SCAD Group

Structure CAD software pack

for Windows

SCAD Structure

TONUS

application is used to build thin-walled sections and calculate their geometric characteristics

User manual

Table of contents

1. Tonus

The **Tonus** application is used to build thin-walled sections and calculate their geometric characteristics.

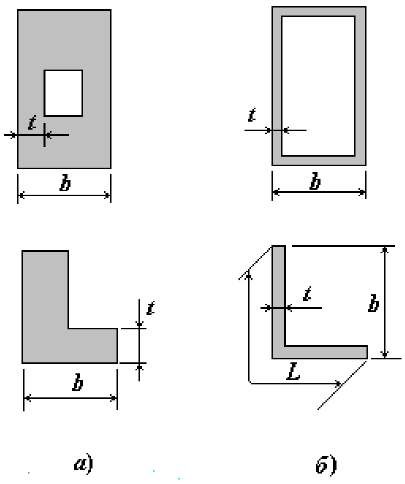


Fig. 1.

Thin-walled bars can be found in a great variety of structures used in various fields of engineering. In some cases a thin-walled bar model simulates a structure as a whole (such as a multi-storey building with load-bearing walls or a span of a bridge), while in other cases this model can be used to simulate important load-bearing components of a structure's framework.

In the science of structural mechanics, a **bar** refers to a body that has the maximum overall dimension of its cross-section, b_{max}, much smaller than its length, l.

In a **solid bar** the smallest size of its cross-section, t_{min}, has the same order of magnitude as b_{max} (Fig. 1, *a*). In a **thin-walled bar**, $t_{min} << b_{max}$, so, obviously, $t_{min} << L$ where L is the length of the bar's cross-section contour [8] (Fig.1, *b*). Usually a bar is considered to be thin-walled if the following inequalities hold:

$$t / b < 0{,}1; \quad b / l < 0{,}1.$$

A key difference in the behavior of a thin-walled bar under a load from that of a solid bar is that the plane-sections hypothesis can be violated in the case of the thin-walled bar. A typical example is an unrestrained torsion of an open-profile bar (a pipe with a longitudinal cut) or a deformation of a double tee loaded by a bimoment at its butt (Fig. 2).

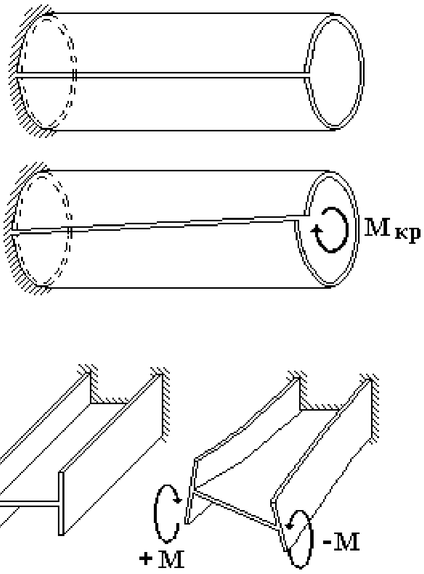


Fig. 2.

A deviation from the plane-sections hypothesis is a feature immanent to **open-profile** thin-walled bars more than to **closed-profile** ones.

A theory for analysis of bars of this type for the open- and closed-profile case was developed by V.Z.Vlasov [2] and A.A.Umansky [6, 7] (see also [4]).

The **Tonus** application lets you deal with any arbitrary (including mixed open-closed) profiles; it makes use of a version of a unified theory of thin-walled bars suggested by E.A. Beilin [1]. Unlike the **Section Builder** and **Konsul** applications, this software implements another approach to the creation of a cross-section model. The application assumes that a section is thin-walled and is being built of strips; the user specifies a thickness of each strip and a position of its median line.

1.1 Window of the application

The **Tonus** application window (Fig. 3) contains a menu, a toolbar, a working area (with scrollbars when necessary), a table panel, and a status bar.

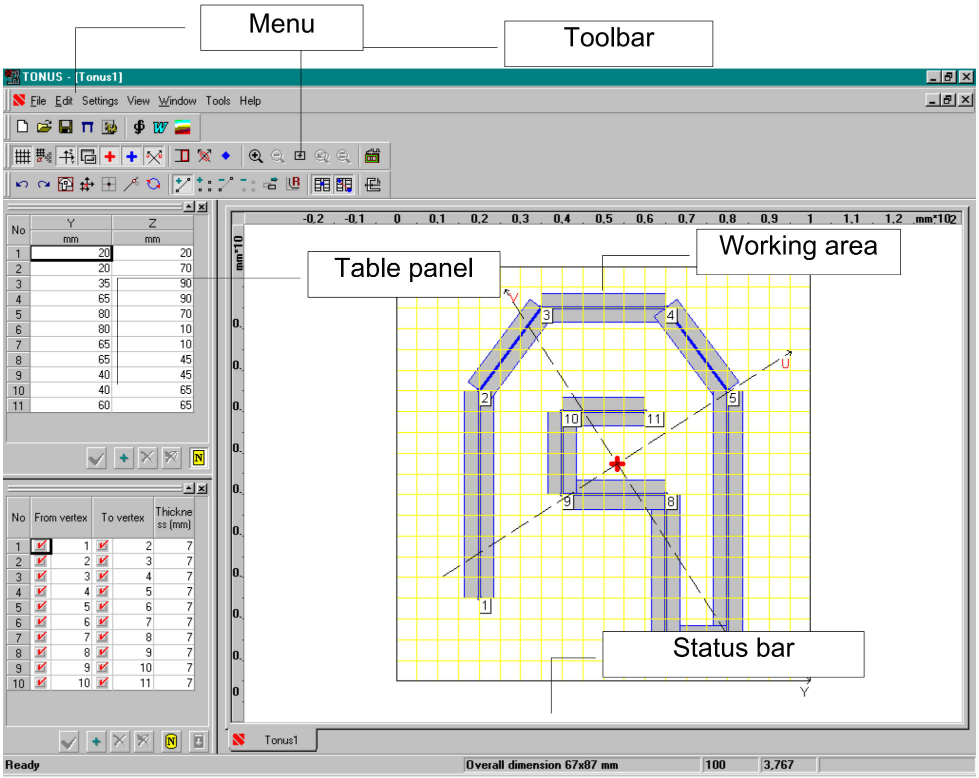
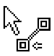
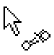


Fig. 3. *A general view of the **Tonus** application's window*

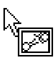
1.2 Cursors

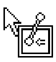
All actions are performed in the working field with specific cursors — different shapes of the mouse pointer. The shape depends on what action is in progress at a certain moment. Below you can see a list of the actions and their respective cursor shapes.

