National Exams May 2013

Setting 04-Env-A3, Geotechnical & 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 contractor needs 800 m^3 of aggregate base material for a highway construction project. It will be compacted to a dry unit weight of 20 kN/m^3. This material is available in a stockpile at a local material supply yard and the moisture content (dry basis) of the stockpile is 8.0%.

(a) How many kilograms of aggregate base material should the contractor purchase to have exactly the correct volume of compacted material?

(b) Now, the contractor needs to prepare another identical section of aggregate base and is ordering the same number of kilograms as before. However, prior to the placement of the second order, an intense rainstorm occurred which raised the moisture content of the stockpile to 18.0%. How many cubic meters of compacted aggregate base will be produced from this second order compared with the first order? Explain.

Question 2 (20 marks):

For a variable head permeability test shown in Figure 1, these values are given:

- Length of the soil specimen (L) = 381 mm
- Area of the soil specimen (A) = 19.4 cm^2
- Area of the standpipe (a) = 0.97 cm^2
- Head difference at time t (Δh_o) = 0 is 635 mm
- Head difference at time t (Δh) = 8 min is 305 mm

Given above information:

a) determine the hydraulic conductivity of the soil; and

b) calculate the head difference at time t = 4 min.

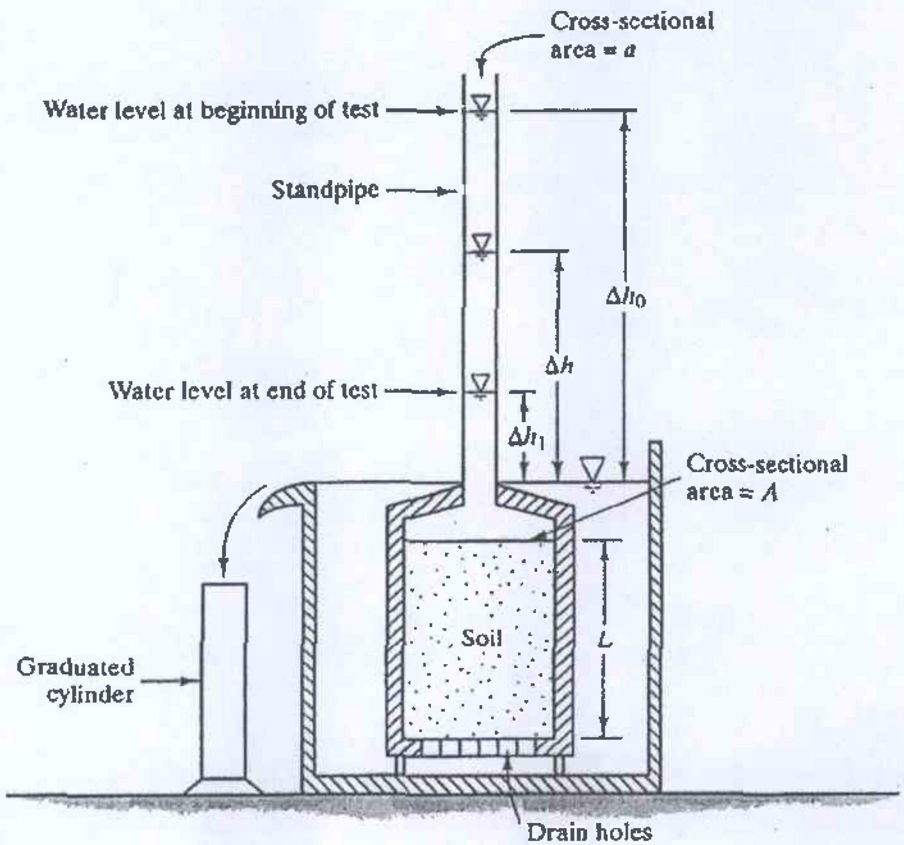


Figure 1

Question 3 (20 marks)

Figure below shows a concrete dam and reservoir on a silty sand. The crest of the dam is 150 m long – that is, length of the dam perpendicular to the picture. The reservoir has a top surface area of approximately 10 ha. The saturated hydraulic conductivity of the silty sand is 8.0×10^{-3} cm/s.

a) determine the quantity of seepage under the dam using flow net analysis; and

b) calculate the rate of drop in the reservoir water level due to seepage (if you could not answer part a, assume a seepage rate of 1 m^3/day).

