Infrastructure and urban systems

ACE095

Course description 2019

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Master Programme Infrastructure and Environmental Engineering 2019

Water Environment Technology, Architecture and Civil Engineering

Chalmers University of Technology

The objective of an engineer is to help public and private decision and policy-makers to solve the problems and resolve the policy issues that they face. Engineers do this by improving the basis for decision-makers judgment by generating information and organizing evidence on their problems and in particular, on possible actions that may be suggested to alleviate them. Thus, a systems analysis commonly focuses on problems arising from the operations of a socio- technical system, considers various responses to these problems and supplies evidence about the costs, benefits, and other consequences of these problems. (Keating, 2014)

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Introduction

Economic growth coupled with increased urbanization, growing population, ageing of infrastructure assets and environmental issues, such as, climate change, are putting pressure on infrastructure demand. To solve this problem, both construction of new infrastructure but also refurbishment, lifetime extension and increased efficiency of current infrastructure stock needs to be made. The demand for infrastructure assets poses multiple challenges throughout their development, for example, planning infrastructure to be resilient to natural disasters, maximizing the efficiency while operating and lack of maintenance.

Additionally, urban areas are shaped by existing infrastructure systems that are also interrelated and interdependent. Infrastructure can enable or constrain the development of cities. Therefore, infrastructure planning and management have to consider societal needs and support a more equal and fair society. This means that knowledge about infrastructure and its connection to urban systems need to be developed with a multidisciplinary approach transcending the common "engineering" perspective. Due to the complexity of the infrastructure systems, there is a need to integrate the stakeholders' perspectives into the answers that engineers can provide to support the development of infrastructure.

Course aim

The course will provide advanced knowledge on the role of engineers on planning, design and construction, operation and maintenance and decommissioning of infrastructure with a systems perspective and with focus on urban systems. The students will learn about the challenges and needs of complex interdisciplinary infrastructure planning and management, where different stakeholders will have different objectives and needs.

Students will also learn stakeholders' relationships in terms of flows of communication, type of information needed and what impact they have on the technical work being developed by infrastructure and environmental engineering students. Additionally, students will learn about trends in infrastructure development, e.g., to be resilient, sustainable and efficient and how they affect complementary infrastructures and urban systems.

Special focus will be given to the main tracks of the MPIEE programme (infrastructure related to water and environment and transportation engineering).

The course also aims at presenting the main concepts about the following concepts, methods and tools: **Transdisciplinary research, Social network analysis, Qualitative research and Systems thinking.**

Learning outcomes

After completing the course, the students should be able to:

- Differentiate between the phases of infrastructure and urban systems (e.g. planning, design and construction, operation and maintenance and decommissioning), and relate to their connection with the engineering role.

- Demonstrate the relationship between infrastructure, urban system and connected concepts, in particular land, water, transport, energy and waste.
- Describe responsibilities and types of information needed to plan, design, operate, maintain and decommission infrastructure.
- Select and collect relevant datasets related to infrastructure and urban systems.
- Select appropriate strategies for infrastructure and urban systems to make the planning, design and construction, operation and maintenance and decommissioning more resilient, sustainable and efficient.
- Quantify and argue for trade-offs, giving priorities to solutions, and how well they meet both ethical and technical constraints.
- Read and use technical texts and scholarly articles in a conscious, critical and effective manner.
- Apply systematic approaches by taking a holistic perspective.
- Specify the multiple roles that actors have and what type of activities need to be conducted depending on the stakeholder type.
- Work in groups in a multi-cultural international setting.
- Understand the type of information to communicate with different stakeholders.

Course content and organisation

The course is designed around: lectures on key aspects of Infrastructure and Urban Systems, mainly Traffic and Water; a group project; and an individual assignment. This combination of activities is planned to provide the students with information and to help them develop an understanding of critical issues in the areas of infrastructure planning and management processes.

