Version AAT/3

EGT3
ENGINEERING TRIPOS PART IIB

Monday 23 April 2018 14.00 to 15.40

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.*

Write your candidate number ***not*** *your name on the cover sheet.*

STATIONERY REQUIREMENTS
Single-sided script paper

SPECIAL REQUIREMENTS TO BE SUPPLIED FOR THIS EXAM
CUED approved calculator allowed
Attachment: Module 4D14 Data Sheets – Waste Containment (3 pages)
Engineering Data Book

10 minutes reading time is allowed for this paper at the start of the exam.

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

1. (a) Explain briefly what type of reactions occur within Municipal Solid Waste (MSW), giving examples of the products that can form. Consider all conditions under which MSW can be present. [20%]

(b) What type of reactions occur at the clay liner – MSW interface in a landfill? What engineering implications can these reactions have? [20%]

(c) Explain with suitable sketches how a slurry wall is constructed in a silty sand layer overlying bedrock. If you were the site engineer, what failure scenarios of these walls would you guard against? [20%]

(d) The population of a new township near Cambridge is expected to be 6,000 at the beginning of 2019. It is expected that the population will grow at 12% in the first three years and this rate will drop to 7% for the next three years. The average MSW produced by each person is expected to be 35 kg per week in the first two years, which will drop to 25 kg per week afterwards with better recycling initiatives.

(i) Estimate the size of the landfill cell that is required to receive this waste for six years. Limit the depth of the landfill cell to 12 m and assume that the waste will be filled only to ground level. The waste will be compacted to a unit weight of 7.5 kN m^{-3}. [25%]

(ii) The average rainfall intensity in Cambridge is about 800 mm per year. Assuming that 10% of this infiltrates into the landfill and an equal amount of leachate will be produced within the landfill, estimate the volume of leachate that must be pumped out of the landfill cell. [15%]

2. (a) Describe the terms ‘continental shelf’, ‘continental slope’, ‘abyssal hills’ and ‘abyssal plains’. How is disposal of waste in the ocean affected by these topographies? [20%]

(b) How would you classify ocean regimes with depth? Explain how these regimes influence waste disposed at the surface of the ocean. [15%]

(c) Explain briefly the geological and hydrological conditions you would look for to site an injection well. [15%]

(d) A landfill side slope at 70^{o} to the horizontal, shown in Fig. 1, is to be lined with a 6 mm thick geomembrane that is specified to have a mass of 20 kg per square metre. The underside of the geomembrane has a friction angle of 14^{o} with respect to the clay, while the top side has a friction angle of 8^{o} with respect to the waste. The unit weight of the waste is 9.6 kN m^{-3}. The yield stress of the geomembrane is 13.8 MPa.

(i) Calculate the self-weight induced stress in the geomembrane. [10%]

(ii) Estimate the down-drag stress induced in the geomembrane due to the settlement of the waste, stating clearly any assumptions you have made. Redesign the geomembrane by increasing its thickness if necessary. [20%]

(iii) A flat bed anchor is to be designed at the top of the landfill to restrain the geomembrane as shown in Fig. 2. The clay in the berm has a unit weight of 17 kN m^{-3} and the height of the berm is 2 m. Design a suitable anchor length L for the berm. State clearly any assumptions you have made. [20%]

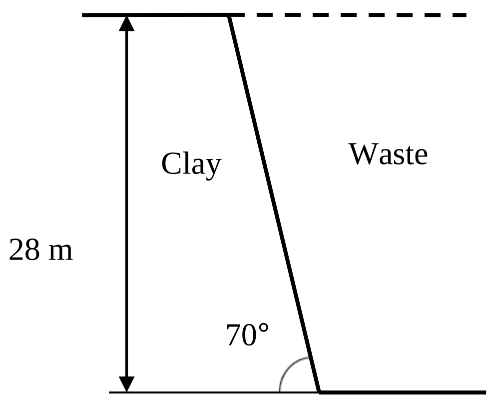

Fig. 1

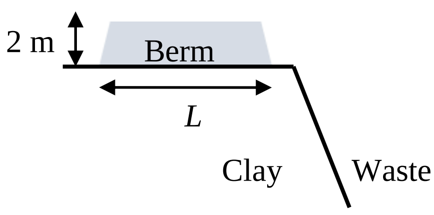

Fig. 2

3. (a) Give three examples of activities that lead to extensive contamination problems in the subsurface together with the potential risks involved. Explain using a diagram, the fundamental requirement for determining whether such activities might pose a risk to a receptor and give an example. [20%]

(b) What is the role of a regulator in protecting the environment in the context of land contamination? What measures and tools are used by the Environment Agency in dealing with contaminated land? [10%]

(c) In a sandy soil historically contaminated with NAPLs, sketch and annotate a section of the soil showing the expected spread of both LNAPLs and DNAPLs with depth above and below the water table. [20%]

(d) What properties are likely to influence the spread of a NAPL pollutant plume? [10%]

(e) Briefly describe the stages of a chemical site investigation that you would conduct on the site in part (c) to provide the required information for the design of remedial work. [20%]

(f) Briefly describe remediation techniques suitable for the treatment of an LNAPL plume and a DNAPL plume respectively. Describe a system that can treat both simultaneously. [20%]

4. Heavy metals, such as lead, copper, nickel, cadmium and chromium, are common pollutants encountered on many contaminated sites. They can be treated collectively, or individually using their distinctive chemical and physical characteristics.

(a) List three different sources of heavy metal contamination in the ground. What are the major issues associated with the presence of heavy metals in the subsurface? [10%]

(b) Immobilisation, soil washing and phytoremediation are three very different techniques suitable for the removal of heavy metals from contaminated soils. Briefly discuss each technique in the context of heavy metal removal and highlight the advantages and disadvantages of each technique relative to the other two. [45%]

(c) Explain briefly how each of the above three techniques would be implemented on a contaminated site. [15%]

(d) What detrimental effects could the presence of heavy metals have on the effectiveness of certain remediation techniques? [10%]

(e) Briefly describe how you would measure the concentration of a heavy metal such as lead in both the laboratory and in the field. [20%]

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