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This book contains a description of the functional capabilities of the **KUST** and **CoCon** programs, as well as their application technologies and recommendations for their use.
The program is meant for structural designers with minimum computer skills.

Table of Contents

1. KUST – Design-Theoretical Reference Manual

1.1 General Information

The **KUST** reference program has been developed by the **SCAD Soft** company and makes part of the **SCAD Office** system. It is designed for solving a certain class of mechanics problems for which there exist analytical or sufficiently accurate approximate solutions that can be found in the relevant literature.

Though the majority of these problems can be solved with the help of the **SCAD** product, using the **KUST** program makes it possible to obtain a solution without creating design models. Moreover, some of the obtained results can be used to specify the initial data when building a finite-element model (e.g., effective length factors, estimation of natural frequencies, etc.).

All problems that can be solved by this program can be classified into the following categories:

- stability of equilibrium;
- natural vibration frequencies;
- other oscillation problems;
- static analysis;
- auxiliary calculations.

The formulation of most of the considered problems is clear and quite simple. Therefore, this reference manual provides only their brief statements, the list of the required initial data, and the results to be obtained by solving them. More detailed information can be found in the references given in the end of each section.

Interface

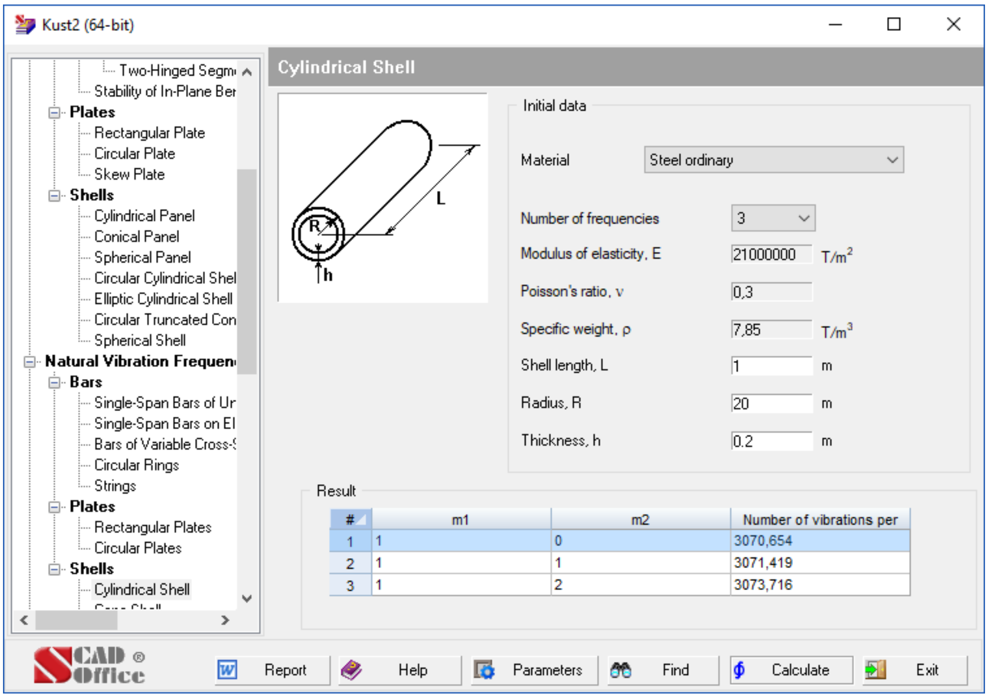


Figure 1.1-1. **KUST** *window*

KUST window has the same set of controls in all modes, namely:

- the problem tree which serves for selecting the problem to be solved;
- text fields used to enter initial data;
- display fields for the analysis results;
- functional buttons for activation of analysis and invocation of different control operations (report generation, help, etc.).

Problem Tree

The problem tree has three levels of hierarchy. The first level contains the names of the problem groups such as STABILITY OF EQUILIBRIUM or NATURAL VIBRATION FREQUENCIES. The second level contains the types of structural components such as Bars, Plates; the third level suggests the name of a particular problem. To invoke a problem type, place the mouse pointer over its name and left-click.

Text Fields

When entering data in the text fields, it is allowed to use floating-point numbers (e. g., 0.214) or their scientific notation (e. g., 1.23e5). The integer and fractional parts are separated by a decimal point. A comma can also be used for this purpose, provided this is indicated in the Windows environment settings. Checking of the entered data validity takes place in the course of analysis.

Functional Buttons

The functional buttons serve to perform the following control operations:

Calculate — activation of the operations of the initial data validation and calculation performance;

Report — generation of a report containing the analysis results;

Parameters — invokes the **Settings** dialog box where you can customize the program (see below);

Help — reference information on the **KUST** program;

Find — a search in the problem tree by the context in the problem name. The search is performed in the **Find in problem tree** dialog box (Fig. 1.1-2) where you should first specify the sought-for text and then click the **Find** button. That done, a list of all problems the names of which contain the specified text will appear in the **Result** list.

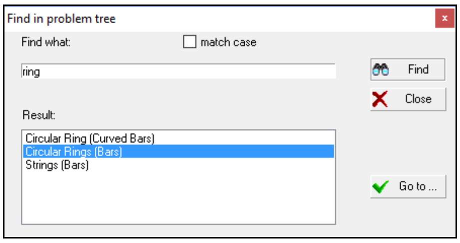


Figure 1.1-2. *The* **Find in problem tree** *dialog box*

If you hover the mouse pointer over the desired problem and click the **Go to** button, the control in the tree will be transferred to the specified problem. To perform the calculation, close the search dialog box.

Exit — exits the program.

Calculation

To perform the calculation, select a problem in the tree, enter the initial data in the text fields, and click the **Calculate** button.

Controls

Principles and means of control implemented in the software are uniform and provide a consistent interactive environment. The program uses a common system of Windows dialog boxes. The following controls and means for accessing information can be used:

- functional buttons, "clicking" which is used to invoke particular functions or modes; to do it, place the mouse pointer over a button and left-click;
- radio buttons and checkboxes which enable you to make a choice from a predefined set of options;
- text fields used to enter initial data for the analysis. Initial data consist of numbers. If the entered number is not an integer, its integer and fractional parts are separated by a period or another separator. The separator is assigned by the user during the customization of the operating system (see **Settings | Regional Settings | Number**). Moreover, the numbers can be entered in scientific notation, for example, 1.56e-7 (when specifying numerical data, you can enter not only numbers, but also simple arithmetic expressions, for example, 0.9*190.8+4.5);
- drop-down or static lists for selecting data;
- tables to enter or display information in a tabular form;
- dynamically digitized diagrams that display values of functions for an argument pointed to by the mouse pointer on the screen.

Settings

This dialog box can be invoked at any moment when working with **Kust**. It is used to customize general parameters of the program. The dialog contains the following tabs: **Units of Measurement, Report and Languages**, **Visualization**, **Sections** and **General**.

Each tab opens a page where you can adjust certain types of settings.

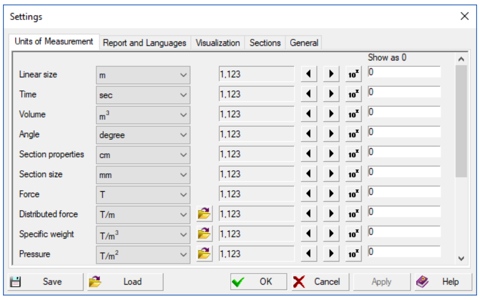


Figure 1.1-3. *The* **Units of Measurement** *tab*

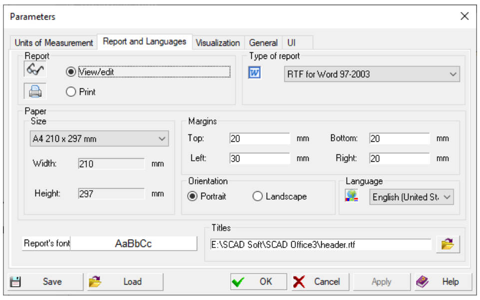


Figure 1.1-4. *The* **Report and Languages** *tab*

The **Units of Measurement** tab (Fig. **Error! Reference source not found.**-3) enables you to define units of measurement used in the analysis. It contains two groups of data. The first group is used to specify measurement units of linear sizes, forces, moments, etc. For compound units (such as those of moment, pressure, etc.), there is a possibility to define their component units (such as those for force and for moment arm) separately using the button . The second group helps to choose a representation and precision of numerical data. Special controls are used here to select data representation formats. Make sure to specify the number of significant digits in either the fixed-point decimal representation or the floating-point scientific notation.The precision of the data representation (the number of significant digits after the decimal point) can be assigned using the (decrease) and (increase) buttons, while the scientific notation is turned on by the button . You can also specify in respective text fields which values should be treated as negligibly small, so that all absolute values less than the given ones will be displayed as 0 in all visualizations. The **Report and Languages** tab (Fig. 1-4-4) enables you to choose a language for the user interface and for the report.

There are two modes for working with a report document: **View/Edit** or **Print**.

In the **View/Edit** mode, clicking the **Report** button in any active dialog will open the report and allow you to view/edit it. An application associated with **RTF** (Rich Text Format) files (such as MS Word Pad or MS Word) will be invoked to serve this purpose. Obviously, it is the user who is fully responsible for any changes made to the text of the report (note that even results of the calculation can be edited). There are differences in RTF formats used by MS Word v.7, MS Word 97 (2000/XP) and Open Office. Therefore, the program allows you to choose one of the formats in the **Type of Report** mode (besides RTF a report can be created in the following formats DOC, PDF, HTML).

Clicking the **Print** button in the **Report** group will print the report in the form it has been generated by the program.

Use the **Titles** text field to specify an RTF file containing headers and footers for pages of the report document. The file can be selected from a standard list by clicking the button .

The **Paper Size** setting enables you to choose the paper format for printing the report (the size is selected from a drop-down list). Moreover, the margins and the page orientation can be selected before generating the report.

Report Font is used to choose a font type for the report. A double left click invokes a standard Windows dialog for selecting the font. Only the selected font type will be used in the generated reports (style and size are assigned by the software).

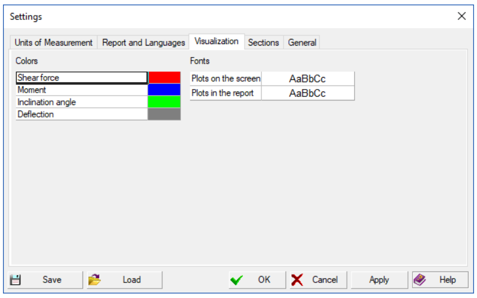


Figure 1.1-5. *The* **Visualization** *tab*

The **Visualization** tab (Fig. 1.1-5) contains two groups of controls: **Colors** and **Fonts**. Each group contains controls for selecting colors and fonts respectively. A double left click invokes a standard Windows dialog for selecting the color/font.

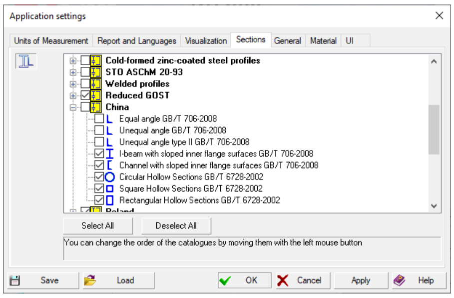


Figure 1.1-6. *The* **Sections** *tab*

The **Sections** tab (Fig. 1.1-6) is intended for selecting steel profile catalogues which will be used for creating compound sections. There is a checkbox next to each group of catalogues. If the checkbox is not checked, the respective group of catalogues will not be available in the application. Catalogues can be arranged in any convenient order (the same order will be used in the lists or the dialog boxes for the profile selection). To move an item, drag it while holding down the right mouse button.

The full list of assortments provided with the package is given in the appendix.

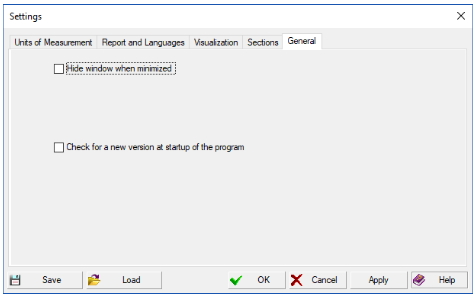


Figure 1.1-7. *The* **General** *tab*

The **General** tab **(**Fig. 1.1-7) allows you to activate the **Hide window when minimized** checkbox. When it is checked the window disappears from the task bar, and an icon appears in the tray area. The window can be opened from the tray area by the left click, and a context menu – by the right click.

Moreover, the **Check for a new version at startup of the program** checkbox can be activated as well. If it is active, the program will check for a new version on the company website at each startup, and it will give a respective message if it finds a new release.

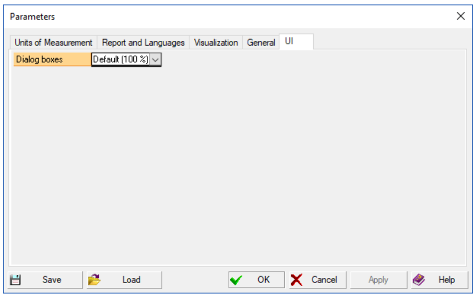


Figure 1.1-8. *The* **UI** *tab*

The **UI** tab **(**Fig. 1.1-8) enables to set scales for dialog boxes.

The settings provided in this tab are intended primarily for users with HiDPI displays.

Settings can be saved to an external file using the **Save** button, which can be subsequently loaded (the **Load** button).

Material Properties

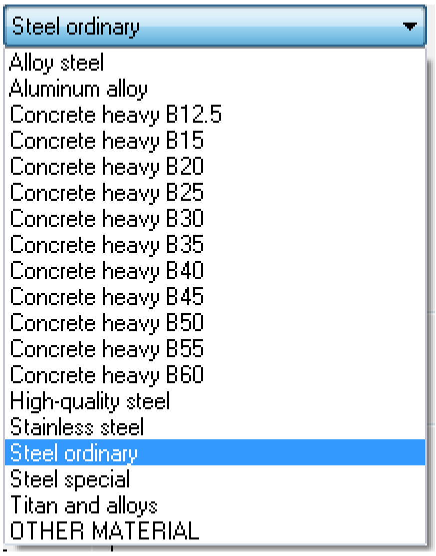


Figure 1.1-9. **Materials** *drop-down list*

Many of the problems handled by the **KUST** program require specification of physical properties of the materials a structure is made of. In most modes, this information can be specified in a unified way. This is done with the help of a drop-down list (see Fig. 1.1-9), from which you can choose the desired material. When you select a material in the list, all properties will be retrieved from the database coming with the program. To check your selection, the program displays the properties of the selected material (as a rule, it shows the modulus of elasticity, Poisson's ratio, etc.).

The **Materials Editor** program, described in the Appendix below, enables you to add, change or remove the data from the materials database. If you select the bottom item of the list, "OTHER MATERIAL", the respective text fields will offer you a possibility to enter the mechanical properties of the desired material, which is not available in the database. Naturally, before performing the analysis, the program will check the correctness of the information entered (for example, no Poisson's ratio greater than 0.5 can be specified).

Moments of Inertia

In many cases (when a bar structure is under consideration) it is required to specify the moment of inertia of a cross-section as the initial data for the analysis. If the structure is made of rolled profile, in order to facilitate specification of those data, the program has the service function activated by the button .

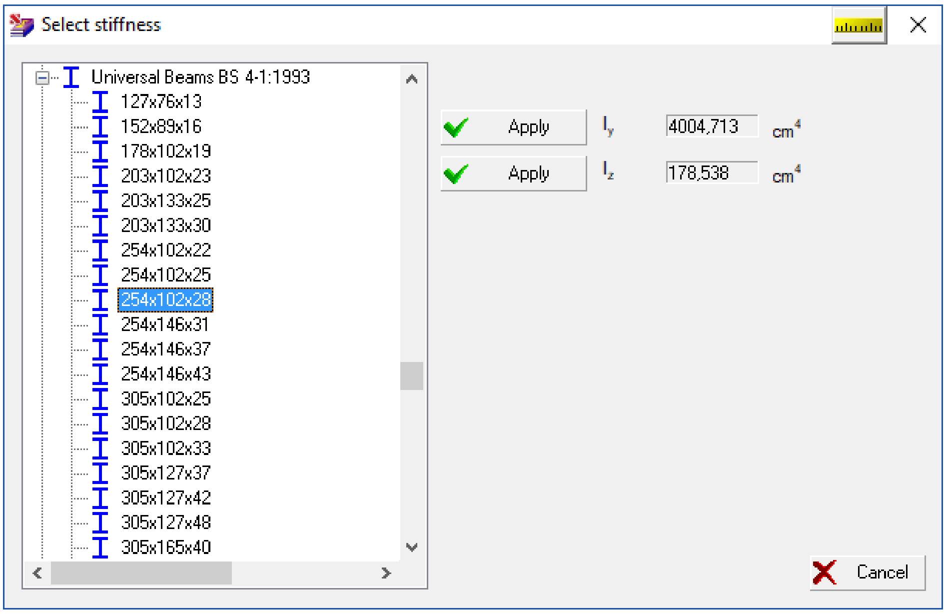


Fig. 1.1-10. **Select stiffness** *dialog box*

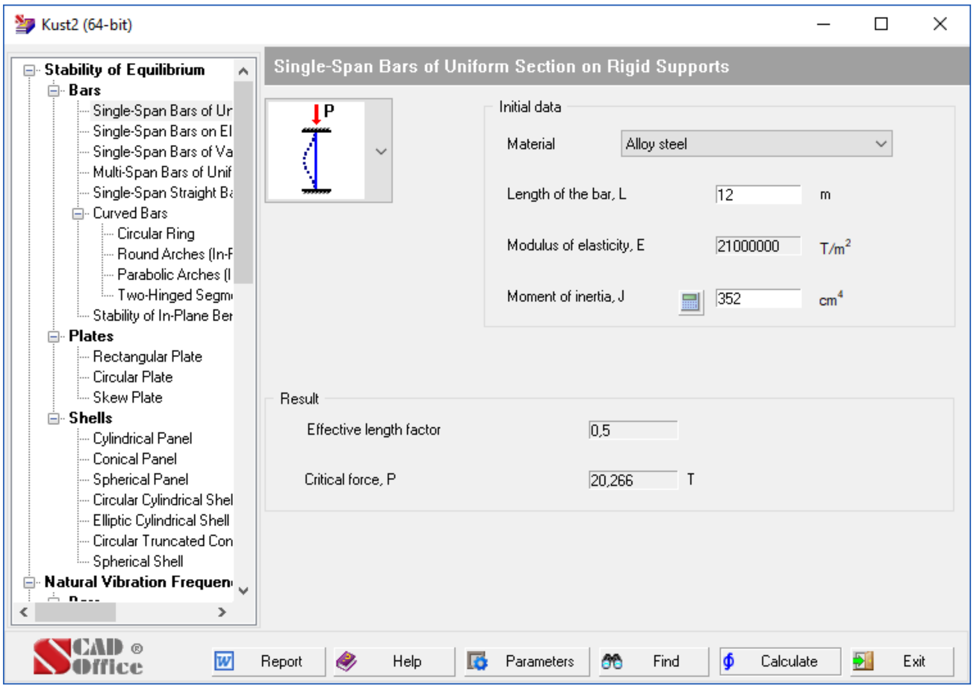
This will open the dialog box that shows a tree with a list of rolled profiles. Having selected a desired profile, the user gets the information about the moments of inertia with respect to the Y and Z axes of the selected section (the X axis is assumed to be collinear with the bar axis). Clicking one of the **Apply** buttons located near I_y and I_z will automatically transfer the moment of inertia information to the respective text field.

1.2 Stability of Equilibrium

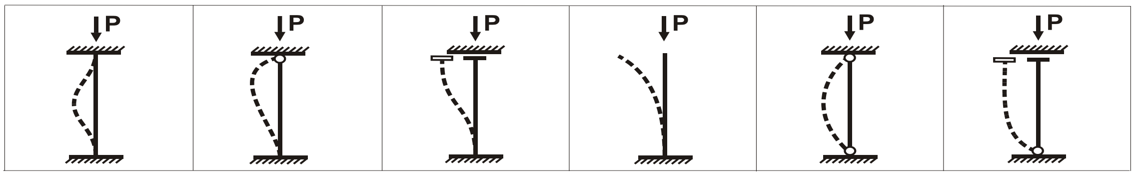
This section deals with the problems associated with the stability of equilibrium of different structures (determination of critical forces/stresses and analysis of the effective length factors for bar-type elements). *Upper* critical loads (i. e., the maximum load before reaching which the initial equilibrium state is stable with regard to small perturbations (stability in small)) are usually determined for shell structures.

Single-Span Bars of Uniform Section on Rigid Supports

The object of consideration is single-span bars of uniform-section on rigid supports with different boundary conditions under the action of a longitudinal compressive force P.



The following types of boundary conditions are analyzed:



They can be selected from the drop-down list. The initial data should include the length of the bar, the moment of inertia of its cross-section in the plane where buckling is expected, the modulus of elasticity (the latter can be specified by selecting one of the materials from the database or by entering an explicit value if the OTHER MATERIAL option has been selected from the materials list).

If the cross-section is a rolled profile, the moment of inertia can be retrieved from the profile database using the button described above in the *Moments of Inertia* section.

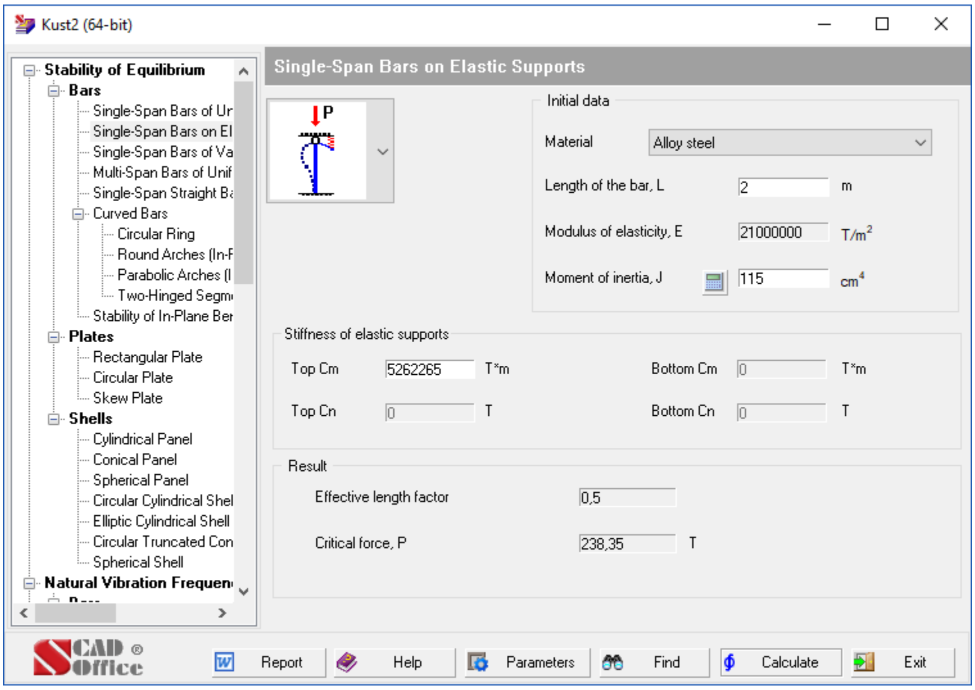
The result of the analysis will be the *effective length factor* (ratio between the effective and the actual bar length) and the *critical force value*.

References

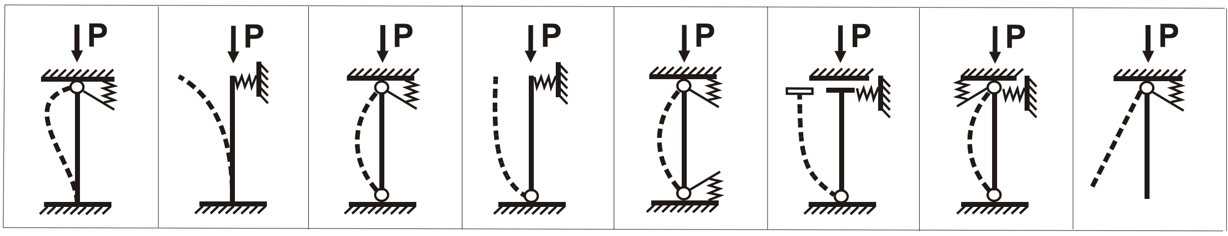
1. S. Timoshenko, J. Gere, *Mechanics of Materials*, Saint Petersburg — Moscow, Lan Publishers, 2002 — 669 pp. *In Russian.*

Single-Span Bars on Elastic Supports

The object of consideration is single-span bars of uniform-section on elastic supports with different boundary conditions under the action of a longitudinal compressive force P.



The following types of boundary conditions are analyzed:



They can be selected from the drop-down list. The initial data should include the length of the bar, the moment of inertia of its cross-section in the plane where buckling is expected, the modulus of elasticity (the latter can be specified by selecting one of the materials from the database or by entering an explicit value if the OTHER MATERIAL option has been selected from the materials list). Moreover, you have to specify the stiffness of the supports depending on the selected boundary conditions.

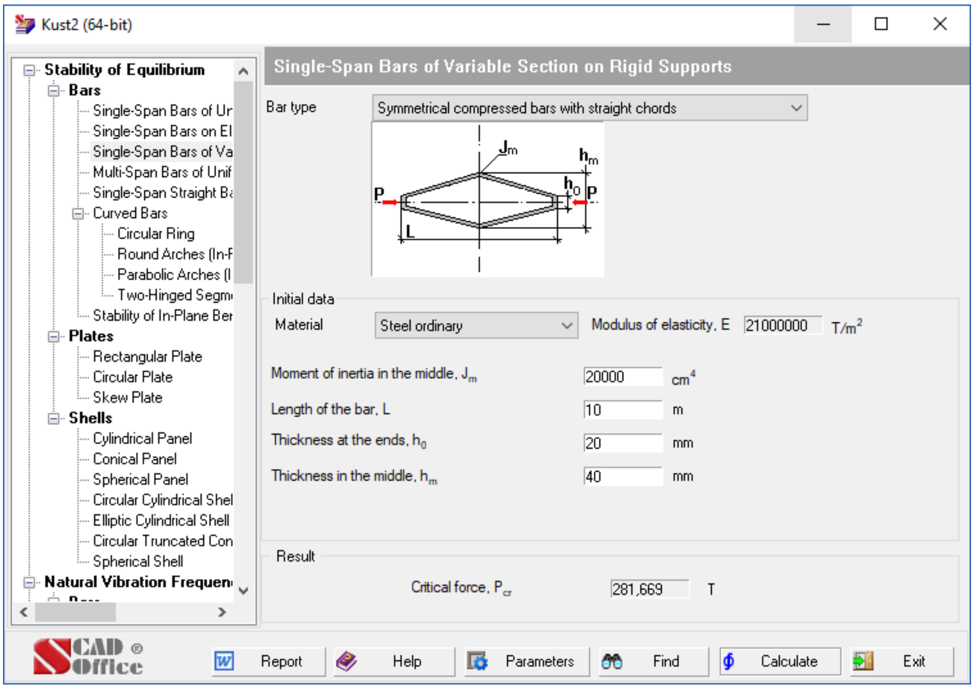
If the cross-section is a rolled profile, the moment of inertia can be retrieved from the profile database using the  button described above in the *Moments of Inertia* section.

The result of the analysis will be the *effective length factor* (ratio between the effective and the actual bar length) and the *critical force value*.

References

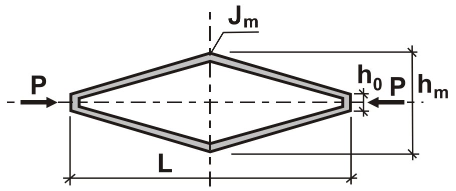
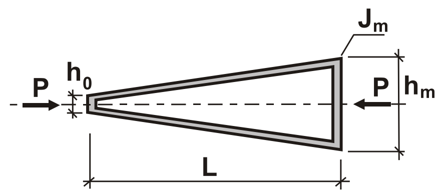
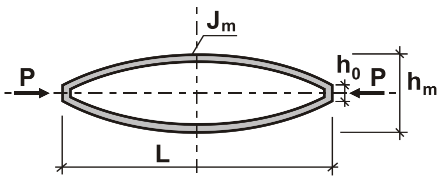
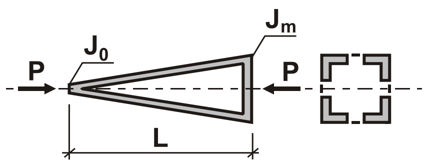
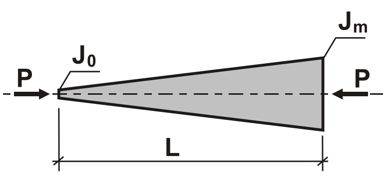
1. I.I. Goldenblat, A.M. Sizov, *Reference manual on stability/vibration structural analysis*, State Publishing House of Civil Engineering and Architecture Books, Moscow-Leningrad, 1952, 251 pp. (See Chapter 2). *In Russian.*

Single-Span Bars of Variable Section on Rigid Supports



The object of consideration is the stability of equilibrium of single-span bars of variable section on rigid supports under the action of a longitudinal compressive force P.

The following types of structures are analyzed:

 Symmetrical compressed bars with straight chords	 Asymmetrical compressed bars with straight chords
 Symmetrical compressed bars with parabolic chords	 Column made of four angles
 Solid conical bar	

The type of structure is selected from the drop-down list. The initial data should include the length of the bar and, depending on the analyzed structure, the moment of inertia of the bar cross-section and its thickness at the end and in the middle.

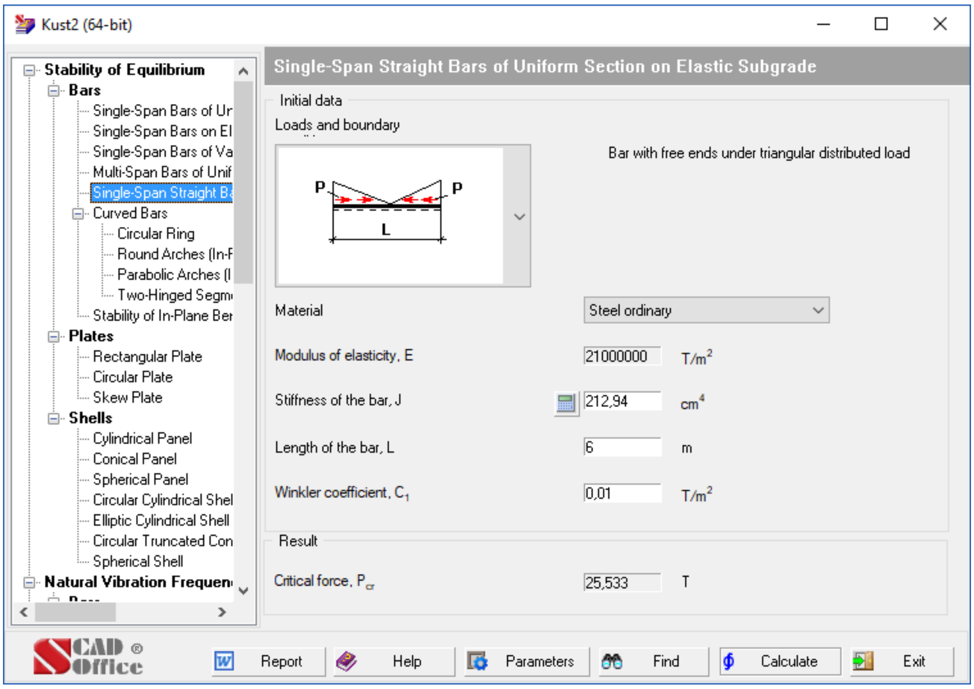
The result of the analysis will be the *critical force value*.

References

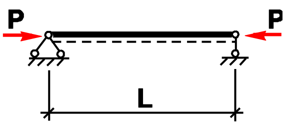
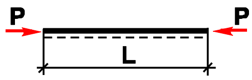
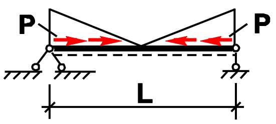
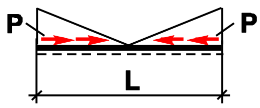
1. F. Bleich, *Stability of steel structures*, Moscow, Fizmatgiz Publishers, 1959, 544 pp. (See pp. 214-219.) . *In Russian.*

2. S.P. Timoshenko, *Stability of elastic systems*, State Publishing House of Technical and Theoretical Books, Moscow, 1955, 567 pp. (See pp. 148-151.) *In Russian.*

Single-Span Straight Bars of Uniform Section on Elastic Subgrade



The object of consideration is the stability of equilibrium of single-span bars of uniform section on elastic subgrade, with the following boundary conditions and loads:

 Simply supported bar on elastic subgrade	 Bar with free ends on elastic subgrade
 Simply supported bar under triangular distributed load	 Bar with free ends under triangular distributed load

The boundary conditions and load type are selected from the drop-down list. The initial data should include the length of the bar, the moment of inertia of its cross-section (stiffness), the modulus of elasticity (the latter can be specified by selecting one of the materials from the database or by entering an explicit value if the OTHER MATERIAL option has been selected from the materials list), and Winkler coefficient C_1.

