Info booklet September 2024
Construction Materials Track
& Structural Engineering Track

Msc Civil Engineering
TU Delft

UBASE

Preface

This booklet was created to provide further information about Construction Materials and Structural Engineering tracks for first years Civil Engineering Masters students, aiming to assist on their track selection. General information about each module is given alongside student experiences. The experiences were written by students that took the respective modules and units in the academic year of 2022-2023 & 2023-2024.

It is important to note that this is not an official booklet of the university. The official brochure from TU Delft can be found on the website: https://filelist.tudelft.nl/TUDelft/Onderwijs/Opleidingen/Master/MSc_Civil_Engineering/MSc-CE.pdf

Also, since 2022-2023 was the first year of the new master programs, the courses referred herein are subject to adjustments for the next academic years. If there is any question regarding the booklet, please contact one of the U-BASE board members. For further information about the courses, contact the track coordinators Oguzhan Copuroglu (Construction Materials) or Roel Schipper and Marko Pavlovic (Structural Engineering).

Contents

Introduction Construction Materials Track

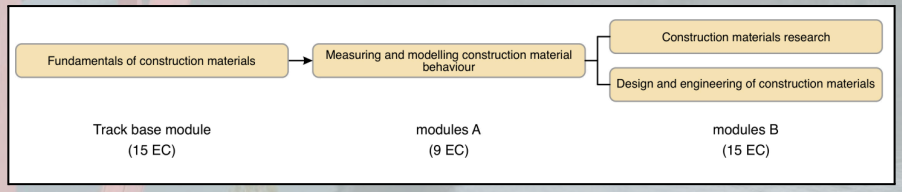
The Construction Materials Engineering education was offered as a specialisation of Structural Engineering in the old masters program, but now became a dedicated track of its own. Nonetheless, the Construction Materials track shares numerous subjects with Structural Engineering, while focusing on engineering materials and structural elements rather than structural systems. The track stands on two main pillars, namely Materials science and Mechanics. In this track you will learn behaviour of the materials and how to relate the microstructure and micro properties of the materials to the large structures. Hence, you will understand the reasoning behind design codes for example, instead of just using them. By choosing this track, you will become an expert in a wide range of different materials and technologies used for constructions, in experimental techniques and equipment, and in numerical modelling.

Moreover, this track consists of several laboratory sessions, where you will be able to put in practice what you have learned in the lectures. In its inaugural year, CM-track has welcomed 9 students, which created a nice environment for the students who have enjoyed close attention from the teaching team. The classes were often 2-ways, where student interaction and discussions were encouraged, and we learned a lot from each other as well. Hence, most classes felt more like a conversation rather than formal lectures.

The track specific modules are listed below, per quarter.

Q1	No track specific modules
Q2	Construction Materials Track Base
Q3	Construction Materials Track Base and A-module: Measuring and Modelling Construction Materials Behaviour
Q4	One of the following B-modules: - B1- Construction Materials Research - B2- Design and Engineering of Construction Materials

Flowchart of modules CM:



Construction Materials - Track Base: Fundamentals of Construction Materials (CIEM1000)

Base-1: Science of Construction Materials

In this unit, main construction materials are introduced, such as concrete, glass, metals, fibre reinforced composites, wood, bituminous materials, and polymers. The fundamental properties, characterization and application of each material are discussed, starting from their basic knowledge and building upon it.

Base-2: Fracture Mechanics

In the Fracture Mechanics unit, the failure of different materials are evaluated, understanding how a crack propagates through the material. From this unit, you will learn to relate the microstructure of the material to its micro properties and how that affects the macro properties, predicting the failure of the element.

Base-3: Construction Materials Selection

In this unit, fundamental principles of comparing different materials properties and selecting the most appropriate one for each application. Moreover, since the database in the software does not have only materials often used in Civil Engineering, you will develop through exercises a critical sense on why certain materials are not used in practice despite showing good properties. Hence, you learn to select materials by evaluating specific properties, but also having the general performance of the material in mind.

Base-4: Construction Materials Technology

In Construction Materials Technology, Concrete and Asphalt are extensively studied, where mix designs, testing methods, failure mechanisms, material production and much more are discussed. After this unit, you will have a very deep understanding of portland cement-concrete and asphalt, both for research and practice.

