Engineering Tripos Part IIB, 4D15: Management of Resilient Water Systems, 2021-22

Leader

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Timing and Structure

Lent term. 16 lectures (Eight 2 hour sessions) + coursework. Assessment: 100% coursework.

Aims

The aims of the course are to:

- Recognise the unsustainable feature of current water engineering practice
- Appreciate the key features of managing the water cycle in a sustainable manner and the need to meet a variety of resilience criteria.
- Be aware of recent practices and developments in managing all aspects of the water cycle in both developed and developing countries

Objectives

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

- Understand the limitations of conventional /traditional water supply and wastewater engineering systems in a sustainability context.
- Appreciate the key features of managing the water cycle in a sustainable manner and the need to meet a variety of resilience criteria.
- Recognise and critically assess the problems and solutions associated with managing water engineering projects.
- Be familiar with key aspects of drainage and wastewater management planning including the merits of Natural Flood Management (NFM) , Sustainable Drainage Systems (SuDS) and strategies for asset selection based on adaptation planning techniques.
- Be aware of the asset management of water infrastructure and how this is influenced by serviceability and levels of service criteria.
- Recognise global issues in relation to the equitable management, distribution and disposal of water under growing environmental, social and political constraints.
- Relect appropriate forms of water supply and sanitation for use in developing countries.

Content

The module will introduce and explore the delivery of water services for water supply, wastewater treatment and flood control, identifying unsustainable aspects of current practice and reviewing more resilient approaches. The changing paradigms of water management towards fully water sensitive cities will be explained to understand how water fits within a wider urban metabolism. The module will describe management strategies for water in both the urban environment and water in the rural environment, through adopting a flexible adaptation planning approach which avoids technical lock-in. The interdependencies between water and other critical resources will be identified with respect to energy use and recovery of nutrients; the carbon budgets associated with the water sector will be assessed. Current progress towards achieving Sustainable Development Goal 6 (Water) will be discussed and the key constraints of delivering essential water services in the developing world will be highlighted

Characteristics and components of water systems (overview)

Potable water treatment and supply. Wastewater collection and treatment. Urban drainage and flood control. Changing paradigms of water management . Unsustainable features of current water management**.** Water as a hazard and an opportunity

Sustainable water engineering and resilience frameworks

5 themes for sustainable water management (less water consumed; local waste treatment and recycling, stormwater retained, climate resilient, minimum energy footprint). System properties and levels of service considerations. Engineering vs ecological resilience; technical vs management resilience. Avoiding technical lock-in to large infrastructure solutions**.** The Safe and SuRe approach; anti-fragile planning of water systems; (*threat based, mitigation focussed* top down water management vs *consequence based, coping focussed* bottom up management strategies)

Water quality issues and resource recovery

Water quality parameters and regulatory requirements; water quality prediction and control; simple river quality models. Engineered systems for resource recovery and re-use

Water in the urban system

Urban water metabolisms; integrated operation of water systems (e.g. rainwater harvesting) ; real time control. Pressure and leakage management in Water Distribution systems. Urban Drainage Systems- purpose, types and historical development. Rainfall and surface runoff. Urban Pollution Management of intermittent discharges at Combined Sewer Overflows. Principles of Urban Flood Risk Management**.** Source control of stormwater and Design of Sustainable Drainage Systems (SuDS Manual)

Flood Risk Management using Adaptation Planning and Adaptive pathways

Concepts of Adaptive Planning (e.g. Thames barrier example). Methodological steps for developing adaptation pathways (London Borough of Sutton Case Study) and appraisal of multiple benefits in Blue Green Cities. Evaluating Blue-Green infrastructure using the CIRIA B£St tool. Preparing Drainage and Wastewater Management Plans

Water in the rural system

Management of water resources, impacts of climate variability, catchment management. Principles of Natural Flood Management (NFM) and Integrated Catchment management (ICM); international experience and practice. Environmental benefits of land management, Upstream Thinking.

Role of water in water-energy-food/land nexus

Hydro-meteorological risks to critical infrastructure (including energy systems); water and energy interdependencies; groundwater implications of shale gas extraction; strategies for a low carbon water industry, UKWIR framework for carbon accounting; energy from water (micro hydro, thermal heat recovery, anaerobic digestion of biomass etc), water for energy in a low carbon energy future; issues around water and food security.

Water in the developing world

Progress towards Sustainable Development Goal 6; global level of access to water services. Water related diseases. Key features of Water Sanitation and Hygiene (WASH) programmes. Systems thinking in WASH. Small community water supply systems. Low cost wastewater treatment (waste stabilisation ponds). On and off site sanitation including dry sanitation.

Coursework

Coursework	Format	Due date & marks
Coursework 1: Individual Research Report on a key water related topic An open ended investigation in further detail of one aspect of water engineering practice Learning objective: • To develop the ability to seek new information and achieve a balanced critique of the existing literature through individual research of relevant details/topics NOT covered in the lecture programme	Individual Report anonymously marked	day during te Thu week 4 [30/60]
Coursework 2: Resilience assessment of one aspect of water engineering practice A critique of one aspect of current water engineering practice (e.g supply, wastewater dispsoal, drainage, development) against resilience criteria and propose key areas for change Learning objective: • To apply a resilience and sustainable mindset to the delivery of water services	Individual Report anonymously marked	Wed week 9 [30/60]

Booklists

1. Ainger C., Fenner R.A. (2016) *Sustainable Water* ICE Publishing ISBN 978-0-7277-5773-9

2. Radhakrishnan M., Lowe R., Ashley R.M., Gersonius B., Arnbkerg-Nielsen K., Pathirana A., Zevenbergen C (2019) Flexible adaptation planning process for urban adaptation in Melbourne, Australia Proceedings of Institution of Civil Engineers – Engineering Sustainability Volume 172 Issue 7 September 2019 pp 393-403

3. Ashley R.M. Gersonius B., Horton B (2020) Managing flooding - From a problem to an opportunity . Royal Society Philosophical Transactions A Volume 378 Issue 2168 Paper 0214

4. David Butler, Sarah Ward, Chris Sweetapple, Maryam Astaraie-Imani, Kegong Diao,Raziyeh Farmani & Guangtao Fu (2016) Reliable, resilient and sustainable water management: the Safe & SuRe approach Global Challenges 2016 (John Wiley)

5. Kate Neely (ed) (2019) Systems thinking in WASH Practical Action Publishing ISBN-078-1-78853-026-2

6. Butler D., Digman C., Makropoulos C., Davies J.W. (2018) Urban Drainage 4th edition. CRC Press ISBN 978-1-4987-5058-5

Examination Guidelines

Please refer to Form & conduct of the examinations [2].

UK-SPEC

This syllabus contributes to the following areas of the UK-SPEC [3] 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.

IA2

Demonstrate creative and innovative ability in the synthesis of solutions and in formulating designs.

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.

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.

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).

P6

Understanding of appropriate codes of practice and industry standards.

P7

Awareness of quality issues.

US1

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

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Links
[1] mailto:raf37@cam.ac.uk
[2] https://teaching21-22.eng.cam.ac.uk/content/form-conduct-examinations
[3] https://teaching21-22.eng.cam.ac.uk/content/uk-spec