If the cross-section is a rolled profile, the moment of inertia can be retrieved from the profile database using the  button described above in the *Moments of Inertia* section.

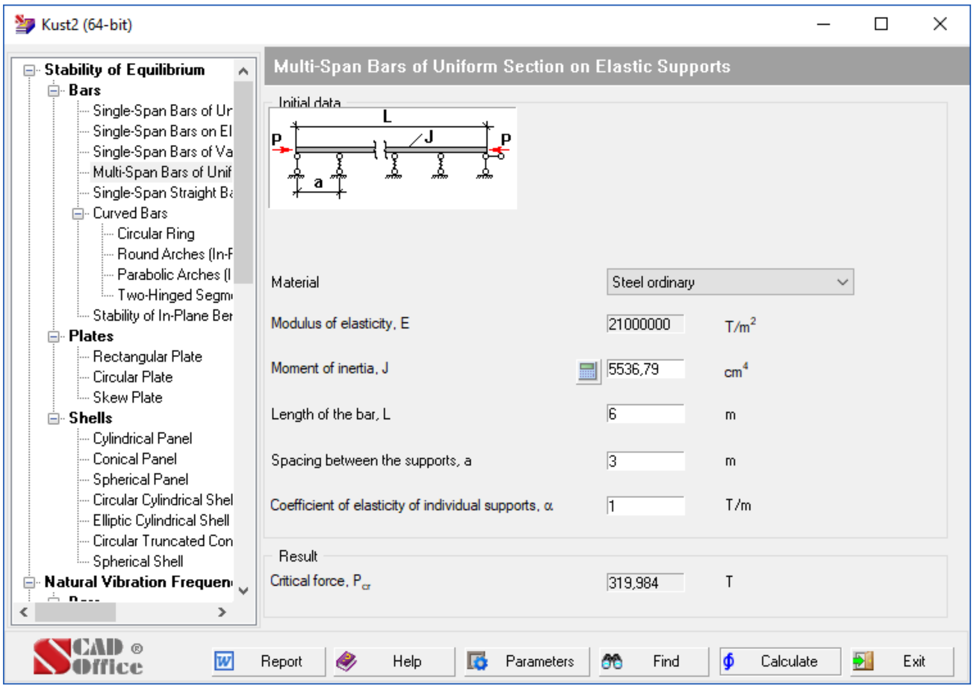
The result of the analysis will be the *critical force value*.

References

1. I.I. Goldenblat, A.M. Sizov, *Reference manual on stability/vibration structural analysis*, State Publishing House of Civil Engineering and Architecture Books, Moscow-Leningrad, 1952, 251 pp. (See p. 57, Paragraph 12). *In Russian.*

2. *Structural designer's reference manual. Design theory and analysis* (ed. by A.A. Umansky), State Publishing House of Civil Engineering and Architecture Books, Moscow-Leningrad, 1960, 1040 pp. (See p. 779, Paragraph 16.1.3). *In Russian.*

Multi-Span Bars of Uniform Section on Elastic Supports



The object of consideration is the stability of equilibrium of a multi-span bar of uniform section on elastic supports.

The initial data should include the length of the bar, the moment of inertia of its cross-section (stiffness), the modulus of elasticity (the latter can be specified by selecting one of the materials from the database or by entering an explicit value if the OTHER MATERIAL option has been selected from the materials list), the spacing between the supports, and the coefficient of elasticity of individual supports.

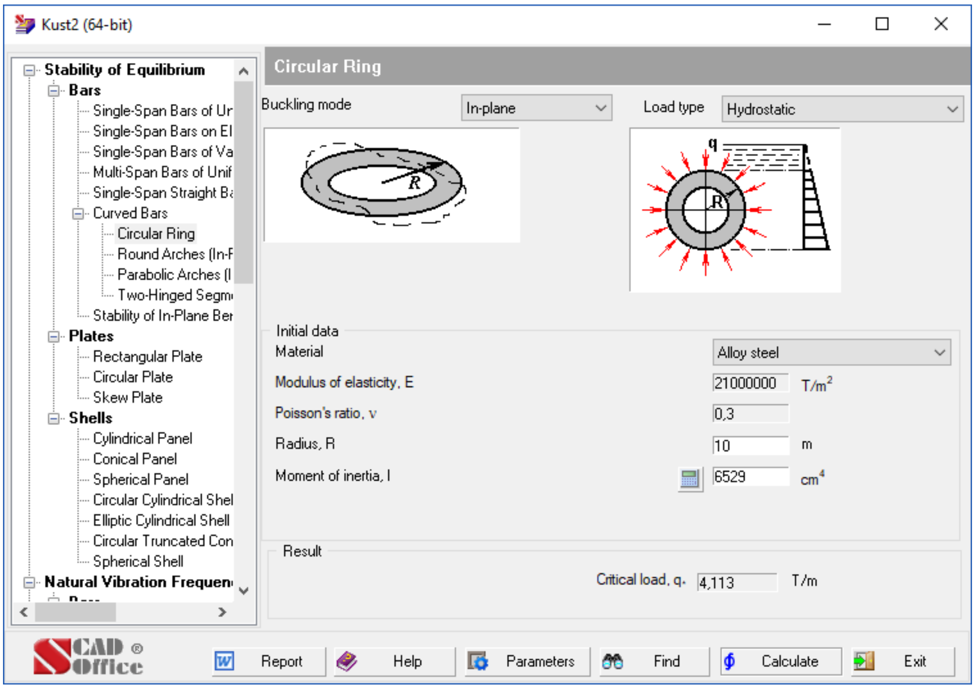
If the cross-section is a rolled profile, the moment of inertia can be retrieved from the profile database using the button described above in the *Moments of Inertia* section.

The result of the analysis will be the *critical force value*.

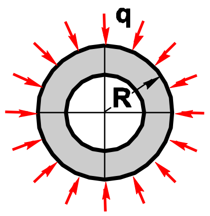
References

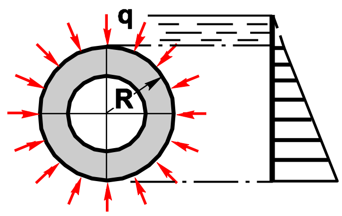
1. S.P. Timoshenko, *Stability of elastic systems*, State Publishing House of Technical and Theoretical Books, Moscow, 1955, 567 pp. (See page 113.) *In Russian.*

Circular Ring



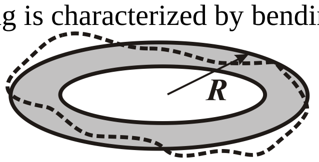
The object of consideration is a circular ring under the action of uniform external (polar) pressure or hydrostatic load.





The study is focused on the critical load that leads to the buckling of the ring in its plane or out of its plane.

The buckling in the plane of the ring is characterized by bending displacements in this plane.



The buckling out of the plane of the ring is characterized by bending displacements that are perpendicular to this plane.

The initial data should include the mode of buckling (in-plane/out-of-plane), the load type (polar/hydrostatic), the ring radius, the moment of inertia of the ring cross-section, the modulus of elasticity and Poisson’s ratio (the last two parameters can be specified by selecting one of the materials from the database or by entering an explicit value if the OTHER MATERIAL option has been selected in the materials list).

Depending on the selected buckling mode (in-plane/out-of-plane), it is necessary to specify the moment of inertia of the ring cross-section either in its plane or in the direction orthogonal to the ring plane.

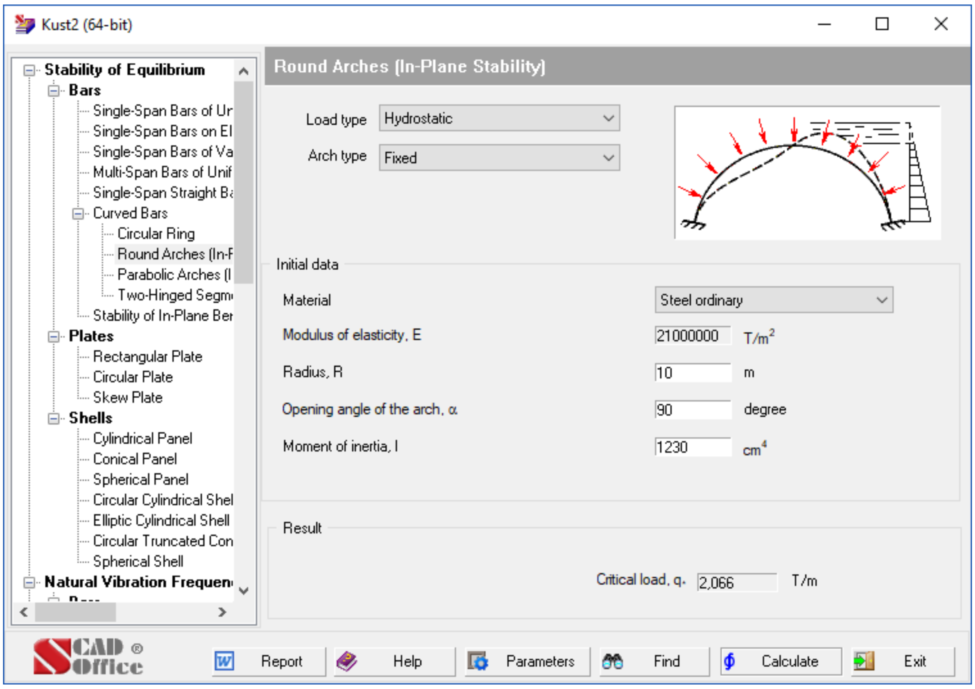
If the ring cross-section is a rolled profile, the moment of inertia can be retrieved from the profile database using the button , described above in the *Moments of Inertia* section.

The result of the analysis will be the *critical load value*.

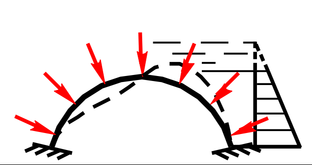
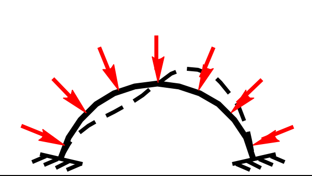
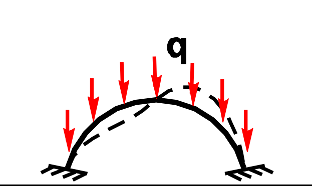
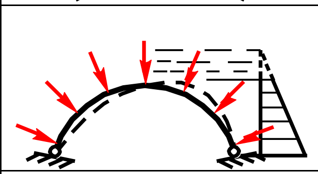
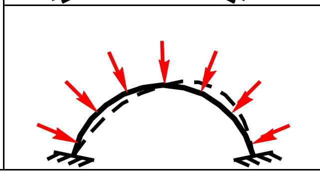
References

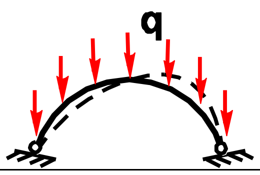
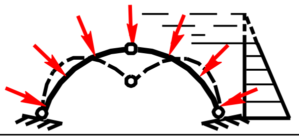
1. *Structural designer's reference manual. Design theory and analysis.* Vol. 2 (ed. by A.A. Umansky), Moscow, Stroyizdat Publishing House, 1973, 415 pp. (See p. 254, Paragraph 17.12.2). *In Russian.*

Round Arches (In-Plane Stability)



The object of consideration is the stability of equilibrium of round arches in their plane. The following combinations of loads and arch types can be analyzed.

Arch type		Load type
Fixed		Hydrostatic
		Polar
		Dead weight
Two-hinged		Hydrostatic
		Polar

Arch type		Load type
		Dead weight
Three-hinged		Hydrostatic

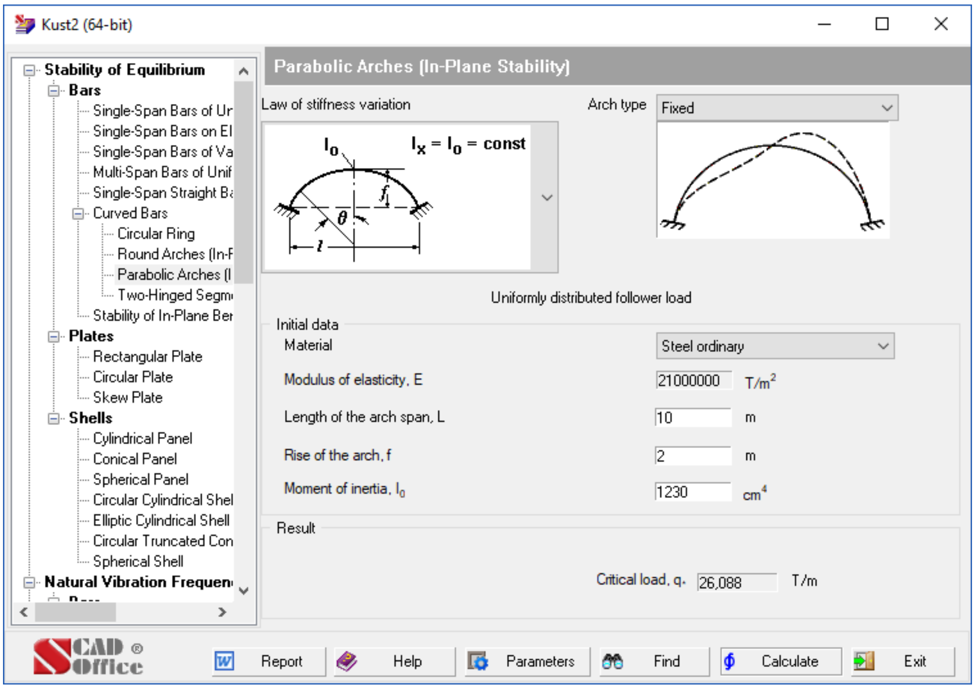
The arch and load types are selected from the drop-down list. The initial data should include the modulus of elasticity (the latter can be specified by selecting one of the materials from the database or by entering an explicit value if the OTHER MATERIAL option has been selected in the materials list), the arch radius, the opening angle of the arch, and the moment of inertia of the arch cross-section in its plane.

The result of the analysis will be the *critical load value*.

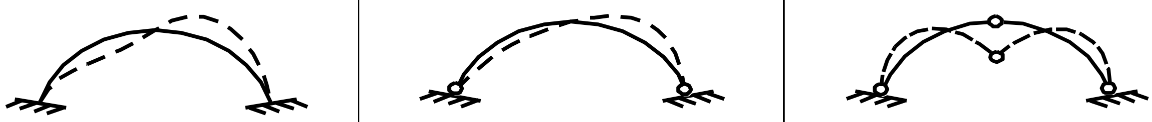
References

1. *Structural designer's reference manual. Design theory and analysis.* Vol. 2 (ed. by A. Umansky), Moscow, Stroyizdat Publishing House, 1973, 415 pp. (See p. 255). *In Russian.*

Parabolic Arches (In-Plane Stability)

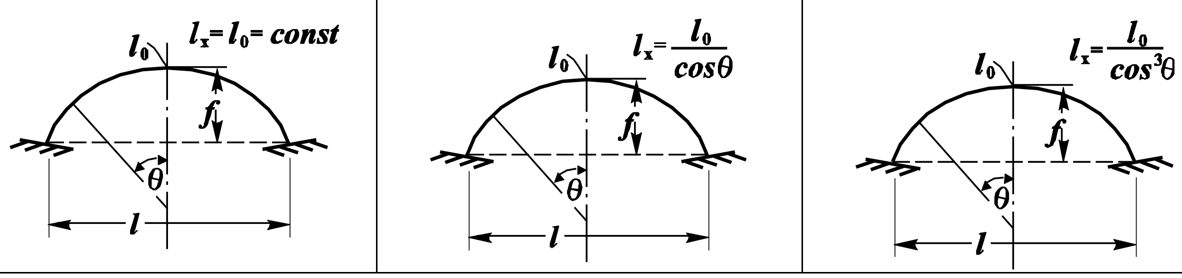


The object of consideration is the stability of equilibrium of parabolic arches (in their plane) under uniformly distributed *follower* load, for the following types of arches:



Fixed	Two-hinged	Three-hinged

The following laws of stiffness variation are assumed:



The arch type and the law of stiffness variation are selected from the drop-down lists. The initial data should include the modulus of elasticity (the latter can be specified by selecting one of the materials from the database or by entering an explicit value if the OTHER MATERIAL option has been selected in the materials list), the span and the rise of the arch, the moment of inertia of the arch cross-section in the middle of the arch (the moment of inertia *in the plane* of the arch should be specified).

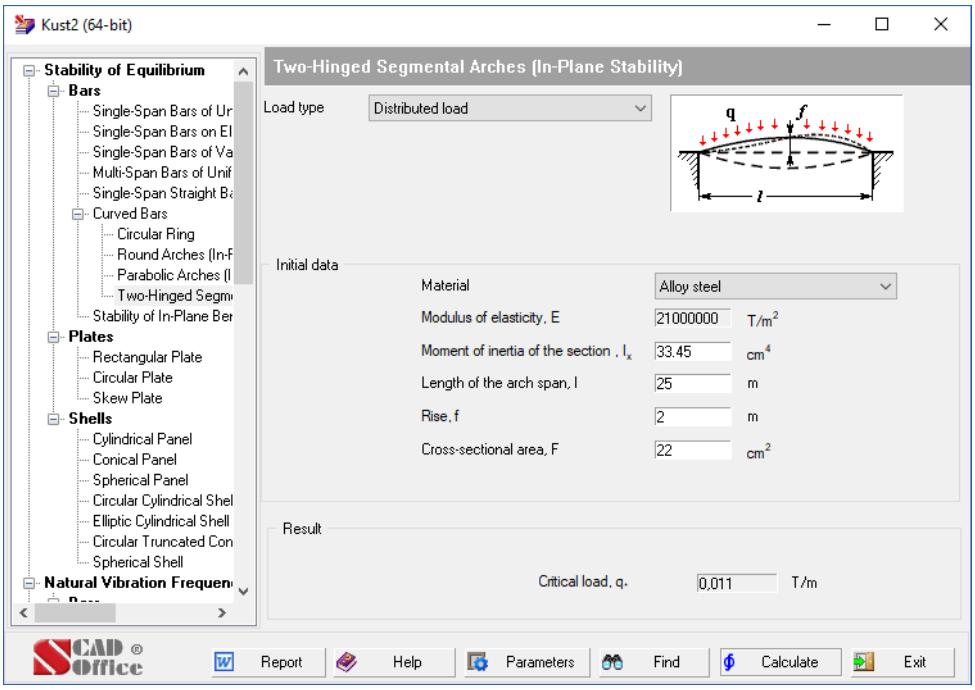
For three-hinged arches, where either a symmetric or antisymmetric buckling mode may occur, the program automatically analyzes both cases and calculates the minimum value of the critical load.

The result of the analysis will be the *critical load value*.

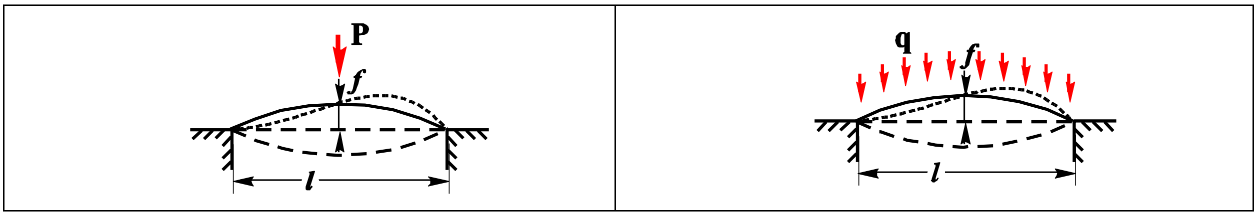
References

1. *Structural designer's reference manual. Design theory and analysis.* Vol. 2 (ed. by A.A. Umansky), Moscow, Stroyizdat Publishing House, 1973, 415 pp. (See p. 256.) *In Russian.*

Two-Hinged Segmental Arches (In-Plane Stability)



The object of consideration is the stability of equilibrium of a two-hinged segmental arch under a distributed load **q** or a concentrated force **P** applied to the keystone.



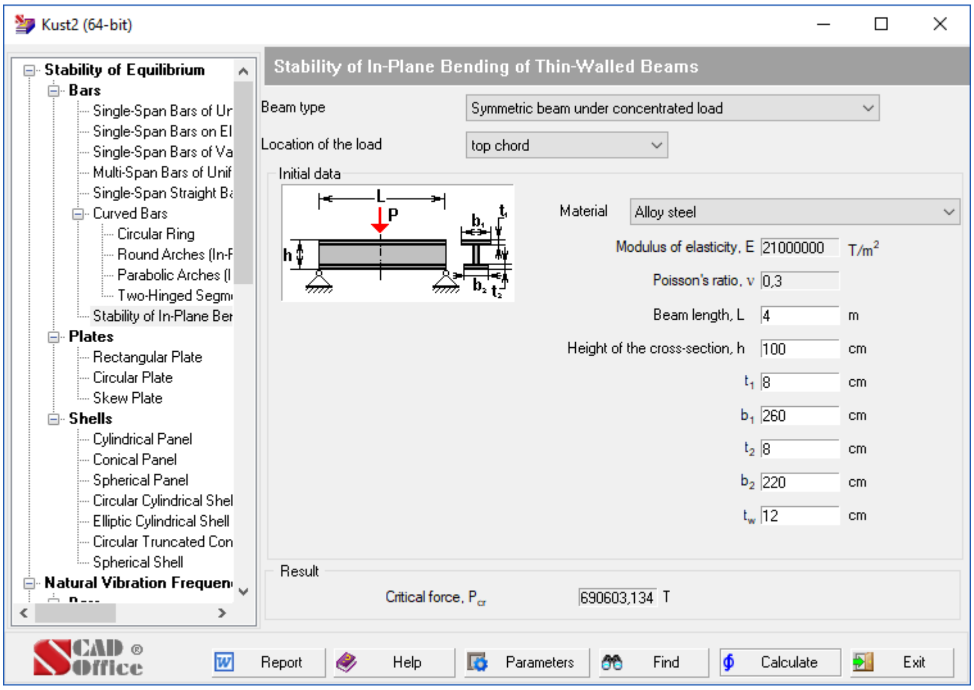
The initial data should include the modulus of elasticity (the latter can be specified by selecting one of the materials from the database or by entering an explicit value if the OTHER MATERIAL option has been selected in the materials list), the span and the rise of the arch, as well as the cross-section area and the moment of inertia with respect to the axis perpendicular to the plane of the arch.

The result of the analysis will be the *critical load value*.

References

1. *Structural designer's reference manual. Design theory and analysis.* Vol. 2 (ed. by A.A. Umansky), Moscow, Stroyizdat Publishing House, 1973, 415 pp. (See p. 256.) *In Russian.*

Stability of In-Plane Bending of Thin-Walled Beams



The object of consideration is the stability of in-plane bending of a thin-walled I-beam (either symmetric or asymmetric) under a uniformly distributed load or under a concentrated force.

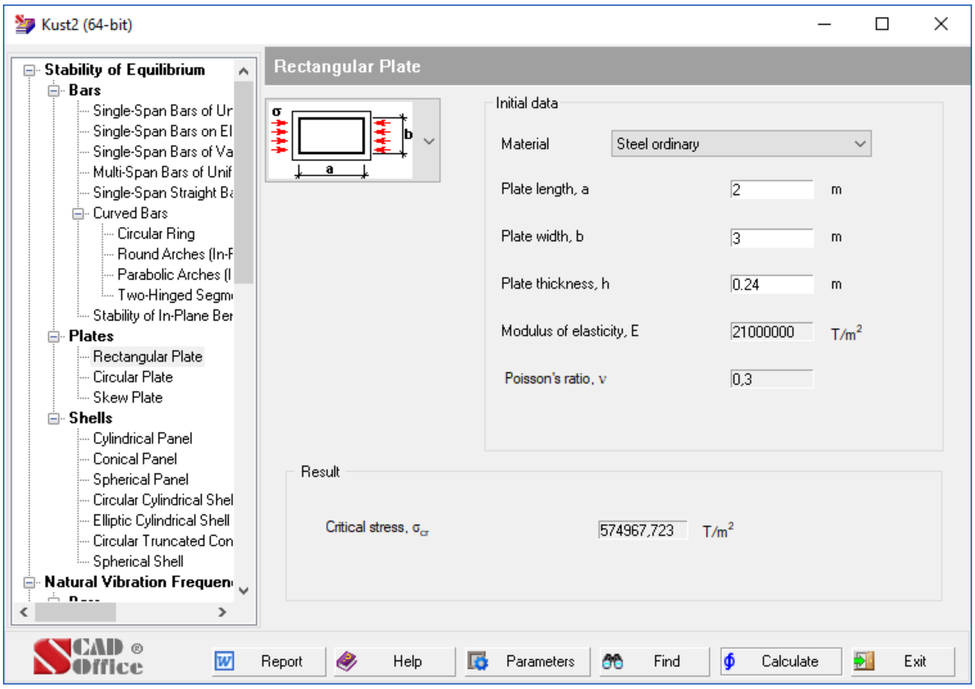
The beam type and the point of load application are selected from the drop-down lists. The initial data should include the type of the beam (symmetric or asymmetric) and the type of load (distributed or concentrated), the modulus of elasticity and Poisson's ratio (the last two parameters can be specified by selecting one of the materials from the database or by entering an explicit value if the OTHER MATERIAL option has been selected in the materials list), the span length and the cross-section size (width and thickness of the webs and flanges). Moreover, location of load application (bottom chord, top chord or the section mass center) has to be selected from the drop-down list.

The result of the analysis will be the *critical load value*.

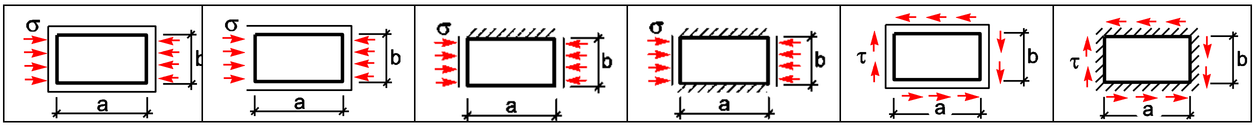
References

1. F. Bleich, *Stability of steel structures*, Moscow, Fizmatgiz Publishing House, 1959, 544 pp. (See p. 186.) . *In Russian.*

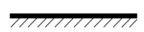
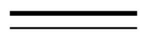
Rectangular Plate



The object of consideration is the stability of equilibrium of a rectangular plate with different boundary conditions and different loads (see the table below).



The following legend for the boundary conditions is used here:

Free edge	
Clamped edge	
Simply supported edge	

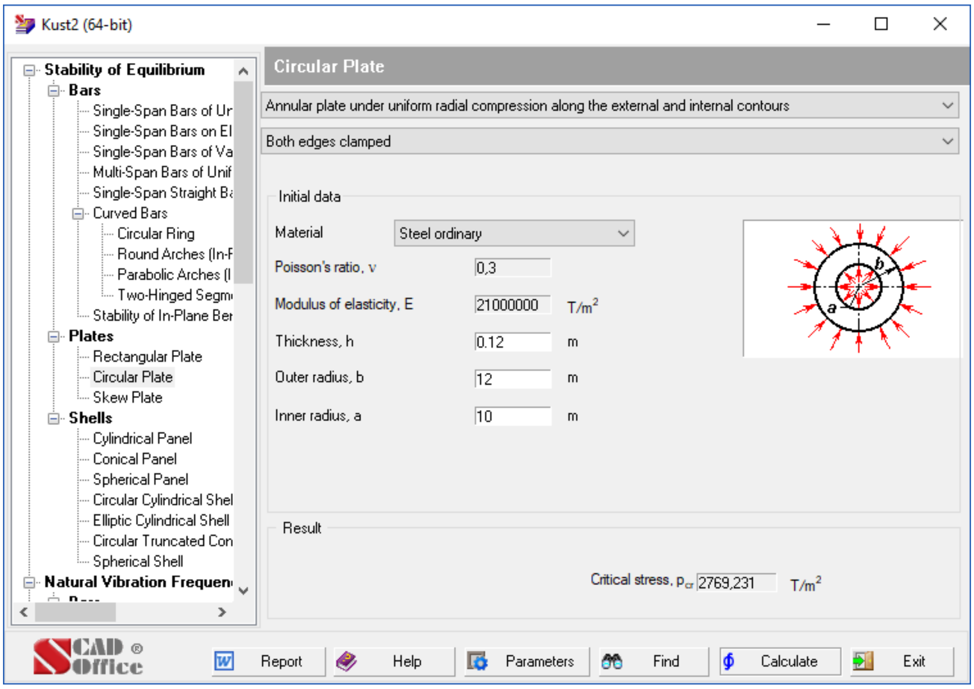
The boundary conditions and load type are selected from the drop-down lists. The initial data should include the plate dimensions (length, width and thickness), the modulus of elasticity and Poisson’s ratio of the material the plate is made of (the last two parameters can be specified by selecting one of the materials from the database or by entering an explicit value if the OTHER MATERIAL option has been selected in the materials list).

The result of the analysis will be the *critical stress* value (either the normal one σ or the tangential one τ, depending on the loading pattern).

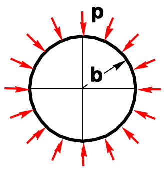
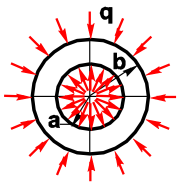
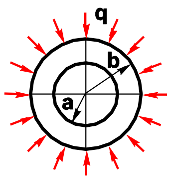
References

1. *Reference manual on elasticity* (ed. by P.M. Varvak), Kiev, Budivelnyk Publishers, 1971, 416 pp. (See p. 411.) *In Russian.*

Circular Plate



The object of consideration is the stability of equilibrium of circular and annular plates under radial compressive forces. For annular plates, consideration is given to the cases of compression along the external, as well as along both external and internal contours. The table below lists all combinations of loads and boundary conditions available in the program for the analysis.

Plate shape and load type	Boundary conditions
 Circular plate under radial compression	♦ Simply supported edges ♦ Clamped along the contour
 Annular plate under uniform radial compression along the external and internal contours	♦ Both edges clamped ♦ Both edges simply supported ♦ The external edge clamped, free displacement of the internal edge but no rotation ♦ The external edge simply supported, free displacement of the internal edge but no rotation
 Annular plate under uniform radial compression along the external contour	♦ Simply supported edges ♦ Clamped along the contour

The type of load and the boundary conditions are selected from the drop-down lists. The initial data should include the type of the plate (circular, annular) and the load type, the boundary conditions, the plate dimensions (external and internal radii, and thickness), the modulus of elasticity and Poisson's ratio of the material the plate is made of (the last two parameters can be specified by selecting one of the materials from the database or by entering an explicit value if the OTHER MATERIAL option has been selected in the materials list).

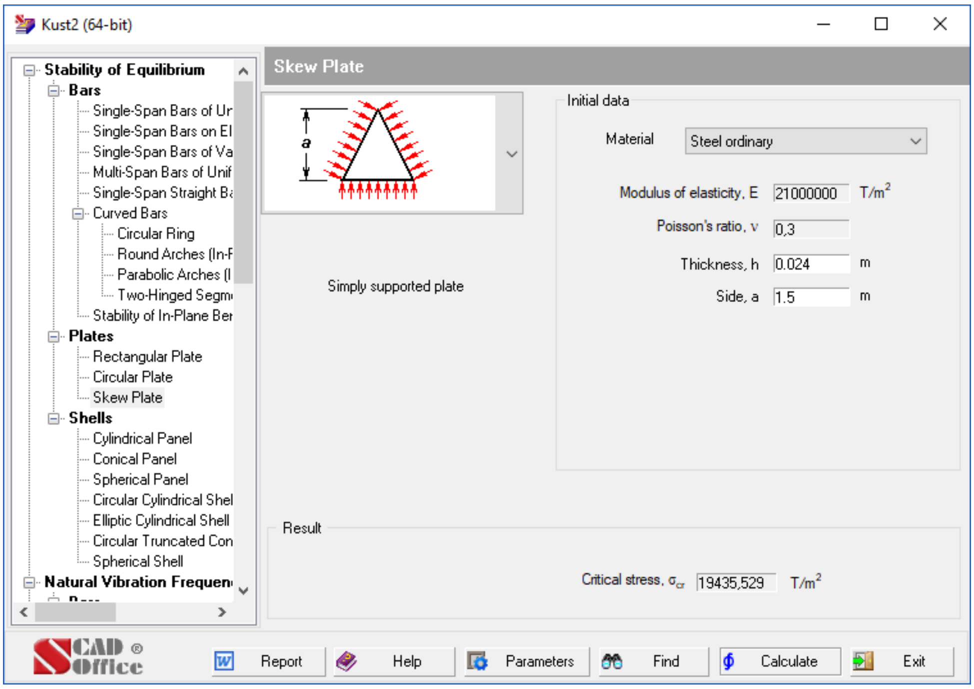
The result of the analysis will be the *critical stress* value.