 — add strips;

 — delete strips;

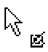
 — smooth (round) angles;

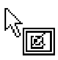
 — delete a group of strips;

 — move vertices;

— display stress values in arbitrary points of a section;

 — add a vertex;

 — delete a vertex;

 — delete a group of vertices;

 — measure a distance between two points within given overall dimensions.

The mouse pointer can be used to determine a distance between two arbitrary points of a section or the working area. To do it, discard an action active at the moment (un-press its button), place the pointer onto first point, and left click. Drag the pointer to the second point while holding the button. The right part of the status bar will display the distance between the points (the accuracy of this indication will depend on a precision specified in the **Units Of Measurement** tab of the **Settings** dialog box). Coordinates of the current cursor's position will be displayed in the second field of the status bar.

1.3 Creating a section

You are recommended to follow these steps to create a section:

- specify sizes (overall dimensions) of the section, ;
- define properties of the coordinate grid, ;
- set the strip thickness, ;
- add vertices, , and strips, ;
- smooth angles (if necessary) .

The vertices and strips can be added both in the graphical mode and in a tabular form. After you add a new vertex, its coordinates will checked for coincidence with those of previously added vertices. The coincident vertices are those the distance between which is less than or equal to a value specified in the **Accuracy** field on the **Other** tab of the **Settings** dialog box. If the vertices are coincident, the newer one will be deleted, and the strip will get the older one as its vertex.

When strips are added or vertices moved, the strips may happen to cross one another. In that case both a crossed strip and a crossing one will be divided into parts automatically, and a new vertex will appear at the point of their intersection. The fact of intersection is analyzed using the given accuracy value.

1.3.1 Coordinate grid

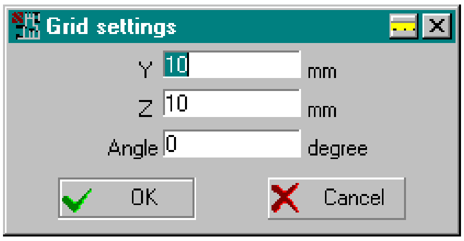


Fig. 4. *The* **Grid Properties** *dialog box*

Properties of a coordinate grid are specified in the **Grid Properties** dialog box (Fig. 4) which opens after youu invoke the respective action. The edit fields of this dialog let you specify a horizontal and vertical grid spacing, and the slope of the grid in degrees with respect to the horizontal axis. The grid is rotated about the coordinate origin.

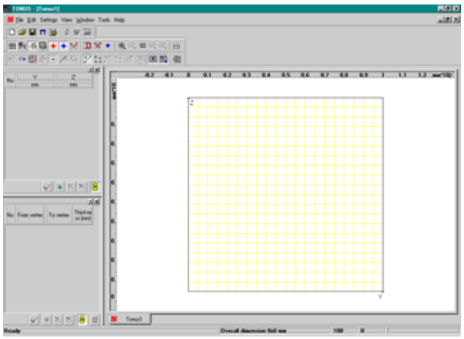
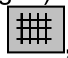
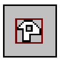


Fig. 5. *A grid displayed in the working area*

Note that the grid spacing and its slope can be varied as many times as needed during the creation of the section's interior contours or editing of the exterior one.

The grid will be displayed as soon as you finish entering its properties (Fig. 5). Its visualization is turned on and off by the **Grid** button, **,** on the toolbar.

1.3.2 Overall dimensions



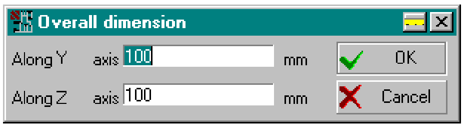


Fig. 6. *The* **Overall Dimensions** *dialog box*

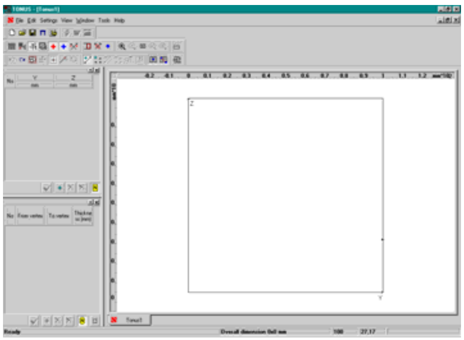
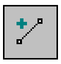


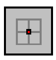
Fig. 7. *Overall dimensions displayed in the working area*

A section is created on a coordinate grid the overall dimensions of which match those of the section. The overall dimensions are specified in the dialog box under the same name (Fig. 6) in units of measurement defined on the respective tab of the **Settings** dialog box.

A rectangle that bounds the section — a dimension box (Fig. 7) — is displayed in the working area. Values of the section's overall dimensions are displayed in the first field of the **Status Bar**. As long as no element is created in the section's area, the status bar will display the specified dimensions. As you add elements to the section, the field will display the actual current overall dimensions of it.

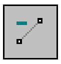
1.3.3 Strips



The strips are line segments. If the **Snap To Grid** mode is active —  depressed — the vertices of the segments will snap to a nearest grid node automatically as soon as they are added. To add a vertex, place the pointer onto a desired point of the working area (within the overall dimensions) and left click to confirm the creation of the new vertex. To interrupt the process, right click.

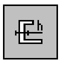
You can have tables of vertex coordinates and properties of strips displayed to the left from the working area (use the **Table Of Vertices** and **Table Of Strips** buttons, respectively). As you add a new strip, the table will be supplemented with information about new objects (vertices and strips).

1.3.4 Delete a strip



When this action is invoked, you can delete any of the strips that make up the section's walls. To do it, point at the strip and left click. The strip will be deleted automatically from the table of strips, too.

1.3.5 Assign thickness



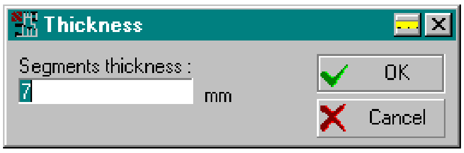
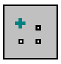
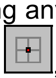


Fig. 8. *The* **Thickness** *dialog box*

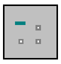
Clicking this button will open the **Thickness** dialog box (Fig. 8) the edit field in which is used to specify a thickness for your section's wall. The said value will be assigned by default to all newly added strips.

1.3.6 Vertices



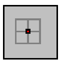
Use this action to add new vertices without adding any strips. To do it, point at a desired location with the mouse and left click. If the **Snap To Grid** mode, , is enabled, then the vertices will snap to a nearest coordinate grid node. The new vertices will be added to the table of vertices.

1.3.7 Delete a vertex



When this action is invoked, you need just to point at a vertex with the mouse and left click to delete it. All strips than join it will be deleted together with the vertex. The vertices and strips will be deleted also from the tables.

1.3.8 Snap to grid



When this mode is active, vertices being added will snap (i.e. will be automatically moved) to a coordinate grid node nearest to the pointer.

