

## National Exams December 2013

Setting 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 may require an answer in essay format. Clarity and organization of the answer are important.

**Question 1 (20 marks)**

A proctor compaction test in the laboratory on a borrow pit soil gives maximum unit weight of  $19 \text{ kN/m}^3$  and optimum water content of 11.5%. The bulk unit weight and water content of the soil in the borrow pit are  $17.2 \text{ kN/m}^3$  and 8.2%, respectively. A highway fill is to be constructed using this soil. The specifications require the fill to be compacted to 95% Proctor compaction.

- a) What is the additional weight of water per unit volume required to bring the moisture content to the optimum value to achieve 95% Proctor compaction?
- b) How many truckloads of borrow pit soil will be required for a  $100,000 \text{ m}^3$  highway embankment – assuming each truck has a capacity of  $10 \text{ m}^3$ ?

### Question 2 (20 marks)

An engineer is searching for a suitable soil to cap a sanitary landfill. This soil must have a hydraulic conductivity no greater than  $1 \times 10^{-8}$  cm/s. A soil specimen from a potential borrow site has been tested in a falling-head permeameter. The specimen was 120 mm in diameter and 32 mm tall. The standpipe had an inside diameter of 8.0 mm. Initially, the water in the standpipe was 503 mm above the water in the water bath surrounding the specimen. Then, 8 hours 12 minutes later the water was 322 mm above the water in the water bath.

- Compute hydraulic conductivity  $k$ ; and
- Determine if this soil meets the specification.

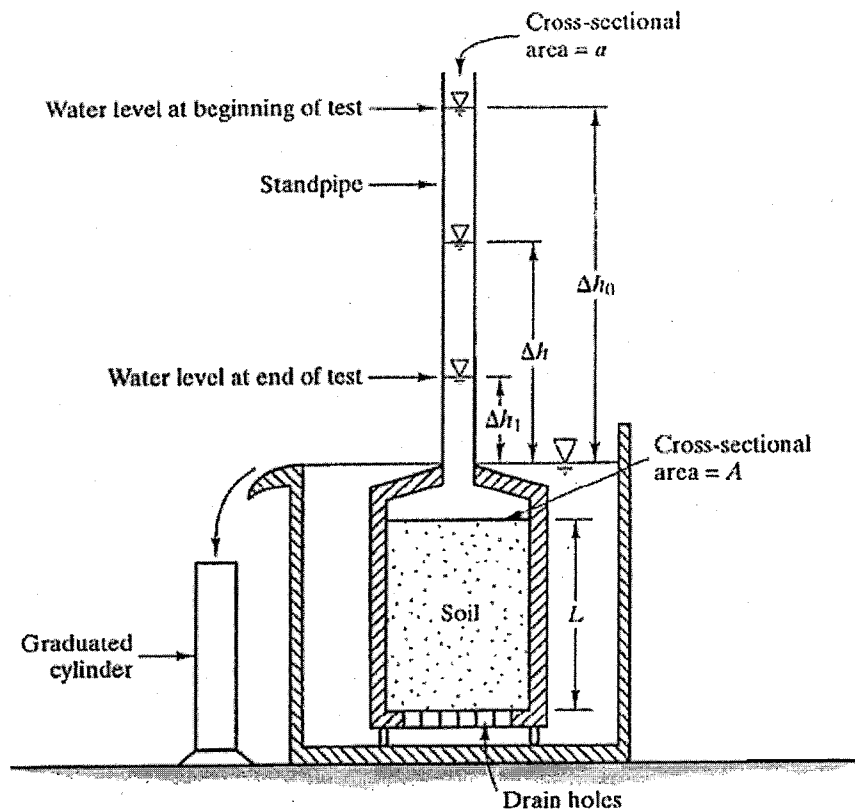
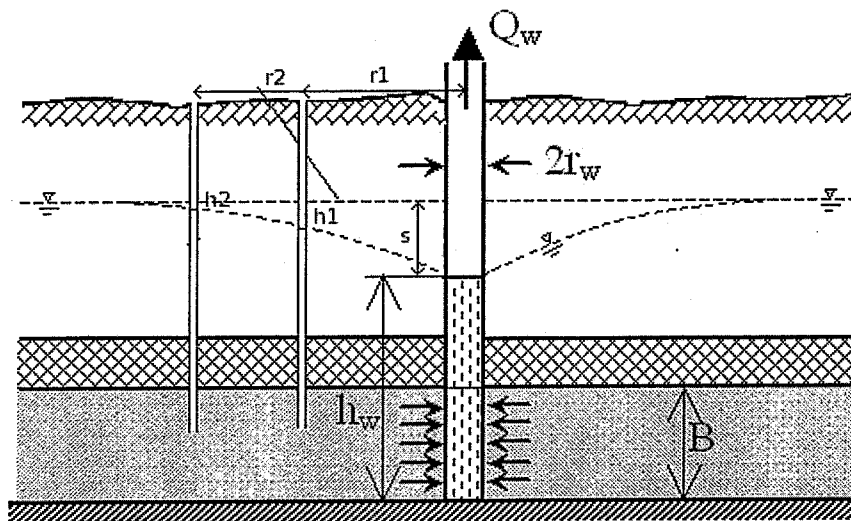


