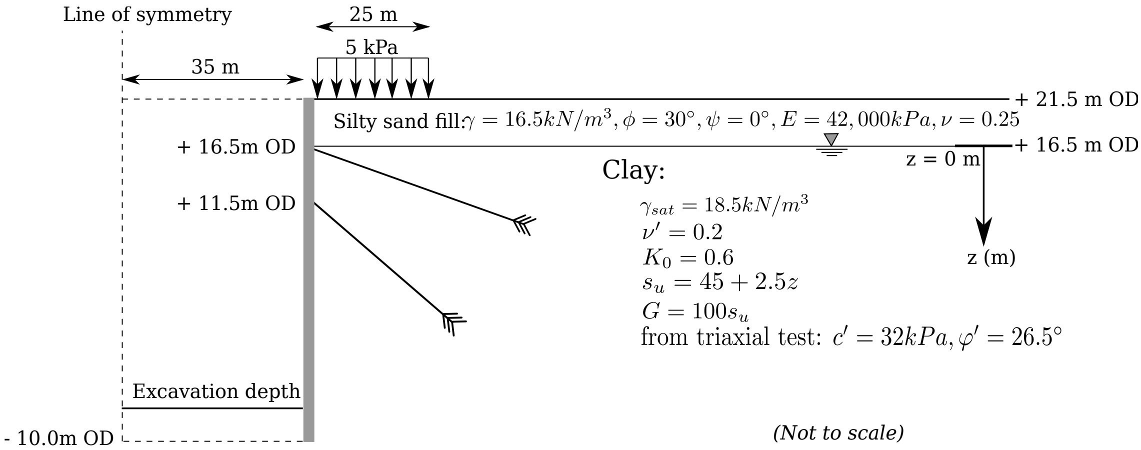
Lent 2017
5R7 Advanced Numerical Methods in Geomechanics
Coursework: Finite Element modelling of a tie-back excavation in clay

A 70m wide excavation is to be dug in uniform stages through 5m of silty-sand fill into normally consolidated clay that extends to a great depth. The excavation will be supported by a 0.35m thick concrete diaphragm walls from the ground surface (+21.5m OD) to a base elevation of -10.0m OD. Two rows of ground anchors are used at each wall to support the walls. The top anchor (located at +16.5m OD) has a length of 15.5m (including grout length of 3m) and an inclination of 2:3. The bottom anchor, located at +11.5m OD, is 8.5m long (including grout length of 1m) and installed at 45°. During excavation, a pressure load of 5kPa will act at the ground surface within 25m of the wall. The geometry and material parameters for the problem are presented below:



Wall Parameters: EA = 12×10^6 kN/m; EI = 0.12×10^6 kN/m^2/m; equivalent thickness d = 0.35m; w = 8.3 kN/m/m; ν=0.15

Anchor Parameters: EA = $2. \times 10^5$ kN/m; Spacing (out-of-plane) = 5m, Pre-stress: 120 kN/m

Grout (use Geo-grid) Parameters: EA = $1. \times 10^5$ kN/m;

1. Perform a plane strain finite element analysis in PLAXIS using the Mohr–Coulomb model without dilation and total stress method. Model the wall using beam and interface elements and the prop using a fixed end anchor. Assume the wall and props are perfectly elastic.

   Hint: Perform a "drained" analysis with no water, but specify undrained material parameters in the clay (note that the Poisson's Ratio cannot be set to ν=0.5 so use ν=0.495 instead).

   (a) Determine the excavation depth at which some material points will begin to exceed the Mohr–Coulomb strength criterion in the clay.

   (b) Determine the maximum excavation depth at which the horizontal wall movements will not exceed 100mm.

(c) When the excavation depth reaches +7.5m:

   i. Plot the total displacement and mean total (or effective) stress contours,

   ii. Plot horizontal displacement and bending moment along the wall,

   iii. Record the anchor forces.

(d) Determine the maximum excavation depth at which the system will collapse. Plot the plastic points at this depth and identify the failure mechanism.

2. Repeat part 1(a – c) using the effective stress method and the parameters determined from triaxial testing.

3. Repeat part 1(a – c) using the effective stress method and equivalent Mohr Coulomb parameters derived from the shear strength profile.

   Hint: Determine effective stress parameters from the shear strength profile by constructing Mohr's Circles.

4. Discuss the role of tension cut-off in finite element simulations and give an example of a situation where this might be important. Does tension cut–off play an important role for this tie-back excavation?

5. Compare and contrast the three different analysis methods, paying particular attention to the anchor forces and depth–displacement curves. What are the advantages and disadvantages of each method?

6. Pore pressures can only be generated using effective stress methods. Are the pore pressures computed using Mohr–Coulomb reasonable? How might the computed pore pressures (and shear strengths) be different if a more advanced soil model was used?