LABORATORY WORK No.2 & 3

APPLICATION OF TNE FINITE ELEMENT METHOD FOR DETERMINATION OF THE STRESS CONCENTRATION COEFFICIENT

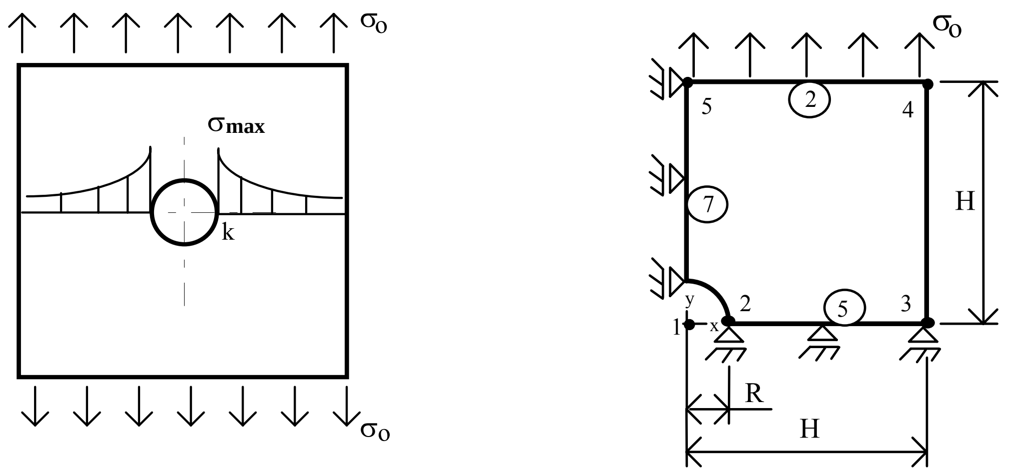
INSTRUCTIONS

1.INTRODUCTION

It is important to take into consideration the stress concentration coefficient in real constructions because in many cases there is a considerable local increasing of the stresses. The problem for determination of this coefficient is analytically solved for many cases but in the most cases there isn't such a solution and The Finite Element Method (FEM) or experimental methods must be used.

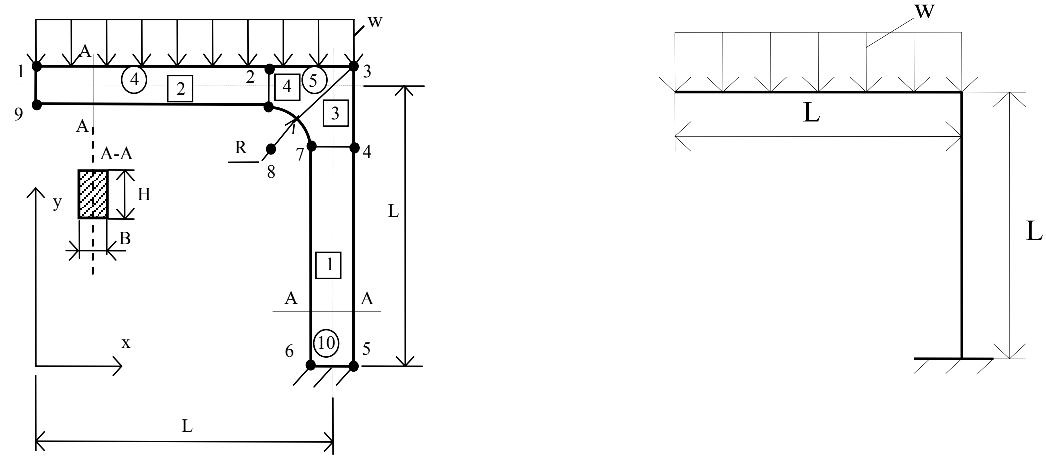
2. THEORETICAL CALCULATIONS

The stress concentration coefficient in the area around a circular hole, made in a plate (fig.1,a), must be found. This problem has an analytical solution if the dimensions of the plate approach infinity. The same problem must also be solved for a frame construction (fig.1,b) in the area around the interior angle.



a) b)

Fig.1



a) b)

Fig. 2

The theoretical stress concentration coefficient can be found from the following relation:

$$\alpha_t = \frac{\sigma_{max}}{\sigma_{nom}},$$

where σ_{max} is the maximum normal stress and σ_{nom} - the nominal stress determined without considering the stress concentrator. The nominal stress for the plate is $\sigma_{nom} = \sigma_o$. If the dimensions of the plate approach infinity, the stress concentration coefficient will be$\alpha_t = 3$.

