CVEN 5768 INTRODUCTION TO ROCK MECHANICS
Final Exam, Spring 2006
Due by Friday May 05, 5:00 p.m.

Problem 1:

Consider a circular opening of radius R_1 subjected to a hydrostatic stress $p_o=\gamma z$ acting at infinity. The internal pressure in the tunnel is p_i. The rock is assumed to be isotropic and has a linearly elastic - perfectly plastic behavior. Failure of the rock is assumed to be described by a Mohr-Coulomb criterion with

$$\sigma_1 = C_o + q\ \sigma_3 \tag{2}$$

with $q = \tan^2(\pi/4 + \phi/2)$ and $C_o = 2S_o\tan(\pi/4 + \phi/2)$. In equation (1), ϕ and S_o are the internal friction angle and shear strength (cohesion) of the rock, respectively.

For certain values of the applied stresses and the rock strength properties, failure of the rock may occur in a region $R_1 \le r \le R$ in which equation (2) is satisfied. Outside this region ($r > R$), the rock behaves elastically.

Consider the following equation of equilibrium

$$\frac{d\sigma_r}{dr} + \frac{\sigma_r - \sigma_\theta}{r} = 0 \tag{3}$$

Also, assume that $\sigma_\theta > \sigma_r$.

(a) Determine the expressions for the stresses in the plastic and elastic zones. Determine the expression of R/R_1 in terms of p_o/p_i and C_o/p_i.

(b) Assume $p_i = 5$ psi, $R_1 = 20$ ft, $\gamma = 160$ pcf, $\phi = 40°$ and $S_o = 1{,}000$ psi. Show the variation of R/R_1 with depth z. Select a depth z for which R/R_1 is much larger than unity. For that depth show the stress distribution around the opening. How do those stresses differ from those obtained assuming elastic response only ?

(Hint: Read section 16.5 in “Fundamentals of Rock Mechanics” by J.C. Jaeger and N.G.W. Cook)

Problem 2

A block weighing 200 MN rests on a plane P, striking N 10 E and dipping 60 NW (60/280). The available friction angle is believed to be 30 degrees.

1) Find the minimum force for stabilizing the block with a safety factor of 2.5 using rock bolts

2) Find the force for stabilizing the block with a safety factor of 2.5 if the bolts are installed 10 degrees below horizontal to the N 88 E.

3) What water force acting on plane P could cause failure after the rock bolts are installed as in case b)?