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## CALCULATION OF THIN-WALLED RODS BY NUMERICAL METHODS

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*Thin-walled steel structures are used extensively in construction. They have become a common design solution for low-rise building, attics, walling multistory building.*

*When modeling thin-walled structures the integrated system SCAD Office is widely used.*

*SCAD Office is a suite of programs designed to perform the calculations of the strength and structural design of various kinds. The system, in particular, includes a program for creating spatial models, forum, formation and calculation of geometrical characteristics of sections, consul strength calculation of structures, SCAD. Modeling of thin-walled elements can be carried out easily in the Forum included in SCAD Office, or directly SCAD.*

*The main objective of this work was to develop a technique for constructing finite-element simulation models of such elements.*

Building a profile to begin tracing its sectional cuts in AutoCAD (or other graphics program), the file is saved as dxf. Then dxf-file with the section profile import preprocessor program "Forum" (Fig. 1).

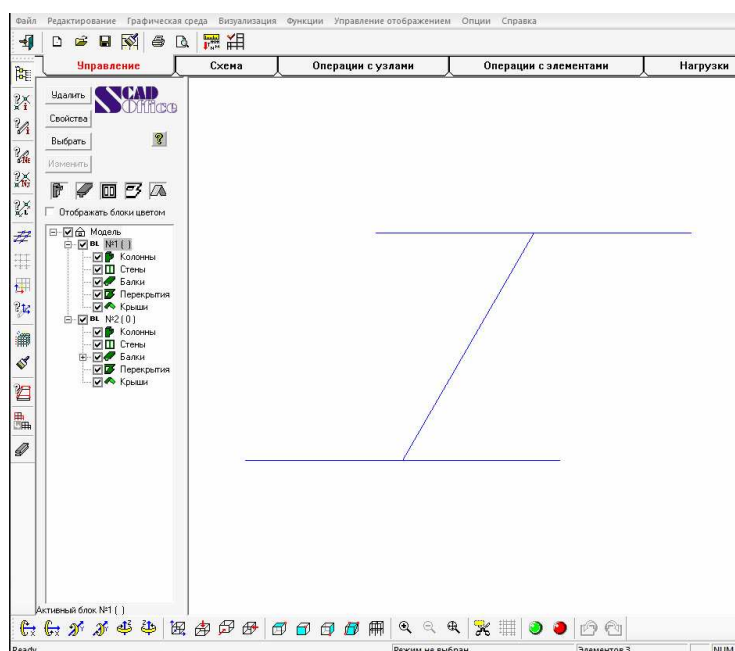


Fig. 1. Result of export dxf-file to the preprocessor "Forum"

Section on individual segments produce consistent formation shelves profile by selecting the function "wall" in the tab "scheme" with the job she needed parameters. Thus the length of the rod is set in "height of the wall". Passing successively from segment to segment, form the whole profile (Fig. 2).

If necessary to form a beam or a thin-walled element with perforations, choose the item in which to perform the holes. Further note the plane in which it is assumed the formation of holes in the left pane, select a function Forum "change". When this function is activated automatically switched to the program Consul.

