



Проектсофт - PMM Expert v 2.0/2011

Проверка на стоманобетонни колони за двоен нецентричен натиск/опън

Колона C18

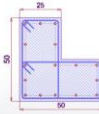
Материали

Бетон клас с изчислително съпротивление на натиск $R_b = 11,5 \text{ MPa}$

Стомана за надлъжна армировка клас АIII с изчислително съпротивление на опън $R_s = 375 \text{ MPa}$

Коefициенти за условие на работа: Бетон: 0,85; Стомана: 1,00

Напречно сечение L50x50-16N16



Площ на бетона - $A_c = 1875 \text{ cm}^2$

Брой на прътите - $n_b = 16$

Диаметър на прътите - $d_b = 16 \text{ mm}$

Площ на армировката - $A_s = 32,2 \text{ cm}^2$

Процент на армизиране - $\mu = 1,7\%$

Данни за изчисляване

Дължина на колоната - $L = 285 \text{ cm}$

Изчислявателна дължина - $L_{ox} = 0,7 \cdot L$

Изчислявателна дължина - $L_{oy} = 0 \cdot L$

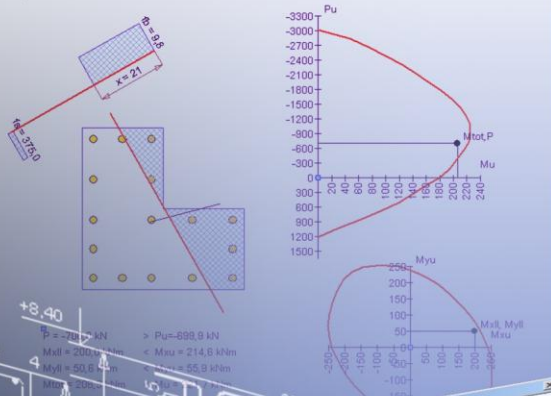
Процент пост. товар - $K_G = 75\%$

Коefициент на пълзене - $\psi(e, d) = 3,5$

Натоварване

Осова сила - $P = -700 \text{ kN}$, Огъващи моменти - $M_x = 200 \text{ kNm}$, $M_y = 50 \text{ kNm}$

Резултати



Software Package

Design Expert version 2.0

PMM Expert

Design of RC columns with arbitrary sections for compression and biaxial bending

User Manual

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2011



TABLE OF CONTENTS

ABOUT THE PROGRAM.....	3
FILES	3
Open a file	3
Save a file	3
New file	3
INPUT DATA.....	3
Working with tables	3
Materials data	4
Material tables.....	4
Loads data	4
Buckling data	4
CROSS SECTIONS.....	5
LOAD SECTIONS IN CURRENT PROJECT	5
Assign sections to columns	5
RC Sections Library	6
Import and remove sections	6
Add a new section	7
Modify existing section.....	7
Delete a section	7
Filter	7
DRAW SECTIONS	8
Settings	8
Section shape and dimensions	8
Main bars.....	9
Shear links.....	9
Section check	9
Detailing requirements to Bulgarian code NPBStBK.....	9
Detailing requirements to Eurocode 2 and Eurocode 8	11
Save a section	11
RESULTS	12
Design checks	12
Export to ZWCAD (AutoCAD) and other applications.....	13
WORKING WITH DESIGN EXPERT CAD GRAPHICAL ENVIRONMENT ...	13
Commands	13
Screen view management.....	14
Zoom In.....	14
Zoom Out	14
Zoom Window	14
Zoom All	14
Pan	14
Using a wheel mouse.....	14
Coordinate input	15
Select and deselect objects	15
Single.....	15
Group.....	15
All	15
Deselect.....	16
Modify objects	16
Delete	16
Move	16
Rotate	16
Scale	16



Mirror	16
Stretch	16
Copy	17
Method of transformation	17
Number of repetitions	17
Pick points	17
Printing graphics.....	17
Copy graphics to other applications.....	17


About the program

PMM Expert is created for design of reinforced concrete columns with arbitrary sections for combined compression/tension **P** and biaxial bending **M_x** and **M_y**. Loads are entered in tabular form. Column cross section should be defined. Sections are stored in a library and can be used over again. New sections are created easily by drawing them into the graphical environment. Ultimate loads are calculated and capacity curves are obtained: Mu-Pu (total moment – axial force) and Mux-Muy (moment - moment).


