On-Site Research Seminar Syllabus
Barbara – University of Oxford

1. Overview

<table>
<tr><td>Title</td><td colspan="3">Introduction to civil and environmental engineering</td></tr>
<tr><td>Targeted Students</td><td colspan="3">The course does not require any prior knowledge. Any high school student who is comfortable with basic physics (e.g., vector notation, Newton’s law) and basic mathematics (e.g., scalar algebra, vector algebra, and basic trigonometry) is welcome to join the course.

Students will receive basic introductory lessons on engineering materials such as steel and concrete and so they don’t need to know these materials in advance.

You can participate even if your English is not perfect. This course is a good course to improve your language skills.</td></tr>
<tr><td rowspan="4">Prerequisites</td><td rowspan="2">High School Students</td><td>Required course/Knowledge</td><td>Basic physics (e.g., vector notation, Newton’s law)
Basic mathematics (e.g., scalar algebra, vector algebra, and basic trigonometry)</td></tr>
<tr><td>Recommended Materials for preparing for the course</td><td>E.g.,
Newton's Laws: Crash Course Physics #5
Torque: Crash Course Physics #12
Skyscrapers, Statics, & Dynamics: Crash Course Engineering #26
by Shini Somara</td></tr>
<tr><td rowspan="2">College Students</td><td>Required course/Knowledge</td><td>Undergraduate physics and mathematics</td></tr>
<tr><td>Recommended Materials for preparing for the course</td><td>Reading: Structures – theory and analysis – Williams & Todd</td></tr>
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2. Program Introduction and Objectives

Course Description	

This Research Seminar is a dense introduction to the fundamentals of civil engineering. It responds to three main questions: What is a structure (e.g., a bridge)? How it carries forces (e.g., the weight or the wind)? What are the environmental impacts of key construction materials?

During this course, the student will learn how structures are idealized, what type of forces act on them (weight, snow, wind, traffic), and how to check that simple structures (such as dry-stone bridges) are in equilibrium. They will also learn how to calculate environmental impacts such as *Global Warming Potential* (GWP, kg CO2 equivalent also named carbon) and *Total Energy* (PE, in MJ) of key construction materials to evaluate embodied environmental impacts. This is extremely important in today's society where we must decrease our environmental impacts.

Indeed, the construction sector is one of the most resource- and waste-intensive economic activities. It is responsible for ≥40% of all carbon emissions and for ≥50% of the global raw material consumption. Carbon embodied in constructions will be responsible for ≥half of the entire carbon footprint of new construction between now and 2050, threatening to consume an immense part of the remaining carbon budget. The current enduring environmental crisis demands significant carbon reductions in the construction sector. For example, one-quarter of steel produced annually is used in the construction sector, the potential decrease of environmental impacts associated with a more efficient use of steel in our built environment is thus colossal.

During the project discussions, with the professor and the mentor, we will look at different topics: forces acting on the structure (weight, snow, wind, traffic), materials used to build the bridge, how the structure was built, how to calculate basic environmental impacts and how to diminish them.

The final outcome will be in the form of one presentation per student (10') and one report per group. The report due date is one week after the end of the program. The student will find information on one specific case-study (research project) and, with the professor, assess how relevant it is. Journal papers, books, newspapers, video's, images…will be consulted and analyzed. While reading and searching, the student will gain technical knowledge as well as extensive reporting knowledge important for university. Information will be understood, extracted, and summarized.

The subject of the essay will be chosen by the students in collaboration with the professor. Many types of subject topics are possible. For instance (this is just an example!), one *theme* is **Environmental impacts of construction site.** The building sector is receiving increasing attention in worldwide policies for sustainable development. This attention arises from its energy consumption and Green House Gas (GHG) emissions. Certainly, in the current context of resource depletion, sustainable buildings are often confused with energy efficient buildings. However, the awareness that sustainability must consider various aspects is increasing. Especially, the construction site is seen as potential lifecycle phase to achieve more sustainable operations involving a decrease of the environmental impacts linked to transport and construction operations, a reduction of the waste and dust production, a diminution of the negative effects to the surrounding community (noise, traffic...). The following *research topics* can be studied by one group: How can we effectively calculate the environmental impacts of construction sites? What are the environmental impacts of construction site operations? Machines, cranes, vehicles and so forth are used daily on construction sites. These machines and the workers using them lead to an environmental print which cannot be neglected. What is the proportion of environmental impacts dedicated to the construction phase in comparison to other lifecycle phases of constructions? How could we evaluate it? Are they database?

Software/Tools (if any)	**Word, Web browser, PowerPoint**

3. Program Schedule

Part 1

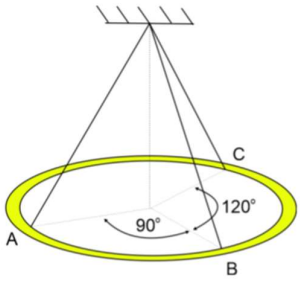
Lecture: What is a force? What is a structure? What is equilibrium?

