

**Греда 1**

**Материали**

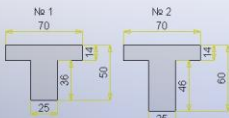
Бетон клас В20 с изчислително съпротивление на натиск  $R_b = 11.5 \text{ MPa}$

Стонана за надлъжна арматура клас АIII с изчислително съпротивление на опън  $R_{sc} = 375 \text{ MPa}$

Стонана за напречна арматура клас АI с изчислително съпротивление на опън  $R_{sw} = 180 \text{ MPa}$

Коефициенти за условия на работа:  $\gamma_b = 1.00$ ;  $\gamma_s = 1.00$

**Напречни сечения**



**Статическа схема и натоварване**

Полета

Опори

№	L, м	Сечение	№	Тип	$R_{k,под}$	Вкл.под	$R_{k,над}$	Вкл.над
1	4	1	1	С	35	25	35	25
2	6	2	2	С	35	25	35	25
3	4	1	3	С	35	25	35	25
4	4	1	4	С	35	25	35	25

Състоими

Натоварвания

№	Тип	Коеф.	№	Поло	Съст	q, kN/m	q <sub>2</sub> , kN/m	$\gamma$ , м	L, м	F, kN	M, kNm	A, м
1	П	1.2	1	1	40	40						
2	П	1.35	2	2	20	20						
3	В	1.3	3	3	10	10						



Software Package  
Design Expert version 2.0

# Beam Expert

Static analysis, design and detailing of reinforced concrete beams

## User Manual



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## About the program

**Beam Expert** software is created for static analysis, design and detailing of reinforced concrete beams. Sections dimensions, span lengths, support types and columns sizes are easily entered in tabular form. Dead and live loads should be specified separately. Beam is calculated for most unfavorable positions of live loads. Envelope diagrams for internal forces and elastic deformations are calculated as a result. Design checks for bending and shear are performed for multiple sections along each span and required main and shear reinforcement diagrams are calculated. Bars counts and sizes are selected automatically based on the required reinforcement diagrams. Detailed reinforcement drawing is generated, including side views, sections, bending schedule and bill of materials. Drawing is viewed in our own **Design Expert CAD** environment and can be exported to a ZWCAD (AutoCAD) command file (script) or transferred directly to ZWCAD (AutoCAD).


## Files

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


### New file

Click the  button to save current data to a new file. Standard file selection dialog appears. Select or write down file path and name and click the "**Save**" button.

### Open a file

Click the  button. Standard file selection dialog appears. Select or write down file path and name and click the "**Open**" button.

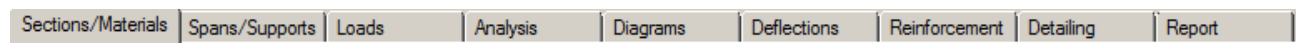
### Save a file

Click the  button. Standard file selection dialog appears. Select or write down file path and name. If a file with the same name already exists, you can overwrite it or select a different name.

## Input data

### Pages

Input data and results are divided into several pages:



You can switch between pages by clicking the corresponding tabs.

### 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.

## Material properties

Select concrete grade **B20** and steel grade for main **All** and shear **Al** reinforcement. Enter strength reduction factors for concrete and steel. These are additional to material safety factors and there you should include the  $\alpha_{cc}$  factor (3.15 – EC2). Characteristic and design material properties for concrete and steel are provided in „**Material tables**”.

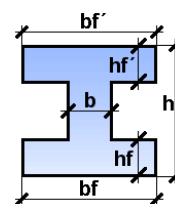
## Material tables

Click the  button in main window to open material tables. A dialog appears, containing two separate tables for both concrete and steel. You can add new records with „+” button and enter a new material. You can delete materials with „-” button or modify material properties. Elastic modulus units and characteristic and design strength units are MPa (N/mm<sup>2</sup>). Click the  „**Save**” button to save the changes. If you want to quit and discard changes, click  „**Exit**” button and return to main window.

