S C A D S o f t

SCAD Structure

CoCon

Stress Concentration Factors

and Stress Intersity Factors

Electronic handbook

version 3.1

U s e r M a n u a l

ОГЛАВЛЕНИЕ

1 Introduction

There are a good deal of constructive parts which feature certain geometrical singularities such as orifices, notches etc. It is the boundaries of these singularities whereat a maximum local stress usually appears. This maximum local stress $\sigma_{\max}$ is many times higher than a nominal stress σ_{nom}. The ratio of the maximum stress $\sigma_{\max}$ to the nominal one σ_{nom} is referred to as a ***stress concentration factor*** K_t, that is,

$$\sigma_{\max} = K_t \sigma_{\text{nom}}$$

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

In some cases, for example, orifices in infinite plates (see Fig. 1), the concepts of gross/net-area stress concentration factors make no sense, therefore one refers to a general *stress concentration* factor K_t.

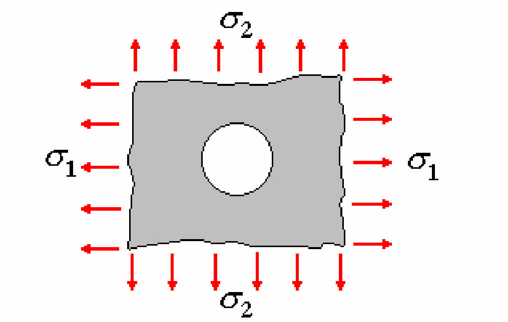


Fig. 1. *Hole in an infinite plate*

Investigations of stress concentration are based on theoretical calculations, numerical analyses of various kinds, or experimentation (photo-elasticity). Numerous studies on the subject of stress concentration have been systematized and presented in the book by W.D. Pilkey *Peterson's Stress Concentration Factors.* The implementation of the **CoCon** software is based on this publication principally.

The **CoCon** software deals with a lot of various constructive parts having singularities and subjected to one load (as a rule). In practice, most structural parts and elements are subjected to combinations of loads. In order to evaluate the maximum stress in these cases, it suffices to find the maximum stresses for single loads using the nominal stresses and the single-load stress concentration factors, and then use the *superposition principle*. It is possible because we assume the construction's material to behave linearly. Another reason for the superposition principle to hold is that the maximum stresses arise usually at the same points of a structure under different kinds of loads upon it.

Also, the **CoCon** software implements modes for calculating the stress intensity coefficients at the crack tip. Depending on a particular problem, three types of intensity coefficients can be calculated:

K_I — intensity coefficients for type I cracks (*tensile cracks* or *bond-failure cracks*);

K_{II} — coefficients for type II cracks (*transverse shear cracks*);

K_{III} — coefficients for type III cracks (*longitudinal, or antiplane, shear cracks*).

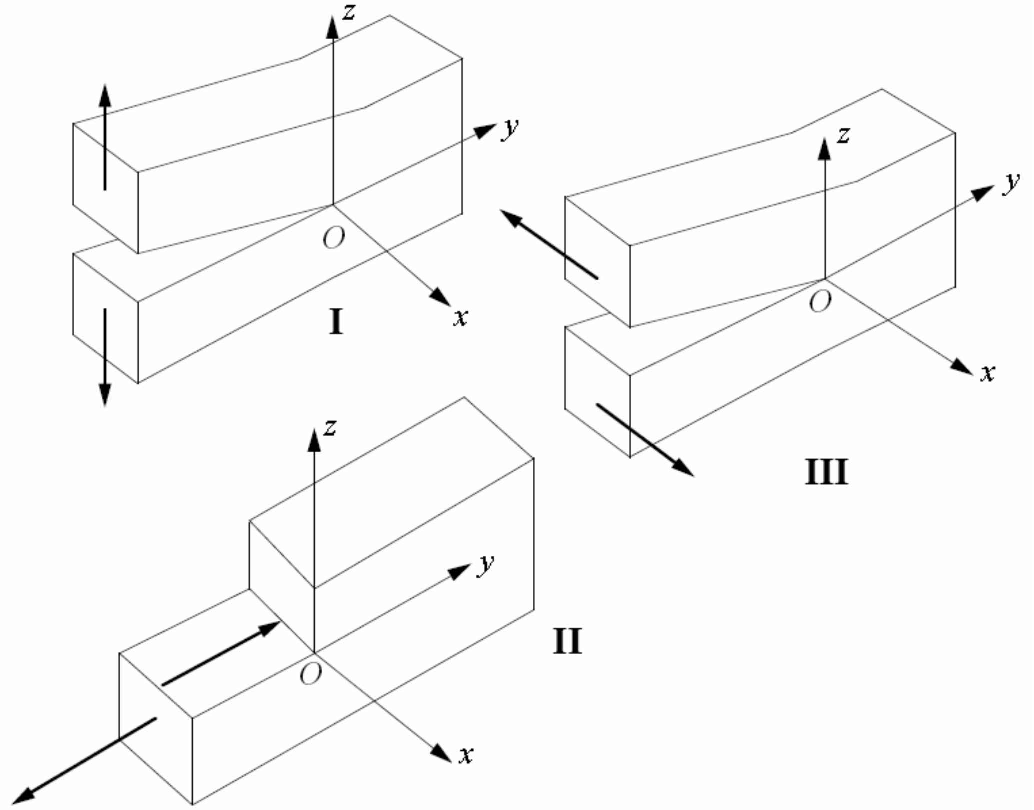


Fig 2. Three crack types:
I — bond-failure cracks, II — transverse shear cracks, III — longitudinal shear cracks.

2 Using the program

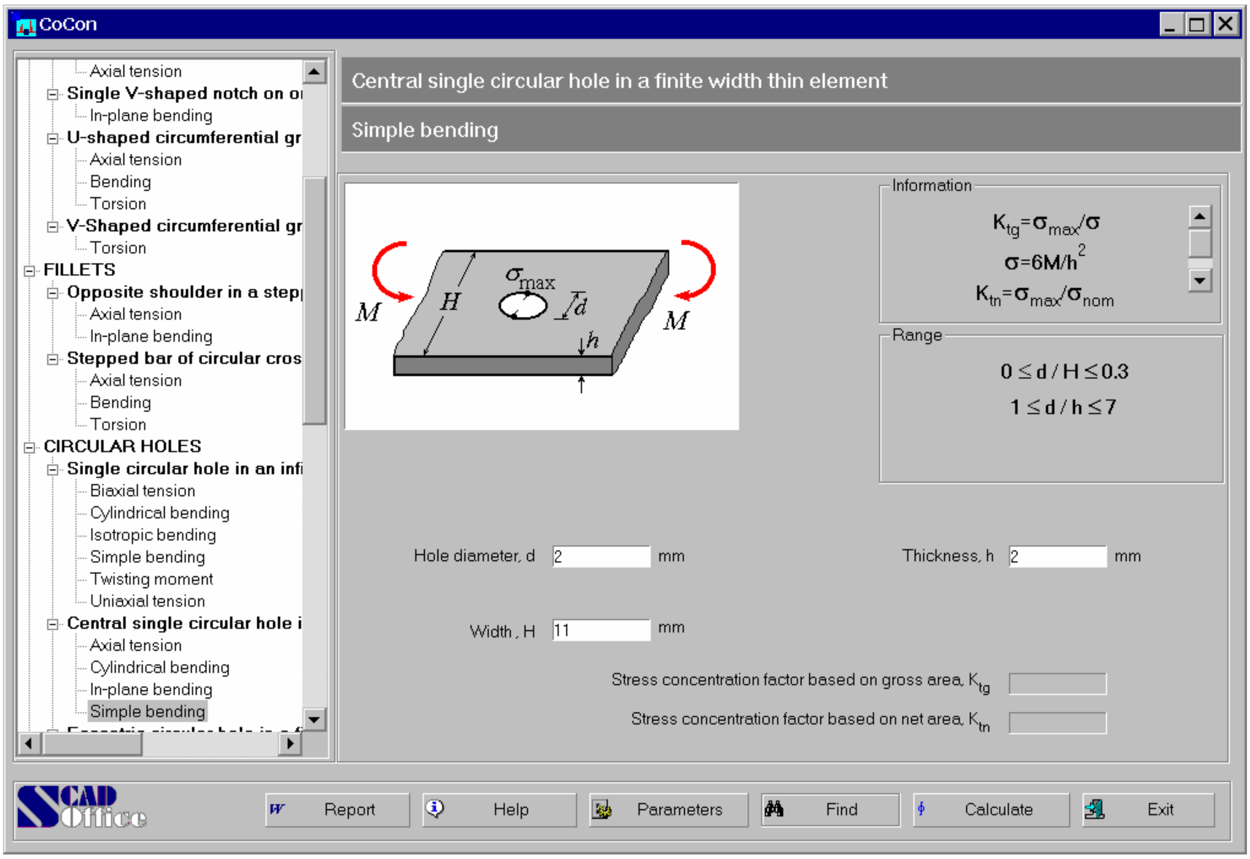


Fig. 2. *The* **CoCon** *program's window*

In all its modes the main window of the **CoCon** program has the same set of controls. These include:

- a task tree to select the type of analysis;
- data fields where source data will be entered;
- analysis result fields where the stress concentration factors will be displayed;
- functional buttons to activate the analysis and invoke various control actions.