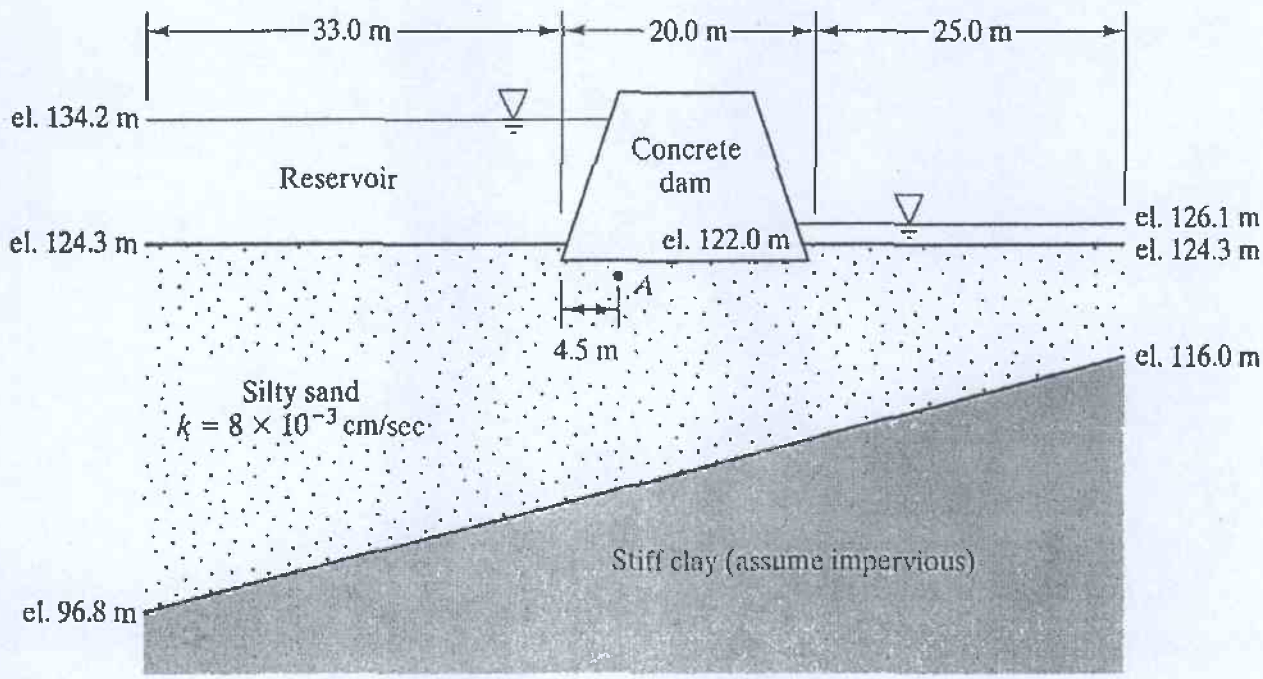


Figure 2

Question 4 (20 marks):

A 2-m deep open drainage ditch is cut in a saturated clay with side slopes of 2 horizontal to 1 vertical, as shown in Figure 3, below. The saturated unit weight of the soil is 18.5 kN m^{-3} and its undrained cohesion is $C_u = 40$ kN m^{-2}. If undrained friction angle $\phi_u \approx 0$, determine:

a) the factor of safety against shear failure of the slide slopes; and

b) the required side slopes that would satisfy minimum factor of safety of 3 against shear failure.