## Cross sections

Enter dimensions of cross sections in „**Sections**” table as shown on the picture. Write “L” in the first cell for end beams with flange on one side. Sections in separate spans are aligned to top edges by default. If you want to move a section up/down fill the column “**ey, cm**” with +/- distance, respectively.

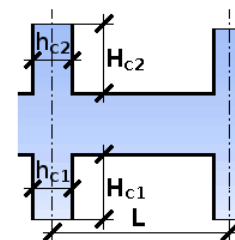
No	L	b, cm	h, cm	bf', cm	hf', cm	bf, cm	hf, cm	ey, cm
1		25	50					



## Spans

Enter effective span length (to centers of columns) and section number for each span.

No	L, m	Section
1		1



## Supports

Enter support type and column dimensions above and below beam. Support types are “**F**” – Fixed, “**P**” – pinned and “**C**” – cantilever (no support). Column dimensions “**hc**” and “**bc**” [cm] are in and out of frame plane, respectively. They are important for reinforcement detailing at

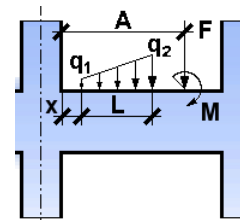


supports. Column height is "Hc". If column heights have nonzero values then beam is calculated together with columns as a frame. In this case, support types refer to columns top and bottom ends. Otherwise column stiffness is not taken in beam analysis.

No	Type	hc1, cm	bc1, cm	Hc1, cm	hc2, cm	bc2, cm	Hc2, cm
1	P		25			25	
2	P		25			25	

## Loads

Enter load cases types and safety factors in table "Load Cases". Load types are "P" – Permanent and "V" – Variable. Characteristic load values should be entered in table "Loads". Design values are calculated by multiplying them by the corresponding safety factors. If a load acts on a single span then enter the span number in the first column. If the column is empty, the load acts on all spans. Second column is the load case. Several loads can have one and the same load case.



Loads can be linearly distributed or concentrated forces and moments. Partially distributed loads are defined by values "q1" and "q2", starting distance "x" from column edge and load length "L". Leave "x" and "L" blank when the load is distributed along full span length. Concentrated forces and moments are defined by load values, respectively "F" and "M" and distance from column edge "A".

Nº	Тип	Коеф.	Nº	Поле	Съст	q1,kN/m	q2,kN/m	x, m	L, m	F, kN	M, kNm	A, m
1	П	1.2	1		1							
2	П	1.35	2		2							
3	В	1.3	3		3							

## Results

### Analysis and internal forces diagrams

Click "Analysis" tab to run static analysis and obtain internal forces diagrams for bending "M" and shear "V" and elastic deformations. Internal forces are calculated from ultimate (factored) loads and deflections - from serviceability loads. Different patterns of live loads are examined and maximum values of bending moments are calculated for most unfavorable loading.

### Deflections and cracks

Linear elastic deflections are based on concrete elastic modulus and gross beam section. Click the "Deflections" tab immediately after the analysis to see them. In order to see inelastic values you should go to "Reinforcement" and "Detailing" first and then back to "Deflections". Design checks for serviceability limit state are performed considering concrete nonlinear properties including creep, shrinkage, cracks and selected reinforcement bars. Each section is checked for cracking and crack widths are calculated if necessary. Factors  $\varphi_{b2}$  and  $\nu$  in tables 36 и 37 in Bulgarian codes are assumed to be:

Load type	$\varphi_{b2}$	$\nu$
Variable loads	1.0	0.45
Permanent loads	2.0	0.15



## Design checks

Bending and shear design checks are performed for ultimate limit state according to Eurocode 2 or Bulgarian codes. Detailed description of design procedure is provided in RC Expert user manual. Effective beam depth is assumed to be  $d = h - 4 \text{ cm}$ . Shear force design is performed for two-leg links and required reinforcement  $A_{sw}$  [ $\text{cm}^2/\text{m}$ ] for one leg is displayed. Link spacing  $s$  [ $\text{cm}$ ] is obtained by the expression  $A_{sw} = \pi \cdot (\varnothing_{sw}/2)^2 \cdot 100/s$ . Click the "**Reinforcement**" tab in order to run design checks. Calculations are performed for each section along the spans and diagrams for required main (top and bottom) and shear reinforcement are displayed.