Task tree

The task tree includes three levels. The first level contains singularity entitlements such as GROOVES AND NOTCHES or HOLES. The second level contains titles of task groups such as Rounded joints of intersected bars, and the third level contains the load types. To invoke a task, place the mouse pointer on a load type and left-click the mouse.

Data fields

When entering data in these fields, one has options of representing real numbers either in floating-point (such as 0.214) or scientific notation (for example, 1.23e5). Period is used to separate the integral and fractional parts of a number. To use comma instead, set up environmental settings of Windows. Correctness of data entered will be checked in the course of analysis.

Functional buttons

Functional buttons are used to activate the following program control operations:

Calculate — invokes actions of source data validation and the calculation itself;

Report — generates a report containing results of the calculation;

Settings — activates the configuration setup mode (see below);

Help — gives helpful reference information on how to work with **CoCon**;

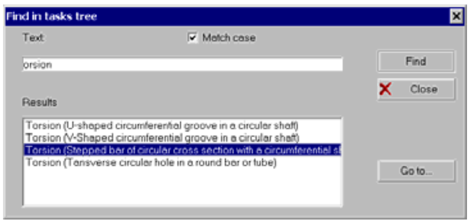


Fig. 3. *The* **Search the task tree** *dialog box*

Find — performs a context search of the task tree for a task entitlement. For this purpose, the **Search the task tree** dialog box is used (Fig. 3) where the text to be searched for should be specified and then the **Find** button clicked. This will cause the **Search results** list to display the list of all tasks the entitlements of which contain the specified text. Placing the pointer on a required task and clicking the button **Go** will pass the control to the task. To perform the calculation, close the search dialog box.

Exit — exits the program.

Calculation

To perform the calculation, do the following:

- select your task in the tree;
- enter source data in the data fields;
- click the **Calculate** button.

3 Settings

This dialog can be invoked at any time when working with **CoCon**. It will help specify common environmental settings. The dialog contains tabs such as **Units of measurement**, **Report and languages** and **View**.

Each tab corresponds to a property page that helps select settings of a certain type and purpose.

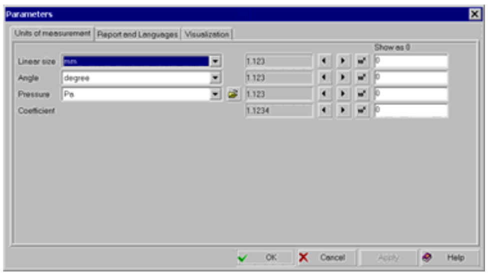


Fig. 4. *The* **Units of measurement** *tab*

The **Units of measurement** tab (Fig. 4) defines physical units of measurement to be used. This includes two data groups. The first group defines units used to determine sizes of a structure, forces, moments and the like. To define a compound unit (such as pressure), one can choose its component units separately using the button: for example, forces and linear units for pressure. The second data group enables one to specify the form of representation and precision of data specification. There are controls to specify data representation formats. Those help indicate the amount of fractional digits in floating-point and scientific notation.

The data representation precision (amount of significant digits after decimal point) is specified using the (decrease) and (increase) buttons, and the scientific notation is invoked by the button. Also, in respective data fields one can define what value of a unit should be interpreted as negligibly small so as to display all values less than this by their magnitude as 0.

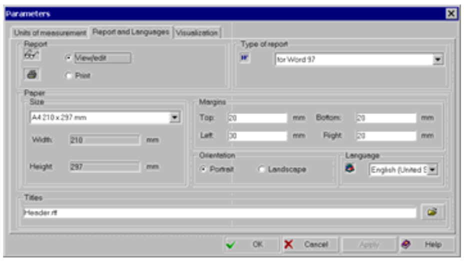


Fig. 5. *The* **Report and languages** *tab*

The **Report and Languages** tab (Fig. 5) helps select a language in which to present captions in dialog boxes and generate a report.

Either the **View/Edit** mode or the **Print** mode can be selected to work with the report document.

In the **View/Edit** mode, clicking the **Report** button in any active dialog will display the text of the report on-screen and suggest to edit it. For this purpose an application associated with the **RTF** (Rich Text Format) will be invoked, such as **WORDPAD** or **WORD**. The user is solely responsible for any corrections whatsoever made to the text of the report (keep in mind that anything including calculation results can be edited). There are differences in the **RTF** file formats used by either the **MS Word v.7** and **WordPad** or the **MS Word 97 (2000)** applications. In this regard the program enables its user to choose the desired **RTF** format in the **Type of report** mode.

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

In the **Headers and footers** field of this tab one can specify the name of an **RTF** file containing page headers and footers to be used with the report document. Clicking the respective button lets one choose an existing file from the list.

The **Paper size** option lets the user select the paper format to print the report on (the size is selected from a drop-down list).

Other things to be set for the report document include

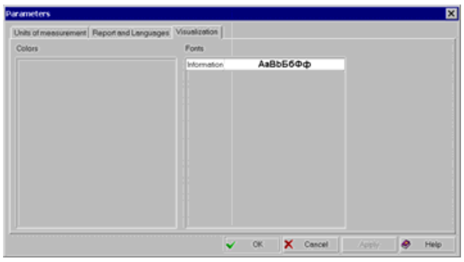


Fig. 6. *The* **View** *tab*

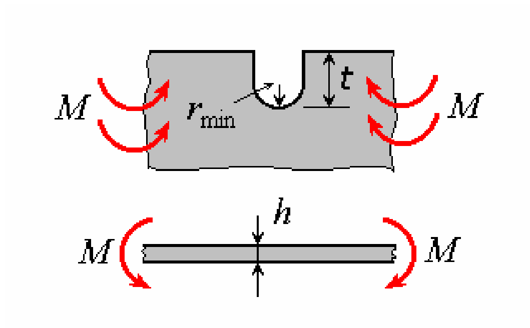
margins and page orientation.

The **Visualization** tab (Fig. 6) contains two groups of controls **Colors** and **Fonts**. Either group includes a list of controls with their respective attributes (color or font). Double-clicking the right mouse button invokes a standard Windows dialog for font settings.

4 Notches and Grooves

4.1 Elliptical or U-shaped notch in a semi-infinite thin element

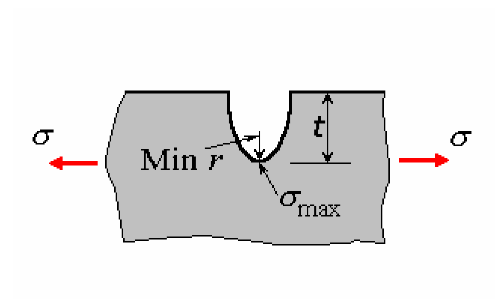
4.1.1 Transverse loading

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

References

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

4.1.2 Uniaxial tension

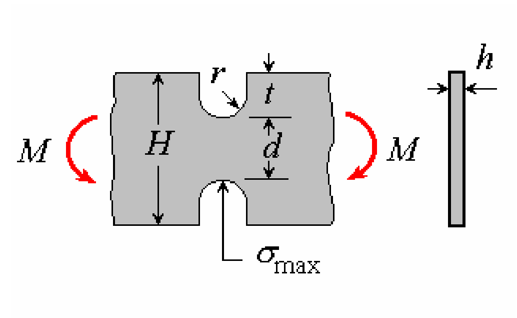
	Information and restrictions
	$1 \le t/r \le 361$ $K_{tg} = \sigma_{max} / \sigma$