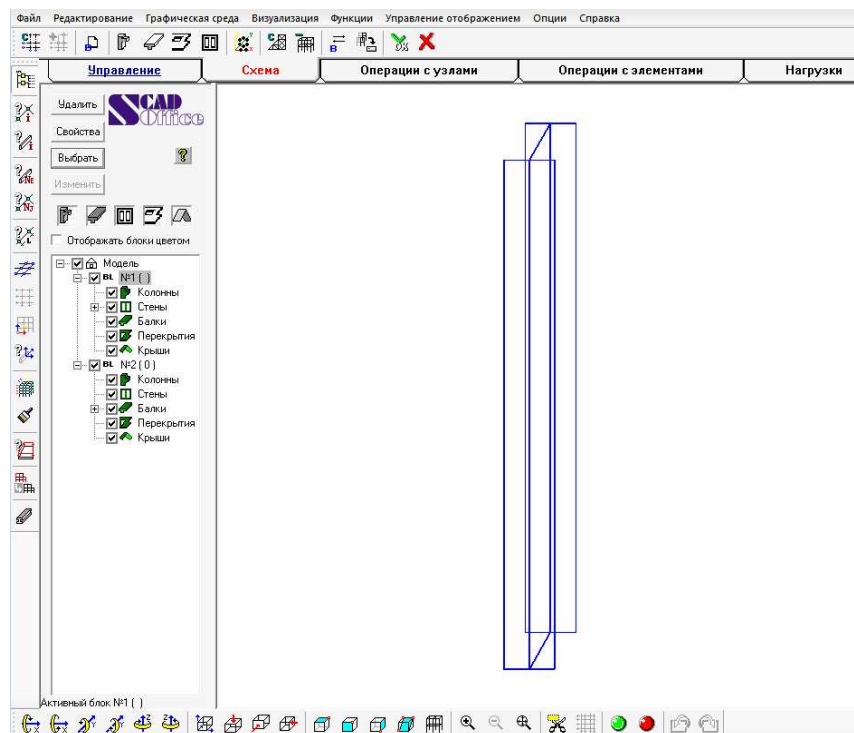


Fig. 2. Shaped profile

For further markup section must create grid. To do this, on top of the selected function, “grid”, which set the new window. Option “Show / Hide grid” make the grid visible. The settings are snapping to the grid. Next, choose the function “inner loop” and the element, focusing on the grid nodes, specify the desired shape holes. It must be remembered that the circuit must be closed. When creating a design model is recommended to smooth corners holes that usually corresponds to the actual shape of the rod hole in the shelf. To do this, select a function to “smooth corners” and set the desired radius of curvature.

If necessary, create a circular hole in the tab “edit” choose function “given radius circular hole” in the dialog box set the radius of the hole. Precise positioning of the hole in two ways. Easier to use a reference to the grid step. In more complex cases, you can use the left panel, which displays the coordinates of all points of the holes, and change them.

To create a duplicate can be created opening holes rip through a predetermined distance. To do this, in the tab “edit” function is selected with the “copy inner loop”. Noting right-click the hole open a window in which you specify the step of copying one or two coordinates.

Described sequence of steps provides a model of the complex profile.

If the calculated design has transverse stiffeners constructing sequence is as follows:

- 1) it is necessary to calculate the coordinates of points of intersection with the walls of the ribs and shelves beams;
- 2) create knots on the edges of shelves and wall beams considering the coordinate system in a given pattern;
- 3) create transverse stiffeners using the “Overlay”. Operations to create shelves and walls will be similar to that described above. The convenience of such techniques job stiffeners that team "Overlap" allows you to create not only the plate perpendicular to the axis of the rod. Sequential assignment of the corner points of the plate allows you to place it in the inclined planes [1].

Formed of a preprocessor Forum enlarged model of the rod with holes and / or transverse ribs generated finite element project SCAD. The key here is to choose the partitioning steps into finite elements (Fig. 4).

One of the important features of the profiles with holes are its size, expressed in hundredths of a millimeter. For correct operation of the program SCAD to adjust some settings, namely, select "Setting environment" and in the tab "design scheme" set assembly accuracy and precision of the estimate coincident nodes 0.001 mm [2].

Since the task loads, fixing conditions and calculation directly considered beams similar to any other structures, will not consider these points. Dwell only on the task types of finite elements and their stiffness.