Additional main reinforcement is provided for the additional tension force  $\Delta F_t$ , required by shear design. This is reflected through widening of main reinforcement diagram.

## Detailing and drafting

Click the "**Detailing**" tab to proceed to beam detailing and drafting. The "**Settings**" dialog appears where you can do the following:

- enter all the settings regarding reinforcement detailing, drawing contents and appearance;
- obtain the required bars sizes and numbers automatically based on reinforcement area diagrams;
- select bar sizes and numbers manually for top, bottom and shear reinforcement in each span;
- generate the entire drawing with the selected reinforcement.



## Settings

**Settings**

**Drawing**

- Bending schedule
- Bill of quantities

**Rounding**

Bar dimensions: 2,5 cm

Bar lengths: 5,0 cm

**Start mark numbers**

Main bars: 1

Shear links: 101

**Detailing**

**Preferred diameters**

Bars:  $\varnothing$ ,min: 12,  $\varnothing$ ,max: 20

Links:  $\varnothing$  8

**Reinforcement curtailment**

- Bottom reinforcement in spans
- Top reinforcement at supports
- Shear reinforcement

**Anchorage in columns**

- Tension bars in tension zone
- Tension bars in compression zone

**Shear links shape**

- Overlapped
- Hooks angle:  90°  45°

**Scale**

For drawing - M 1: 50,0

For sections - M 1: 25,0

Printed text size: 2,5 mm

**Concrete cover**

To links: 1,5 cm

To bars: 2,0 cm

Seismic factor: 0,00

External CAD: ZWCAD

**Selected reinforcement in spans**

Diagram showing reinforcement details for Span 1 between points 1 and 2. Top reinforcement: 2 Ø 12. Bottom reinforcement: 5 Ø 18. Links: Ø 8 / 33 cm. Additional link details: 0 Ø 0, L= 0 cm.

Buttons: Generate, Exit, Draw

You can specify a lot of different settings as described below.

### Drawing

**Bending schedule** includes bar sketches with all dimensions as well as total number, length, unit weight and total weight for each bar mark.

**Bill of quantities** includes reinforcement weights for separate diameters, total weight (kg), concrete volume (m<sup>3</sup>) and formwork area (m<sup>2</sup>).

### Rounding

Set rounding factors for bars dimensions (excluding links) and total lengths.

### Scale

You can specify different scale factors for view and sections. Text size is provided for printed text. Actual text size in the drawing is calculated automatically using the scale factor.



## Concrete cover

You can specify concrete cover from concrete surface to surfaces of bars and links. Distance of bars to the edge of concrete is taken the greater of

- concrete cover to bars or
- concrete cover to links + half the link diameter.

## External CAD

Select a name of an external CAD application (ZWCAD or AutoCAD) to export the drawing to – see “Export to ZWCAD (AutoCAD) and other applications.”

## Seismic factor

Detailing requirements either for seismic or non-seismic zone are applied depending on specified seismic factor. If seismic factor is  $\leq 0.05$ , Eurocode 2 requirements are applied. If seismic factor is  $> 0.05$ , Eurocode 8 requirements are applied (see “Detailing rules” bellow).

## Reinforcement detailing

The program automatically selects counts and sizes of bars to cover maximum values from the required reinforcement diagram. This happens with the first appearance of the dialog or when you click the „**Generate**” button.

