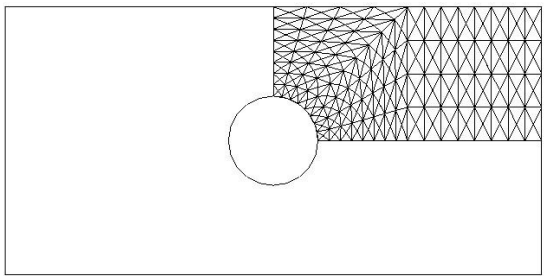
Exercise E6.4:



The geometry in exercise E6.1 is used, but instead of the CST elements 4-node isoparametric elements is utilized. Assume that the strain energy for the material is given as in exercise E6.2, i.e.

$$U=\frac{1}{2}K(\frac{1}{2}[J^2-1]-\ln J)+\frac{1}{2}G(J^{-2/3}tr(\boldsymbol{C})-3)$$

where

$K=\frac{E}{3(1-2v)}$ and $G=\frac{E}{2(1+v)}$

are the initial bulk and shear moduli, respectively. Moreover, $J=det(\boldsymbol{F})$ and $\boldsymbol{C}=\boldsymbol{F}^T\boldsymbol{F}$.

Implement the two routines:

1. **plan4gie**: Calculating the stiffness matrix.
2. **plan4gis**: Calculating Green's strain and the deformation gradient.
3. **plan4gif:** Calculating the internal force vector.

The implementation data regarding the numerical integration can be found in Ottosen and Peterson, Introduction to the finite element method. The book also provide information regarding the isoparametric mapping.

The data for the stucture is given by the material properties are E=210GPa and v=0.3. The geometry is defined by the width 600mm, height 300mm and radius 50mm describing the size of the hole. Displacement controlled loading is assumed. Modify the script file nrchap6.m from exercise E6.1 such that the 4 node element is used. Plot the force vs. the displacement. To plot the undeformed geometry and deformed geometries use the Calfem commands eldraw2 and eldisp2, respectively.