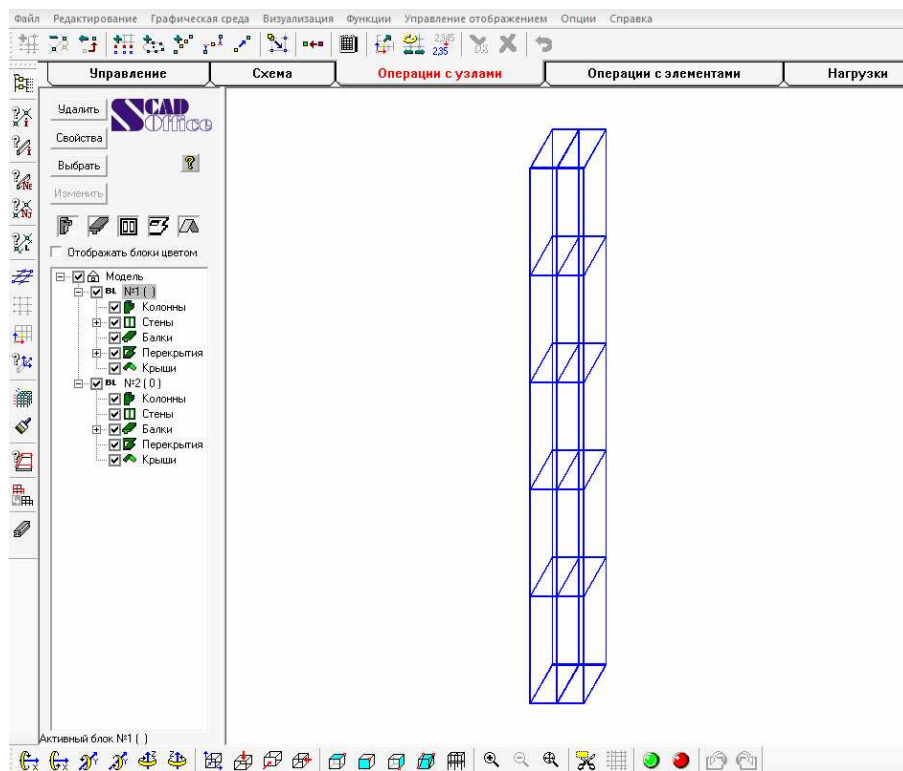


Fig. 3. Beam with transverse stiffeners

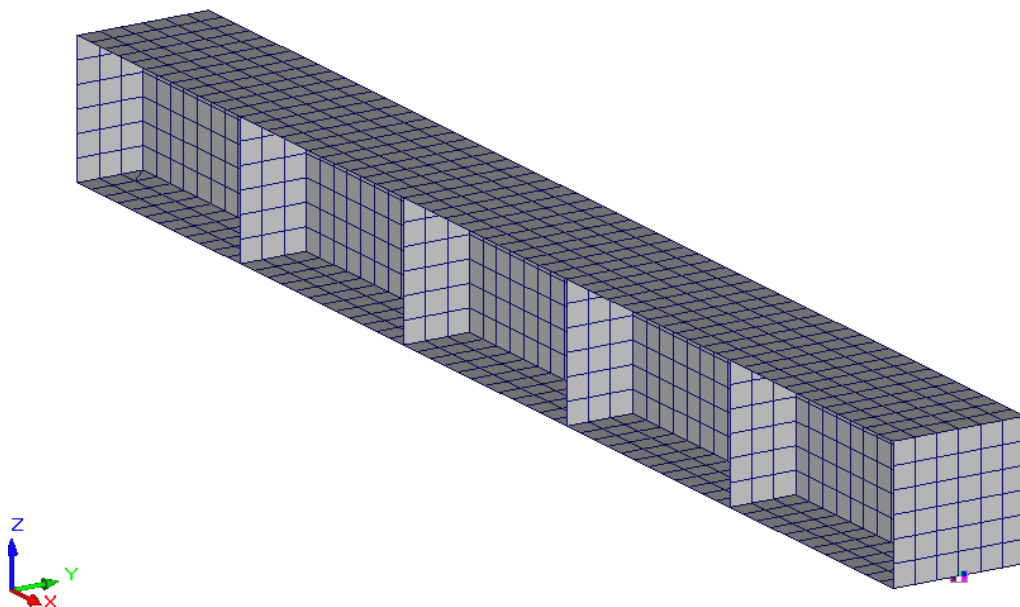


Fig. 4. Finite element design SCAD, presentation graphics

## Architecture and Civil Engineering

Finite elements library computer system allows the calculation of the most complex designs. It includes a variety of finite elements (FE). Each finite element in the library assigned type – serial number. Table 1 gives a classification of types of FE possible signs of a design scheme for their work, the identification of calculated forces (stresses).