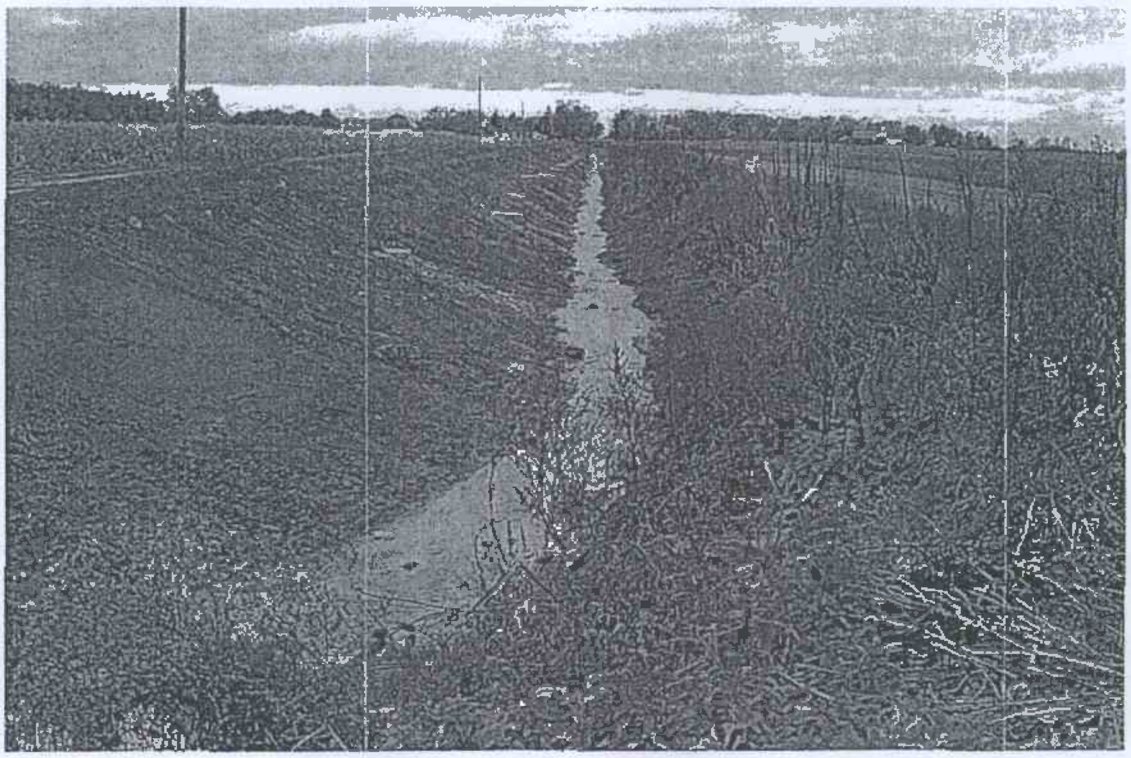
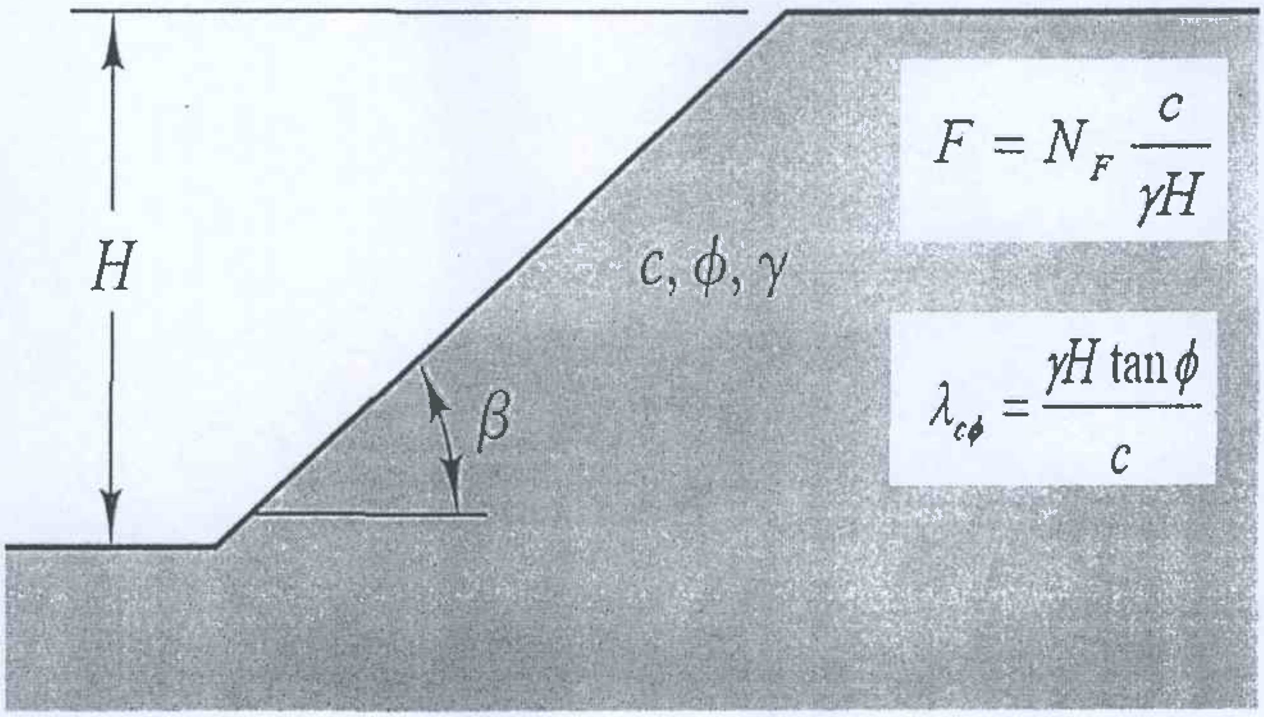
