Ground Engineering and Monitoring

22CVC106

Semester 2 2023 | Online Short-window Exam paper

This is an online short-window examination, meaning you have a total of **2 hours plus an additional 30 minutes** to complete and submit this paper. The additional 30 minutes are for downloading the paper and uploading your answers when you have finished. If you have extra time or rest breaks as part of a Reasonable Adjustment, you will have further additional time as indicated on your exam timetable.

It is your responsibility to submit your work by the deadline for this examination. You must make sure you leave yourself enough time to do so.

It is also your responsibility to check that you have submitted the correct file.

Exam Help

If you are experiencing difficulties in accessing or uploading files during the exam period, you should contact the Exam Helpline. For urgent queries please call **01509 222900**.

For other queries email examhelp@lboro.ac.uk

You may handwrite and/or word process your answers, as you see fit.

You may use a calculator for this exam.

Answer **FOUR** questions.

All questions carry equal marks.

A formula sheet is provided.

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1. A new landfill is to be built at a site with the ground profile shown in **Figure Q1**, which consists of a soft organic CLAY layer of variable thickness.

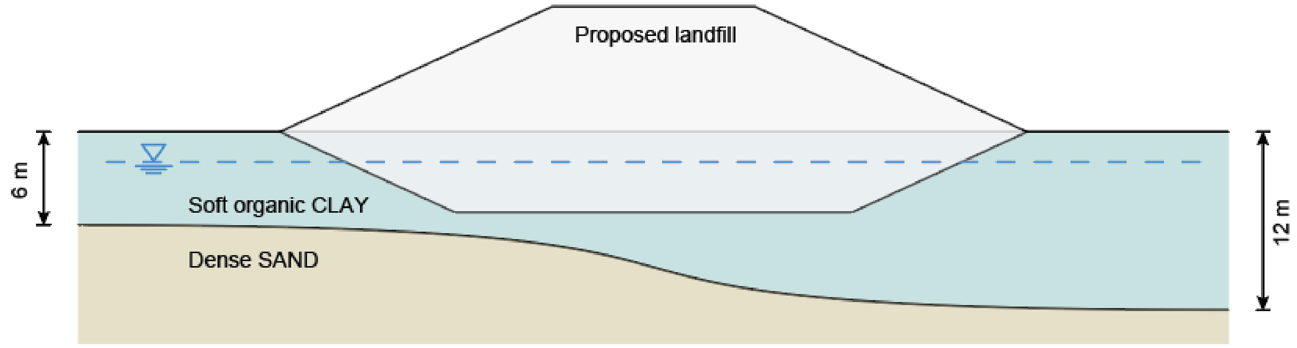

Figure Q1. Cross-section of the site for the proposed landfill

a) What *ground improvement* solution would you recommend, to enable construction of the proposed landfill on the soft organic CLAY? [*Hint: Your solution could comprise more than one ground improvement technique*.]

[6 marks]

b) **Table Q1** gives the properties for four lining systems.

Table Q1. Liner hydraulic properties

	Clay (0.5 m thick) Liner	Geomembrane Liner	Composite Liner 1	Composite Liner 2
Clay hydraulic conductivity (m/s)	$1x10^{-9}$	N/A	$1x10^{-9}$	$1x10^{-9}$
Head of leachate (m)	8	8	8	8
Geomembrane/clay contact	N/A	N/A	Good	Poor
Holes per hectare	N/A	30	40	25
Hole size (mm^2)	N/A	10	10	15

i) Calculate the leakage rate through each liner system in **Table Q1.**

[12 marks]

ii) Compare the advantages and disadvantages of geomembrane liners compared to clay liners and explain why a composite liner is typically selected over single material barriers in containment engineering.

[7 marks]

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2. A soil wall reinforced with geogrid strips is shown in **Figure Q2**. The top strip is placed at 0.5 m below ground level. The strips are 0.15 m wide, 7 m long, and the horizontal and vertical spacings are 1.0 m. The 120-year ultimate tensile load is 64 kN. The granular fill has a bulk unit weight of 19 kN/m^3, an effective cohesion of 0 kN/m^2 and an effective friction angle of 33°. The geogrid/fill friction angle is 22°. The surcharge is 25 kN/m^2/m run, while the horizontal force is 30 kN/m run.