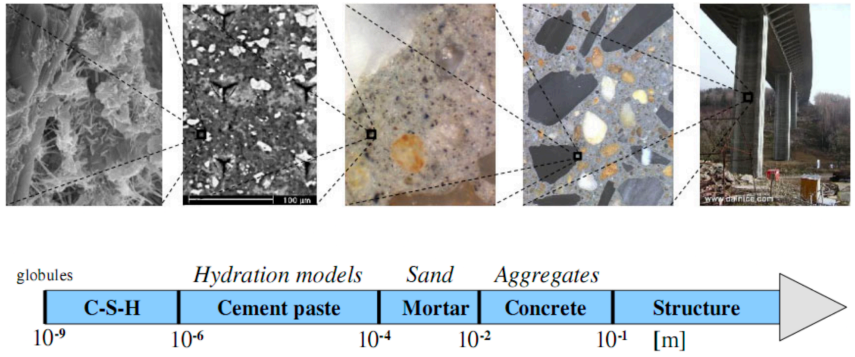


Figure 1: Multiscale features of concrete structures

Student experience

The base track module was divided into 4 topics which I believe indeed are required for you to be expert in construction materials. In unit 1, I learned a lot about a wide range of materials. I only had pre knowledge of concrete but I did not feel lost at any time, as each material was introduced from its basic concepts. Unit 3 was also very surprising for me as I did not expect the large amount of materials that can be chosen for a project. It was really nice that in the exercises, we were encouraged to choose and compare unconventional materials with concrete and metals for example. Also, during one class in Unit 1, the lecturer was going to oversee one experiment right after the end of the lecture, and due to the small class size and more personal interaction, the class was invited to join and watch the experiment, which was very interesting and helped us to learn more about the topic.

Student experience

The base was a bit overwhelming at first, with subjects I didn't spend a lot of time on in my Bachelor's and a lot of different teachers. However, as time rolled along, I got the hang of the rhythm and got to appreciate how every teacher is telling about advancements in their own field, meaning that not a lot of other people in the world know about it, nevermind get lectures on it. That is pretty cool.

Construction Materials - A Module: Measuring and Modelling Construction Materials Behaviour (CIEM1110)

A-1: Numerical Modelling of Construction Materials

In this Unit, many numerical modelling tools are introduced, such as FEM in python notebooks, Diana software, and Lattice models. The theory behind each modelling tool is explained, and workshops are given for students to grasp how to model materials with these tools. Also, one group project is done with each tool learned, so students work together to understand and make the necessary adjustments to correctly model the material of interest.

A-2: Experimental Characterization of Construction Materials

In this unit, you learn about several analytical techniques used for experimental characterization of construction materials, from microstructure to destructive and non-destructive techniques. During the lectures, the concepts behind each equipment and experiment are described, alongside the outputs and an explanation on how to interpret the data obtained.

Student experience

This module was very interesting, as in unit 2 you learn about experiment devices and how they work, which also gives you insight on potential problems, and where uncertainty may arise from them. This module was also very good due to the connection between units. Each group of students had to write three different reports. For each case report, an experiment was performed and interpreted alongside a modelling tool to validate the data obtained. Then a comparison between experimental and numerical tests was performed.

Student experience

The general idea of the module is very nice: for different material properties you compare lab tests with computer models simulating those properties. It was sometimes hard with planning all of it, since lectures should ideally line up with the lab tests, but this was not always the case. Still, if you're interested in learning how the microscale properties affect the macroscale properties of a material, this module is a step in that direction.

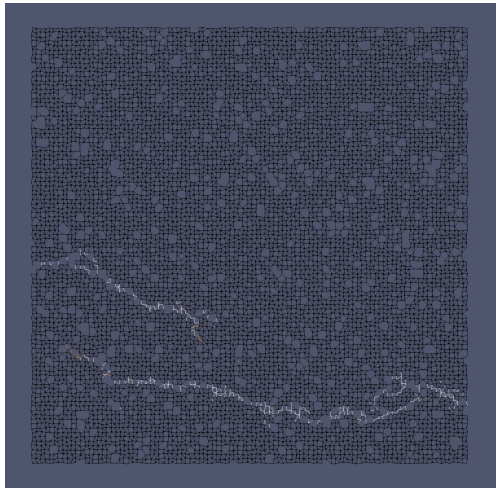


Figure 2: Crack propagation of mortar samples with different porosities using lattice modelling

Construction Materials - B1 Module: Construction Materials Research (CIEM1210)

B1-1: Durability of construction materials and infrastructure

The durability unit, B1-1, will teach you about different types of degradation in materials. The main focus is on reinforced concrete, which will also include some lab-measurements. However, also bituminous materials and biobased materials will be discussed, as well as the general concept of service life design.

B1-2 Residual Stresses and Eigen Strains

The unit on residual stresses and eigen strains, B1-2, looks at stresses and strains that occur in materials and structures due to internal processes in the material and their interaction with (internal or external) restraints. Also here, materials such as concrete, asphalt, wood, and metals are considered.

B1-3: Advanced constitutive modelling

The modelling unit, B1-3, is an expansion of the modelling unit of module A. It goes into plasticity, fracture modelling, large deformation and viscoelasticity. Tensor algebra is introduced to be able to set up advanced (non-linear) analyses of material behaviour.

Student experience

This module is a bit less cohesive than the A module, but that's not necessarily a problem. For the durability unit it was really nice to learn about how internal problems lead to external damage, which you can then try to recognize in the outside world. With the residual stresses unit and the constitutive modelling, you are really looking at physical phenomena within elements and materials, which you can then use to predict stresses or model the material. What is also nice, is how you get to work with a lot of different modelling softwares, even though that can also be a challenge at times, since not all of them are very intuitive.