Figure 1

**Question 3 (20 marks)**

A confined aquifer with a porosity of 0.15 is 30 m thick. The potentiometric surface elevations at two observation wells - located at a distance of 1000 m and 2000 m from the pumping well - are 52.35 m and 56.90 m. If the horizontal hydraulic conductivity of the aquifer is 25 m/day,

- a) Determine the flow rate of the pumping well  $Q_w$  and the specific discharge (Darcy flux) towards the observation well at a radius of 2000 m from the pumping well - assuming steady axisymmetric radial flow.
- b) How long would it take for a conservative tracer to travel the distance between the observation wells?



**Figure 2**

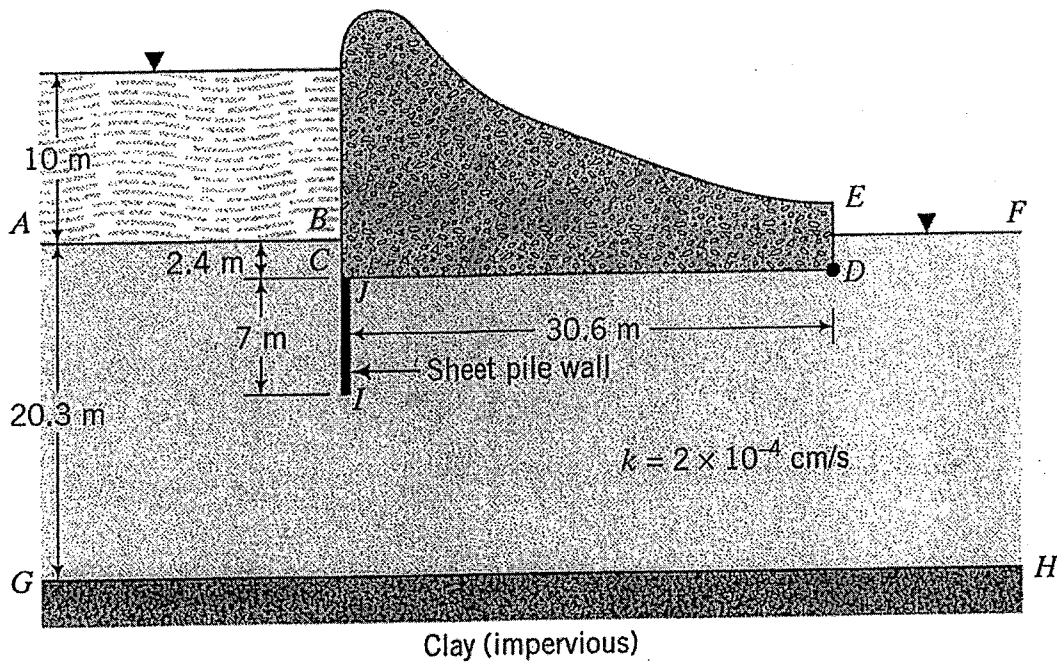
**Question 4 (20 marks)**

A fill is to be placed at a proposed construction site, and you need to determine the ultimate consolidation settlement due to its weight. Write a 300-500 word discussion describing the kinds of field exploration, soil sampling, and laboratory testing you will need to perform to generate the information needed for this analysis. Your discussion should describe specific things that need to be done, and what information will be gained from each activity.