References

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

4.1.3 Opposite single U-shaped notches in a finite width thin element

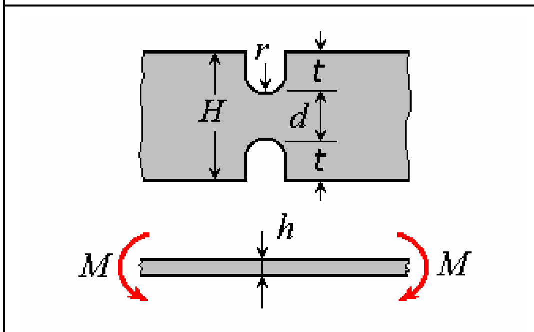
4.1.4 In-plane bending

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

References

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

4.1.5 Transverse bending

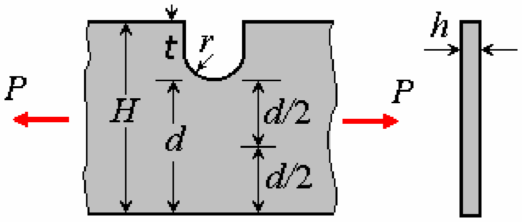
	Information and restrictions
	$0.1 \le t/r \le 5$ $0 \le 2t/H \le 1$ $t/h \gg 1$ $K_{tn} = \sigma_{max} / \sigma_{nom}$ $\sigma_{nom} = 6M / dh^2$

References

1. W.D.Pilkey *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 2.39 p. 120 § 2.7.2)
2. S.Shioya *On the Transverse Flexure of a Semi-Infinite Plate with an Elliptic Notch*, Ingenieur-Archiv, 1960, **29**, p. 93.
3. H. Lee *The Influence of Hyperbolic Notches on the Transverse Flexure of Elastic Plates*, Trans. ASME, Applied Mechanics Section, 1940, **62**, p. A-53
5. 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.

4.2 Single U-shaped notch on one side of a finite width thin element

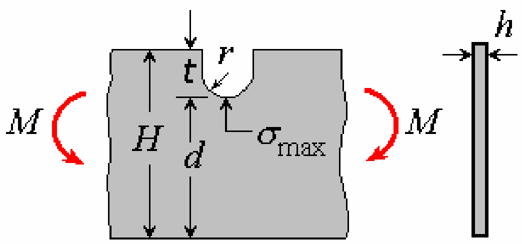
4.2.1 Axial tension

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

References

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

4.2.2 In-plane bending

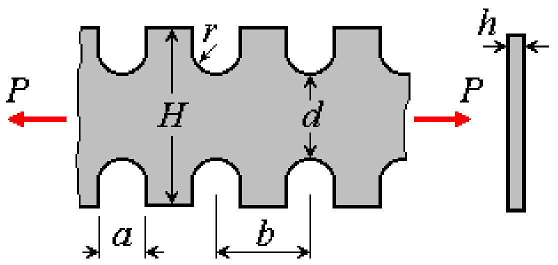
	Information and restrictions
	$0.5 \le t / r \le 20$ $0 \le t / H \le 1$ $K_{tn} = \sigma_{max} / \sigma_{nom}$ $\sigma_{nom} = 6M / hd^2$

References

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

4.3 Infinite row of semi-circular notches in a finite width thin element

4.3.1 Axial tension

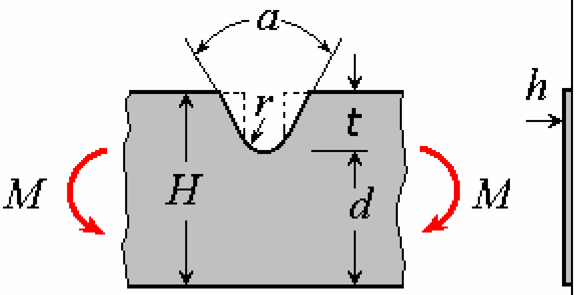
	Information and restrictions
	$0 \le a/H \le 0.4$ $0 \le a/b \le 1$ $K_{tn} = \sigma_{max} / \sigma_{nom}$ $\sigma_{nom} = P / hd$

References

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

4.4 Single V-shaped notch on one side of a finite width thin element

4.4.1 In-plane bending

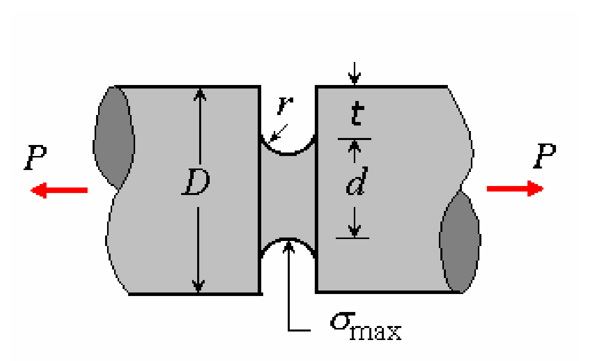
	Information and restrictions
	$0.5 \le t/r \le 4$ $0 \le t/H \le 1$ $0 \le \alpha \le 150^0$ $K_{tn} = \sigma_{max} / \sigma_{nom}$ $\sigma_{nom} = 6M / hd^2$

References

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

4.5 U-shaped circumferential groove in a circular shaft

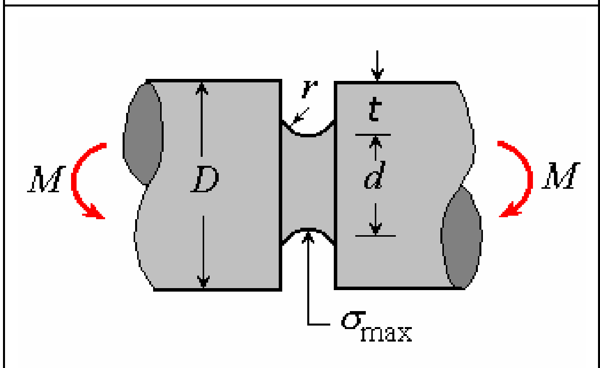
4.5.1 Axial tension

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

References

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

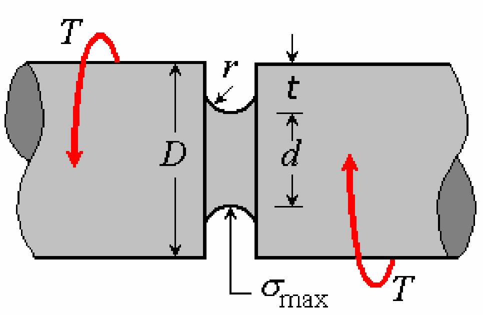
4.5.2 Bending

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

References

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

4.5.3 Torsion

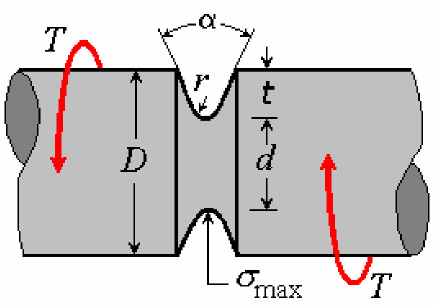
	Information and restrictions
	$0.25 \le t/r \le 50$ $0 \le 2t/D \le 1$ $K_{tn} = \tau_{max}/\tau_{nom}$ $\tau_{nom} = 16T/\pi d^3$

References

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

4.6 V-shaped circumferential groove in a circular shaft

4.6.1 Torsion

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

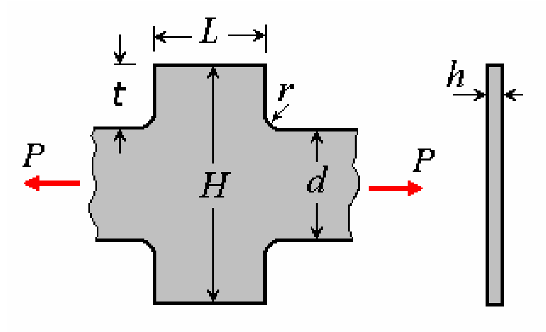
References

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

1. Fillets

4.7 *Opposite shoulder in a stepped flat bar*

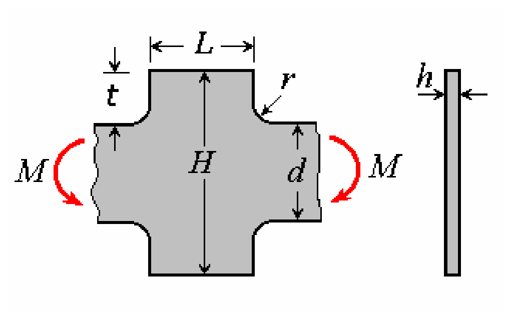
4.7.1 Axial tension

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

References

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

4.7.2 In-plane bending

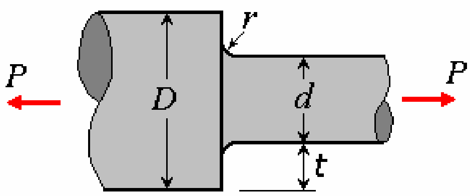
	Information and restrictions
	$0.1 \le t/r \le 20$ $0 \le 2t/H \le 1$ $L/H \ge 2.0 - 2.05(r/d - 0.025)$ $K_t = \sigma_{max} / \sigma_{nom}$ $\sigma_{nom} = 6M/hd^2$

