# Engineering Tripos Part IIA, 3D8: Environmental Geotechnics, 2020-21

### Module Leader

Prof S P G Madabhushi [1]

### Lecturers

Prof S P G Madhabhushi and Prof A Al-Tabbaa [2]

### Lab Leader

Prof S P G Madabhushi [1]

### Timing and Structure

Lent term. 16 lectures and Lab.

## Aims

The aims of the course are to:

- The aim of the course is to introduce the transport processes of fluids, water and pollutants, in the porous media that constitute the geo-environment.
- The module aims to address the factors that influence groundwater, heat and pollutant transport, practical and design applications and problems that might arise.
- This course aims to introduce the students to the flow regimes that occur in porous media and ways to estimate the flow quantities using flownets.
- Similarly heat flow through porous media is introduced drawing parallels with the groundwater flow.
- Contaminant transport through porous media is another important aspect in geo-environmental engineering that is addressed in this module.
- Practical ways to dispose waste into the ground, the effects the contaminants have on the host soil and necessary aspects of remediation of contaminated land will also considered.

## Objectives

As specific objectives, by the end of the course students should be able to:

- Understand the geotechnical environment.
- Determine flow patterns in steady state groundwater seepage.
- Evaluate potentials, pore water pressures, and flow quantities in the ground by constructing flow nets.
- Anisotropic soils and flow nets
- Seepage below concrete dams
- Seepage through embankment & earth dams
- Excavations and seepage, Cofferdams and stability
- Draw parallels between groundwater flow and heat flow in porous media
- Develop necessary skills to estimate heat storage and extraction from ground
- Introduction to contaminated soil and its remediation
- Understand the soil properties that affect the geo-environment and vice versa
- Develop an understanding of the interactions between soils and contaminants

- Understand the effect of soil contamination on geotechnical properties
- Develop an understanding of the fate and transport mechanisms of contaminants in the ground
- Solving of Advection-Dispersion equation using error functions
- Develop appreciation of the contaminated land/landfills environment
- Understand disposal of waste into well-engineered systems
- Be able to design a solution relevant to land remediation or a landfill

## Content

The following topics will be covered:

**Flow of Water through Porous Media,** is an important aspect in the design of many civil engineering structures such as retaining walls, caissons, excavation for foundations, etc. As it will be shown in the second part of the module, the same physical principles and mathematical concepts can be used to understand flow of heat in porous media, for example, in the design of energy piles or ground source heat pumps.

**Contaminant Transport through Porous Media,** is important to understand the presence of contaminants in the ground and how they are transported through various mechanisms and how they affect the properties of the soil. Equally disposal of waste of waste safely into well-engineered facilities is critical to minimise the environmental impact of the waste.

#### Groundwater, Seepage and Heat Flow in Granular media (8L)

- Introduction
- Concept of porous media and bulk properties.
- Definitions of potential head, pressure head and pore pressure.
- Groundwater flow and seepage
- Theory of flownets
- Anisotropic soils and flownets
- Darcy's law and Hydraulic conductivity
- Laboratory and in situ measurements
- Seepage below concrete dams
- Seepage through embankments and earth dams
- Stability and seepage around excavations
- Coffer dams and their stability
- Fourier’s law and heat flow in porous media
- Parallels between ground water flow and heat flow
- Ground source heat pumps
- Storage and extraction of heat from ground

#### Contaminated Land and transport of contaminants through ground (8L)

- Introduction to contaminated land and contaminants in the geo-environment
- Introduction to waste containment structures – landfills
- The structure of clays
- The clay-water interactions
- The clay-water-contaminant interactions
- The effect of contaminants on the geotechnical properties of soils
- Mechanisms of contaminant transport
- Fick’s law for diffusion in porous media, dispersion and sorption, Peclet’s number
- Solving advection-dispersion equation, Error functions
- Land remediation and waste containment design applications
- Relevant case studies and project examples.

## Coursework

#### Environmental Geotechnical Engineering

Learning objectives:

- Axi-Symmetric flow of ground water into a well boring
- Axi-Symmetric heat flow in saturated soil

Practical information:

- Sessions will take place in [ISG-88], during week(s) [2-6].
- This activity [doesn't involve] preliminary work but read the lab handout prior to the lab session ([1 hr]).

Full Technical Report:

Students will have the option to submit a Full Technical Report.

## Booklists

Please refer to the Booklist for Part IIA Courses for references to this module, this can be found on the associated Moodle course.

## Examination Guidelines

Please refer to Form & conduct of the examinations [3].

## UK-SPEC

This syllabus contributes to the following areas of the UK-SPEC [4] standard:

Toggle display of UK-SPEC areas.

### GT1

Develop transferable skills that will be of value in a wide range of situations. These are exemplified by the Qualifications and Curriculum Authority Higher Level Key Skills and include problem solving, communication, and working with others, as well as the effective use of general IT facilities and information retrieval skills. They also include planning self-learning and improving performance, as the foundation for lifelong learning/CPD.

### IA1

Apply appropriate quantitative science and engineering tools to the analysis of problems.

### KU1

Demonstrate knowledge and understanding of essential facts, concepts, theories and principles of their engineering discipline, and its underpinning science and mathematics.

### KU2

Have an appreciation of the wider multidisciplinary engineering context and its underlying principles.

### D1

Wide knowledge and comprehensive understanding of design processes and methodologies and the ability to apply and adapt them in unfamiliar situations.

**S1**

The ability to make general evaluations of commercial risks through some understanding of the basis of such risks.

**S3**

Understanding of the requirement for engineering activities to promote sustainable development.

**S4**

Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues.

**E1**

Ability to use fundamental knowledge to investigate new and emerging technologies.

**E2**

Ability to extract data pertinent to an unfamiliar problem, and apply its solution using computer based engineering tools when appropriate.

**E3**

Ability to apply mathematical and computer based models for solving problems in engineering, and the ability to assess the limitations of particular cases.

**E4**

Understanding of and ability to apply a systems approach to engineering problems.

**P1**

A thorough understanding of current practice and its limitations and some appreciation of likely new developments.

**P3**

Understanding of contexts in which engineering knowledge can be applied (e.g. operations and management, technology, development, etc).

**US1**

A comprehensive understanding of the scientific principles of own specialisation and related disciplines.

**US2**

A comprehensive knowledge and understanding of mathematical and computer models relevant to the engineering discipline, and an appreciation of their limitations.

**US3**

An understanding of concepts from a range of areas including some outside engineering, and the ability to apply them effectively in engineering projects.

**US4**

An awareness of developing technologies related to own specialisation.

Last modified: 13/09/2020 18:24



**Links**
[1] mailto:mspg1@cam.ac.uk
[2] mailto:aa22@cam.ac.uk
[3] https://teaching.eng.cam.ac.uk/content/form-conduct-examinations
[4] https://teaching.eng.cam.ac.uk/content/uk-spec