The lecture contains introductory material, math's (vector algebra, Newton's law) and small exercises at the end. The small exercises will be solved "live" with the instructor to train for the problem set 1. The solved exercises are like those given as homework.

Mentor Session: Tension forces in cable structures

Homework: The student will receive simple problem sets that replicate the level of knowledge expected by undergraduate students following a course in engineering at university level. They will be given guidance and help on how to solve these problems as well as feedback on their solutions.

Problem set 1: one example of problem is the one of a suspended lamp and how to find the forces in each cable:



Reading Materials: Lecture notes "Statics Lesson 1" (The lecture is given by the instructor. All slides will be sent to the student using the interactive platform Ed after the lecture, guidance will be given about this as well.)

Part 2

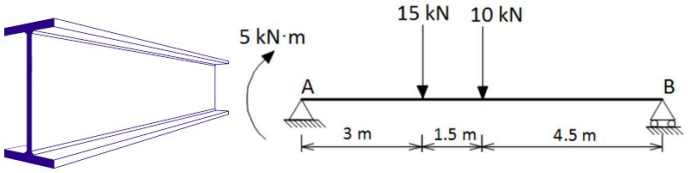
Lecture: How to calculate a simple static structure?

The students now understand what a force is, what Newton means and why structures are in equilibrium. It is now time to apply these concepts together to see if we can calculate the reaction forces i.e., how large are the forces acting onto the ground.

Mentor Session: Reactions in beam structures

Homework: Here too, the student will receive simple problem sets and loads of help from the mentor. The problems replicate what is done during the lecture. Simple structures are calculated. There is no need for software or computer, basic calculator is enough.

Problem set 2: one example of problem is the one of a horizontal beam submitted to a series of forces and how to find the reaction forces:



Reading Materials: Lecture notes "Statics Lesson 2"

Part 3

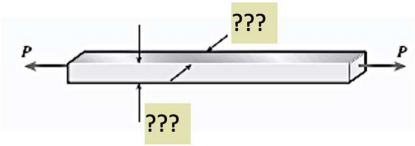
Lecture: Introduction to metals, concrete and reinforced concrete and their environmental impacts.

We are now ready to use our previous knowledge to design simple engineer structures like a beam. It means that we are ready to calculate the minimum dimensions required to sustain a force. For that we first need to know the basic mechanical characteristics of steel and concrete. That is the topic of this lecture.

Mentor Session: Design of a steel bar, calculation of GWP and PE.

Homeworк: For the first time, the students will be able to compare strength and external forces. It is a very important step of all engineers' lives when we design (i.e., give proper dimensions) components. This is the topic of the third problem set.

Problem set 3: one example of problem is the one of a steel bar in tension and how to find its best cross-section dimensions:



Reading Materials: Lecture notes "Steel", "Concrete" and "Reinforced concrete"

Part 4

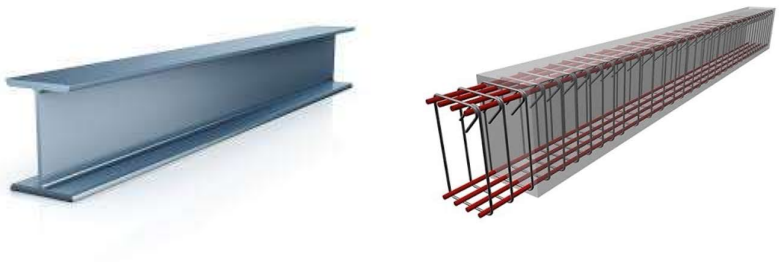
Lecture: How does a bridge transmit a force to the ground?

The last lecture will introduce bridges as structures. Beam, arch, cable-stayed, truss, suspended bridges will be described. For example, we will look at the Golden Gate bridge and check how large the steel cables were. At this stage, it is very exciting for the student for once in their life to finally completely understand how forces pass through the bridge to get to the ground.

Mentor Session: Serviceability and ultimate limit states

Homeworк: The same applies here where the students are proposed to design simple structures using steel and concrete and respond to questions related to the behavior of bridges.

Problem set 4: one example of problem is where simply supported steel beams are compared to reinforced concrete beams



Reading Materials: Lecture notes "Types of bridges" and "Genoa – The story of the collapse of a bridge"

Part 5 Final Project Phase I
Lecture: Students will discuss their chosen topic.

Example, discuss the type of bridge that is studied and the forces acting on the structure (weight, snow, wind, traffic).

During the project discussions, students will work in group of 2 to 3 people (this will be done randomly but according to the students' level of expertise and interests) and will study a given structure (e.g. the famous Golden Gate bridge). Each group will go over the type of bridge that they chose prior to the class with the professor to make sure its workable. The professor makes sure in advance that enough material is available online (papers, books, video's…).

During the session, mini conversations are organized during which the student shows what he has found and discusses the relevance of the paper with the professor. Students will also go over the information they collected about the bridge with the instructor. The professor will also discuss with students the questions raised by them regarding the chosen structure. If a question cannot be answered, the professor will share her screen and show where and how to find information and copy these in the chatbox.