1.3.9 Smooth an angle

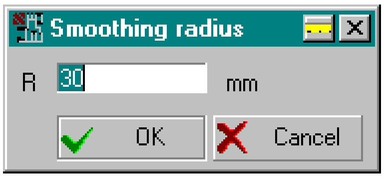
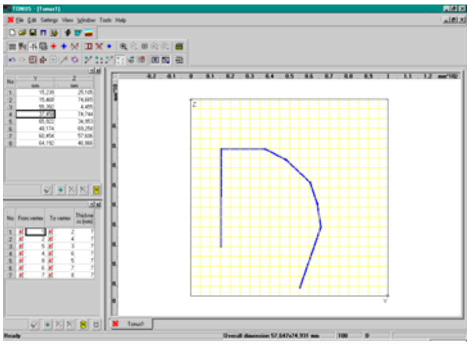


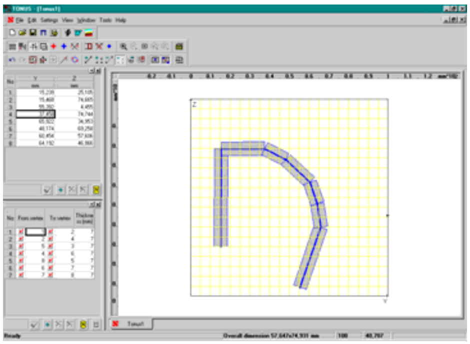
Fig. 9. *The* **Rounding Radius** *dialog box*

An angle can be smoothed by inscribing a circular arc of a given radius in it. After you invoke the action, point at a corner of the contour with the mouse, wait for the smoothing action cursor to appear, , and left click. In the **Rounding Radius** dialog box that opens (Fig. 9), specify a radius and click the **OK** button. Fig. 10, *a* shows a section in the form of a contour with its corners smoothed, and Fig. 10, *b* shows the same section with the **Show Thickness** mode enabled.

The number of points (vertices) on a circular arc is set on the **Other** tab of the **Settings** dialog box.



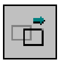
(a)



(b)

Fig. 10. *An example of a section with its angles smoothed*

1.3.10 Move a group of selected vertices



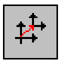
This action is used to move a group of vertices selected with a rectangular marquee. To do the move action, follow these steps:

- invoke the action;
- capture the vertices to be moved with the rectangular marquee;
- drag the marquee into a new position together with the vertices it captures.

To confirm the new position of the vertices, left click.

If moving the vertices causes any strips to intersect, the intersection points will become new vertices and the strips will be split.

1.3.11 Move the coordinate origin



This action is used to move the coordinate origin to a point with known coordinates, to a vertex, or to the center of mass of a section (Fig. 11). The application can calculate such things as the moments of inertia with respect to a custom coordinate system, not only the principal axes, therefore the capability of moving the coordinate origin can be useful in geometric analysis.

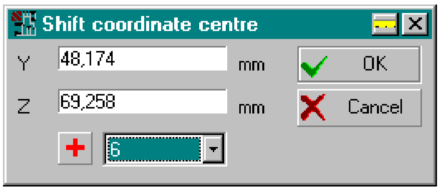
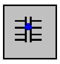


Fig. 11. *The* **Coordinate Origin** *dialog box*

If you need to move the coordinate origin to the center of mass or to a particular vertex, click the red cross button or choose No. of the vertex from the drop-down list, respectively. This will put the required coordinates into the edit fields.

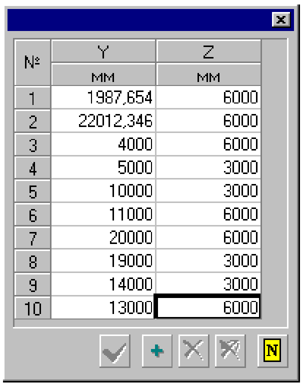
The coordinate origin will be actually moved to the specified point after you click the **Apply** button.

1.3.12 Table of vertices



To add, delete, or edit the coordinates of existing vertices, you can use a table placed on the table panel and opened when you click the respective button on the toolbar. A number of buttons is used to control the table editing process; the buttons are found under the table itself (Fig. 12).

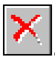
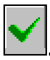
The table can be filled in either automatically, as you use graphic tools to add vertices and strips, or directly, by entering coordinates of new vertices to it. In the latter case you should click the + button before you can specify a vertex; this will add a new row to the table in which you enter the coordinates for the new vertex.



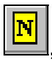
№	Y	Z
	мм	мм
1	1987,654	6000
2	22012,346	6000
3	4000	6000
4	5000	3000
5	10000	3000
6	11000	6000
7	20000	6000
8	19000	3000
9	14000	3000
10	13000	6000

Fig. 12. *A table of vertices*

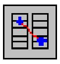
The results of editing the table will be displayed in the working area only after you click the **Apply** button, .

To delete vertices, you select the respective rows in the table and then click the button . The vertices in the section's view will be highlighted, but deleted only when you click the button . To remove the highlighting from the selected vertices, click the button .

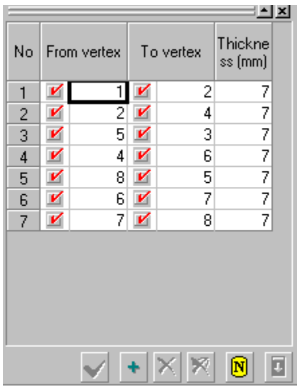
To select one or more successive rows, place the pointer onto No. of a row, click-and-hold the left mouse button, and drag the pointer to the last row you want to delete.

Use the **Numbering** button, , to have the vertices numbered in the section's view.

1.3.13 Table of strips



The table of strips is very similar to the table of vertices (Fig. 13). Each row of the table contains information about one strip. The information consists of Nos. of vertices at the beginning and end of a strip, accompanied by connection checkboxes, and of a thickness of the strip.

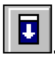


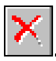
No	From vertex	To vertex	Thickness (mm)
1	1	2	7
2	2	4	7
3	5	3	7
4	4	6	7
5	8	5	7
6	6	7	7
7	7	8	7

Fig. 13. *A table of strips*

The table can be filled in either automatically, as you use graphic tools to add strips, or directly, by entering coordinates of new strips to it. In the latter case you should click the + button before you can specify a strip; this will add a new row to the table in which you specify the data for the new strip. If a strip is stiffly attached to other strips at its vertex, its respective connection checkbox wil be turned on (when you add strips with graphic tools, the checkboxes are turned on by default). A disabled checkbox means there is no connection between this particular strip and other ones that come into the same vertex.

By default the thickness of every new strip is set equal to a value specified with the **Thickness** button, . The thickness can be modified when adding new strips or by editing in the table.

