. Concrete cover is maintained automatically. If you click closer to concrete edge, bars are moved inside at the required distance. That is how you can snap to concrete edge and then get your bars inside the concrete.

Shear links

You should specify numbers of those bars that are located at link corners (P1 - P4). You can have 2 to 4 bars for each link.

You can fill in the numbers into the respective columns in the table. Current link is updated in the drawing with each input. Links can be opened or closed. For a closed link, last column "C" should contain the starting bar number.

You can draw the link with the  "Draw" button. Click close to corner bars consequently. Input is finished when you select four bars or click with the right button. Then you are prompted to close the link. Answer "Yes" for closed or "No" for opened link. Then link is drawn automatically with all required bends and hooks.

Section check

You can check if the section complies with code requirements for the specified seismic factor "Kc". Select $K_c = 0$ for columns in non-seismic zones. Program verifies section dimensions, reinforcement ratio, bars spacing (minimum and maximum), spacing between link bends, minimum diameters for bars and links, concrete cover etc.



Detailing requirements to Bulgarian code NPBStBK

The following requirements are used for section verification and automated column detailing:

| Section dimensions | k_c | ≤ 0.05 | ≤ 0.15 | > 0.15 |
|-------------------------------------|------------------|-------------|-------------|----------|
| Minimum section dimensions | $\min b_c$ | 15 cm | 25 cm | 25 cm |
| Maximum ratio of section dimensions | $\max h_c / b_c$ | ∞ | 4 | 2.5 |

| Main reinforcement | k_c | ≤ 0.05 | ≤ 0.15 | > 0.15 |
|--|-----------------------|--|--------------------|--------------------|
| Minimum diameter | $\varnothing_{l,MIN}$ | 12 mm | 14 mm | 14 mm |
| Minimum reinforcement ratio | μ_{MIN} | 2·0.05 % | 1 % | 1 % |
| Maximum reinforcement ratio | μ_{MAX} | 3 % | 4 % | 4 % |
| Minimum clear spacing between bars | d_{MIN} | 5 cm | | |
| Maximum spacing between bars centers (c/c) | d_{MAX} | 40 cm | $b_c/2^*$ 30 cm | $b_c/2^*$ 20 cm |
| Maximum spacing between link bends | $d_{h,MAX}$ | 40 cm | 30 cm | 20 cm |
| Bending diameter | d_{bend} | 2.5 \varnothing | | |
| Anchorage length | L_{an} | $= (0.5 \cdot R_{sc}/R_b + 8) \cdot \varnothing > 12 \cdot \varnothing$ и $> 20\text{cm}$ | | |
| Lap length | L_{lap} | $= (0.65 \cdot R_{sc}/R_b + 8) \cdot \varnothing > 15 \cdot \varnothing$ и $> 40\text{cm}$ | | |

* $b_c \geq 30$ cm

| Shear reinforcement | k_c | ≤ 0.05 | ≤ 0.15 | > 0.15 |
|--|-----------------------|---------------------------------------|---|--|
| Minimum diameter | $\varnothing_{h,MIN}$ | 5 mm | 6.5 mm | 8 mm |
| | | 0.25· \varnothing_l | | |
| Maximum c/c spacing between links | $a_{h,MAX}$ | b_c 15· \varnothing_l 50 cm | b_c 12· \varnothing_l 30 cm | b_c 10· \varnothing_l 20 cm |
| Maximum c/c spacing between links in critical (bar lap) zone | $a_{hc,MAX}$ | 10 cm | $b_c/2$ 10· \varnothing_l 15cm(10cm*) | $b_c/2$ 8· \varnothing_l 10 cm |
| Bending diameter | d_{bend} | 2.5 \varnothing | | |
| Anchorage (lap) length | L_{an}, L_{lap} | 10· \varnothing_h | | |
| Critical zone length | l_c | L_{lap} | h_c Hst/6 45 cm(L_{lap}^*) | |

