National Exams December 2012

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) A rectangular catchment area has a W-E dimension of 8.0 km and a N-S dimension of 6.0 km. The area is bisected by a river which runs principally from west to east. The river is connected to the surficial aquifer for the area. The water surface elevation of the river elevation is nominally 120.0 m and the surficial aquifer is underlain by a horizontal, impermeable till layer, at an elevation of 110m. Mean annual discharges in the river are approximately 10.8 and 12.8 L/s and the west and east boundaries of the catchment area, respectively. Given the sandy nature of the soil and the relatively flat slopes, essentially all the precipitation in the area is either infiltrated or lost to evapotranspiration.
    a. What is the net recharge to the aquifer on an annual basis?
    b. What might be an appropriate hydraulic conductivity for the aquifer?
    c. If the surficial groundwater flow is principally toward the river, what are the elevations of the water table throughout the catchment area?

2. (20 Marks) A single well fully penetrates a confined aquifer that can be considered to have an infinite extent in all directions. There is no recharge to the aquifer and no other wells in the area. The aquifer and well have the following properties:

    - Depth to top of aquifer: 48 m
    - Aquifer thickness: 4.8 m
    - Aquifer hydraulic conductivity: 0.1 cm/s
    - Porosity: 0.35
    - Storativity:0.0001
    - Well diameter: 20 cm
    - Pumping rate: 100,000 L/day
    - Static depth to water in well: 20 m
    - Recharge to aquifer: 0 m/yr
    - Mean aquifer grain size: 5 mm

    a. Determine the drawdown of the static water level for this discharge at points 100 and 500 m from the well under steady state conditions. State any assumptions.
    b. If the well head protection zone is the larger of 100 m from the well or the 2-year time of travel, what is the well head protection zone for this well?

3. (20 Marks) A large building is to be built using a slab-on-grade construction. Prior to construction the area has a water table at a 4 m depth. The soil beneath the proposed construction is 2 m of sand followed by 5.0 m of clay. The construction calls for removal of 1.0 m of sand before constructing the building. Soil specific weights are given below.
   a. Prior to any work, what are the pore, effective and total pressures at the bottom of the clay layer?
   b. After the excavation of the 1.0 m of sand, and prior to building construction, what are the pore, effective and total stresses at the bottom of the clay layer?
   c. Immediately after construction of the building, whose total dead load is equivalent to 48 kN/m^2, what are the pore, effective and total pressures at the bottom of the clay layer.

   Data:
   Specific weight of dry sand:15.7 kN/m^3
   Specific weight of saturated sand: 19.6 kN/m^3
   Specific weight of dry clay: 16.7 kN/m^3
   Specific weight of saturated clay: 17.9 kN/m^3

4. (20 Marks) The table below shows the results from a grain size analysis for two soils.

Sieve		Soil Sample, % Passing	
No.	Opening (mm)	A	B
4	4.76	90	94
8	2.38	64	84
10	2.00	54	72
20	0.85	34	66
40	0.425	22	58
60	0.250	17	50
100	0.150	9	44
200	0.075	5	38
Characteristics of -40 Fraction			
LL		-	44
PL		-	23

a. For Sample A:
   i. Plot the grain size distribution (a plot is provided for you at the end of the exam paper –return this with your exam booklet)
   ii. Determine the D_{10}, D_{60}, and D_{30} sizes,
   iii. Determine the coefficient of uniformity and the coefficient of concavity,
   iv. Classify the soil according to a soil classification system of your choice (e.g. USCS).

b. Sample B has values for the liquid and plastic limits while Sample A does not.
   i. Explain why these analyses would be done for B but not for A
   ii. Describe the apparatus and procure commonly used to determine one of either the liquid or plastic limit.

5. (20 Marks) A cohesionless soil sample (c = 0) is placed in a direct shear apparatus and subjected to a normal stress of 180 kN/m^2. The sample failed in shear at a shear stress of 122 kN/m^2. For this sample, determine:
   a. The angle of internal friction (φ)
   b. The magnitude of the principal stresses, based on Mohr's circle being tangent at (180, 122). Note that a figure is provided for this at the end of the exam paper
   c. The normal and shear stresses on a properly oriented failure plane
   d. For the condition in part b, determine α_f and draw the corresponding stress path on the figure.

