National Exams May 2010

04-Env-A3, Geotechnical and Hydrogeological Engineering

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. This is an OPEN BOOK EXAM.
   Any non-communicating calculator is permitted.

3. Five (5) questions constitute a complete exam paper.
   The first five questions as they appear in the answer book will be marked.

4. Each question is of equal value.

5. Some questions require an answer in written format. Clarity and organization of the answer are important.

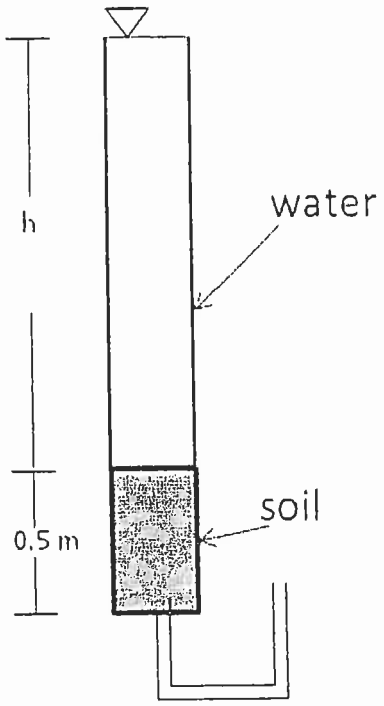
1.(20 Marks)
Soil from a borrow pit is to be used for a constructed fill in the construction of a storage lagoon. The construction details call for the fill to be placed and compacted to 95% Proctor density. This is known to correspond to a void ratio of 0.35. The material to be used for the fill comes from a borrow pit with a void ratio of 0.60.

a) Describe what "95% Proctor Density" means.
b) What volume of material from the borrow pit will need to be removed to make up the required 1000 m^3 of in-place material?
c) Plot the relationship between water content and bulk density for a soil undergoing a standard compaction effort.
d) Show on the same graph as used for item c, the affects of increasing or decreasing the compaction effort.
e) Suggest ways that the required compaction might be achieved in the construction.

2. (20 Marks) Define 10 of the following terms
   a. Capillarity
   b. Consolidation
   c. Saturated hydraulic conductivity
   d. Effective stress
   e. Kaolinite
   f. Silt
   g. Well graded soil
   h. USCS
   i. Texture
   j. Soil structure
   k. Triaxial test

3. (20 Marks)

A falling head test has been conducted on a soil sample using a field-made sampler. In this case the sampler contains both the water and the soil sample. The sampler consists of a large diameter (25 cm) pipe, 2 m in length. The soil is contained in the bottom 0.5 m of the pipe and the remainder is filled with water. Water is able to exit the bottom as shown through a 1 cm diameter flexible U-tube whose exit is 10 cm above the bottom of the pipe. The depth of water over the soil sample is measured over time and are given in the table below.



a. What is the saturated hydraulic conductivity of the soil?
b. How would you characterize this soil – highly permeable, somewhat permeable or not very permeable? Support your answer.
c. If the water level over the soil had dropped too quickly, what modifications would you recommend to make the system work better?
d. If the water level over the soil had dropped too slowly to be practical, what changes to the system could you recommend?

t (min)	h (m)
0	1.50
30	1.45
60	1.40
90	1.36
120	1.31
150	1.27

4. (20 Marks)

An area is planned for use as a large lagoon for the storage of liquid wastes. The underling material consists of 20 m of compressible soil, of which the bottom 15 m are below the water table. Under these conditions the density of the saturated soils is 20.3 kN/m^3 and the unsaturated soil is 17.0 kN/m^3. The lagoon is to be made by excavating the area to a depth of 4.0 m, lining it with an impermeable membrane and then filling it to a depth of 3.5 m with the waste which is essentially water. The area is to be pre consolidated by placing a depth of dry fill over the unexcavated area with a depth such that the effective stresses below the area will equal the effective stresses after installation and filling of the lagoon.

a. Prior to any work being done, what is the total and effective stresses at a point 10 m below the surface in the centre of the proposed lagoon?
b. What depth of dry fill is required to achieve the desired effective stress at the point indicated in part a?
c. Immediately after the fill is placed, what is the effective stress at the point used in part a?
d. Sketch the variation of the effective stresses over time from before the fill is placed until a time just before it is removd at the location used in part a.

5. (20 Marks)

A soil sample (S_g = 2.65) was determined to have a volume of 22.3 cm^3 and a mass of 26.7 g. The dry mass of the sample was determined to be 23.0 g. Determine:

a. The void ratio
b. Water content
c. Porosity
d. Degree of saturation of the soil.

6. (20 Marks)

A slope of infinite extent consists of a dry clayey silt with C = 24 kN/m^2 and $\varphi = 17^o$. At a given point along the critical plane, the normal and shear stresses are found to be 95.4 and 32.5 kN/m^2, respectively. Determine:

a. The maximum shear strength the soil can develop,
b. The safety factor against shear failure,
c. The critical depth H_c, if $\gamma = 18.2$ kN/m^3 and the slope angle, i = 20^o.

7. (20 Marks)

A cohesionless soil sample was placed in a direct shear apparatus and subjected to a normal stress of 190 kN/m^2. The specimen failed at a shear stress of 180 kN/m^2. Determine for this:

a. The angle of internal friction for this soil,
b. The magnitude of the principal stresses, based on Mohr's circle being tangent at 190 and 180, and
c. The normal and shear stresses on a properly oriented failure plane.