*Along bar lap

**Detailing requirements to Eurocode 2 and Eurocode 8**


| Section dimensions | k_C | $k_C = 0$ Non-seismic element EC2 | $k_C > 0$ Seismic element EC8 DCH |
|-------------------------------------|------------------|---|---|
| Minimum section dimensions | $\min b_C$ | 20 cm | 25 cm |
| Maximum ratio of section dimensions | $\max h_C / b_C$ | 4 | |

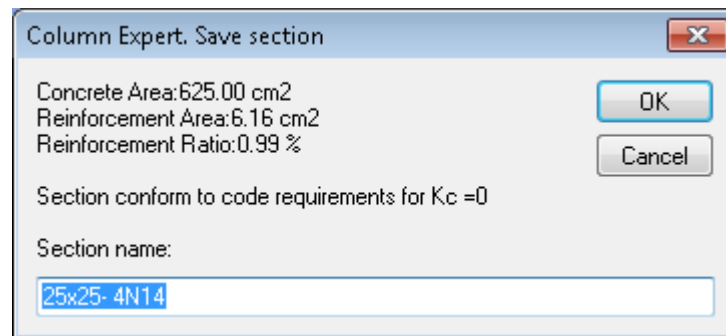
| Main reinforcement | k_C | $k_C = 0$ Non-seismic element EC2 | $k_C > 0$ Seismic element EC8 DCH |
|------------------------------------|---------------|---|---|
| Minimum diameter | $d_{L,\min}$ | 8 mm | |
| Minimum reinforcement ratio | ρ_{\min} | 0.2 % | 1 % |
| Maximum reinforcement ratio | ρ_{\min} | 4 % | |
| Minimum clear spacing between bars | a_{\min} | 5 cm | |
| Maximum c/c spacing between bars | $a_{L,\max}$ | 30 cm | 15 cm |
| Maximum spacing between link bends | $a_{h,\max}$ | 30 cm | 15 cm |
| Bending diameter | d_m | При $\varnothing \leq 16$ mm - $d_m = 4\varnothing$ При $\varnothing > 16$ mm - $d_m = 7\varnothing$ | |
| Anchorage length | l_{bd} | $f_{bd} = 2.25 \eta_1 \eta_2 f_{ctd}$, $l_{b,rgd} = d_L / 4 \cdot \sigma_{sd} / f_{bd}$ $l_{bd} = \alpha_1 \alpha_2 \alpha_3 l_{b,rgd} > l_{b,\min}$ $l_{b,\min} = \max\{0.6 l_{b,rgd}, 10 d_L, 10 \text{ cm}\}$ | |
| Lap length | l_0 | $l_0 = \alpha_1 \alpha_2 \alpha_3 \alpha_6 l_{b,rgd}$, $\alpha_6 = 1.5$ | |

| Shear reinforcement | k_C | $k_C = 0$ Non-seismic element EC2 | $k_C > 0$ Seismic element EC8 DCH |
|--|-------------------|---|---|
| Minimum diameter | $d_{w,\min}$ | 6 mm, $0.25 \cdot d_L$ | $6 \text{ mm}, 0.4 \cdot d_L \cdot (f_{ydL} / f_{ydw})^{1/2}$ |
| | s_{\max} | $b_C, 20 \cdot d_L, 40 \text{ cm}$ | |
| Maximum c/c spacing between links | $s_{C,\max}$ | $0.6 \cdot s_{\max}$ | $b_0 / 3, 6 d_L, 12.5 \text{ cm}$ |
| Maximum c/c spacing between links in critical (bar lap) zone | $s_{l,\max}$ | $h/4$ 10 cm | |
| Bending diameter | d_{bend} | $4 d_w$ | |
| Anchorage (lap) length | l_{bw} | $10 d_w$ | |
| Critical zone length | l_c | $h (l_0^*)$ | $1.5 h_C$, Нет/6, 60 cm (l_0^*) |

*Along bar lap

Save a section

You should save the section in order to use it further. Click the  button. A dialog is displayed with general information about the section and results from code compliance checks. Enter section name only without path. Name is recommended to include information about shape, dimensions and reinforcement count and diameter.



