Assignment 8: Elastic-Perfectly Plastic Finite Element Analysis
Assigned: 24th April 2019
Due: 3rd May 2019

1. Using the Soil Test option within the finite element program PLAXIS 2D, analyze the response of an isotropically consolidated triaxial specimen under drained loading in triaxial compression. Assume that the soil can be modeled as a linear elastic-perfectly plastic material (Mohr-Coulomb model in PLAXIS). Please read Section 3 of the Material Models Manual for background on this soil model.

   Again, consider the consolidated-drained triaxial test data for a sand found in hw3-tx-data.xlsx posted on Canvas. Use the triaxial data to determine ϕ' (assume $c' = 0kPa$), and use this value along with the baseline linear elastic parameters from Homework 3 ($E' = E_{0.5\%}, \nu' = 0.2, \gamma_t = 18kN/m^3, and \psi' = 0^o$) to define the Mohr-Coulomb parameters for this sand. Isotropically load the triaxial specimen in PLAXIS to a confining stress of 100 kPa, and compute the response up to an axial strain of 5%.

   (a) For this baseline case, plot the results in the familiar deviator stress ($q = \sigma_1 - \sigma_3$) vs. axial strain and volumetric strain vs. axial strain. Check the predicted yield stress and associated volumetric strain from PLAXIS with a hand calculation. Compare the predicted curves with those from the triaxial test and discuss any differences.

   (b) Vary $\phi' \pm 5^o$, plot the results, and comment on the influence of ϕ' on the results

   (c) Analyze the baseline conditions with $\psi' + 3^o$ and $+10^o$. For the $\psi' = 3^o$, confirm the predicted volumetric strain at an axial strain of 5% with a hand calculation. Plot the results and comment on the influence of ϕ' on the results.

   (d) Repeat the baseline analysis for an undrained loading. Plot deviator stress vs. axial strain, volumetric strain vs. axial strain, and pore water pressures vs. axial strain. Comment on the undrained vs. drained response of the soil.

   (e) Repeat the undrained analysis with $\psi' = 10^o$. Plot deviator stress vs. axial strain, volumetric strain vs. axial strain, and pore water pressures vs. axial strain. Comment on the influence of phi' the undrained response.

2. Using the finite element program PLAXIS with the Mohr-Coulomb model, analyze the plane strain problem of a long strip surface loading of a finite, elastic-perfectly plastic soil layer underlain by a rigid base (see figure below). There is no water; hence, effective stresses equal total stresses. For the baseline case, use: $E' = 20,000kPa, \nu' = 0.2, c' = 5kPa, \phi' = 36^o, \phi' = 0^o, \gamma_t = 18kN/m^3, K_0 = 0.6, H = 10m, q = 250kPa$, and $B = 3m$. The soil is treated as an existing foundation with no water, and the surface load as an applied

distributed load. Use a "medium" mesh of 15-node triangles in this analysis. Examine the results from the FE analysis to observe the distribution of displacements, strains, and stresses across the region. Specifically:

(a) Show a plot of the finite element mesh used in your baseline analysis with the deformed mesh for the baseline case. Show the distribution of shear stress level (τ_{rel} in PLAXIS) within the finite element domain.

(b) Compare the results (i.e., vertical and horizontal displacements at the edge of the strip loading and the vertical stress versus depth beneath the edge of the strip loading) for the Mohr-Coulomb case and the linear elastic case from Homework 3.

(c) Evaluate the sensitivity of the results (i.e., displacements at the edge of the loading, distribution of shear stress level) to the finite element model employed in the analysis by re-analyzing the baseline case using a "very coarse" mesh of 6- node triangles.

(d) Evaluate the sensitivity of the results (i.e., displacements at the edge of the loading, distribution of shear stress level) to variations in the input parameters $K_o, \phi', and \psi'$. Specifically, perform analyses where the following changes to the baseline parameters are made: (1) $K_0 = 0.4$, (2) $\phi' = 33^o$, (3) $\phi' = 39^o$, (4) $\psi' = 3^o$ and (5) $\psi' = 10^o$