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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.

 $\ensuremath{\mathbb{C}}$ Authors, 2024 г.

Table of Contents

1.1 GENERAL INFORMATION	
Interface	•••••
Controls	
Settings	
Material Properties	1
Moments of Inertia	1
1.2 STABILITY OF EQUILIBRIUM	1
Single-Span Bars of Uniform Section on Rigid Supports	1
Single-Span Bars on Elastic Supports	1
Single-Span Bars of Variable Section on Rigid Supports	1
Single-Span Straight Bars of Uniform Section on Elastic Subgrade	1
Multi-Span Bars of Uniform Section on Elastic Supports	1
Circular Ring	1
Round Arches (In-Plane Stability)	2
Parabolic Arches (In-Plane Stability)	2
Two-Hinged Segmental Arches (In-Plane Stability)	2
Stability of In-Plane Bending of Thin-Walled Beams	2
Rectangular Plate	2
Circular Plate	2
Skew Plate	
Cylindrical Panel	3
Conical Panel	
Spherical Panel	3.
Circular Cylindrical Shell	
Cylindrical basket shell	
Circular Truncated Cone Shell	
Spherical Shell	
1.3 NATURAL VIBRATION FREQUENCIES	3
Single-Span Bars of Uniform Section on Rigid Supports	3
Single-Span Bars on Elastic Subgrade	4
Bars of Variable Cross-Section	4
Circular Rings	4
Strings	4
Rectangular Plates	
Circular Plates	4
Cylindrical Shell	4
Cone Shell	
1.4 OTHER OSCILLATION PROBLEMS REFERENCE DATA ABOUT INTERNAL FRICTION	4
1.5 STATIC ANALYSIS	
Circular Plates	5 5
Roctangular Platos	
Spherical Domes	
Contact Stresses	
16 AUXILIARY CALCULATIONS	
Polynomial Roots	5 5
I Orynomuur Roots Moments of Inertia of Simple Rodies	رک ء
Intomenis of Inerita of Simple Doales	ک ۲
Geometric Fropernes	0 7
Determinant of a Matrix	0.
inverse mairix Caiculation	04

Table of Contents

Systems of Linear Equations	65 66
COCON – STRESS INTENSITY FACTORS	67
2.1 GENERAL INFORMATION	67
2.7 OLIVERIA IN ORDERING CONTROLOGICAL STREET	69
2.3 SETTINGS	0) 70
2.4 NOTCHES AND GROOVES	70
<i>Elliptical or U-shaped notch in a semi-infinite plate</i>	72
Opposite U-shaped notches in a finite-width plate	73
Single U-shaped notch on one side of a finite-width plate	74
Infinite row of opposite semicircular notches in a finite-width plate	75
Single V-shaped notch on one side of a finite-width plate	75
U-shaped circumferential groove in a circular shaft	76
V-shaped circumferential groove in a circular shaft	77
2.5 Shoulder Fillets	78
Stepped flat bar with shoulder fillets	78
Shaft with a circumferential shoulder fillet	79
2.6 CIRCULAR HOLES	80
Single circular hole in an infinite plate	80
Central single circular hole in a finite-width plate	82
Eccentric circular hole in a finite-width plate	83
Two equal circular holes in an infinite plate	84
Infinite row of circular holes in an infinite plate	85
Transverse circular hole in a round bar or tube	86
2.7 Non-Circular Holes	87
Infinite row of elliptical holes in an infinite-width plate	87
Rectangular hole with rounded corners in an infinite plate	88
Slot with semicircular ends in a finite-width plate	88
Triangular hole with rounded corners in an infinite plate	89
Single elliptical hole in an infinite plate	90
Single elliptical hole in a finite-width plate	92
Eccentric elliptical hole in a finite-width plate	93
2.8 STRESS INTENSITY FACTORS	94
Strip with a central transverse crack in bending	94
Rectangular plate with a central crack, its faces subjected to concentrated normal tension force.	s 94
<i>Rectangular plate with a central crack, the external contour subjected to concentrated normal</i>	
tension forces	95
Rectangular plate with a central crack, the external contour subjected to concentrated	
longitudinal compressive forces	95
Rectangular plate with a central crack subjected to uniform tension or displacement of edges	95
Strip with a central transverse crack and clamped edges in tension	96
Strip with an eccentric transverse crack in tension	96
Rectangular plate with an eccentric crack in uniform tension normal to the crack axis	96
Strip with a central longitudinal crack subjected to concentrated normal tension forces at the center	97
Strip with simply supported edges and a central longitudinal crack subjected to concentrated normal tension forces at the center	
Strip with clamped edges and a central longitudinal crack subjected to concentrated normal tension forces at the center	رر ۵۵
Strip with a central longitudinal crack subjected to uniform tension along the external contour	70
or to uniform internal pressure Strip with a central longitudinal crack subjected to uniform displacement of the clamped edges	98
along the normal to the crack axis	99

	Strip with a central longitudinal crack subjected to uniform displacement of the edges along the normal to the crack axis, no shear	99
	Strip with two symmetric edge cracks in pure bending	99
	Rectangular plate with an edge crack on the symmetry line, in uniform tension normal to the crack axis	100
	Strip with a semi-infinite central crack under constant displacement of clamped faces along the normal to the crack axis	100
	Strip with a semi-infinite central crack under constant displacement of clamped faces along the normal to the crack axis, no shear	100
	Rectangular plate with an edge crack on the symmetry line under constant displacement of clamped side faces along the normal to the crack axis	101
3.	APPENDIX	102
	3.1 MATERIALS EDITOR	102
	General Information	102
	Interface	102
	Controls	102
	Settings	103
	Adding and Modifying Materials	104
	Remove a Material from the List	105
		105
	Generating a Report	105
	Generating a Report Saving a Materials Database when Updating the Version	105 105

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

Kust2 (64-bit)					-		×
- Two-Hinged Segm	hell						
Stability of In-Plane Ber		Initial data					
- Rectangular Plate	\frown						
Circular Plate)7	Material	Steel ordi	nary		\sim	
Skew Plate							
Cylindrical Panel	/ L	Number of freque	encies	3 ~			
Conical Panel	£	Modulus of elast	icity F	2100000	T (2		
Circular Culindrical Shel		modulus of class	iony, E	21000000	1/m		
Elliptic Cylindrical Shell		Poisson's ratio, v	1	0,3			
- Circular Truncated Con		Specific weight,	ρ	7,85	T/m ³		
Natural Vibration Frequen		Shell length		-			
Bars		Sheinengar, E		1			
Single-Span Bars of Un		Radius, R		20	m		
- Single-Span Bars on El		Thickness, h		0.2	m		
- Circular Rings							
Strings							
Plates #	m1		m2	Number of	vibrations	s per	
Circular Plates		0		3070,654			
- Shells 2 1		1		3071,419			
Cylindrical Shell 🚽 📃 🤰 1		2		3073,716			
> C Ch.II							
Report 🤣	Help 🚺	Parameters 👌	👌 Find	of Calcul	late	<mark>Э</mark> Е	xit

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.



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

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

Inits of Measurement	Report and La	nguages	Visua	lization	Sections	General				
									Show as 0	^
Linear size	m	~		1,123		•		10 ^X	0	
Time	sec	~		1,123		•	Þ	10 ^x	0	
Volume	m ³	~		1,123		•	Þ	10 ^x	0	
Angle	degree	~		1,123		•	Þ	10 ^x	0	
Section properties	cm	~		1,123		•	Þ	10 ^x	0	
Section size	mm	~		1,123		•	Þ	10 ^x	0	
Force	т	~		1,123		•	Þ	10 ^x	0	
Distributed force	T/m	~	8	1,123		•	Þ	10 ^x	0	
Specific weight	T/m ³	~	8	1.123		•		10 ^x	0	
Pressure	T/m ²	~	2	1,123		•		10 ^X	0	

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

inits of Measurement	Report and Languages	Visualization	General	UI .			
Report			Type of r	eport			
	edit		w	RTF for \	Vord 97-200	13	Ŷ
Paper Size		Margins					
A4 210 x 297 mm	~	Top: 20		mm	Bottom:	20	mm
Width: 210	mm	Left 30		mm	Right	20	mm
Height 297	mm	Orientation Portrait	⊖ Lan	dscape	Lan <u>o</u>	uage English (Ur	nited St. \sim
		Titles					
Report's font	AaBbCc	E:\SCAD	Soft\SCA	D Office3\	header.rtf		2

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 \blacksquare (decrease) and \blacktriangleright (increase) buttons. while the scientific notation is turned on by the button 10⁵. 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 $\boxed{\textcircled{P}}$.

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



Figure 1.1-6. The Sections tab



Figure 1.1-7. The General tab

Parameters								×
Units of Measurement	Report and Languages	Visualization	General	UI				
Dialog boxes)efault (100 %) 🗸							
💾 Save 🎾	Load	×	ОК	×	Cancel	Apply	2	Help

Figure 1.1-8. The UI tab

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

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.

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.

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.

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.

Steel ordinary 👻
Alloy steel Aluminum alloy Concrete heavy B12.5 Concrete heavy B15 Concrete heavy B20 Concrete heavy B25 Concrete heavy B30 Concrete heavy B35 Concrete heavy B40 Concrete heavy B45 Concrete heavy B55 Concrete heavy B55 Concrete heavy B60 High-quality steel Stainless steel
Steel ordinary
Steel special Titan and alloys OTHER MATERIAL

Material Properties

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.).

Figure 1.1-9. Materials drop-down list

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 .

Select stiffness			nlunlu	Х
→ T Universal Beams BS 4-1:1993	^	 ✓ Apply ↓ 4004,713 cm⁴ ✓ Apply ↓ 1z 178,538 cm⁴ 		~
 305x165x40 > 	۲	×	Cano	el

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.