References

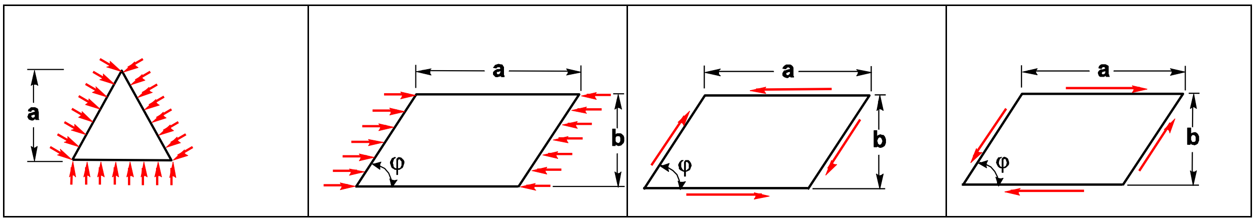
1. *Strength. Stability. Vibrations.* Vol. 3 (eds. I.A. Birger, Y.G. Panovko), Moscow, Mashinostroyeniye Publishing House, 1968, 567 pp. (See p. 110.) *In Russian.*

1. *Structural designer's reference manual. Design theory and analysis.* Vol. 2 (ed. by A.A. Umansky), Moscow, Stroyizdat Publishing House, 1973, 415 pp. (See p. 278.) *In Russian.*

Skew Plate



The object of consideration is the stability of equilibrium of simply supported plates shaped as an equilateral triangle or a parallelogram and subjected to various loads (see the table below).



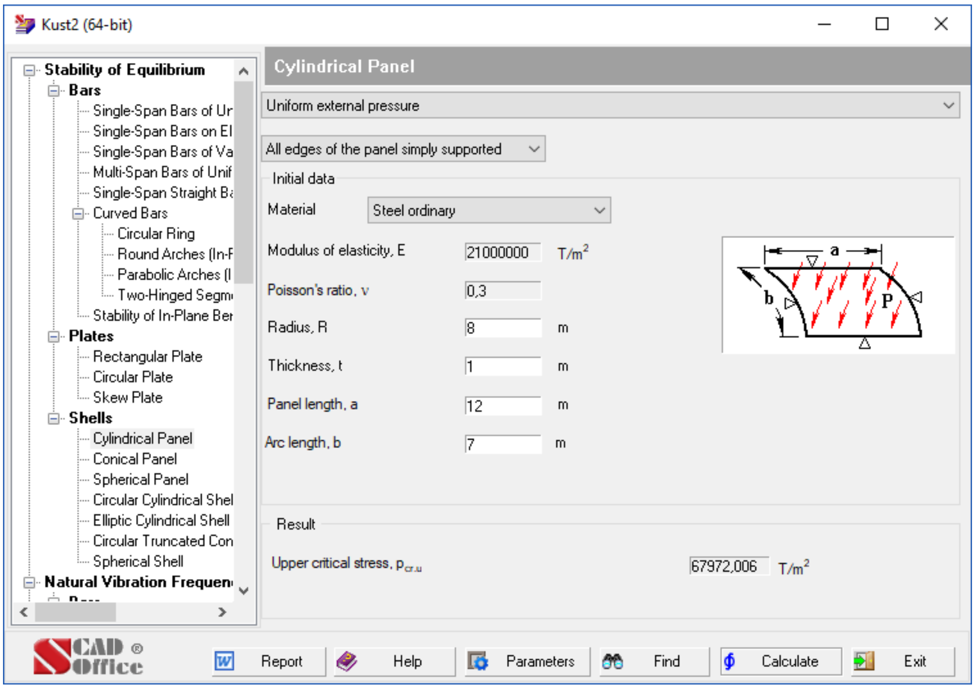
The type of the plate is selected from the drop-down list. The initial data should include the plate dimensions, the modulus of elasticity and Poisson’s ratio of the material the plate is made of (the last two parameters can be specified by selecting one of the materials from the database or by entering an explicit value if the OTHER MATERIAL option has been selected in the materials list).

The result of the analysis will be the *critical stress* value (either the normal one σ or the tangential one τ, depending on the loading pattern).

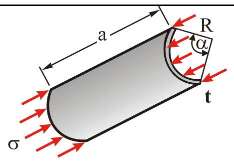
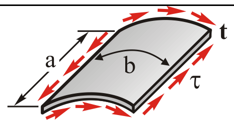
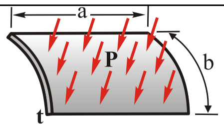
References

1. *Strength. Stability. Vibrations.* Vol. 3 (eds. I.A. Birger, Y.G. Panovko), Moscow, Mashinostroyeniye Publishing House, 1968, 567 pp. (See p. 112.) *In Russian.*

Cylindrical Panel



The object of consideration is the stability of equilibrium of a cylindrical panel. The following cases of boundary conditions and loads are available for the analysis:

Load type	Boundary conditions
 Compressive forces uniformly distributed along the edges	♦ All edges of the panel simply supported ♦ All edges of the panel clamped
 Tangential loads uniformly distributed along the edges	♦ All edges of the panel simply supported ♦ All edges of the panel clamped
 Uniform external pressure	♦ All edges of the panel simply supported

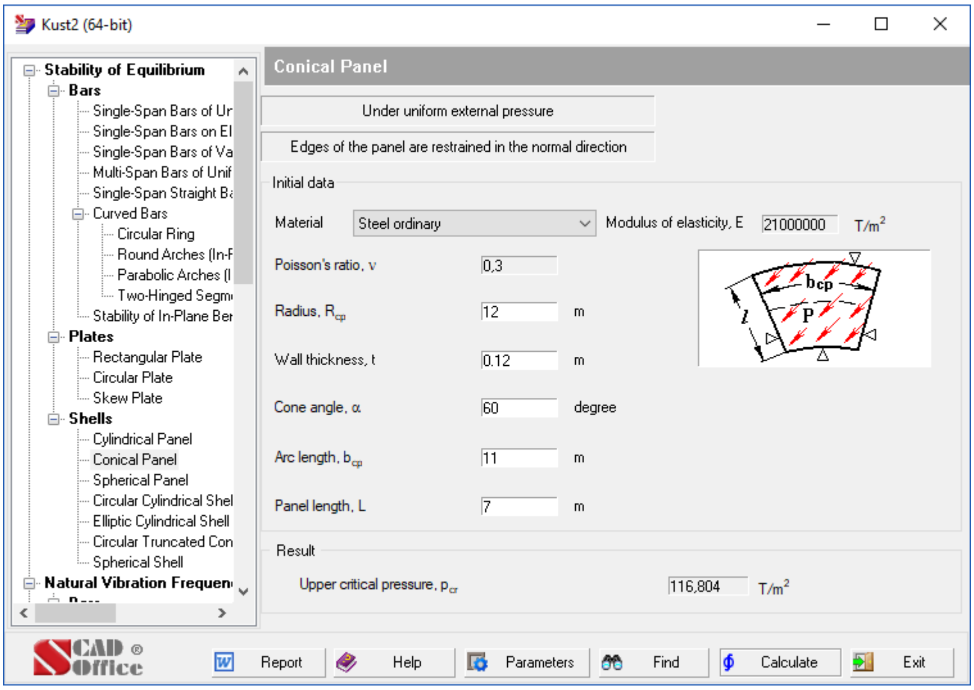
The type of load and the boundary conditions are selected from the drop-down list. The initial data should include the dimensions of the panel (its radius, thickness, length, and the arc length), the modulus of elasticity and Poisson's ratio of the material the panel is made of (the last two parameters can be specified by selecting a material from the database or by entering the explicit values if the OTHER MATERIAL option has been selected in the materials list).

The result of the analysis will be the *upper critical stress* value.

References

1. *Structural designer's reference manual. Design theory and analysis.* Vol. 2 (ed. by A.A. Umansky), Moscow, Stroyizdat Publishing House, 1973, 415 pp. (See p. 279.) *In Russian.*

Conical Panel



The object of consideration is the stability of equilibrium of a conical panel under the action of uniform external pressure (the edges of the panel are restrained in the normal direction).

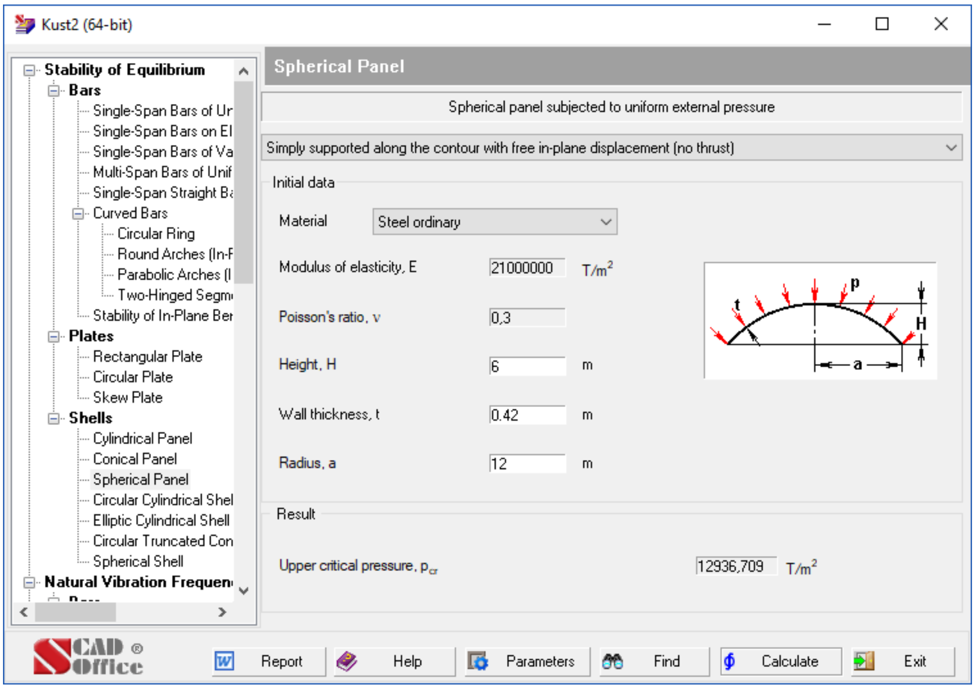
The initial data should include the geometric dimensions of the panel (radius, wall thickness, arc length, and the length of the panel). Moreover, you have to specify the modulus of elasticity and Poisson's ratio of the material the panel is made of (the last two parameters can be specified by selecting a material from the database or by entering the explicit values if the OTHER MATERIAL option has been selected in the materials list).

The result of the analysis will be the *upper critical pressure* value.

References

1. *Structural designer's reference manual. Design theory and analysis.* Vol. 2 (ed. by A.A. Umansky), Moscow, Stroyizdat Publishing House, 1973, 415 pp. (See p. 281.) *In Russian.*

Spherical Panel



The object of consideration is the stability of equilibrium of a spherical panel subjected to uniform external pressure for the following boundary conditions:

- simply supported along the contour with free in-plane displacement (no thrust);
- simply supported along the contour without in-plane displacement;
- clamped edges but no thrust;
- clamped edges and no displacement.

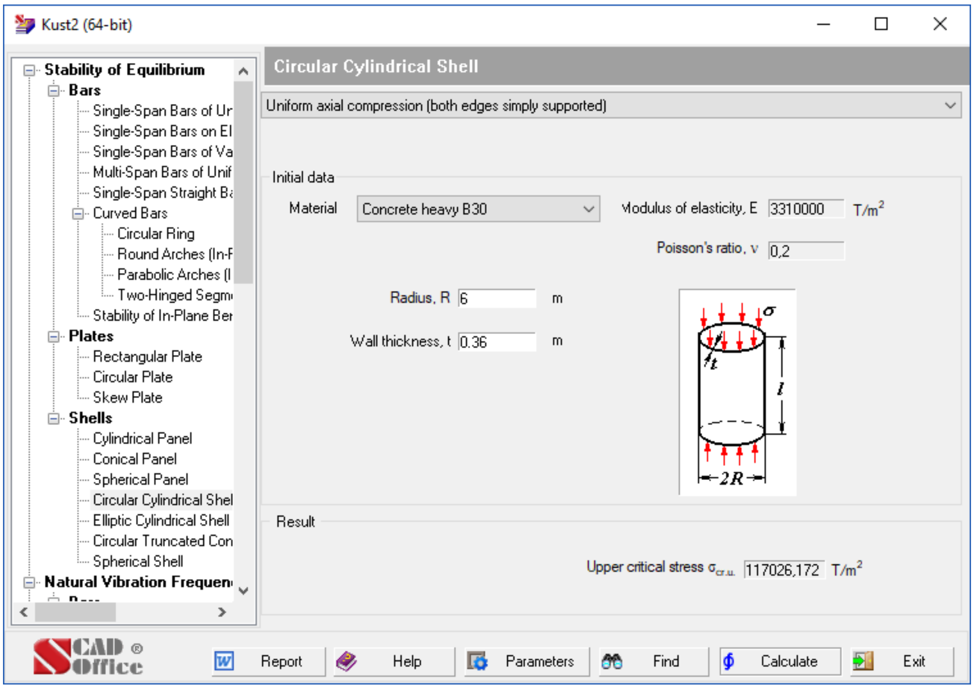
Boundary conditions are selected from the drop-down list. The initial data should include the height of the panel, its radius and thickness. Moreover, you have to specify the modulus of elasticity and Poisson's ratio of the material the panel is made of (the last two parameters can be specified by selecting a material from the database or by entering the explicit values if the OTHER MATERIAL option has been selected in the materials list).

The result of the analysis will be the *upper critical pressure* value.

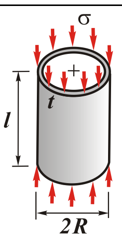
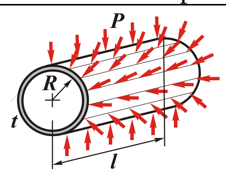
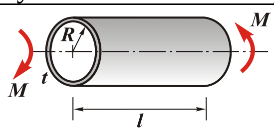
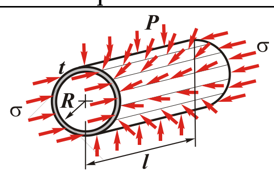
References

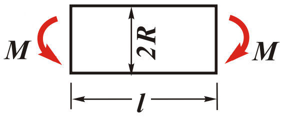
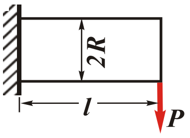
1. *Structural designer's reference manual. Design theory and analysis.* Vol. 2 (ed. by A.A. Umansky), Moscow, Stroyizdat Publishing House, 1973, 415 pp. (See p. 281.) *In Russian.*

Circular Cylindrical Shell



The object of consideration is the stability of equilibrium of a circular cylindrical shell under the following combinations of loads and boundary conditions:

Load type	Boundary conditions
 Uniform axial compression	Both edges simply supported
 Uniformly distributed external pressure	Both edges simply supported
 Torques at ends	♦ clamped shell edges ♦ simply supported shell edges
 Combined action of uniform axial compression	Simply supported ends

Load type	Boundary conditions
and uniform external lateral load	
 Action of a pair of bending moments acting in the diametral plane	Simply supported
 Bending caused by the lateral force	One end is clamped, the second end is free

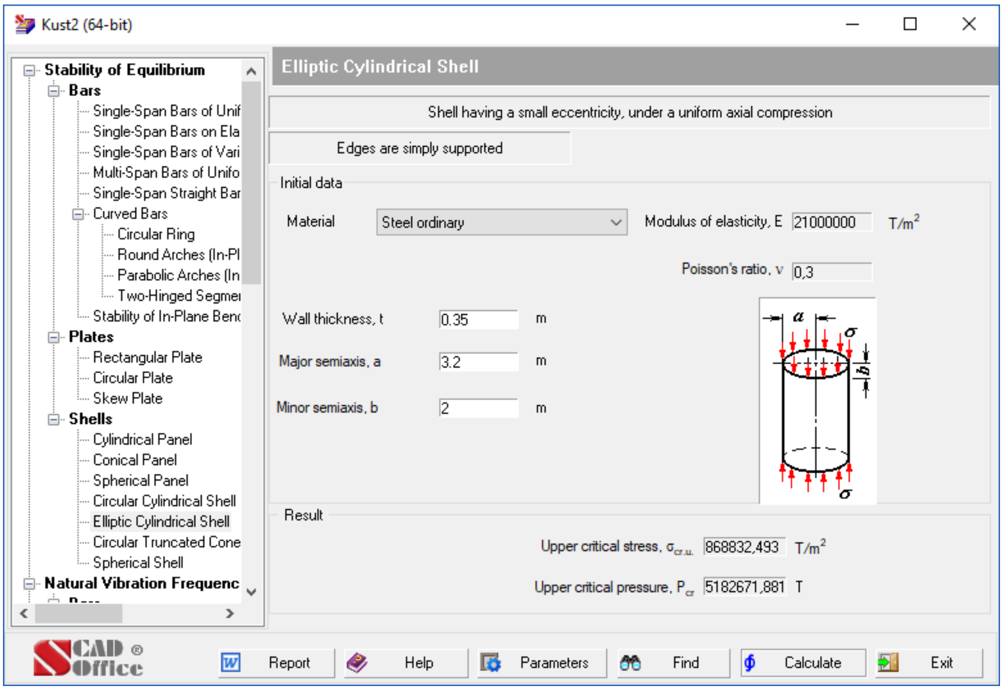
The type of load and the boundary conditions are selected from the drop-down list. The initial data should include the dimensions of the shell (its radius, thickness, and length). Moreover, you have to specify the modulus of elasticity and Poisson's ratio of the material the shell is made of (the last two parameters can be specified by selecting a material from the database or by entering the explicit values if the OTHER MATERIAL option has been selected in the materials list).

The result of the analysis will be the *upper critical stress* or *upper critical moment* value, depending on the loading pattern.

References

1. *Structural designer's reference manual. Design theory and analysis.* Vol. 2 (ed. by A.A. Umansky), Moscow, Stroyizdat Publishing House, 1973, 415 pp. (See p. 281.) *In Russian.*

Cylindrical basket shell



The object of consideration is the stability of equilibrium of an elliptic cylindrical shell having a small eccentricity, under a uniform axial compression, when the shell edges are simply supported.

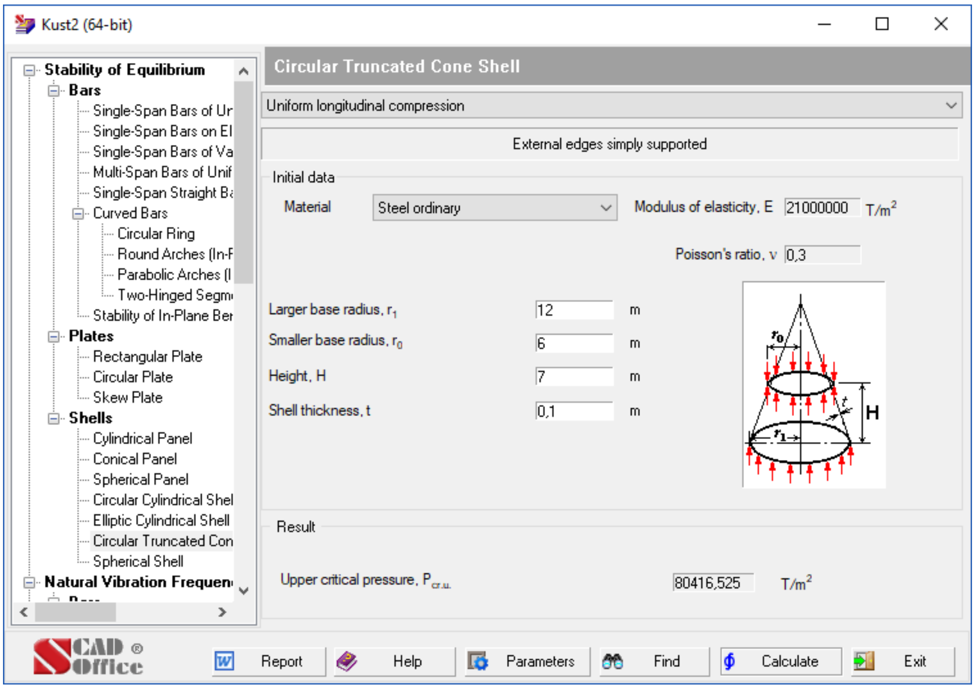
The initial data should include the major and minor semi-axes, and thickness of the shell, as well as the modulus of elasticity and Poisson's ratio of the material the shell is made of (the last two parameters can be specified by selecting a material from the database or by entering the explicit values if the OTHER MATERIAL option has been selected in the materials list).

The result of the analysis will be the *upper critical stress* value $\sigma_{cr.u}$ and the *upper critical pressure* $P_{cr.u}$ (which is the product of $\sigma_{cr.u}$ and the shell cross-sectional area).

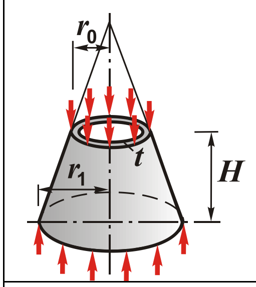
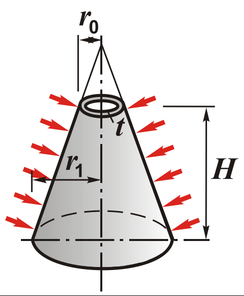
References

1. *Structural designer's reference manual. Design theory and analysis.* Vol. 2 (ed. by A.A. Umansky), Moscow, Stroyizdat Publishing House, 1973, 415 pp. (See p. 285.) *In Russian.*

Circular Truncated Cone Shell



The object of consideration is the stability of equilibrium of a circular truncated cone shell. The following two cases are available for the analysis:

	Uniform longitudinal compression. External edges simply supported.
	Uniform external pressure. The smaller base is clamped, the larger one is simply supported.

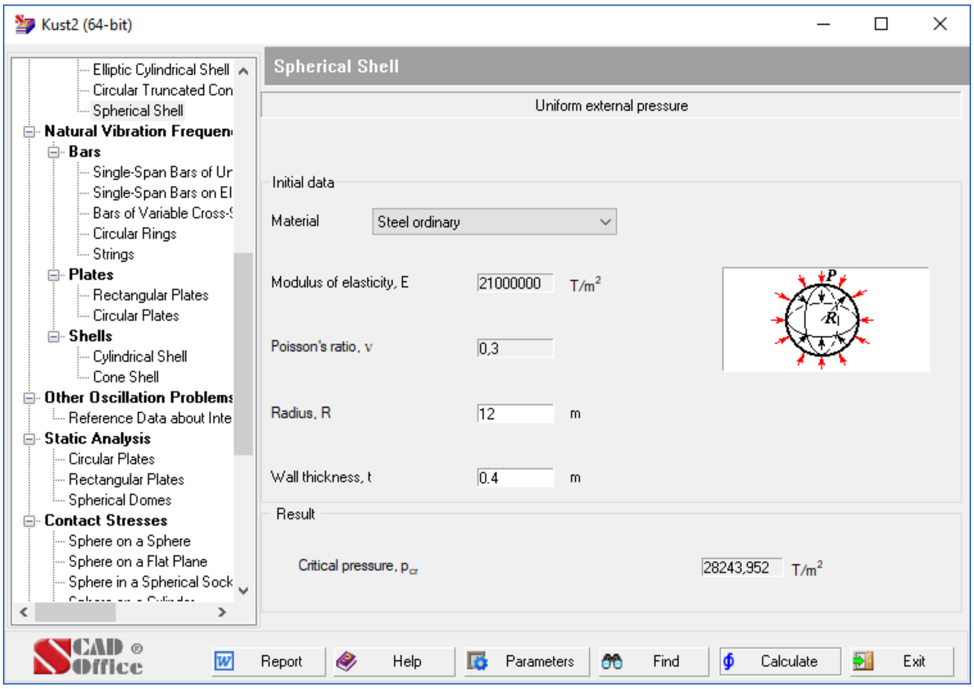
The type of analysis is selected from the drop-down list. The initial data should include the radii of the smaller and larger bases; the thickness and the height of the shell. Moreover, you have to specify the modulus of elasticity and Poisson’s ratio of the material the shell is made of (the last two parameters can be specified by selecting a material from the database or by entering the explicit values if the OTHER MATERIAL option has been selected in the materials list).

The result of the analysis will be the *upper critical pressure* value.

References

1. *Strength. Stability. Vibrations.* Vol. 3 (eds. I.A. Birger, Y.G. Panovko), Moscow, Mashinostroyeniye Publishing House, 1968, 567 pp. (See pp. 146, 168-173.) *In Russian.*

Spherical Shell



The object of consideration is the stability of equilibrium of a spherical shell under the action of uniform external pressure.

The initial data should include the radius and the thickness of the shell. Moreover, you have to specify the modulus of elasticity and Poisson's ratio of the material the shell is made of (the last two parameters can be specified by selecting a material from the database or by entering the explicit values if the OTHER MATERIAL option has been selected in the materials list).

The result of the analysis will be the *critical pressure* value.

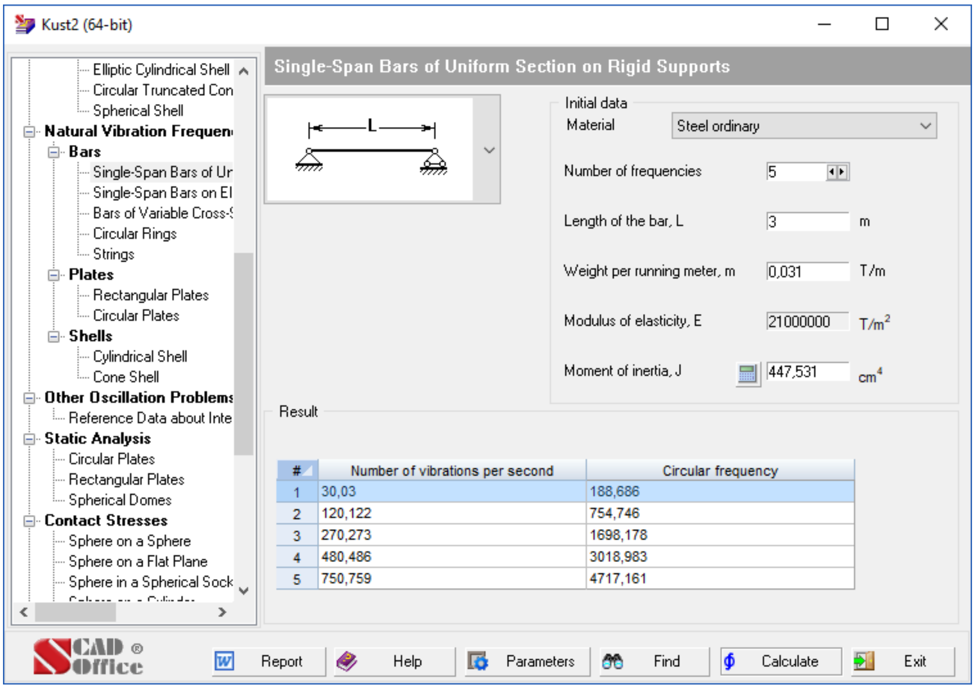
References

1. *Structural designer's reference manual. Design theory and analysis.* Vol. 2 (ed. by A.A. Umansky), Moscow, Stroyizdat Publishing House, 1973, 415 pp. (See p. 287). *In Russian.*

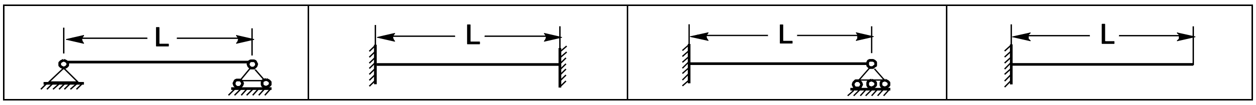
1.3 Natural Vibration Frequencies

This section deals with vibrations of single-span bars of uniform section on rigid supports, single-span bars of uniform section on elastic subgrade, circular rings of uniform section, transverse vibrations of a string with fixed ends, vibrations of a rectangular plate, a circular plate, a cylindrical shell, and a cone shell.

Single-Span Bars of Uniform Section on Rigid Supports



The object of consideration is vibrations of single-span bars of uniform section on rigid supports for the following boundary conditions:



Boundary conditions are selected from the drop-down list. The initial data should include the length of the bar, the weight per running meter, the moment of inertia of the bar cross-section, and the modulus of elasticity of the material the bar is made of (the latter can be specified by selecting a material from the database or by entering an explicit value if the OTHER MATERIAL option has been selected in the materials list). Moreover, you have to specify the number of natural vibration frequencies the program has to calculate.

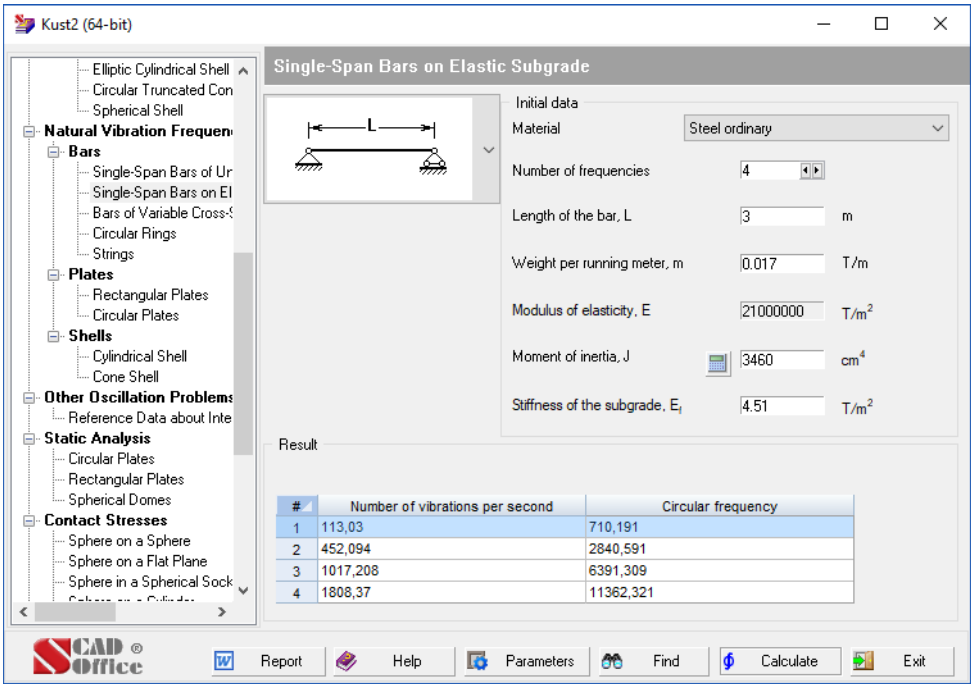
If the cross-section is a rolled profile, the moment of inertia can be retrieved from the profile database using the button described above in the *Moments of Inertia* section.

The result of the analysis will be the *vibration frequency in Hz (number of vibrations per second)* and the *circular frequency in rad/s* for the specified number of the first modes of natural vibrations.

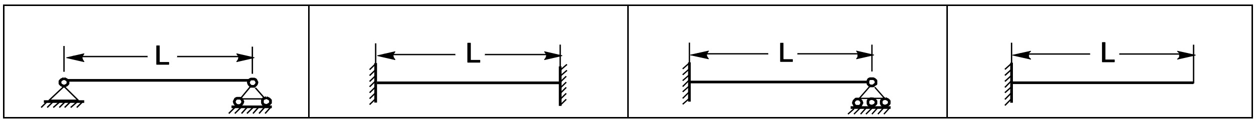
References

1. *Reference manual on stability/vibration structural analysis* (ed. by I.I. Goldenblat), State Publishing House of Civil Engineering and Architecture Books, Moscow, 1952, 251 pp. (See p. 104.) *In Russian.*
2. R.D. Blevins, *Formulas for natural frequency and mode shape*, Malabar Florida, Krieger Publishing Company, 2001. — 492 pp. (see p. 106).

Single-Span Bars on Elastic Subgrade



The object of consideration is vibrations of single-span bars of uniform section on elastic subgrade for the following boundary conditions:



Boundary conditions are selected from the drop-down list. The initial data should include the length of the bar, the weight per running meter, the moment of inertia of the bar cross-section, stiffness of the subgrade, and the modulus of elasticity of the material the bar is made of (the latter can be specified by selecting a material from the database or by entering an explicit value if the OTHER MATERIAL option has been selected in the materials list). Moreover, you have to specify the number of natural frequencies the program has to calculate.