Results

Design checks

Design to Bulgarian code NPBStBK

Columns are designed as short axially loaded elements according to equation (48):

$N \leq m \cdot \varphi \cdot (\gamma_b \cdot R_b \cdot A + \gamma_s \cdot R_{sc} \cdot A_{s,tot})$, where

- γ_b – strength reduction factor for concrete;
- R_b – concrete compressive strength;
- A – concrete area;
- γ_s – strength reduction factor for reinforcement;
- R_{sc} – reinforcement compressive strength;
- $A_{s,tot}$ – total main reinforcement area;
- $m = 1$;
- $\varphi = \varphi_b + 2(\varphi_r - \varphi_b) \cdot \alpha \leq \varphi_r$ – buckling factor;
- $\alpha = R_{sc} \cdot A_{s,tot} / (R_b \cdot A)$

Factor φ_b is defined in table 31 in the code:

| N_l | Factor φ_b for l_0/h | | | | | | | |
|-------|--------------------------------|------|------|------|------|------|------|------|
| | ≤ 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 |
| 0 | 0.93 | 0.92 | 0.91 | 0.90 | 0.89 | 0.88 | 0.86 | 0.84 |
| 1 | 0.92 | 0.91 | 0.89 | 0.86 | 0.82 | 0.76 | 0.69 | 0.61 |

Factor $\tau \varphi_r$ is defined in table 33 in the code:

| $\frac{A_{s,int}}{A_{s,tot}}$ | N_l | Factor φ_r for l_0/h | | | | | | | |
|-------------------------------|-------|--------------------------------|------|------|------|------|------|------|------|
| | | ≤ 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 |
| <1/3 | 0 | 0.93 | 0.92 | 0.91 | 0.90 | 0.89 | 0.88 | 0.86 | 0.84 |
| | 1 | 0.92 | 0.91 | 0.90 | 0.88 | 0.86 | 0.83 | 0.79 | 0.74 |
| $\geq 1/3$ | 0 | 0.93 | 0.92 | 0.91 | 0.89 | 0.87 | 0.85 | 0.82 | 0.79 |
| | 1 | 0.92 | 0.91 | 0.89 | 0.86 | 0.82 | 0.77 | 0.71 | 0.64 |

- l_0 – effective column length – assumed to be storey height;
- h – lower column dimension;

N_l / N – ratio of permanent to total load – assumed to be 0.9, conservatively;




$A_{s,int} / A_{s,tot}$ – ratio of intermediate bars area to total reinforcement area. It is calculated using actual bar arrangement.

This check is for axially loaded columns only with initial imperfections. If bending moments or load eccentricities are present then additional checks are required using "PMM Expert" program.


Design to Eurocode 2

PMM Expert 2.0 module is recommended for column design to Eurocode 2. For more information see PMM Expert user manual [PMM Expert.pdf](#).


Check current sections

Before proceeding to detailing, you can check if selected sections have sufficient capacity for the specified loads. To start design checks go to "Columns Loads and Sections"  table and click the  button or submenu  ▼ "Check Using Current Sections". Capacity is calculated for each column and each storey and is displayed in the respective cells in the table. Each load is compared to the capacity and is colored in green if smaller and in red if greater than capacity. That is how you get clear indication of all columns with insufficient capacities and you can select new sections for them.


Automatically select reinforcement

Click submenu  ▼ "Automatically Select Reinforcement". Current sections are checked first. New sections with same dimensions and greater reinforcement are searched for all columns that have failed the checks.


Automatically select sections


Click submenu  ▼ "Automatically Select Sections". Current sections are checked first. New sections with either greater dimensions or greater reinforcement are searched for all columns that have failed the checks.

Calculation report

You can print a calculation report including input data and design results. Click the  button. It is enabled only when you are into the "Columns Loads and Sections" table. You should have run design calculations before printing the report. Report is saved as an html file and is viewed with Internet Explorer.