Files

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


Open a file

Opening of a ***. pmm** file is performed by the  button. A standard dialog is displayed. Choose or write down the name and path of the file and click "**Open**".

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.

New file

File with a new name is created by the  button. A standard dialog appears where you should enter file path and name.

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.

Materials data

Select concrete grade **C20/25** and steel grades for bars **S500** 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

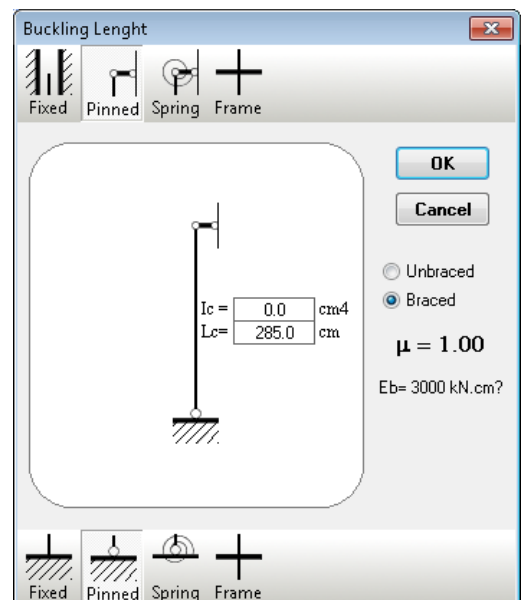
Material tables can be opened by clicking the  button in the main window. A dialog is displayed with two separate tables for concrete and steel. You can add new rows with the „+“ button and enter new materials, remove rows with „-“ or edit values. Elastic modules and strengths are entered in MPa. With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

Loads data

You can have multiple load cases. Add the required number of rows with the „+“ button in „**Loads**“ table and fill in load values. Negative value (-) of axial force is compression and positive value (+) is tension.

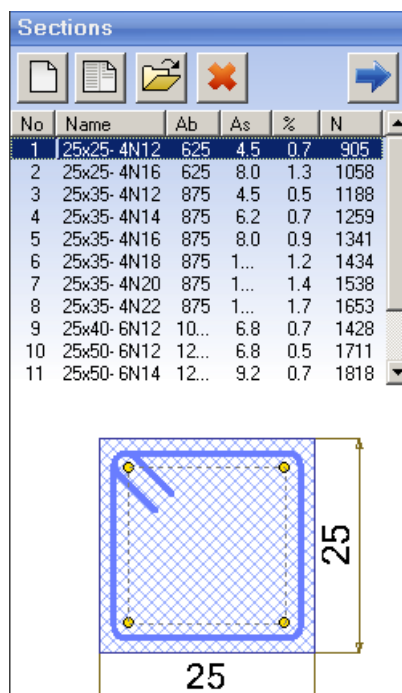
Buckling data

Enter column length and buckling factors for the corresponding buckling lengths **Lox** and **Loy** along **x** and **y** axes, respectively. Buckling calculation dialog is opened by the  button. Select top and bottom support type and the program will calculate buckling factor μ automatically. You can have fixed, pinned and spring supports as well as beams in frames. In this case buckling factor is calculated from column to beam stiffness ratio according to Eurocode.







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:

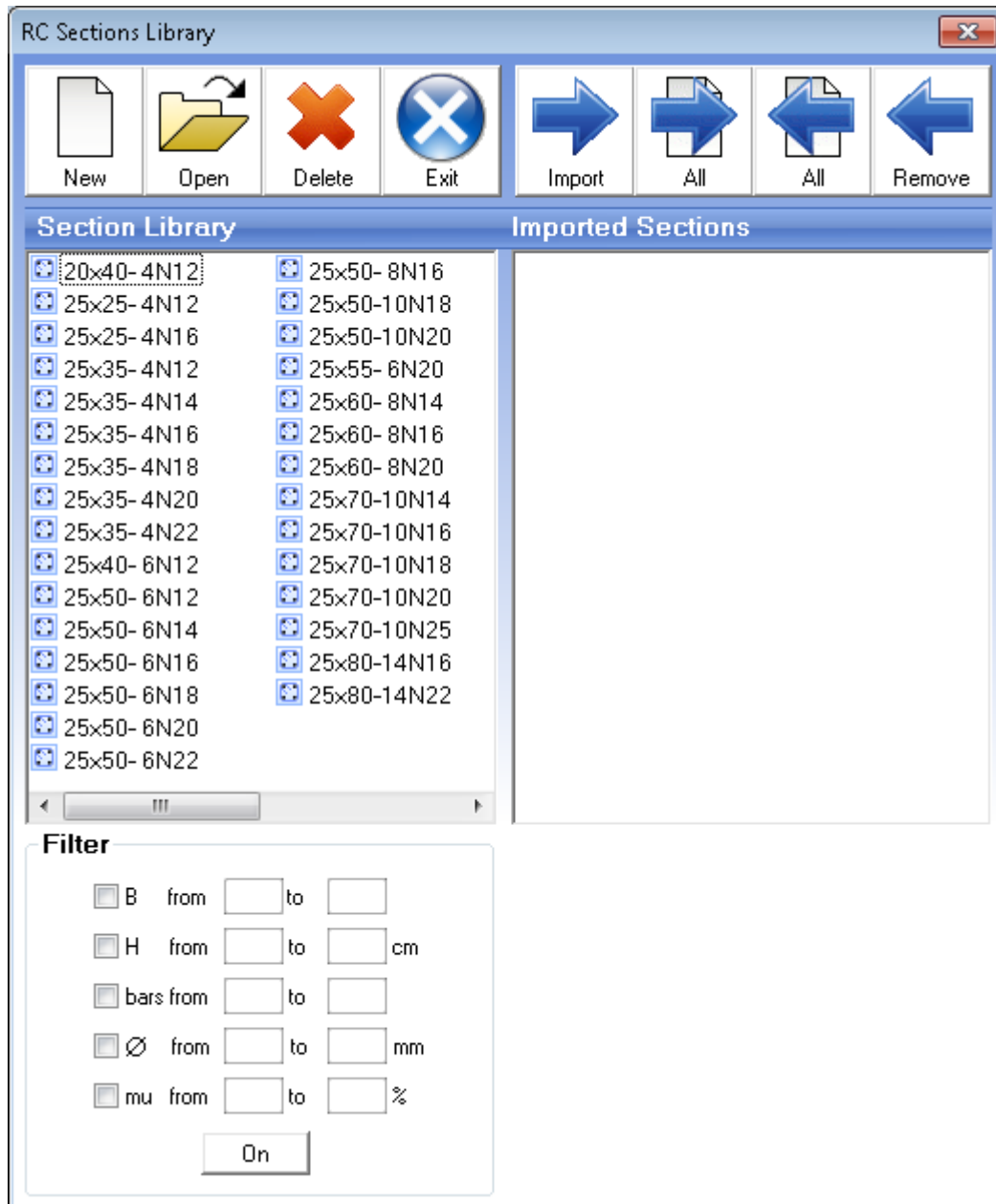
1. Select a range of cells in the table.
2. Select a section in the list.
3. Click the  button.