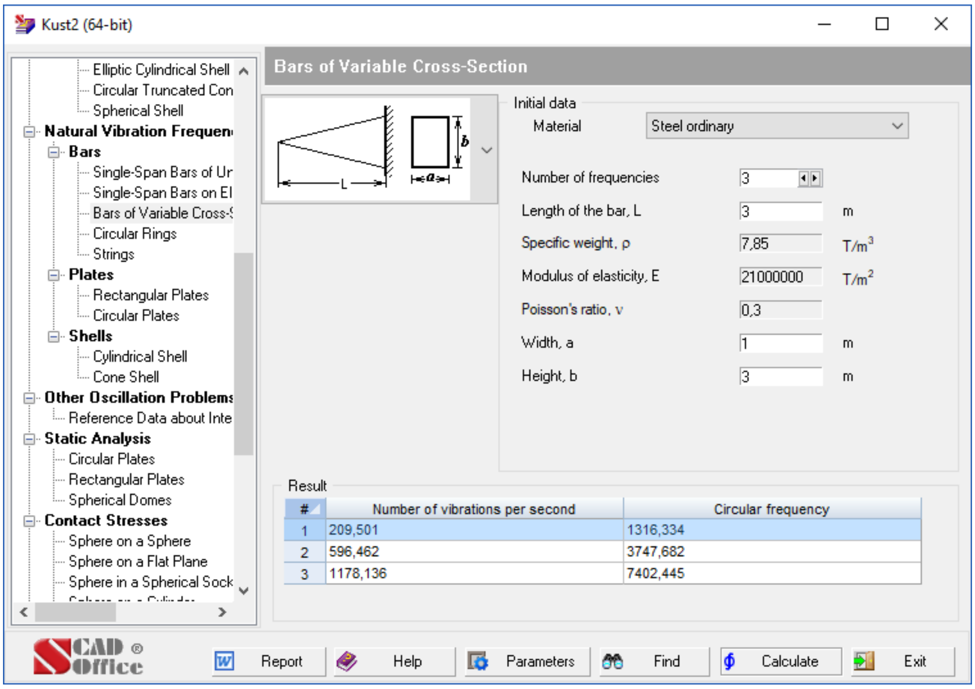
If the cross-section is a rolled profile, the moment of inertia can be retrieved from the profile database using the button described above in the *Moments of Inertia* section.

The result of the analysis will be the *vibration frequency in Hz (number of vibrations per second)* and the *circular frequency in rad/s* for the specified number of the first modes of natural vibrations.

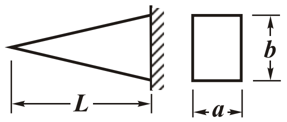
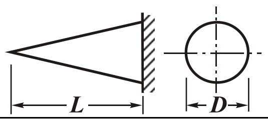
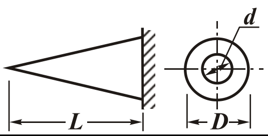
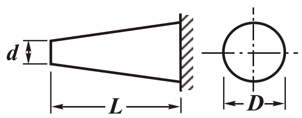
References

1. *Reference manual on stability/vibration structural analysis* (ed. by I.I. Goldenblat), State Publishing House of Civil Engineering and Architecture Books, Moscow, 1952, 251 pp. *In Russian.*

Bars of Variable Cross-Section



The object of consideration is vibrations of cantilever bars of a variable cross-section. The program enables you to determine the vibration frequencies for the following cases:

	A wedge-shaped cantilever: the height of the section is proportional to the distance to the vertex, the width is constant
	A cantilever shaped as a circular cone
	A hollow cone, the wall thickness of which varies linearly
	A cantilever shaped as a truncated circular cone

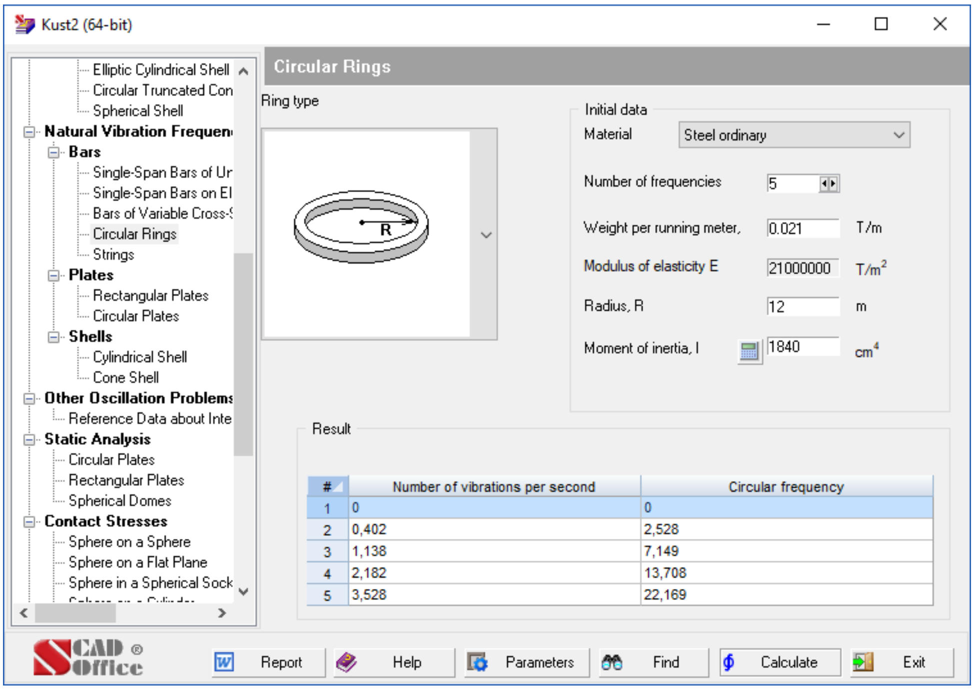
The structure is selected from the drop-down list. The initial data should include the length of the bar, the dimensions of the cross-section at the clamped end, the specific weight, the modulus of elasticity and Poisson's ratio of the material the bar is made of (the last two parameters can be specified by selecting a material from the database or by entering an explicit value if the OTHER MATERIAL option has been selected in the materials list). In the case of a truncated cone, it is necessary to specify the diameter of the cone at the free end. Moreover, you have to specify the number of natural frequencies the program has to calculate.

The result of the analysis will be the *vibration frequency in Hz (number of vibrations per second)* and the *circular frequency in rad/s* for the specified number of the first modes of natural vibrations.

References

1. *Structural designer's reference manual. Design theory and analysis.* Vol. 2 (ed. by A.A. Umansky), Moscow, Stroyizdat Publishing House, 1973, 415 pp. (See p. 366.) *In Russian.*

Circular Rings



The object of consideration is vibrations of circular rings of uniform section, one of the principal axes of inertia of which lies in the plane of the ring axis. Two cases are available for the analysis: a circular ring and an incomplete ring where a part of the ring with the angle α is clamped at both ends. Flexural vibrations in the plane of the ring are under study. The type of the ring is selected from the drop-down list.

The initial data should include the radius of the ring centerline, the weight per running meter, the moment of inertia of the ring cross-section with respect to the principal axis orthogonal to the ring plane, the opening angle (for an incomplete ring only), and the modulus of elasticity of the material the ring is made of (the latter can be specified by selecting a material from the database or by entering an explicit value if the OTHER MATERIAL option has been selected in the materials list). Moreover, you have to specify the number of natural frequencies (only the first frequency is determined for an incomplete ring).

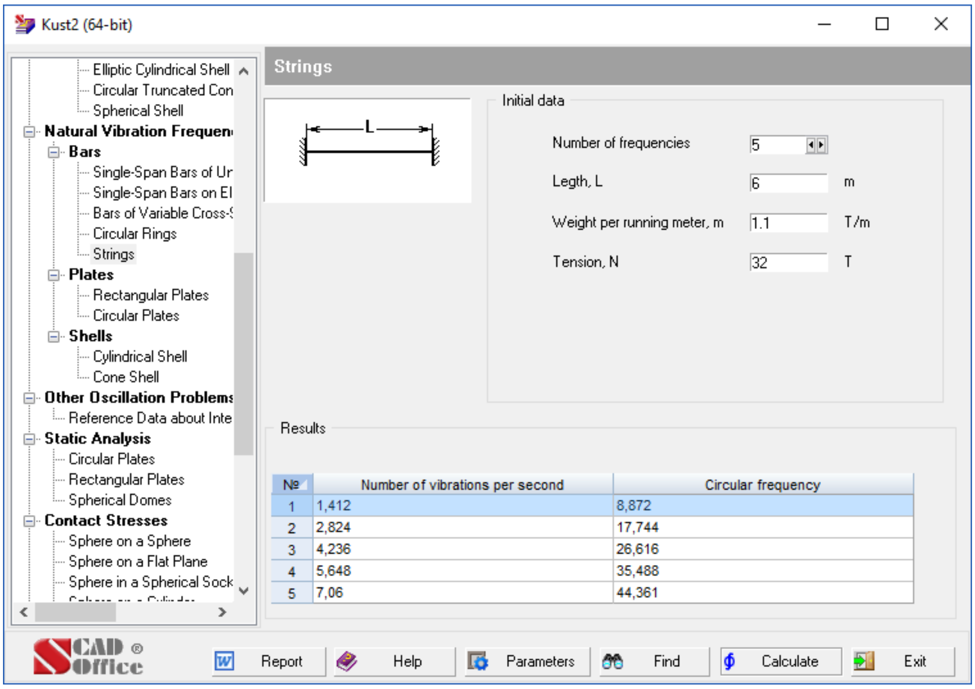
If the cross-section is a rolled profile, the moment of inertia can be retrieved from the profile database using the button described above in the *Moments of Inertia* section.

The result of the analysis will be the *vibration frequency in Hz (number of vibrations per second)* and the *circular frequency in rad/s* for the specified number of the first modes of natural vibrations.

References

1. *Structural designer's reference manual. Design theory and analysis.* Vol. 2 (ed. by A.A. Umansky), Moscow, Stroyizdat Publishing House, 1973, 415 pp. (See p. 362). *In Russian.*

Strings



The object of consideration is lateral vibrations of a string with fixed ends.

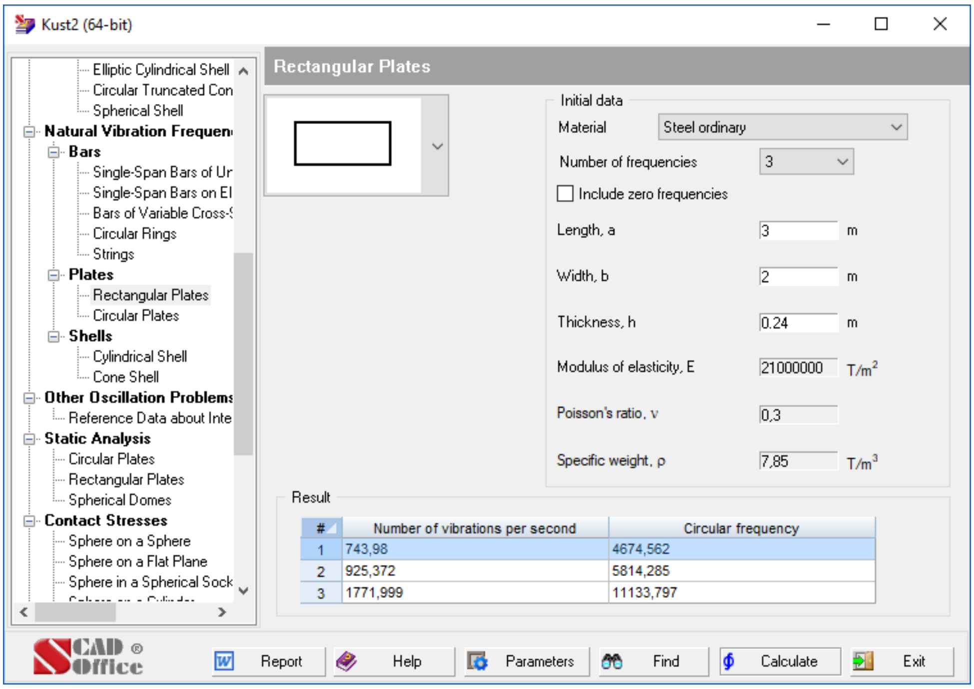
The initial data should include the length of the string, the weight per running meter, its tension, and the number of natural frequencies.

The result of the analysis will be the *frequency of vibrations in Hz* (*number of vibrations per second*) and the *circular frequency in rad/s* for the specified number of the first modes of natural vibrations.

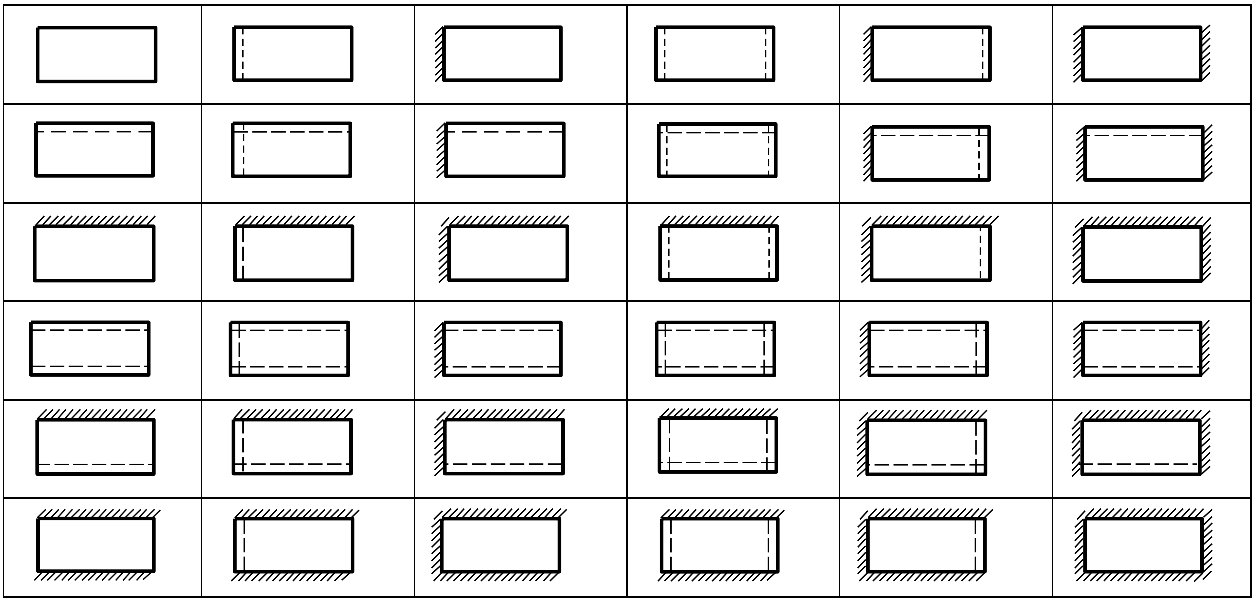
References

1. *Structural designer's reference manual. Design theory and analysis.* Vol. 2 (ed. by A.A. Umansky), Moscow, Stroyizdat Publishing House, 1973, 415 pp. (See p. 369.) *In Russian.*

Rectangular Plates



The object of consideration is the vibrations of rectangular plates for the following boundary conditions:



The following legend is used to designate the boundary conditions:

Free edge	
Clamped edge	
Simply supported edge	

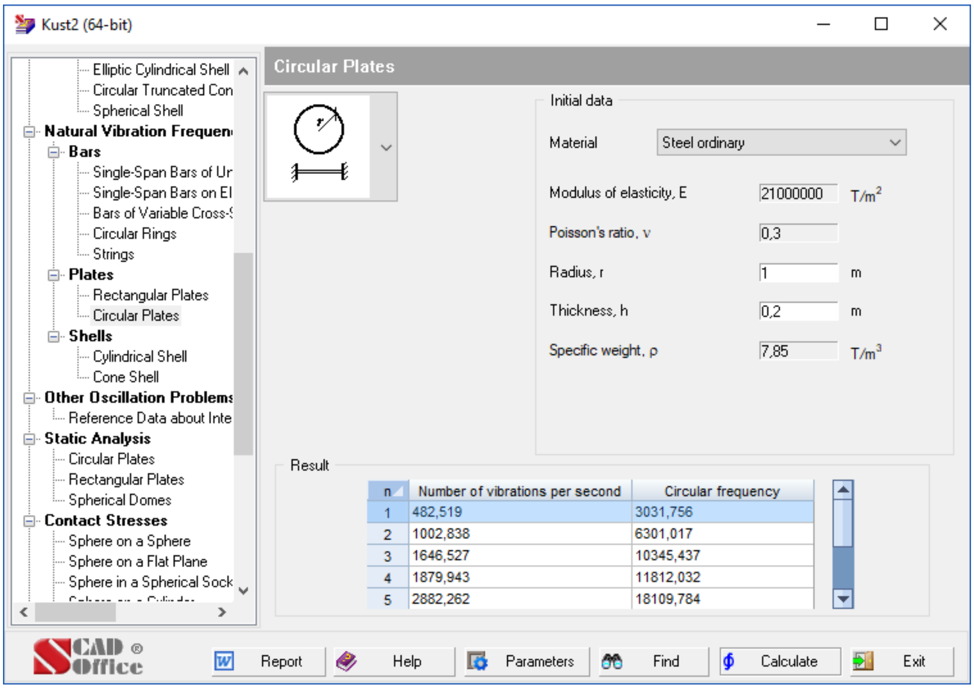
Boundary conditions are selected from the drop-down list. The initial data should include the plate dimensions (length, width, thickness), the modulus of elasticity, Poisson's ratio, and specific weight of the material the plate is made of (the last three parameters can be specified by selecting a material from the database or by entering the explicit values if the OTHER MATERIAL option has been selected in the materials list). Moreover, you have to specify the number of natural frequencies. Since under certain boundary conditions zero frequencies may occur, the special checkbox **Include zero frequencies** should be used to decide whether you want to have such zero frequencies in the results or not.

The result of the analysis will be the *frequency of vibrations in Hz (number of vibrations per second*) and the *circular frequency in rad/s* for the specified number of the first modes of natural vibrations.

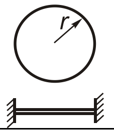
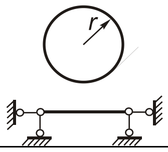
References

1. *Structural designer's reference manual. Design theory and analysis.* Vol. 2 (ed. by A.A. Umansky), Moscow, Stroyizdat Publishing House, 1973, 415 pp. (See p. 363.) *In Russian.*

Circular Plates



The object of consideration is vibrations of circular plates for the following boundary conditions:

	Clamped along the contour
	Simply supported with restrained horizontal displacements
	Rigid support at the center of the plate

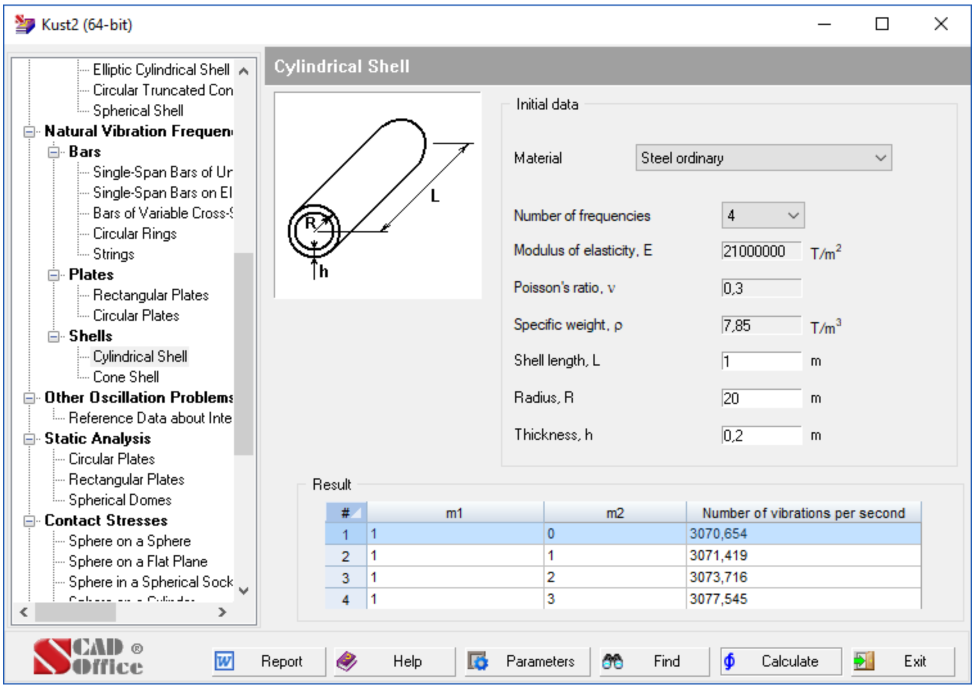
Boundary conditions are selected from the drop-down list. The initial data should include the radius and thickness of the plate, the specific weight, the modulus of elasticity and Poisson’s ratio of the material the plate is made of (the last three parameters can be specified by selecting a material from the database or by entering the explicit values if the OTHER MATERIAL option has been selected in the materials list).

The result of the analysis will be the *frequency of vibrations in Hz (number of vibrations per second*) and the *circular frequency in rad/s* for the several first modes of natural vibrations.

References

1. *Structural designer’s reference manual. Design theory and analysis.* Vol. 2 (ed. by A.A. Umansky), Moscow, Stroyizdat Publishing House, 1973, 415 pp. (See p. 365.) *In Russian.*

Cylindrical Shell



The object of consideration is natural vibrations of a cylindrical shell with simply supported ends.

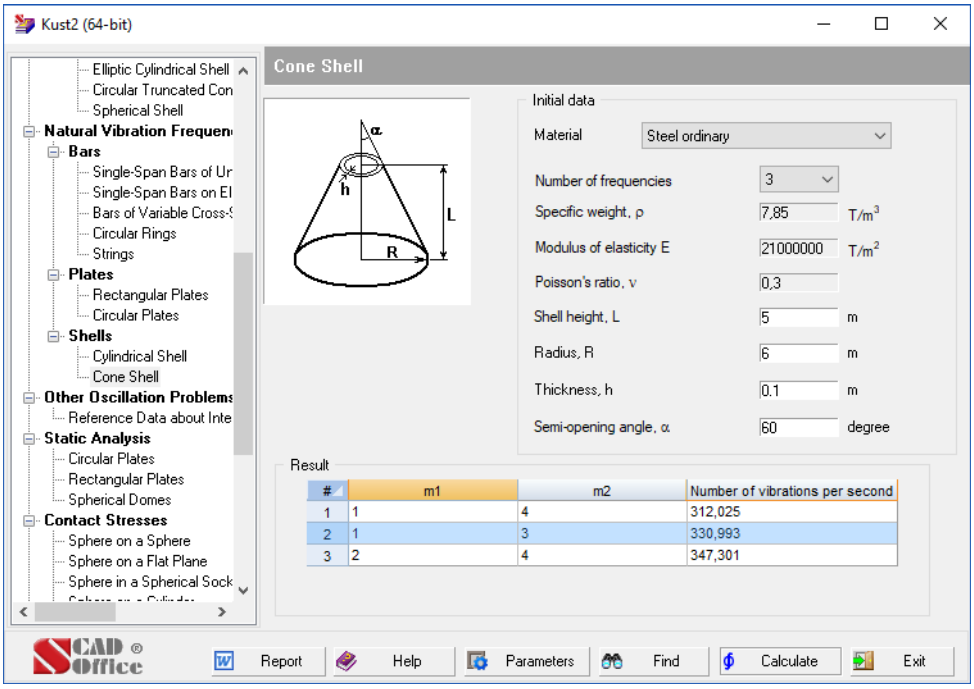
The initial data should include the radius and thickness of the shell, the modulus of elasticity, Poisson's ratio and the specific weight of the material the shell is made of (the last three parameters can be specified by selecting a material from the database or by entering the explicit values if the OTHER MATERIAL option has been selected in the materials list), and the number of frequencies.

The result of the analysis will be the *frequency of vibrations in Hz* (*number of vibrations per second*) for the several first modes of natural vibrations. Moreover, the table of results will list wave numbers (m_1, m_2) for the respective modes of natural vibrations.

References

1. *Strength. Stability. Vibrations.* Vol. 3 (eds. I.A. Birger, Y.G. Panovko), Moscow, Mashinostroyeniye Publishing House, 1968, 567 pp. (See p. 429.) *In Russian.*

Cone Shell



#	m1	m2	Number of vibrations per second
1	1	4	312,025
2	1	3	330,993
3	2	4	347,301

The object of consideration is natural vibrations of a cone shell with simply supported ends.

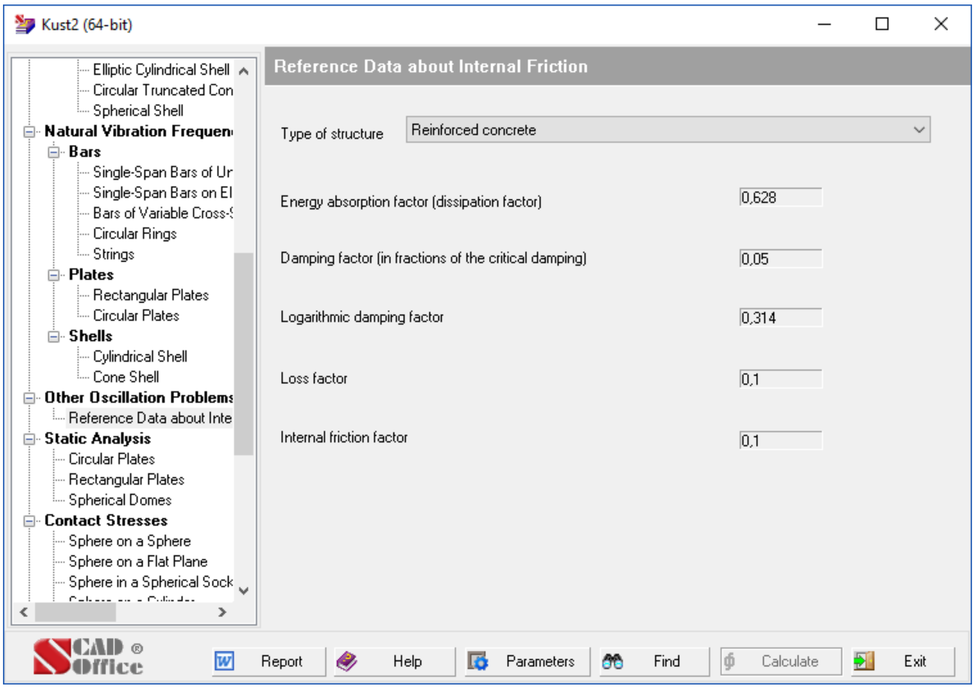
The initial data should include the radius, height and thickness of the shell, the semi-opening angle, the modulus of elasticity, Poisson's ratio and the specific weight of the material the shell is made of (the last three parameters can be specified by selecting a material from the database or by entering the explicit values if the OTHER MATERIAL option has been selected in the materials list), and the number of frequencies.

The result of the analysis will be the *frequency of vibrations in Hz* (*number of vibrations per second*) for several first modes of natural vibrations. Moreover, the table of results will list wave numbers (m_1, m_2) for the respective modes of natural vibrations.

References

1. *Strength. Stability. Vibrations.* Vol. 3 (eds. I.A. Birger, Y.G. Panovko), Moscow, Mashinostroyeniye Publishing House, 1968, 567 pp. (See p. 457.) *In Russian.*

1.4 Other Oscillation Problems. Reference Data about Internal Friction



In this mode, having selected the type of a structure from the drop-down list, you can obtain all the above-listed parameters. If OTHER option has been selected in the list of structures, you can enter the value of one of the parameters and obtain the values of all other parameters by clicking the **Calculate** button.

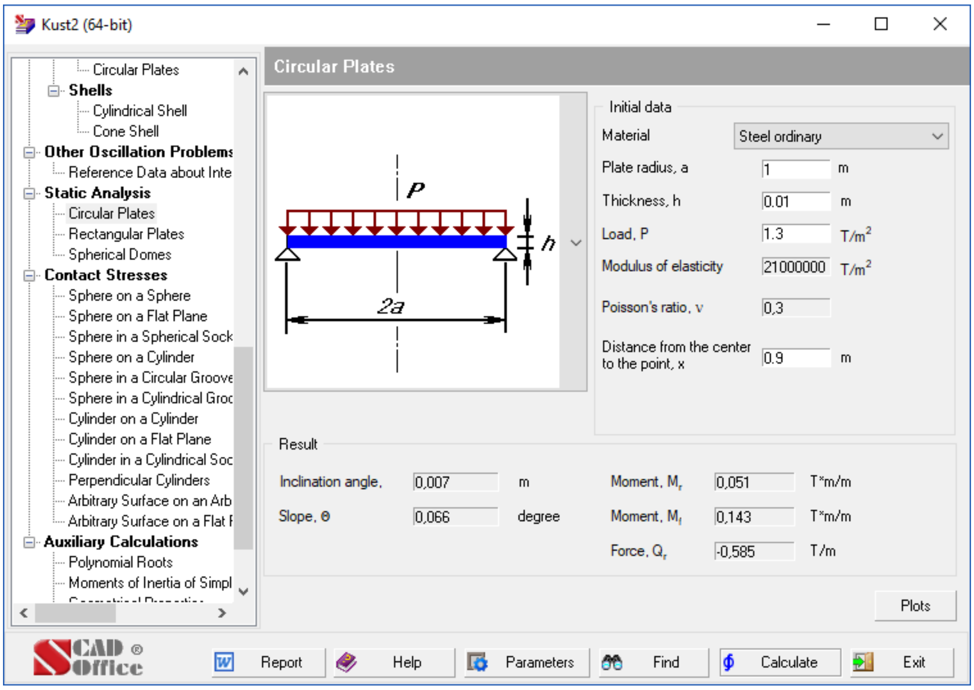
References

1. *Reference on the dynamics of structures*. B.G. Korenev, I.M. Rabinovich (Editors). - M., Stroyizdat, 1972. - 511 p. (see section 3). (See Section 3.) *In Russian.*

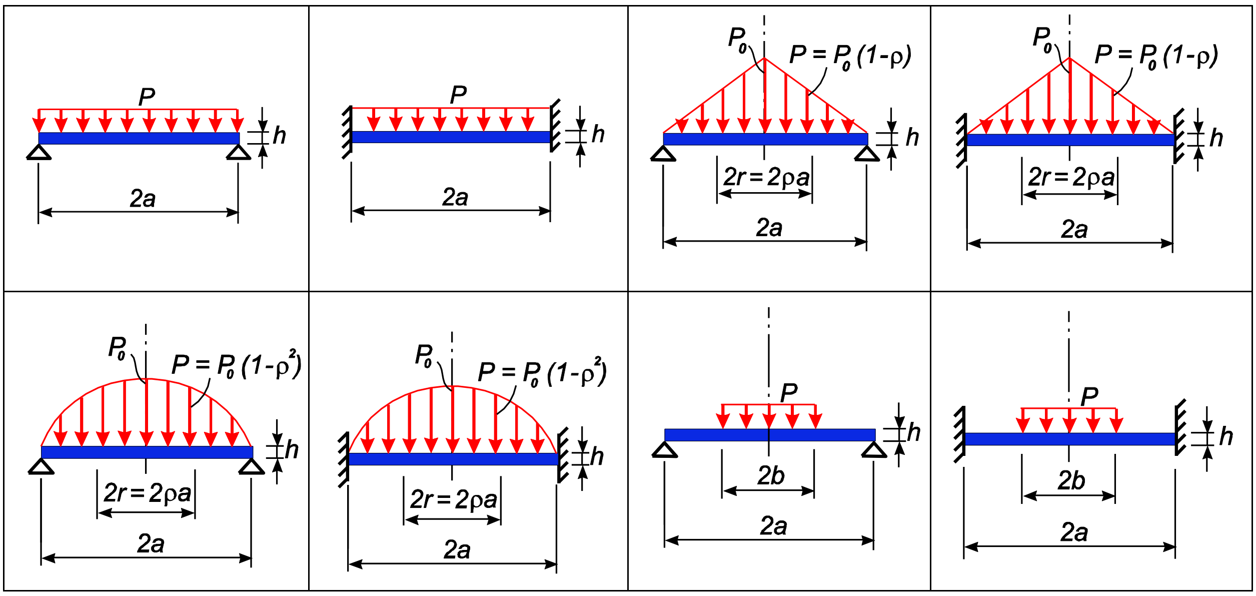
1.5 Static Analysis

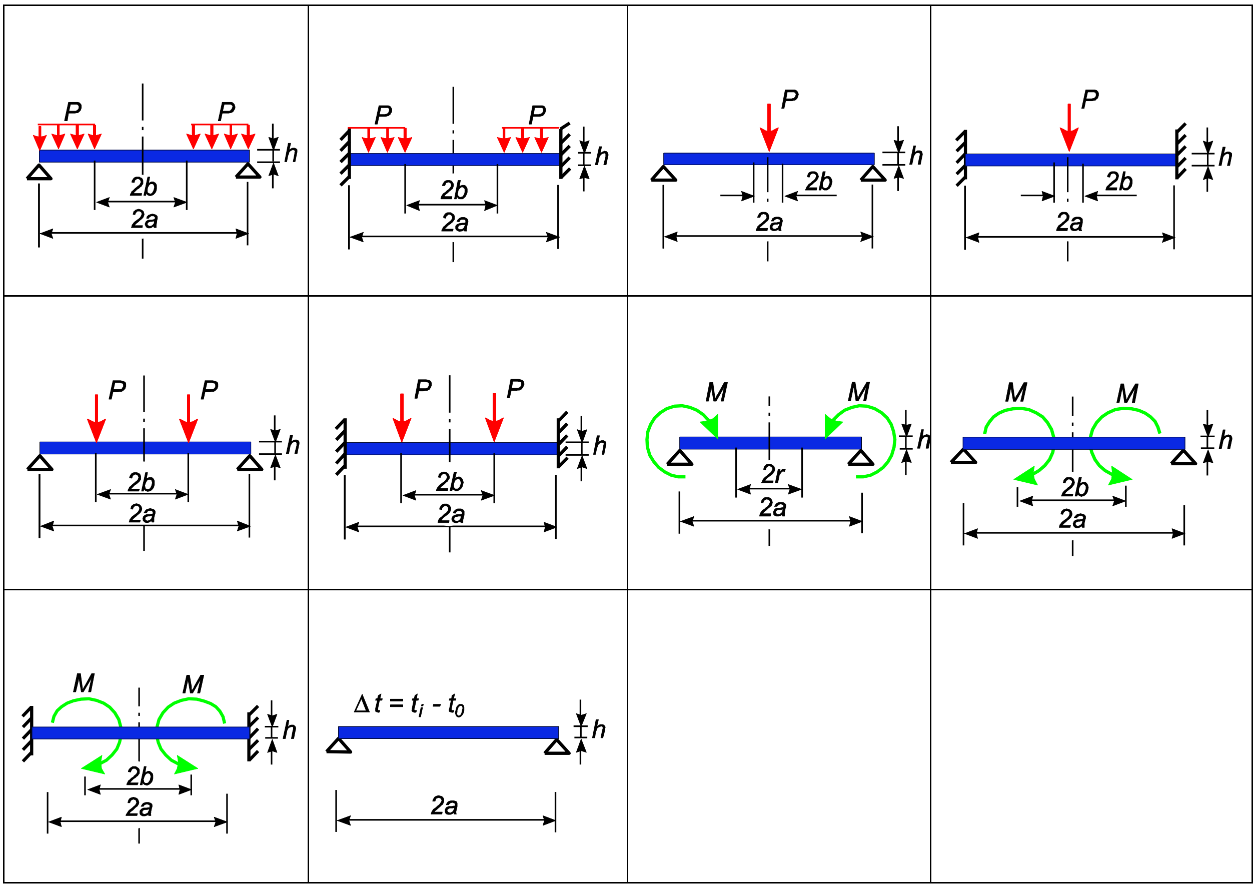
This section deals with the analysis of circular plates under different load patterns and boundary conditions; rectangular plates; spherical domes; the stress ranges in case of a point or linear contact of elastic bodies.