Because of the two axes of symmetry we can study only one fourth of the plate (fig.1,b). The maximum stress is in point K (fig.1, a).

For the frame construction the stress concentration coefficient depends on the radius of the fillet R. The maximum stress in a definite point is calculated with FEM. The normal stress can be found according to the following formula:

$$\max \sigma_x = \frac{|\max M_b|}{W_b} + \frac{|N|}{A}.$$

3. SEQIENCE OF WORKING

The software COSMOS/M is used for the numerical solution of the problem with FEM. We can work with this product either in an interactive way or with a preliminary saved file. During the interactive way of working the commands can be compiled either with the falling menus which are situated at the upper part of the window or written in the command panel.

When we use the command panel the commands and their parameters can be entered on one line as we use comma or space to separate the particular parameters. If we put semicolon at the end of the command, the other parameters will be entered automatically. It is recommended to press ENTER at the end of every command. In this way every command and its parameters are compiled separately and massages appear if a mistake is made in the command.

1. A plate with a circular hole. Commands for solving the problem.

PARASSIGN, qr, REAL, 2; PARASSIGN, nr, INTEG,8;	Entering parameters which will be varied further, (qr=2, nr=8),.
VIEW; PLANE;	Choosing a plane X,Y(Z=0) which is identical with the plane of the screen..
PT,1,0,0; PT,2,10,0; PT,3,100,0; PT,4,100,100; PT ,5,0,100;	Defining point 1 with coordinates X=0, Y=0 . Defining point 2 with coordinates X=10, Y=0 Defining point 3 with coordinates X=100, Y=0 Defining point 4 with coordinates X=100, Y=100 Defining point 5 with coordinates X=0, Y=100.
CRLINE,1,3,4; CRLINE,2,4,5; CRPCIRCLE,3,1,2,10,90,2;	Defining line 1 between points 3 and 4. Defining line 2 between points 4 and 5. Defining of a line as a part of a circle.
SF2CR,1,3,1; SF2CR,2,4,2; CRPLOT;	Defining plane 1 between lines 3 and 1. Defining plane 1 between lines 3 and 1. Plotting the lines with their numbers .
M_SF,1,2,1,8,3,nr, 1,qr;	Generating a mesh in planes 1 and 2 of 8-noded elements, with 3 elements in tangent direction and nr elements in radial direction. qr is compressing mesh coefficient.
NMERGE,1,9999,1,0.01; NCOMPRESS,1,9999;	Merging the common nodes of the two planes. Rearranging the numbers of the nodes.

EGROUP,1,PLANE2D; MPROP,1, EX,200000; MPROP,1,NUXY,0.3; RCONST,1,1,1,2,1,0;	Defining the type of the elements – PLANE 2D. Material properties: E=200000 MPa. Material properties: μ=0.3 (Pissons coefficient) Real constants. Thickness 1.0 mm.
FCLR,5; DCR,5,UY,0.0; DCR,7,UX,0.0; FCLR,10; PCR,1,-1;	Defining color of plotting. Defining displacement 0.0 for line 5, along Y-axis. Defining displacement 0.0 for line 7, along X-axis. Defining color of plotting. Defining of pressure -1.0 MPa along line 1.
R_STATIC STRMAX,1,SY; ACTSTR; STRPLOT; ACTSTR,1,SY; STRPLOT;	Starting the static analysis solver. Showing max σ_y. Activating the equivalent stresses. (IV stress theory) Plotting the equivalent stresses. (IV stress thepry). Activating the stresses σ_y. Plotting the stresses σ_y.
NEW,1a; EDIT,1.SES; FILE,C:\Cosmosm\Working\1.SES; R_STATIC STRMAX,1,SY;	Starting a new problem with name 1a. Editing file 1. qr and nr are being changed. The file 1.SES have to be loaded in the problem 1a. Starting the static analysis solver. Showing max σ_y .