6. (20 Marks) Provide definitions of the following terms
    a. Plasticity index
    b. Shrinkage limit
    c. Friction angle
    d. Capillary rise
    e. Triaxial test
    f. Vane Shear test
    g. Montmorillonite
    h. Falling head test
    i. Quick condition
    j. Overconsolidation

7. (20 Marks) The table below gives the results from a standard compaction test on a soil using a mold with a 1000 cm^3 volume. Using a value of the soil grain specific gravity of 2.67:
    a. Plot the dry density-water content curve (a chart is provided at the end of the test for this),
    b. Determine the optimum water content,
    c. Determine the maximum dry density
    d. Value of the air content at the maximum dry density.

Mass (g)	1900	2000	2050	2075	2040
water content (%)	12.7	14.3	15.5	16.4	18.8

Chart for Question 7 – include this with your answer book.

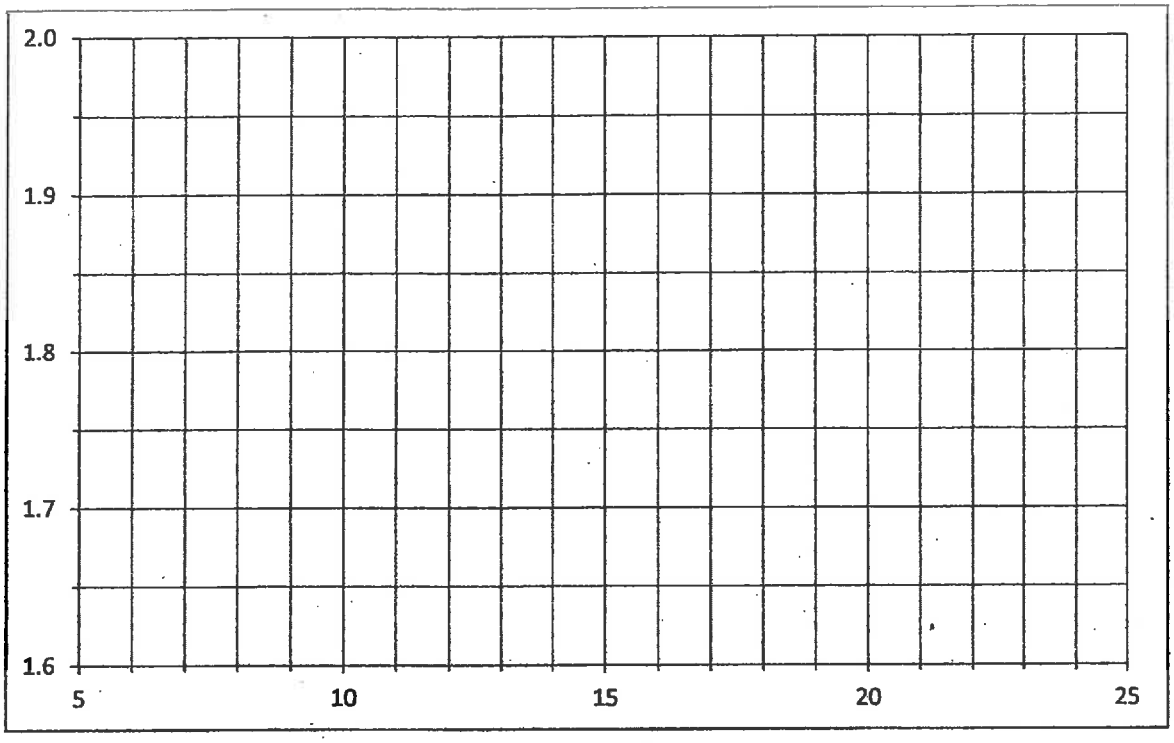

Figure for use with Queston 4 – inlcude with your test booklet.