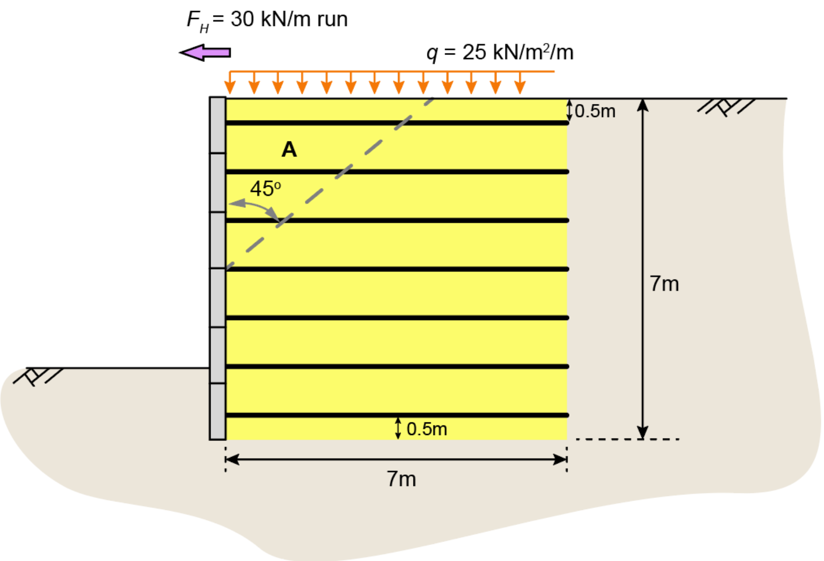

Figure Q2 Reinforced soil wall

a) Determine the factor of safety against tensile failure assuming this occurs in the bottom layer of the reinforcement.

[5 marks]

b) Determine the factor of safety of the soil/reinforcement bond using the maximum tensile force found in (a).

[5 marks]

c) Determine the factor of safety for the failure plane and associated ***wedge A*** shown in **Figure Q2**.

[12 marks]

d) Comment on your results from (a), (b) and (c) and suggest design improvements that could be made to the wall.

[3 marks]

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3. (a) Using appropriate diagrams, describe the requirements from a surveying perspective of setting out a tunnel with a steep gradient.

[10 marks]

(b) Using appropriate diagrams, describe 2 geospatial/surveying methods for monitoring deformation inside tunnels. Describe any equipment and methods used.

[15 marks]

4. Geographical Information Systems (GIS) and Spatial Data have an important role to play in ground monitoring. Describe the following:

a) Define GIS, including its components and applications.

[8 marks]

b) Describe using appropriate diagrams and examples the difference between raster data and vector data.

[12 marks]

c) Briefly define the term “crowd sourced data” and explain some of its potential advantages.

[5 marks]

5. A 12km long tunnel to transport storm water is proposed in North Leicester, at cover depths of 10-20m below ground level. The route crosses partly underneath an urban residential and commercial area of the city for several kilometres and under undeveloped countryside for several kilometres. The expected geology comprises alluvial deposits (0-5m deep) and beneath this a firm to stiff clay (weathered mudstone) becoming a weak rock (mudstone) to substantial depth.

(a) List and explain what **specific soil information** you would need from a Ground Investigation, **and any other relevant data,** to analyse and design for **both** the tunnel face stability and surface settlement?

[14 marks]

(b) For the proposed tunnelling under the urban section of route, explain what factors should be considered in the estimation of potential damage to the buildings from any surface ground movements due to the tunnelling works, and how the designer may estimate the potential risks of damage to any structures and possible mitigation measures.

[11 marks]

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6. (a) Explain what a ‘Conceptual Site Model’ (CSM) is, and the role of the desk study in the CSM development, for a potentially contaminated site. Include the information required for a thorough desk study and why/how this is useful for planning the Ground Investigation phase.

[12 marks]

(b) Explain the UK philosophy of ‘source – path – receptor’ for identifying contaminated land, and how this philosophy can be simply used to explain possible remediation strategies. In addition, describe two examples from each of the remediation categories ‘engineering’ and ‘process based’ methods and consider any issues and/or limitations for the methods you describe. (any case study examples given marked on merit)

[13 marks]

P Fleming
A Smith
C Hancock

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Standard Formula Sheet for Ground Engineering (CVC106)

Barrier Permeability

$$q = C_B.a.\sqrt{(2.g.h)}$$

$$q = 0.21(h^{0.9}a^{0.1}k^{0.74})$$

$$q = 1.15(h^{0.9}a^{0.1}k^{0.74})$$

Reinforced Soil/Walls

Base Sliding

$$Rs = (\gamma_F.z + q)\ L \tan \phi_{UF} \quad \text{or}$$

$$Rs = C_{UB}.L + (\gamma_F.z + q)\ L \tan \phi_{UB}$$

Earth pressures

$$K_a = (1 - \sin \phi')/(1 + \sin \phi')$$

$$p_a = K_a.\sigma_z' - 2.c.\sqrt{K_a}$$

Soil/reinforcement bond

$$F_T = 2.b.n.L\ (\gamma_F.z + q) \tan \mu$$

Tensile failure

$$T = K_a.\sigma_z'.\ S_V.\ S_H$$

Maximum vertical effective stress at front face

$$\sigma_{v\ max}' = (q + \gamma_F.z).(1 + K_a.z^2/L^2)$$