References

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

4.8 Stepped bar of circular cross section with a circumferential shoulder fillet

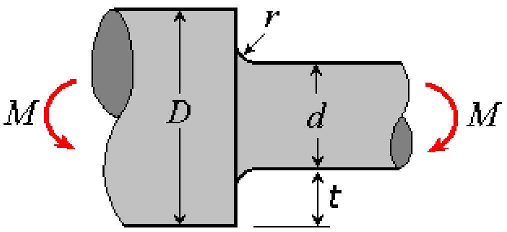
4.8.1 Axial tension

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

References

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

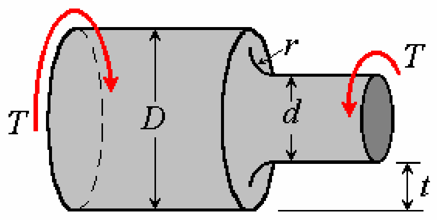
4.8.2 Bending

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

References

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

4.8.3 Torsion

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

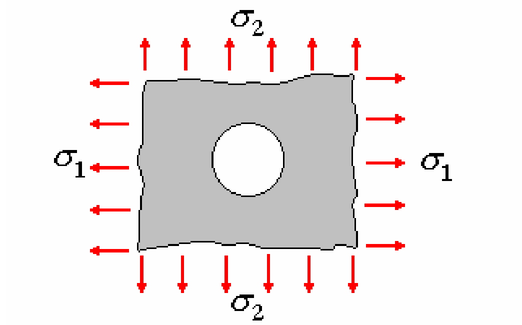
References

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

1. Circular Holes

4.9 Single circular hole in an infinite width thin element

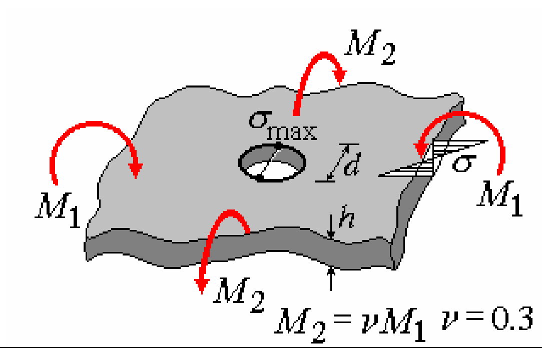
4.9.1 Biaxial tension

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

References

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

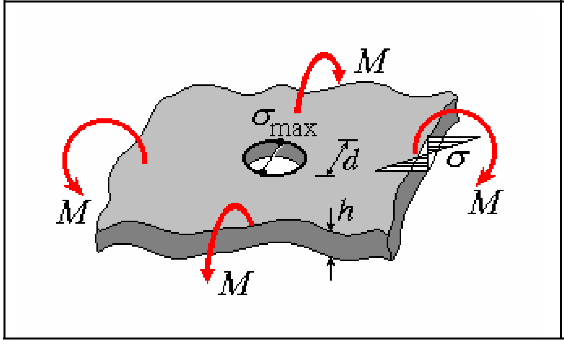
4.9.2 Cylindrical bending

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

References

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

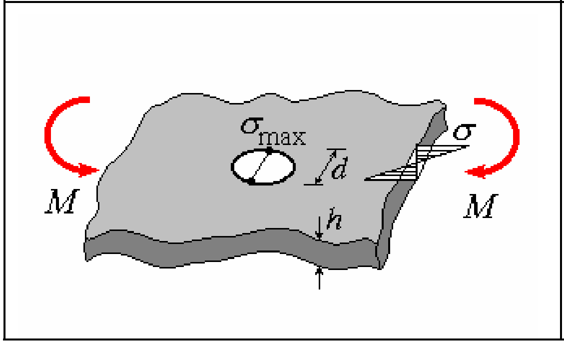
4.9.3 Isotropic bending

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

References

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

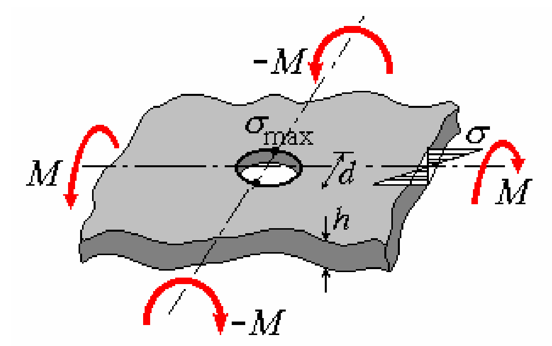
4.9.4 Simple bending

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

References

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

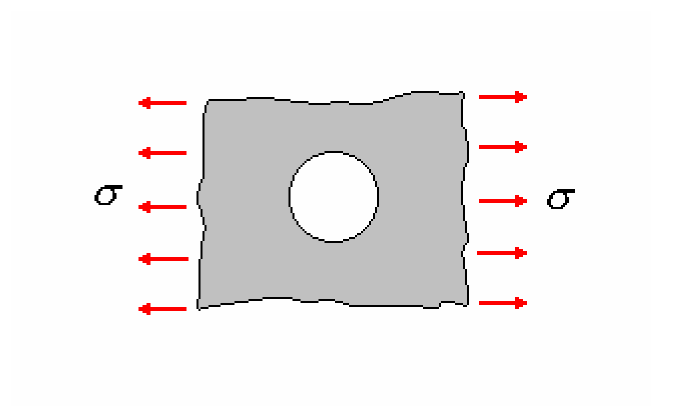
4.9.5 Twisting moment

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

References

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

4.9.6 Uniaxial tension

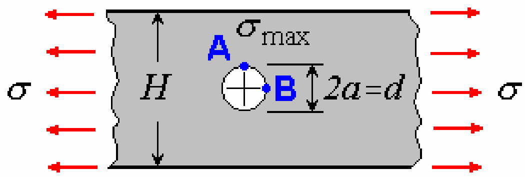


References

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

4.10 Central single circular hole in a finite width thin element

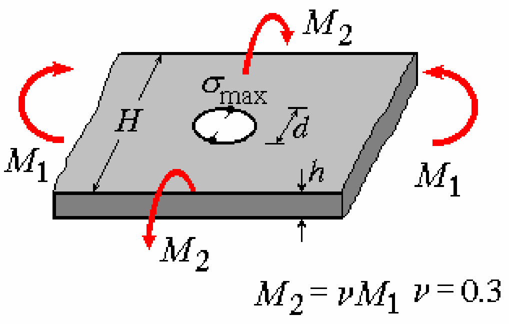
4.10.1 Axial tension

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

References

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

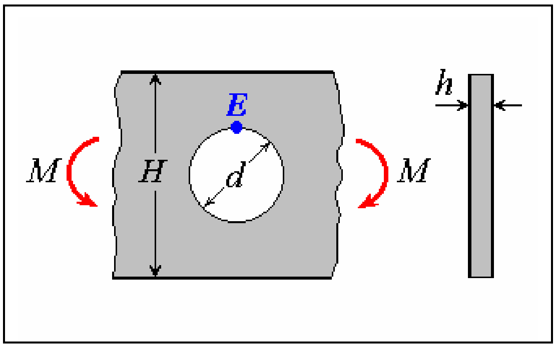
4.10.2 Cylindrical bending

	Information and restrictions
	$0 \le d/H \le 0.3$ $0 \le d/h \le 7$ $K_{tg} = \sigma_{max}/\sigma$ $\sigma = 6M_1/h^2$ $K_{tn} = \sigma_{max}/\sigma_{nom}$ σ_{nom}=6M$_1$H/((H-d)h^2) $\nu = 0.3$

