ME 478 FINITE ELEMENT ANALYSIS – Spring 2013

Project #2 - Due May 10

Consider a thin plate loaded in tension with a hole through it (Figure 1). The plate has a length $l = 1.0$ meters, width $w = 0.4$ meters, thickness $t = 0.01$ meters, and a central hole with diameter $d = 0.2$ meters. The plate is made of steel with an *elastic modulus* $E = 2.07 \times 10^{11}$ N/m^2 and *Poisson's ratio* $v = 0.29$. A tensile loading is applied in the x-direction as a pressure $p = 1.0$ N/m^2 along the vertical edges of the plate. The goal of this project is to determine the *stress concentration factor* K_t as a function of d/w using ANSYS. You will then compare your results with published results.

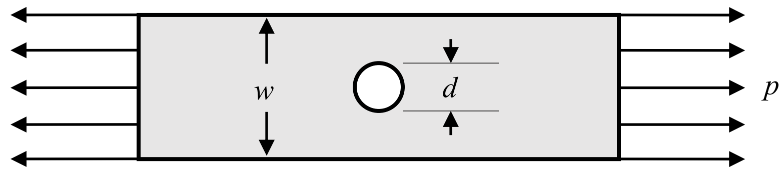

Figure 1. Thin plate with central hole.

As a savvy FEM engineer, you should be on the lookout for conditions of symmetry that you can exploit. In the plate model, you can take advantage of its symmetry by cutting the model down to a quarter-section of the plate with a quarter-circle. When reducing a model by exploiting its symmetry, you will need to use *rollers* as the boundary condition at the cut surface.

Results

In your report, be sure to include the following:

1. What does the deformed shape and the stress fields σ_x, σ_y, τ_{xy}, and von Mises stress look like?
2. The heat map for any of the stresses in part 1 should be smooth and continuous across the elements. If your result shows otherwise, the solution is not correct. Fix these 'rough' results by refining the mesh.
3. What is the effect of mesh refinement on your model? Show a graph of maximum von Mises stress at the hole versus the number of elements in the model, *i.e.* mesh density.
4. After completing the mesh refinement, compare your maximum value for σ_x in ANSYS against the expected maximum σ_x for a plate with a hole using the relationship for the stress concentration factor K_t in Figure 2. Specifically, $\sigma_{x,max} = K_t\, p\, w\, /\, (w - d)$. If they're not identical, compute the percent error.

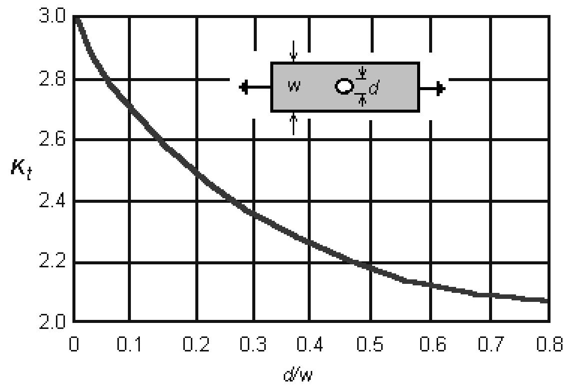

Figure 2. Stress concentration factor K_t for a thin plate with central hole.

5. For the round hole, determine the stress concentration factor K_t as a function of *d/w* by redoing your model with different values for the diameter of the hole. Compare your results with Figure 2.
6. How sensitive is your result to Poisson's ratio? Why?
7. If you were designing a structure with different hole types (square, oval, diamond), but having the same characteristic length as the circle diameter *d*, what shape would you choose and why? Show your results for each shape you model.