To change the thickness of multiple strips, select the respective rows in the table and click the **Fill Thickness** button, . In the **Thickness** dialog box that appears, specify a new value and click the **Apply** button.

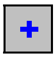
To delete selected strips (table rows), use the **Delete** button .

To select one or more successive rows, place the pointer onto a No. of a row, click-and-hold the left mouse button, and drag the pointer to the last row you want to delete.

The results of editing the table will be displayed in the working area only after you click the **Apply** button.

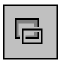
Use the **Numbering** button to have the strips numbered in the section's view.

1.3.14 Flexural center

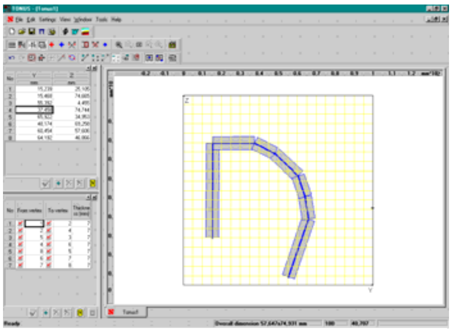
 (blue)

This button turns on the visibility of a section's flexural center.

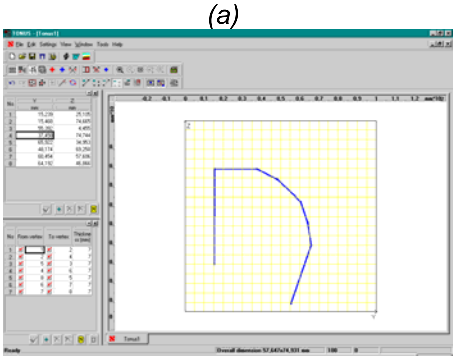
1.3.15 Show no thickness



Depending on whether this button is depressed or not, the working area will display either a whole section (if the button *is* depressed) or just a contour of it, that is, the median lines of the strips (Figs. 14, *a* and 14, *b*, respectively).



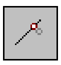
(a)



(b)

Fig. 14. *A section displayed in the working area*

1.3.16 Snap to vertices



If this is enabled, the distance measurement will be bound to nearest vertices, i.e. only the distances between vertices of a section can be measured.

1.3.17 Standard sections

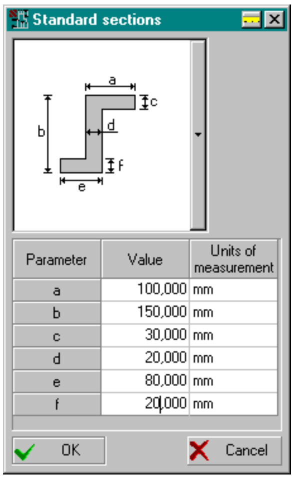


Fig. 15. *The* **Standard Sections** *dialog box*

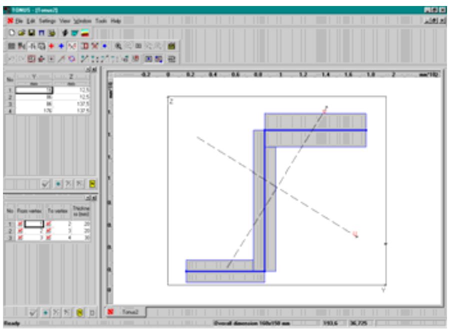


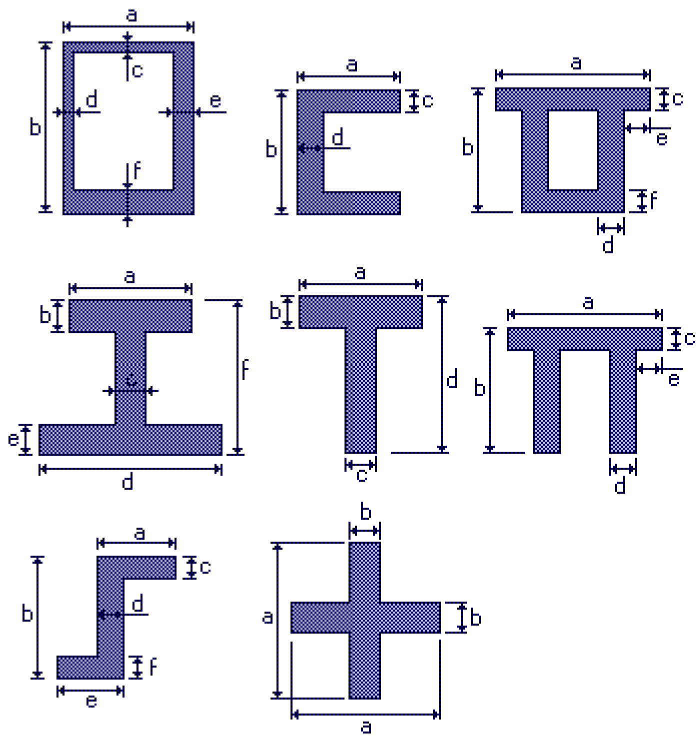
Fig. 16. *A section created with* **Tonus**

To create a section, you can use a set of standard parametric sections/profiles. Use the **Create Standard Section** item from the **File** menu. This will open a dialog box (Fig. 15) which contains a list of standard sections, a picture of a selected one, a legend of its properties, and a few fields to enter numerical values of those.

To add a section, do the following:

- choose a desired section from the drop-down list;
- enter numbers in the fields as the chosen model requires;
- click the **OK** button.

The last action will close the dialog, and the working area of the **Tonus** application will display the section that has been just created (Fig. 16). The following set of standard parametric sections is available in the application:



2. Appendices

2.1 Definitions of geometric characteristics

2.1.1 Moments of inertia

To calculate some of the geometric characteristics (such as an area, moments of inertia, a location of a center of mass), we actually calculate moments of an area (Ω) covered by a section, that is, we deal with quantities like this:

$$\nu_{pq} = \int_{\Omega} y^p z^q dydz .$$

For example, at $p = q = 0$ this expression becomes the area of the section, A.

Sometimes it is necessary to calculate a moment normalized by the area (A), that is, a quantity like this:

$$\alpha_{pq} = \nu_{pq} / A .$$

For example, the α_{01} and α_{10} quantities will be coordinates of the section's center of mass.

At $p + q \geq 2$, centered (central) moments are of interest:

$$\mu_{pq} = \int_{\Omega} (y - \alpha_{10})^p (z - \alpha_{01})^q dydz .$$

The μ_{20}, μ_{02}, μ_{11} quantities are central moments of inertia with respect to the **Z**, **Y** axes and a cetrifugal moment of inertia, respectively.