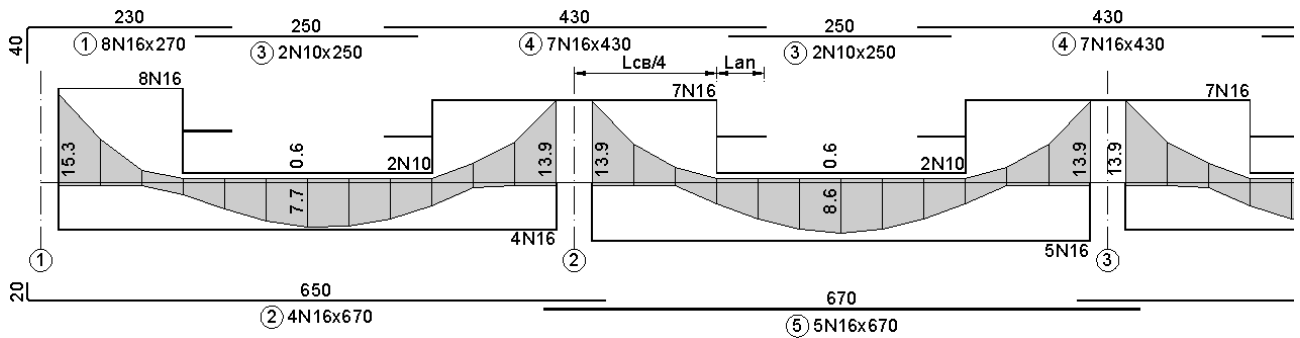
You can set a range of „**Preferred diameters**” that program can use for selection of diameters. For main reinforcement minimum and maximum diameters [ $\emptyset_{\min}$ ;  $\emptyset_{\max}$ ] are required. Lower values of  $\emptyset_{\max}$  will result in greater number of bars with smaller diameters. Only one value of diameter  $\emptyset$  is required for links. It is used for the whole beam as much as possible. Diameter is increased  $\emptyset$  only where links spacing becomes too dense.

You can choose whether the reinforcement diagram will be covered in one or two zones separately for top, bottom and shear reinforcement (reinforcement curtailment). If you do not use curtailment all bars in span (or above support) will be equal and their number will be calculated for the maximum reinforcement value. Link spacing is calculated for the maximum required shear reinforcement and is equal for the whole span. Standard top bar length is determined assuming that bar extends into spans at 1/4 clear span length. Bar is symmetric and greater length from both adjacent spans is relevant. Required reinforcement diagram outside this area is covered by top bars in spans. Top bars in a cantilever span are extended to the end of the cantilever. If the curtailment option is used, part of the reinforcement ( $\geq 50\%$ ) covers full span length and the rest covers only the area that is not covered by the first part. Bars are additionally extended with anchoring length at both sides beyond this area. Links are designed in two areas. Greater spacing is provided in the middle of the beam and smaller spacing – in the quarters.

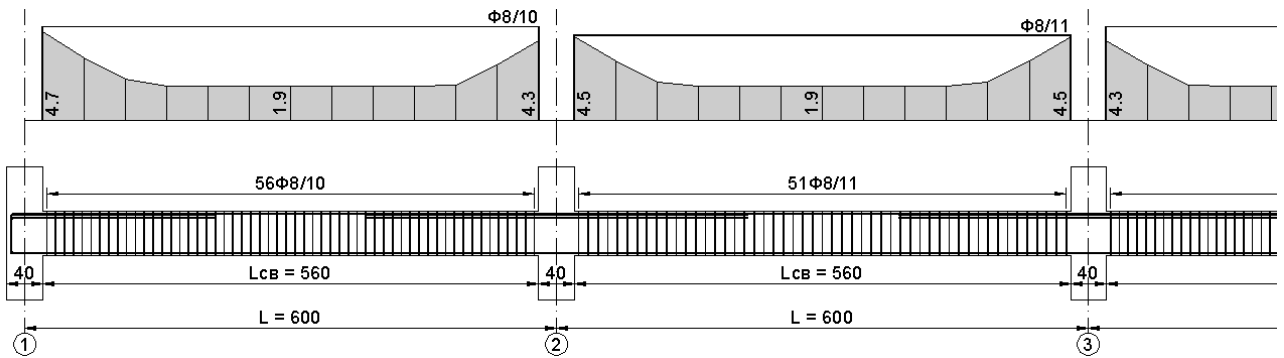
Curtailment is more economical, but results in more complex reinforcement and is more difficult for construction. It is suitable for more heavily loaded beams with greater spans.