Circular Plates

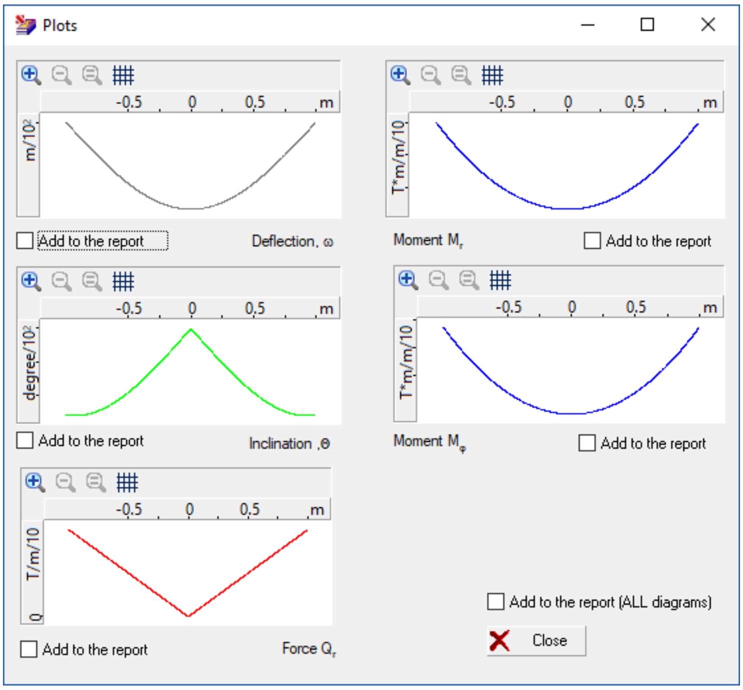


The object of consideration is circular plates under different symmetric load patterns and different boundary conditions. All scenarios that can be analyzed by the program are given in the Table below. The scenario to be analyzed is selected from the drop-down list.





The initial data should include the radius of the plate and its thickness, as well as the load intensity (and the load position, if necessary). You also have to specify the modulus of elasticity and Poisson’s ratio of the material the plate is made of (these data can be specified by selecting a material from the database or by entering the explicit values if the OTHER MATERIAL option has been selected from the materials list).



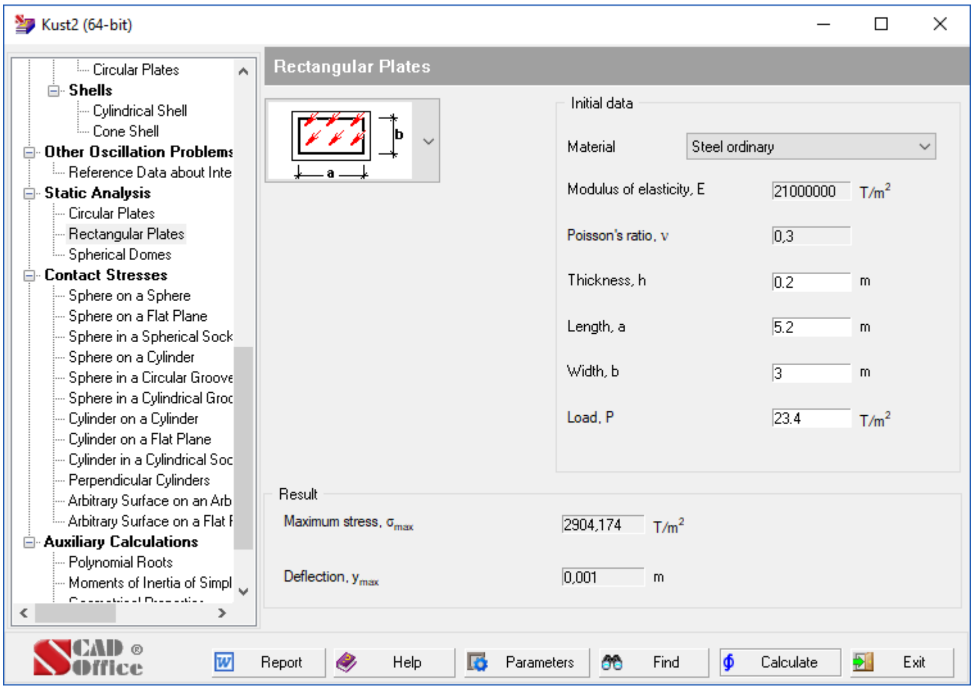
For the point located at the distance *x* from the center of the plate (this parameter must also be specified by the user) the program can calculate the deflection, the inclination angle, the shear force, and both tangential and radial moments. Moreover, clicking the **Plots** button will show the plotted diagrams of the above-listed parameters.

The **Plots** dialog box allows you to check off, in the respective checkboxes, the diagrams to be included in the report document.

References

1. *Reference manual on elasticity* (ed. by P.M. Varvak), Kiev, Budivelnyk Publishers, 1971, 416 pp. (See p. 335.) *In Russian.*

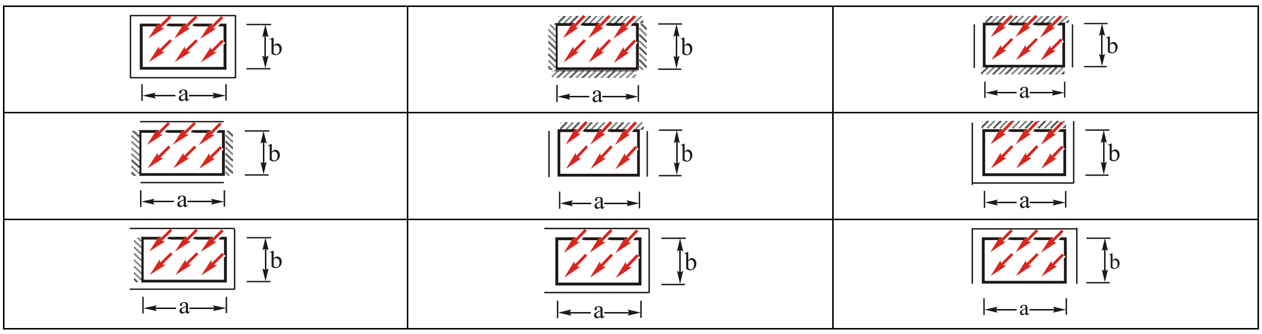
Rectangular Plates



The object of consideration is rectangular plates with different boundary conditions, which are subjected to uniform load orthogonal to the surface of the plate.

The initial data should include the plan dimensions of the plate and its thickness, as well as the intensity of the load. Moreover, the modulus of elasticity and Poisson's ratio must be specified for the material the panel is made of (these data can be specified by selecting a material from the database or by entering the explicit values if the OTHER MATERIAL option has been selected from the materials list).

The following boundary conditions can be selected from the drop-down list:



The following legend for the boundary conditions is used here:

Free edge	———

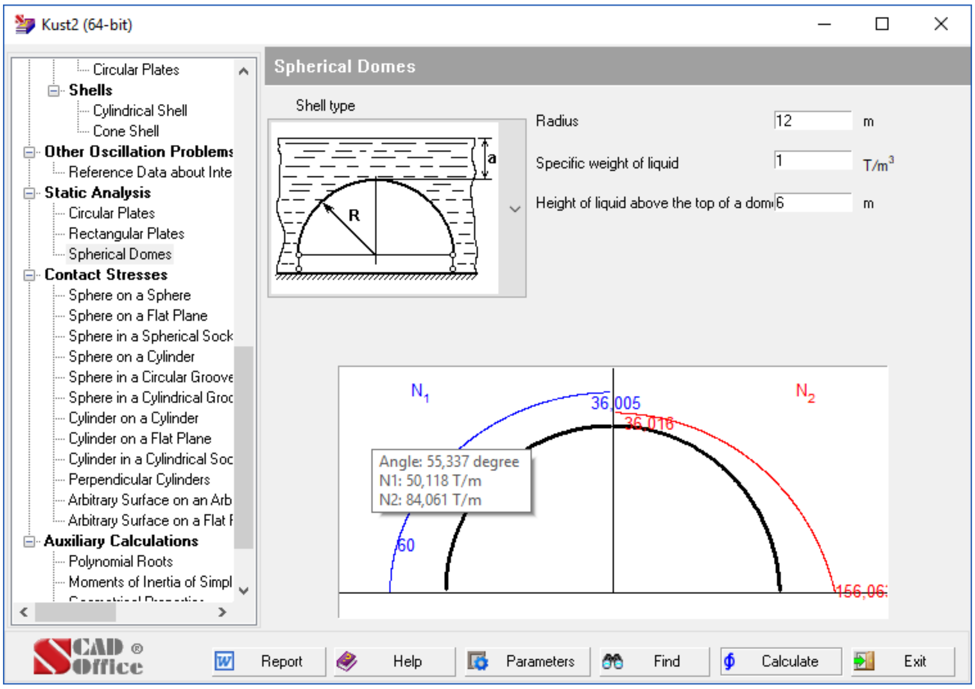
Clamped edge	
Simply supported edge	

The result of this analysis will be the *maximum stress* σ and the *maximum deflection* value.

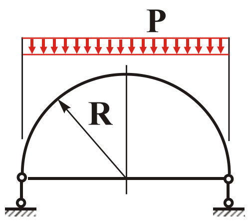
References

1. *Reference manual on elasticity* (ed. by P.M. Varvak), Kiev, Budivelnyk Publishers, 1971, 416 pp. (See p. 376.) *In Russian.*

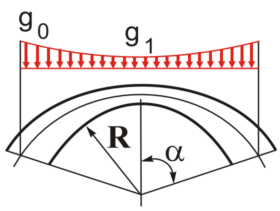
Spherical Domes



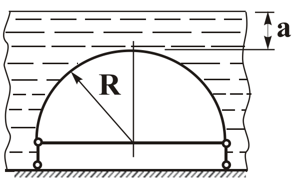
The object of consideration is spherical domes simply supported along their contours and subjected to the following loads:



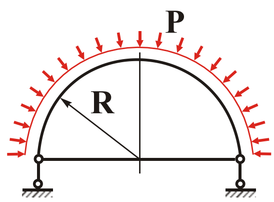
Uniform load on the horizontal projection



Dead load



Hydrostatic load



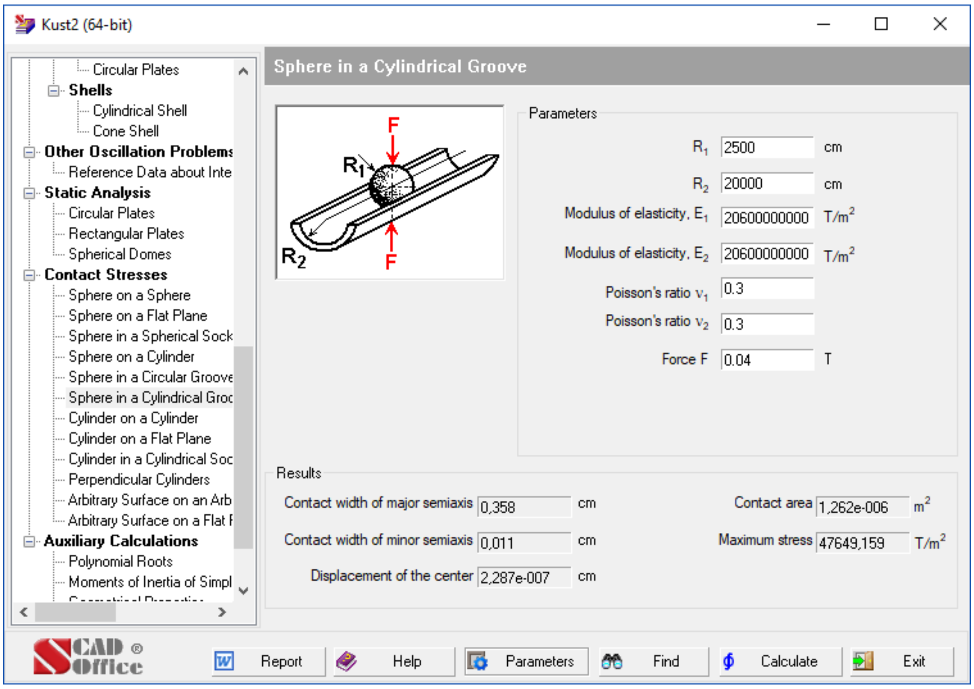
Uniform external pressure

The type of load is selected from the drop-down list. The initial data should include the radius of the dome and the load intensity. Clicking the **Calculate** button will display the diagram of tangential stress components in the circumferential and meridian directions (N_1, N_2). This diagram has the dynamic digitization feature, with the help of which the values of functions for an argument pointed to by the mouse pointer are displayed on the screen.

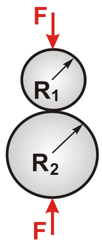
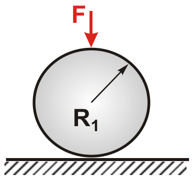
References

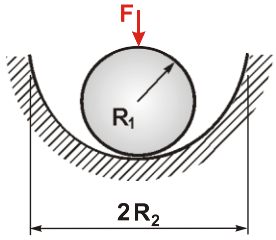
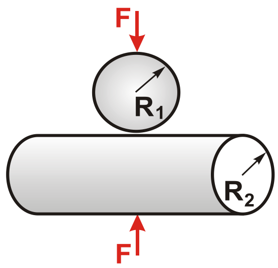
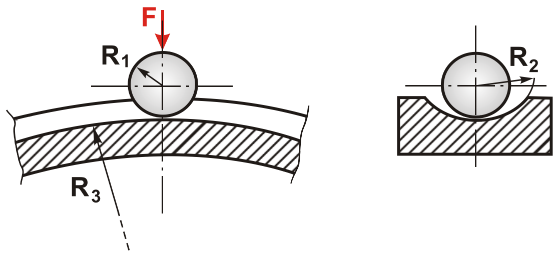
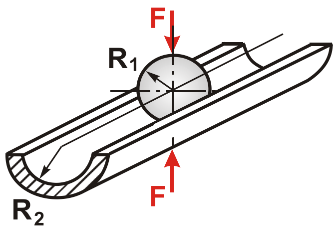
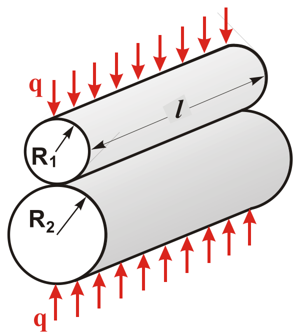
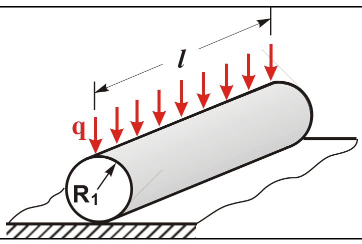
1. *Structural designer's reference manual. Design theory and analysis.* Vol. 2 (ed. by A.A. Umansky), Moscow, Stroyizdat Publishing House, 1973, 415 pp. (See p. 95.) *In Russian.*

Contact Stresses



The object of consideration is the problem of determining the maximum stresses, the size and area of the contact area in case of a point or linear contact between two isotropic elastic bodies. The initial data should include the radii of curvature of the contacting bodies, the moduli of elasticity and Poisson's ratios of the materials the above bodies are made of, and the load value. The following particular cases of the Hertz contact problem are analyzed:

Sphere on a sphere	
Sphere on a flat plane	

Sphere in a spherical socket	
Sphere on a cylinder	
Sphere in a circular groove	
Sphere in a cylindrical groove	
Cylinder on a cylinder	
Cylinder on a flat plane	

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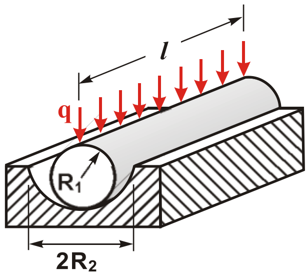
<tr><td>Cylinder in a cylindrical socket</td><td>
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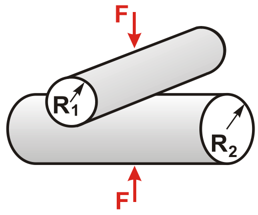
<tr><td>Perpendicular cylinders</td><td>
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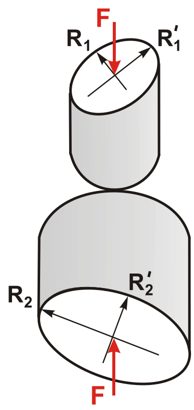
<tr><td>Arbitrary surface on an arbitrary surface</td><td>
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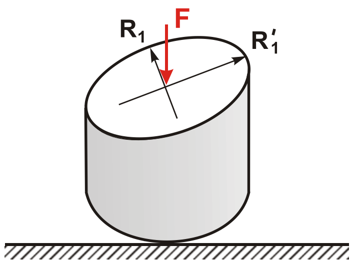
<tr><td>Arbitrary surface on a flat plane</td><td>
</td></tr>
</table>

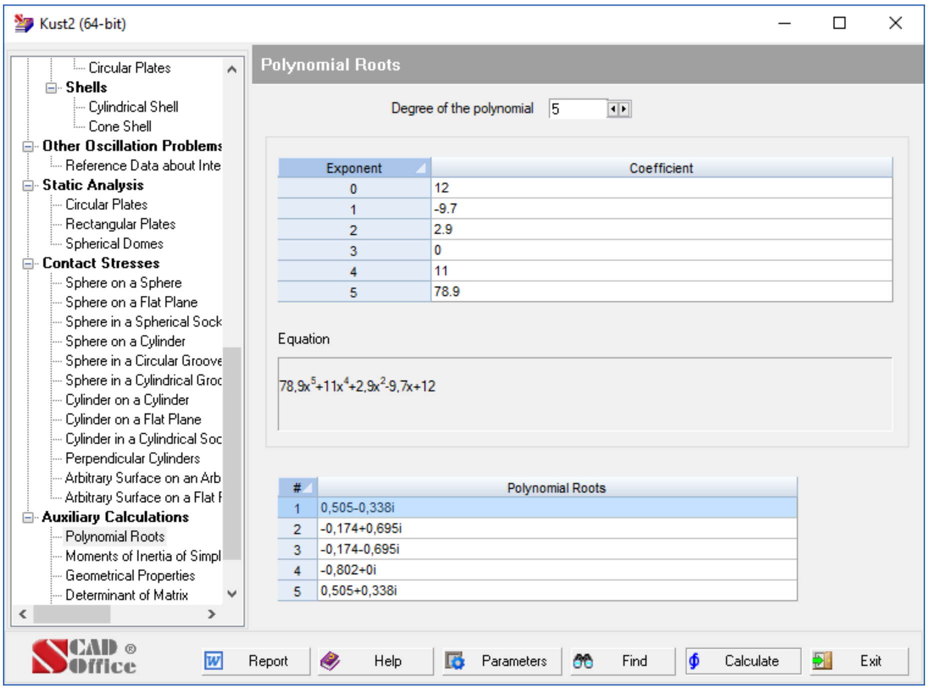
References

1. W.D. Pilkey. *Stresses, Strains and Structural Matrices*, New-York, John Wiley & Sons Inc. 1994.

1.6 Auxiliary Calculations

The modes of this section make it possible to calculate the following: polynomial roots, systems of linear equations, the inverse matrix, the determinant of a matrix, geometric properties of different geometric shapes, the moments of inertia of simple bodies.

Polynomial Roots



Considered here is a problem of finding all feasible solutions of the equation

$$\sum_{i=0}^{n} a_i x^i = 0,$$

$a_i, i = 0, \ldots, n$.

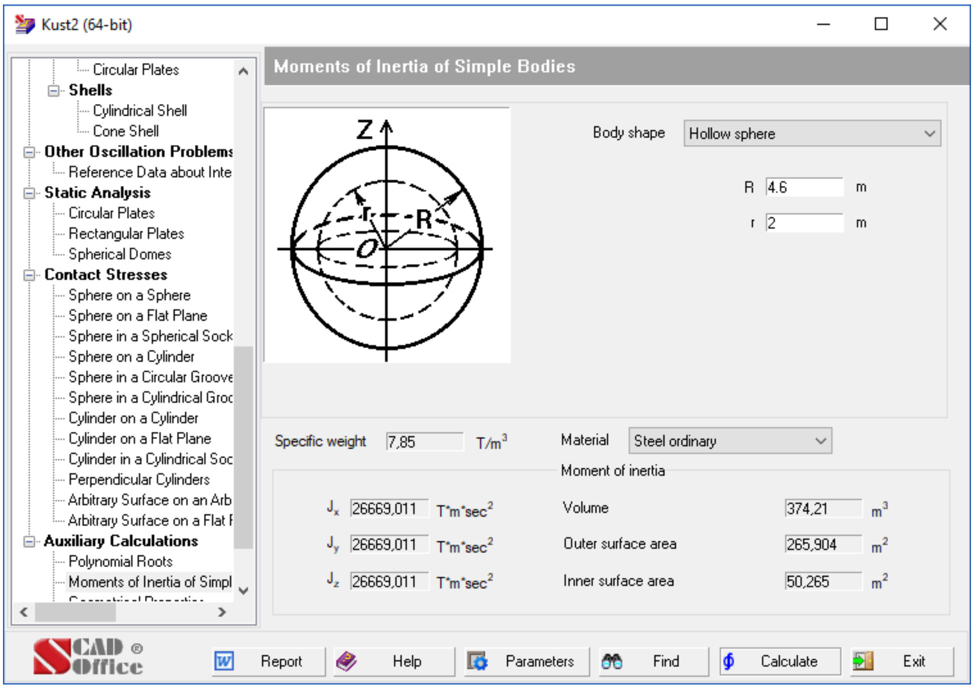
To solve this problem it is necessary to specify the degree of the polynomial and fill in the table with coefficients. After the equation is solved, the table at the bottom of the window will display all polynomial roots (both real and complex ones).

The Muller's iteration method is used to solve this problem.

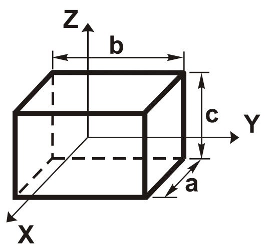
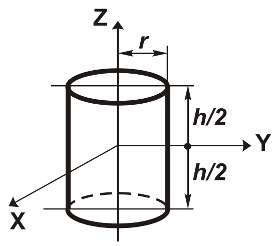
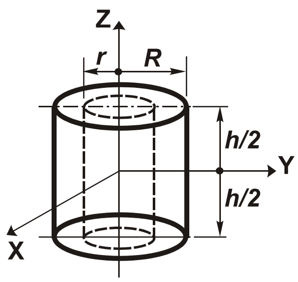
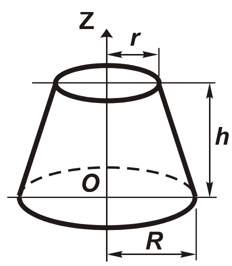
References

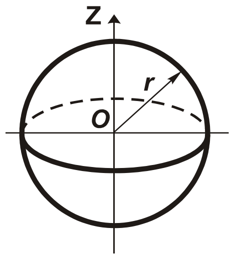
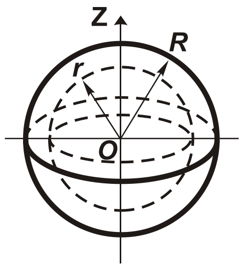
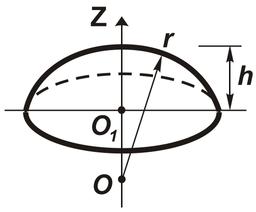
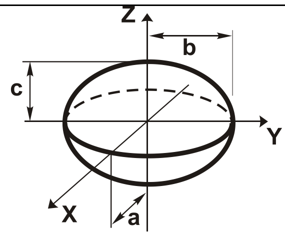
1. W.H. Press, B.P. Flannery, S.A. Teukolsky, W.T. Vetterling, *Numerical Recipes in C: The Art of Scientific Computing, 2nd ed.* Cambridge, England: Cambridge University Press, 1992. (see [1, Paragraph 9.5]).

Moments of Inertia of Simple Bodies

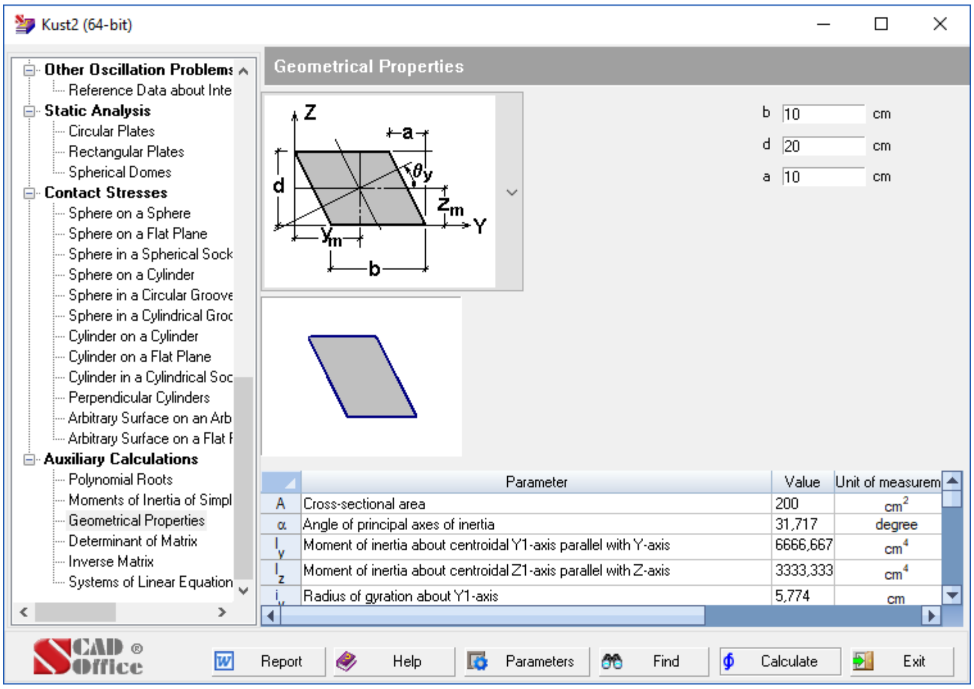


This mode allows to calculate the *moments of inertia* of bodies of simple geometric shapes, as well as their *volume* and *surface area(s)*. The available shapes are listed in the table below. The initial data should include the specific weight of the material (this parameter can be specified by selecting one of the materials from the database or by entering the explicit value if the OTHER MATERIAL option has been selected from the materials list). Moreover, depending on the selected shape, you have to specify the required geometric dimensions. The shape of a body is selected from the drop-down list.

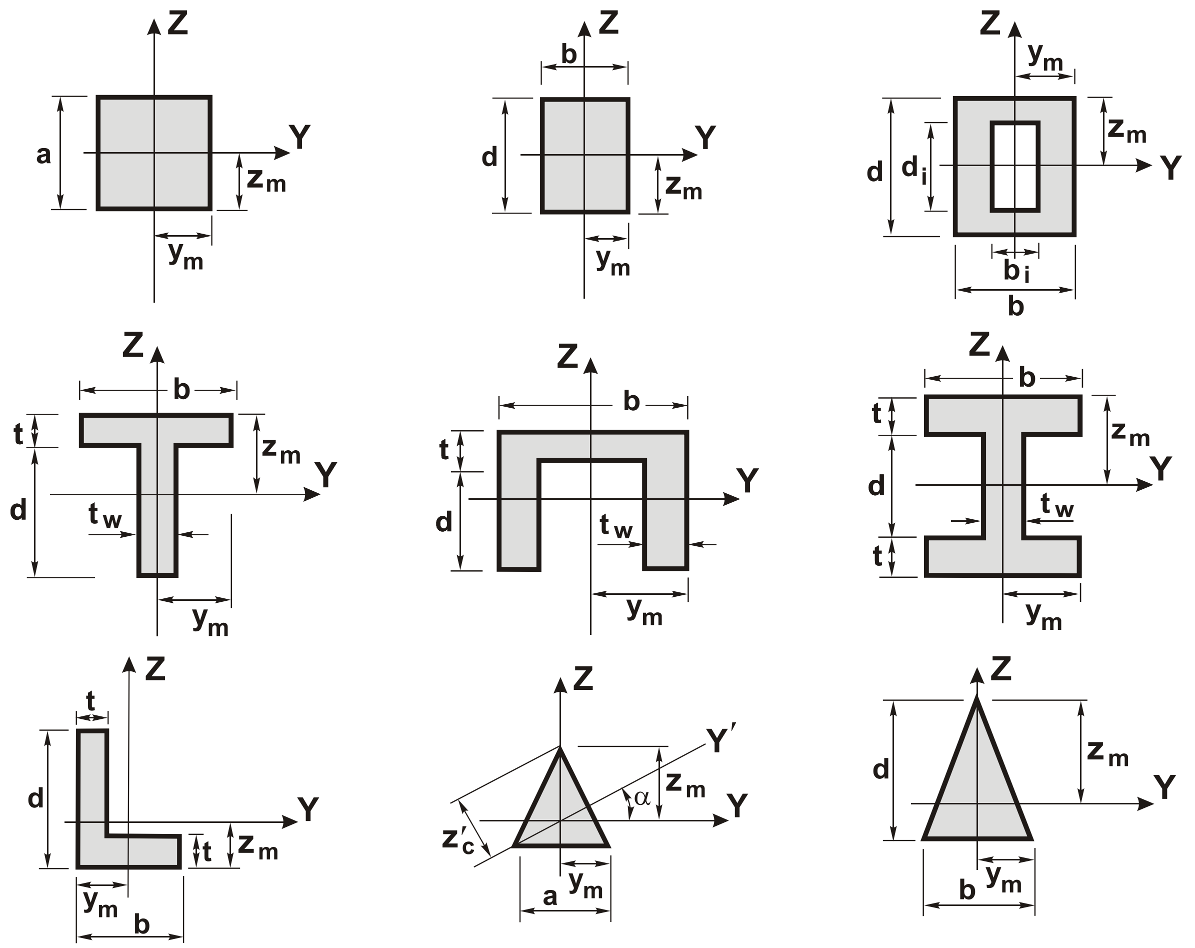
 Rectangular parallelepiped	 Cylinder
 Hollow cylinder	 Right truncated cone

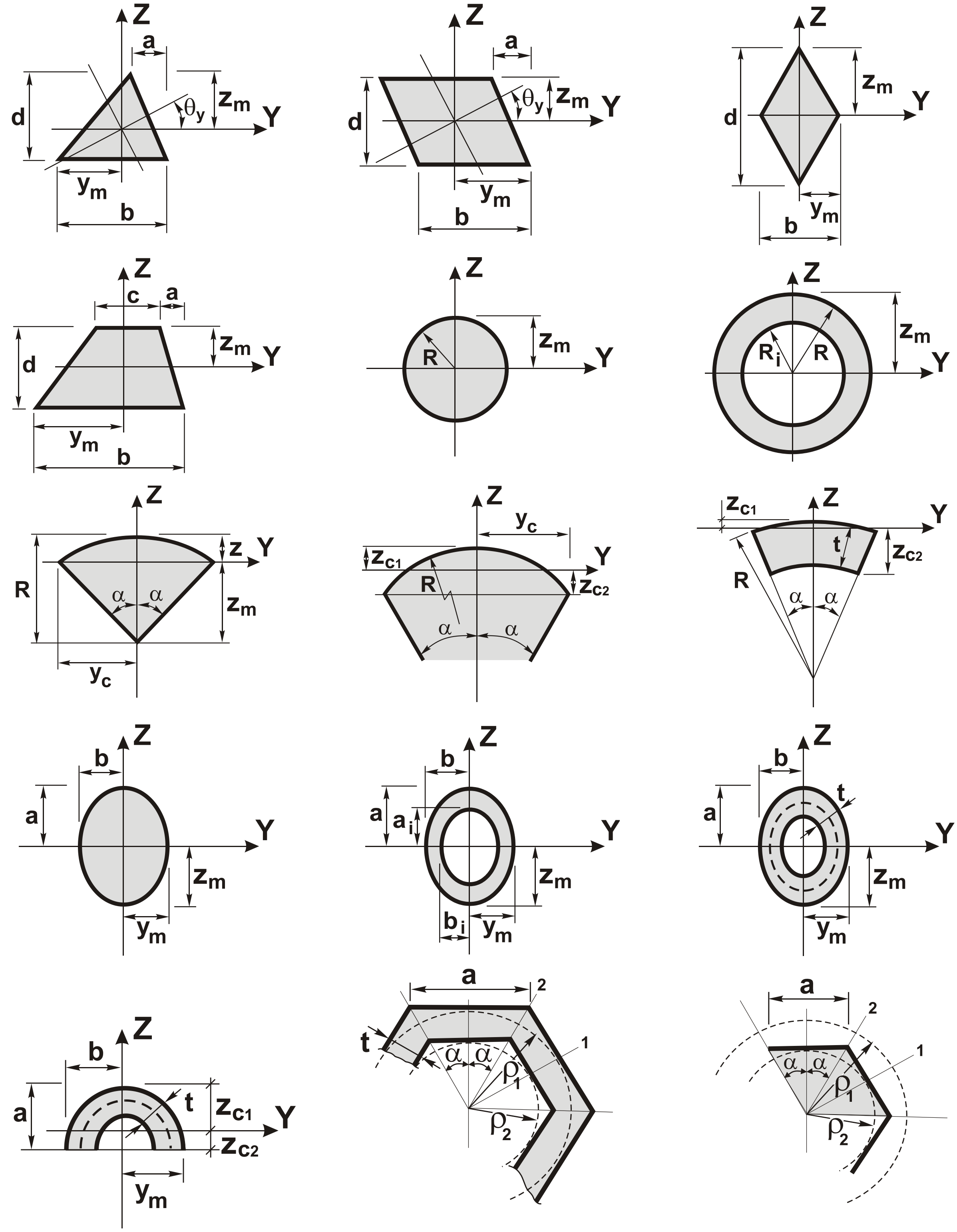
 Sphere	 Hollow sphere
 Sphere segment	 Ellipsoid

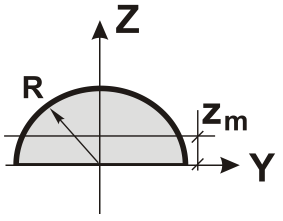
Geometric Properties

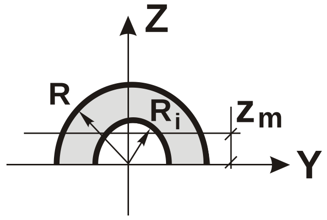


This mode allows you to determine the geometric properties (such as the area, moments and radii of inertia, etc.) for different geometric shapes shown below.