2.1.2 Principal moments of inertia, a slope of principal axes

The principal moments of inertia are calculated by this formula:

$$I_{u/v} = \frac{(I_y + I_z)}{2} \pm \sqrt{\left(\frac{I_y - I_z}{2}\right)^2 + I_{yz}^2} .$$

This is a slope of the principal axes of inertia:

$$\alpha = \operatorname{arctg}\left(\frac{I_{yz}}{I_y - I_{u/v}}\right) .$$

In the last formula, you should substitute I_u to its right part to find a slope of the axis of the maximum moment of inertia; to find a slope of the minimum inertia moment axis, substitute I_v.

Note: The **Konsul** application does not confine you to working with an area bounded by polygons; curves are also allowed (these may appear when you use the “Smooth an angle” or “Make a round orifice” actions). In the latter case the application will replace the curve by a polygonal line to do the calculation.

2.1.3 Radii of inertia

$$i_y = \sqrt{\frac{I_y}{A}} ; \quad i_z = \sqrt{\frac{I_z}{A}} ; \quad i_u = \sqrt{\frac{I_u}{A}} ; \quad i_v = \sqrt{\frac{I_v}{A}} .$$

2.1.4 Moduli of section

Axial moduli of section

$$W_{u+} = \frac{I_u}{v_{\max}}; \quad W_{u-} = \frac{I_u}{v_{\min}}; \quad W_{v+} = \frac{I_v}{u_{\max}}; \quad W_{v-} = \frac{I_v}{u_{\min}},$$

where $u_{\max}$, $u_{\min}$, $v_{\max}$, $v_{\min}$ are respective maximum distances from points of the section's exterior boundary to the **U, V** axes (on one and the other sides).

Polar modulus of section

$$W_\rho = \frac{I_y + I_z}{\rho_{\max}},$$

where $\rho_{\max}$ is a maximum distance from points of the section to its center of mass.

The $I_y + I_z$ quantity is called a ***polar moment of inertia***.

2.1.5 Core distances

$$a_{u+} = \frac{W_{u+}}{A}; \quad a_{u-} = \frac{W_{u-}}{A}; \quad a_{v+} = \frac{W_{v+}}{A}; \quad a_{v-} = \frac{W_{v-}}{A}.$$

2.1.6 Torsional stiffness

Let's consider a function $\varphi(y, z)$ in the Ω area (a stress function or Prandtl's function) which satisfies the equation $\Delta\varphi + 2 = 0$ and also $\varphi = 0$ on the boundary of Ω in the case when Ω is singly connected. In case of a multiply connected area (i.e. if there are orifices) we assume that $\varphi = 0$ on the exterior boundary of the area Ω and it is constant on every interior boundary (L_i, i=1, … n), the constants U_i (i=1, … n) being such that the following relationships hold:

$$\oint_{L_i} \frac{\partial\varphi}{\partial n} ds = -2\Omega_i$$

where Ω_i is an area bounded by the contour L_i.

The quantity $I_t = 2\left(\int_\Omega \varphi(y, z)dy \quad dz + \sum_{i=1}^{n} U_i \Omega_i\right)$ is called a torsional moment of inertia.

2.1.7 Flexural center

The coordinates of the flexural center (in principal central axes) can be determined by these formulas:

$$y = \frac{1}{J_y} \int_\Omega \omega(y, z) z \quad dy \quad dz;$$

$$z = -\frac{1}{J_z} \int_\Omega \omega(y, z) y \quad dy \quad dz,$$

where $\omega(y,z)$ is Saint-Venant's torsion function, or a displacement function. This function is harmonic in the Ω area ($\Delta\omega = 0$) and satisfies the following condition on the boundary:

$$\frac{\partial\omega}{\partial n} = z \quad \cos \quad ny - y \quad \cos \quad nz$$

Also,

$$\oint \frac{\partial \omega}{\partial n} ds = 0 .$$

2.1.8 Shear areas of a section

Suppose Fig. 17 depicts a section, and its **Y**, **Z** axes are principal ones.

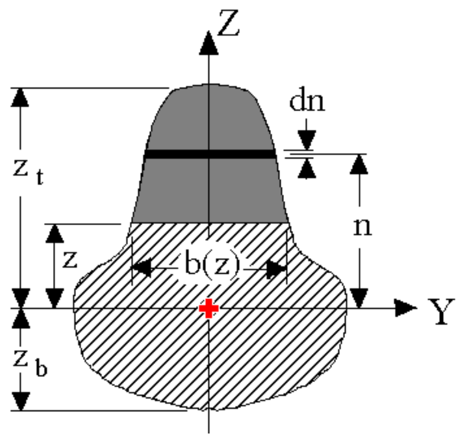


Рис. 17

Let

$$Q(z) = \int_{z}^{z_t} n\, b(n)\, dn .$$

A shear area with respect to the **Y** axis is a quantity

$$\frac{I_y^2}{\int_{z_b}^{z_t} \frac{Q(z)^2}{b(z)} dz}$$

In the same way a shear area with respect to the **Z** axis can be defined.

2.1.9 Plastic moduli of section

Let **Ω** be an area occupied by the section. Let **Ω₂** be a part of the **Ω** area lying on one side of the principal axis **U**. A ***plastic modulus of section*** for bending with respect to the **U** axis is a quantity

$$W_{\mathrm{pl},u} = 2 \int_{\Omega_2} v d\omega .$$

In the similar way, a plastic modulus $W_{\mathrm{pl},v}$ with respect to the **V** principal axis can be defined.

2.1.10 Sectorial characteristics

A bimoment (***sectorial moment***) of inertia of a solid section is

$$I_\omega = \int_\Omega \omega^2 (y, z) \;\; dy \;\;\; dz,$$

where $\omega(y,z)$ is Saint-Venant's torsion function. In a thin-walled section, the sectorial moment is defined by V.Z.Vlasov's theory (see [2, 1]).

Note that the sectorial characteristics are usual in the thin-walled bar theory developed by V.Z.Vlasov [2]. However, G.Y. Janelidze [3] has shown that the above formulas, obviously applicable to all sections, conform with the accuracy $1+O(h/\rho)$ to the concepts of the biboment and the sectorial static moment of Vlasov's theory, where h is a thin-walled section's thickness and ρ is its radius of curvature.

2.1.11 Normal stresses

You are required to specify components of integral forces in the section, i.e. the N component of an integral force vector and the M_u, M_v components of an integral moment of forces with respect to the section's center of mass.

The normal stress at a point is equal to

$$\sigma = \frac{N}{A} - \frac{M_u \; v}{I_u} - \frac{M_v \; u}{I_v}$$

where $N, \; M_u, \; M_v$ are the respective normal force and moments (in principal axes) that act in the section;

u, v are coordinates of a point in the section's principal axes.

2.2 File formats

2.2.1 Konsul application

The application is capable of importing sections created by other software. In particular, **Konsul** can import files of the **CON** format (which can be created, for example, by the **SCAD** system [5]).