Examples for reinforcement design using both methods are provided bellow.

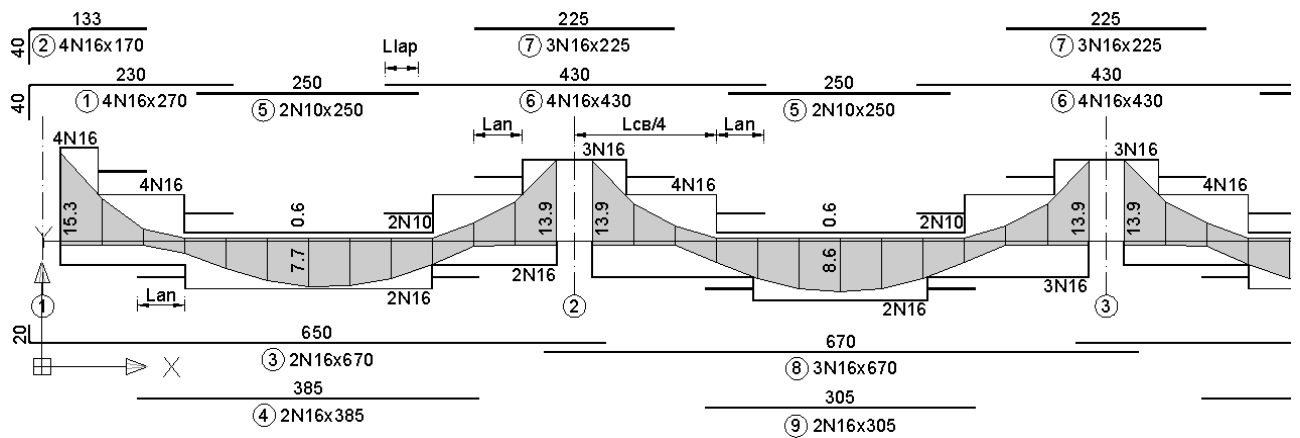




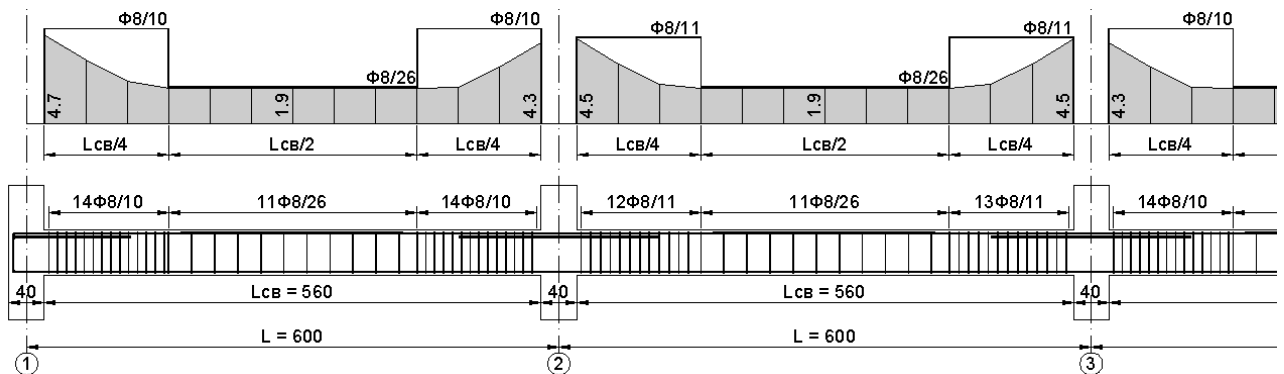
**Top and bottom reinforcement without curtailment**