2. L-shaped construction. Commands for solving the problem.

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PARASSIGN, R, REAL,0.05;
PARASSIGN, L, REAL,1;
PARASSIGN, H, REAL,0.1;
PARASSIGN, B, REAL,0.05;
VIEW;
PLANE;
PT,1,0,L;
PT,2,L-H-R,L;
PT,3,L,L;
PT,4,L,L-H-R;
PT,5,L,0;
PT,6,L-H,0;
PT,7,L-H,L-H-R;
PT,8,L-H-R,L-H-R;
PT,9,0,L-H;
SCALE;
CRPCIRCLE,1,8,7,r,90,2;
CRLINE,3,11,9;
CRLINE,4,2,1;
CRLINE,5,3,2;
CRLINE,6,4,3;
CRLINE,7,4,5;
CRLINE,8,7,6;
SF2CR,1,8,7;
SF2CR,2,3,4;
SF2CR,3,1,6;
SF2CR,4,2,5;
CRPLOT;
M_SF,1,2,1,8,7,6, 4,3;
M_SF,3,4,1,8,3,6,1,3;
NMERGE,1,9999,1,0.0001;
NCOMPRESS,1,9999;
EGROUP,1,PLANE2D;
MPROP,1,EX,2E11;
MPROP,1,NUXY,0.3;
RCONST,1,1,1,2,B,0;
FCLR,5;
DCR,10,AL,0;
FCLR,10;
PCR,4,1,5;

R_STATIC
STRMAX;
NEW,1a;
EDIT,1.SES;

FILE,C:\Cosmosm\Working\1.SES;
R_STATIC
STRMAX;
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PROTOCOL No.2 & 3

APPLICATION OF TNE FINITE ELEMENT METHOD FOR DETERMINATION OF THE STRESS CONCENTRATION COEFFICIENT.

Student:	....	....	....
Fac.No...........	group	Date:...............	Signature:............
Assistent:	....	Date:...............	Signature:............

PURPOSE AND TASKS

The purpose of the laboratory work is to examine the stresses in areas around stress concentrators with the use of FEM softwares.

Tasks:

1. Determination of:
   a) the theoretical stress concentration coefficient α around a hole in a rectangular plate;
   b) the variation of α due to refining of the mesh.
2. Determination of:
   a) α in a frame construction;
   b) the variation of α with the change of the radius of the fillet.

1. DETERMINATION OF α IN A RECTANGULAR PLATE WITH A HOLE

1. Schemes (fig. 1)

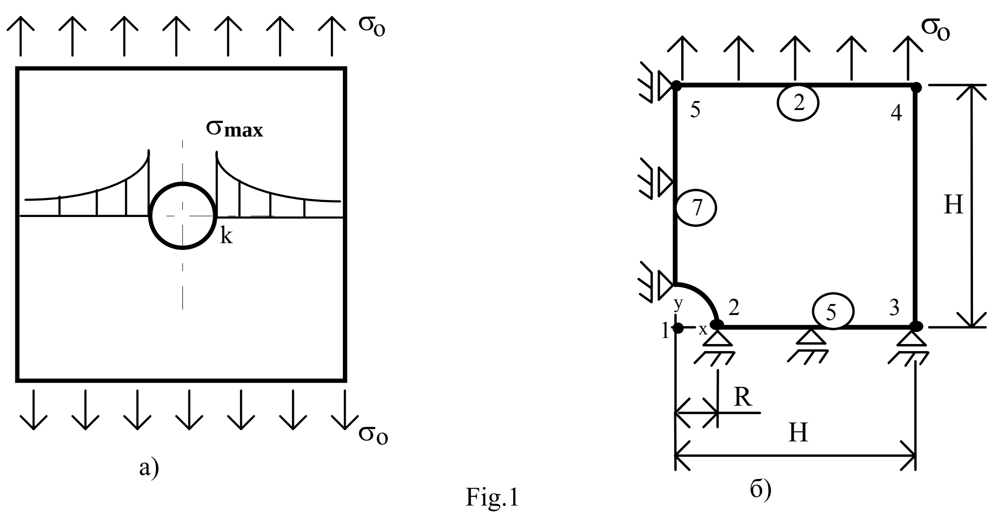

Fig.1

2. Base data: 2H=200 mm, R=10 mm, σ_o=1 MPa, T=1 mm (thickness of the plate).

3. Reached results:

a) Nominal stress σ_{nom}

A_1 =.............m^2 - cross sectional area outside the hole.