References

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

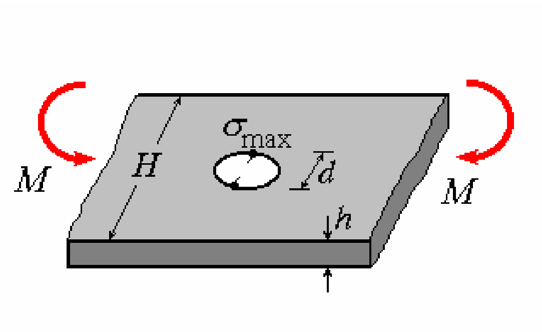
4.10.3 In-plane bending



References

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

4.10.4 Simple bending

	Information and restrictions
	$0 \le d/H \le 0.3$ $0 \le d/h \le 7$ $K_{tg} = \sigma_{max}/\sigma$ $\sigma = 6M_1/h^2$ $K_{tn} = \sigma_{max}/\sigma_{nom}$ σ_{nom}=6M$_1$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)

4.11 Eccentric circular hole in a finite width thin element

4.11.1 In-plane bending

<table>
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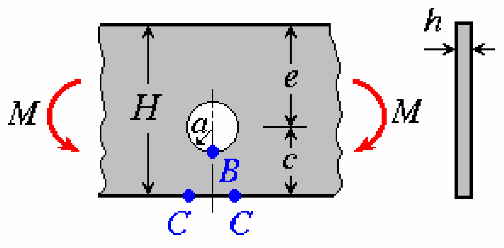

</td><td>

$0 \le a/c \le 0.5$

$0 \le c/e \le 1$

$K_{tg} = \sigma_{max} / (6M/(H^2 h))$

</td></tr>
</table>

References

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

4.12 Two equal circular holes in an infinite panel

4.12.1 Biaxial tension

<table>
<tr><th></th><th>Information and restrictions</th></tr>
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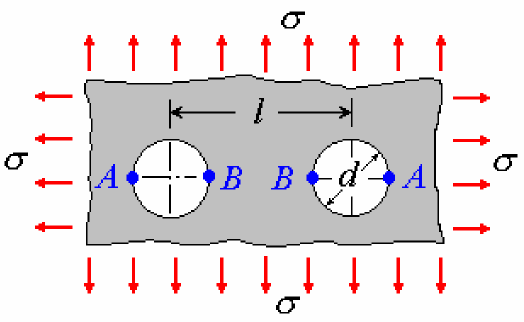


</td><td>

$0 \le d/l \le 1$

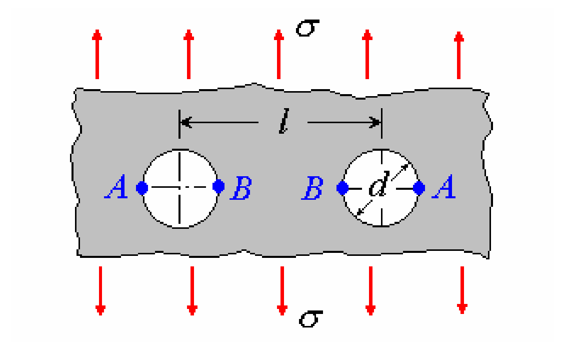
$K_{tnB} = \frac{\sigma_{max\,B}}{\sigma} \frac{1 - d/l}{\sqrt{1-(d/l)^2}}$

</td></tr>
</table>

References

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

4.12.2 Uniaxial normal tension

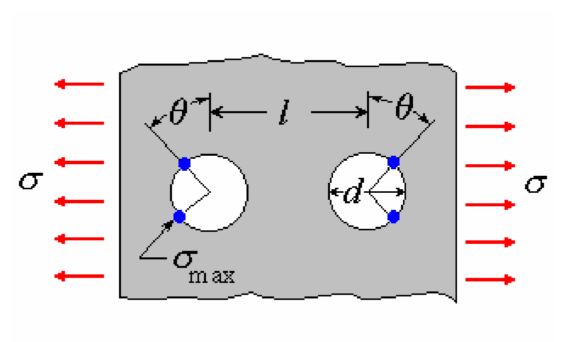


	Information and restrictions
	$0 \le d/l \le 1$ $K_{tnB} = \dfrac{\sigma_{\max B}}{\sigma} \dfrac{1 - d/l}{\sqrt{1-(d/l)^2}}$

References

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

4.12.3 Uniaxial parallel tension



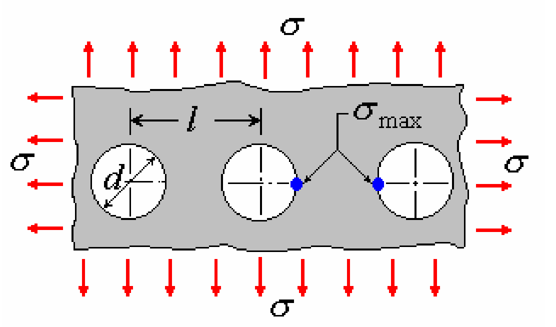
	Information and restrictions
	$0 \le d/l \le 1$ $K_{tg} = \sigma_{\max}/\sigma$

References

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

4.13 Infinite row of circular holes in an infinite thin element

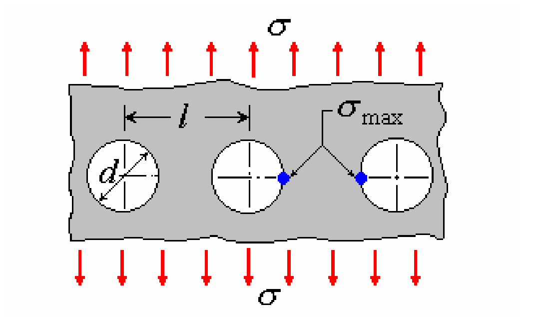
4.13.1 Biaxial tension

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

References

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

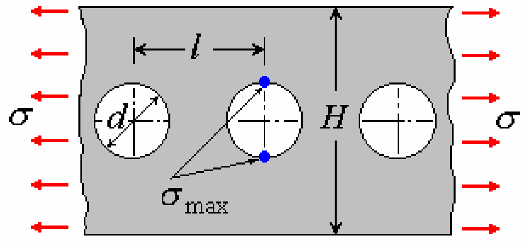
4.13.2 Uniaxial normal tension

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

References

1. W.D.Pilkey *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 4.32 p. 299 § 4.3.12 p. 207)
2. J. Schulz *Over den Spannungstoestand in doorborde Platen (On the State of Stress in Perforated Plates)*, Doctoral Thesis, Techn. Hochschule, 1941, Delft (in Dutch).
3. P.Meijers *Doubly-Periodic Stress Distributions in Perforated Plates*, Dissertation, Tech. Hochschule Delft, Netherlands, 1967.

4.13.3 Uniaxial parallel tension

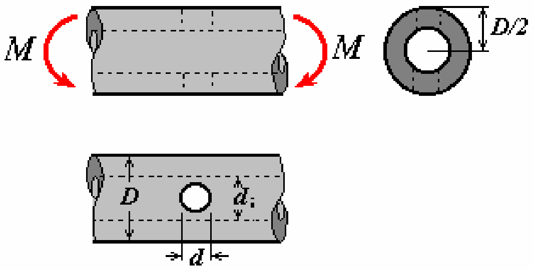
	Information and restrictions
	$0 \le d/l \le 1$ $K_{tn} = \sigma_{max}/\sigma_{nom}$ $\sigma_{nom} = \sigma/(1 - d/H)$

References

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

4.14 Transverse circular hole in a round bar or tube

4.14.1 Bending

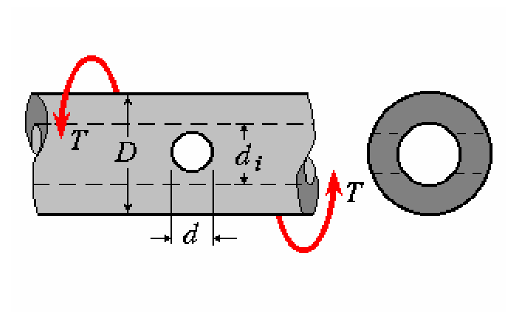
	Information and restrictions
	$d_i / D \le 0.9$ $d / D \le 0.4$ $K_{tg} = \sigma_{max}/\sigma_{nom}$ $\sigma_{nom} = 32MD/[\pi(D^4 - d^4)]$

