Version AAT/2

EGT3
ENGINEERING TRIPOS PART IIB

_____

Friday 2 May 2014   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.*

*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: 4D14 Contaminated Land and Waste Containment data sheet (3 pages).
Engineering Data Book

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

1   (a)   How does the ocean environment affect waste disposal?   [15%]

(b)   What is the 'room and pillar' method of excavation in mines? How will this method help in the disposal of toxic waste in old mines?   [15%]

(c)   A new landfill is to be constructed at a site in the Greater London area. The average precipitation at the site is 580 mm per year. The site has dimensions of 200 m × 400 m as shown in the plan view in Fig. 1. The site has a natural slope of 1:600 in the shorter direction. Once the top cover has been placed, it is estimated that about 10 % of the precipitation will enter the landfill. A similar quantity of leachate will be produced due to the reactions in the waste. The porosity of the waste is 0.4.

    (i)   Assuming no pumping out, calculate the quantity of leachate and the height to which it stands within the landfill after one year of operation.   [10%]

    (ii)   The leachate collection system comprising two HDPE pipes will be placed in a base drainage layer that is 120 cm thick and has a hydraulic conductivity of 2×10^{-2} m s^{-1}. Determine the spacing between the two pipes, assuming that the leachate level is maintained at the surface of the drainage layer.   [15%]

    (iii)   Determine the diameter of the HDPE pipes to carry the leachate in the shorter direction. The pipes are to run half full and the maximum flow velocity in these pipes is limited to 0.5 m s^{-1}.   [15%]

    (iv)   The HDPE pipes are to be joined into a concrete pipe that runs along one edge of the landfill. This allows for a single point pumping-out of the leachate from its end. The slope of this pipe is 1:2000. The concrete pipe can run 60% full but the flow velocity is again limited to 0.5 m s^{-1}. Determine a suitable diameter for the concrete pipe.   [30%]
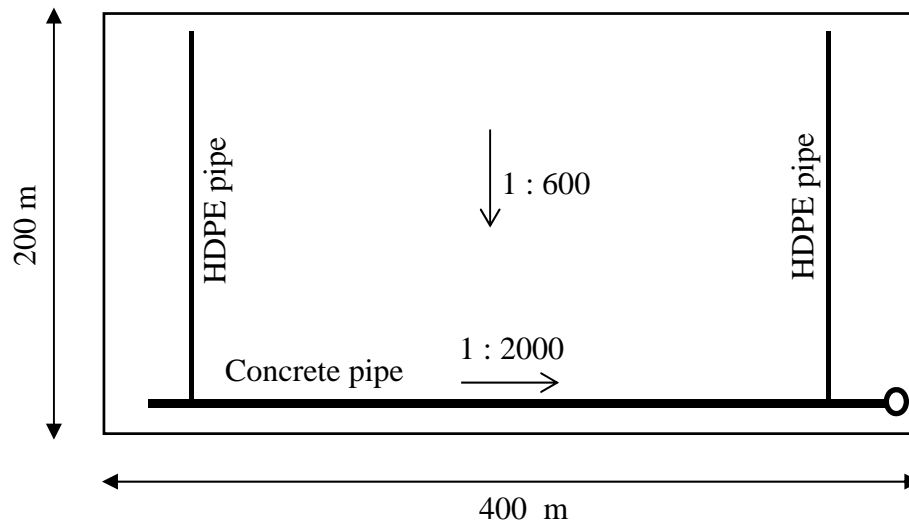
(cont.

Fig. 1

2   The majority of contaminated site soils are polluted with (i) heavy metals, (ii) organics, or (iii) a cocktail of both.

(a)   What type of sites and industrial activities would usually be associated with each of these three pollutant groups?   [15%]

(b)   What are the general characteristics of each of those groups that will impact on their remediation strategies?   [15%]

(c)   Suggest and describe a method, or a suite of methods, of analysis for measuring the concentration of each group of contaminants.   [30%]

(d)   Hydrocarbon organic contamination is usually classed into LNAPLs and DNAPLs. What do these acronyms refer to? Highlight the main difference between these two types of organics and give an example of each?   [10%]

(e)   What common remediation methods are used to treat each of the three pollutant groups?   [15%]

(f)   List one remediation method that would not generally be suitable for remediating each of those three groups of pollutants.   [15%]

3   (a)   Name any two minerals that make up the mineralogy of a clay.   [10%]

(b)   Explain the term 'diffused double layer of water' in clay. What effect can the presence of hydrocarbons have on the thickness of the diffused double layer? Why is this important?   [20%]

(c)   A geomembrane layer is to be placed next to a fractured rock quarry slope to form a landfill cell. The geomembrane is anchored at the top using a berm. The slope angle of the quarry wall changes as shown in Fig. 2. The geomembrane has a thickness of 6 mm and has a mass of 18 kg m^{-2}. The underside of the geomembrane has an interface friction angle of 12° with respect to the fractured rock. Calculate the self-weight induced tensile stress in the geomembrane at the top of the slope at A.   [30%]

(d)   The landfill cell, shown in Fig. 2, is filled with municipal solid waste (MSW) to a depth of 25 m. The unit weight of the waste is 8 kN m^{-3}. The interface friction angle between the geomembrane and the waste is 10°. Making suitable assumptions, calculate the down drag stress in the geomembrane at A. Justify your assumptions.   [40%]
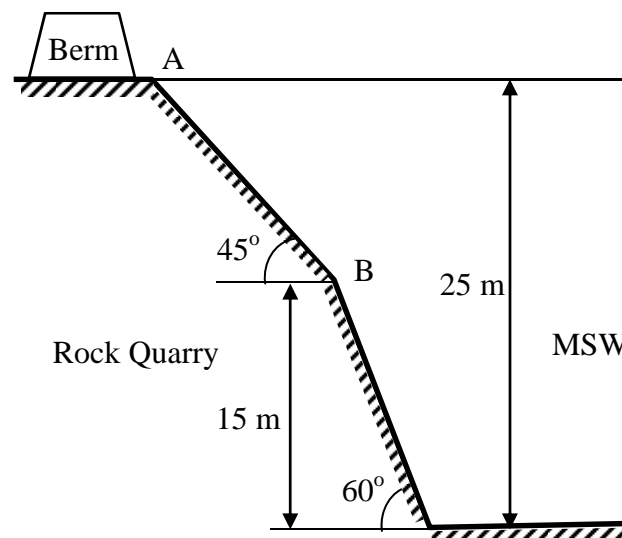

Fig. 2

4   (a)   For the effective selection of a remediation solution for a particular contaminated site redevelopment project, the following factors usually need to be considered:

(i)   project drivers;

(ii)   risk management;

(iii)   technical suitability and feasibility;

(iv)   stakeholder satisfaction;

(v)   sustainable development;

(vi)   costs and benefits.

Briefly describe the important aspects of each factor.   [60%]

(b)   Recent developments in land remediation strategies have led to the employment of 'multi-scale treatment trains'.

(i)   Explain the principles of 'multi-scale treatment trains' in the context of land remediation.   [10%]

(ii)   Give three examples of how such principles would work in practice and explain why.   [30%]

END OF PAPER

THIS PAGE IS BLANK

4D14 Contaminated Land and Waste Containment

2014

Numerical Answers

Q1 (c) (i) 0.29m

(ii) 350m

(iii) 100mm

(iv) 500mm

Q3 (c) 585 kPa

(d) 7.2 MPa