Z
Y
a
d
b
θy
zm
ym
c
R
Ri
z
zc1
zc2
yc
t
α
ai
bi
ρ1
ρ2
1
2



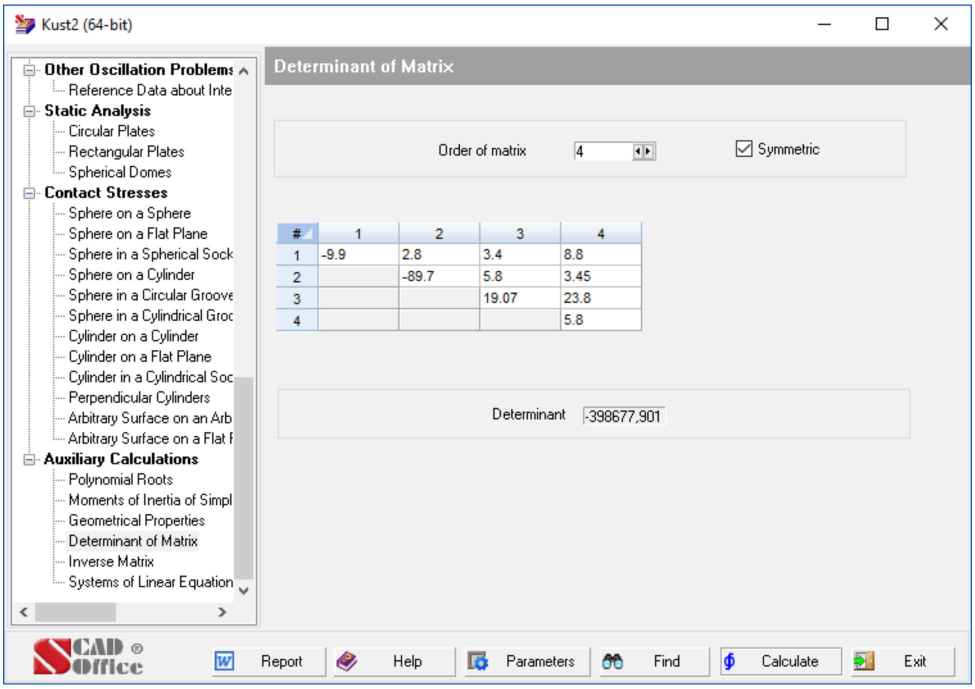


A geometric shape is selected from the drop-down list. To calculate the geometric properties, choose a desired shape in the drop-down list, specify the required dimensions (depending on the selected shape), and click the **Calculate** button. The calculated geometric properties will be displayed in the table at the bottom of the window.

References

1. W.C. Young, R.G. Budynas, *Roark's formulas for stress and strains, Seventh Edition*, 2002, ISBN 0-07-072542-X, 2001, 832 pp.
2. I.A. Birger, Y.G. Panovko et al., *Strength, stability, vibrations.* Vol. 1, Moscow, Mashinostroyeniye Publishing House, 1988, 831 pp. *In Russian.*

Determinant of a Matrix



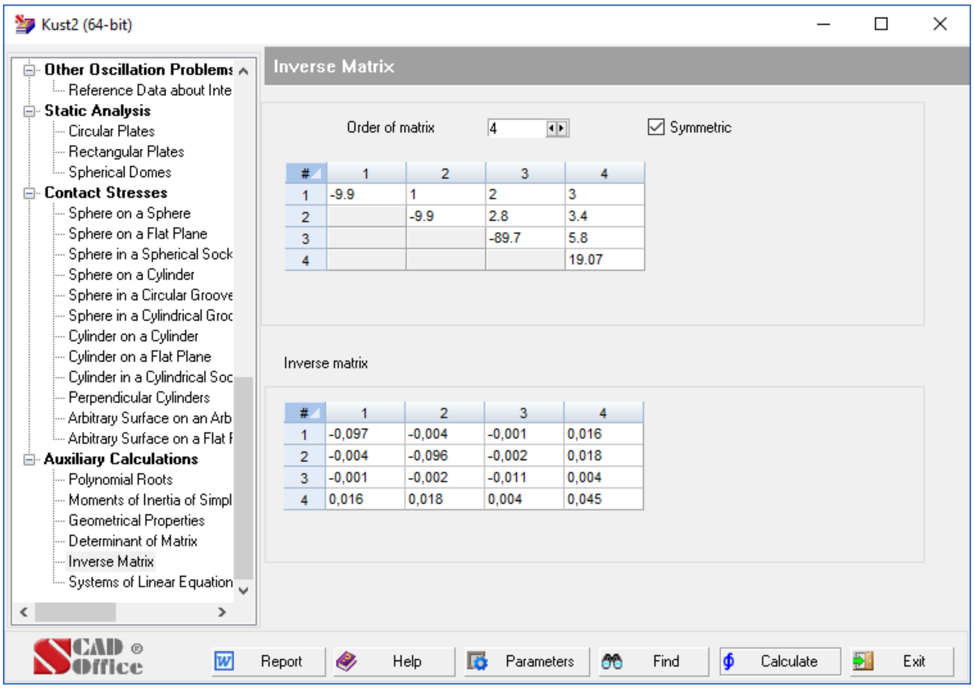
This mode allows you to calculate the determinant of any given matrix, the order of which does not exceed 50. When entering the initial data, specify the order of the matrix and then fill in the table of coefficients. For the case of symmetric matrices, the special **Symmetric** checkbox allows you to enter only the coefficients listed in the top triangle of those matrices.

The result of the analysis will be the *determinant* of the given matrix.

References

1. F.R. Gantmacher, *The theory of matrices***,** Moscow, Nauka Publishers, 1967, 576 pp. *In Russian.*

Inverse Matrix Calculation



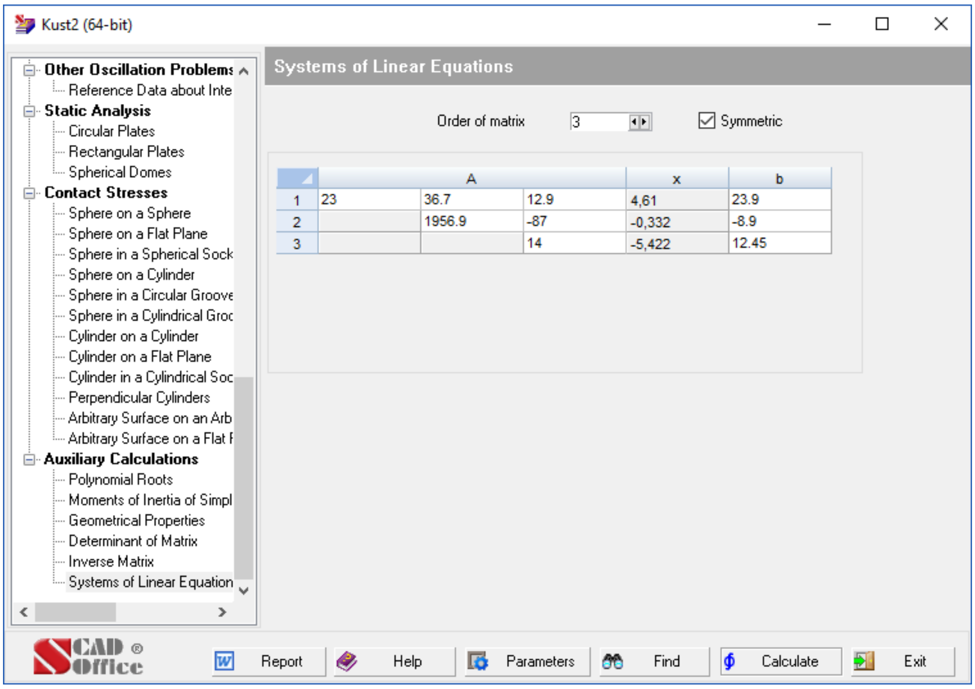
This mode allows you to calculate the inverse matrix of an arbitrary matrix the order of which does not exceed 50. When entering the initial data, you have to specify the order of the matrix and then fill in the table of coefficients. For the case of symmetric matrices, the special **Symmetric** checkbox allows you to enter only the coefficients listed in the top triangle of those matrices.

The result of the analysis will be the *inverse matrix* displayed in the table at the bottom of the screen.

References

1. F.R. Gantmacher, *The theory of matrices***,** Moscow, Nauka Publishers, 1967, 576 pp. *In Russian.*

Systems of Linear Equations



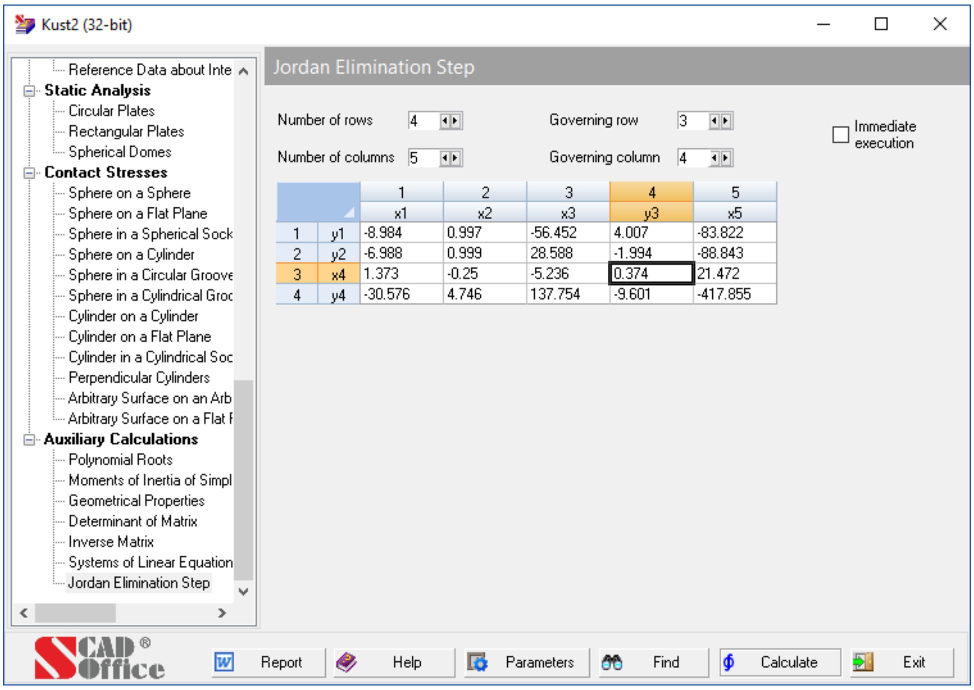
This mode enables you to solve a system of linear equations A**x** = **b** for an arbitrary matrix A (the order of which does not exceed 50) and the right-part vector **b**. When entering the initial data, you have to specify the order of the matrix and then fill in the table of coefficients. For the case of symmetric matrices, the special **Symmetric** checkbox allows you to enter only the coefficients listed in the top triangle of those matrices. Enter the right-part vector **b** in the table under the column heading **b**.

The result of the analysis will be the vector of unknowns **x** displayed in the table under the column heading **x**.

References

1. F.R. Gantmacher, *The theory of matrices***,** Moscow, Nauka Publishers, 1967, 576 pp. *In Russian.*

Jordan Elimination Step



The Jordan elimination step for a system of linear algebraic equations, the number of which is not necessarily equal to the number of variables, is the procedure of solving the r-th equation with respect to the s-th variable and substituting the resulting expression for x_s into all other equations. The coefficient matrix is transformed, and its new numerical representation is provided by the considered application.

The mechanical interpretation of this procedure is described in [1].

You have to specify the dimensions of the matrix in the dialog box and fill in the table of coefficients. A governing element can be selected by the mouse pointer or by specifying the numbers of the governing row and the governing column. Clicking the **Calculate** button will execute the Jordan elimination step. You can select another governing element then and execute the next step. The **Immediate execution** checkbox enables to execute the Jordan elimination step automatically every time a new governing element is selected by the mouse pointer.

References

1. A.V. Perelmuter, V.I. Slivker, *Numerical Structural Analysis: Methods, Models and Pitfalls*, Springer, 2003, 501 p.

2. CoCon – Stress Intensity Factors

2.1 General Information

Quite a few structural elements feature certain geometrical singularities, for example, holes, notches, etc. Usually, maximum local stresses occur specifically on the boundaries of such singularities. This maximum local stress $\sigma_{\max}$ is by far higher than the nominal stress σ_{nom}. The ratio of the maximum stress $\sigma_{\max}$ to the nominal one σ_{nom} is known as the ***stress concentration factor*** K_{t}, that is

$$\sigma_{\max} = K_{\text{t}}\sigma_{\text{nom}}$$

Suppose we deal with the flat stress problem. Depending on the way the nominal stress σ_{nom} is calculated — either by the total area of the given element (without distracting the singular object (hole) area)) or that minus the singular object's area — one distinguishes between the gross-area stress concentration factor (K_{tg}) and the net-area stress concentration factor (K_{tn}).

In some cases, for example, if we deal with holes in infinite plates (see Fig. 2.1-1), the concepts of the gross-/ net-area stress concentration factors lose their significance, therefore one should refer only to the *stress concentration factor* $\boldsymbol{K_t}$.

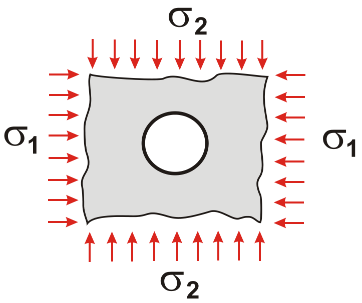


Fig. 2.1-1. Hole in an infinite plate

The studies of stress concentration are based on theoretical calculations, numerical analyses of various kinds, or experimental findings (photoelasticity). The results of numerous researches on stress concentration have been systematized and presented in the book by W.D. Pilkey *Peterson's Stress Concentration Factors.* The implementation of **CoCon** is based largely on this publication.

CoCon deals with quite a few structural elements having various singularities and subjected to the action of one load (as a rule). In practice, most structural elements are subjected to the action of combined loads. In order to evaluate the maximum stresses in these cases, it suffices to determine the maximum stresses for single loads, using the single-load stress concentration factors and the nominal stresses, and then use the *superposition principle*. This is a possibility, since we assume the structure material to behave linearly and, in addition to that, the maximum stresses occur, as a rule, at the same points of a structure under different kinds of loading.

Moreover, **CoCon** offers the modes for calculating the stress intensity factors at the tip of a crack. Depending on a particular problem, the following three types of intensity factors can be calculated:

K_I — intensity factors for the type I cracks (*bond-failure cracks,* or *opening mode crack*s);

K_{II}, — intensity factors for the type II cracks (*transverse shear cracks*);

K_{III} — intensity factors for the type III cracks (*longitudinal* or *out-of-plane shear cracks*).

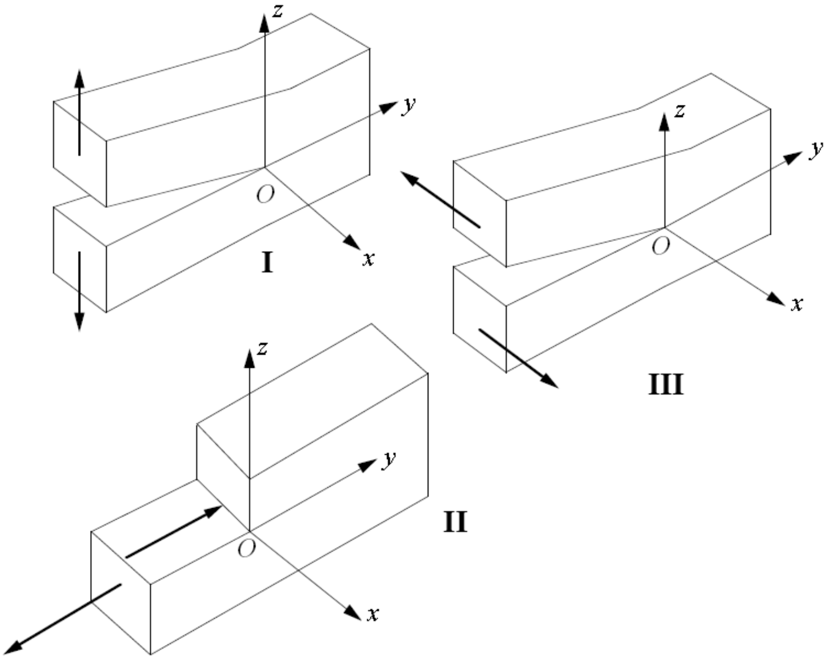


Fig. 2.1-2. Three types of cracks:
I – *bond-failure cracks;* II – *transverse shear cracks;* III – *longitudinal shear cracks*

2.2 Interface

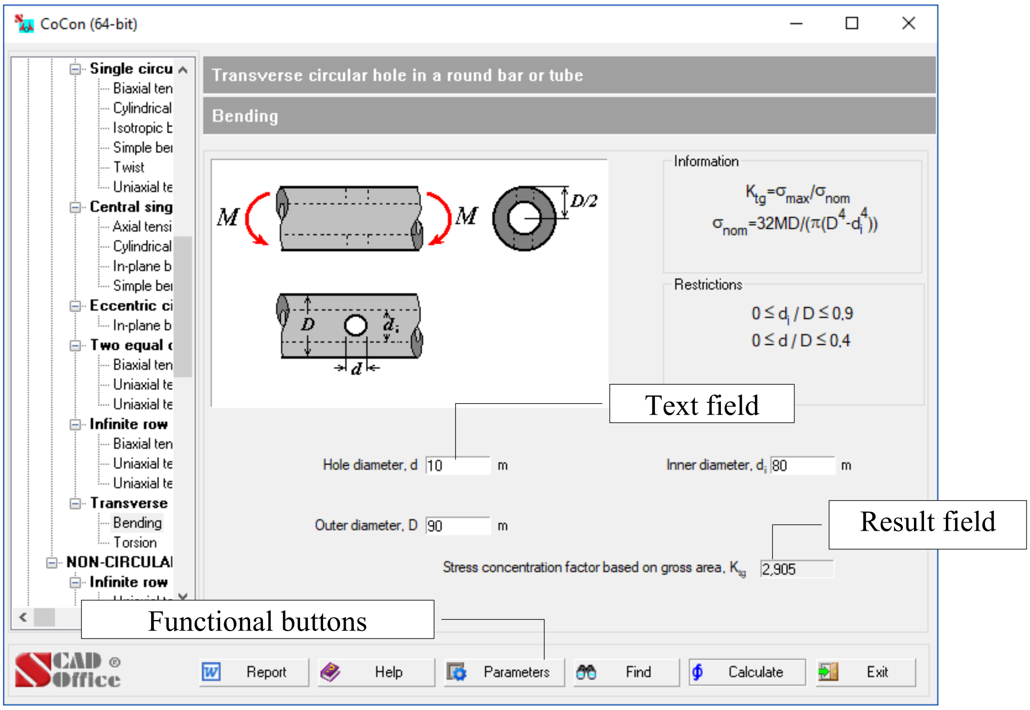


Figure 2.2-1. **CoCon** *window*

CoCon window has the same set of controls in all modes, namely:

- the problem tree which serves for selecting the problem to be solved;
- text fields used to enter initial data;
- display fields for the analysis results, which display the values of the stress concentration factors;
- functional buttons for activation of analysis and invocation of different control operations.

Problem Tree

The problem tree has three levels of hierarchy. The first level contains the names of shapes such as GROOVES AND NOTCHES or HOLES. The second level contains the names of the problem groups such as *Rounding of crossover bars*, and the third level contains the load types. To invoke a problem, place the mouse pointer over a load type and left-click.

Text Fields

When entering data in the text fields, it is allowed to use floating-point numbers (e. g., 0.214) or their scientific notation (e. g., 1.23e5). The integer and fractional parts are separated by a decimal point. A comma can also be used for this purpose, provided this is indicated in the Windows environment settings. Checking of the entered data validity takes place in the course of analysis.

Functional Buttons

The functional buttons serve to perform the following program control operations:

Calculate — activation of the operations of the initial data validation and calculation performance;

Report — generation of a report containing the analysis results;

Parameters — invokes the **Settings** dialog box where you can customize the program (see below);

Help — reference information on the **CoCon** program;

Find — a search in the problem tree by the context in the problem name. The search is performed in the **Find in problem tree** dialog box (Fig. 2.2-2) where you should first specify the sought-for text and then click the **Find** button. That done, a list of all problems the names of which contain the specified text will appear in the **Result** list**.** If you hover the mouse pointer over the desired problem and click the **Go to**

button, the control in the tree will be transferred to the specified problem. To perform the calculation, close the search dialog box.

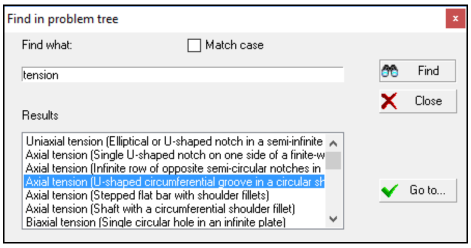


Fig. 2.2-2. *Dialog box*

Exit — exits the program.

Calculation

Follow these steps to perform the calculation:

- select a problem in the tree;
- enter the initial data in the text fields;
- click the **Calculate** button.

2.3 Settings

This dialog box can be invoked at any moment when working with **CoCon**. It is used to customize general parameters of the program. The dialog contains the following tabs: **Units of Measurement, Report and Languages**, **Visualization** and **General**.

Each tab opens a page where you can adjust certain types of settings.

The **Units of Measurement** tab (Fig. 2.3-1) enables you to define units of measurement used in the analysis. It contains two groups of data. The first group is used to specify measurement units of linear sizes, forces, moments, etc.

For compound units (such as those of moment, pressure, etc.), there is a possibility to define their component units (such as those for force and for moment arm) separately using the button . The second group helps to choose a representation and precision of numerical data. Special controls are used here to select data representation formats. Make sure to specify the number of significant digits in either the fixed-point decimal representation or the floating-point scientific notation.

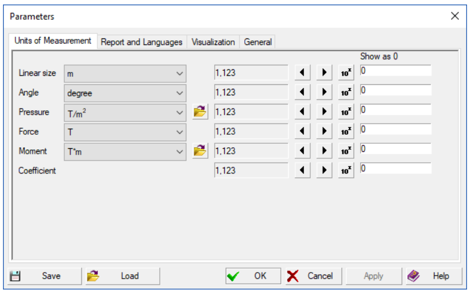


Figure 2.3-1. *The* **Units of Measurement** *tab*

The precision of the data representation (the number of significant digits after the decimal point) can be assigned using the (decrease) and (increase) buttons, while the scientific notation is turned on by the button . You can also specify in respective text fields which values should be treated as negligibly small, so that all absolute values less than the given ones will be displayed as 0 in all visualizations.

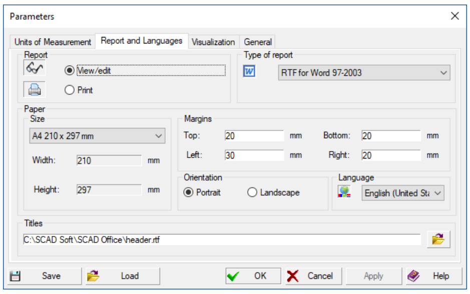


Figure 2.3-2. *The* **Report and Languages** *tab*

The **Report and Languages** tab (Fig. 2.3-2) enables you to choose a language for the user interface and for the report.

There are two modes for working with a report document: **View/Edit** or **Print**.

In the **View/Edit** mode, clicking the **Report** button in any active dialog will open the report and allow you to view/edit it. An application associated with **RTF** (Rich Text Format) files (such as MS Word Pad or MS Word) will be invoked to serve this purpose. Obviously, it is the user who is fully responsible for any changes made to the text of the report (note that even results of the calculation can be edited).

There are differences in RTF formats used by MS Word v.7, MS Word 97 (2000/XP) and Open Office. Therefore, the program allows you to choose one of the formats in the **Type of Report** mode (besides RTF a report can be created in the following formats DOC, PDF, HTML).

Clicking the **Print** button in the **Report** group will print the report in the form it has been generated by the program.

Use the **Titles** text field to specify an RTF file containing headers and footers for pages of the report document. The file can be selected from a standard list by clicking the button .

The **Paper Size** setting enables you to choose the paper format for printing the report (the size is selected from a drop-down list). Moreover, the margins and the page orientation can be selected before generating the report.

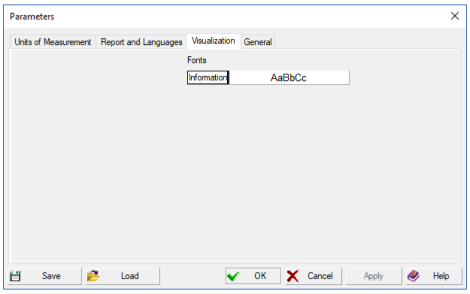


Figure 2.3-3. *The* **Visualization** *tab*

The **Visualization** tab (Fig. 2.3-3) is used to choose a font for the user interface and for the report. A double left click invokes a standard Windows dialog for selecting the font.

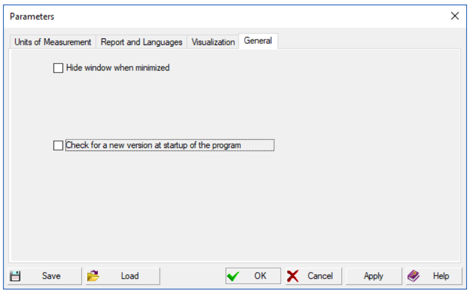


Figure 2.3-4. *The* **General** *tab*

The **General** tab (Fig. 2.3-4) allows you to activate the **Hide window when minimized** checkbox. When it is checked the window disappears from the task bar, and an icon appears in the tray area. The window can be opened from the tray area by the left click, and a context menu – by the right click.

Moreover, the **Check for a new version at startup of the program** checkbox can be activated as well. If it is active, the program will check for a new version on the company website at each startup, and it will give a respective message if it finds a new release.

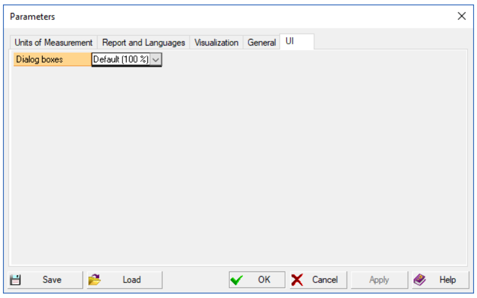


Figure 2.3-5. *The* **UI** *tab*

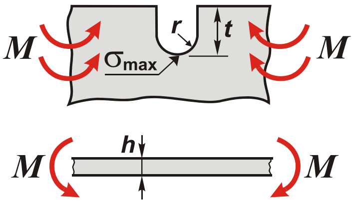
The **UI** tab **(**Fig. 2.3-5) enables to set scales for dialog boxes.

The settings provided in this tab are intended primarily for users with HiDPI displays.

2.4 Notches and Grooves

Elliptical or U-shaped notch in a semi-infinite plate

Transverse load

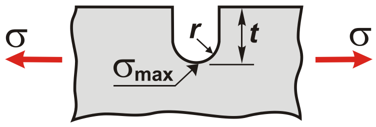


	Information and restrictions
	$0 \le t/r \le 7$ $K_{tn} = \sigma_{max} / \sigma_{nom}$ $\sigma_{nom} = 6M / h^2$

References

1. W.D. Pilkey. *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 2.37, p. 118 § 2.7.1, p. 72).
2. S. Shioya. *On the Transverse Flexure of a Semi-Infinite Plate with an Elliptic Notch*, Ingenieur-Archiv, 1960, 29, p. 93.

Uniaxial tension



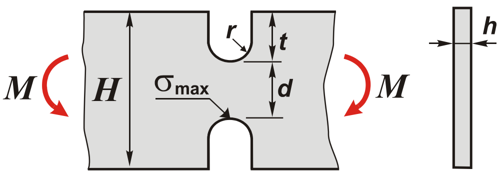
	Information and restrictions
	$0 \le t/r \le 361$ $K_{tg} = \sigma_{max} / \sigma$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 2.2 p. 82 § 2.3.1, p. 62).
2. M. Seika, *Stresses in a Semi-Infinite Plate Containing a U-Type Notch Under Uniform Tension,* Ingenieur-Archiv., 1960, 27, p. 20.
3. L. Bowie, *Analysis of Edge Notches in a Semi-Infinite Region*, J. Math and Phys, 45, 356-366.
4. F. I.Barrata, D. M. Neal, *Stress Concentration Factors in U-Shaped and Semi-Elliptical Shaped Edge Notches*, Strain Anal., 1970, 5, p. 121.

Opposite U-shaped notches in a finite-width plate

In-plane bending

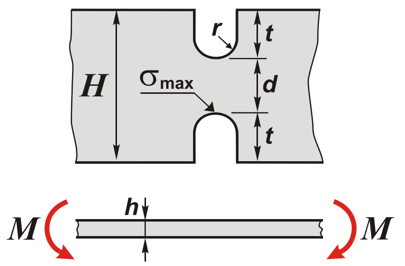


Information and restrictions
$0.1 \le t/r \le 50$
$0 \le 2t/H \le 1$
$K_{tn} = \sigma_{max} / \sigma_{nom}$
$\sigma_{nom} = 6M / hd^2$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 2.25 p. 105 § 2.6.3 p. 70).
2. M. Frocht, *Factors of Stress Concentration Photoelasticity Determined*, Trans. ASME, Applied Mechanics Section, 1935, 57, p. A-67.
3. M. Isida, *On the Tension of the Strip with Semi-Circular Notches*, Trans. Japan Soc. Mech.Eng., 1953, 19, p. 5.
4. Chi-Bing Ling, *On Stress Concentration at Semicircular Notch*, Trans. ASME, Applied Mechanics Section, 1967, 89, p. 522.