The course is planned around 5 modules:

Module 1 include a set of lectures where students will learn about **background information on infrastructure**
Module 2 reflects on the **challenges faced today in cities** and how they affect infrastructure planning and management.
Module 3 aims at providing **concepts, tools and methods** to understand how to describe and analyse infrastructure decision making processes throughout the phases of planning and management. This part includes exercises done in class.
Module 4 covers the **infrastructure sectors,** focusing on concrete aspects of planning and management within the waste, traffic and water sectors.
Module 5 is the **assignments** module and puts into practice the concepts learned through a case study performed in groups and individually. This part includes a group project and an individual assignment.

Lectures

A series of lectures on relevant topics will be given to support knowledge development. The lectures should provide basic concepts in specific topics, as well as contextualization for these topics. The lectures will be given by a combination of course and invited lecturers.

- **Course overview, Cities as complex systems, Sustainable Development Goals and Agenda 2030, Group project description, Infrastructure development case study, Systems thinking in infrastructure development, Individual assignment guidelines, Waste planning and management,** Leonardo Rosado
- **Stormwater, stakeholders and communication**, **Urban Water Management,** Sébastien Rauch
- **Future infrastructure development challenges**, Anna Kaczorowska
- **Wicked problems and infrastructure**, Alexandra Lavers
- **Multi-stakeholder theories and methods,** Marco Adelfio
- **Social Network Analysis,** Clara Camarasa
- **Qualitative analysis,** João Patrício
- **Transportation engineering**, Ivana Tasic

The lecture slides will be available on Canvas after each session. Complementary readings will be available before the lectures.

Concepts, tools and methods

During the course, several concepts, methods and tools will be taught covering different aspects of system analysis for infrastructure and urban systems.

Transdisciplinary research

*Explained in lecture **Wicked problems and infrastructure***

Transdisciplinary Research is defined as research efforts conducted by investigators from different disciplines working jointly to create new conceptual, theoretical, methodological, and translational innovations that integrate and move beyond discipline-specific approaches to address a common problem.

Multi-stakeholder theories and methods

*Explained in lecture **Multi-stakeholder theories and methods***

Several concepts, tools and methods are used to support stakeholder dialogues in planning. Top-down and bottom-up approaches, and driver-based and stakeholders led approaches which include an introduction to several specific tools, such as, Actor-network theory, onion diagrams, salience mode, influence-interest matrix and social network analysis among others.

Social Network Analysis

*Explained in lecture **Social Network Analysis***

Social network analysis (SNA) is the process of investigating social structures through the use of networks and graph theory. It characterizes networked structures in terms of nodes (individual actors, people, or things within the network) and the ties, edges, or links (relationships or interactions) that connect them.

Systems thinking

*Explained in lecture **Systems thinking in infrastructure development***

A key aspect to an infrastructure system is developing a process to enable informed decisions as to the potential for loss in the face of uncertain conditions. Decision analysis provides insight about the problem, uncertainty, objectives, and trade-offs. Such an analysis is needed to

construct models of uncertainty and preferences necessary to evaluate a decision. A strategy is to reduce a complicated problem into something smaller so that it can be more readily analysed and understood. Systems analysis offers a more holistic approach to assessing a problem. The process provides a disciplined way of structured thinking grounded in a common worldview.

Qualitative research
*Explained in lecture **Qualitative analysis***

Qualitative research is a scientific method of observation to gather non-numerical data. This type of research "refers to the meanings, concepts definitions, characteristics, metaphors, symbols, and description of things" and not to their "counts or measures". Qualitative research approaches are employed across many academic disciplines, focusing particularly on the human elements of the social and natural sciences.

Learning style

The assignments are organised as a problem-based learning (PBL) project with focus on a type of infrastructure. PBL is a process that consists of four phases:

- Identification of a problem instead of facts and theories;
- Co-operative identification of skills that need to be learned or developed;
- Self-study to solve the problem;
- Summary and argumentation based on the learned and developed skills.

PBL therefore allows for the students to acquire or extend skills to improve student's knowledge that can be applied in a professional setting.

Assignments

Group Project (3,5 credits)

Supervisors: Leonardo Rosado, Sébastien Rauch, João Patrício and Divia Jiménez

The aim of the project is to understand the complexity of decision-making processes within an urban challenge related to an infrastructure system. You will work in groups, and study a real example case study.