獅 Kust2 (64-bit)			_		×
Stability of Equilibrium	Single-Span Bars of Uniform Se	ction on Rigid Supports			
Single-Span Bars of Ur Single-Span Bars on El Single-Span Bars of Va	P Initial Mate	rial Alloy steel		\sim	
Multi-Span Bars of Unit Single-Span Straight Ba Curved Bars	Leng	th of the bar, L 12	m		
Circular Ring Round Arches (In-F Parabolic Arches (I	Mod	ulus of elasticity, E 210000	00 T/m ²		
Two-Hinged Segm Stability of In-Plane Ber Plates	Mon	ent of inertia, J 📃 352	cm ⁴		
Rectangular Plate Circular Plate Skew Plate	Besult				
Shells Cylindrical Panel Conical Panel	Effective length factor	0,5			
	Critical force, P	20,266 T			
- Circular Truncated Con - Spherical Shell					
Natural Vibration Frequent Natural Vibration Frequent					
SCAD © W	Report 🤌 Help 🎼 Para	meters 💏 Find 🧕 (Calculate 👲	📒 Exi	t

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.

🎾 Kust2 (64-bit)	- □ >	×
Stability of Equilibrium	Single-Span Bars on Elastic Supports	
⊡- Bars Single-Span Bars of Ur	↓P Initial data	
Single-Span Bars on El Single-Span Bars of Va	Material Alloy steel 🗸	
Multi-Span Bars of Unif Single-Span Straight Ba	Length of the bar, L 2 m	
⊡- Curved Bars Circular Ring	Modulus of elasticity, E 21000000 T/m ²	
Hound Arches (In-F Parabolic Arches (I Two-Hinged Segm	Moment of inertia, J 🔤 115 cm ⁴	
Stability of In-Plane Ber	Stiffness of elastic supports	
Rectangular Plate Circular Plate	Top Cm 5262265 T*m Bottom Cm 0 T*m	
Shells Culindrical Papel	Top Cn 0 T Bottom Cn 0 T	
Conical Panel	Result	
Circular Cylindrical Shel Elliptic Cylindrical Shell	Effective length factor 0,5	
- Circular Truncated Con Spherical Shell	Critical force, P 238,35 T	
🖹 Natural Vibration Frequen		
< >		
CAD ©	Report 🧼 Help 🚺 Parameters 😚 Find 👂 Calculate 🛃 Exit	

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*.

∃- Stability of Equilibrium 🛛 🔺	Single-Span Bars of Variable Section	on Rigid Supports
Bars Single-Span Bars of Ur Single-Span Bars of Ur Single-Span Bars of Un Multi-Span Bars of Unif Single-Span Bars of Unif Single-Span Bars of Unif Curved Bars Curved Bars Round Arches (In-f Parabolic Arches (In-f	Bar type Symmetrical compressed bars with	straight chords
Two-Hinged Segm Two-Hinged Segm Stability of In-Plane Ber Totalar Plate Circular Plate Skew Plate Skew Plate Conical Panel Conical Panel Spherical Panel	Initial data Material Steel ordinary Moment of inertia in the middle, J _m Length of the bar, L Thickness at the ends, h ₀ Thickness in the middle, h _m	Modulus of elasticity, E 21000000 T/m² 20000 cm ⁴
Circular Cylindrical Shel Elliptic Cylindrical Shel Circular Truncated Con Spherical Shell Natural Vibration Frequen	Result Critical force, P _{cr}	281,669 T

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:



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*.

		_ ,
Stability of Equilibrium	Single-Span Straight Bars of	Uniform Section on Elastic Subgrade
Bars Single-Span Bars of Ur Single-Span Bars on El Single-Span Bars of Va Multi-Span Bars of Va Multi-Span Bars of Unif Single-Span Straight Br Curved Bars Curved Bars Round Arches (In-F Warabolic Arches (In-F	Initial data Loads and boundary	Bar with free ends under triangular distributed load
Two-Hinged Segm Stability of In-Plane Ber	Material	Steel ordinary 🗸
⊡ • Plates Rectangular Plate Circular Plate	Modulus of elasticity, E	21000000 T/m ²
Skew Plate	Stiffness of the bar, J	[212,94 cm ⁴
Cylindrical Panel Conical Panel	Length of the bar, L	6 m
Spherical Panel Circular Cylindrical Shel Elliptic Cylindrical Shell	Winkler coefficient, C ₁	0,01 T/m ²
Circular Truncated Con Spherical Shell	- Result	
Natural Vibration Frequent	Critical force, P _{cr}	25,533 T

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:



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*.

獅 Kust2 (64-bit)				-		×
Stability of Equilibrium	Multi-Span Bars of Uniform Section on	Elastic Suppor	rts			
→ Single-Span Bars of Ur → Single-Span Bars on El → Single-Span Bars of Va → Multi-Span Bars of Unif → Single-Span Straight Ba						
Curved Bars Circular Ring Round Arches (In-F						
Parabolic Arches (I Two-Hinged Segm	Material	Steel ordinary		\sim		
Stability of In-Plane Ber Plates	Modulus of elasticity, E	21000000	T/m ²			
Rectangular Plate Circular Plate	Moment of inertia, J	5536,79	cm ⁴			
Skew Plate	Length of the bar, L	6	m			
	Spacing between the supports, a	3	m			
Circular Cylindrical Shel Elliptic Cylindrical Shell	Coefficient of elasticity of individual supports, $\boldsymbol{\alpha}$	1	T/m			
Circular Truncated Con Spherical Shell	Result					
Natural Vibration Frequent	Critical force, P _{cr}	319,984	Т			
SCAD ©	Report 🧼 Help 🚺 Parameters	😚 Find	∮ Calculate		E	xit

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*.

🎾 Kust2 (64-bit)					-	×
Stability of Equilibrium	Circular Ring					
- Bars - Single-Span Bars of Ur	Buckling mode	In-plane V	Load type	Hydrostatic	•	~
 Single-Span Bars on EI Single-Span Bars of Va Multi-Span Bars of Unif Single-Span Straight Bars Curved Bars Circular Ring Round Arches (In-F Parabolic Arches (I Two-Hinged Segminal)	Ķ			
Stability of In-Plane Ber	Initial data Material			Allou steel		 ~
Circular Plate	Modulus of elasticity, E			21000000	T/m ²	
	Poisson's ratio, v			0,3		
Cylindrical Panel	Radius, R			10	m	
Circular Cylindrical Shel Circular Cylindrical Shel Elliptic Cylindrical Shel	Moment of inertia, I			6529	cm ⁴	
Circular Truncated Con Sherical Shell Natural Vibration Frequent Source Statement	Result	G	ritical load, q. 4	,113	T/m	
SCAD ©	Report 🧼 Help	🚯 Parameters 🕻	😚 Find	of Calcu	ulate	Exit

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.

Kust2 (64-bit)		_		×
Stability of Equilibrium	Round Arches (In-Plane Stability)			
Bars				
Single-Span Bars of Ur Single-Span Bars on El	Load type Hydrostatic ~		===	
- Single-Span Bars of Va	Arch tupe Fixed	1 dest	X	£
Multi-Span Bars of Unif	Tixed A	11	\sim	1
			Ja-	1
Curved Bars	ľ		\	7
- Circular Bing	777		de	_
Bound Arches (In-F				
- Parabolic Arches (I	Initial data			
Two-Hinged Segm	Mahadal	P		
	Material Steel or	linary	~	
	Modulus of elasticity, E 2100000	0 T/m ²		
Bectangular Plate	2100000	• 1710		
- Circular Plate	Radius, R 10	m		
Skew Plate				
Shelle	Opening angle of the arch, α 90	degree		
- Gulindrical Panel				
Conical Panel	Moment of inertia, I 1230	cm ⁴		
Spherical Panel				
Circular Culindrical Shel				
Eliptic Culindrical Shell				
Circular Truncated Con	Result			
Sebarical Shall				
Natural Vibration Frequent	Critical load o.	DCC T/m		
	cintourioud, qr Z,	066 1710		
>				

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
	q	Dead weight
Two-hinged		Hydrostatic
	A A A	Polar

Arch type		Load type
	A A A A A A A A A A A A A A A A A A A	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.*

Kust2 (64-bit)		- 0	×
Stability of Equilibrium	Parabolic Arches (In-Plane Stability)]	
	Law of stiffness variation	Arch type Fixed ~	
Single-Span Bars on El Single-Span Bars of Va Multi-Span Bars of Unif Single-Span Straight Ba Curved Bars Curved Bars Circular Ring Round Arches (In-F	$I_{X} = I_{0} = const$		
Parabolic Arches (I Two-Hinged Segm	Uniformly dis	tributed follower load	
Stability of In-Plane Ber Plates Rectangular Plate	Initial data Material	Steel ordinary 🗸 🗸	
Circular Plate	Modulus of elasticity, E	21000000 T/m ²	
	Length of the arch span, L	10 m	
- Conical Panel	Rise of the arch, f	2 m	
Spherical Panel Circular Cylindrical Shel	Moment of inertia, I ₀	1230 cm ⁴	
Elliptic Cylindrical Shell Circular Truncated Con Spherical Shell Natural Vibration Frequen	Result	Critical load, q. 26,088 T/m	
× n >			
	Report 🤌 Help 🌃 Parameter	rs Mo Find 🚺 Calculate 🏭 B	- sit

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:



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.*

Kust2 (64-bit)				- 0	×
🖃 Stability of Equilibrium 🔥	Two-Hinge	ed Segmental Arches (In-Plane Stabili	ity]		
Bars Single-Span Bars of Ur Single-Span Bars of Va Single-Span Bars of Va Multi-Span Bars of Va Single-Span Bars of Va Single-Span Straight Ba Curved Bars Curved Bars Circular Ring	Load type	Distributed load ~		++++	
	— Initial data —	Material Modulus of elasticity, E 2 Moment of inertia of the section , I _x 3 Length of the arch span, I 2	Alloy steel 21000000 T/m ² 33.45 cm ⁴ 25 m	~	
Shells Cylindrical Panel Conical Panel Spherical Panel Dircular Cylindrical Shel		Rise, f 2 Cross-sectional area, F 2	2 m 22 cm ²		
Elliptic Cylindrical Shell Circular Truncated Con Spherical Shell Natural Vibration Frequen	Result	Critical load, q.	0,011 T/m		
Natural Vibration Frequent		Critical load, q.	0,011 T/m		