Transverse bending



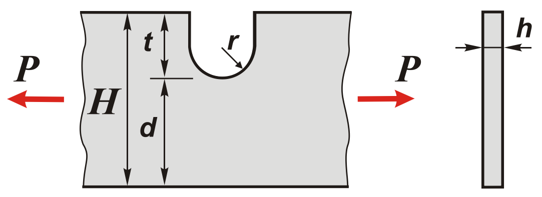
Information and restrictions
$0.1 \le t/r \le 5$
$0 \le 2t/H \le 1$
$t/h >> 1$
$K_{tn} = \sigma_{max} / \sigma_{nom}$
$\sigma_{nom} = 6M / dh^2$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 2.39 p. 120 § 2.7.2).
2. S. Shioya, *On the Transverse Flexure of a Semi-Infinite Plate with an Elliptic Notch*, Ingenieur-Archiv, 1960, 29, p. 93.
3. H. Lee, *The Influence of Hyperbolic Notches on the Transverse Flexure of Elastic Plates*, Trans. ASME, Applied Mechanics Section, 1940, 62, p. A-53
4. H. Neuber, *Theory of Notch Stresses: principles for exact calculation of strength with reference to structural form and material*, 2nd ed., Berlin, Springer-Verlag, 1958.

Single U-shaped notch on one side of a finite-width plate

Axial tension

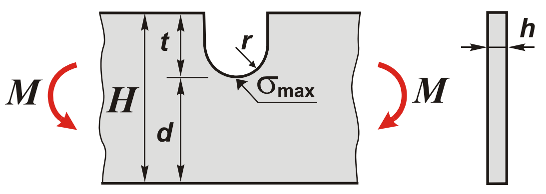


Information and restrictions
$0.5 \le t/r \le 20$
$0 \le t/H \le 1$
$K_{tn} = \sigma_{max} / \sigma_{nom}$
$\sigma_{nom} = P/hd$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (*Chart* 2.9 p. 89 § 2.3.6 p. 65).
2. G. Cole, A.F. Brown, *Photoelastic Determination of Stress Concentration Factors Caused by a Single U-Notch on One Side of a Plate in Tension*, Royal Aero. Soc., 1958, 62, p. 597.

In-plane bending



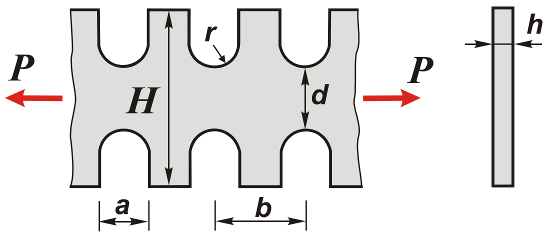
Information and restrictions
$0.5 \le t/r \le 20$ $0 \le t/H \le 1$
$K_{tn} = \sigma_{max} / \sigma_{nom}$ $\sigma_{nom} = 6M/hd^2$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 2.30a p. 110 § 2.6.5 p.70).
2. M. Leven, M. M. Frocht, *Stress Concentration Factors for a Single Notch in a Flat Plate in Pure and Central Bending*, Proc. SESA, 1953, 11, No. 2, p. 179.

Infinite row of opposite semicircular notches in a finite-width plate

Axial tension



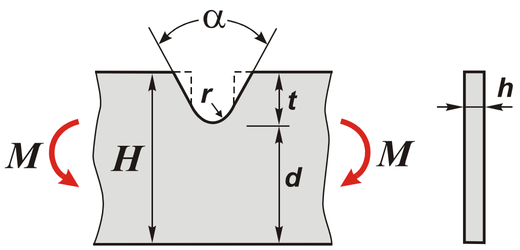
Information and restrictions
$0 \le a/H \le 0.4$
$0 \le a/b \le 1$
$K_{tn} = \sigma_{max} / \sigma_{nom}$
$\sigma_{nom} = P/hd$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors*, 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 2.12 p. 92 § 2.3.8 p. 66).
2. A. Atsumi, *Stress Concentration in a Strip under Tension and Containing an Infinite Row of Semicircular Notches*, Q. J. Mech. & Appl. Math., 1958, 11, Part 4, p. 478.

Single V-shaped notch on one side of a finite-width plate

In-plane bending



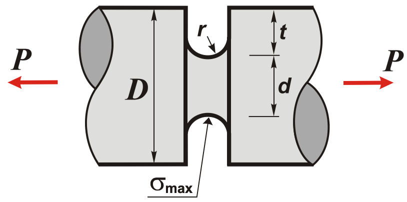
Information and restrictions
$0.5 \le t/r \le 4$
$0 \le t/H \le 1$
$0 \le \alpha \le 150^0$
$K_{tn} = \sigma_{max} / \sigma_{nom}$
$\sigma_{nom} = 6M/hd^2$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors*, 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 2.28 p. 108 § 2.6.4 p. 70).
2. M. Leven, M. M. Frocht, *Stress Concentration Factors for a Single Notch in a Flat Plate in Pure and Central Bending*, Proc. SESA, 1953, 11, No. 2, p. 179.

U-shaped circumferential groove in a circular shaft

Axial tension

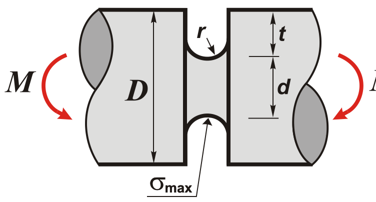


Information and restrictions
$0.3 \le r/d \le 1$ $1.005 \le D/d \le 1.1$ $K_{tn} = \sigma_{max} / \sigma_{nom}$ $\sigma_{nom} = 4P / \pi d^2$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 2.21 p. 101 § 2.5.2 p. 69).
2. H. Neuber, *Theory of Notch Stresses: principles for exact calculation of strength with reference to structural form and material*, 2nd ed., Berlin, Springer-Verlag, 1958.

Bending

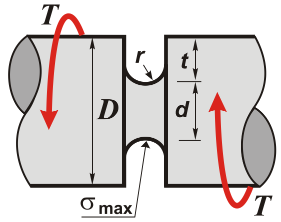


Information and restrictions
$0.25 \le t/r \le 50$ $0 \le 2t/D \le 1$ $K_{tn} = \sigma_{max} / \sigma_{nom}$ $\sigma_{nom} = 32M / \pi d^3$

References

1. W.D.Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 2.41 p. 122 § 2.8.2 p. 72).

Torsion



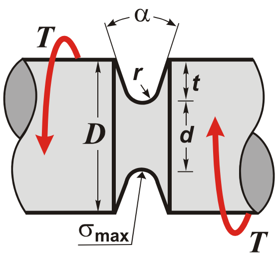
Information and restrictions
$0.25 \le t/r \le 50$ $0 \le 2t/D \le 1$ $K_{tn} = \tau_{max} / \tau_{nom}$ $\tau_{nom} = 16T / \pi d^3$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 2.47 p. 128 § 2.9.3 p. 74).
2. R. Rushton, *Stress Concentrations Arising in the Torsion of Grooved Shafts*, J. Mech. Sci., 1967, 9, p. 697.

V-shaped circumferential groove in a circular shaft

Torsion

	Information and restrictions
	$0.1 \le t/r \le 50$ $0 \le 2t/D \le 1$ $0 \le \alpha \le 125^0$ $r/d \le 0.01$, if $90 \le \alpha \le 125$ $K_{tn} = \tau_{max} / \tau_{nom}$ $\tau_{nom} = 16T / \pi d^3$

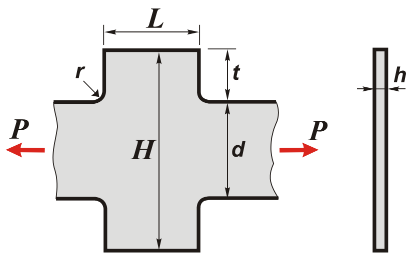
References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 2.51 p. 132 § 2.9.4 p. 76).
2. R. Rushton, *Stress Concentrations Arising in the Torsion of Grooved Shafts*, J. Mech. Sci., 1967, 9, p. 697.

2.5 Shoulder Fillets

Stepped flat bar with shoulder fillets

Axial tension

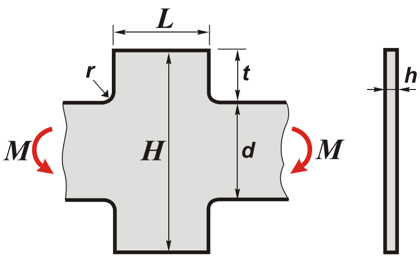


Information and restrictions
$0.1 \le t/r \le 20$
$0 \le 2t/H \le 1$
$L/H \ge 5.5 - 1.89(r/d - 0.15)$
$K_t = \sigma_{max}/\sigma_{nom}$
$\sigma_{nom} = P/hd$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 3.2a p. 151 § 3.3.2 p. 138).
2. K. Kumagai, H. Shimada, *The Stress Concentration Produced by a Projection under Tensile Load*, Bull. Japan Soc. Mech. Eng., 1968, 11, p. 739.

In-plane bending



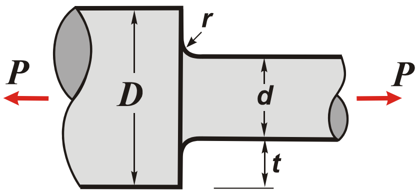
Information and restrictions
$0.1 \le t/r \le 20$
$0 \le 2t/H \le 1$
$L/H \ge 2.0 - 2.05(r/d - 0.025)$
$K_t = \sigma_{max}/\sigma_{nom}$
$\sigma_{nom} = 6M/hd^2$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 3.8a, p. 160 § 3.4.2 p. 143).
2. M. Leven, J. B. Hartman, *Factors of Stress Concentration for Flat Bars with Centrally Enlarged Section*, Proc. SESA, 1951, 19, No. 1, p. 53.

Shaft with a circumferential shoulder fillet

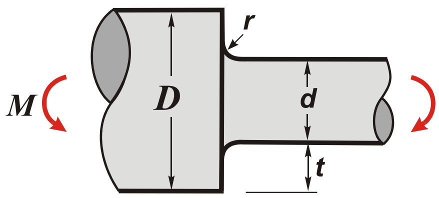
Axial tension

	Information and restrictions
	$0.1 \le t/r \le 20$ $0 \le 2t/D \le 1$ $K_t = \sigma_{max}/\sigma_{nom}$ $\sigma_{nom} = 4P/\pi d^2$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 3.4 p. 156 § 3.3.5 p. 142).

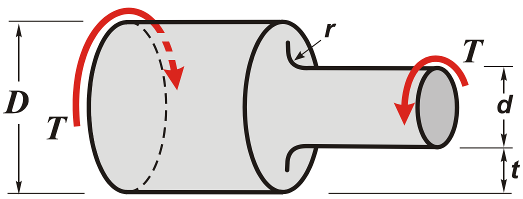
Bending

	Information and restrictions
	$0.1 \le t/r \le 20$ $0 \le 2t/D \le 1$ $K_t = \sigma_{max}/\sigma_{nom}$ $\sigma_{nom} = 32M/\pi d^3$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 3.10 p. 164 § 3.4.4 p. 143).
2. M. Leven, J.B. Hartman, *Factors of Stress Concentration for Flat Bars with Centrally Enlarged Section*, Proc. SESA, 1951, 19, No. 1, p. 53.
3. H. Wilson, D.J. White, *Stress Concentration Factors for Shoulder Fillets and Grooves in Plates*, Strain Anal., 1973, 18, p. 43-51.

Torsion

	Information and restrictions
	$0.25 \le t/r \le 4$ $0 \le 2t/D \le 1$ $K_t = \tau_{max}/\tau_{nom}$ $\tau_{nom} = 16T/\pi d^3$

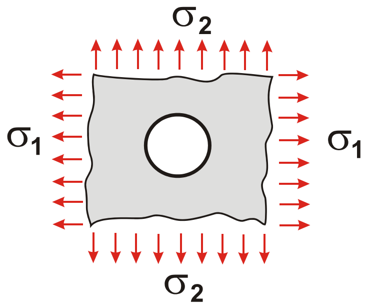
References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 3.12, p. 166 § 3.5.1 p. 144).
2. J. Matthews, C. J. Hooke, *Solution of Axisymmetric Torsion Problems by Point Matching*, Strain Anal., 1971, 6, p. 124.

2.6 Circular Holes

Single circular hole in an infinite plate

Biaxial tension

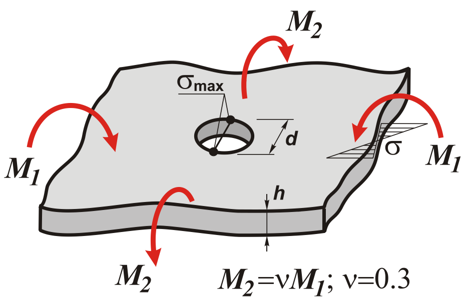


Information and restrictions
$-1 \le \sigma_2 / \sigma_1 \le 1$ $K_t = \sigma_{max} / \sigma$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (§ 4.3.2 p. 184).

Cylindrical bending

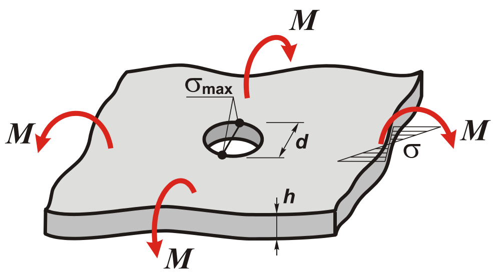


Information and restrictions
$0 \le d / h \le 7$ $K_t = \sigma_{max} / \sigma$ $\sigma = 6M / h^2$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 4.82 p. 358 § 4.6.4 p. 240).

Isotropic bending

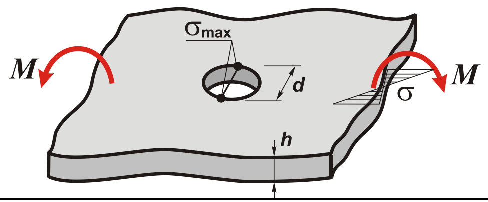


Information and restrictions
$K_t = \sigma_{max} / \sigma$ $\sigma = 6M / h^2$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 4.82 p. 358 § 4.6.4 p. 240).

Simple bending

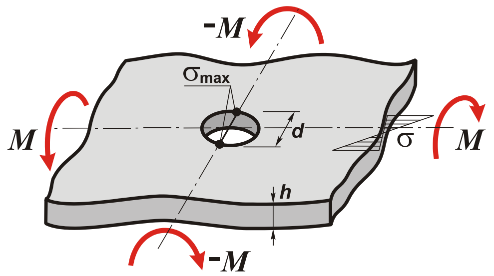


Information and restrictions
$0 \le d/h \le 7$ $K_t = \sigma_{max}/\sigma$ $\sigma = 6M/h^2$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 4.82 p. 358 § 4.6.4 p. 240).

Twist

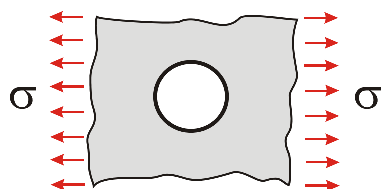


Information and restrictions
$0 \le d/h \le 7$ $K_t = \sigma_{max}/\sigma$ $\sigma = 6M/h^2$ $\nu = 0.3$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors*, 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 4.97 p. 374 §4.7.6 p. 244).
2. E. Reissner, *The Effect of Transverse Shear Deformation on the Bending of Elastic Plates*, Trans. ASME, Appl. Mech. Section, 1945, 67, p. A69-A77.

Uniaxial tension

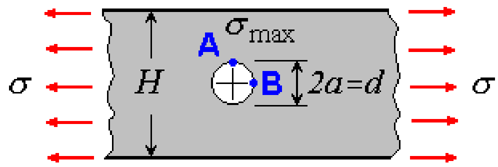


References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (§ 4.3.1 p. 180).

Central single circular hole in a finite-width plate

Axial tension

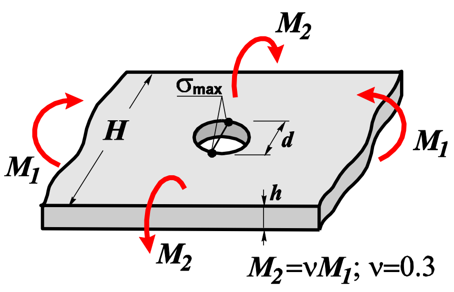


Information and restrictions
$0 \le d/H \le 1$ $\sigma_{max} = \sigma_A$ $K_{tg} = \sigma_{max}/\sigma$ $K_{tn} = K_{tg}(1 - d/H)$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 4.1 p. 256 § 4.3.1 p. 180).
2. C.J. Howland, *On the stresses in the neighborhood of a circular hole in a strip under tension*, Phil. Trans. Roy. Soc. (London) A, 1929-30, 229, 67.

Cylindrical bending

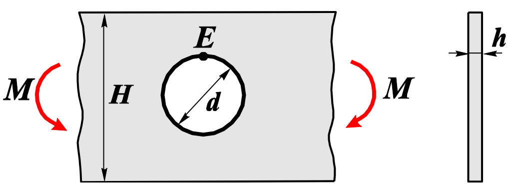


Information and restrictions
$0 \le d/H \le 0.3$ $1 \le d/h \le 7$ $K_{tg} = \sigma_{max}/\sigma$ $\sigma = 6M_1/h^2$ $K_{tn} = \sigma_{max}/\sigma_{nom}$ $\sigma_{nom} = 6M_1 H/((H-d)h^2)$ $\nu = 0.3$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 4.83 p. 359 § 4.6.4 p. 240).

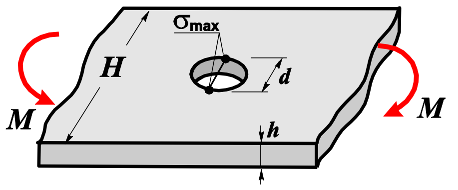
In-plane bending



References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 4.79 p. 355 § 4.6.1 p. 239).
2. C.J. Howland, A.C. Stevenson, *Biharmonic Analysis in a Perforated Strip*, Phil. Trans. Royal Soc. A, 1933, 232, p. 155.
3. R.B. Heywood, *Designing by Photoelasticity*, Chapman and Hall, London, 1952.

Simple bending

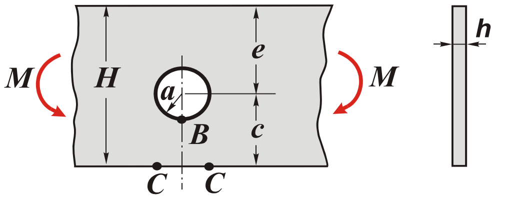
	Information and restrictions
	$0 \le d/H \le 0.3$ $1 \le d/h \le 7$ $K_{tg} = \sigma_{max}/\sigma$ $\sigma = 6M/h^2$ $K_{tn} = \sigma_{max}/\sigma_{nom}$ $\sigma_{nom} = 6M\,H/((H-d)h^2)$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 4.83 p. 359 § 4.6.4 p. 240).

Eccentric circular hole in a finite-width plate

In-plane bending

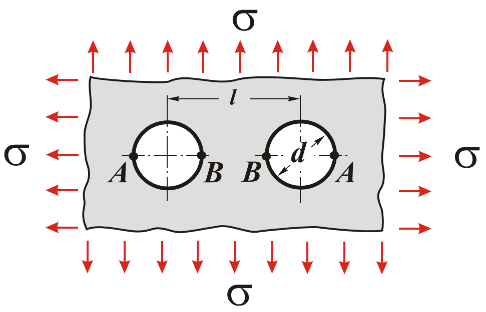
	Information and restrictions
	$0 \le a/c \le 0.5$ $0 \le c/e \le 1$ $K_{tg} = \sigma_{max}/(6M/(H^2h))$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors*, 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 4.80 p. 356 § 4.6.2 p. 240).
2. M. Isida, *On the Bending of an Infinite Strip with an Eccentric Circular Hole*, Proc. 2nd Japan Congr. Appl. Mech., 1952, p. 57.

Two equal circular holes in an infinite plate

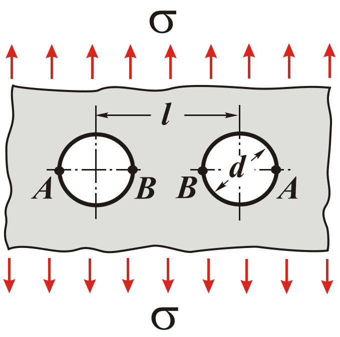
Biaxial tension

	Information and restrictions $0 \le d/l \le 1$ $K_{tnB} = \frac{\sigma_{\max B}}{\sigma} \frac{1-d/l}{\sqrt{1-(d/l)^2}}$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 4.24 p. 285 § 4.3.10-4.3.11 p. 200).
2. Chi-Bing Ling, *On the Stresses in a Plate Containing Two Circular Holes*, Appl. Physics, 1948, 19, p. 77.
3. W. Haddon, *Stresses in an Infinite Plate with Two Unequal Circular Holes*, Q. J. Mech. Appl. Math., 1967, 20, pp. 277-291.

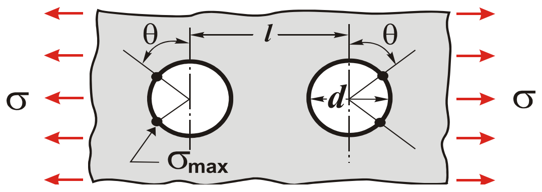
Uniaxial tension normal to the row of holes

	Information and restrictions $0 \le d/l \le 1$ $K_{tnB} = \frac{\sigma_{\max B}}{\sigma} \frac{1-d/l}{\sqrt{1-(d/l)^2}}$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 4.22 p. 283 § 4.3.10-4.3.11 p. 200).
2. Chi-Bing Ling, *On the Stresses in a Plate Containing Two Circular Holes*, Appl. Physics, 1948, 19, p. 77.
3. W. Haddon, *Stresses in an Infinite Plate with Two Unequal Circular Holes*, Q. J. Mech. Appl. Math., 1967, 20, pp. 277-291.

Uniaxial tension parallel to the row of holes

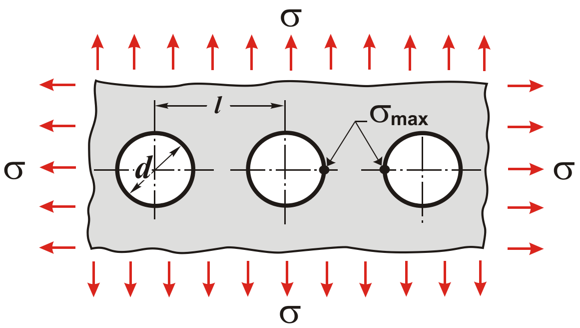
	Information and restrictions
	$0 \le d/l \le 1$ $K_{tg} = \sigma_{max} / \sigma$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 4.21 p. 282 § 4.3.10 p. 200).
2. Chi-Bing Ling, *On the Stresses in a Plate Containing Two Circular Holes*, Appl. Physics, 1948, 19, p. 77.
3. A.W. Haddon, *Stresses in an Infinite Plate with Two Unequal Circular Holes*, Q. J. Mech. Appl. Math., 1967, 20, p. 277-291.

Infinite row of circular holes in an infinite plate

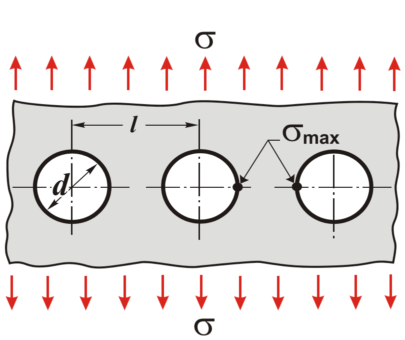
Biaxial tension

	Information and restrictions
	$0 \le d/l \le 1$ $K_{tg} = \sigma_{max} / \sigma$ $K_{tn} = \sigma_{max} / \sigma_{nom}$ $\sigma_{nom} = \sigma / (1 - d/l)$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 4.34 p. 301 § 4.3.12 p. 207).
2. A. Hütter, *Die Spannungsspitzen in gelochten Blechscheiben und Streifen*, Z. angew. Math. Mech., 1942, 22, p. 322.

Uniaxial tension normal to the row of holes

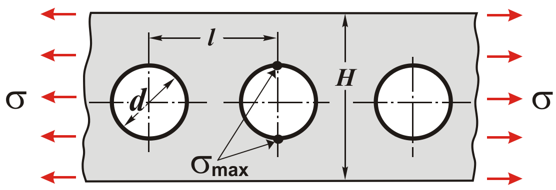
	Information and restrictions
	$0 \le d/l \le 1$ $K_{tg} = \sigma_{max} / \sigma$ $K_{tn} = \sigma_{max} / \sigma_{nom}$ $\sigma_{nom} = \sigma / (1 - d/l)$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 4.32 p. 299 § 4.3.12 p. 207).

2. J. Schulz, *Over den Spannungstoestand in doorborde Platen (On the State of Stress in Perforated Plates)*, Doctoral Thesis, Techn. Hochschule, 1941, Delft (in Dutch).
3. P. Meijers, *Doubly-Periodic Stress Distributions in Perforated Plates*, Dissertation, Tech. Hochschule Delft, Netherlands, 1967.

Uniaxial tension parallel to the row of holes



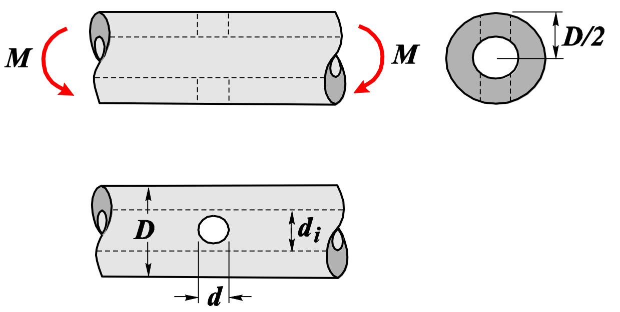
Information and restrictions
$0 \le d / l \le 1$
$K_{tn} = \sigma_{max} / \sigma_{nom}$
$\sigma_{nom} = \sigma / (1 - d / H)$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 4.33 p. 300 § 4.3.12 p. 207).
2. J. Schulz, *Over den Spannungstoestand in doorborde Platen (On the State of Stress in Perforated Plates)*, Doctoral Thesis, Techn. Hochschule, 1941, Delft (in Dutch).
3. P. Meijers, *Doubly-Periodic Stress Distributions in Perforated Plates*, Dissertation, Tech. Hochschule Delft, Netherlands, 1967.

Transverse circular hole in a round bar or tube

Bending

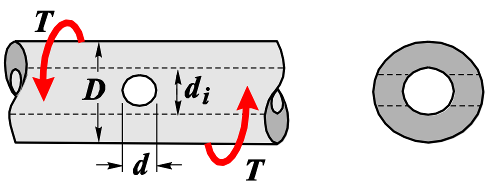


Information and restrictions
$0 \le d_i / D \le 0.9$
$0 \le d / D \le 0.4$
$K_{tg} = \sigma_{max} / \sigma_{nom}$
$\sigma_{nom} = 32MD / [\pi (D^4 - d_i^4)]$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 4.87 p. 363 § 4.6.8 p. 242).
2. A. Thum, W. Kirmser, *Überlagerte Wechselbeanspruchungen, ihre Erzeugung und ihr Einfluss auf die Dauerbarkeit und Spannungsausbildung quergebohrter Wellen*, VDI-Forschungsheft 419, 1943, 14(b), p. 1.
3. H.T. Jessop, C. Snell, I.M. Allison, *The Stress Concentration Factors in Cylindrical Tubes with Transverse Cylindrical Holes*, Aeronaut. Q., 1959, 10, p. 326.
4. ESDU (Engineering Science Data Unit), *Stress Concentrations*, London, 1965.

Torsion



Information and restrictions
$0 \le d_i / D \le 0.8$
$0 \le d / d_i \le 0.4$
$K_{tg} = \sigma_{max} / 16TD / [\pi (D^4 - d_i^4)]$

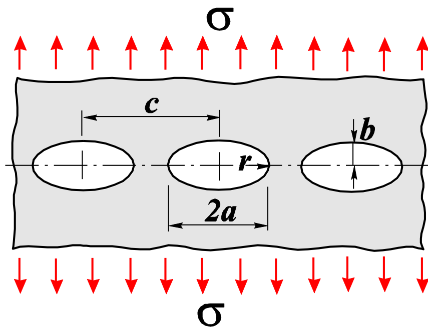
References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 4.99 p. 376 § 4.7.8 p. 245).
2. A. Thum, W. Kirmser, *Überlagerte Wechselbeanspruchungen, ihre Erzeugung und ihr Einfluss auf die Dauerbarkeit und Spannungsausbildung quergebohrter Wellen*, VDI-Forschungsheft 419, 1943, 14(b), p. 1.
3. H.T. Jessop, C. Snell, I.M.Allison, *The Stress Concentration Factors in Cylindrical Tubes with Transverse Cylindrical Holes*, Aeronaut. Q., 1959, 10, p. 326.
4. ESDU (Engineering Science Data Unit), *Stress Concentrations*, London, 1965.

2.7 Non-Circular Holes

Infinite row of elliptical holes in an infinite-width plate

Uniaxial tension normal to the row of holes

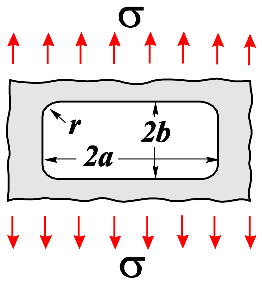
	Information and restrictions
	$0 \le 2a/c \le 0.7$ $0 \le a/b \le 10$ $K_{tn} = \sigma_{max} / \sigma_{nom}$ $\sigma_{nom} = \sigma / (1 - 2a/c)$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 4.56 p. 325 § 4.4.4 p. 224).
2. H. Nisitani, *Method of Approximate Calculation for Interference of Notch Effect and its Application*, Bull. Japan Soc. Mech. Eng., 1968, 11, p. 725.
3. J. Schulz, *Over den Spannungstoestand in doorborde Platen (On the State of Stress in Perforated Plates),* Doctoral Thesis, Techn. Hochschule, 1941, Delft (in Dutch).

Rectangular hole with rounded corners in an infinite plate

Uniaxial tension

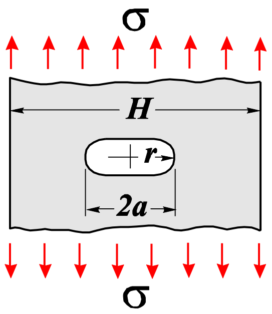
	Information and restrictions
	$0.05 \le r/2b \le 0.5$ $0.2 \le b/a \le 1$ $K_t = \sigma_{max}/\sigma$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 4.62 p. 333 § 4.5.3 p. 227).
2. J. Sobey, Stress *Concentration Factors for Rounded Rectangular Holes in Infinite Sheets*, ARC R&M 1963, 3407, Her Majesties Stationery Office, London.
3. ESDU (Engineering Science Data Unit), *Stress Concentrations*, London, 1970.

Slot with semicircular ends in a finite-width plate

Uniaxial tension

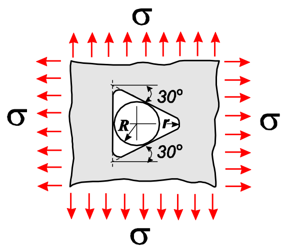
	Information and restrictions
	$1.0 \le a/r \le 4.0$ $0 \le a/H \le 0.49$ $K_{tg} = \sigma_{max}/\sigma$ $K_{tn} = \sigma_{max}/\sigma_{nom}$ $\sigma_{nom} = \sigma/(1-2a/H)$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors*, 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 4.51 p. 320).
2. http://www.stacieglass.com/scf/symmetric_notch_with_circular_ends.html

Triangular hole with rounded corners in an infinite plate

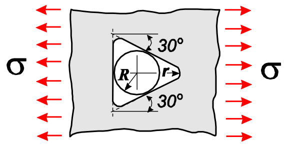
Uniform biaxial tension

	Information and restrictions
	$0.25 \le r/R \le 0.75$ $K_t = \sigma_{max}/\sigma$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 4.65a p. 340 § 4.5.6 p. 228).
2. W.H. Wittrick, *Stress Concentrations for Uniformly Reinforced Equilateral Triangular Holes with Rounded Corners*, 1963, Aeronaut. Q., 14, p. 254.

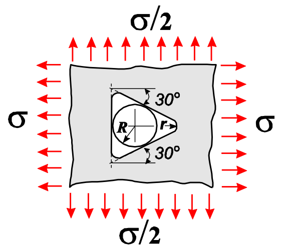
Uniaxial tension

	Information and restrictions
	$0.25 \le r/R \le 0.75$ $K_t = \sigma_{max}/\sigma$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 4.65a p. 340 § 4.5.6 p. 228).
2. W.H. Wittrick, *Stress Concentrations for Uniformly Reinforced Equilateral Triangular Holes with Rounded Corners*, 1963, Aeronaut. Q., 14, p. 254.

Nonuniform biaxial tension

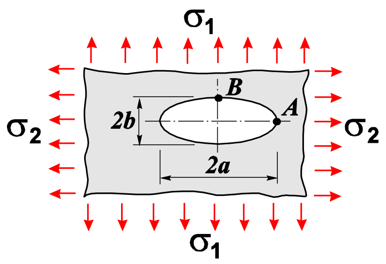
	Information and restrictions
	$0.25 \le r/R \le 0.75$ $K_t = \sigma_{max}/\sigma$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 4.65a p. 340 § 4.5.6 p. 228).
2. W.H. Wittrick, *Stress Concentrations for Uniformly Reinforced Equilateral Triangular Holes with Rounded Corners*, 1963, Aeronaut. Q., 14, p. 254.