Table 1 – FE classification

Type of FE	Content	Signs scheme	Calculated efforts
1 – 10	Rods		
	1 – flat farm	1, 2, 4, 5	N
	2 – flat frame	2, 5	N, M(My), (Qz)
	3 - beam raft foundation	3, 5	Mκ(Mx), My, Qz
	4 - spatial farm		
	5 - spatial	4, 5	N
	6 - taking into account the spatial shear	5	N, Mk, My, Qz, Mz, Qy
	7 - beam on an elastic base raft foundation	5	N, Mk, My, Qz, Mz, Qy
10 - universal	3, 5	<i>Mk (Mx), My, Qz</i> depending on the type of circuit	
11 – 20	Plates	3, 5	Mx, My, Mxy, Qx, Qy
21 – 30	Elements for solving the plane elasticity problem tense (beam-wall) and the calculation of plane strain 21, 22, 29, 30, 23, 24, 27	1, 2, 4, 5	For flat-hard problem: Nx, Ny, Txz; For plane strain: Nx, Ny, Nz, Txz
31 – 40	Elements to solve the bulk of the elasticity problem	4, 5	Nx, Ny, Nz, Txy, Txz, Tyz
41 – 50	Shells	5	Nx, Ny, Txy, Mx, My, Mxy, Qx, Qy
51 – 60	Elastically pliable connection		
61 – 70	Elements for the solution of the axisymmetric problem of elasticity theory	11	Nx(r), Ny(), Nz(z), Txz(Trz)
71 – 80	Elements for the calculation of multilayer shallow plates and shells, taking into account the transverse shear, compression layers and curvature	8	Nx, Ny, Nz, Txy, Txz, Tyz, vertical movement at the boundary layers
81 – 90	Elements for the calculation of multilayer shallow plates and shells, taking into account the interlayer shifts and curvature	9	
150 – 160	Zero elements for calculating effort to questions	1-5	
200	Empty element	any	

Forces and stresses are evaluated at the beginning and at the end of the rod, and for other types of finite element – the center of gravity calculation serves to support the rods in the intermediate sections, other types of finite element – at the nodes.

Typically, the stresses and strains in the FE calculated in the local coordinate system. For rods such, that the major axis of the cross sections of the flexible portion. If the figure in the table element is not specified local coordinate system X1Y1Z1, then the stresses and strains are calculated in the global coordinate system. For all flat and spatial FE is possible to set the coordinate system computing effort.

Universal finite elements for the solution of the plane problem of elasticity theory can count as flat-tight and flat deformable systems. In the most general case, each node of finite element has three degrees of freedom: U - axis of linear movement along X; V - linear movement along the axis Y; W - linear movement along the axis Z [3].

Degree of freedom, V is absent in all the elements that can only lie in the plane XOZ: 21, 22, 29, 30.

In type elements 23, 24, 27 which may lie freely in the space, it is introduced to the docking space of the structure.

The complex SCAD includes the following FE solutions for the plane problem:

- 1) rectangular elements such as 21 (in the plane XOZ) and type 23 (an arbitrary position in space);
- 2) triangular elements 22 type (belongs to pl . XOZ) and type 24 (arbitrary position in the space);
- 3) quadrangular elements with the number of nodes from 4 to 8, type 30 (mp lies . XOZ) and type 27 (an arbitrary position in space. Besides the quad on each side may be one more node. Numbering nodes 5 to 8-th – arbitrary);
- 4) quadrilateral element with the number of nodes from 4 to 12 in the plane XOZ type 29. Besides the quad on each side may be even up to two nodes. The numbering of nodes from the 5th to the 12th arbitrary.

Elements beams, walls often located in the plane XOZ common system of coordinates (and planes parallel to it). In this case such elements are represented by the local coordinate axis system elements when the element lie in the plane of the axis X1 and Z1, and an axis Y1 perpendicular to its plane.

If the beam-wall is not in the plane XOZ (or in a plane parallel to it), and arbitrarily located plane (as part of a spatial structure), it uses elements of the same kind of shape (rectangular, triangular, rectangular), but they will treat other types than those described above.

Force (tension) in the plane problem is calculated either in the center of gravity or more elements (as indicated by calculators) and element nodes.

As a result, bills are calculated move nodes in the global coordinate system, as well as efforts at the center point (center of gravity) of the element in the local coordinate system (the default) or any other (by the user) coordinate system, the position of which is determined by the data specified in the document. Nodal reactions are only issued in the local coordinate system.

Positive displacement directions are coincident with the corresponding directions of the basis vectors (right Cartesian coordinate system).

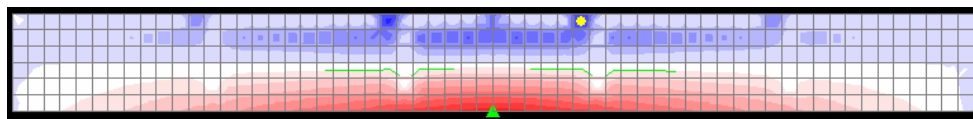


Fig. 5. Example display contour plots of stress Nz wall-beam.