Construction Materials - B2 Module: Design and Engineering of Construction Materials (CIEM1220)

B2-1: Recycling and Renewable Construction Materials

In this unit, recycling methods for concrete and asphalt are discussed, as well as the recycling process and properties of the final product. The End of Life and sustainability of structures is also addressed, focusing on circularity. From the lectures, you will learn the new technologies for recycling, and the mechanisms behind each of those.

B2-2: Advanced Construction Materials and Smart Technologies

In this unit, new construction materials and smart materials are introduced such as 3D printing of concrete, alkali activated cementitious materials (geopolymer), self healing concrete and asphalt, and self sensing materials. It introduces state of the art technologies that are being researched and its progress to be widely used in practice.

B2-3: Bio-Based/ Hybrid/ Composite Materials in Construction Technology

In this unit, composites are introduced, including the basic concepts, micro and macro properties, manufacturing processes, etc. The course provides a general introduction to fiber reinforced composites, comparison between natural and synthetic fibers, crack initiation and propagation in composite laminates, fatigue life, and properties and design of timber members.

Student experience

This module was good to learn about the new materials that are being developed and how they can be used in construction practices, and learning about circularity and sustainability of these materials. During the module, our class visited an asphalt recycling facility and we had many lab sessions, one of which we were in charge of the whole experiment, from raw materials characterization to casting. These practical activities were really interesting to see how the theory we learned during classes can be applied in practice as a material expert.

Figure 4: Site Visit to Dura Vermeer recycling asphalt plant. Excursion together with B6 of Structural Engineering and B4 of Traffic and Transport Engineering track

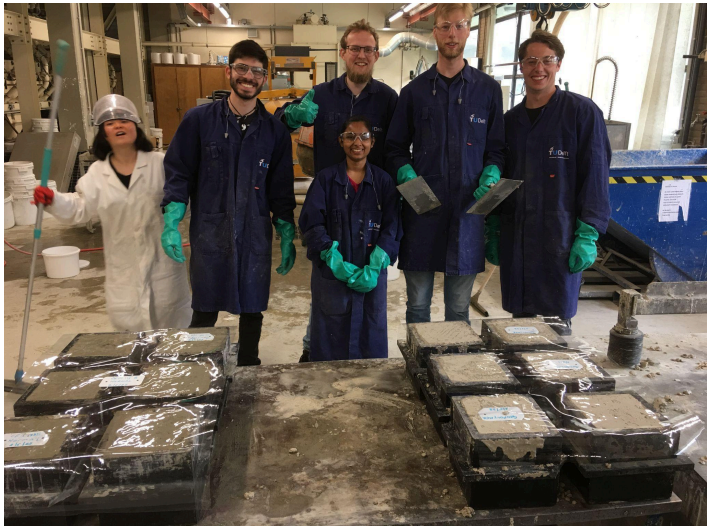


Figure 5: Casting of Geopolymer concrete for Unit 2

The three units that formed unit B2 are a good mix of different subjects to learn a lot about not just concrete and asphalt, but also materials like timber and composites. For different materials we looked at different building and recycling techniques. Besides exams, a lot of (small) graded reports had to be written, which was a nice change of pace. We 3D printed some concrete, crushed some concrete cubes, made some asphalt and did some experiments with that as well. These things took multiple days in total, which really showed how much work research is.

Introduction Structural Engineering Track

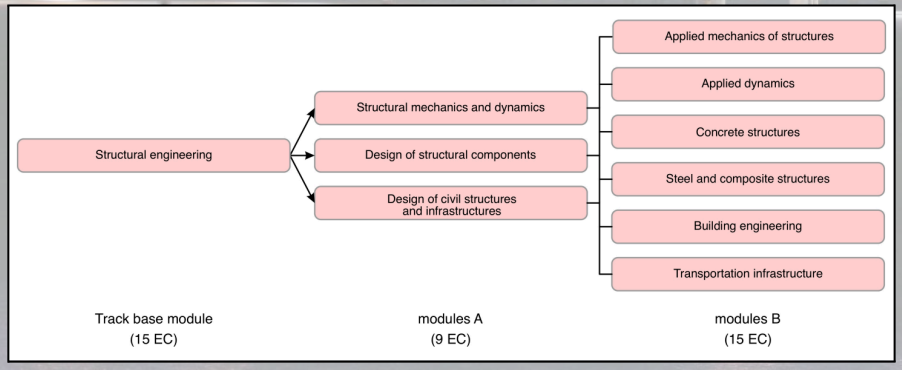
Structures such as bridges, high-rise buildings, tunnels and storm surge barriers clearly should not collapse or fall over. They may not deflect or vibrate in excess. Moreover, often they need to last for more than 100 years without much maintenance. In the MSc Structural Engineering track you will learn to calculate and design whether a structure is safe; whether it will buckle; whether its strength will be sufficient, among many other aspects relevant to the design of our built infrastructure.