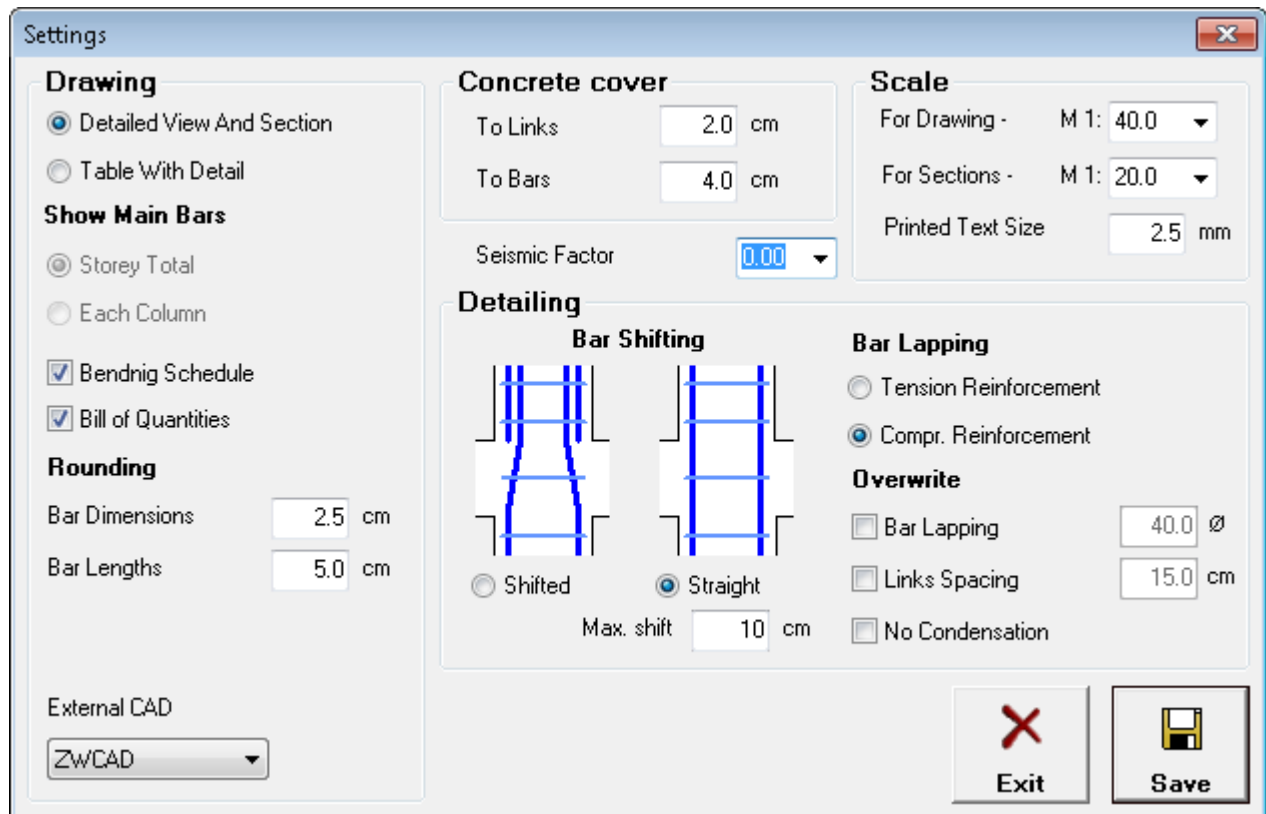
View columns elevations and align columns in height

Next step after selection and design of sections is to review the geometry and align columns in height. Click the  button. Graphical window is activated and columns elevations are drawn including dimensions and floor levels. Columns are aligned by default so that column centers are located along a vertical line with on eccentricities.

Columns can be shifted left or right at each storey by using the respective  grips. Select a grip and drag it to the new location using the mouse. You can also move multiple grips at a time using the "Move" command. Column eccentricity relative to the original position is displayed in the drawing.

These eccentricities are only for detailing purposes and are not used for calculations. You should perform additional checks with PMM Expert by adding the respective moments.

Detailing settings



There are various settings including reinforcement detailing rules, drawing type and scale, etc. The “**Settings**” dialog is displayed using the button. Detailed descriptions of all settings are provided below.

Seismic factor



Different requirements to reinforcement detailing are applied depending on specified seismic factor. See “Detailing requirements” above. If seismic factor is ≤ 0.05 non-seismic code requirements are applied (Eurocode 2). If value is > 0.05 seismic code requirements are applied (Eurocode 8).