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

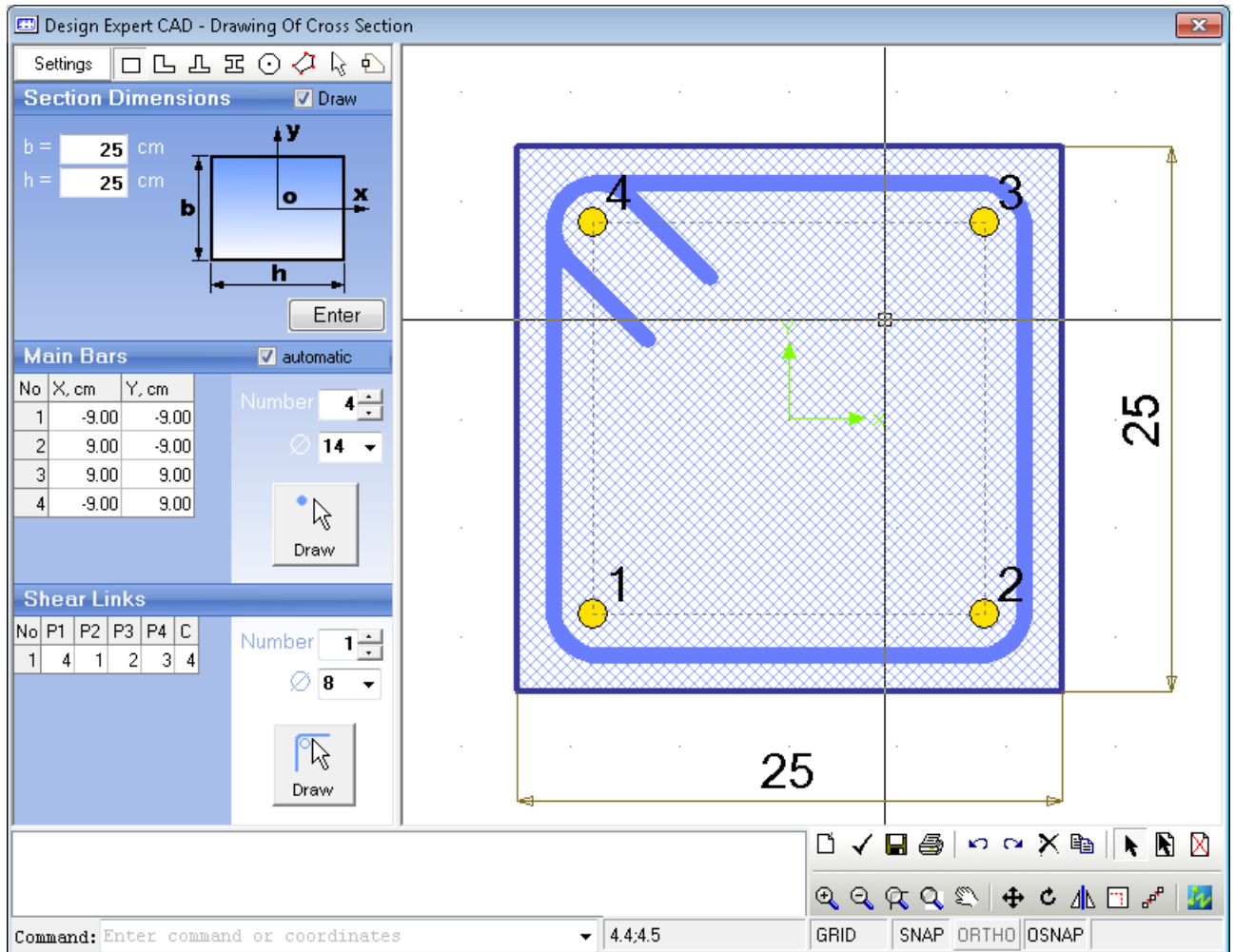
With the filter option you can view only those sections that satisfy selected criteria:

- **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.

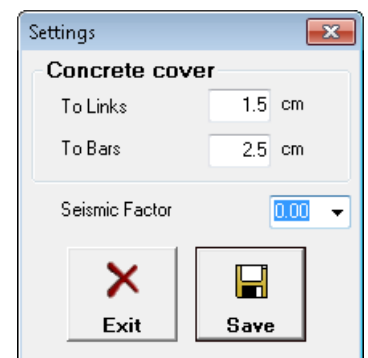


Draw sections



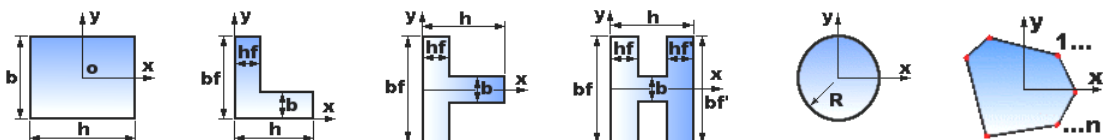
Settings

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 (\square , \square , \square , \square , \odot or \diamond - 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 Kc = 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	$\varnothing_{I,MIN}$	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_I		
Maximum c/c spacing between links	$a_{h,MAX}$	b_C 15· \varnothing_I 50 cm	b_C 12· \varnothing_I 30 cm	b_C 10· \varnothing_I 20 cm
Maximum c/c spacing between links in critical (bar lap) zone	$a_{hc,MAX}$	10 cm	$b_C/2$ 10· \varnothing_I 15cm(10cm*)	$b_C/2$ 8· \varnothing_I 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	

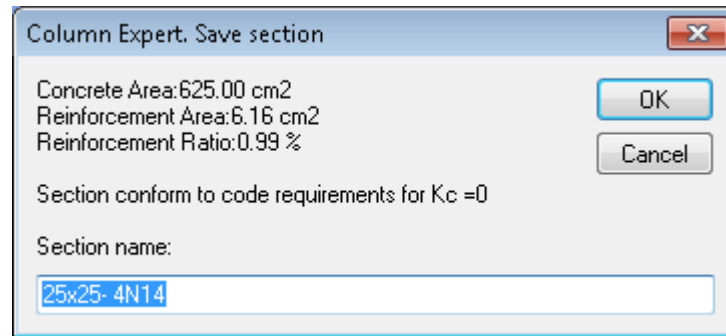
Main reinforcement	k_C	$k_C = 0$ Non-seismic element EC2	$k_C > 0$ Seismic element EC8 DCH
Minimum diameter	$d_{L,\min}$	8 mm	
Minimum reinforcement ratio	ρ_{\min}	0.2 %	1 %
Maximum reinforcement ratio	ρ_{\min}	4 %	
Minimum clear spacing between bars	a_{\min}	5 cm	
Maximum c/c spacing between bars	$a_{L,\max}$	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

