LAB 1. A 2D quarter model of a plate with notches. Stress concentration factor as a function of the notch radius.

1. Geometry of a quarter model of a thin plate with the notch r_1 (Fig. 1):
a) create a rectangle (X- coordinates: 0 to $a+r_1$, Y- coordinates: 0 to $3a+r_1$, Fig. 2)
b) display and move the working plane (X, Y, Z Offsets) : $a+r_1$, 0, 0 (Fig. 3)
c) create a circle (outer radius: r_1) (Fig. 4)

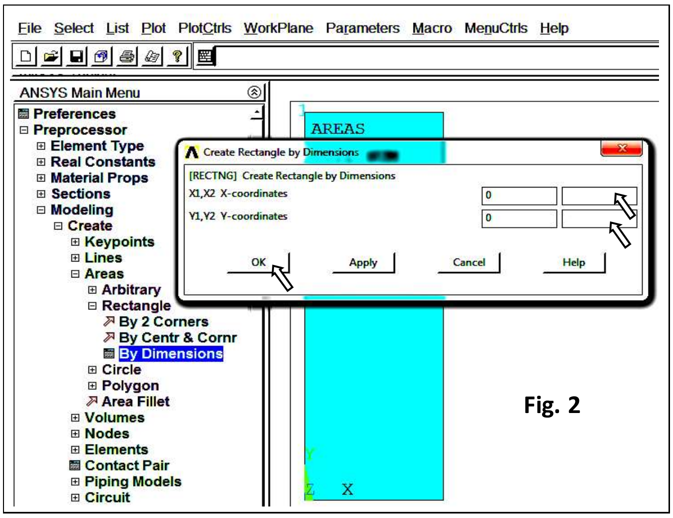


Fig. 2

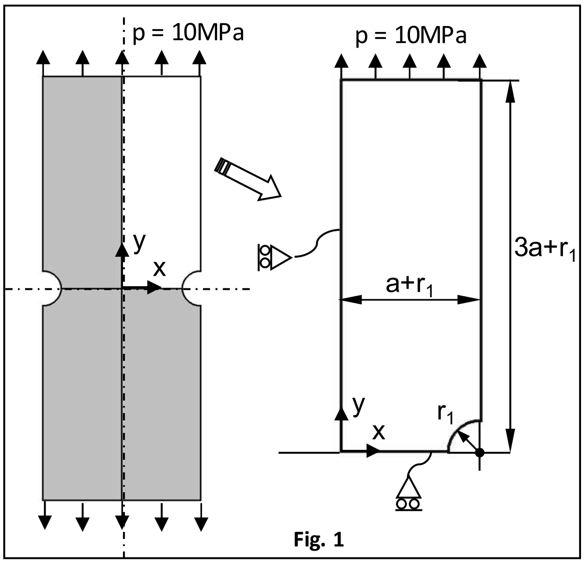


Fig. 1

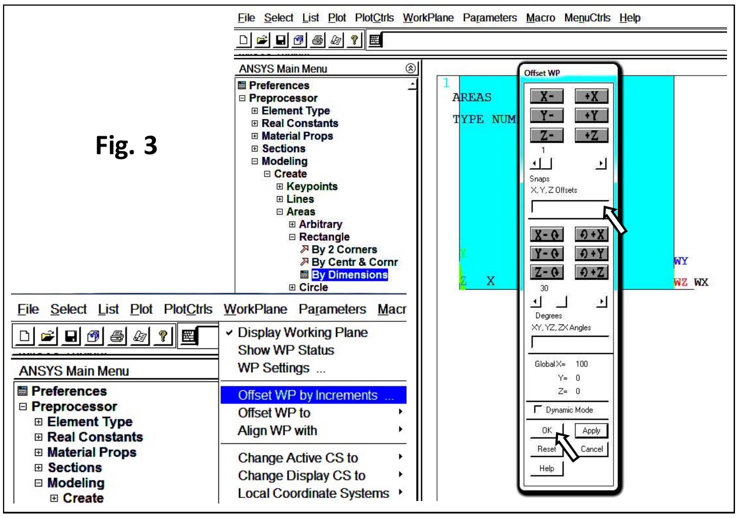


Fig. 3

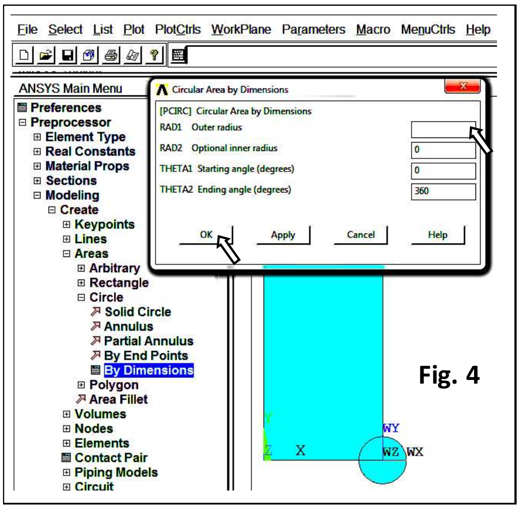


Fig. 4

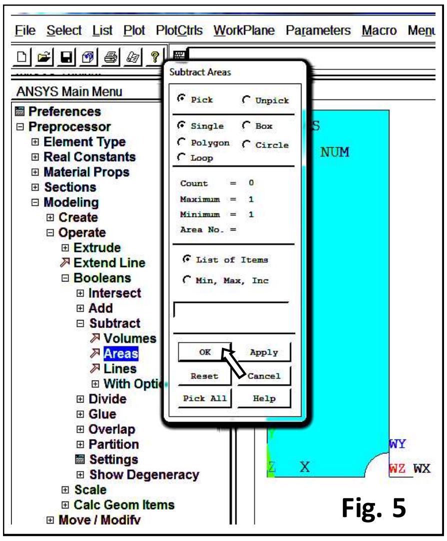


Fig. 5

d) subtract the circle from the rectangle (Fig. 5): (*pick or enter base areas from which to subtract* -> select the rectangle (-> ok), *pick or enter areas to be subtracted* -> select the circle (-> ok)

2. Choose a finite element: PLANE182 (Quad 4 node) with the plane stress option and the enhanced strain technology (Fig. 6) :

3. Define linear isotropic material properties: E (Young's modulus) and ν (Poisson's ratio) (Fig. 7)

4. Save the database (*Utility Menu>File>Save As…, *.db*)

5. Define the discretisation density: calculate the element size on keypoints using the parameter *m* (from **Tables 1** and **2**, initial value of *m* = 1) and mesh the plate (Fig. 8)

6. Save the mesh as an image (Plot> Elements, PlotCtrls> Redirect Plots-> To JPEG File …)

7. Save in **Table 1**:

- numbers of finite elements (NOE) and nodes (NON) (*Utility Menu>List> Status> Global Status*)
- the distance *d* between the two nodes close to the notch tip (*Utility Menu>List>Picked Entities+*) (Fig. 9)