**Shear reinforcement without curtailment**



**Top and bottom reinforcement with curtailment**



**Shear reinforcement with curtailment**



### Detailing rules to Bulgarian code

Reinforcement detailing is performed following specific rules as required by design codes. Detailing rules used by the program are presented in the following tables:

Main reinforcement		$k_c$	$\leq 0.05$	$\leq 0.15$	$> 0.15$
Minimum diameter		$\emptyset_{L,MIN}$	12 mm		
Minimum reinforcement ratio		$\mu_{MIN}$	0.05 %	$1.4 / R_{sn}$	$1.4 / R_{sn}$
Maximum reinforcement ratio		$\mu_{MAX}$	3 %	$7 / R_{sn}$	$7 / R_{sn}$
Minimum clear spacing between bars		$a_{MIN}$	2.5 cm – bottom reinforcement 3 cm – top reinforcement		
Maximum c/c spacing between bars		$a_{MAX}$	25 cm		
Bending diameter		$d_{bend}$	2.5 $\emptyset$		
Anchorage length	Tension	$L_{an} =$	$(0.7 \frac{R_{sc}}{R_b} + 11)\emptyset$ $> 20\emptyset$ и $> 25cm$		
	Compression	$L_{an} =$	$(0.5 \frac{R_{sc}}{R_b} + 8)\emptyset$ $> 12\emptyset$ и $> 20cm$		
Lap length	Tension	$L_{lap} =$	$(0.9 \cdot \frac{R_{sc}}{R_b} + 11)\emptyset > 20\emptyset$ и $> 25cm$		
	Compression	$L_{lap} =$	$(0.65 \cdot \frac{R_{sc}}{R_b} + 8)\emptyset > 15\emptyset$ и $> 20cm$		

Shear reinforcement		$k_c$	$\leq 0.05$	$\leq 0.15$	$> 0.15$
Minimum diameter		$\emptyset_{h,MIN}$	for $h \leq 80$ – 6mm for $h > 80$ – 8mm		
Minimum c/c spacing between links		$a_{h,MIN}$	5 cm		
Maximum c/c spacing between links		$a_{h,MAX}$	$3h/4$ 50cm	$h/2$ b 25cm	$h/2$ b 20cm
Maximum c/c spacing between links in critical zone		$a_{hc,MAX}$	за $h \leq 60$   $h/2$ 20cm за $h > 60$   $h/3$ 50cm	$h/4$ 8 $\emptyset_1$ 20	$h/4$ 6 $\emptyset_1$ 15
Bending diameter		$d_{bend}$	2.5 $\emptyset$		
Anchorage (Lap) length		$L_{an}, L_{lap}$	10 $\cdot \emptyset_h$		
Critical zone length		$l_{1,2}$	$L_{cl}/4$		