Single elliptical hole in an infinite plate

Biaxial tension

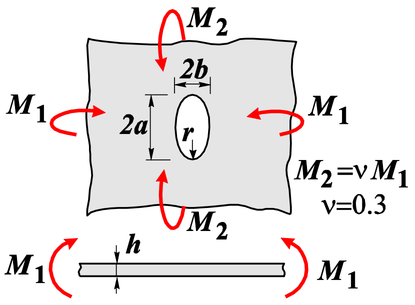


Information and restrictions
$0.25 \le a/b \le 4$ $-1 \le \sigma_1/\sigma_2 \le 1$ $K_{tA} = \sigma_A/\sigma_1$ $K_{tB} = \sigma_B/\sigma_1$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 4.54 p. 323 § 4.4.3 p. 215).

Cylindrical bending

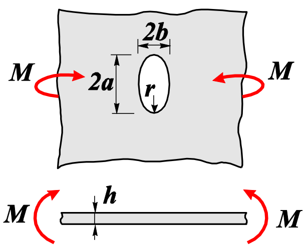


Information and restrictions
$0.2 \le a/b \le 5$ $2a/h > 5$ $K_t = \sigma_{max}/\sigma$ $\sigma = 6M_1/h^2$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 4.85 p. 361 § 4.6.6 p. 241).
2. H. Neuber, *Theory of Notch Stresses: principles for exact calculation of strength with reference to structural form and material*, 2nd ed., Berlin, Springer-Verlag, 1958.
3. H. Nisitani, *Method of Approximate Calculation for Interference of Notch Effect and its Application*, Bull. Japan Soc. Mech. Eng., 1968, 11, p. 725.

Simple bending



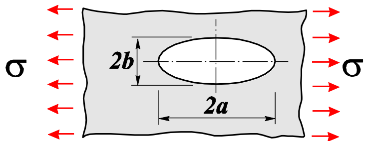
Information and restrictions
$0.2 \le a/b \le 5$ $2a/h > 5$ $K_t = \sigma_{max}/\sigma$ $\sigma = 6M/h^2$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 4.85 p. 361 § 4.6.6 p. 241).
2. H. Neuber, *Theory of Notch Stresses: principles for exact calculation of strength with reference to structural form and material*, 2nd ed., Berlin, Springer-Verlag, 1958.

3. H. Nisitani, *Method of Approximate Calculation for Interference of Notch Effect and its Application*, Bull. Japan Soc. Mech. Eng., 1968, 11, p. 725.

Tension along the major axis of the ellipse

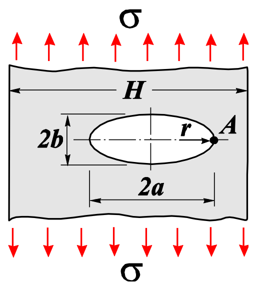
	Information and restrictions
	$0 \le a/b \le 10$ $K_t = \sigma_{max} / \sigma$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 4.50 p. 319 § 4.4.1 p. 213).
2. G.V. Kolosov, *On an application of the complex variable theory to the plane elastic problem. Doctoral thesis*, Saint Petersburg, 1909, 187 pp. *In Russian.*
3. C.E. Inglis, *Stresses in a Plate Due to the Presence of Cracks and Sharp Corners*, Trans. Inst. Nav. Arch., 1913, Eng., 95, 415.

Single elliptical hole in a finite-width plate

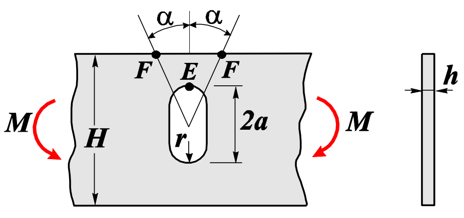
Uniaxial tension

	Information and restrictions
	$1 \le a/b \le 8$ $0 \le 2a/H \le 1$ $\sigma_{\max} = \sigma_A$ $K_{tn} = \sigma_{\max}/\sigma_{nom}$ $\sigma_{nom} = \sigma/(1-2a/H)$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 4.51 p. 320 § 4.4.1 p. 213).
2. M. Isida, *Form Factors of a Strip with an Elliptic Hole in Tension and Bending*, Scientific Papers of Faculty of Engrg., Tokushima University, 1953, 4, p. 70.
3. M. Isida, *On the Tension of a Strip with a Central Elliptic Hole*, Trans. Japan Soc. Mech. Eng., 1955, 21, p. 507-523.

In-plane bending

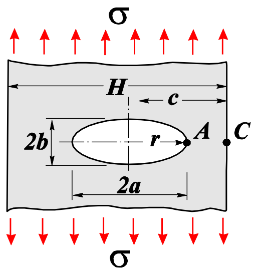
	Information and restrictions
	$1 \le a/b \le 2$ $0.4 \le 2a/H \le 1$ $K_{tn} = \sigma_{\max} h(H^3 - 8a^3)/12Ma$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 4.81 p. 357 § 4.6.3 p. 240).
2. M. Isida, *Form factors of a strip with an elliptic hole in tension and bending*, Scientific papers Of Engrg., Tokushima University, 1953, 4, 70.

Eccentric elliptical hole in a finite-width plate

Uniaxial tension

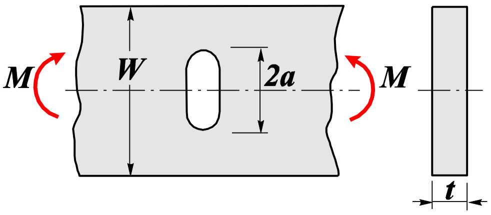
	Information and restrictions
	$1 \le a/b \le 8$ $0 \le a/c \le 1$ $\sigma_{max} = \sigma_A$ $K_{tn} = \sigma_{max} / \sigma_{nom}$ $\sigma_{nom} = \sigma/(1-2a/H)$

References

1. W.D. Pilkey, *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (chart 4.51, p.320 § 4.4.1, p.215).
2. M. Isida, *Form factors of a strip with an elliptic hole in tension and bending*, Scientific papers Of Engrg., Tokushima University, 1953, 4, 70.
3. M. Isida, *On a tension of a strip with a central elliptic hole*, Trans. Japan Soc. Mech, Eng., 1955, 21, 514.

2.8 Stress Intensity Factors

Strip with a central transverse crack in bending

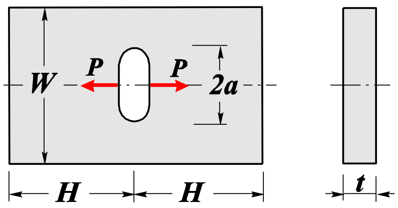


Restrictions
$a \le W/2$.

References

1. *Stress Intensity Factors Handbook, Vol. 1, Paragraph* 2.1. Ed. by Y. Murakami, Oxford etc., Pergamon press, 1987.

Rectangular plate with a central crack, its faces subjected to concentrated normal tension forces

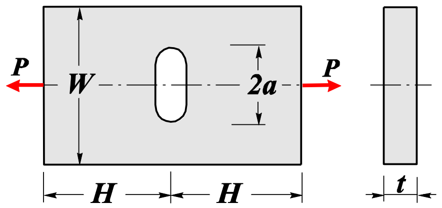


Restrictions
$2a/W \le 0.9$; $0.5 \le 2H/W \le 2$.

References

1. *Stress Intensity Factors Handbook,* Vol. 1, Paragraph 2.2. Ed. by Y.Murakami, Oxford etc., Pergamon press, 1987.

Rectangular plate with a central crack, the external contour subjected to concentrated normal tension forces

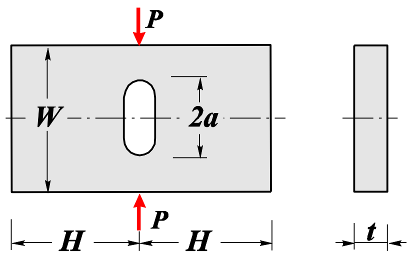


Restrictions
$2a/W \leq 0.7$; $0.5 \leq 2H/W \leq 2$.

References

1. *Stress Intensity Factors Handbook, Vol. 1, Paragraph* 2.3. Ed. by Y. Murakami, Oxford etc., Pergamon press, 1987.

Rectangular plate with a central crack, the external contour subjected to concentrated longitudinal compressive forces

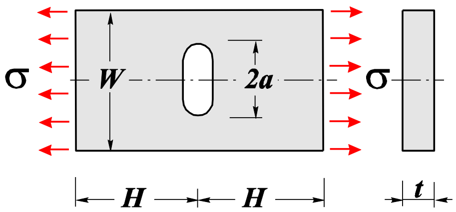


Restrictions
$2a/W \leq 0{,}7$; $0{,}5 \leq 2H/W \leq 2$.

References

1. *Stress Intensity Factors Handbook, Vol. 1, Paragraph* 2.4. Ed. by Y. Murakami, Oxford etc., Pergamon press, 1987.

Rectangular plate with a central crack subjected to uniform tension or displacement of edges

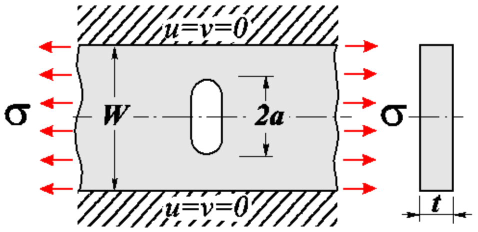


Restrictions
$2a/W \leq 0{,}7$; $0{,}4 \leq 2H/W \leq 1{,}8$.

References

1. *Stress Intensity Factors Handbook, Vol. 1, Paragraph* 2.5. Ed. by Y. Murakami, Oxford etc., Pergamon press, 1987.

Strip with a central transverse crack and clamped edges in tension

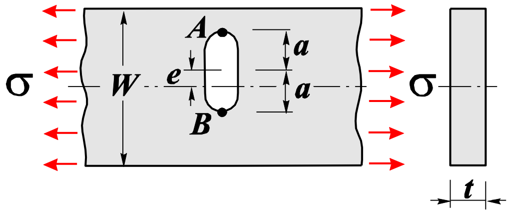


Restrictions
$2a/W \le 1.$

References

1. *Stress Intensity Factors Handbook, Vol. 1, Paragraph* 2.7. Ed. by Y. Murakami, Oxford etc., Pergamon press, 1987.

Strip with an eccentric transverse crack in tension

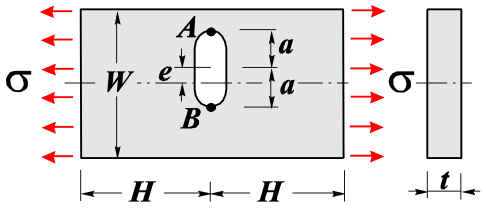


Restrictions
$0{,}1 \le 2a/W \le 0{,}9;$ $2e \le W.$

References

1. *Stress Intensity Factors Handbook, Vol. 1, Paragraph* 2.8. Ed. by Y. Murakami, Oxford etc., Pergamon press, 1987.

Rectangular plate with an eccentric crack in uniform tension normal to the crack axis

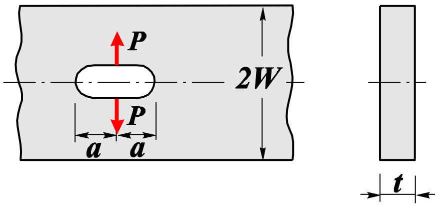


Restrictions
$0{,}1 \le 2a/(W\text{-}2e) \le 0{,}6;$ $2e/W \le 0{,}6.$

References

1. *Stress Intensity Factors Handbook, Vol. 1, Paragraph* 2.9. Ed. by Y. Murakami, Oxford etc., Pergamon press, 1987.

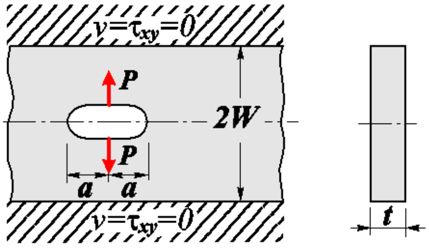
Strip with a central longitudinal crack subjected to concentrated normal tension forces at the center

	Restrictions
	$0{,}5 \le W/a \le 6.$

References

1. *Stress Intensity Factors Handbook, Vol. 1, Paragraph* 2.10. Ed. by Y. Murakami, Oxford etc., Pergamon press, 1987.

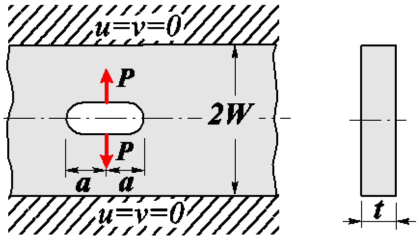
Strip with simply supported edges and a central longitudinal crack subjected to concentrated normal tension forces at the center

	Restrictions
	$1 \le W/a \le 6.$

References

1. *Stress Intensity Factors Handbook, Vol. 1, Paragraph* 2.11. Ed. by Y. Murakami, Oxford etc., Pergamon press, 1987.

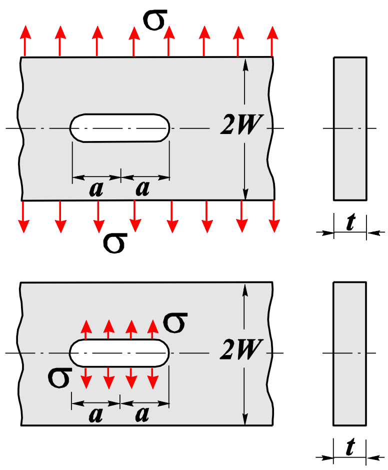
Strip with clamped edges and a central longitudinal crack subjected to concentrated normal tension forces at the center

	Restrictions
	$1 \leq W/a \leq 6.$

References

1. *Stress Intensity Factors Handbook, Vol. 1, Paragraph* 2.12. Ed. by Y. Murakami, Oxford etc., Pergamon press, 1987.

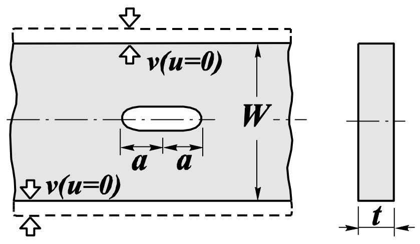
Strip with a central longitudinal crack subjected to uniform tension along the external contour or to uniform internal pressure

	Restrictions
	$a/W \leq 1.$

References

1. *Stress Intensity Factors Handbook, Vol. 1, Paragraph* 2.13. Ed. by Y. Murakami, Oxford etc., Pergamon press, 1987.

Strip with a central longitudinal crack subjected to uniform displacement of the clamped edges along the normal to the crack axis

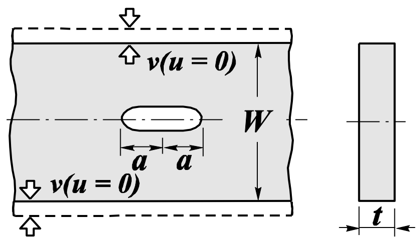


Restrictions

References

1. *Stress Intensity Factors Handbook, Vol. 1, Paragraph* 2.14. Ed. by Y. Murakami, Oxford etc., Pergamon press, 1987.

Strip with a central longitudinal crack subjected to uniform displacement of the edges along the normal to the crack axis, no shear

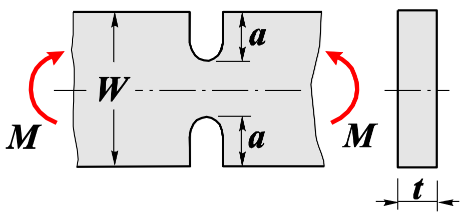


Restrictions

References

1. *Stress Intensity Factors Handbook, Vol. 1, Paragraph* 2.15. Ed. by Y. Murakami, Oxford etc., Pergamon press, 1987.

Strip with two symmetric edge cracks in pure bending

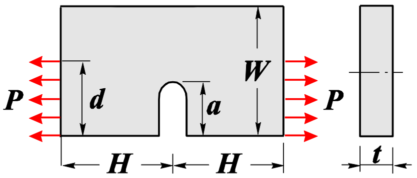


Restrictions
$2a/W \le 1.$

References

1. *Stress Intensity Factors Handbook, Vol. 1, Paragraph* 2.16. Ed. by Y. Murakami, Oxford etc., Pergamon press, 1987.

Rectangular plate with an edge crack on the symmetry line, in uniform tension normal to the crack axis

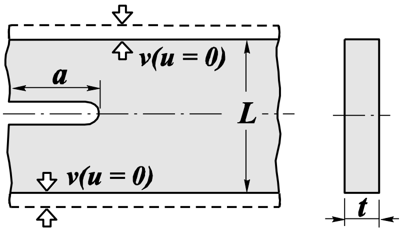


	Restrictions
	$0{,}1 \le a/W \le 0{,}8$; $d/W \le 1$.

References

1. *Stress Intensity Factors Handbook, Vol. 1, Paragraph* 2.17. Ed. by Y. Murakami, Oxford etc., Pergamon press, 1987.

Strip with a semi-infinite central crack under constant displacement of clamped faces along the normal to the crack axis

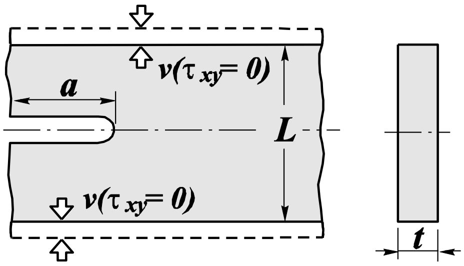


	Restrictions

References

1. *Stress Intensity Factors Handbook, Vol. 1, Paragraph* 2.18. Ed. by Y. Murakami, Oxford etc., Pergamon press, 1987.

Strip with a semi-infinite central crack under constant displacement of clamped faces along the normal to the crack axis, no shear

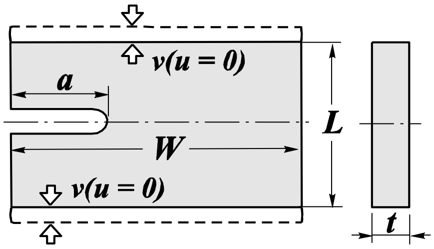


	Restrictions

References

1. *Stress Intensity Factors Handbook, Vol. 1, Paragraph* 2.19. Ed. by Y. Murakami, Oxford etc., Pergamon press, 1987.

Rectangular plate with an edge crack on the symmetry line under constant displacement of clamped side faces along the normal to the crack axis

	Restrictions
	$0{,}1 \le a/W \le 1$; $0{,}5 \le L/W \le 3$.

References

1. *Stress Intensity Factors Handbook, Vol. 1, Paragraph* 2.20. Ed. by Y. Murakami, Oxford etc., Pergamon press, 1987.

3. Appendix

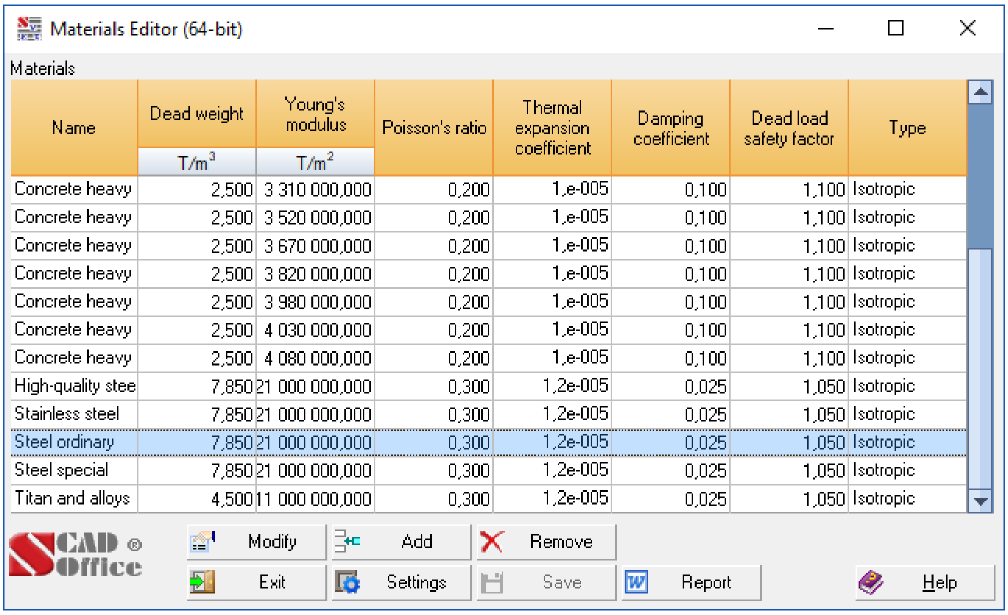
3.1 Materials Editor

General Information

Some of the programs included in **SCAD Office** use physical and mechanical properties of materials as their initial data. All these programs enable their users to specify material properties directly (such as specific weight, elastic modulus, etc.). However, a more convenient way for a user can be to access a database of materials, choose a desired material from a list, and retrieve its physical properties from the database tables.

The material database provided with **SCAD Office** is not large. The **Materials Editor** program described in this manual will enable its user to modify the database in any desirable manner (remove, modify and add materials).

Interface



Name	Dead weight T/m³	Young's modulus T/m²	Poisson's ratio	Thermal expansion coefficient	Damping coefficient	Dead load safety factor	Type
Concrete heavy	2,500	3 310 000,000	0,200	1,e-005	0,100	1,100	Isotropic
Concrete heavy	2,500	3 520 000,000	0,200	1,e-005	0,100	1,100	Isotropic
Concrete heavy	2,500	3 670 000,000	0,200	1,e-005	0,100	1,100	Isotropic
Concrete heavy	2,500	3 820 000,000	0,200	1,e-005	0,100	1,100	Isotropic
Concrete heavy	2,500	3 980 000,000	0,200	1,e-005	0,100	1,100	Isotropic
Concrete heavy	2,500	4 030 000,000	0,200	1,e-005	0,100	1,100	Isotropic
Concrete heavy	2,500	4 080 000,000	0,200	1,e-005	0,100	1,100	Isotropic
High-quality stee	7,850	21 000 000,000	0,300	1,2e-005	0,025	1,050	Isotropic
Stainless steel	7,850	21 000 000,000	0,300	1,2e-005	0,025	1,050	Isotropic
Steel ordinary	7,850	21 000 000,000	0,300	1,2e-005	0,025	1,050	Isotropic
Steel special	7,850	21 000 000,000	0,300	1,2e-005	0,025	1,050	Isotropic
Titan and alloys	4,500	11 000 000,000	0,300	1,2e-005	0,025	1,050	Isotropic

Figure 3.1-1. *The main window of* **Materials Editor**

The main window of the **Materials Editor** software contains the following controls:

- a table including a list of materials and their basic properties;
- functional buttons for performing various actions (such as data modification, report generation, help invocation, etc.).

Functional buttons

Use functional buttons to perform the following actions:

Report — generate a report containing a materials table;

Settings — invoke the **Settings** dialog box, where you can customize the program;

Help — obtain help information;

Exit — finish the working session.

Controls

Principles and means of control implemented in the software are uniform and provide a consistent interactive environment. The program uses a common system of Windows dialog boxes. The following controls and means for accessing information can be used:

♦ functional buttons, "clicking" which is used to invoke particular functions or modes; to do it, place the mouse pointer over a button and left-click;

- radio buttons and checkboxes which enable you to make a choice from a predefined set of options;
- text fields used to enter initial data for analysis. Initial data consist of numbers. If the entered number is not an integer, its integer and fractional parts are separated by a period or another separator. The separator is assigned by the user during the customization of the operating system (see **Settings | Regional Settings | Number**). Moreover, the numbers can be entered in scientific notation, for example, 1.56e-7;
- drop-down or static lists for selecting data;

tables to enter or display information in a tabular form.

Settings

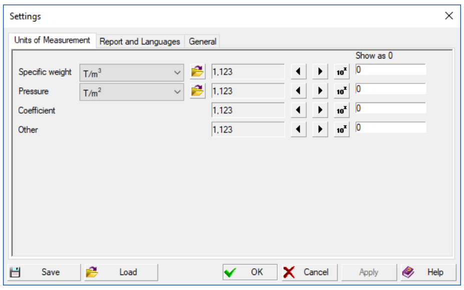


Figure 3.1-2. *The* **Units of Measurement** *tab*

This dialog box can be invoked at any moment when working with **Materials Editor**. It is used to customize general parameters of the program. The dialog contains the following tabs: **Units of Measurements, Report and Languages** and **General**.

Each tab opens a page where you can adjust certain types of settings.

The **Units of Measurement** tab (Fig. 3.1-2) helps to define units of measurement used in the analysis. It contains two groups of data. The first group is used to specify measurement units of linear sizes, coefficients, etc.

For compound units (such as those of pressure), there is a possibility to define their component units (such as those for forces and for linear sizes) separately using the button. The second group enables you to choose a representation and precision of numerical data. Special controls are used here to select data representation formats. Make sure to specify the number of significant digits in either the fixed-point decimal representation or the floating-point scientific notation.

The precision of the data representation (the number of significant digits after the decimal point) can be assigned using the (decrease) and (increase) buttons, while the scientific notation is turned on by the button. You can also specify in respective text fields which values should be treated as negligibly small, so that all absolute values less than the given ones will be displayed as 0 in all visualizations.

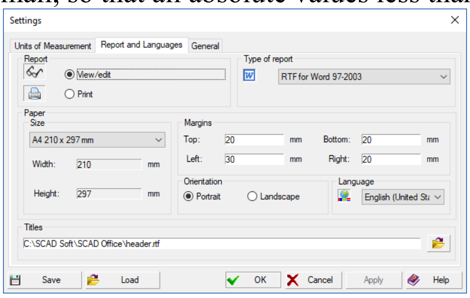


Figure 3.1-3. *The* **Report and Languages** *tab*

The **Report and Languages** tab (Fig. 3.1-3) enables you to choose a language for the user interface and for the report.

There are two modes for working with a report document: **View/Edit** or **Print**.

In the **View/Edit** mode, clicking the **Report** button in any active dialog will open the report and allow you to view/edit it. An application associated with **RTF** (Rich Text Format) files (such as MS Word Pad or MS Word) will be invoked to serve this purpose.

Obviously, it is the user who is fully responsible for any changes made to the text of the report (note that even results of the calculation can be edited). There are differences in **RTF** formats used by MS Word v.7, MS Word 97 (2000/XP) and Open Office. Therefore, the program enables the user to choose one of the formats in the **Type of Report** mode (besides RTF a report can be created in the following formats DOC, PDF, HTML).

Clicking the **Print** button in the **Report** group will print the report in the form it has been generated by the program.

Use the **Titles** text field to specify an **RTF** file containing headers and footers for pages of the report document. The file can be selected from a standard list by clicking the button.

The **Paper size** setting enables you to choose the paper format for printing the report (the size is selected from a drop-down list).

Moreover, the margins and the page orientation can be selected before generating the report.

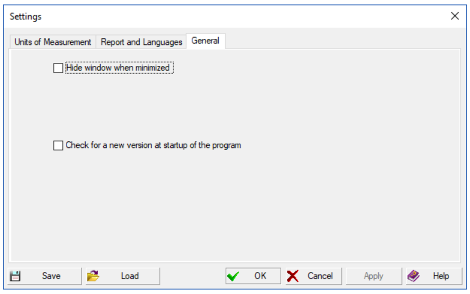


Figure 3.1-4. *The* **General** *tab*

The **General** tab (Fig. 3.1-4) allows you to activate the **Hide window when minimized** checkbox. When it is active the window disappears from the task bar, and an icon appears in the tray area. The window can be opened from the tray area by the left click, and a context menu – by the right click.

Moreover, the **Check for a new version at startup of the program** checkbox can be activated as well. If it is active, the program will check for a new version on the company website at each startup, and it will give a respective message if it finds a new release.

Adding and Modifying Materials

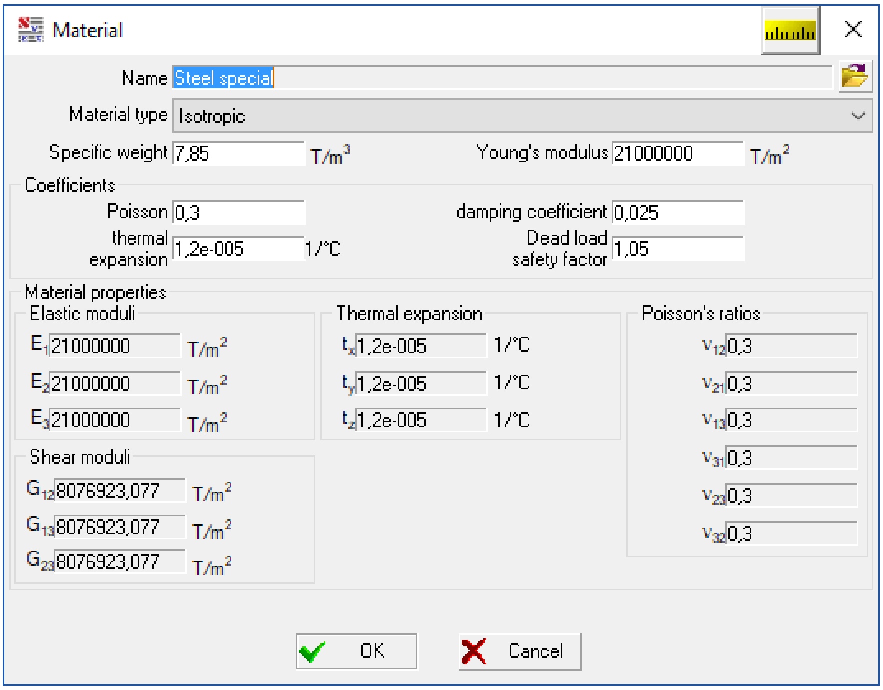


Figure 3.1-5. *The* **Material** *dialog box*

To add a new material to the database, click the **Add** button in the main window of the program. This will open a dialog box (see Fig. 3.1-5) where you should specify the type, name and mechanical properties of this material. The current version of the software supports the following types of materials:

- isotropic;
- orthotropic;
- transversely isotropic.

The following constants must be specified for an isotropic material:

- specific weight;
- elastic modulus;
- Poisson's ratio;
- linear coefficient of thermal expansion;
- damping coefficient;
- dead load safety factor (it is used to assign a rated/design dead weight load).

For orthotropic and transversely isotropic materials, you should specify multiple values for the elastic modulus, Poisson's ratio etc., conforming to respective directions. The following relationships must always hold: $E_i\nu_{ij} = E_j\nu_{ij}$.

See below how to specify a name for the new material.

When the information about materials is displayed in the main window and in the report (see below), the elastic modulus displayed for non-isotropic materials will be E_1, the Poisson's ratio – ν_{12}, etc.

To modify data on a material already present in the database, place the pointer over the respective row in the table of materials and click the **Modify** button (or just left-click). This will open the dialog shown in Fig. 5 where you can make desired changes.

After you have made the modification, click the **Save** button to store the newly entered information in the database file.

Specifying a Name for a Material

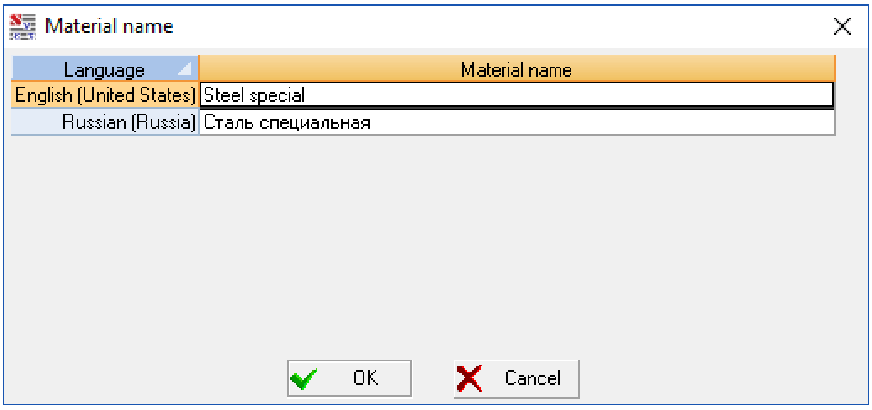


Figure 3.1-6. *The* **Material Name** *dialog box*

The material database enables the user to specify names of materials in multiple languages (in the current version these include *Russian* and *English*). To specify the name of a material, click the  button, and in the table of the dialog box (see Fig. 3.1-6) specify the names of materials corresponding to various languages.

Remove a Material from the List

The **Remove** button serves to remove a record from the table. The record corresponds to the material currently selected in the table.

After removing a record, click the **Save** button to save the modified information in the database file.

Generating a Report

You can obtain a report in the **RTF** format using the **Report** button. The report will be automatically opened in the MS Word environment or in another editor associated with this format. The report contains all materials from the database together with their basic properties.

Saving a Materials Database when Updating the Version

The database of materials is stored in a file named SCADMaterials.mdb located in the DATA subdirectory. To avoid losing the modified database information when reinstalling **SCAD Office** (for example, when the system is being transferred to another computer, or a newer version is being installed), it is recommended to save this file before the reinstallation, and then copy it to the DATA subdirectory after the reinstallation is completed.