8. Apply boundary conditions: symmetry conditions (Fig. 10) and pressure of - 10 MPa (Fig. 11)

9. Solve (Solution-> Solve-> Current LS)

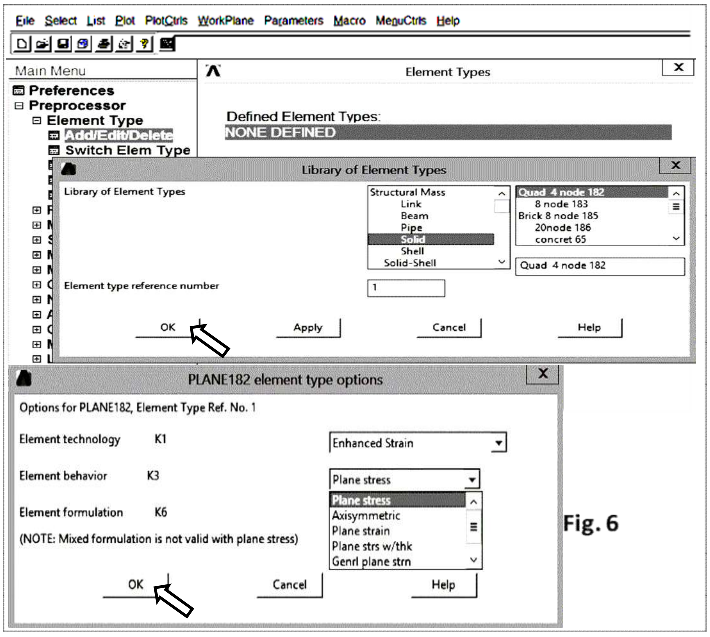


Fig. 6

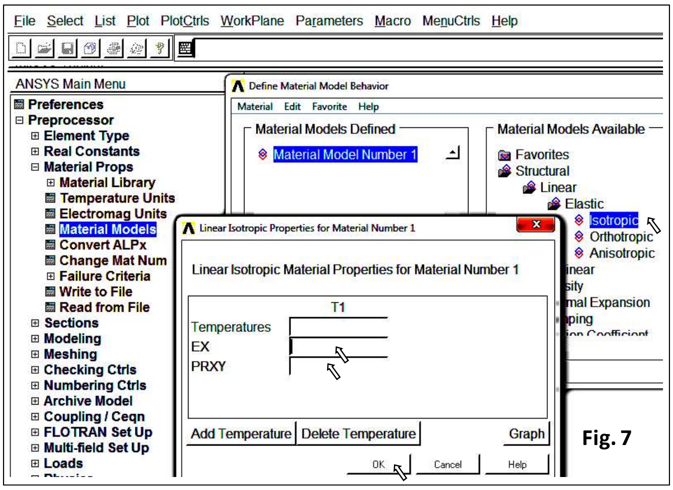


Fig. 7

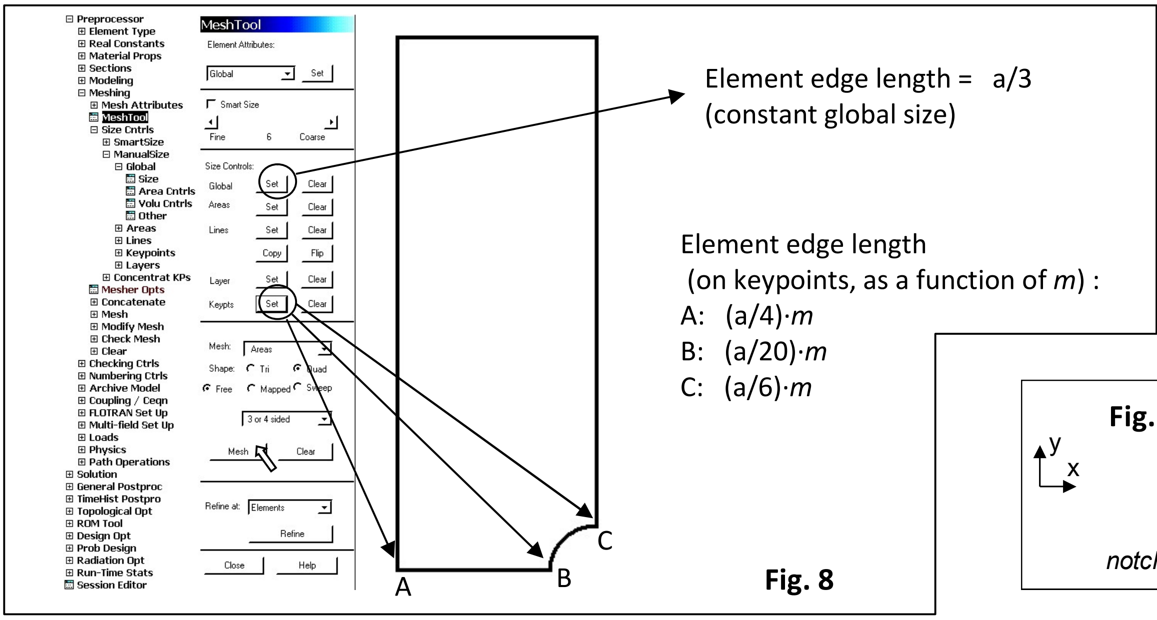


Fig. 8

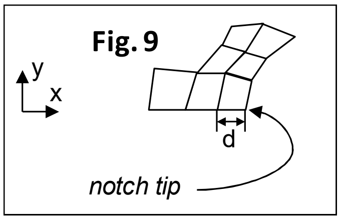


Fig. 9

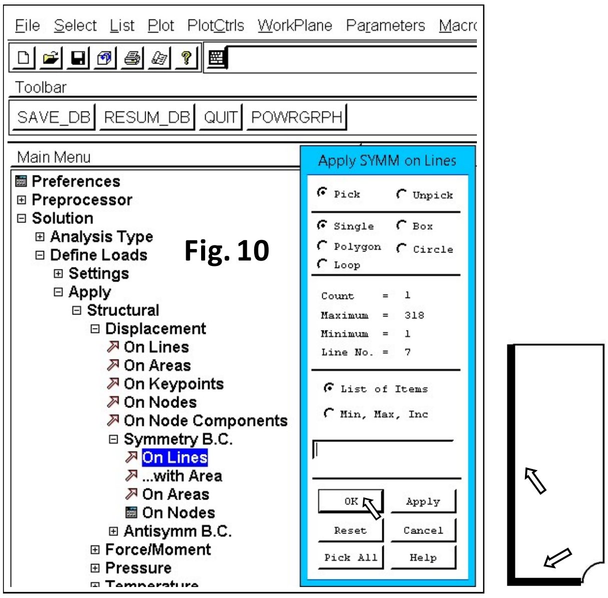


Fig. 10

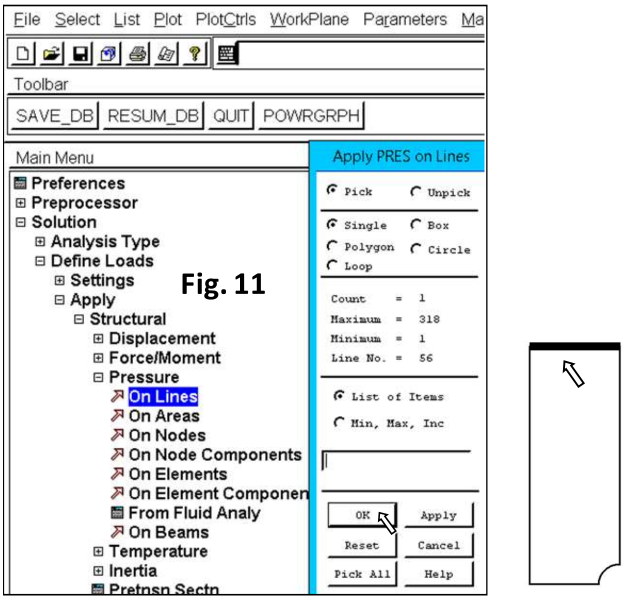
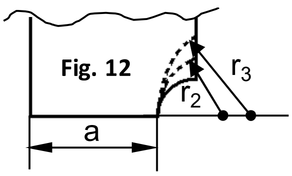


Fig. 11

10. Plot and save as an image a contour map of the displacement magnitude (Main Menu>General Postproc> Read Results> First Set, *Main Menu> General Postproc> Plot Results> Contour Plot> Nodal Solu> DOF Solution> Displacement Vector sum 'USUM')* and write the maximum value of USUM in **Table 1.**
11. Plot and save as images contour maps of stress components SX, SY, SXY and Von Mises stress SEQV (*Main Menu>General Postproc>Plot Results>Contour Plot>Nodal Solu>Stress …)*
12. Find stress components SX, SY, SXY at the node located at the notch tip (point B, Fig. 8) (*Main Menu>General Postproc> Query Result> Subgrid Solu*) and save the data in **Table 1**:
13. Decrease the value of m and repeat steps 5, 6, 7, 9 and 12**.**
14. Change a finite element to PLANE 183 (the *'Quad 8 node'* element with mid-side nodes is a higher order version of PLANE 182)
15. Repeat steps 5, 7, 9 and 12 starting from m = 1 and fill the **Table 2**.
16. Find and underline in the worksheet the optimal value of '*m*' separately for both element types. Consider the following criteria:
- normal stress (SX) at the notch tip near to zero,
- shear stress (SXY) at the notch tip near to zero,
- the number of nodes as small as possible.

(*Final report should also include three graphs of SX(d), SY(d), SXY(d) for both element types, where d is the distance shown in Fig. 9*)

17. Perform FE analyses of plates with notches r_1 , r_2 , and r_3. Choose one type of a finite element (4-node or 8-node) and the relevant value of m determined at point 16. For each analysis write in the worksheet or save on the disc:



- numbers of nodes and elements,
- image of finite elements,
- contour map of the displacement magnitude (USUM),
- contour map of the equivalent Von Mises stress (SEQV),
- graph with distribution of the stress components between points A and B (SX, SY, SXY, SEQV). To plot the graph:
  - · select points A and B (Main Menu>General Postproc>Path Operations>Define Path>By Nodes (ok), *Name*= path1, *nSets* =30, *nDiv*=200)
  - · select stress components in sequence (Main Menu>General Postproc>Path Operations>Map onto Path (ok) – the field 'Lab' can be left blank)
  - · select stress components to plot (Main Menu>General Postproc>Path Operations>Plot Path Item>On Graph)
- calculation of a stress concentration factor α:

$$\alpha = \frac{SY_B}{p \cdot \left(\frac{a + r_1}{a} \right)}$$

(r_1 for all radii (see Fig. 12))

18. Plot α(*r*) as a graph (Excel).
19. Perform analyses of a plate with the notch r_1 for the plane strain and axis-symmetry conditions (Fig. 13). Use the same type of a finite element and *m* value chosen at point 17. Calculate α values for 3 different element options (to calculate α for the axis-symmetry case divide the stress by $p\cdot((a+r_1)/a)^2$ instead of $p\cdot(a+r_1)/a$).

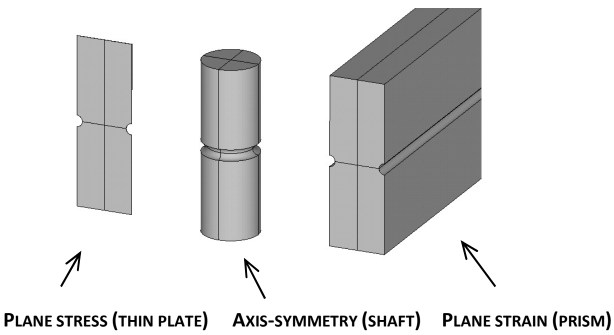


Fig. 13

20. Discuss results and write conclusions.