Essential to this are physical models of structures, of materials and of loading. You will learn to formulate these models, to test them and to apply them. Simple models are used for hand calculations to quickly make decisions in early design stages to prepare for meetings with owners, architects, contractors and local governments. Complicated models are used for computer simulations to accurately determine whether a structure will comply with the design specifications. An example is the stresses that will occur a high-rise building due to a strong earthquake.

The track specific modules are listed below, per quarter.

Q1	No track specific modules
Q2	Structural Engineering Track Base
Q3	Structural Engineering Track Base and One of the following A-modules: - A1- Structural Mechanics and Dynamics - A2- Design of Structural Components - A3- Design of Civil Structures and Infrastructures
Q4	One of the following B-modules: - B1- Applied Mechanics of Structures - B2- Applied Dynamics of Structures - B3- Concrete Structures - B4- Steel and Composite Structures - B5- Building Engineering - B6- Transportation Infrastructures

Flowchart of modules SE:



Structural Engineering - Track Base: Structural Engineering (CIEM5000)

Designing skills are important for all structural engineers and in this module the goal is that students embrace principles and good "feeling" of structural design with "traditional" construction systems and materials.

Base-1: Sustainable Construction Members and Systems

In this unit, the focus lies on loads and sustainability aspects of structural design and design and analysis of steel, timber and concrete members. It covers the topics of identification and quantification of loads on structures, design of steel and timber cross-sections and members, analysis and verification of response of prestressed concrete members exposed to forces and the application of the principles of sustainability and circularity in civil engineering structures.

The content of Unit 1 is divided into six themes offered in Q2 and Q3 with a workload of 5EC and 3EC, respectively. In Q2, loads and sustainability aspects of structural design and design and analysis of steel and timber members are covered. In Q3, the design and analysis of prestressed concrete systems and connections in steel and timber structures are covered.

Base-2: Mechanics of Slender Structures

Unit 2 treats the mechanics of slender structures (Rod, Cable, Beam & Plate). Both the Statics & Dynamic parts of these slender elements are taught. In Q2, simple cases are treated in which analytical solutions of single elements are possible. The goal is to explain physics and the basics of the methods. In Q3, the focus is shifted towards design-type assignments in which students apply the solution methods in more complex systems consisting of combined one-dimensional structural elements and plates together with complex boundary/interface conditions.

Student experience

The Base-1 unit of Q2 and Q3 were very interesting; I got to learn more about designing with steel, timber and pre-stressed concrete materials. The classes were also made interesting with formative assignments and in a few lectures, the professors would bring the material to the classroom to better understand the lectures. The Base-2 unit of Q2 was mainly solving analytical problems. The unit was very informative and the professors did a great work in helping us understand the unit with lots of example problems and formative assignments. In Q3, the unit was assessed based on 3 assignments. In the assignments, we would numerically solve complex problems using software like maple, python and a FEM software (ABAQUS/ DIANA/ ANSYS).

Structural Engineering - A1 Module: Structural Mechanics and Dynamics (CIEM5110)

This module provides students with in-depth knowledge and understanding in Structural Mechanics and Dynamics, providing theoretical and relevant application cases for structural engineers.

A1-1: Stability of structures

In this unit, you will learn to analyse and explain the criteria for the stability of structure for static and dynamic loads. A range of instabilities for the conceptual design are considered, like, buckling of building columns, flutter and galloping of bridges and power lines, plastic collapse of frames (linear & non-linear analysis) and vortex-induced vibrations.

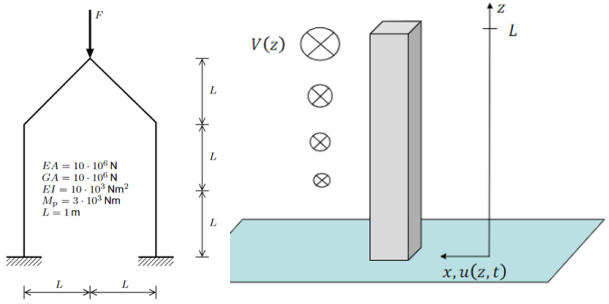


Figure 6: Example exercise

A1-2: Finite Element Method

In this unit, the learning line of MUDE is continued. You will receive a theoretical background into the finite element formulations for structural analysis, with which you would perform the FEM analysis on frame structures to analyse their force distribution and their static and dynamic responses.