Each group has to identify a case study within the chosen topic. The case study needs to be a city with multiple planned or applied solutions within an infrastructure system that address an historic or current urban challenge. The final output of the group work will be a PowerPoint and a summary report, with an overview of the case study as well as an analysis of the problem and proposed solutions. The PowerPoint presentation and summary report should use the following structure and answer the following questions:

1. **Urban challenge definition:** Define the challenge/s you are focusing. Motivate your choice. Identify who is affected. Choose an infrastructure system affected.

2. **Case study description:** Identify a city affected by the challenge. Describe the city in terms of its main characteristics with focus on the chosen infrastructure system. Show figures and numbers.
3. **Infrastructure analysis:** What role can the infrastructure system and supporting policy decisions play in solving the identified urban challenge? What data (regular reports, statistical data, regular measurements, etc.) exists or can be created to help inform the challenge? Who are the stakeholders and what are their roles in the planning and management process?
4. **Solution identification:** What infrastructure solutions were found and at what level – and from whose viewpoint? How does it address the challenge?

The groups have 2 group project consultation meetings with the supervisors, these meetings are mandatory. The schedule for each group will be provided by the course administrator.

Presentations of the Group Project should be made in English and can be up to 10 minutes. The presentations will be followed by a discussion session where the group needs to answer questions during a 3 min lead by another assigned student group. The discussion lead groups will have to come up with questions based on the presentation. The discussion lead is not graded.

We expect all group members to participate in the presentation seminar, but it is up to the group to decide who does the presentation and who leads the discussion for another group's presentation. The presentation should be presented both orally and in the format of a PowerPoint. Presenters should be prepared to answer questions from anyone in the audience, not just the discussion lead group. The PowerPoint has to be uploaded in Canvas on the day that the presentation takes place.

The summary report should be two pages with font size 11 and normal spacing and the document should be uploaded in Canvas with the PowerPoint pdf.

Throughout the group work, the students must submit their work, as specified below.

Group Project Timeline:

Each student will sign up in Canvas for their preferred TOPIC (between 17:00 11/09/2019 and 12:00 13/09/2019). During the afternoon of 13/09/2019, teachers will inform by Canvas who are the group members (groups of up to 5 students will be randomly formed within each topic). Specific case studies will be selected by the students in the group afterwards.

- Group project preparation document submission: by 17:00 19/09/2019
- Group project draft submission: by 17:00 30/09/2019
- Group project consultations: 23/09/2019 and 02/10/2019
- Group project presentation: 09/10/ 2019

Groups have to submit the PowerPoint and the summary report through Canvas by 17:00 09/10/2019

Individual assignment (4 credits)

Supervisors: Leonardo Rosado, Sébastien Rauch, João Patrício and Divia Jiménez

Each student will prepare a report to address and expand on a specific aspect of their group project. The length should be maximum 2,500 words (include the number of words in your document), excluding abstract, tables and references (General writing guidelines can be found in the Course information module in Canvas. Specific guidelines will be discussed in the lecture **Individual assignment guidelines**).

The aim of the individual assignment is to analyze the decision-making process through planning and management stages. Each student will be studying an existing solution of their choice, from those presented in the group work. The solution choice is done individually. The objective is not to change the solution, but to evaluate whether the decision-making process was effective.

Students are expected to use the concepts (and justify the use of them!) presented in the lectures, including:

Concepts to be used: Stakeholder mapping (e.g. Social Network Analysis) and Qualitative research.
Optional: Transdisciplinary research and Multi-Stakeholder theories and methods

The report should be developed addressing the topics below:

1. Use the summary of group work to present the case study, focusing on a chosen solution (your report needs to work as a stand-alone document).
2. Select a specific infrastructural solution that was planned or implemented. Use the course's Life cycle perspective diagram to place the solution in the correct planning and management stage and justify your option.
3. Choose at least one planning or management stage of the chosen solution to focus your analysis. The analyzed stage/s can be the one identified in #2 and/or any previous stage/s.
4. Use qualitative research to: define the research question/s, identify the stakeholders involved in the decision-making process; the flows of communication/information required; and the technical and legal requirements considered.
5. Use the Social Network Analysis to map the network of relationships between stakeholders (What were the responsibilities of stakeholders? Were stakeholders more or less important during different stages of the project?) and discuss the results obtained
6. Discuss possible improvements in the decision-making process and propose recommendations. Motivate your choices.

