Engineering Tripos Part IIA, 3D8: Building Physics & Environmental Geotechnics, 2018-19

Module Leader

Prof S P G Madabhushi [1]

Lecturers

Prof S P G Madhabhushi and Dr R Choudhary

Lab Leader

Dr R Choudhary

Timing and Structure

Lent term. 16 lectures and Lab.

Aims

The aims of the course are to:

- Introduce the physics behind heat, liquid, and mass (air and moisture) transfer in materials,buildings, and energy systems and their interactions with outside environment, both air and ground.
- Provide the foundational knowledge for understanding environmental characterstics of the built environment, with a focus on aspects important for structural durability and energy effi ciency.

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.
- Analyze environmental behaviour of building components, such as heat flow rates, temperature variations (seasonal and diurnal).
- Calculate steady state energy balance for a building to determine hearing, cooling and ventilation demand from auxillary systems.
- Understand how choice of design and components influences the indoor environment and energy consumption of building.

Content

The following topics will be covered:

Flow of Water through Porous Media, which 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.

Heat, air and moisture transfer across building elements: composite roofs and walls, surface-to-air, air gaps, ventilated spaces, transparent envelopes, and heat exchange between surfaces in a room; Heat exchange with ground will be covered for slab-on-grade, sub-surface structures, and ground-source heat exchangers.

The topics cover theoretical aspects of important energy flows through most common building elements, from foundations to the building envelope. This knowledge is also pre-requiste for learning simulation and modelling techniques for energy balance and environmental control systems of buildings.

Groundwater and Seepage (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.
- Darcy's law and Hydraulic conductivity
- Laboratory and in-stu measurements

Heat, Air and Moisture Transfer through Building Elements (8L)

- Conservation of energy, Fourier's laws, concept of steady state, periodic and transient.
- Conduction: 1D heat flow through single and multi -layered structures, response to temperature variations, contact temperature between layers, network analysis.
- Heat exchange with ground: examples of 2D and 3D heat flow between ground and building elements - pipes, slabs, sub-surfaces.
- Radiation: reflectance, absorption and transmission; radiant surfaces and block bodies; heat gains from solar (short wave) radiation, long wave radiation exchange between 2 isothermal surfaces in enclosures.
- Ventilation: Driving forces (wind, stack, mechanical), air exchange rates.
- Infliteration: air through permeable materials, gaps, ventilated cavities, heat losses due to transmission and ventilation.
- Moisture: Water vapour in air and relative humidity, characteristics of moist air, mold and surface condensation, moisture balance of building components and ventilated spaces.
- combined Heat and Mass Transfer: exercised from practical scenarios.

Coursework

Building Physics and Environment Geotechnics

<u>Learning objectives</u>:

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<u>Practical information</u>:

- Sessions will take place in [Location], during week(s) [xxx].
- This activity [involves/doesn't involve] preliminary work ([estimated duration]).
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<u>Full Technical Report</u>:

Students [will/won't] have the option to submit a Full Technical Report.

Booklists

Please see the Booklist for Part IIA Courses [2] for references for this module.

Examination Guidelines

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

UK-SPEC

The UK Standard for Professional Engineering Competence (UK-SPEC) [4] describes the requirements that have to be met in order to become a Chartered Engineer, and gives examples of ways of doing this.

UK-SPEC is published by the Engineering Council on behalf of the UK engineering profession. The standard has been developed, and is regularly updated, by panels representing professional engineering institutions, employers and engineering educators. Of particular relevance here is the 'Accreditation of Higher Education Programmes' (AHEP) document [5] which sets out the standard for degree accreditation.

The Output Standards Matrices [6] indicate where each of the Output Criteria as specified in the AHEP 3rd edition document is addressed within the Engineering and Manufacturing Engineering Triposes.

Last modified: 15/05/2018 15:11

Source URL (modified on 15-05-18): http://teaching.eng.cam.ac.uk/content/engineering-tripos-part-iia-3d8-building-physics-environmental-geotechnics-2018-19

Links
[1] mailto:mspg1@cam.ac.uk
[2] https://www.vle.cam.ac.uk/mod/book/view.php?id=364091&chapterid=46631
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[4] http://www.engc.org.uk/ukspec.aspx
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