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 \mathbf{q} or a concentrated force \mathbf{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.*

🎾 Kust2 (64-bit)			_		×
🖃 Stability of Equilibrium 🛛 🔺	Stability of In-Plane B	ending of Thin-Walle	ed Beams		
🖻 Bars Single-Span Bars of Ur	Beam type	Symmetric beam under c	concentrated load	\sim	
Single-Span Bars on El Single-Span Bars of Va	Location of the load	top chord	~		
	Initial data				
Curved Bars	∣⊷−∟—⇒∣ ↓₽	, b , <u>t</u> , Material	Alloy steel		~
Circular Ring Round Arches (In-F	h‡		Modulus of elasticity, E 21000000	T/m ²	
Parabolic Arches (I		b, t	Poisson's ratio, v 0,3]	
Stability of In-Plane Ber	,		Beam length, L 4	m	
Rectangular Plate		Height o	f the cross-section, h 100	cm	
- Circular Plate			t ₁ 8	cm	
			b ₁ 260	cm	
Cylindrical Panel Conical Panel			t ₂ 8	cm	
Spherical Panel Circular Culindrical Shel			b ₂ 220	cm	
Elliptic Cylindrical Shell			t _w 12	cm	
Circular Truncated Con Spherical Shell	- Posult				
Natural Vibration Frequent	Critical force	e, P _{cr} 69060	3,134 T		
	Report 🧼 Help	🚯 Parameters 🕅 🎢	Find 6 Calculate	E E	Exit

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.*

Stability of Equilibrium	Rectangular Plate		
Stability of Equilibrium Single-Span Bars of Ur Single-Span Bars of Va Multi-Span Bars of Va Multi-Span Bars of Va Multi-Span Bars of Va Multi-Span Bars of Unif Single-Span Straight Ba Curved Bars Curved Bars		Initial data Material Steel ordinary Plate length, a Plate width, b Plate thickness, h Modulus of elasticity, E Poisson's ratio, v	2 m 3 m 0.24 m 21000000 T/m ² 0.3
	Result Critical stress, σ _{cr}	574967,723	T/m ²

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	11/1//////
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

🎾 Kust2 (64-bit)							-		×
Stability of Equilibrium	Circular Plate								
Single-Span Bars of Ur	Annular plate under u	uniform rad	ial compression a	along the e	ternal and inte	ernal cont	ours		\sim
Single-Span Bars on El Single-Span Bars of Va	Both edges clamped	l							\sim
Multi-Span Bars of Unif Single-Span Straight B≀ ⊡ Curved Bars	Initial data								
Circular Ring	Material	Steel ord	inary	`	~		. X.	441	
Round Arches (In-F Parabolic Arches (I	Poisson's ratio, ν		0,3				-Yo	per	-
Two-Hinged Segm	Modulus of elasticit	y, E	21000000	T/m ²				ØΪ	
Plates Rectangular Plate	Thickness, h		0.12	m			17	+ 10	
Circular Plate	Outer radius, b		12	m					
- Shells	Inner radius, a		10	m					
Cylindrical Panel									
Conical Panel									
- Circular Cylindrical Shel									
Elliptic Cylindrical Shell	Result								
Spherical Shell									
🖃 Natural Vibration Frequen 🖉				Critic	al stress, p _{cr} 2	769,231	T/m ²		
< > >									
	Report A	Holo	Dayamat		Find	6 (Coloulato	5 1 C	uit l
D ffice	Heport 🛛	нер		ers 00	Find	y (Laiculate	- E:	XIC

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
	 Simply supported edges Clamped along the contour
Circular plate under radial compression	
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

獅 Kust2 (64-bit)		- [ı x
Stability of Equilibrium	Skew Plate		
Engle Coord Deve at the	Initial data		
Single-Span Bars on El			
- Single-Span Bars of Va	a Naterial Steel ordinary		\sim
- Multi-Span Bars of Unif			
Single-Span Straight Ba	Modulus of elasticity, E 2100	.0000 T/m	2
Curved Bars	Deixees la artie au la a		
Circular Ring	Poisson's ratio, V [0,3		
Round Arches (In-F	Thickness, h 0.024	4 m	
Parabolic Arches (I	Simply supported plate		
Stability of In Plane Per	Side, a 1.5	m	
Plates			
Bectangular Plate			
- Circular Plate			
Skew Plate			
- Shells			
Cylindrical Panel			
Conical Panel			
Spherical Panel			
Circular Cylindrical Shel			
Elliptic Uylindrical Shell	Result		
Circular Truncated Lon			
Natural Vibration Frequence	Critical stress, G., 19425-529, T/	m ²	
< >			
CAD ©			
	Report 🤗 Help 🎼 Parameters 💏 Find 🧕 Calcula	ite 🛃	Exit

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

Stability of Equilibrium 🔥 🔺	Cylindrical	Panel					
i⊟⊷ Bars I Single-Span Bars of Ur	Uniform external	pressure					
Single-Span Bars on El Single-Span Bars of Va	All edges of the	panel simply	supported \checkmark]			
 Multi-Span Bars of Unif Single-Span Straight B; 	Initial data						
Curved Bars Circular Diag	Material	Steel ordina	ary	~			
Round Arches (In-F	Modulus of elas	icity, E	21000000	T/m ²		, a , →	1,
Two-Hinged Segm	Poisson's ratio, v	/	0,3		b	11.4	PN
Stability of In-Plane Ber	Radius, R		8	m	1 <u>1</u>	<u> </u>	<u> </u>
Rectangular Plate Circular Plate	Thickness, t		1	m	I		
Skew Plate	Panel length, a		12	m			
Cylindrical Panel Conical Panel Spherical Panel Circular Culindrical Shal	Arc length, b		7	m			
Elliptic Cylindrical Shell Circular Truncated Con	Result						
Natural Vibration Frequen	Upper critical st	ress, p _{cr.u}			67972,006 T/m ²		
> n							

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.*

Kust2 (04-bit)						-		×
Stability of Equilibrium	Conical F	^p anel						
⊟ Bars Single-Span Bars of Ur		Under uniform e	xternal pressure	•	_			
Single-Span Bars on El	Edges of	the nanel are restr	ained in the nor	mal direction	_			
Single-span Bars of Va Multi-Span Bars of Unif Single-Span Straight B≀	Initial data							
Curved Bars Circular Ring	Material	Steel ordinary		~ Modu	llus of elasticity, E	21000000	T/m ²	
Round Arches (In-F Parabolic Arches (I	Poisson's ra	tio, v	0,3]		Then-	27	-
Two-Hinged Segm Stability of In-Plane Ber	Radius, R _{cp}		12	m	$\sum_{i=1}^{n}$	P	7	
Plates … Rectangular Plate … Circular Plate	Wall thickne	ess, t	0.12	m			<u>_</u>	
Skew Plate	Cone angle	α	60	degree				
Cylindrical Panel Conical Panel Spherical Panel	Arc length, I) _{ep}	11	m				
Circular Cylindrical Shel	Panel length	n, L	7	m				
Circular Truncated Con Spherical Shell	Result							
Natural Vibration Frequent	Upper o	ritical pressure, p _{cr}			116,804	T/m ²		

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.*

獅 Kust2 (64-bit)						_		×
Stability of Equilibrium	Spherical P	anel						
Bars Single-Span Bars of Ur Single Span Bars of Ur		S	pherical panel subj	ected to ur	niform external pressure			
	Simply supported	along the con	tour with free in-pla	ne displace	ement (no thrust)			\sim
Multi-Span Bars of Unif Single-Span Straight B≀	Initial data							
Curved Bars	Material	Steel ordinary	J	\sim				
Round Arches (In-F Parabolic Arches (I 	Modulus of elas	sticity, E	21000000	T/m ²		L ZP	1	
Stability of In-Plane Ber	Poisson's ratio,	v	0,3			┽┵		₽
Plates Plate Circular Plate Circular Plate Scour Plate	Height, H		6	m				ŧ.
Shells	Wall thickness,	.t	0.42	m				
Cylindrical Panel Conical Panel Spherical Panel Circular Cylindrical Shel	Radius, a		12	m				
	Result							
Sprieical Shell Natural Vibration Frequent Natural Vibration Shell	Upper critical p	ressure, p _{cr}			12936,709 T/	/m²		
Scap ®	Report 🤌	Help	👩 Parameter:	s 💏	Find 🧕 Calcul	ate	E>	it

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.*

\times 獅 Kust2 (64-bit) Circular Cylindrical Shell 😑 Stability of Equilibrium ٨ Bars Uniform axial compression (both edges simply supported) \sim Single-Span Bars of Ur Single-Span Bars on El Single-Span Bars of Va Multi-Span Bars of Unif Initial data Single-Span Straight Ba Material Concrete heavy B30 \sim Modulus of elasticity, E 3310000 T/m² - Curved Bars Circular Ring Poisson's ratio, v 0,2 Round Arches (In-F Parabolic Arches (I Two-Hinged Segm Stability of In-Plane Ber Radius, R 6 m σ 📙 Plates Wall thickness, t 0.36 m - Rectangular Plate - Circular Plate Skew Plate 🛓 Shells Cylindrical Panel Conical Panel Spherical Panel Circular Cylindrical Shel Elliptic Cylindrical Shell Result Circular Truncated Con Spherical Shell Upper critical stress ocr.u. 117026,172 T/m² Natural Vibration Frequen ė n > < SCAD ® W 🔯 Parameters 🔗 Find 🧕 Calculate 🇾 Report 2 Help Exit