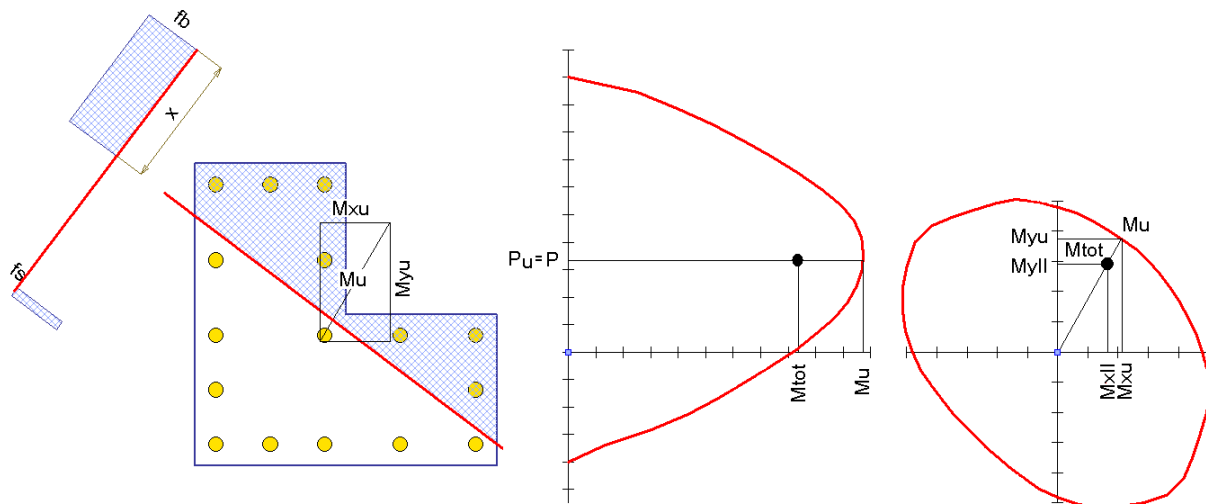
You should save the section in order to use it further. Click the  button. A dialog is displayed with general information about the section and results from code compliance checks. Enter section name only without path. Name is recommended to include information about shape, dimensions and reinforcement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




Results

Design checks



Design checks are started by the  button or in real time when input data for loads or sections are changed. Calculations can be performed according to Bulgarian code or Eurocode 2. Detailed descriptions of design procedures are provided in RC Expert manual. Opposite to RC Expert, here cross section and reinforcement are defined and ultimate capacity loads for the section (P_u , M_{xu} , M_{yu}) are calculated. After that they are compared to section loads (P , M_{xII} , M_{yII}). Bending moments M_{xII} and M_{yII} are calculated from the input moments including initial imperfections and second order effects. Compression zone height for certain direction of neutral line is calculated using the condition $P = P_u$. Direction of neutral line is calculated by an iterative algorithm using the condition $M_{xII}/M_{xu} = M_{yII}/M_{yu}$. That is how ultimate capacity moment has the same direction as total external moment $M_{tot} = (M_{xII}^2 + M_{yII}^2)^{1/2}$. Checks are satisfied when ultimate capacity forces/moments are greater or equal to the corresponding external forces/moments ($P \geq P_u$, $M_{xu} \geq M_{xII}$, $M_y \geq M_{yII}$). Capacity curves M_u - P_u and M_{xu} - M_y , can be also displayed by the respective buttons  and .



Calculation report

You can print a professional html report including input data for materials, sections, column dimensions and calculation results. Click the  button. Report file is generated and displayed in Internet Explorer.

Export to ZWCAD (AutoCAD) and other applications













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

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



Following commands are available only in section drawing window:

	Command	Alias	Description
	ACAD		Transfers the drawing into ZWCAD (AutoCAD)
	BAR	B	Draws main bars
<input checked="" type="checkbox"/>	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.