ENGINEERING TRIPOS PART IIB

Monday 29 April 2013 2 to 3.30

Module 4D14

CONTAMINATED LAND AND WASTE CONTAINMENT

*Answer not more than **three** questions.*

All questions carry the same number of marks.

*The **approximate** percentage of marks allocated to each part of a question is indicated in the right margin.*

Attachment: Special Datasheets (3 pages)

STATIONERY REQUIREMENTS
Single-sided script paper

SPECIAL REQUIREMENTS
Engineering Data Book
CUED approved calculator allowed

You may not start to read the questions printed on the subsequent pages of this question paper until instructed that you may do so by the Invigilator

1 (a) What are the main functions of the top cover of a landfill? [10%]

(b) How does the design of the top cover change depending on whether hazardous or non-hazardous wastes are to be deposited in a landfill? [20%]

(c) What are the main functions of the base layer of a landfill? [10%]

(d) How would soft areas of ground such as undetected peat zones below the base layer influence the performance of the base layer of a landfill? What measures can be taken to improve its performance? [20%]

(e) You are to design a flat-bed anchor system for the geo-membrane layer of a landfill with a side slope of 60° as shown in Fig. 1. The tension force T induced in the geo-membrane due to self-weight and down drag from the waste is estimated to be 200 kN per metre width. The thickness of the geo-membrane is 5 mm. The interface friction angles of the top and bottom sides of the geo-membrane are 6° and 10° respectively. Due to space limitations at the site, the flat-bed anchor can only extend to 2.5 m from the edge of the side slope. Calculate the height of the berm that is required to anchor the geo-membrane. You may take the unit weight of the berm material to be 16 kN m^{-3}. [40%]

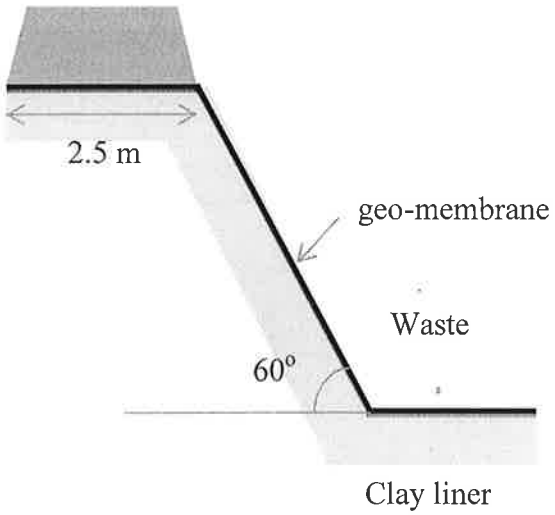

Fig. 1

2 (a) Describe briefly how you would construct a slurry wall in a silty clay layer underlain by a stiff clay layer. [15%]

(b) A vertical slurry wall is to be constructed in a silty clay layer with a saturated unit weight of 19.2 kN m^{-3} and an undrained shear strength of 25 kPa. The permeability of the silty clay was determined to be 2.4×10^{-5} m s^{-1}. Calculate the theoretical limit on the height of an unsupported vertical cut that can be made in this soil. [15%]

(c) It is anticipated that the construction plant required to mix the backfill material will exert a bearing pressure of 30 kPa next to the trench. How will this affect your calculation in part (b)? [10%]

(d) The depth of the slurry wall required to form a vertical barrier against contaminant migration was determined to be 10 m excluding the keying depth. Assume that the construction plant described in part (c) will be present. Estimate the unit weight of the soil-bentonite slurry required to maintain stability of the trench if:

(i) the water table is well below the 10 m depth of the slurry wall; [10%]

(ii) the water table is at the ground surface. [10%]

(e) Describe the siting criteria you would use to locate an injection well for disposal of liquid waste. What hydro-geological conditions do you need to satisfy to locate such an injection well? [20%]

(f) Describe how the following topographical features of the ocean environment affect the spread of the waste deposited:

(i) continental slopes; [10%]

(ii) abyssal hills. [10%]

3 (a) What are the barriers to the redevelopment of contaminated land and how can they be overcome? [20%]

(b) Benzene, xylene and MTBE (methyl t-butyl ether) are often found on contaminated sites.

(i) Which is likely to be the most mobile, i.e. most easily moved by the groundwater? [10%]

(ii) Which is likely to be the least mobile? [10%]

Give reasons for your answers.

(c) What types of contaminants can be analysed in the laboratory by:

(i) Gas chromatography (GC) and [10%]
(ii) Inductively coupled plasma optical emission spectrometry (ICP-OES)? [10%]

Give three examples of contaminants for each technique.

(d) Briefly describe the operating principles of one of the above two analytical techniques. [20%]

(e) A site is contaminated with benzene and MTBE, both in the soil and groundwater. What are the typical sources of such contamination and what method(s) would you recommend for the remediation of these two contaminants and why? [20%]

4 Bioremediation is generally considered an efficient and cost-effective remediation technique for hydrocarbon contaminated ground.

(a) Describe the four basic processes of bioremediation. [30%]

(b) Describe one in-situ and one ex-situ bioremediation technique. [15%]

(c) What are the ideal environmental conditions for bioremediation? [15%]

(d) Discuss the effects of contaminant chemistry and soil type on the effectiveness of bioremediation. [15%]

(e) What is monitored natural attenuation and when is it appropriate to use it? [15%]

(f) Explain how bioremediation takes place within the rhizosphere zone. [10%]

END OF PAPER