The list and the rules of reading effort and nodal reactions are shown in (table 2). The dimension is given for the case of job stiffness characteristics, origin and loads in tons and meters. If other units of measurement results of the calculation will be prepared according to the selected measurement units.

Table 2

Type of FE	Indexation	Description	Rule of signs
a)			
21 – 30 41 – 50	$N_x (\sigma_x)$	Normal stress acting along the axis X1	Positive sign corresponds to tension
21 – 30 41 – 50	$N_y (\sigma_y)$	Normal stress acting along the axis Y1	Positive sign corresponds to tension. For items 21 – 30 is calculated only for plane-deformed systems
21 – 30	$N_z (\sigma_z)$	Normal stress acting along the axis Z1	Positive sign corresponds to tension
41 – 50	$T_{xy} (\tau_{xy})$	Shear stress	Shifting section belonging end member in directions opposite to the axes X1 and Y1
21 – 30	$T_{xz} (\tau_{xz})$	Shear stress	Shifting section belonging end member in directions opposite to the axes X1 and Z1
b) Bending stresses (forces)			
11 – 20 41 – 50	$M_x$	Moment acting on the cross section orthogonal to the X axis	The positive thing is stretching the lower (relative to the axis Z) fiber cross-section
	$M_y$	That is, the orthogonal axes Y	The same
11 – 20 41 – 50	$M_{xy}$ $Q_x$	Torque (acting in section orthogonal to the axis X1) Shear force in a section orthogonal to the axis X	Rotation section belonging to the end of the element counterclockwise when viewed from the end of the axis X1 Positive shearing force acts in the direction of Z axis on the part of TFE, wherein the missing node 1

11 – 20 41 – 50	Q <sub>y</sub>	That is, orthogonal to the axis Y	
11 – 20 41 – 50	RZ	Reactive soil resistance when calculating shell plates on elastic foundation	Positive force acts in the direction of the axis Z (minus sign indicates that the soil is compressed)
c) Nodal reaction			
21 – 30 41 – 50	RX	Horizontal force in the <i>i</i> -node finite element coinciding with the direction of the X axis direction	The positive force exerted on the <i>i</i> -th node in the direction of the axis X
41 – 50 23, 24, 27	RY	Horizontal force in the <i>i</i> -node finite element coinciding with the direction of the Y-axis direction	The positive force exerted on the <i>i</i> -th node in the direction of the axis Y
11 – 20 21 – 30 41 – 50	RZ	Horizontal force in the <i>i</i> -node finite element coinciding with the direction of the Z-axis direction	The positive force exerted on the <i>i</i> -th node in the direction of the axis Z
11 – 20 41 – 50	RUX	The reactive moment in the <i>i</i> -node FE relative to the axis X	Positive moment acts on the <i>i</i> -th node counterclockwise when viewed from the end of the X axis
11 – 20 41 – 50	RUY	The reactive moment in the <i>i</i> -node FE relative to the axis Y	Positive moment acts on the <i>i</i> -th node counterclockwise when viewed from the end of the Y axis

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## PRECAST BENDING REINFORCED CONCRETE CONSTRUCTIONS

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Currently, precast reinforced concrete constructions are widely used in the building industry of the Republic of Belarus. They are used both in the reconstruction of buildings, structures and in new construction. The advantage of precast structures is associated with the possibility of connection of multiple layers with different properties in one construction. The versatility of precast construction includes the use of positive properties of each layer separately and joint work of layers as a single unit up to structural failure.

So, during the reconstruction of buildings and structures a method of enlargement of the cross section of a construction to reinforce steel bending concrete structures is commonly used. It is a fairly simple way of reinforcement. It allows to increase the structural strength and to reduce the time of strengthening. The use of other ways of strengthening is limited by weight and overall dimensions of structures, as well as the use of large construction equipment.

The efficiency of reinforcing work technique is based on the use of a horizontal surface of a former construction as a fixed formwork. Reinforcement can be carried out under total or partial discharge or under a load. Reinforcement-under-the-load-activities are the most profit-proved. The works are carried out with minimal efforts. So, for example, there is no need to dismantle and then mount back the work equipment which can remain non-removable. Besides it is practically impossible to relieve a fully unloaded structure. The proper weight of an item is a minimum load.