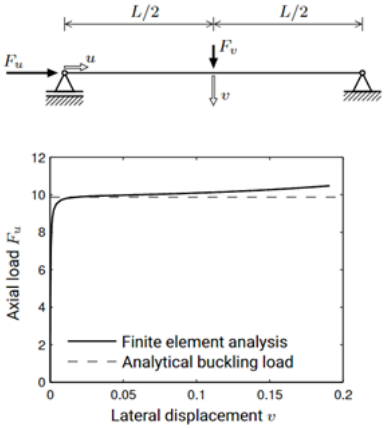


Figure 7: Nonlinear Elastic Analysis: Euler Beam

A1-3: Measurement and Analysis of Vibrations

In this unit, students will develop on the contents learned in MUDE about Signal Processing. Students will be taught to analyse and interpret measured signals for characterising dynamic systems and to assess the uncertainty. The unit is assessed based on group work, which involves laboratory set-ups to quantify and interpret the uncertainties in the vibration analysis. There are weekly assignments provided to receive better understanding into the unit.

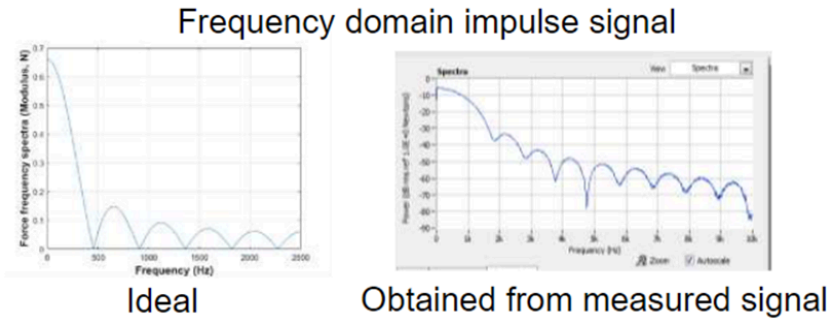


Figure 8: Example of a measured signal

Student experience

The U-1 has 2 subparts: Static Instability and Dynamic Instability. The unit starts with how Instability which happens during a load is different from the response of structure to the same load. Static Instability deals with various types of buckling (Euler buckling, Torsional buckling and Lateral buckling (LTB)). I learnt the fundamentals behind various analyses such as Geometrically Linear/Non-linear Elastic/Plastic analysis, Buckling analysis. Static stability uses the Energy approach to derive the EOM and then the Buckling load. I also learnt how structures may not necessarily fail after reaching static instability. There are quite some mathematical derivations involved including finding the higher order approximations using Taylor series which forms the basis for finding the Post buckling state. Dynamic Instability deals with Galloping, flutter, gyroscopic systems and Parametric instabilities. This feels like the continuation of the Slender structures. I learnt the fundamental difference between Static and Dynamic Instability which can be explained after solving the EOM and finding the eigenvalues. We start any problem with the EOM & Boundary/Interface conditions. If you like Prof. Metrikine's lectures, then you're going to love this unit. You simplify the real life structures into equivalent 1-D structures and apply the concepts of Instability to find what parameters can cause instability. The professor brought us the real equipment where you can see both linear and non linear effects on the parametric instability.

The U-2 deals with FEM. This is a continuation of the FEM topic from MUDE and this forms the foundation for the B1 module. We started with some recap of MUDE (not much). Then we dive into deriving the weak form of a Timoshenko beam element followed by the weak form of a more general 3-D element. The derivation from strong form to weak form involves quite some mathematics and vector algebra which is also important for the exam. Another great thing about this unit is that the professors made available an online textbook (similar to MUDE) whose content at times is even better than the lectures! The unit also links to the U1, where you learn the different types of analysis (Geometrically Linear/Nonlinear Elastic/Plastic) analytically. This unit extends on the same topics but using FEM. Bridging this link is a really essential learning element. Another important aspect is the PYJIVE, an in house Python

code which has all the implementation of FEM required to solve some basic to even complex problems. Your coding skills come handy when you use it during weekly workshops. Personally, I am not very good at Python but this module offers a lot of scope into developing your python skills as well.

The U-3 is where you practically implement the concept of mode shapes and natural frequencies. The workload is a bit on the heavier side, and the assignments involve some amount of coding, but the professor provides a lot of hints on how to implement it in Python. The study material from the professor contains a lot of material but most of it is optional and can come handy if you want to further your journey with Signal processing. Mathematics involves some understanding of complex numbers. At the end, we performed an experiment where we hit a rail beam with a hammer to measure its mode shapes and natural frequencies. You get to see the practical importance of finding the dynamic properties of a system and this unit forms the foundation for the SHM course. This is a photo of me taking revenge on the rail beam. There was a separate lecture at the end where they also connected this unit to U2: FEM, where you model the experiment using PYJIVE.

Structural Engineering - A2 Module: Design of Structural Components (CIEM5120)

A2-1: Prefabricated and composite structures

Within this unit, the focus of the lectures lies on four themes; steel, timber, concrete and railway. In the form of home assignments, you'll learn to do a structural analysis with hand calculations on simple structures from steel, timber or concrete. For example, the stresses, strains and deformation of a floor and wall of the CLT structure below is analysed, given certain loads.