Concrete cover

This setting is applied only for drawing of new sections. Existing sections do not change automatically. Clear distance from surface of main reinforcement to concrete edge is taken to be the greater value of:

- specified concrete cover to bars or
- concrete cover to links + links diameter.

Detailing

You can select whether main bars are be straight  or shifted  at top to allow upper storey bars to fit easily.

Regardless this option, when a bar goes out of the column on upper storey, it is shifted to fit inside the column. This is controlled by the “**Maximum shift**” setting. Bars that should be bended more than maximum shift will not continue to upper storey. If there are upper bars

that are cannot by lapped with lower bars, additional short starters are provided in the lower column.

You can overwrite default link spacing and lap lengths. "**No condensation**" means no denser link spacing in critical zones. All links will be with the same spacing along the column.

Drawing

You can select detailed view with sections when columns are with complex geometry, different sections or deviations in height. That is how anyone will understand your drawing better. You can select table view for simple columns. Then each column and each storey is represented by cross section and details for shear links and main bars. Main bars can be specified for each separate column or altogether for the whole storey. Bars dimensions and total lengths are rounded to the numbers specified in "**Rounding**" section. You can also select external CAD (ZWCAD® or AutoCAD®) to export to.

Bill of Materials





Bending schedule includes detailed dimensions, total count, length and unit and total weight for each bar mark.

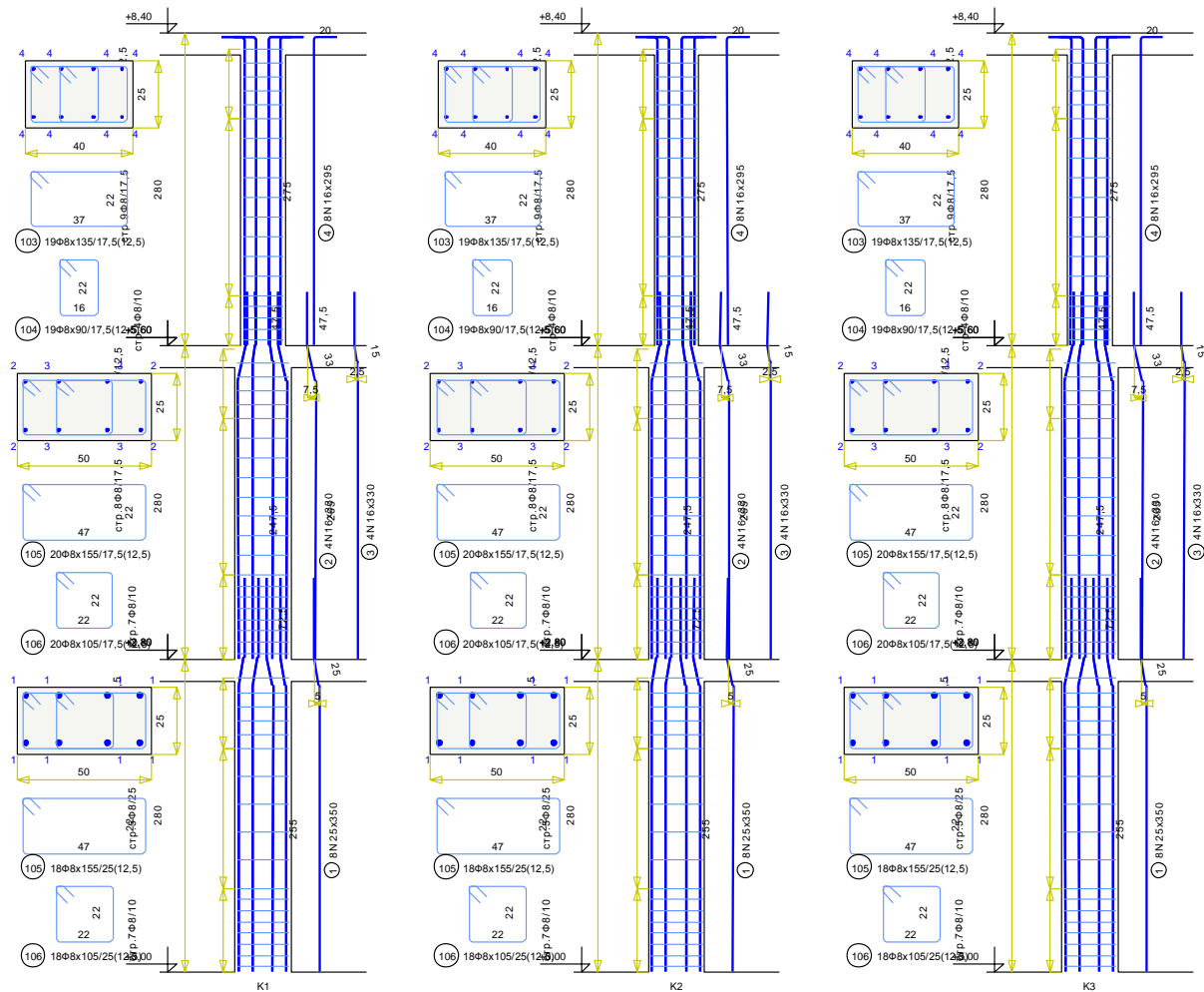
Bill of quantities includes reinforcement weight (kg) for each diameter and total, concrete volume (m³) and area of formwork (m²).