**Detailing rules to Eurocode 2 and Eurocode 8**

Main reinforcement	$k_c$	$k_c = 0$ Non seismic EC2	$k_c > 0$ Seismic EC8 DCH
Minimum diameter	$d_{L,min}$	10 mm	14 mm
Minimum reinforcement ratio	$\rho_{min}$	$0.26 \cdot f_{ctm}/f_{yk}$ 0.0013	$f_{ctm}/2f_{yk}$
Maximum reinforcement ratio	$\rho_{max}$	0.04	
Minimum clear spacing between bars	$a_{min}$	$\text{Max}\{d_{L,max}, d_g + 5 \text{ mm}, 20 \text{ mm}\}$ $d_g = 20 \text{ mm}$	
Maximum c/c spacing between bars	$a_{max}$	25 cm	
Bending diameter	$d_m$	При $\varnothing \leq 16 \text{ mm}$ - $d_m = 4\varnothing$ При $\varnothing > 16 \text{ mm}$ - $d_m = 7\varnothing$ $d_m \geq F_{bt}/f_{cd}(1/a_b + 1/2d_s)$	
Anchorage length	$l_{bd}$	$f_{bd} = 2.25 \eta_1 \eta_2 f_{ctd}$ , $l_{b,rgd} = d/4 \cdot \sigma_{sd}/f_{bd}$ $l_{bd} = \alpha_1 \alpha_2 \alpha_3 l_{b,rgd} > l_{b,min}$ $l_{b,min} = \text{max}\{0.6 l_{b,rgd}, 10d_L, 10 \text{ cm}\}$	
Lap length	$l_0$	$l_0 = \alpha_1 \alpha_2 \alpha_3 \alpha_6 l_{b,rgd}$ $\alpha_6 = 1.5$ при снаждане над 50%	

Напречна армировка	$k_c$	$k_c = 0$ Non seismic EC2	$k_c > 0$ Seismic EC8 DCH
Minimum diameter	$d_{w,min}$	6 mm	
Minimum clear spacing between links	$s_{min}$	5 cm	
Maximum c/c spacing between links	$s_{max}$	$0.75d(1 + \cot\alpha)$	
Maximum c/c spacing between links in critical zone	$s_{c,max}$	$0.75d(1 + \cot\alpha)$	$h/4, 24d_w, 6d_L, 17.5 \text{ cm}$
Bending diameter	$d_m$	$4d_w$	
Anchorage (Lap) length	$l_{bw}$	$10d_w$	
Critical zone length	$l_{cr}$	$l_n/4 > h$	$l_n/4 > 1.5h$

**Selected reinforcement in spans**



The program can select diameters and counts for bars and links automatically based on theoretically required reinforcement. This function is started by clicking the "Generate" button. You can review and edit manually this information for each span. You can switch to different spans using the button. Go to left of span #1 in order to access support # 1. You must be careful not to click the "Generate" button once again. It will ignore your changes and will replace them with automatically generated reinforcement.





## Drawing

Reinforcement drawing is automatically generated by clicking the **"Draw"** button. The **"Settings"** dialog is closed. If you go back to **"Reinforcement"** tab you will see how theoretical reinforcement is covered.

## 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" in properties of current dimension. 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 beam. 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.

## Calculation report








You can generate a professional calculation report by clicking the **"Report"** tab. Report is in html format and can be viewed and printed by **Internet Explorer** or any other web browser or office application (e.g. **Word**).

## 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	Abbreviation	Description
	ACAD		Transfers the drawing into ZWCAD (AutoCAD)
	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
	EXIT	E, X, EX	Ends current program session
	GRID	GR	Turns grid on/off
	MIRROR	MI	Mirrors objects in the drawing
	MOVE	M, MO	Moves objects in the drawing
	NEW	N	Opens a new file



	OPEN	O, OP	Opens an existing file
	ORTHO	OR	Turns orthogonal drawing on/off
	OSNAP	OS	Turns snap to points on/off the
	PRINT	PR, PRN	Prints current drawing display
	QUIT	Q	Same as EXIT
	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
	SAVE	S, SA	Saves a file to disc
	SCALE	SC	Scales objects in the drawing
	SCRIPT	SCR	Saves SCRIPT file with commands for ZWCAD/AutoCAD
	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

## 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
<b>Absolute</b>	<b>X;Y</b>	10,5;15	Absolute coordinates in OXY coordinate system.
<b>Relative</b>	<b>_ΔX;ΔY</b>	_25;35	Relative distances "25" and "35" along X and Y from the last entered point.
<b>Polar</b>	<b>&lt;α°;L</b>	<45;100	Relative distance "100" from the last entered point measured at angle 45° from X axis.
<b>Distance</b>	<b>L</b>	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.