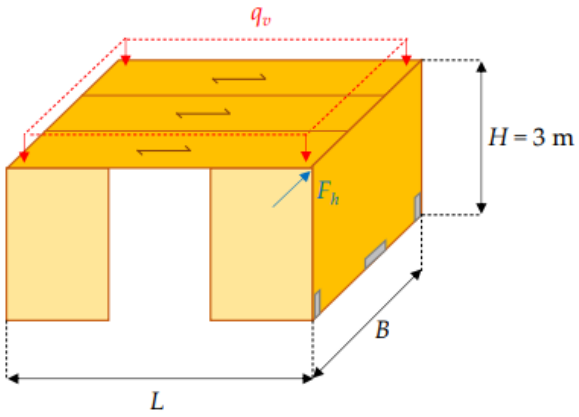


Figure 9: Example exercise

A2-2: Design with innovative materials

The lectures of this unit are given from field experts and teachers on topics like high performance steel and concrete, recycled materials, structural glass, digital manufacturing, pavement and railway engineering. Students are then challenged to dive deeper in their chosen topic, with a research paper as the end product.

Student experience

I did research into the design of a large span bridge using structural glass components. Together with my group, we did literature research into the history of glass and the different techniques currently available. With this knowledge, we designed three variants for a glass bridge, on conceptual level. A fun challenge was to write a research paper on this, instead of a regular report. I enjoyed the project and it piqued my interest in structural glass.

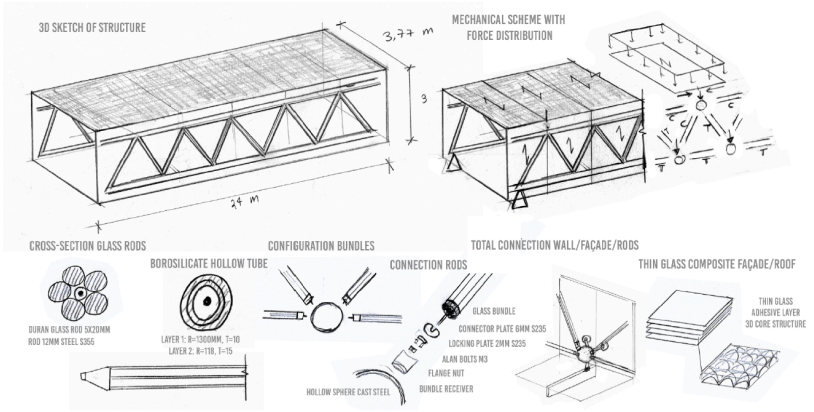


Figure 3: Complete overview of design variant 2, the truss bridge

Figure 10: Figure made by students for the research paper on structural glass

Structural Engineering - A3 Module: Design of Civil Structures and Infrastructure (CIEM5130)

A3-1: General design principles of (infra)structural systems

This unit's lectures focus on the design principles of five main themes: buildings, bridges, railways, pavement and circularity. These lectures take place during the first four weeks. For instance, for bridge design, you will gain insight into various bridge types, their components and loading types. Moreover, the initial two weeks include six workshops that offer useful skills such as parametric design, visual presentation and setting up a clear calculation. For example, the parametric design workshop introduces you to the practical use of the software Grasshopper.

A3-2: Specific design aspects of building, bridges, rail and road structural systems

Once you have acquired knowledge about the design principles of the themes in unit 1 and have worked on their structural system in the design assignment of unit 3, you may come across a subject that you would like to research in more detail. In this particular unit, you are encouraged to select a topic within your chosen theme and write a research paper about it.

Student experience

Within the theme of railways, I researched the feasibility of plastic railway sleepers on a ballasted track. I looked into the benefits and drawbacks of plastic sleepers and the uncertainties surrounding the long-term performance of plastic sleepers. The research paper should also contain a simple model. For this, I used a beam on an elastic foundation model to compare the stiffness behaviour of plastic sleepers with concrete sleepers. It was nice to be able to choose my own topic and to write the paper in the form of a research paper.

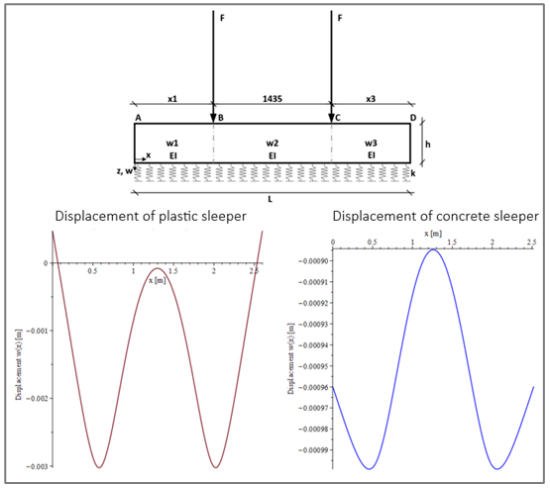


Figure 11: Beam on an elastic foundation for railway sleepers

A3-3: Design Challenge

In this unit, students will be participating in a group design assignment. Each group chooses their own theme to work on. The challenge involves designing a building, bridge, pavement, railway and including circularity as an integral aspect of the assignment.