References

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

4. ESDU (Engineering Science Data Unit), *Stress Concentrations,* London, 1965

4.14.2 Torsion

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

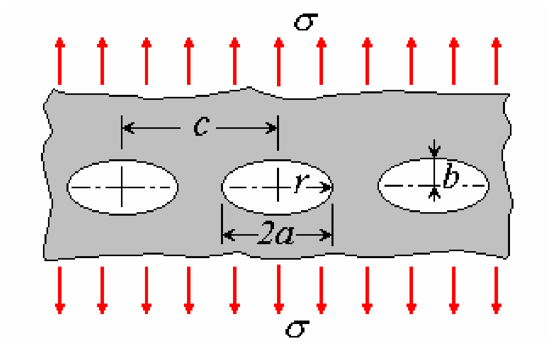
References

1. W.D.Pilkey *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 4.99 p. 376 § 4.7.8 p. 245)
2. 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

1. Non-Circular Holes

4.15 Infinite row of elliptical holes in an infinite tension member

4.15.1 Uniaxial tension

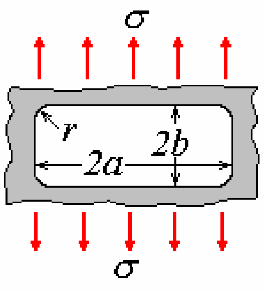
	Information and restrictions
	$0 \le 2a/c \le 0.7$ $0 \le a/b \le 10$ $K_{tn} = \sigma_{max} / \sigma_{nom}$ $\sigma_{nom} = \sigma/(1-2a/c)$

References

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

4.16 Rectangular hole with rounded corners in an infinite width thin element

4.16.1 Uniaxial tension

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

References

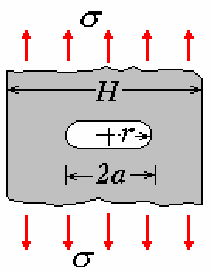
1. W.D.Pilkey *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 4.62 p. 333 § 4.5.3 p. 227)

2. J. Sobey *Stress Concentration Factors for Rounded Rectangular Holes in Infinite Sheets*, ARC R&M 1963, **3407**, Her Majesties Stationery Office, London.

3. ESDU (Engineering Science Data Unit), *Stress Concentrations,* London, 1970.

4.17 Slot having semi-circular ends in a finite width thin element

4.17.1 Axial tension

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

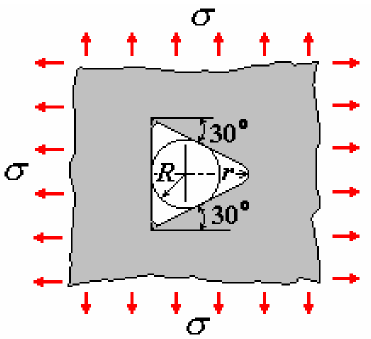
References

1. W.D.Pilkey *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 4.51 p. 320)

2. http://www.stacieglass.com/scf/symmetric_notch_with_circular_ends.html

4.17.2 Triangular hole with rounded corners in an infinite thin element

4.17.3 Equal biaxial tension

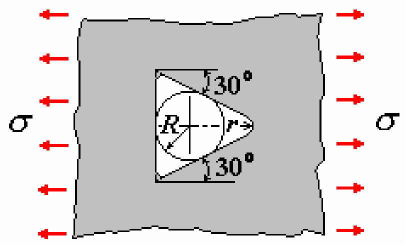
	Information and restrictions
	$0.25 \le r/R \le 0.75$ $K_t = \sigma_{max} / \sigma$

References

1. W.D.Pilkey *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 4.65a p. 340 § 4.5.6 p. 228)

2. W.H.Wittrick *Stress Concentrations for Uniformly Reinforced Equilateral Triangular Holes with Rounded Corners*, 1963, Aeronaut. Q., 14, p. 254.

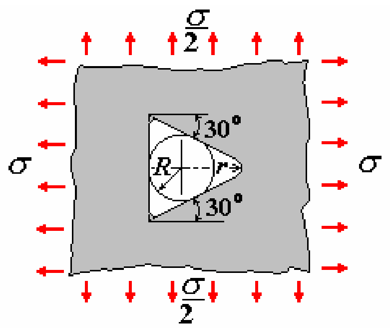
4.17.4 Uniaxial tension

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

References

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

4.17.5 Unequal biaxial tension

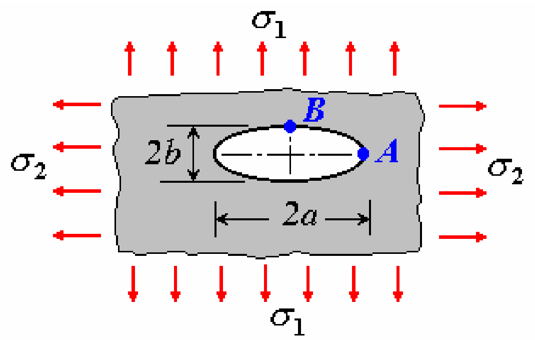
	Information and restrictions
	$0.25 \le r/R \le 0.75$ $K_t = \sigma_{max} / \sigma$

References

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

4.18 Single elliptical hole in an infinite width thin element

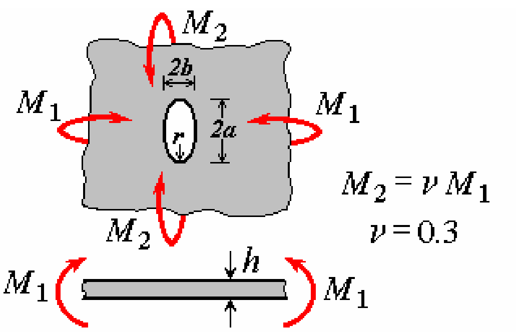
4.18.1 Biaxial tension

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

References

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

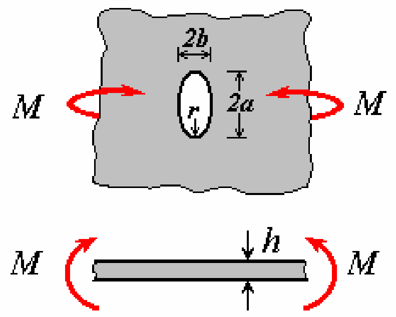
4.18.2 Cylindrical bending

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

References

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

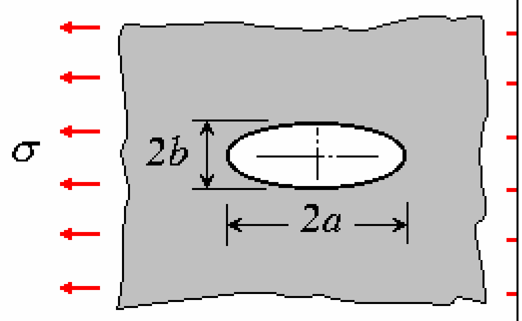
4.18.3 Simple bending

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

References

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

4.18.4 Uniaxial tension

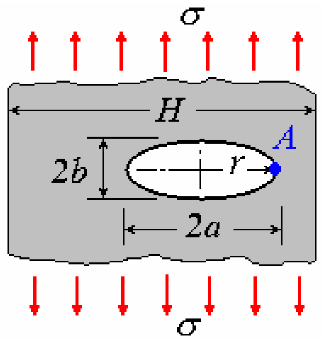
	Information and restrictions
	$0 \le a/b \le 10$ $K_{tg} = \sigma_{max}/\sigma$

References

1. W.D.Pilkey *Peterson's Stress Concentration Factors,* 2nd edition, John Wileys and Sons Inc, 2000, 508 pp. (Chart 4.50 p. 319 § 4.4.1 p. 213)
2. G.V.Kolosov *On an application of the theory of functions of complex variables to the mathematical plane elasticity problem. Doctoral thesis*, Sankt-Petersburg, 1909, 187 pp
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.