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
$M \xrightarrow{R} I \xrightarrow{I} I$ Torques at ends	 clamped shell edges simply supported shell edges
σ r	Simply supported ends

Circular Cylindrical Shell



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.*

Kust2 (64-bit) \times Stability of Equilibrium ^ 🛓 🛛 Bars Single-Span Bars of Unif Shell having a small eccentricity, under a uniform axial compression Single-Span Bars on Ela Edges are simply supported Single-Span Bars of Vari Multi-Span Bars of Unifo Initial data Single-Span Straight Bar - Curved Bars Material Steel ordinary Modulus of elasticity, E 21000000 T/m² Circular Ring Round Arches (In-PI Poisson's ratio, v 0,3 Parabolic Arches (In Two-Hinged Segmer Stability of In-Plane Bend Wall thickness, t 0.35 m Plates Rectangular Plate 32 Major semiaxis, a m Circular Plate Skew Plate 2 Minor semiaxis, b m Shells Cylindrical Panel Conical Panel Spherical Panel . Circular Cylindrical Shell Resul Elliptic Cylindrical Shell Circular Truncated Cone Upper critical stress, o_{cr.u.} 868832,493 T/m² Spherical Shell Natural Vibration Frequenc Upper critical pressure, P_{cr} 5182671,881 T < > CAD © 🔯 Parameters 💏 Find ø W Report - 🧼 Help Calculate **₽** Exit Office

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.
| Stability of Equilibrium 🔥 🔥 | Circular Truncated Cone | e Shell | | | | |
|-----------------------------------------------------------------------------------|---------------------------------------------|-------------------|--------------------------|------------------|------------------|----|
| ⊡- Bars
Single-Span Bars of Ur | Uniform longitudinal compression | | | | | `` |
| - Single-Span Bars on El | | External edges si | mply supported | | | |
| | _ Initial data | | | | | |
| Single-Span Straight B≀
⊟Curved Bars | Material Steel ordinary | ~ | Modulus of elasticity, E | 21000000 | T/m ² | |
| Circular Ring
Round Arches (In-F
Parabolic Arches (I | | | Poisson's ratio, | v 0,3 |] | |
| Two-Hinged Segm | Larger base radius, r ₁ | 12 | m | * | | |
| Plates Rectangular Plate | Smaller base radius, ${\rm r_0}$ | 6 | m | ∻ ∖ | | |
| Circular Plate | Height, H | 7 | m | | Ŧ | |
| Skew Plate | Shell thickness, t | 0,1 | m / | <u>† ††† †\</u> | н | |
| | | | l 🗧 | | Ŧ | |
| - Spherical Panel | | | 113 | <u>₹</u> ₩₩₩ | | |
| Circular Cylindrical Shel Elliptic Cylindrical Shell | Davida | | | | | |
| - Circular Truncated Con | nesuit | | | | | |
| | Upper critical pressure, P _{cr.u.} | | 80416.525 | T/m ² | | |
| ∴ n > | | | , | | | |

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:



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.

Elliptic Cylindrical Shell 🗸	Spherical Shel								
- Circular Truncated Con			Un	iform external	pressure				
Natural Vibration Frequen									
⊡• Bars									
Single-Span Bars of Ur Single-Span Bars on El	Initial data								
Bars of Variable Cross-{ Circular Rings	Material Ste	el ordinary		~					
Strings Plates Rectangular Plates	Modulus of elasticity,	E	21000000	T/m²		d'	*	_	
Cricular Plates Shells Cylindrical Shell Core Shell	Poisson's ratio, v		0,3						
Other Oscillation Problems Arrow Reference Data about Inte	Radius, R		12	m					
- Static Analysis 									
Rectangular Plates Spherical Domes	Wall thickness, t		0.4	m					
- Contact Stresses Sphere on a Sphere	Result								
Sphere on a Flat Plane	Critical pressure,	р _{ст}			282	243,952 T/m ²			

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, singlespan 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.

獅 Kust2 (64-bit)									-		×
Elliptic Cylindrical Shell 🔨	Singl	e-Span	Bars of U	niforn	n Sectio	on on Rig	id Supp	orts			
Cohorinal Chall						Initial data					
Natural Vibration Frequence	l H	⊫L				Material	Stee	el ordinar	y		\sim
Bars	l 😓		<u> </u>	\sim							
Single-Span Bars of Ur		•	,,,,,,			Number of I	frequencies		5 🔳		
Single-Span Bars on El											
Bars of Variable Cross-						Length of th	ne bar, L		3	m	
Circular Rings						-					
- Strings						Weight ner	running me	ter m	0.031	T/m	
Bectangular Plates						ii olgin poi			10,001		
Circular Plates						Madulus of	alaatiaitu E		21000000	2	
						Modulus of	elasticity, E		21000000	I/m*	
Cylindrical Shell								_		_	
Cone Shell						Moment of	inertia, J		447,531	cm ⁴	
Other Oscillation Problems	- Besult										
Reference Data about Inte	rresuit										
Static Analysis Circular Plates											
Bectangular Plates	#4	Num	ber of vibrati	ions per	second		Circula	ar freque	ncy		
Spherical Domes	1	30,03				188,68	6				
Contact Stresses	2	120,122				754,74	6			_	
Sphere on a Sphere	3	270,273				1698,1	78			_	
Sphere on a Flat Plane	4	480,486				3018,9	83			_	
Sphere in a Spherical Sock 🗸	5	750,759				4717,1	61				
< <u>></u>											
	Report	٨	Help	6	Paramete	ers 😚	Find	ø	Calculate	•	Exit



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).

🎾 Kust2 (64-bit)			_	
Elliptic Cylindrical Shell	Single-Span Bars on Elastic	Subgrade		
Calcular Truncated Con		Initial data		
Sprincal Shell	⊢ « L>(Material	Steel ordinaru	~
		in atomar	otoororainary	
Single-Span Bars of Ur		Number of frequencies	4	
Single-Span Bars on El				
Bars of Variable Cross-		Length of the bar	3 m	
Circular Rings		Longar of the bar, E	13	
Strings		Vi (night end a muine and a m	0.017 T/m	
Plates		weight per funning meter, m	0.017 170	1
Rectangular Plates				
Circular Plates		Modulus of elasticity, E	21000000 T/m	12
Shells				
Cylindrical Shell		Moment of inertia, J	🔲 3460 cm ⁴	
Cone Shell				
Other Oscillation Problems		Stiffness of the subgrade, Er	4.51 T/m	2
Reference Data about Inte				
Static Analysis	Result			
- Circular Plates				
Coloridad Domos				
	# Number of vibrations per	second Circ	ular frequency	
Sobere on a Sobere	1 113,03	710,191		
Sobere on a Flat Plane	2 452,094	2840,591		
- Sphere in a Spherical Sock	3 1017,208	6391,309		
Colore and Colored a	4 1808,37	11362,321		
< >				
CAD ©	Report 🧼 Help 🚺	Parameters 馣 Find	∮ Calculate 🖢	E xit

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*.

찰 Kust2 (64-bit)				_		×
Elliptic Cylindrical Shell	Bars of Variable Cross-S	ection				
		- Initial data Material	Steel ordina	ary	```	/
- Single-Span Bars of Ur - Single-Span Bars on El - Bars of Variable Cross-		Number of freque	encies ır. L	3	m	
- Circular Rings		Specific weight,	ρ inite Γ	7,85	T/m ³	
Frates Frates		Poisson's ratio, v	ICITY, E	0,3	T/m²	
Cylindrical Shell		Width, a Height, b		3	m m	
Other Oscillation Problems Generation Problems Generation Problems Static Analysis						
Circular Plates	Result					
Spherical Domes Gontact Stresses	# Number of vibrat	ions per second	(Circular frequency		
Sphere on a Sphere	2 596,462		3747,682			
Sphere on a Hat Plane Sphere in a Spherical Sock Sock	3 1178,136		7402,445			
	Report 🧼 Help 📗	攱 Parameters 🛛 💏) Find	∮ Calculate		Exit

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.*

Kust2 (64-bit)		- 0
- Elliptic Cylindrical Shell 🔺	Circular Rings	
Circular Truncated Con Spherical Shell	Ring type	Initial data
Natural Vibration Frequen		Material Steel ordinary 🗸
🚊 🛛 Bars		
Single-Span Bars of Ur Single-Span Bars on El		Number of frequencies 5
Bars of Variable Cross-{ Circular Rings		Weight per running meter, 0.021 T/m
Strings		Modulus of elasticity E 21000000 T/m ²
Bectangular Plates		
- Circular Plates		Radius, R 12 m
Culindrical Shell		Moment of inertia, I 🔤 1840 cm ⁴
Cone Shell		
Other Oscillation Problems		
Reference Data about Inte	Bault	
- Static Analysis	Hesuit	
Circular Plates		
Rectangular Plates	# Number of vibrations of	er second Circular frequency
Spherical Domes	1 0	0
Contact Stresses	2 0.402	2 528
- Sphere on a Sphere	3 1 138	7 149
- Sphere on a Flat Plane	4 2 182	13 708
— Sphere in a Spherical Sock 🗸	F 3.528	22.169
· · · · · · · · · · · · · · · · · · ·	3 3,320	22,100
		nature 🔗 Final 🙆 Calculate 🎫 Finit

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.