**Question 5 (20 marks)**

A concrete gravity dam, shown below, retains 10 m of water. A sheet pile wall (cutoff curtain) on the upstream side, which is used to reduce seepage under the dam, penetrates 7 m into a 20.3 m thick silty sand stratum. Below the silty sand is a thick deposit of clay. The average coefficient of permeability of the silty sand is  $2.0 \times 10^{-4}$  cm/s. Assume that the silty sand is homogeneous and isotropic.

- a) Calculate the unit width seepage flow rate underneath the dam; and
- b) Calculate the unit width uplift force on the dam.

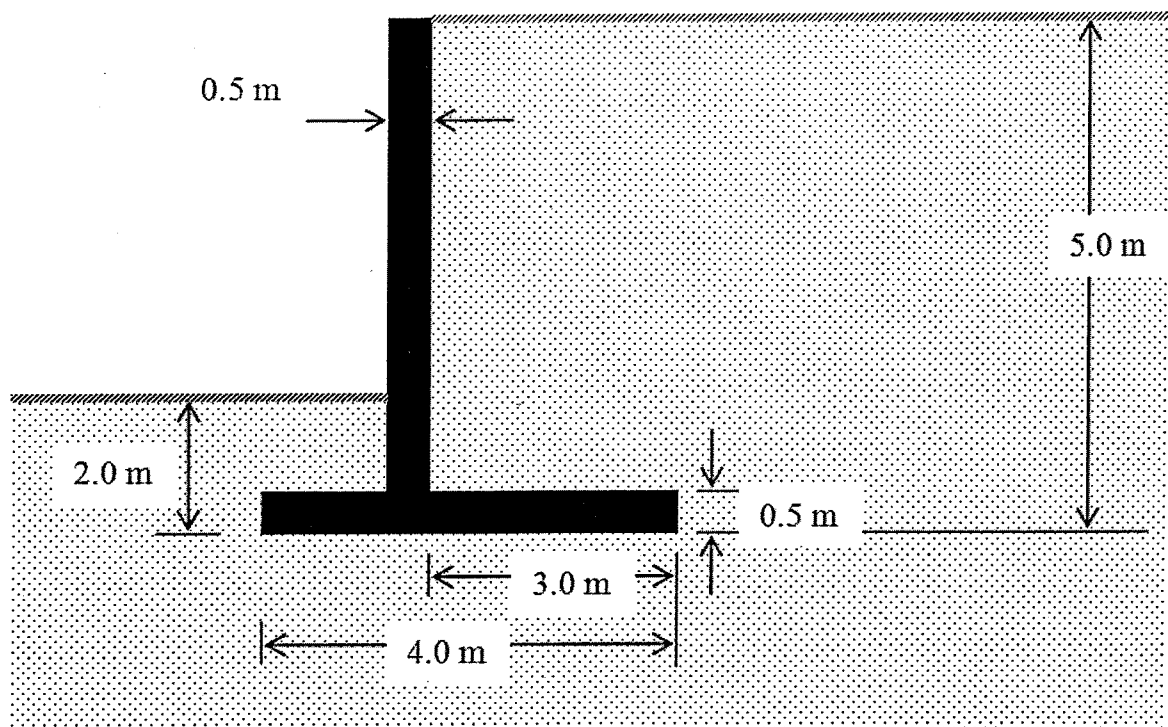


**Figure 3**

**Question 6 (20 marks)**

A concrete retaining wall is shown in Figure 3. The effective shear strength parameters of the sandy soil are  $\phi = 38^\circ$  and  $c = 0$ . The ground water table is 30 m below ground surface. Unit weight of the sandy soil is  $18 \text{ kN m}^{-3}$ . The unit weight of the concrete is  $24 \text{ kN m}^{-3}$ . The angle of internal friction between the wall and soil is  $\delta = 25^\circ$ .

- a) Determine the factor of safety against tipping; and
- b) Determine the factor of safety against sliding.



**Figure 4**

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### Marking Scheme

**Q1. 20 marks total**

- (a) 10 marks
- (b) 10 marks

**Q2. 20 marks total**

- (a) 10 marks
- (b) 10 marks

**Q3. 20 marks total**

- (a) 10 marks
- (b) 10 marks

**Q4. 20 marks total**

Essay type question.

**Q5. 20 marks total**

- (a) 10 marks
- (b) 10 marks

**Q6. 20 marks total**

- (a) 10 marks
- (b) 10 marks