4.19 Single elliptical hole in an infinite width thin element

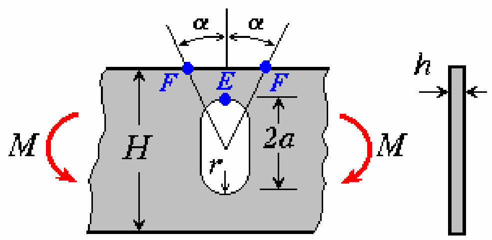
4.19.1 Axial tension

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

References

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

4.19.2 In-plane bending

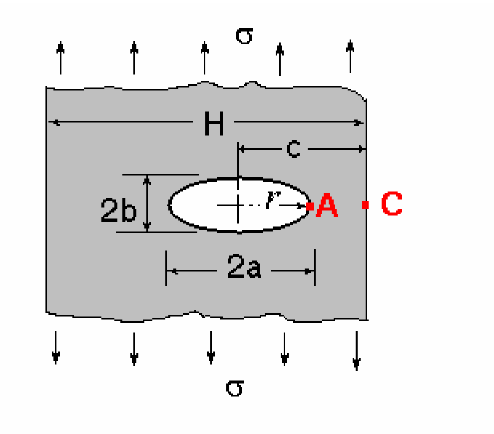
	Information and restrictions
	$1 \le a/b \le 2$ $0.4 \le 2a/H \le 1$ $K_{tn} = \sigma_{max} h(H^3 - 8a^3)/12Ma$

References

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

4.20 Eccentric elliptical hole in a finite width thin element

4.20.1 Axial tension

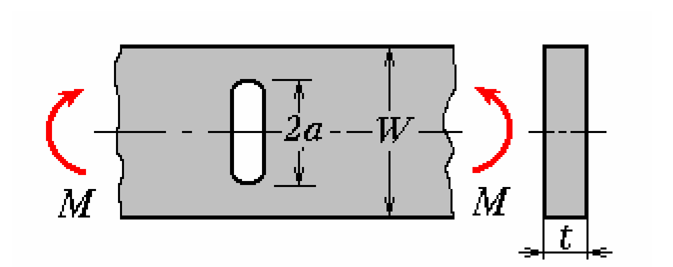
	Information and restrictions
	$1 \le a/b \le 8$ $0 \le a/c \le 1$ $\sigma_{\max} = \sigma_A$ $K_{tn} = \sigma_{\max} / \sigma_{nom}$ $\sigma_{nom} = \sigma / (1 - 2a/H)$

References

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

5 Stress Intensity Factors

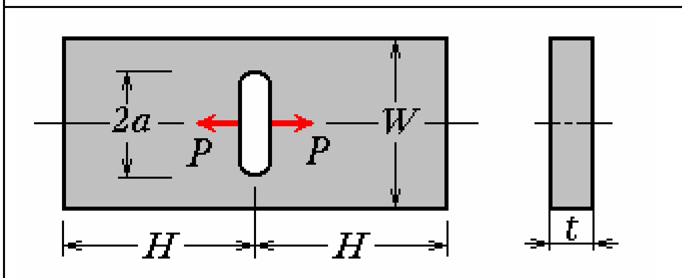
5.1 *Strip with a central transverse crack in bending*

	Restrictions
	$a \le W/2$.

References

Stress intensity factors handbook. Editor-in-Chief Y. Murakami , v.1, Chapter 2.1. – Pergamon Press, — 1987.

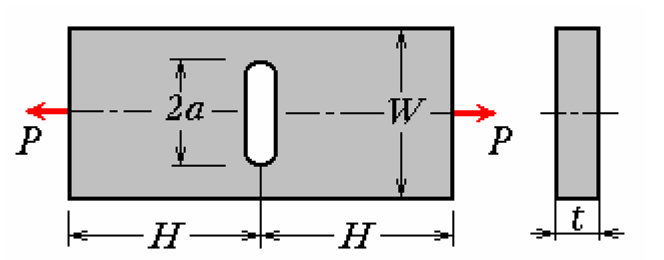
5.2 *Rectangular plate with a central crack, its faces subject to concentrated normal tension forces*

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

References

Stress intensity factors handbook. Editor-in-Chief Y. Murakami , v.1, Chapter 2.2. – Pergamon Press, — 1987.

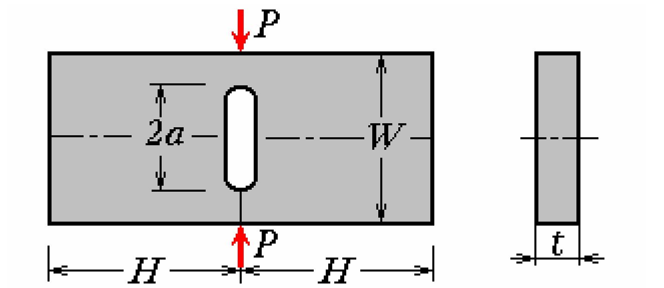
5.3 Rectangular plate with a central crack, the exterior contour subject to concentrated normal tension forces

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

References

Stress intensity factors handbook. Editor-in-Chief Y. Murakami , v.1, Chapter 2.3. – Pergamon Press, — 1987.

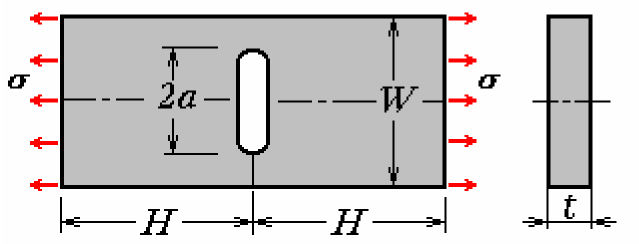
5.4 Rectangular plate with a central crack, the exterior contour subject to concentrated longitudinal compressive forces

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

References

Stress intensity factors handbook. Editor-in-Chief Y. Murakami , v.1, Chapter 2.4. – Pergamon Press, — 1987.

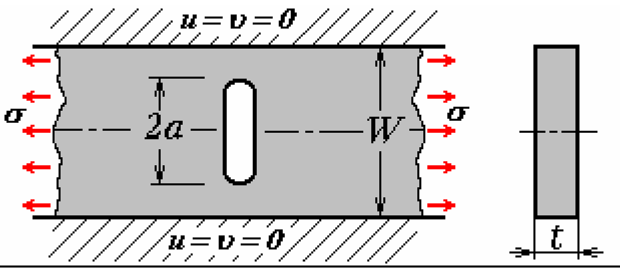
5.5 Rectangular plate with a central crack in uniform tension or displacement of the edges

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

References

Stress intensity factors handbook. Editor-in-Chief Y. Murakami , v.1, Chapter 2.5. – Pergamon Press, — 1987.

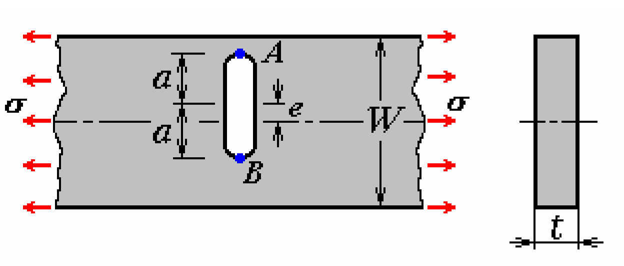
5.6 Strip with a central transverse crack and the clamped edges in tension

	Restrictions
	$2a/W \leq 1$.

References

Stress intensity factors handbook. Editor-in-Chief Y. Murakami , v.1, Chapter 2.7. – Pergamon Press, — 1987.

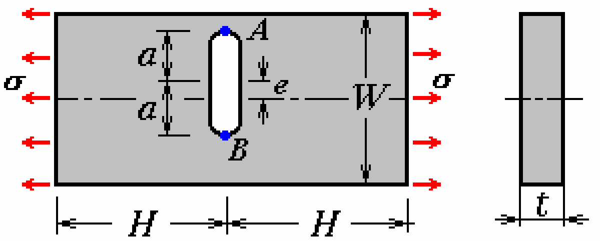
5.7 Strip with an eccentric transverse crack in tension

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

References

Stress intensity factors handbook. Editor-in-Chief Y. Murakami , v.1, Chapter 2.8 – Pergamon Press, — 1987.

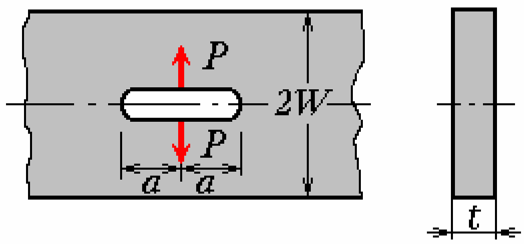
5.8 Rectangular plate with an eccentric crack in uniform tension along the normal to the crack axis

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

References

Stress intensity factors handbook. Editor-in-Chief Y. Murakami , v.1, Chapter 2.9 – Pergamon Press, — 1987.

