4A2 – Hydrogeology and Engineering Geology [5 credits]

Lecturer(s): Assoc. Prof. Bruce Misstear [bmisster@tcd.ie] and Assoc. Prof. Trevor Orr

Module organisation
Department of Civil, Structural and Environmental Engineering

This module consists of 39 hours of lectures and tutorials during the Second Semester. The hydrogeology lectures and tutorials are given by Prof. Bruce Misstear, whilst the engineering geology elements are presented by Prof. Trevor Orr. The teaching strategy (as described later) is to combine lectures with tutorial examples in class, and thus these elements are not itemised separately in the table below.

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<tr>
<th>Semester</th>
<th>Start Week</th>
<th>Hours of Associated Practical Sessions</th>
<th>End Week</th>
<th>Lectures (incl tutorials)</th>
<th>Total Contact Hours: 39</th>
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<tr>
<td>2</td>
<td>1</td>
<td>0</td>
<td>9</td>
<td>5: Wks 1 to 6 3: Wks 8 to 10</td>
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Module description, aims and contribution to programme
This is an applied geology module aimed specifically at civil engineers. The hydrogeology component covers the analysis of groundwater flow, both regional flow and radial flow to wells, with an emphasis on teaching the student to compare and evaluate different methods of analysis, and to critically examine the underlying assumptions. Students are also taught how to plan groundwater investigations in a systematic manner, with the aid of case studies. The engineering geology component deals with the analysis of rock properties and their application to geotechnical problems (as such, this module component is complementary to compulsory modules in the students’ third and fourth years which focus on geotechnical issues in soils).

Learning outcomes
On completion of this module the student will be able to:

1. Solve mathematical problems concerned with groundwater flow, geophysical surveys, rock discontinuities and slope stability.
2. Question the assumptions underlying common methods of groundwater analysis, particularly in the context of the heterogeneous nature of the bedrock aquifers found in Ireland.
3. Develop a conceptual model of an aquifer system and plan a groundwater investigation programme, including identification of suitable drilling, geophysical and other investigation techniques.
4. Appraise rock behaviour in a variety of contexts, such as how to identify and then deal with the occurrence of karst features when designing a road.

Module content

- Groundwater concepts [Prof. Bruce Misstear]
  - Aquifers, aquitards and aquicludes
  - Confined and unconfined aquifers
  - Aquifer properties
- Groundwater flow [Prof. Bruce Misstear]
  - General flow equations
  - Methods of solution: flow nets, analytical solutions, numerical methods
  - Analytical solutions for regional flow in confined and unconfined aquifers
  - Radial flow to wells under steady state and transient conditions
  - Multiple wells: principle of superposition
  - Hydraulic boundary effects
  - Introduction to the use of distributed groundwater models
- Groundwater exploration and development [Prof. Bruce D Misstear]
  - Hydrogeological surveys
  - Geophysical techniques: resistivity, EM, seismic refraction
  - Exploratory drilling methods
  - Formation sampling and geophysical logging
  - Introduction to well design
- Properties of rock and rock mass [Dr Trevor Orr]
  - Engineering geology terminology
  - Standard laboratory tests
  - Logging and discontinuity analysis
  - Stereographic projection
  - Behaviour of rock samples: strength and deformation
  - Behaviour of rock mass
  - Slope failures in rock
  - Analysis of slope stability
  - Hazardous rock conditions, such as karst and pyrite, and their implications for design.

The module outcomes are targeted at analysis and evaluation, and the implications of this evaluation for engineering design and practice. It aims to motivate students to develop an interest in the subject matter, but also to enhance their skills in critical thinking within an engineering context. The applications to engineering practice consider the social and business context.

Teaching strategies
The module integrates formal instruction with analytical and other tutorial-type exercises, an approach that is facilitated by most of the module being delivered in 2-hour slots. The exercises are used to develop the skills of the student in analysing a
problem based on the lecture material, not only with respect to coming up with a mathematical solution, but also to assess its meaning and application. There is a strong emphasis on teaching the assumptions that underlie each analytical approach, and then to consider how well these assumptions are met in practice.

Assessment
Assessment is by one two-hour exam at the end of the second semester. All of the material taught in the module is examinable. Students are obliged to answer questions from both main components of the module i.e. hydrogeology and engineering geology.

Required textbook
Module material includes comprehensive handouts. Some of the material is presented in a way that requires the student to insert additional notes based on the lecture material. Recommended texts include:

Hydrogeology

Engineering geology