Student experience

The design challenge consisted of the preliminary design of an airport. The airport contains a terminal (building aspect), a railway track, an overpass and a run- and highway for the pavement design. Regarding the railway, I looked into the track that leads to the terminal. For example, I calculated the number of passengers to be expected to make use of the railway station at the terminal. Also, various track structures were considered to choose the most suitable one for the project and amongst others I calculated the minimum rail displacements.

Structural Engineering - B1 Module: Applied Mechanics of Structures (CIEM5210)

B1-1: Computational modelling of structures

This unit focuses on the application of the Finite Element Modelling package DIANA to structural engineering. It teaches very practically how to work with DIANA, but also FEM packages in general. The unit consists partly of lectures on Finite Element Modelling, but mostly of seminars where you work on informal assignments and can ask questions. In these assignments, you will replicate a real experiment in DIANA and compare the results. Towards the end of the quarter, you work on a final assignment, on which you have to write a report. After submitting this report, you have to do an oral exam which focuses both on your final report and the information given in the lectures. Assessment is done partly on your report and partly on your oral exam.

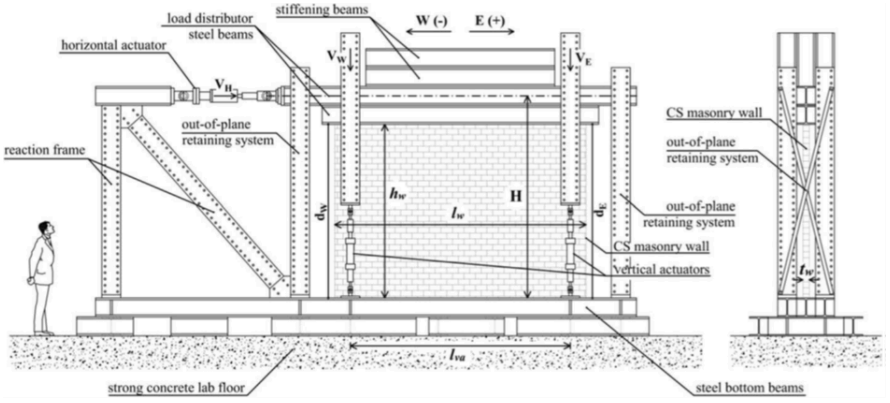


Figure 12: Masonry wall to be modelled in final assignment 2023

B1-2: Advanced constitutive modelling (same as CM B1-3)

This unit focuses on the modelling of the constitutive behaviour of materials. It consists of two parts, given by two different lecturers. The first part explains the theory behind finite element modelling and shows different ways to model material damage. The second part focuses on how to mathematically describe different material models, like hyperelastic, elasto-plastic, viscous, visco-elastic and thermos-elastic. Both parts are assessed separately in the form of oral exams.

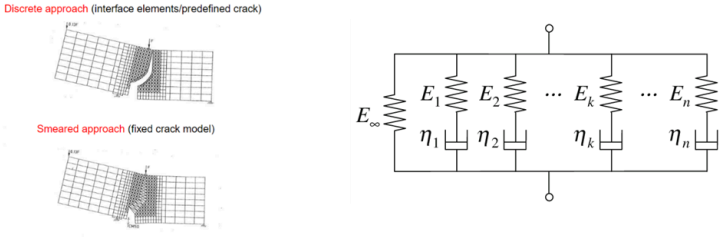


Figure 13: Discrete/smeared modelling of crack interface

For this unit, prior knowledge from the Structural Mechanics and Dynamics module is useful, but not necessary.

B1-3: Advanced mechanics of structures

This unit consists of two parts: an elastic part and a plastic part. The elastic part focuses on torsion as well as on elastic analysis of plates. The plastic part consists of different kinds of plastic behaviour like the Bauschinger effect, yielding contours, upper bound and lower bound theorem and yield line patterns. This unit is assessed with a written exam.

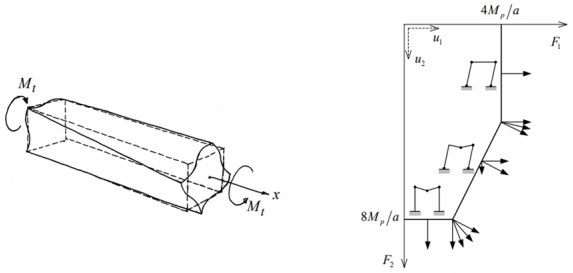


Figure 14: Yield contour of a simple portal frame

Student experience

I liked this course a lot. It wasn't a very heavy workload. Sometimes you have to read and sometimes there are some exercises to do. The lectures of Unit 1 are very nice, but sometimes the content overlaps with Unit 2. For Unit 2, the content you learned in A1 module really helps. If you did not follow the A1 module, you might have to do a lot of homework to catch up. There was a guest lecture from an expert in the medical field who used FEM for predicting a heart attack to learn its applications. For unit 3, a suggestion is to start working on sample exams early. There was also a cool competition for Unit 3 which allowed you to gain extra points in the exam which was fun. It's a very nice course which can help a lot.