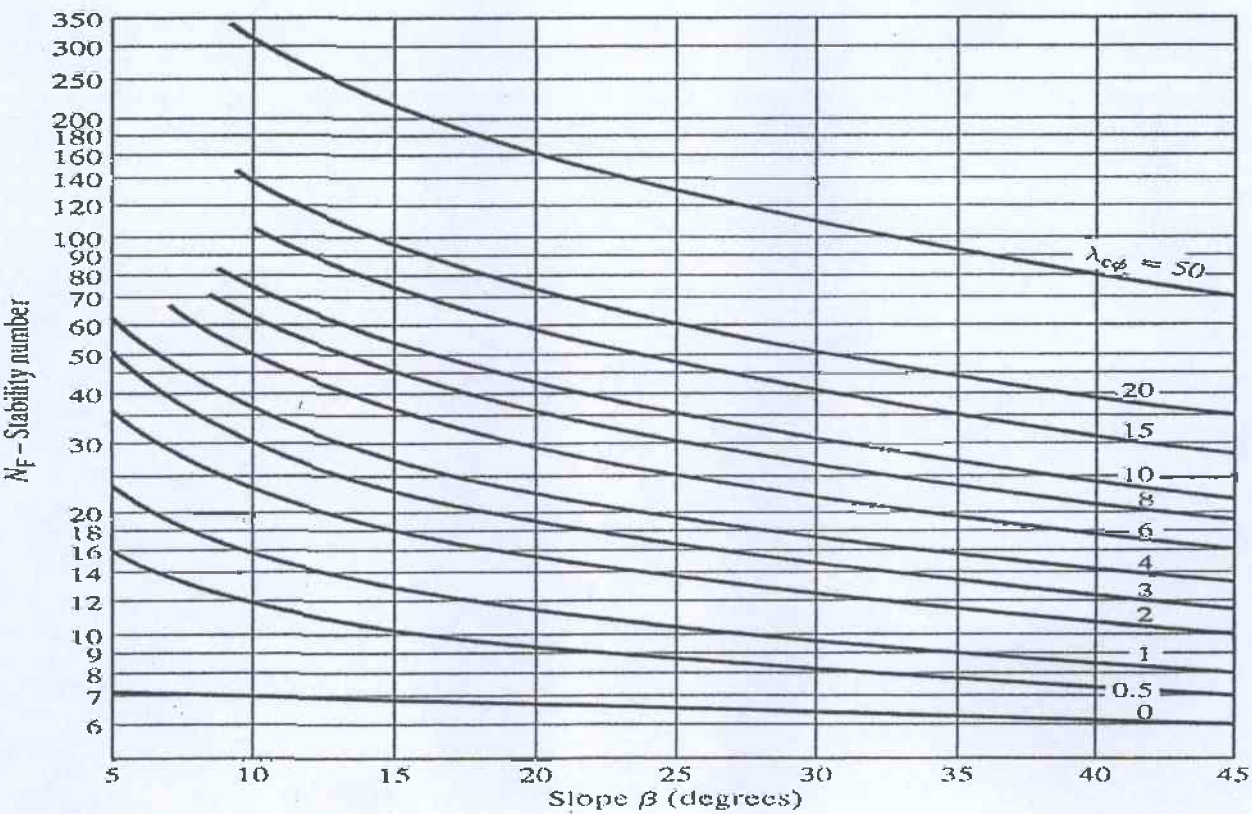