The students have 2 individual assignment consultation sessions, one optional and one mandatory. Attendance to the optional consultation will be defined by a doodle link. The schedule for each student will be provided by the course administrator. Students must submit their work, as specified below.

Individual Assignment Timeline:

- Optional consultation: 16/10/2019
- Draft report submission: by 17:00 18/10/2019
- Mandatory consultation: 23/10/2019

Students have to submit the report through Canvas by 17:00 30/10/2019

In-lecture exercises (Pass/Fail)

Exercises in class for the lectures on **Qualitative analysis** and **Social Network analysis** have to be handed-in. Students can only pass the individual assignment if they submit their exercises in Canvas. The submission is individual. The exercises will not be evaluated but, if asked, feedback can be provided by the specific lecturers.

Literature

Recommended reading for this course will be provided on the Canvas course page. Further information can be found from a variety of sources, including scientific journals (available from the Chalmers library website), books and the internet. We recommend you to ensure that the information you get (especially from the internet) is reliable.

We recommend the use of scientific databases available on the Chalmers Library website, including Science Citation Index, Scopus, ScienceDirect and Springer Link. Some of the articles and books can be read online.

Communication

We ask for communication between students and teachers is made through Canvas messages or email using Chalmers credentials (Chalmers email).

For group work, students should identify a spokesperson that communicates with the supervisor.

Teachers will reply to students' enquiries as soon as possible.

Writing guidelines

Report writing

For report writing please read "**Writing guideline for reports, BSc theses, MSc theses at Chalmers University of Technology**" (*available in Canvas in Course Information module*). Number all tables and figures; table notations above the tables, and figure captions below the figures. Refer to all tables, figures and references in the text. Summarise and discuss them in the text and make conclusions from the results. When writing the report, *you must use your own words* (no copy from references) and cite (in-text) the references you use. Follow the Harvard system (author-date) for in-text citation. This means that the author's last name and the year of publication should appear in the text, e.g. "Safe water is key to sustainable development (Jones, 1998)" for one author, (Jones and Smith, 1998) for two authors, or (Jones

et al., 1998) for three authors or more. It may also be on the format: “According to Jones (1998), Safe water is key to sustainable development”. A complete reference should appear in the reference list at the end of the report. The complete reference implies that you give the information needed for another person to find that reference (e.g. URL for Internet sources, complete report title, publisher, ISBN etc.).

Plagiarism

Direct copying from the Internet, literature or your classmates is strictly prohibited!!

We verify all assessments via the Urkund system. Urkund controls all documents submitted against three main sources; the Internet, published material, and Urkund archives (e.g. reports from previous years). All documents, which are controlled through the system, are stored in Urkund archives and prevent plagiarism from former and fellow students. For further information, please read the document “Academic honesty and integrity at Chalmers”.

Assessment and grading

Continuous assessment is the central examination form in this course. Grading is based on the individual assignments and the group work, as described below. All assignments are graded on a scale of 0.0-5.0. The final grade is F (fail), 3, 4, 5 with 5 being the highest grade.

Exercises for lectures on Qualitative analysis and Social Network Analysis are mandatory and are graded only pass or fail. The grade for the group work is the same for all the group members.

Assignment	Component	Percentage of credits	Credits
Group work	Powerpoint Presentation Report	70% 10% 20%	3,5
Individual assignment	Report Qualitative analysis exercise Social Network analysis exercise	100% Pass/Fail Pass/Fail	4

Compulsory attendance

Attendance to supervised group sessions and presentations is compulsory and will be verified. If you miss any of these instances, please email the course administrator Divia Jiménez and provide a motivation.

You are expected to actively participate and contribute to the group work. Submission of all assignments (Individual assignments, group work, selected exercises) is compulsory and should be done according to the schedule.