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Sti	nn	σs
		5

🎾 Kust2 (64-bit)								_		×
Elliptic Cylindrical Shell 🔺	Strin	gs								
Circular Truncated Con				1	nitial data —					
Natural Vibration Frequent	L F	د L								
Bars			ł		Numbe	r of frequencies	5	4 ►		
Single-Span Bars of Ur	3		r		1					
Single-Span Bars on El					Legth,	L	6		m	
Bars of Variable Cross-(Weight	ner running meter	m 11		T/m	
Circular Rings					ti olgi i	per running meter	/ 11.1		17.00	
Strings					Tensio	n, N	32	_	Т	
- Plates										
Circular Plates										
Cylindrical Shell										
Cone Shell										
Other Oscillation Problems										
Reference Data about Inte	Beeu	lto								
Static Analysis	nesc	iits								
Circular Plates										
	Nº	Nu	mber of vibr	ations pe	r second		Circular frequ	uency		
Spherical Domes	1	1,412				8,872				
	2	2,824				17,744				
Sobere on a Elat Plane	3	4,236				26,616				
- Sphere in a Spherical Sock	4	5,648				35,488				_
	5	7,06				44,361				
< >										
SCAD ©	Report	\$	Help	G	Parameters	😚 Find	∮ Calo	culate	.	Exit

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

獅 Kust2 (64-bit)			_	
- Elliptic Cylindrical Shell 🔺	Rectangular Plates			
Circular Truncated Con		Initial data		
		Material Ste	el ordinarv	~
	~			
Single-Span Bars of Ur		Number of frequenci	es 3 🔨	-
- Single-Span Bars on El		Include zero frea	uencies	
Bars of Variable Cross-				
Circular Rings		Length, a	3	m
Strings				
Plates		Width, b	2	m
Rectangular Plates				
Circular Plates		Thickness, h	0.24	m
En Snells				
Cone Shell		Modulus of elasticity,	E 21000000	T/m ²
Reference Data about Inte		Poisson's ratio, v	0,3	
🗐 Static Analysis				
Circular Plates		Specific weight, p	7,85	T/m ³
Rectangular Plates				
Spherical Domes	Result			
Contact Stresses	# Number of vibration	is per second	Circular frequency	
Sphere on a Sphere	1 743,98	4674,562		
Sphere in a Spherical Sock	2 925,372	5814,285		
	3 1771,999	11133,797		
< >				
CAD ©		-		
Office	eport 🤗 Help 🎼	Parameters 💏 Find	Calculate	🛃 Exit

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

獅 Kust2 (64-bit)						-		\times
Elliptic Cylindrical Shell 🔺	Circular Pla	tes						
Circular Truncated Con				- Initial data -				
sphencal shell	(γ)							
		\sim		Material	Steel ordinar	у	\sim	
Single-Span Bars of Ur	} —€							
Single-Span Bars on El	, .			Modulus of el	asticity, E	21000000	T/m ²	
Bars of Variable Cross-								
Circular Rings				Poisson's ratio	0, V	0,3		
Strings				De tra				
- Plates				Hadius, r		11	m	
Circular Plates				Thickness, h		0.2	m	
				Specific weight	ht, p	7,85	T/m ³	
Cone Shell								
Other Oscillation Problems								
Reference Data about Inte								
Static Analysis								
Circular Plates	Result							
- Rectangular Flates		n.4	Number of vibration	ns per second	Circular free	quency		
Contact Stresses		1	482,519		3031,756			
Sphere on a Sphere		2	1002,838		6301,017			
- Sphere on a Flat Plane		3	1646,527		10345,437			
Sphere in a Spherical Sock 👃		4	1879,943		11812,032			
Contraction of the second s		5	2882,262		18109,784		*	
	Benort 🚕	H	elo 😽 Para	meters 🔗	Find	Calculate	Ex Ex	át
				00	y y	Calculate		

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.*

👂 Kust2 (64-bit)										_		>
	Cylindrical S	Shell										
Circular Truncated Con Spherical Shell		_	_	Initia	al data -							
Natural Vibration Frequen		\frown										
Bars)	1	Mate	erial	Ste	el ordina	iry			\sim	
- Single-Span Bars of Ur												
Bars of Variable Cross-	6	///	L	Nium	her of fre	augacies.		4	~			
- Circular Rings	((RX))/	_		Num	ber of fre	quencies		4	~			
	¥			Mod	ulus of el	asticity, E		210000	00 T	/m ²		
- Plates	∏h			Poie	eon'e rati			0.2				
Rectangular Plates				1 013	30113100	, v		10,0				
				Spee	cific weig	ht, ρ		7,85	Т	/m ³		
- Cylindrical Shell				She	l lenath.	L		1	m			
Cone Shell						-						
Other Oscillation Problems				Rad	ius, R			20	m	1		
Etatio Apalusio				Thic	kness, h			0.2	m			
- Circular Plates								10,12				
Rectangular Plates	Result											
Spherical Domes	# /		m1			m2	N	umber of	vibration	s ner	second	1
Contact Stresses	1	1			0		307	0,654	ribi acioi	io por i	Jocoma	
Sphere on a Sphere	2	1			1		307	1,419				1
- Sphere in a Spherical Sock	3	1			2		307	3,716				
l chuir na chuir 🗡	4	1			3		307	7,545				
Be Be	port 🤌	Help		Paran	neters	66 E	ind	6 C	alculate		F	vit

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

🎦 Kust2 (64-bit)			- 0	×
Elliptic Cylindrical Shell 🔺	Cone Shell			
- Circular Truncated Con		Initial data		
Natural Vibration Frequent	Nor.	Material Charles fina		
Bars		Material Steel ordinal	ry v	
Single-Span Bars of Ur		Number of fraguencies	3	
- Single-Span Bars on El	/h \	Number of frequencies		
Bars of Variable Cross-{	/ \ L	Specific weight, p	7,85 T/m ³	
- Circular Hings 		Modulus of elasticity E	21000000 T/m ²	
Plates		Poisson's ratio	0.2	
Rectangular Plates		10155011511010, V	0,5	
Circular Plates		Shell height, L	5 m	
		Padius P	C	
Cone Shell		riadius, ri	0 11	
Other Oscillation Problems		Thickness, h	0.1 m	
Reference Data about Inte				
Static Analysis		Semi-opening angle, a	60 degree	
- Circular Plates	Result			
Rectangular Plates	# m1	m2 Num	ber of vibrations per second	
Spherical Domes	1 1	4 312,0	025	
Sobere on a Sobere	2 1	3 330,9	993	
Sphere on a Flat Plane	3 2	4 347,3	301	
Contraction of the second seco				
SCAD ©	Report 🧼 Help	🕉 Parameters 💏 Find	∮ Calculate 🛃 E	кit

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

🎾 Kust2 (64-bit)							-		×
Elliptic Cylindrical Shell 🔺	Reference Data	about	Internal Friction						
Circular Truncated Con							_		
Spherical Shell									
Natural Vibration Frequen	Type of structure	Reinford	ed concrete						\sim
- Bars									
- Single-Span Bars of Ur									
- Single-Span Bars on El	Energy absorption fa	actor (dissi	ipation factor)			0,628			
Bars of Variable Cross-									
- Strings	Damping factor (in fr	actions of	the critical damping)			0,05			
Bestevendes Distan									
Circular Plates									
	Logarithmic damping	Logarithmic damping factor [0,314							
Culindrical Shall									
Cono Sholl	Les faite								
	Loss lactor	Loss factor 0,1							
Beference Data about Inte									
Static Analysis	Internal friction factor								
- Circular Plates						10,1			
- Spherical Domes									
E Contact Stresses									
- Sphere on a Sphere									
Sphere on a Flat Plane									
- Sphere in a Spherical Sock 🤳									
S Calcara a Cultura S									
	Denut A U		Durant		First 1	6 C.I. I			
NOffice 🖤	Heport 🧭 H	eip	Los Parameters	00	Find	y Calcula	ite		: 80

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 🔥 🔥	Circular Plates							
				L-M-L-L-L-				
Cylindrical Shell				Initial data	_			
Cone Shell				Material	Sb	eel ordinary		~
Deference Data about Inte		1		Plate radius, a		1	m	
Static Analysis		P						
- Circular Plates	· · · · · · · ·		- L	Thickness, h		0.01	m	
- Rectangular Plates	║ ॑ ╈ ╈ ╈ ╈	****	↓ ੈ.	Load, P		1.3	T/m^2	
Spherical Domes		1	<u>∼</u> †″ ĭ				17111	
Contact Stresses			T	Modulus of elasti	city	21000000	T/m ²	
Sphere on a Sphere)-a	-	Paisson's ratio		0.0		
- Sphere on a Flat Plane	−	<u>a</u>	-	FOISSOFT'S TALLO, V		0,3		
Sphere in a Spherical Sock			•	Distance from th	e center			
- Sphere on a Cylinder				to the point, x		0.9	m	
- Sphere in a Circular Groove								
Sphere in a Lylindrical Groc								
- Cylinder on a Cylinder								
- Cylinder on a had hade	Hesult							
- Perpendicular Cylinders	Inclination angle	0.007	m	Moment M	0.051	T×m	n/m	
Arbitrary Surface on an Arb		10,001			10,001			
Arbitrary Surface on a Flat F	Slope, O	0,066	degree	Moment, M _f	0,143	T×n	n∕m	
Auxiliary Calculations				Force Q	0.595	T/n	•	
- Polynomial Roots				roice, a _r	10,000	171		
Moments of Inertia of Simpl 🧹								
>								Plots

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.



Circular Plates



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

KUST

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*.