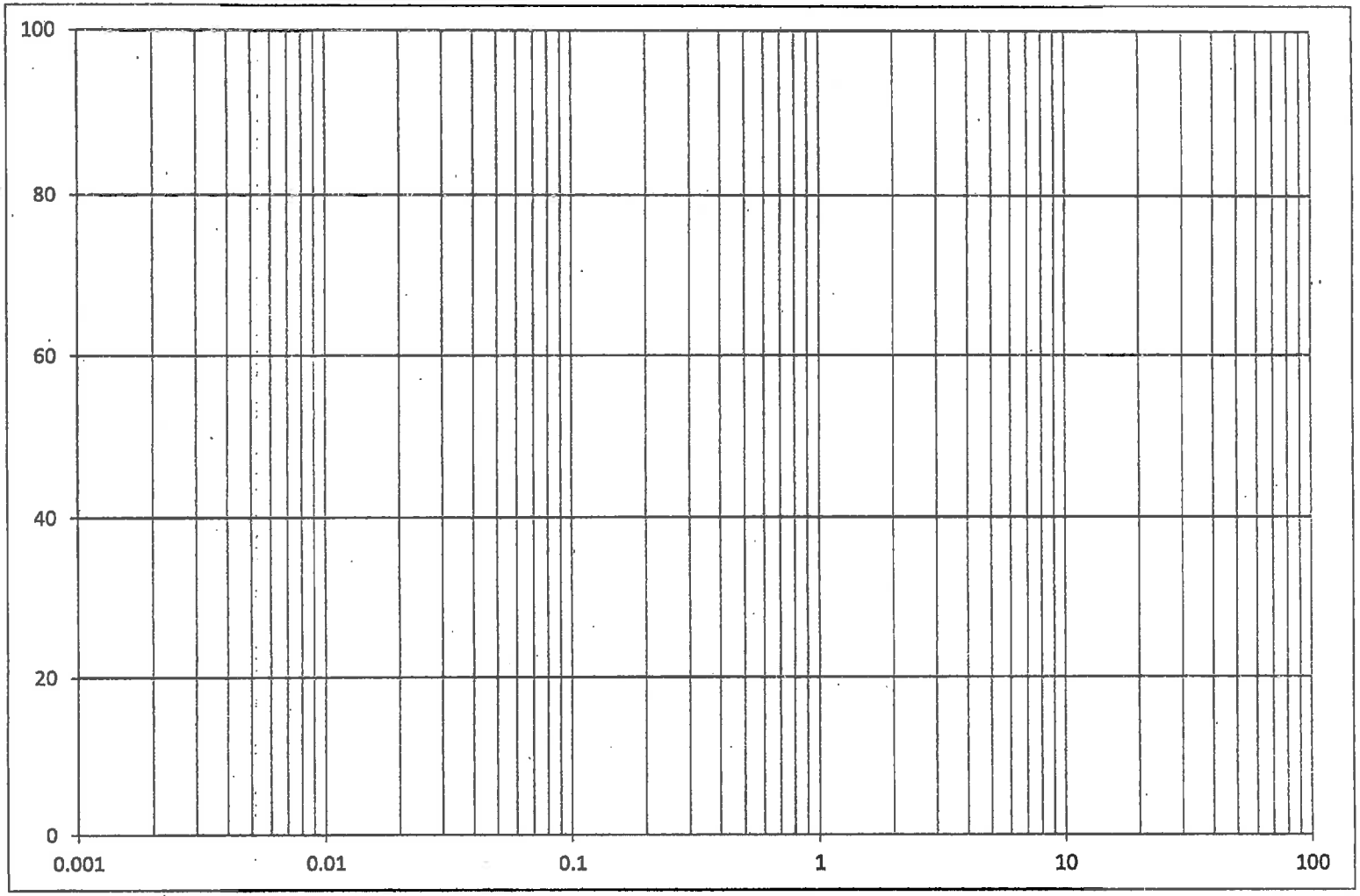

Figure for Question 5