Course Title: Principles of Infrastructure Sustainability

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Lecturer
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Office: G170
Office Hours: Thursdays, 1:00pm-2:00pm, G170; and by appointment

Class Time and Location
Mondays and Wednesdays, 08:30am to 10:00am, 3556 DANA.

Course Website and Credentials
We will use Canvas for the course. The syllabus, assignments, reading materials, and announcements will be posted to the Canvas site.

Prerequisites
Need to be comfortable with algebra and conversion of units.

Course Description
Understanding the principles of infrastructure sustainability is the foundational element for current and future industrial ecologists and engineers. Every year, a massive amount of materials and energy is being supplied for constructing and maintaining, and for operating the infrastructure systems, respectively. Also, the potential for infrastructure to attain societal goals and environmental pledges has been now recognized by governments. The $2 trillion investment of the federal government for reshaping and overhauling the nation’s infrastructure can be perceived as a foundational transformation towards sustainable infrastructure. However, to make a meaningful solution for investing in sustainable constructions, a deep understanding of the infrastructure components and their interactions with ecosystem services is required. In fact, most contemporary cities have yet to understand the criteria and the extent to which can be achieved by the increased investment in the infrastructure. The extensive potential of resources and alternatives as well as interconnections of infrastructure systems provide great opportunities for the authorities to superpose the sustainability benefits under a constraint budget as well as increased investment.

This course enlightens graduate students to the emerging field of infrastructure sustainability from multiple disciplinary perspectives, primarily sustainable systems, urban planning, policy analysis, civil
engineering, and architecture. The course provides students with lectures around the concept and methodological tools in which to explore the life cycle impacts of infrastructure systems and buildings considering their context and interconnections. Different assessment tools and analytical approaches will be introduced, and examples will be provided to assess multiple aspects of infrastructure projects, such as buildings, roads, railways, and bridges. A separate module will consist of urban infrastructure sustainability. The importance of climate change on the life cycle performance of infrastructure and solutions to improve the sustainability impacts will be discussed.

**Intended learning outcomes**

At the end of this course, students should be able to:

- Identify the key drivers of sustainability impacts in infrastructure life cycle.
- Propose the solutions for impact reduction at different stages of the project and life cycle phases.
- Contemplate the interaction of built environment elements and its role in net-zero goal targets.
- Envision the importance of climate change in the sustainability evaluation of infrastructure.

**Topics Covered**

**List of Topics**

I. **Introduction to Infrastructure Sustainability**
   - High-level introduction and implications of infrastructure systems on the community
   - Project and homework description

II. **Sustainability impacts of infrastructure systems**
   - Infrastructure design and operation principles
   - Infrastructure types and life cycle phases (embodied vs. operational)

III. **Variables and processes in the infrastructure sustainability**
   - Construction materials and methods
   - Infrastructure aging
   - Stakeholders and contributions

IV. **Urban metabolism and symbiosis**
   - Infrastructure’s interactions and symbiosis
   - Urban Heat Island effect

V. **Consequences of climate change on infrastructure sustainability performance**
   - Climate change impacts on the life cycle impacts and resiliency.
   - Adaptation vs. optimization
VI. Sustainability improvement and decarbonization of infrastructure sectors
- Net-zero impact, reduction priorities, and compensation necessity
- Carbon sinks and trade-offs between embodied and operational.

VII. Project presentation.
The class-by-class topics will be posted on the course website.

Readings
Specific readings will be announced on Canvas under the “reading” folder and will be posted before each class.

Supplementary Textbooks
Students may find this supplementary resource valuable, but it is not required for the course:
The Rightful Place of Science: Infrastructure in the Anthropocene, Mikhail Chester and Braden Allenby, Publisher: Consortium for Science, Policy & Outcomes, ISBN-10: 0999587781.

Evaluation

<table>
<thead>
<tr>
<th>Class Participation</th>
<th>15%</th>
<th>Depending on the active participation</th>
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<tbody>
<tr>
<td>Written report</td>
<td>20%</td>
<td>See the project description below</td>
</tr>
<tr>
<td>Project Presentation</td>
<td>20%</td>
<td>See the project description below</td>
</tr>
<tr>
<td>Homework</td>
<td>15%</td>
<td>See the homework description below</td>
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<tr>
<td>Final Exam</td>
<td>30%</td>
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The participation grade is based on in-class participation in weekly lectures and discussions. Students will be asked to help lead a class discussion on assigned reading(s).

Homework
There is one homework associated with the quantification of the greenhouse gas (GHG) mitigation solutions for urban heat island effect in a city. Student will calculate the GHG savings and burdens associated with different solutions in a geographical context (e.g., a city) for a given morphology characteristics (e.g., different buildings density and height) according to the input data and emission factors that will be shared with them. Along with the calculation, a 1–3-page results discussion is required. Homework results discussion should use 1-inch margins, 12-point fonts, and double spacing.
Project

Overview: A course project will be conducted either individually or as a group of Max 2 persons. The project will be based on the quantifications and simulation of environmental and service life performance of concrete mixtures using the eco-concrete tool (publicly available tool).

Expectation: The project must include quantitative and qualitative components. Students are expected to define a base case concrete mixture following the instruction provided by the instructor and develop an alternative mixture with minimized environmental impacts while maximizing the concrete structure service life. Students are encouraged to seek for local sources of materials to improve the environmental impacts of alternative mixtures.

Reporting: The length of the project report must be between 10 and 20 pages and begin with one-page Executive Summary. Project reports should use 1-inch margins, 12-point fonts, and double spacing. Additional information can be included as Supporting Information or Appendices (this can be additional text, additional calculations, and tables of data, that support the main text). The project report must be submitted in DOC or .DOCX format. The APA referencing style should be used for the citation and include a bibliography at the end of the report. This bibliography does not count towards the length requirement.

Presentation: Students are expected to present their project report in a 7-minute presentation and 3-minutes Q/A.

Grading: Projects will be graded based on the comprehensiveness of the proposed solution, the accuracy of the results generated and presented, and the generation of policy and decision-based conclusions. 10% of the project grade will be the class presentation. Late assignments (homework and report) will be accepted within 24 hours of the due date and time with a 10% reduction of the initial grade (assignments will not be accepted after this 24-hour late window).

All assignments should be prepared for submission as if you are in a professional environment. Appropriate writing should be used to introduce the problems you are assessing (e.g., in homework) and discuss/describe results, regardless of whether the assignment asks for a writeup. Your name and the name of the assignment should appear at the top of your assignments. Points will be deducted for poor grammar and spelling.