Drawing scale


Separate scale factors can be entered for main views and sections. Text size is specified for text after printing. Actual height of letters in the drawing is calculated using the scale factor.

Generation of reinforcement drawing


Click the  button to generate the reinforcement drawing. Button is enabled only when you are in "**Columns Drawing**". The "**Settings**" dialog is displayed first. Click  „**Save**” if you have changed some settings and would like to apply them or click  „**Exit**” otherwise. Reinforcement drawing is generated automatically based on the input data. Main bar are labeled (01, 02 etc.) and links are labeled (101, 102 etc.). Lengths and counts are calculated automatically for all marks. Code requirements are applied to the reinforcement detailing. Drawing is created into the embedded Design Expert CAD environment. You can modify it here when you unlock the drawing with the  button and use the respective commands.



Export to ZWCAD (AutoCAD) and other applications

Click the  button to export the drawing to ZWCAD/AutoCAD. Version 2009i and higher is supported for ZWCAD and 15 (2000) and higher is supported AutoCAD. If ZWCAD/AutoCAD is opened then drawing is sent to the active document. If it is not opened then new session is started automatically.

Drawing is made from lines, polylines, texts, dimension lines, circles and solid hatches. There are no blocks or other complex objects and drawing can be easily edited. In order to achieve better results set "Text Placement" to be "Over the Dimension Line, Without a Leader" for current dimension properties. Objects are divided in layers such as „AXES“, „CONC“, „BARS“, „SEC“, „TEXT“ etc.

With  ▾ "Save script file *.scr" submenu you can export a script file with all commands necessary for drawing the column. Script can be loaded into ZWCAD/AutoCAD with the "SCRIPT" command or "Tools\Run Script..." menu. Export to other CAD systems can be developed on request. You can also export the drawing as bitmap or metafile to other applications through system clipboard.

Working with Design Expert CAD graphical environment

Version 2.0 of Design Expert includes embedded graphical environment with a lot of commands to review, edit and print drawings.



Commands

Each command can be activated by typing its full name or some of the aliases into the command line or by the respective button in the toolbar. Descriptions of all graphical environment commands are provided in the following table:

| | Command | Alias | Description |
|--|--------------|----------------|---|
| | COPYBMP | CB | Copies drawing to Clipboard as Bitmap |
| | COPYMETAFILE | CM | Copies drawing to Clipboard as Metafile |
| | DELETE | E, D, DEL | Deletes selected objects |
| | DESELECTALL | DE, DESEL | Deselects all objects |
| | DISTANCE | DI, DIST | Measures distances |
| | GRID | GR | Turns grid on/off |
| | MIRROR | MI | Mirrors objects in the drawing |
| | MOVE | M, MO | Moves objects in the drawing |
| | ORTHO | OR | Turns orthogonal drawing on/off |
| | OSNAP | OS | Turns snap to points on/off the |
| | PRINT | PR, PRN | Prints current drawing display |
| | REDO | RE | Restores last command |
| | REDRAW | RD | Redraws the screen |
| | REPLICATE | CP, CO, COPY | Copies objects in the drawing |
| | ROTATE | RO | Rotates objects in the drawing |
| | RTPAN | PA, PAN | Moves the screen view |
| | SCALE | SC | Scales objects in the drawing |
| | SELECT | SE, SEL, READY | Enters select mode |
| | SELECTALL | A, ALL, SELALL | Selects all objects |
| | SNAP | SN | Turns coordinate snap on/off |
| | UNDO | U | Undoes last command |
| | ZOOMIN | ZI, Z+ | Increases screen view |
| | ZOOMLIMITS | ZL, ZA, ZE | Increases screen view to fit all objects in the drawing |
| | ZOOMOUT | ZO, Z- | Decreases screen view |
| | ZOOMWINDOW | ZW | Increases screen view to fit the selected window |

The following commands are available only in section drawing window:

| | Command | Alias | Description |
|--|---------|------------|---|
| | ACAD | | Transfers the drawing into ZWCAD (AutoCAD) |
| | BAR | B | Draws main bars |
| | CHECK | | Checks design code requirements for the section |
| | EXIT | E, X, EX | Ends current drawing session |
| | HELP | | Displays user manual |
| | LINK | L | Draws shear links |
| | NEW | N | Opens a new file |
| | OPTIONS | OP, OPT | Displays settings dialog |
| | QUIT | Q | Same as EXIT |
| | SAVE | S, SA, SAV | Saves a file to disc |
| | SECTION | SE, SEC | Draws section outline |

Screen view management

All objects in the drawing are defined by their coordinates in Cartesian coordinate system OXY, which is displayed in program window in certain scale. This view can be scaled and moved using the following commands:


Zoom In

Click the  button. Screen view is enlarged by 25%.


Zoom Out

Click the  button. Screen view is shrunk by 25%.


Zoom Window

Click the  button. Click with left mouse button, and move the cursor to enclose the objects, which you want to zoom into a rectangular window. Click once again. The image is zoomed to fit the selected window into the screen.

Zoom All

Click the  button. This command scales and centres the view to fit all objects into the program window.

Pan

Click the  button. Enter first point, move the cursor at the desired direction and enter second point. Screen view is moved at direction and distance, defined by the vector between the two points.

Using a wheel mouse

If you have a wheel mouse with three buttons you can pan without the above commands. Click and hold the middle button, move the mouse and release the button to pan the screen view. Roll the wheel forward and backward to zoom in and zoom out the screen view, respectively.


Coordinate input

All objects in the drawing are defined in OXY coordinate system, projected to the screen. Some commands require the user to enter coordinates of points. There are two ways to enter point coordinates:

1. By left mouse click in the preferred position. Current cursor coordinates are displayed in status bar when moving the mouse. Precision tools "**Snap**", "**OSnap**" and "**Ortho**" help you to snap the cursor to grid with spacing of 5 mm, to an existing point or restrain it to horizontal (vertical) line. When precision tools are turned off then a mouse click produces imprecise coordinates depending on current view scale.
2. By typing with the keyboard. Write coordinates in the command line and press "**Enter**". It is not necessary to click into the command line first. It is activated automatically when you press the first key. Following formats are allowed for coordinate input:

| Name | Format | Example | Description |
|-----------------|-----------------|---------|--|
| Absolute | X;Y | 10,5;15 | Absolute coordinates in OXY coordinate system. |
| Relative | _ΔX;ΔY | _25;35 | Relative distances "25" and "35" along X and Y from the last entered point. |
| Polar | <α°;L | <45;100 | Relative distance "100" from the last entered point measured at angle 45° from X axis. |
| Distance | L | 50 | Relative distance "50" from the last entered point, measured at direction defined by the cursor. |

Select and deselect objects



Selection creates a group of objects using the mouse in order to apply certain command on them (e.g. erase). It can be done before or after the command. Objects in locked layers cannot be selected even when they are visible on screen. You can go to "**Selection**" mode by pressing the  button or the "**Esc**" key. The following ways for selection are available:

Single


Position the mouse cursor over the object so that it crosses the small square and press the left button. Selected object is colored in red.

