MG EN 5160 Rock Mechanics Applications

Lab #5

Spreadsheet Coding of the Circular and Elliptical Shaft Problems

Reference Text Book: Pariseau, W. G., *Design Analysis in Rock Mechanics*, 2nd Edition, CRC

Objective: In Lab #5 you write spreadsheet code to develop safety factors for circular and elliptical unlined shafts using the stress concentration equations along with the various premining stress states. You will need to verify that your code is running correctly by comparing it to known solutions from example problems given in the text book and then use your spreadsheet to solve the last problem.

General Guidelines: Develop your spreadsheet so that intermediate steps can be checked against known solutions. Show each test case in a separate tab so that you can document your work. As before, write your code to solve problems in both English and metric units.

Equations:

Safety Factor Expressions for Single Unlined Naturally Supported Shafts:

$$FS_C = \frac{C_0}{\sigma_c} \qquad \text{(EQ 1)}$$

$$FS_T = \frac{T_0}{\sigma_t} \qquad \text{(EQ 2)}$$

$$FS_V = \frac{C_0}{\sigma_v} \qquad \text{(EQ 3)}$$

where C_0 is the unconfined compressive strength of the shaft wall rock, T_0 is the tensile strength of the shaft wall rock, σ_c is the peak compressive stress at the shaft wall, σ_t is the peak tensile stress at the shaft wall, and σ_v is the peak vertical stress at the shaft wall.

Expressions for Shaft Wall Stress Concentration:

$$\sigma_c = K_c S_1 \qquad \text{(EQ 4)}$$

$$\sigma_t = K_t S_1 \qquad \text{(EQ 5)}$$

$$\sigma_v = S_v \qquad \text{(EQ 6)}$$

where K_c is the compressive stress concentration factor, K_t is the tensile stress concentration factor, S_1 is major horizontal premining principal stress, and S_v is vertical premining stress.

Expressions for Stress Concentration Factors in Circular Shafts:

$$K_{max} = (3 - M) \quad \text{(EQ 7)}$$

$$K_{min} = (-1 + 3M) \quad \text{(EQ 8)}$$

where M is the premining principal stress ratio S_3/S_1.

Expressions for Stress Concentration Factors in Elliptical Shafts:

$$K_a = -1 + M\left(\frac{2}{k} + 1\right) \quad \text{(EQ 9)}$$

$$K_b = (1 + 2k) - M \quad \text{(EQ 10)}$$

where k is the aspect ratio: k= b/a (where a is in the direction of or is parallel to S_1) of the ellipse.

<u>Stress Concentration Plots:</u>

For each problem solved in your spreadsheet, compute and plot the stress concentration factors around the circular and elliptical shaped problems. Use an angle increment of 5° or smaller (you can check your results in the text, e.g. page 111 for the ellipse with M = 0 and k = 2/3 and 3/2). You do not need to include a diagram showing the location of the stress concentration (you can if you like) but you do have to write in your spreadsheet what you are calculating and what the results are describing so that I can follow your work.

Solve the following 4 problems in the text with your spreadsheet. Check that your spreadsheet is working correctly using the first 3 solutions. Solve the last problem with your verified spreadsheet:

<u>Test Cases:</u> Text example 3.3 (pp 109-110), text example 3.7 (pp 117) but disregard the inclination angle and assume that the a-axis is aligned to S_1, text problem 3.1 (pp 187) that was a hand solution from the last lab, and finally the last text problem 3.26 (pp 191) for only the circular and elliptical solutions (you do not need to compute the ovaloidal and rectangular shaft shapes). Check your spreadsheet computations to the text example solutions and with your hand solutions from the previous lab (you will need to work problem 3.26 by hand in order to check the solution).

<u>Deliverables:</u> Email your completed spreadsheet to the TA: Daniel.Amoakoh@utah.edu and cc: me at jeffreycraig.johnson@utah.edu by the end of the day of our next lab.