During the discussions, the emphasis will be put on what the student has completed about the final project and what still need to be done.

If time allows, a mini presentation will be given on "How to find a good reference" by the professor.

Mentor Session: With the mentor, we will look at all previously cited topics i.e., type of bridge, forces acting on the structure.

More questions usually arise at the mentor session, the mentor then help by sharing information on his/her screen or copying them in the chatbox.

If time allows, the mentor and students will also discuss how to write a report and how to make a good presentation to the public. A second mini presentation on the topic "How to make a good impression with PowerPoint" will be given by the mentor. The mentor will give guidance for the final presentation, e.g., how to use videos found online, how to build a simple scale model and test it with weights to show how forces are transmitted (using scales) and where the maximum displacements will occur (using lasers).

Part 6 Final Project Phase II
Lecture: Students will discuss specific parts of their chosen topic.

Example, discuss how the structure was built and draw the structure at scale. Indeed, if the type of structure and forces applied are now defined, it is time to uncover how the structure was built and draw bridges at scale; discuss the materials and their respective volume, weights and impacts.

Also, at this point, each student should have already decided which specific topic related to the chosen case-study he/she wishes to present according to his/her own personal passion.

Mini discussion will occur regarding:

- Specific topic related to the chosen case-study he/she wishes to present,
- Their written ideas to receive direct comments from the professor,
- Questions regarding the chosen structure.

These can also be further discussed with the mentor.

If time permits, on the topic of the construction methods, videos are watched with the professor. This can also happen at the mentor's session.

Teaching Fellow Session: Again, with the mentor, we will look at the previously cited topics of construction phase and drawings. More questions usually arise at the mentor session, the mentor then help again by sharing information on his/her screen or copying them in the chatbox.

In between Part 6 and Part 7, each student will have the chance to send a mail to the mentor with all the questions he/she still has about the final presentation.

Part 7 Final Oral Presentation and Written Reporting

4. Final Oral and Written Project

4.1 Final objectives for Phase I and II

Phase I: Students are required to meet the following objectives before attending the session in Part 5:

- Have attended all theoretical lectures (Part 1 – 4), unless unforeseen and reasonable circumstances are preventing the student to and have been discussed in advance with the faculty, in which case, the lecture is reorganized with the mentor,
- Have attempted all problem sets and discussed their mistakes with the mentor.
- Have chosen the type of bridge that will be studied based on the lecture of Part 4, with the professor's and the mentor's help,
- Have collected information following the guidance of the professor given on Part 4.
- Have prepared their questions to ask to the professor regarding the chosen topic.

Phase II: Students are required to meet the following objectives before attending the session in Part 6:

- Have attended Phase 1's presentations, and online discussions,
- Have chosen and started to describe their topic, for example the type of bridge that is studied based on the lecture of Part 4, with the professor's and the mentor's help,
- Have defined specific parts of their topic, for example, the forces acting on the structure (weight, snow, wind, traffic), with the professor's and the mentor's help, based on the lectures of Part 2 and 3.
- Students get prepared to share part of their written ideas to receive direct comments from the professor.
- Have decided which specific part related to the chosen topic he/she wishes to present in Part 7 according to his/her own personal passion and discuss it with the professor.
- Have prepared their questions to ask to the professor regarding the chosen structure.

4.2 Final Oral Presentation Requirements (e.g., if slides needed; Format; Criteria; Deadline)

The final presentation is given on Part 7. It lasts 10 minutes per student followed by a 10' Q&A session. It is a personal presentation and not a group one.

The student should use all the prepared material of Part 6 and 7 to prepare the presentation using what media he/she prefers i.e., PowerPoint, videos, images, etc.

It is not necessary to present all the parts worked on during week 6 and 7 but the student can decide to focus on one preferred part.

Example, focus on the materials that were used to make the bridge.

Following the professor's guidance, a simple scale model of the structure can be made (e.g., using craft sticks or else) and tested with weights to show how the structure works.

4.3 Written Project Requirements (e.g., word count; style; criteria; Deadline):
The final outcome will be in the form of one report per group. The report due date is one week after the end of the program. Its length is maximum 10-15 pages including graphs, tables and references, font 11, single spacing, 2cm margin and cannot be shorter than 6 pages. For two weeks (Part 5 and 6), students will have looked at different questions.

Example of questions: type of bridge, forces acting on the structure, materials used to build the bridge, how the structure was built, what are the environmental impacts, how to diminish the impacts.

Likewise, the report can thus be divided in four parts plus introduction, conclusion, and reference list thus 7 parts in total.

The report is not individual. All questions raised must be covered. It is written by the group. The same groups as those previously used during Weeks 5 and 6 will be kept.

5. Suggested Future Research Fields/Direction/Topics
Burg Burj Khalifa or Empire State building?
Why is the golden gate bridge so iconic?
Can metals always be recycled?
How can buildings be more sustainable?
Can we build windmills using 3D printing?