CON files are plain text ones of the following structure:

- ◊ a section is defined as a set of polygons;
- ◊ first polygon is an exterior contour, and the next ones (if any) define orifices (interior contours);
- ◊ each polygon (both exterior and interior) must be defined in the following format:
  - first line is an integer number *n* defining the number of vertices in the polygon;
  - next go *n* lines, each one containing three floating-point numbers — coordinates of a vertex in the section's plane and a radius of the rounded corner in that vertex (the latter number may be absent when there is no rounding).

All sizes are specified in meters. The numbers in a line are separated by spaces. The decimal separator is a period.

Example: A section shown in Fig. 18 is described in the **CON** format as follows:

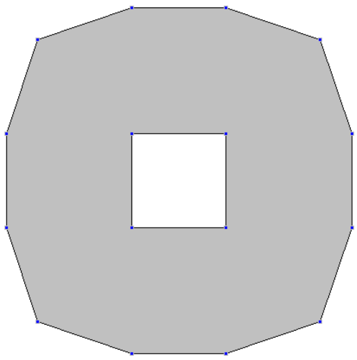


Fig. 18

```
12
  -1.000   3.000
   0.000   0.000
   3.000  -1.000
   6.000  -1.000
   9.000   0.000
  10.000   3.000
  10.000   6.000
   9.000   9.000
   6.000  10.000
   3.000  10.000
   0.000   9.000
  -1.000   6.000
4
   3.000   3.000
   6.000   3.000
   6.000   6.000
   3.000   6.000
```

2.2.2 Tonus application

TNS files are plain text files. A section is defined by a set of vertices and segments.

First line in a file specifies two numbers of the section's dimensions. The next line contains an integer, *n*, that defines the number of vertices. Next go *n* lines with coordinates of the vertices. Each line consists of two floating-point numbers separated by spaces. Then a line stands that contains an integer, *m*, to define the number of segments. This line must be followed by *m* lines of segment descriptions. Each line that describes a segment contains five numbers. First two numbers are integers; they are respective Nos. of start and end vertices (the vertices are numbered starting from 0). The second couple of integers (each can be either 0 or 1) defines whether the respective ends of a segment are connected to their vertices. The last number in the line is a thickness of the segment.

All sizes are specified in meters. The numbers in a line are separated by spaces. The decimal separator is a period.

Example: A section shown in Fig. 19 is described in the **TNS** format as follows:

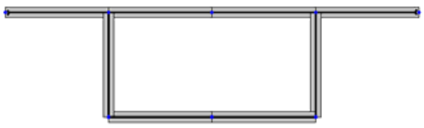


Fig. 19

```
100.0 100.0
9
25.0 75.0
35.0 75.0
45.0 75.0
55.0 75.0
65.0 75.0
55.0 65.0
45.0 65.0
35.0 65.0
45.0 75.0
9
0 1 0 1 1.0
1 2 1 1 1.0
2 3 1 1 1.0
3 4 1 0 1.0
3 5 1 1 1.0
5 6 1 1 1.0
6 7 1 1 1.0
7 1 1 1 1.0
8 2 1 1 1.0
```

2.3 Service tools

2.3.1 Formula calculator

As you work with the software package, sometimes you need to perform certain relevant auxiliary calculations. The **Tools** menu contains items for invoking additional calculators: a standard MS Windows one (if it has been installed together with the system), and a special calculator (Fig. 20) that processes user-specified formulas.

This calculator is used to perform calculations by formulas that one can specify in a text edit field. The following rules should be observed when entering a formula:

- names of functions are entered in lowercase Roman letters;
- the fractional and the integral parts of a number are separated by a period;
- arithmetic operations are specified by the symbols +, –, *, /, ^ (raising to a power); for example, 2.5*2.5*2.5 can be written also as 2.5^3.

The following mathematical functions can be used in the formulas:

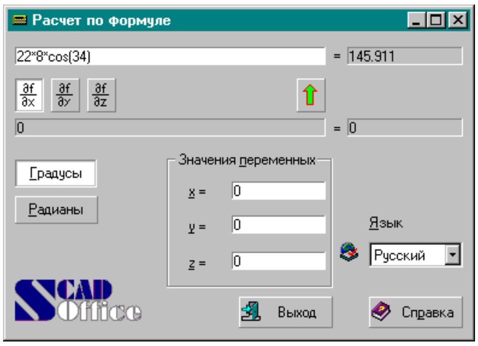


Fig. 20. *The calculator's window*

floor — the greatest integer not greater than the argument;;
tan — tangent;
sin — sine;
cos — cosine;
asin — arc sine;
acos — arc cosine;
atan — arc tangent;
exp — exponent;
ceil — the least integer greater than the argument;
tanh — hyperbolic tangent;
sinh — hyperbolic sine;
cosh — hyperbolic cosine;
log — natural logarithm;
log10 — decimal logarithm;
abs — absolute value;
sqrt — square root.

Depending on the state of the **Degrees/Radians** switch buttons, arguments of the trigonometric functions (**sin, cos, tan**) and results of inverse trigonometric functions (**asin, acos, atan**) can be presented in degrees or radians, respectively.

Only parentheses are allowed for grouping arguments together; these can be nested as deeply as desired.

Example.

The following formula

$$1,2+\sin(0,43)+6,7\sqrt{6,8}-\sqrt[5]{0,003}$$

should be written as follows:

1.2+sin(0.43)+6.7*sqrt(6.8)–0.003^(1/5).

There is an additional option of using three independent variables **x, y, z** in formulas. Values for the variables will be specified in respective edit fields. This makes it possible to perform a series of similar calculations with different parameters. For example, to use this mode with the following formula:

$$1,2+\sin(x)+6,7\sqrt{6,8}-\sqrt[5]{y}$$

write it as

1.2+sin(x)+6.7*sqrt(6.8)–y^(1/5).

The application lets you also write a symbolic expression in the formula edit field that depends on the variables *x, y, z* and then enable one of the selection buttons, $\frac{\partial f}{\partial x}$, $\frac{\partial f}{\partial y}$, $\frac{\partial f}{\partial z}$, to get a symbolic expression for the respective partial derivative.

2.3.2 Converter of measurement units

This converter can be started both from the **SCAD Office** program group with the icon and from the **Tools** menu. The application converts between data specified in different units of measurement (Fig. 21). To do the action, select a tab of respective measures (**Length**, **Area** etc.).