Group



Click the left mouse button near the objects you want to select and move the cursor to draw a rectangle around them. Second click will select all objects which:

- are entirely inside the rectangle if you draw from left to right; 
- either cross or fit inside the rectangle if you draw from right to left. 

All



Click the  button or press **Ctrl+A**. You will select all objects, except those which are in locked layers.

Deselect


Click the  button or press **Ctrl+D** or **Esc**. All selected objects will be deselected. To deselect a single object, click on it with right mouse button. The "**Undo**"  command undoes last selection.

Modify objects


Delete

Removes all selected objects from both memory and screen. In case of error objects can be restored using the "**Undo**"  command immediately after that. Delete command is started by the  button or "**Del**" key.


Move

Moves the selected objects along specified vector of translation. Command is performed in the following sequence: 1) Select objects. 2) Press the  button. 3) Pick the coordinates of the first and the second point of the translation vector.


Rotate

Rotates the selected objects around specified centre and angle of rotation. You are required to enter two points. The first point defines the rotation centre and the second one is for the angle. Angle is measured from the positive X axis towards the vector defined by the points. Command is performed in the following sequence: 1) Select objects. 2) Press the  button. 3) Enter first and second point.

Scale

Scales the selected objects with a specified factor. This command requires two points: The first one is for the base point and the second one defines the scale factor. Command is performed in the following order sequence: 1) Select objects. 2) Press the  button. 3) Enter first and second point.


Mirror

Mirrors the selected objects about a line, defined by two points. Command is performed in the following order: 1) Select objects. 2) Press the  button. 3) Enter first and second point.

Stretch

Geometric objects can be modified by stretching their grip points. Select the object first. Click with left button on the desired point to "catch" it. Move the cursor to the new position and click again to release it. Stretching a centre of a circle moves the circle, and stretching points at 0°, 90°, 180°, 270° changes the radius. If you had picked a point and you want to release it press "Esc" or right mouse button.

Copy

Creates multiple copies of the selected objects. Command is started with the  button. The "Copy" dialog appears where you have to define the following parameters:

Method of transformation

The coordinates of the copied objects are calculated from the coordinates of the source objects through the preferred transformation as follows:

- translation ; - rotation ; - copy ; - mirror .

Number of repetitions


Objects can be copied multiple times as specified.

Pick points

The "Copy" dialog disappears and the user is prompted to enter two points that define the transformation parameters (vector of translation, angle of rotation etc.) If the "First-Second" option is selected, these points define the position of the second object relative to the first and the others are located after it. If the option "First-Last" is selected, these points define the position of the last object relative to the first and the others are located between them.



Printing graphics

Current screen view can be printed with the  button. A dialog box for selection of printer and paper format is displayed. Press "**Start**" to send the drawing directly to the printer. Only part of the drawing which is visible in the program window is printed.

Copy graphics to other applications

The drawing can be copied to the Clipboard and then pasted to a CAD program or text editor (e.g. **Word**) and printed. Only part of the drawing which is visible in the program window is copied. Two formats are supported:

- Raster (**Bitmap**) – Command name is "**COPYBITMAP**". Data for the color of each pixel in the image is stored. Image quality decreases when image is resized. Image can be opened with **MS Paint**.
- Vector (**Metafile**) – Command name is "**COPYMETAFILE**". Coordinates of geometrical objects and their equations are stored. Pixels are calculated each time, when the image is displayed on screen. In that case the image can be resized without affecting the quality. When image contains a lot of objects it gets heavier and raster format is preferable. It can be pasted to other programs in two formats - **Metafile** and **Enhanced Metafile**. The second one is recommended. The program **MS Word** converts it to **Word Picture** after insertion. If you try to edit the picture, it is possible to damage it.