Kust2 (64-bit)			-		×
Circular Plates	Rectangular Plates				
		Initial data			
- Lylindrical Shell					
	//// Þ ~	Material Steel o	dinaru		\sim
- Utner Uscillation Problems - Beference Data shout into		indicinal brook of	anay		
Statio Applueio	*a*	Modulus of elasticity F	21000000	T/m ²	
- Static Analysis - Circular Plates		negative of eldeneny, p	21000000	1700	
Rectangular Plates		Peissen's ratio	0.0	-	
Spherical Domes		Poisson's faulo, v	0,3		
Contact Stresses				_	
Sohere on a Sohere		I hickness, h	0.2	m	
Sphere on a Elat Plane				_	
- Sphere in a Spherical Sock		Length, a	5.2	m	
- Sphere on a Cylinder					
- Sphere in a Circular Groove		Width, b	3	m	
- Sphere in a Cylindrical Groc					
- Cylinder on a Cylinder		Load, P	23.4	T/m ²	
- Cylinder on a Flat Plane				17111	
- Cylinder in a Cylindrical Soc					
- Perpendicular Cylinders					
- Arbitrary Surface on an Arb	Result				
Arbitrary Surface on a Flat F	Maximum stress, σ _{max}	2904.174 T/m ²			
Auxiliary Calculations					
Polynomial Roots					
- Moments of Inertia of Simpl 🖉	Deflection, ymax	0,001 m			
1 C					
-					

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:

b a	

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:



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.*

Kust2 (64-bit)		- □ >
Circular Plates	Sphere in a Cylindrical Groove	
Cylindrical Shell	Parameters	
- Cone Shell	F	
Other Oscillation Problems	R ₁ 2500	cm
Beference Data about Inte	River	
- Static Analysis	R ₂ 2000) cm
- Circular Plates	Modulus of elasticity E. Docor	2000000 T/m ²
Bectangular Plates		JUUUUUU 17m
	Modulus of elasticity, E. 20600	000000 T/m ²
- Contact Stresses	F	1711
Sohere on a Sohere	Poisson's ratio v. 0.3	
Sphere on a Flat Plane		
Sphere in a Spherical Sock	Poisson's ratio V ₂ 0.3	
Sphere on a Culinder	Forma F 0.04	т
Sphere in a Circular Groove	Force r 0.04	1
Sphere in a Culindrical Groc		
- Culinder on a Culinder		
Cylinder on a Elat Plane		
- Cylinder on a Fulindrical Soc		
- Perpendicular Culinders	Results	
Arbitrary Surface on an Arb	Contact width of major comjavia a crea	tact ama lu ana lu ana la 2
Arbitrary Surface on a Elat F	Contact width of major semiaxis (0,358 cm	1,262e-006 m ⁻
- Auxiliary Calculations	Contact width of minor semiaxis 0 011 cm Maxim	um stress 17C19 1E9 T/m
- Polynomial Boots		47043,103 17/1
Moments of Inertia of Simpl	Displacement of the center 2,287e-007 cm	
Completed Describer		
>		

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	R ₁ R ₂ F
Sphere on a flat plane	R ₁

Sphere in a spherical socket	
Sphere on a cylinder	R ₁ R ₂
Sphere in a circular groove	R ₁ R ₂ R ₃
Sphere in a cylindrical groove	R ₁ R ₂ F
Cylinder on a cylinder	$\begin{array}{c} q \downarrow $
Cylinder on a flat plane	$q \downarrow \downarrow \downarrow \downarrow \downarrow \downarrow \downarrow$ R_1

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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.

Kust2 (04-bit)			_	
Circular Plates 🔺	Polynomial Roots			
Cylindrical Shell Cone Shell	Degree	e of the polynomial 5		
Other Oscillation Problems				
Reference Data about Inte	Exponent	Coefficient		
Static Analysis	0	12		
Circular Plates	1	-9.7		
Rectangular Plates	2	2.9		
Spherical Domes	3	0		
Contact Stresses	4	11		
- Sphere on a Sphere	5	78.9		
Sphere in a Cylindrical Groc Cylinder on a Cylinder Cylinder on a Flat Plane Cylinder in a Cylindrical Soc	78,9x ⁵ +11x ⁴ +2,9x ² -9,7x+1	2		
- Perpendicular Cylinders				
Arbitrary Surface on a Flat F	#⊿	Polynomial Roots		
Auxiliary Calculations	1 0,505-0,338i			
Polynomial Boots	2 -0,174+0,695i			
- Moments of Inertia of Simpl	3 -0,174-0,695i			
Geometrical Properties	4 -0,802+0i			
Determinant of Matrix 🛛 👻	5 0,505+0,338i			
>				

Polynomial Roots

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

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

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

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]).

Circular Plates Cone Shell	Kust2 (64-bit)			-		>
Cone Shell Other Oscillation Problems Reference Data about Inte Static Analysis Circular Plates Rectangular Plates Sphere on a Spherical Domes Sphere on a Sphere Sphere on a Sphere Sphere on a Sphere Sphere on a Spherical Sock Sphere on a Cylinder Sphere in a Cylindrical Groove Sphere in a Cylindres Arbitrary Surface on a Arb Arbitrary Surface on a Flat Plane Specific weight 7,95 T/m ³ Material Steel ordinary Volume 374.21 m ³ J_z 26663,011 T'm'sec ² Inner surface area 50,265 m ²	Circular Plates	Moments of Inertia of Simple Bo	dies			
Other Oscillation Problems Reference Data about Inte Reference Data about Inte Static Analysis - Circular Plates Rectangular Plates - Spherical Domes Spherical Domes Contact Stresses Spherical Sock - Sphere on a Spherical Sock Sphere on a Cylinder - Sphere on a Cylinder Sphere on a Cylinder - Sphere on a Cylinder Sphere on a Cylinder - Sphere on a Cylinder Sphere on a Cylinder - Sphere on a Cylinder Sphere on a Cylinder - Sphere on a Cylinder Sphere on a Cylinder - Sphere on a Cylinder Sphere on a Cylinder - Cylinder on a Flat Plane Specific weight 7,85 - Cylinder on a Flat Plane Specific weight 7,85 - Cylinder on a Flat Plane Specific weight 7,85 - Cylinder on a Flat Plane Specific weight 7,85 - Arbitrary Surface on a Flat Plane J_x 26663,011 - Arbitrary Surface on a Flat Plane J_x 26663,011 - Polynomial Roots J_x 26663,011 - Moments of Inertia of Simpl J_z 26663,011 - Specific Weight 7,85 Inner surface area - Specific Weight 7,85 Specific Weight 7,85	Cone Shell	ZΛ	Body shape Holld	ow sphere		~
 Reference Data about Inte Static Analysis Circular Plates Spherical Domes Contact Stresses Sphere on a Sphere Sphere on a Sphere Sphere on a Dylinder Sphere on a Cylinder Sphere in a Cylindical Groov Sphere on a Flat Plane Cylinder on a Flat Plane Contact Stresses Contact Stresses Contact Stresses Contact Stresses Contact Str	Other Oscillation Problems					
Static Analysis Oricular Plates Spherical Domes Contact Stresses Spherical Domes Contact Stresses Sphere on a Sphere Sphere on a Sphere Sphere on a Sphere Sphere on a Cylinder Sphere in a Cylindical Groov Sphere in	Reference Data about Inte	(\pm)				
Circular Plates Prectangular Plates Spherical Domes Spherical Domes Sphere on a Sphere Sphere on a Sphere Sphere on a Cylinder Sphere on a Cylinder Sphere on a Cylinder Sphere on a Cylinder Cylinder on a Cylinder Cylinder on a Cylindical Groc Cylinder on a Cylindical Soc Perpendicular Cylinders Arbitray Surface on a Flat Auxiliary Calculations Polynomial Roots Moments of Inertia of Simpl Consult of Departure Sphere in a fixed Sphere on a Flat Sphere in a Cylinder Cylinder on a Cylinders Autilitary Surface on a Flat J_x 26669.011 T'm'sec ² Uoture Sphere in a Simpl Consult of Simpl Constrained Sphere in a Cylinders Sphere in a Cylinder Sphere in a Cylinders Sphere in a Cy	Static Analysis			R 4.6	m	
Prectangular Plates Spherical Domes Contact Stresses Sphere on a Sphere Sphere on a Cylinder Sphere on a Cylinder Sphere in a Cylindiral Groove Sphere in a Cylindiral Groove Sphere in a Cylindiral Groove Cylinder on a Flat Plane Ovlinder on a Flat Plane Ovlinder on a Flat Plane Ovlinder on a Splare Ovlinder on a Splare Volume Moment of inertia Jx 26669.011 T'm'sec ² Outer surface area Sp. 26669.011 T'm'sec ² Numents of Inertia of Simpl Jz Ze6669.011 T'm'sec ² Inner surface area 50,265 Material Comment of Inertia of Simpl Jz Specific Weight T'm'sec ² Inner surface area 50,265	Circular Plates	$\int \vec{J} = \vec{x} + -\mathbf{R} \hat{\boldsymbol{x}}$		r 2	m	
Spherical Domes Contact Stresses Sphere on a Sphere Sphere on a Plat Plane Sphere on a Cylinder Sphere in a Cylindical Groc Cylinder on a Cylinder Cylinder on a Flat Plane Cylinder on a Cylinders Arbitrary Surface on a Arb Arbitrary Surface on a Flat Flane Jy 26669.011 T'm'sec ² Volume 374.21 Jy 26669.011 T'm'sec ² Outer surface area 265.904 Jz 26669.011 T'm'sec ² Inner surface area 50.265	Rectangular Plates	VV-At-SN		. 12		
■ Contact Stresses ■ Sphere on a Sphere ■ Sphere in a Spherical Sock ■ Sphere in a Cylinder ■ Sphere in a Cylinder ■ Cylinder on a Stat Plane ■ Cylinder on a Stat Plane <t< td=""><td> Spherical Domes</td><td></td><td></td><td></td><td></td><td></td></t<>	Spherical Domes					
 Sphere on a Flat Plane Sphere in a Spherical Sock Sphere in a Spherical Sock Sphere in a Cylinder Sphere in a Cylinder Sphere in a Cylinder Cylinder on a Flat Plane Cylinder and a	Contact Stresses					
Sphere on a Sphere on a Sphere on a Cylinder Sphere on a Cylinder Sphere on a Cylinder Sphere on a Cylinder Cylinder on a Flat Plane Arbitray Surface on a Flat Flate J_x 26669.011 T'm'sec ² Volume J_z 26669.011 T'm'sec ² Unter surface area J_z 26669.011 T'm'sec ² Inner surface area 50.265 m ²	Sphere on a Sphere	$X \times [Z]$				
Sphere in a Synetic a Subs Sphere in a Synetic a Subs Sphere in a Synetic a Subs Sphere in a Cylinder on a Cylinder Synete in a Cylinder on a Flat Plane Cylinder on a Flat Plane Auxiliary Surface on a Alth J _x 26669.011 T'm"sec ² Volume 374.21 m ³ Auxiliary Calculations J _x Polynomial Roots J _z Moments of Inertia of Simpl J _z J _z 26669.011 T'm"sec ² Duter surface area 50,265 m ²	Sphere on a Flat Plane					
Sphere on a Cylinder Sphere in a Cylinder Sphere in a Cylinder Cylinder on a Cylinder Moment of inertia Jx 26669.011 T'm'sec ² Outer surface area Consential Departies Jz 26669.011 T'm'sec ² Inner surface area 50,265 m ²	Sohere on a Culinder					
Sphere in a Cylinder Sphere in a Cylinder Sphere in a Cylinder Specific weight Cylinder on a Flat Plane Specific weight Cylinder on a Flat Plane Moment of inertia Cylinder on a Flat Plane Moment of inertia Aubitrary Surface on a Flat F Jx Aubitrary Surface on a Flat F Jy Aubitrary Surface on a Flat F Jy Perpendicular Cylinders Jy Polynomial Roots Jy Polynomial Roots Jz Z6669.011 T'm*sec ² Unter surface area 265.904 Moments of Inertia of Simpl Jz Z6669.011 T'm*sec ² Inner surface area 50,265 m ²	Sphere in a Circular Groove					
Cylinder on a Cylinder Moment of inertia Jx 26669.011 T'm"sec ² Volume 374.21 m ³ Jy 26669.011 T'm"sec ² Outer surface area 265.904 m ² Jz 26669.011 T'm"sec ² Inner surface area 50,265 m ²	- Sphere in a Cylindrical Groc					
Cylinder on a Flat Plane Specific weight 7,85 T/m ³ Material Steel ordinary Cylinder in a Cylindrical Soc Perpendicular Cylindrical Soc Moment of inertia Arbitrary Surface on a Arb Jx 26669,011 T'm'sec ² Volume 374,21 m ³ Auxiliary Calculations Jy 26669,011 T'm'sec ² Outer surface area 265,904 m ² Moments of Inertia Jz 26669,011 T'm'sec ² Inner surface area 50,265 m ²	- Cylinder on a Cylinder					
Cylinder in a Cylindrical Soc Perpendicular Cylindres Arbitrary Surface on a Arb J_x Arbitrary Surface on a Flat f J_y Polynomial Roots J_z Moments of Inertia of Simpl J_z 26669,011 T'm"sec ² Volume 374.21 mail J_y 26669,011 T'm"sec ² Outer surface area 265,904 m ² J_z 26669,011 T'm"sec ² Inner surface area 50,265 m ²	- Cylinder on a Flat Plane	Specific weight 7.85 T/m ³	Material Steel ordinary	~		
Perpendicular Cylinders Arbitrary Surface on an Arb Arbitrary Surface on a Flat J_x 26669.011 T'm'sec ² Volume 374.21 m ³ Auxiliary Calculations Polynomial Roots Moments of Inertia of Simpl J _x 26669.011 T'm'sec ² Outer surface area 265.904 m ² Moments of Inertia of Simpl J _x 26669.011 T'm'sec ² Inner surface area 50,265 m ²	- Cylinder in a Cylindrical Soc		Manager Market			
Arbitrary Surface on an Arb J_x 26669.011 T'm'sec ² Volume 374.21 m ³ Auxiliary Calculations J_y 26669.011 T'm'sec ² Outer surface area 265.904 m ² Polynomial Roots J_x 26669.011 T'm'sec ² Outer surface area 265.904 m ²	Perpendicular Cylinders		Moment or Inertia			
Auxiliary Calculations Jy 26669,011 T'm'sec ² Outer surface area 265,904 m ² Moments of Inertia of Simpl J _x 26669,011 T'm'sec ² Inner surface area 50,265 m ²	- Arbitrary Surface on an Arb	J _x 26669.011 T [*] m*sec ²	Volume	374.21	m ³	
Auxiliary Calculations Jy 26669.011 T'm'sec ² Outer surface area 265.904 m ² Polynomial Roots - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - <td< td=""><td> Arbitrary Surface on a Flat f</td><td></td><td></td><td></td><td></td><td></td></td<>	Arbitrary Surface on a Flat f					
Proynomial Hoots Moments of Inertia of Simpl J_z [26669,011] T'm'sec ² Inner surface area [50,265] m ²	Auxiliary Calculations	J _y 26669,011 T*m*sec ²	Outer surface area	265,904	m ²	
Moments or inerta or simple vz (26663,011) 1 m sec* inner surface area (50,265 m*	- Polynomial Roots			50.005	2	
	Comparison Inertia or Simpl	*z [26663,011] [misec*	muel sullace alea	100,265	m-	
	>					
	W Re	port 🥔 Help 🚺 Para	meters 💏 Find	o Calculate	🗭 E	Exit