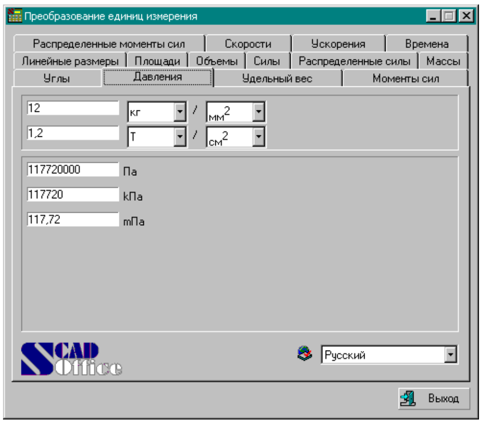


Fig. 21. *The* **Convert Units Of Measurement** *dialog box*

The conversion procedure depends on whether the units are simple (such as length, area, or time) or compound (such as pressure, velocity, or specific weight).

To convert a simple unit, you just enter a number in one of the text fields. Its respective values in all the other units will be displayed automatically. If the unit is compound, select units to convert from in the drop-down lists of one row and select units to convert to in the lists of the other row. Next, enter a number in the edit field of the first row, and see the conversion result in the second row field.

2.3.3

2.3.4 Rolled profile catalogue browser

The browser can be started from the **SCAD Office** folder on the desktop and used to browse through rolled steel profile databases/catalogues. The browser's window (Fig. 22) contains a list of the databases and a table of profile properties.

To see a table of profiles of a certain type, you should open a list of profiles of a respective database and choose the name of a group of your desired profiles in it.

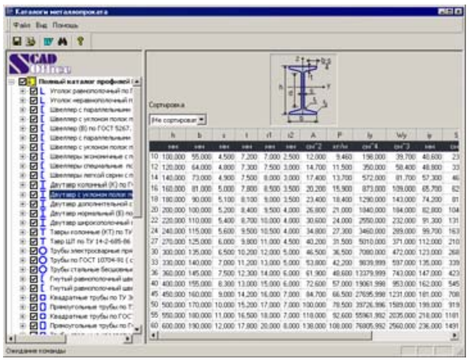


Fig. 22. *The profile browser's window*

To get a picture of a profile of particular dimensions, you should open the profile group's list and choose a desired profile in it (Fig. 23).

There are checkboxes to the left from the profile names in the list, which are enabled by default. Disabling a checkbox will exclude profiles thus indicated from a list which will be used for proportioning in the steel construction section check mode; however, the disabled profile can still be used to associate stiffness properties with elements.

The profile tables can be sorted in an ascending order of various characteristics. To choose a characteristics, use the **Sort** drop down list. By default, the order in which the profiles follow one another in the list will conform to that in the standard (or the catalogue).

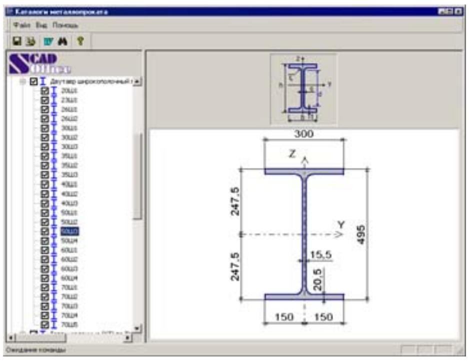
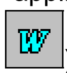
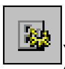


Fig. 23. *Viewing a profile*

If necessary, a selected table of profiles can be exported as RTF file to a word processing application associated with this format (the **Report** button, ). If a catalogue or database rather than a group of profiles is selected for printing, then all profile tables of that catalogue/database will be printed out.

The setup of the view/print mode (the **Settings** button, ) follows the same conventions as those in the applications described earlier.

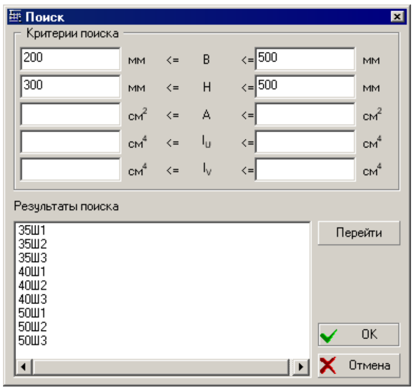
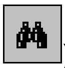


Fig. 24. *The* **Find** *dialog box*

To search for a profile that matches certain geometric characteristics (the **Find** button, ), use a dialog box under the respective name (Fig. 24). In the text fields of the **Search criteria** group you put down characteristics (minimum and maximum) of a profile, to use as search criteria. Clicking the **OK** button will start the search. If one or more profiles matching the specified characteristics are found, their names will be displayed in the **Search results** list.

As you select one of the found profiles in the list and click the **Go** button, the selected profile will be highlighted in the section table.

2.4 List of assortments (databases) of rolled profiles shipped with the software package

List of sections of the full GOST profile catalogue
Angle, equal, per GOST 8509-93
Angle, unequal, per GOST 8510-86*
Channel with parallel web faces, per GOST 8240-89
Channel (B) per GOST 5267yu1-90
Channel, with oblique webs, per GOST 8240-89
Double-T for columns (K) per GOST 26020-83
Double-T with oblique webs, per 8239-89
Double-T of additional series (D), per GOST 26020-83
Double-T, normal (B), per GOST 26020-83
Double-T, wide-flange, per GOST 26020-83
T-shape for columns (KT), per TU 14-2-685-86
T-shape ShT per TU 14-2-685-86
Pipes, electric welded, longitudinal, per GOST 10704-91
Pipes, per GOST 10704-91 (shortened)
Pipes, steel, seamless, hot-formed
Roll-formed equal-web channel, per GOST 8278-83, of steels C239-C245
Roll-formed equal-web channel, per GOST 8278-83, of steels C255-C275
Square pipes, per TU 36-2287-80
Rectangular pipes, per TU 67-2287-80
Channels, economical, with parallel web faces, per GOST 8240-97
Channels of lightweight series, with parallel web faces, per GOST 8240-97
Channels, special, per GOST 8240-97
Channel with parallel web faces, per GOST 8240-97
Channel with oblique webs, per GOST 8240-97
List of sections of the GOST abridged database
Angle, equal, per GOST 8509-93
Angle, unequal, per GOST 8510-86*
Channel with parallel web faces, per GOST 8240-89
Double-T for columns (K), per GOST 26020-83
Double-T with oblique webs, per GOST 8239-89
Channel with oblique webs, per GOST 8240-89
Double-T of additional series (D), per GOST 26020-83
Double-T, normal (B), per GOST 26020-83
Double-T, wide-flange, per GOST 26020-83
T-shapes for columns (KT), per ТУ 14-2-685-86
T-shape ShT per TU 14-2-685-86
Pipes, electric welded, longitudinal
Roll-formed equal-web channel, per GOST 8278-83, of steels C239-C245
Roll-formed equal-web channel, per GOST 8278-83, of steels C255-C275
Square pipes per ТУ 36-2287-80
Rectangular pipes per ТУ 67-2287-80