Figure 3



H
c, ϕ, γ
β
$F = N_F \frac{c}{\gamma H}$
$\lambda_{c\phi} = \frac{\gamma H \tan\phi}{c}$



N_F – Stability number
Slope β (degrees)
$\lambda_{c\phi} = 50$
20
15
10
8
6
4
3
2
1
0.5
0

Question 5 (20 marks):

A retaining wall is shown in Figure 4, below. Assuming H = 6 m, H_1 = 2 m, γ_1 = 16 kN/m^3, γ_2 = 19 kN/m^3, ϕ_1 = 32°, ϕ_2 = 36°, q = 15 kN/m^3; determine:

a) Rankine's active force per unit length of the wall; and

b) the location of the resultant active force of the soil and groundwater on the wall.

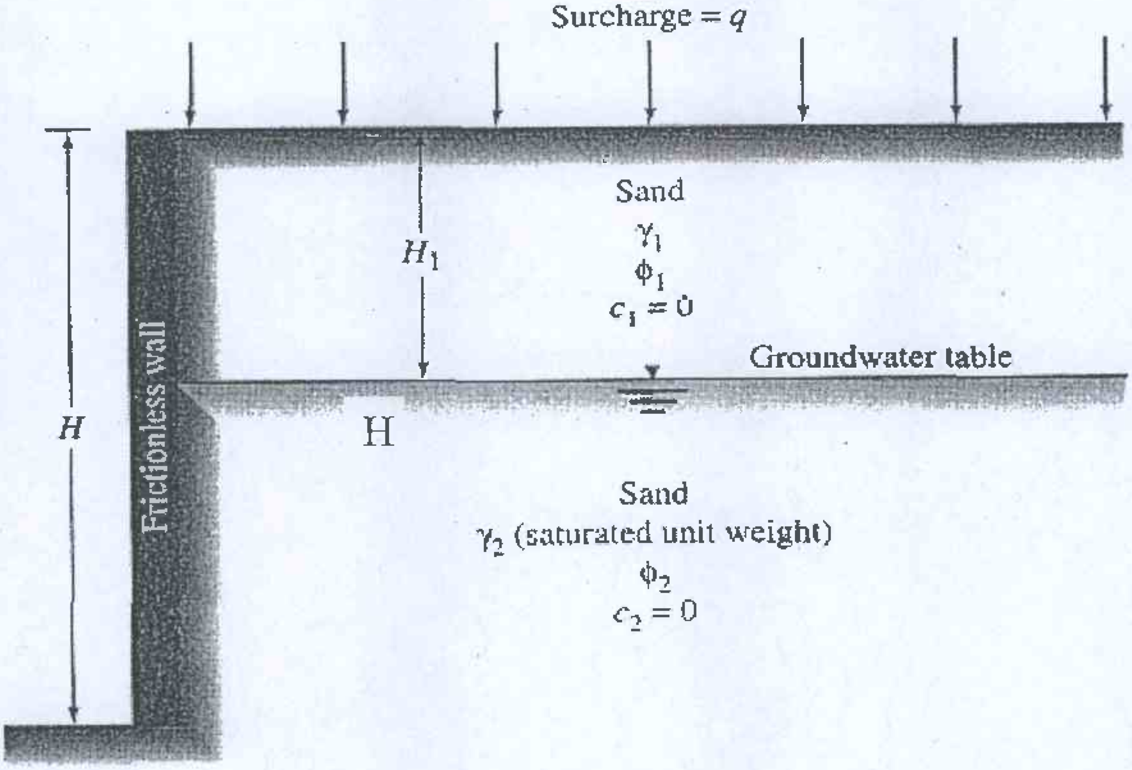


Figure 4

Question 6 (20 marks):

A confined aquifer with a porosity of 0.15 is 30 m thick. The potentiometric surface elevations at two observation wells 1000 m apart are 52.35 m and 56.90 m. If the horizontal hydraulic conductivity of the aquifer is 25 m/day, determine:

a) the flow rate per unit width of the aquifer, specific discharge, and average linear velocity of the flow assuming steady unidirectional flow directly from one well to another.

b) How long would it take for a tracer to travel the distance between the observation wells? What assumptions are required to make this determination?

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Marking Scheme

1. 20 marks total
- (a) 10 marks
- (b) 10 marks

2. 20 *marks total*
- (a) 10 marks
- (b) 10 marks

3. 20 marks total
- (a) 10 marks
- (b) 10 marks

4. 20 marks total
- (a) 10 marks
- (b) 10 marks

5. 20 marks total
- (a) 10 marks
- (b) 10 marks

6. 20 marks total
- (a) 10 marks
- (b) 10 marks