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.





獅 Kust2 (64-bit) \times Other Oscillation Problems - Reference Data about Inte Static Analysis z b 10 cm Circular Plates +-а d 20 cm Rectangular Plates Spherical Domes a 10 cm Contact Stresses Ż_m Sphere on a Sphere Sphere on a Flat Plane Sphere in a Spherical Sock Sphere on a Cylinder Sphere in a Circular Groove Sphere in a Cylindrical Groc Cylinder on a Cylinder Cylinder on a Flat Plane Cylinder in a Cylindrical Soc Perpendicular Cylinders Arbitrary Surface on an Arb Arbitrary Surface on a Flat F Auxiliary Calculations Polynomial Roots Value Unit of measurem Parameter Moments of Inertia of Simpl 200 A Cross-sectional area cm Geometrical Properties 31,717 Angle of principal axes of inertia α. degree Determinant of Matrix Moment of inertia about centroidal Y1-axis parallel with Y-axis 6666,667 cm4 Inverse Matrix Moment of inertia about centroidal Z1-axis parallel with Z-axis 3333,333 cm4 Systems of Linear 5,774 Radius of gyration about Y1-axis cm < > SCAD © Office W 2 🔯 Parameters 🕅 Find ∮ Calculate Report Help Exit

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.



Geometric Properties















Ζ

y_m

Z_{C1}

Z_{C2}

b

a















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.

Other Oscillation Problems 🔺	Inver	se Matri>						
Reference Data about Inte							 	_
Static Analysis								
Circular Plates		Urder o	of matrix	4	()	Symmetric		
Rectangular Plates								
Spherical Domes	#/	1	2	3	4			
Contact Stresses	1	-9.9	1	2	3			
Sphere on a Sphere	2		-9.9	2.8	3.4			
Sphere on a Flat Plane	3			-89.7	5.8			
Sphere in a Spherical Sock	4				19.07			
Sphere on a Cylinder								
Cohere in a Circular Groove								
Culinder on a Culinder								
- Cylinder on a Flat Plane								
- Culinder in a Culindrical Soc	Invers	e matrix						
- Perpendicular Cylinders								
Arbitrary Surface on an Arb	#	1	2	3	4			
Arbitrary Surface on a Flat F	1	-0,097	-0,004	-0,001	0,016			
Auxiliary Calculations	2	-0,004	-0,096	-0,002	0,018			
- Polynomial Roots	3	-0,001	-0,002	-0,011	0,004			
- Moments of Inertia of Simpl	4	0,016	0,018	0,004	0,045			
Geometrical Properties								
- Determinant of Matrix								
lucroson kilostriu								
Inverse Maux								
Systems of Linear Equation								

Cal

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.

Kust2 (64-bit)										×
Other Oscillation Problems	Syste	ms of Li	near Equ	ations						
Heterence Data about Inte Static Analysis Circular Plates Bectangular Plates			Ord	er of matrix	3	•	🗹 Symi	metric		
Spherical Domes						~		b		
Contact Stresses	1	23	36.7	12	9	4.61	23	Q U		
- Sphere on a Sphere	2	20	1956	9 -87	,	0.332	-8	9		
- Sphere on a Flat Plane	3		1000.	14		5 422	12	45		
Sphere in a Spherical Sock						-0,422				
- Sphere on a Cylinder										
- Sphere in a Circular Groove										
- Sphere in a Cylindrical Groc										
Cylinder on a Cylinder										
- Cylinder on a Flat Flahe										
- Percendicular Culinders										
- Arbitrary Surface on an Arb										
Arbitrary Surface on a Flat f										
- Auxiliary Calculations										
Polynomial Roots										
- Moments of Inertia of Simpl										
Geometrical Properties										
- Determinant of Matrix										
- Inverse Matrix										
Systems of Linear Equation 🧹										
· >										
									100	

Systems of Linear Equations

This mode enables you to solve a system of linear equations $A\mathbf{x} = \mathbf{b}$ 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 \mathbf{x} displayed in the table under the column heading \mathbf{x} .

References

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

П \times Kust2 (32-bit) - Reference Data about Inte 🔥 Static Analysis Circular Plates Number of rows 4 • • 3 • • Governing row Rectangular Plates Immediate execution Spherical Domes Number of columns 5 • • Governing column 4 • • Contact Stresses Sphere on a Sphere 2 3 5 1 x2 0.997 0.0 y3 4.007 .1 Sphere on a Flat Plane x5 -83.822 x1 xЗ y1 -8.984 -56.452 Sphere in a Spherical Sock -6.988 0.999 28.588 -1.994 -88.843 Sphere on a Cylinder у2 1.373 -0.25 Sphere in a Circular Groove ×4 -5.236 0.374 21.472 Sphere in a Cylindrical Groc y4 -30.576 4.746 137.754 -9.601 -417.855 4 Cylinder on a Cylinder Cylinder on a Flat Plane Cylinder in a Cylindrical Soc Perpendicular Cylinders Arbitrary Surface on an Arb Arbitrary Surface on a Flat F Auxiliary Calculations Polynomial Roots Moments of Inertia of Simpl Geometrical Properties Determinant of Matrix Inverse Matrix Systems of Linear Equation Jordan Elimination Step > CAD ® W Report 2 Help 🔯 Parameters <u> 66</u> Find ∮ Calculate ₽. Exit Office

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

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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 σ_{max} is by far higher than the nominal stress σ_{nom} . The ratio of the maximum stress σ_{max} to the nominal one σ_{nom} is known as the *stress concentration factor* K_t , that is

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

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_{tg}).