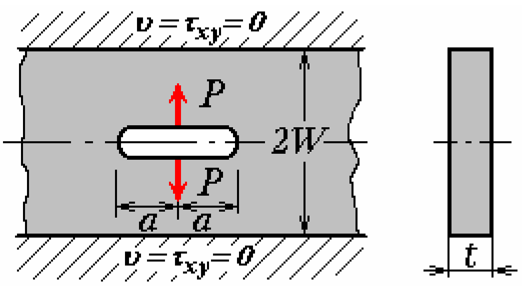
5.9 Strip with a central longitudinal crack subject to concentrated normal tension forces at the center

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

References

Stress intensity factors handbook. Editor-in-Chief Y. Murakami , v.1, Chapter 2.10 – Pergamon Press, — 1987.

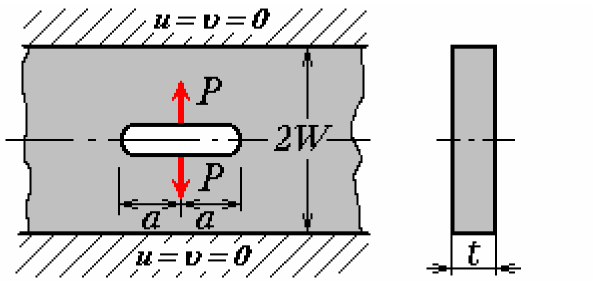
5.10 Strip with the simply supported edges and a central longitudinal crack subject to concentrated normal tension forces at the center

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

References

Stress intensity factors handbook. Editor-in-Chief Y. Murakami , v.1, Chapter 2.11. – Pergamon Press, — 1987.

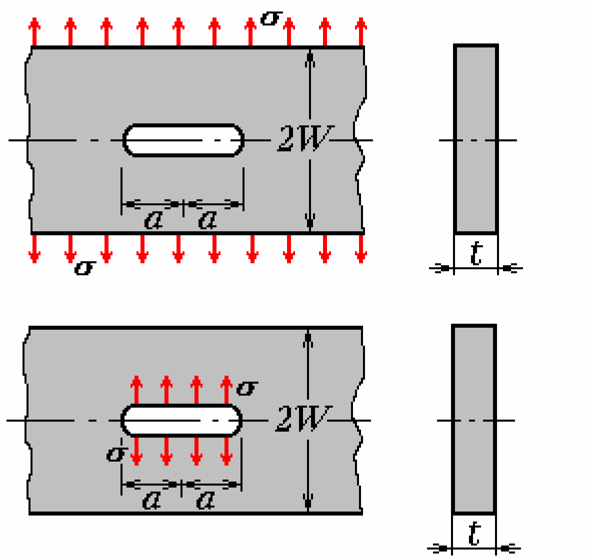
5.11 Strip with the clamped edges and a central longitudinal crack subject to concentrated normal tension forces at the center

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

References

Stress intensity factors handbook. Editor-in-Chief Y. Murakami , v.1, Chapter 2.12. – Pergamon Press, — 1987.

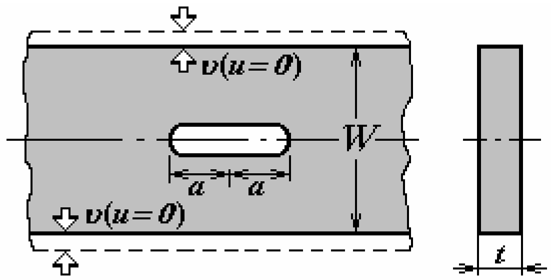
5.12 Strip with a central longitudinal crack subject to a uniform tension at the exterior contour or a uniform interior pressure

	Restrictions
	$a/W \le 1$.

References

Stress intensity factors handbook. Editor-in-Chief Y. Murakami , v.1, Chapter 2.13. – Pergamon Press, — 1987.

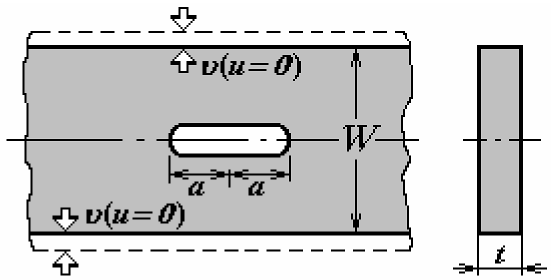
5.13 Strip with a central longitudinal crack subject to a uniform displacement of the clamped edges along the normal to the crack axis

	Restrictions
	

References

Stress intensity factors handbook. Editor-in-Chief Y. Murakami , v.1, Chapter 2.14. – Pergamon Press, — 1987.

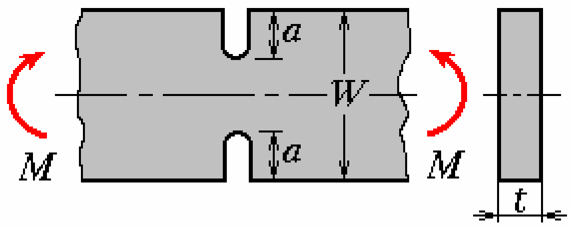
5.14 Strip with a central longitudinal crack subject to a uniform displacement of the edges along the normal to the crack axis, no shear

	Restrictions
	

References

Stress intensity factors handbook. Editor-in-Chief Y. Murakami , v.1, Chapter 2.15. – Pergamon Press, — 1987.

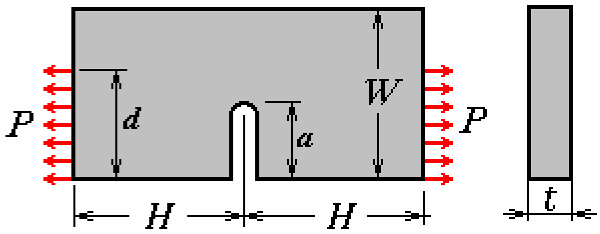
5.15 Strip with two symmetric edge cracks in pure bending

	Restrictions
	$2a/W \leq 1$.

References

Stress intensity factors handbook. Editor-in-Chief Y. Murakami , v.1, Chapter 2.16. – Pergamon Press, — 1987.

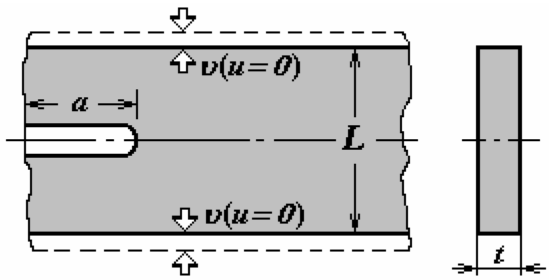
5.16 Rectangular plate with an edge crack on the symmetry line, in uniform tension along the normal to the crack axis

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

References

Stress intensity factors handbook. Editor-in-Chief Y. Murakami , v.1, Chapter 2.17. – Pergamon Press, — 1987.

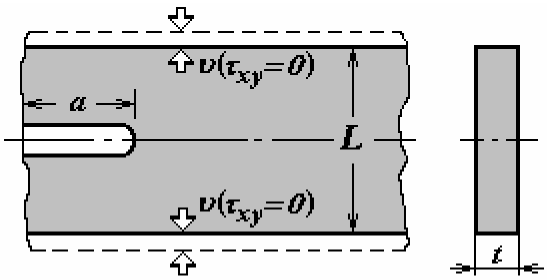
5.17 Strip with a semi-infinite central crack, the clamped faces subject to a constant displacement along the normal to the crack axis

	Restrictions
	

References

Stress intensity factors handbook. Editor-in-Chief Y. Murakami , v.1, Chapter 2.18. – Pergamon Press, — 1987.

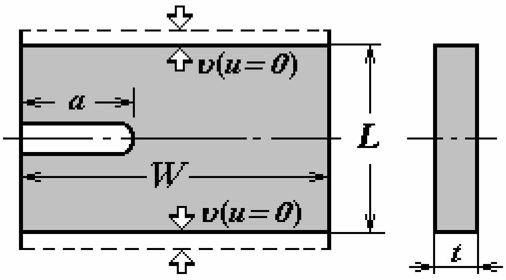
5.18 Strip with a semi-infinite central crack, the faces subject to a constant displacement along the normal to the crack axis, no shear

	Restrictions
	

References

Stress intensity factors handbook. Editor-in-Chief Y. Murakami , v.1, Chapter 2.19. – Pergamon Press, — 1987.

5.19 Rectangular plate with an edge crack on the symmetry line, the clamped side faces subject to a displacement along the normal to the crack axis

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

References

Stress intensity factors handbook. Editor-in-Chief Y. Murakami , v.1, Chapter 2.20. – Pergamon Press, — 1987.