Ground Engineering and Monitoring
23CVC106

Semester 2 2024 | 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.

Answer **FOUR** questions.

All questions carry equal marks.

A formula sheet is provided.

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1. (a) Describe the components of a landfill lining system and explain the importance of interface shear strength for landfill lining system stability. Use sketches to support your answer.

[9 marks]

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

Table Q1. Liner hydraulic properties

	Clay (0.5 m thick) Liner	Geomembrane Liner	Composite Liner
Clay hydraulic conductivity (m/s)	$1x10^{-8}$	N/A	$1x10^{-8}$
Head of leachate (m)	7	7	7
Geomembrane/clay contact	N/A	N/A	Good
Holes per hectare	N/A	35	35
Hole size (mm^2)	N/A	10	10

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

[9 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. As part of the construction of a new motorway, a road must cross a 19 m wide river. Two reinforced soil bridge abutments have been proposed on either side of the river with a single span bridge deck between them. The ground profile at the site comprises 4 m of soft alluvial CLAY which is underlain by 3 m of fine silty SAND, which is in turn underlain by limestone bedrock, as shown in **Figure Q2**.

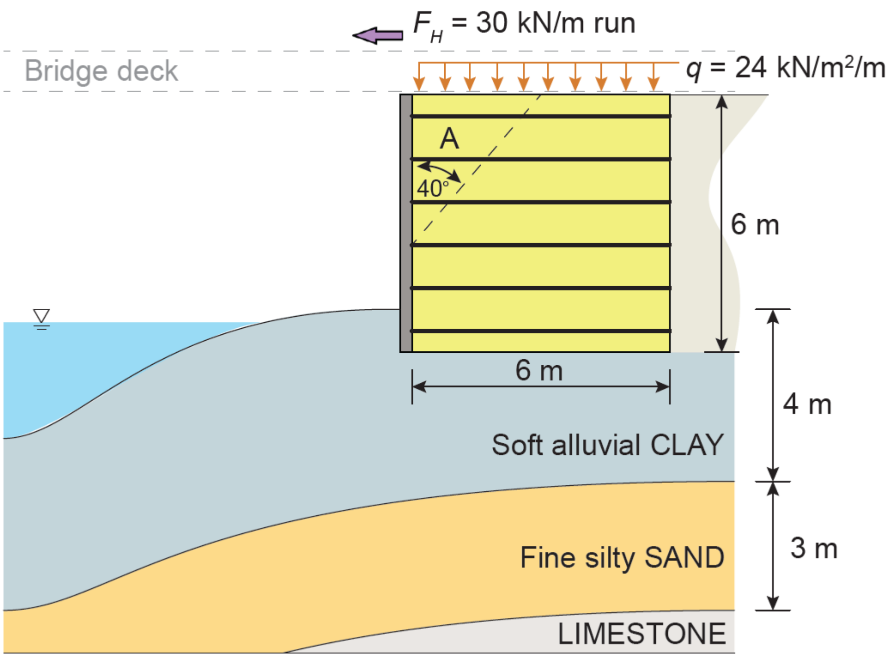

Figure Q2 Reinforced soil wall and site cross-section

a) Discuss the geotechnical challenges associated with constructing the bridge abutments at this site. Discuss the possible *ground improvement* techniques that may be considered suitable to enable the construction of the reinforced soil bridge abutments on this project.

[10 marks]

b) The proposed reinforced soil walls (**Figure Q2**) comprise geogrid strips. The top strips are placed at 0.5 m below the top of the wall, and the bottom strips are placed 0.5 m above the base of the wall. The strips are 0.125 m wide, 6 m long, and the horizontal and vertical spacings are 1.0 m. The 120-year ultimate tensile force is 60 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 23°. The surcharge is 24 kN/m^2/m run, while the horizontal force is 30 kN/m run.

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

[12 marks]

(ii) Comment on your results from (b-i) and suggest design improvements that could be made to the wall.

[3 marks]

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3. a) Using appropriate diagrams, describe how you would establish a temporary benchmark inside a tunnel from control established on the surface via a deep shaft.
[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) Describe the Functions of a GIS.
[8 marks]

b) Describe using appropriate diagrams and examples the difference between raster data and vector data.
[12 marks]

c) Briefly describe “Open Street Map” and explain how the maps are created
[5 marks]

5. a) Describe three important factors that affect the choice of tunnelling method in ‘soft’ ground (e.g. Clay).
[6 marks]

b) With the aid of a sketch, show the steps and assumptions for estimating numerically the surface settlement above tunnels in soft ground and using the data given below, estimate the maximum vertical settlement and the settlement trough width for this proposed tunnel. Clearly explain your assumptions.

Cover depth of the tunnel = 10.5 m; tunnel diameter = 3 m; estimated volume loss at the tunnel = 1.5%; soil profile comprises mainly stiff clay.

Briefly comment on your answer regarding the likely effects on your analysis of the clay being soft not stiff, the tunnel constructed at a shallower depth; or reducing the tunnel diameter.
[13 marks]

c) Give three key objectives for the ground investigation for this proposed tunnel to help plan its design.
[6 marks]

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6. Your Client owns a very large site in Leicester and is considering either: selling it for development; developing it themselves; or doing nothing with it and waiting for land values to rise. The site history is not known in detail but is thought to have included some industrial chemical manufacturing in the 19th and 20th centuries.

   a) Assuming the site is potentially contaminated, for the options being considered, explain what advice you would give to your client to ensure they understand the UK guidance and the implications for them and for their decision.

   [12 marks]

   b) Assume the site is to be developed for a mix of housing and commercial properties and that a site investigation has been carried out (see the description of the site and its geology below).

   Explain your strategy and relevant methods for remediating this site, giving examples where possible.

   [13 marks]

SITE SUMMARY

The site is currently derelict, with no live services, and covering many hectares. It is generally flat and grassed over and marshy in places with a river some 150 m away from its boundary.

The 'Site Investigation Report' in summary showed various depths of made ground of mixed content (silt to gravel size), silt and clay layers (alluvium) up to 4 m thick, overlying sand and gravel layers (alluvium) to up to 10-15 m deep overlying Mercia Mudstone. Limited piezometer monitoring following the fieldwork showed a water table at approximately 3-4 m below ground level. Chemical testing of the soils showed low level contamination across the site at shallow depths of 1-3 m, and one large area of highly contaminated waste buried to a depth of several metres associated with an old waste disposal are/settling pond.

P Fleming
A Smith
C Hancock

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Standard Formula Sheet for Ground Engineering & Monitoring (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

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

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

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

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