List of sections of the assortment of Chelyabinsk Integrated Iron-And-Steel Works
Double-T, normal (B), per STO ASCHM 20-93
Double-T, wide-flange, per STO ASCHM 20-93
Double-T, for columns (K), per STO ASCHM 20-93
Double-T, per R40-93
Special double-Ts, per STO ASCHM
List of sections of old assortments
Angle, equal, per OST 14-1926
Angle, equal, per OST 14-1932
Angle, unequal, per OST 15-1926
Angle, unequal, per OST 15-1932
Double-T (H-beam), per OST 16-1926
Double-T (H-beam), per OST 16-193
Channel with oblique webs, per OST 17-1926
Channel with oblique webs, per OST 17-1933
H beams per OST 10016-39
Channel per OST 10017-39
Angle, equal, per OST 10014-39
Angle, unequal, per OST 10015-39
List of sections of Great Britain assortments, standard profiles
Double-T Universal Beams to BS4
Double-T Universal Columns to BS4
Double-T Universal Bearing Piles to BS4
Pipe, rectangular, EN10210 (UK)
Pipe, round, EN10210(UK)
Pipe, square, EN10210 (UK)
Double-T, Joists
Angle, equal
Angle, unequal
Channel
Tees from UBs to BS4
Tees from UCs to BS4
List of sections of Great Britain assortments, imported profiles
Double-T ASTM Shapes
Double-T Euronorm IPE Sections
Double-T Euronorm HE Sections
Pipe, rectangular, EN10210 (OS)
Pipe, round, EN10210 (OS)
Pipe, square, EN10210 (OS)
List of sections in OTUA
Equal angle (NF A 45-009)
Unequal angle (NF A 45-010)
Double-T with oblique webs (NF A 45-210)
Double-T with parallel webs (NF A 45-206)

Double-T with parallel webs (NF A 45-206)
Double-T with parallel webs (NF A 45-206)
Double-T with parallel webs (NF A 45-206)
Double-T with parallel webs (NF A 45-211)
Double-T with parallel webs (NF A 45-211)
Double-T with parallel webs (NF A 45-211)
Double-T with parallel webs (NF A 45-211)
T-shape
T-shape
T-shape
T-shape
T-shape
T-shape
T-shape
T-shape
Channel UPN (NF A 45-202)
Channel UPN-A (NF A 45-202)
Channel UAP (NF A 45-255)
Channel UAP-A (NF A 45-255)
Pipe, round
Pipe, rectangular
Pipe, square
List of sections of DIN
Equal angle per DIN 1028
Unequal angle per DIN 1029
Double-T beams per DIN 1025
H-beams per DIN 1025 (parallel flanges)
H-beams per DIN 1025 (9% slope)
Channels per DIN 1026
Pipe, round, DIN 2448
Pipe, rectangular, DIN 59410
Pipe, square, DIN 59410
List of sections of ARBED
Equal angle per 56-77
Unequal angle per Euronorm 57-78
Double-T IPE Euronorm 19-57
Double-T IPN
Double-T HE Euronorm 53-62
Double-T HL Euronorm 53-62
Double-T HD
Double-T HP
Double-T W
Double-T UB
Double-T UC
Channel UAP
Channel UPN

List of sections of ASTM
Equal angle
Unequal angle
Double-T HP
Double-T M
Double-T S
Double-T W
T-shape MT
T-shape ST
T-shape WT
Channel C
Channel MC
Pipe, round, P
Pipe, round, PX
Pipe, round, PXX
Pipe, square
Pipe, rectangular
List of welded profile assortments
Welded double-T per TU У 01412851.001-95
List of sections in the Indian assortment
Equal angle
Unequal angle
Double-T ISHB
Double-T ISJB
Double-T ISLB
Double-T ISMB
Channel ISJC
Channel ISLC
Channel ISMC
Pipe, round
List of sections in the Japanese assortment
Equal angle per JIS G3192:1990
Unequal angle
Unequal angle 2
I beam, narrow, per JIS G3192:1990
I beam, medium
I-beam, wide (H-beam) per JIS G3192:1990
Channel per JIS G3192:1990
T-shape, narrow
T-shape, medium
T-shape, wide
Pipe, round
Pipe, rectangular
Pipe, square

List of sections in the assortments of zinked steel cables per GOST
Cable, locked-coil, load-bearing, with two layers of Z-shaped wire and a TK-type core. GOST 18901-73*
Cable, double lay, LK-RO type. ТУ 14-4-902-78
Cable, locked-coil, load-bearing, with one layer of Z-shaped wire and a TK-type core. GOST 3090-73*
Cable, locked-coil, with one layer of wedge and Z-shaped wire and a TK-type core. GOST 7675-73*
Cable, locked-coil, with layers of wedge and Z-shaped wire and a TK-type core. GOST 7676-73*
Cables, zinked steel, spiral, locked-coil. TU 14-4-1216-82
Cable of single lay, LK-O type. GOST 3062-80*
Cable of single lay, TK-type. GOST 3063-80*
Cable of single lay, T12 type. GOST 3064-80*
Cable of double lay, LK-O type. GOST 3066-80*
Cable of double lay, LK-3 type. GOST 7667-80*
Cable, steel, double lay, DK-RO type. GOST 7669-80*
Cable of double lay, LK-R type. GOST 14954-80*
List of sections of the rebar assortment per GOST
Reinforcement of Class A-I per GOST 5781-82*
Reinforcement of Class A-II per GOST 5781-82*
Reinforcement of Class A-III per GOST 5781-82*
Reinforcement of Class A-IV per GOST 5781-82*
Reinforcement of Class A-V per GOST 5781-82*
Reinforcement of Class A-VI per GOST 5781-82*
Reinforcement of Class At-VII per GOST 10884-81
Reinforcement of Class Bp-I per GOST 6727-80
Reinforcement of Class Bp -II per GOST 7348-81
Reinforcement of Class V-II per GOST 7348-81
Reinforcement of Class A400C per STO ASCHM 7-93
Reinforcement of Class A500C per STO ASCHM 7-93
Reinforcement cables of Class K-7 per GOST 13840-68
Reinforcement cables of Class K-19 per TU 14-4-22-71
List of sections of the rebar assortment in Republic of Belarus
Reinforcement of Classes S400, S500 per TU RB 190266671.001-2002
Reinforcement of Classes S400, S500 per TU RB 04778771.001-97
Reinforcement of Class S800 per TU RB 04778771.001-97
Reinforcement of Class S500 per STB1341-2002
List of sections of the rebar assortment as per ENV 10080:1996
Reinforcement of Class B500A per ENV 10080:1996
Reinforcement of Class B500B per ENV 10080:1996
Reinforcement of Class B450C per ENV 10080:1996

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