A_2 =............ m^2 - cross sectional area of the section which passes through the centroid of the hole

$\sigma_{nom} = \sigma_o \dfrac{A_1}{A_2}$ =.................MPa

b) Results reached wit FEM
nr – number of elements in radial direction
qr – a coefficient of refining of the mesh towards the center of the hole.

The stress concentration coefficient can be found by the following formula:

$$\alpha = \frac{\max \sigma_y}{\sigma_{nom}}$$

Table 1.

Qr	2			4		
Nr	4	8	16	4	8	16
$\max\sigma_y[\mathrm{MPa}]$						
α						

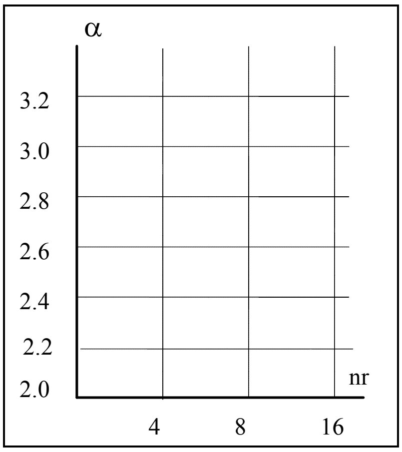

Fig. 2

Conclusions:
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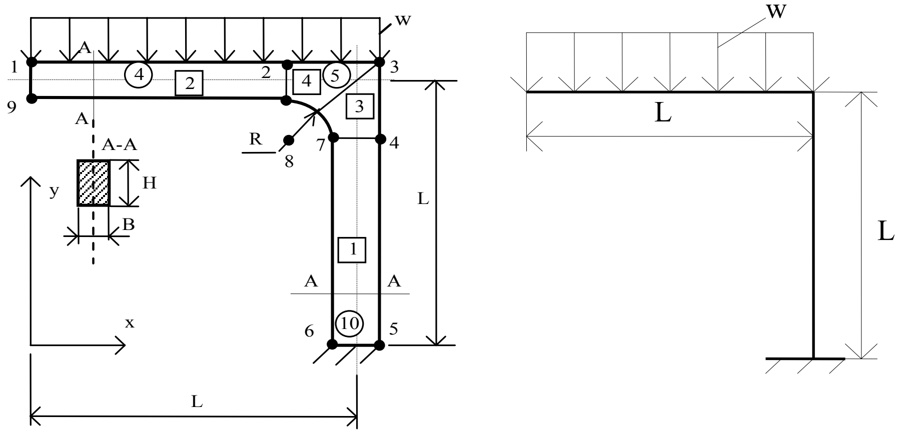
2. DETERMINATION OF α IN A FRAME CONSTRUCTION

1. Schemes (fig. 3)



a) b)

Fig.3

2. Base data: L=1 m, H=0,1 m, B=0,05 m, w=50 kN/m.

3. Reached results:

a) Nominal stress (fig. 3, b)

S_b = ... = ... m^3 , A =.......... m^2 .

M_b = ... = ...kNm , N = ... kN , $_{\max}\sigma_x$ = ...MPa ,

b) Maximum equivalent stress calculated with FEM according to Von Misses Stress Yielding Criterion

Table 2.

R [mm]	20	50	100
$_{\max}\sigma_{ekv}^{2D}$ [MPa]			
$\alpha = {}_{\max}\sigma_{ekv}^{2D} / {}_{\max}\sigma_x$			

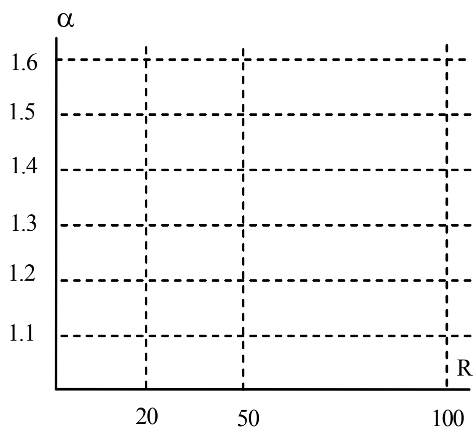


Fig. 4

Conclusions:

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