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 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.

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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 cracks);
- 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

🍇 CoCon (64-bit)	– 🗆 X
Gradiente Single circu ∧ Biaxial ten Cylindrical	Transverse circular hole in a round bar or tube Bending
	$M \bigoplus^{1/2} M \bigoplus^{1/2} \sigma_{nom} = 32MD/(\pi (D^4 - q_i^4)))$
- Cylindicai - In-plane b - Simple bei - Eccentric ci - In-plane b - Two equal c - Biavial ten	$0 \le d_i / D \le 0.9$ $0 \le d / D \le 0.4$
Uniaxial te Uniaxial te Infinite row Biaxial ten	Text field
Uniaxial te Uniaxial te Transverse Bending 	Hole diameter, d 10 m Inner diameter, d 80 m Outer diameter, D 90 m Result field
NON-CIRCULA	Stress concentration factor based on gross area, K ₁₀ 2,905
SCAD ©	Image: Control of Calculate Image: Control of Calculate Image: Control of Calculate Image: Control of Calculate Image: Control of Calculate

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**

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

nd in problem tree			
Find what	Match case		
tension		60	Find
Results		×	Close
Uniaxial tension (Ellipt Axial tension (Single L Axial tension (Infinite r	ical or U-shaped notch in a semi-infinite I-shaped notch on one side of a finite-w ow of opposite semi-circular notches in	^	
Axial tension (U-shape Axial tension (Stepped Axial tension (Shaft wi Biavial tension (Shaft wi	ed circumferential groove in a circular sh d flat bar with shoulder fillets) ith a circumferential shoulder fillet) circular bole in an infinite plate)	↓ <u> </u>	Go to

Fig. 2.2-2. Dialog box

Exit — exits the program.

Calculation

Follow these steps to perform the calculation:

- \clubsuit select a problem in the tree;
- \clubsuit enter the initial data in the text fields;
- \checkmark 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.

nts of Mea	surement	Report and Languages	Visua	lization	General					
									Show as 0	
Jinear size	m	~		1,123		•		10 ^X	0	
Angle	degree	~		1,123		•	►	10 ^x	0	
ressure	T/m ²	~	8	1,123		•	►	10 ^X	0	
Force	т	~		1,123		•		10 ^X	0	
Moment	T'm	~	2	1,123		•		10 ^x	0	
Coefficient				1,123		•	•	10 ^X	0	

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 \bigcirc (decrease) and \bigcirc (increase) buttons, while the scientific notation is turned on by the button 100. 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 P.

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.

arameters						>
Units of Measurement	Report and Languages	Visualization	General			
		Fonts				
		Information	AaBb	Cc		

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 2.3-3. The Visualization tab







Figure 2.3-5. The UI 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.

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



References

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- 2. S. Shioya. On the Transverse Flexure of a Semi-Infinite Plate with an Elliptic Notch, Ingenieur-Archiv, 1960, 29, p. 93.

Uniaxial tension



References

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- 2. M. Seika, *Stresses in a Semi-Infinite Plate Containing a U-Type Notch Under Uniform Tension*, Ingenieur-Archiv., 1960, 27, p. 20.
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Opposite U-shaped notches in a finite-width plate

In-plane bending



References

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Transverse bending



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- 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



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



- 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



References

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- 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



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U-shaped circumferential groove in a circular shaft

Axial tension



References

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- 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



References

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Torsion



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- 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



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- 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



References

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- 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



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- 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



References

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Bending



References

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Torsion



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2.6 Circular Holes

Single circular hole in an infinite plate

Biaxial tension



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



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



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
M Ja M	$0 \le d/h \le 7$ $K_{\rm t} = \sigma_{\rm max}/\sigma$
	$\sigma = 6M/h^2$

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



References

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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



References

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Cylindrical bending



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In-plane bending



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- 3. R.B. Heywood, *Designing by Photoelasticity*, Chapman and Hall, London, 1952.

Simple bending

	Information and restrictions
	$0 \le d / H \le 0.3$
<u>Omax</u>	$1 \le d / h \le 7$
	$K_{tg} = \sigma_{max} / \sigma$ $\sigma = 6M / h^2$
•	$K_{ m in}=\sigma_{ m max}/\sigma_{ m nom}$
	$\sigma_{\text{nom}} = 6M H/((H - d)h^2)$

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



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- 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



References

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Uniaxial tension normal to the row of holes



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- 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



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Infinite row of circular holes in an infinite plate

Biaxial tension



References

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Uniaxial tension normal to the row of holes



References

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- 3. P. Meijers, *Doubly-Periodic Stress Distributions in Perforated Plates*, Dissertation, Tech. Hochschule Delft, Netherlands, 1967.

Uniaxial tension parallel to the row of holes



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).
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- 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



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).
- 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 $0 \le d_i / D \le 0.8$ $0 \le d / d_i \le 0.4$

$$K_{\rm tg} = \sigma_{\rm max} / 16TD / [\pi (D^4 - d_{\rm i}^4)]$$

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



- 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



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



- 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



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



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



- 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



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



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



- 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



- 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



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



- 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



- 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



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



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



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



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



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



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



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



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



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



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



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



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



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



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



References

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

СоСоп

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



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



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



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



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).

Materials E	ditor (64-bit)						_		×
Materials									
Name	Dead weight	Young's modulus	Poisson's rat	io	Thermal expansion	Damping coefficient	Dead load safety factor	Туре	
	T/m ³	T/m ²			coenicient				
Concrete heavy	2,500	3 310 000,00	0 0,20	00	1,e-005	0,100	1,100	Isotropic	
Concrete heavy	2,500	3 520 000,00	0,20	00	1,e-005	0,100	1,100	Isotropic	
Concrete heavy	2,500	3 670 000,00	0,20	00	1,e-005	0,100	1,100	Isotropic	
Concrete heavy	2,500	3 820 000,00	0 0,20	00	1,e-005	0,100	1,100	Isotropic	
Concrete heavy	2,500	3 980 000,00	0 0,20	00	1,e-005	0,100	1,100	Isotropic	
Concrete heavy	2,500	4 030 000,00	0 0,20	00	1,e-005	0,100	1,100	Isotropic	
Concrete heavy	2,500	4 080 000,00	0 0,20	00	1,e-005	0,100	1,100	Isotropic	
High-quality stee	7,850	21 000 000,00	0 0,30	00	1,2e-005	0,025	1,050	Isotropic	
Stainless steel	7,850	21 000 000,00	0,30	00	1,2e-005	0,025	1,050	Isotropic	
Steel ordinary	7,850	21 000 000,00	0,30	00	1,2e-005	0,025	1,050	Isotropic	
Steel special	7,850	21 000 000,00	0 0,30	00	1,2e-005	0,025	1,050	Isotropic	
Titan and alloys	4,500	11 000 000,00	0 0,30	00	1,2e-005	0,025	1,050	Isotropic	-
) 😭 N	Aodify 🔤 🔤	Add	×	Remove				
N Office	1	Exit 🚺	Settings	H	Save	👿 Report		🧼 н	elp

Interface

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

nits of Measuren	ent Report ar	nd Languages	Gene	ral					
								Show as 0	
pecific weight	T/m ³	~	P	1,123	•	•	10 ^x	0	
ressure	T/m ²	~	2	1,123	•	F	10 ^X	0	
oefficient				1,123	•	Þ	10 ^x	0	
ther				1,123	•		10 ^x	0	

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 $\stackrel{\checkmark}{=}$ 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 \square (decrease) and \square (increase) buttons, while the scientific notation is turned on by the \square 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.

rd 97-2003	
Pottom:	20
bottom.	20 m
Right:	20 m
Langua	age
	English (United Sta
	Bottom: Right: Langua

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.

Settings						×
Units of Measurement	Report and Languages	General				
Hide win	dow when minimized					
Check fo	x a new version at startu;	of the program	n			
💾 Save 📔	Load	~	ок	🗙 Cancel	Apply	🔶 Help

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.

Name Steel special					_
Material type Isotropic					
Specific weight 7,85	T/m ³	Young's mod	lulus 21000000	T/m ²	
Coefficients Poisson 0,3 thermal 1.2e-005 expansion	1/°C	damping coeffic Dead safety fa	cient 0,025 load load 1,05	-	
Material properties Elastic moduli	Thermal e	xpansion	Poisson's rai	ios	
E ₁ 21000000 T/m ²	t _x 1,2e-00	5 1/°C	v ₁₂ 0	,3	
E ₂ 21000000 T/m ²	t _y 1,2e-00	5 1/°C	V ₂₁ 0	,3	
E ₃ 21000000 T/m ²	t _z 1,2e-00	5 1/°C	V ₁₃ 0	,3	
Shear moduli			V ₃₁ 0	,3	
G ₁₂ 8076923,077 T/m ²			V ₂₃ 0	,3	_
G ₁₃ 8076923,077 T/m ²			V ₃₂ 0	,3	_
G ₂₃ 8076923,077 T/m ²					

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: $E_i v_{ij} = E_j v_{ij}$.

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 $-v_{12}$, 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

Material name			×
Language 🛛		Material name	
English (United States) Ste	el special		
Russian (Russia) Ctr	эль специальная		
		Y Cancel	

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 E 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.