Structural Engineering - B2 Module: Applied Dynamics of Structures (CIEM5220)

B2-1: Structural response to earthquakes

In this unit, you will learn the different methods of dynamic analysis for simple and more complicated structures with ground motion as a source of excitation. This includes the methods mentioned in the Eurocode as well as soil structure interaction. In the graded assignment, you will apply your knowledge in an analytical as well as a numerical approach using a FE-software. In 2022-2023, we analysed the dynamic ground excitation on a bridge and a real-life jetty structure placed in the port of Groningen.

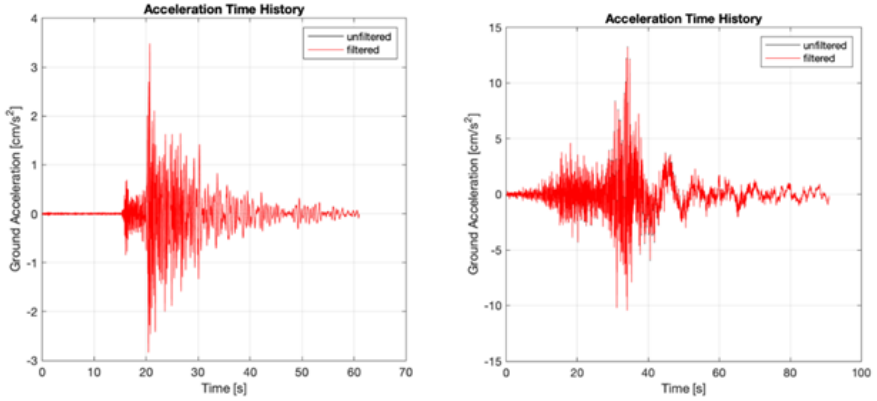


Figure 15: Example graphs showing acceleration of the ground over time

B2-2: Structures subjected to wind and waves

This unit focuses on an assignment, while the lectures and literature provide the necessary information. In the assignment, you analyse the dynamic behaviour of an offshore wind turbine subject to randomly generated wind and wave time signals. The analysis will be computed numerically by building your own dynamic FEM model.

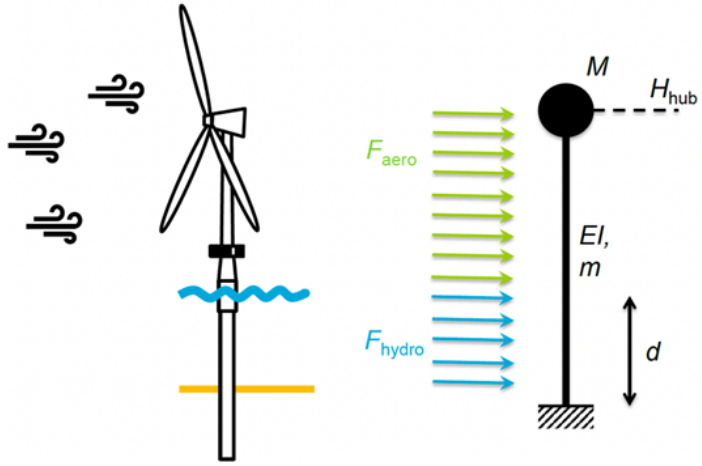


Figure 16: Example model for windturbine

B2-3: Structures under moving loads

This Unit is split into two approaches. The first one focused on showing the dynamic effects on simple beam structures subject to moving loads using an analytic approach. The second one focuses on numerical modelling methods and more complex systems using Ansys and MATLAB code. In the graded assignment, you analyse several systems' dynamics analytically and do the same thing numerically for the high-speed case (Hyperloop).

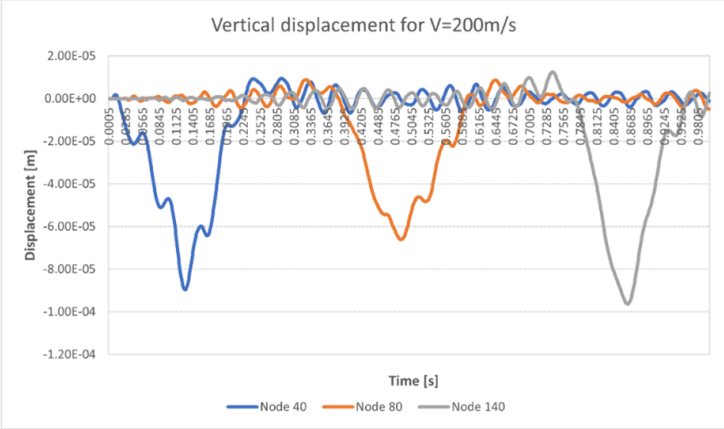


Figure 17: Example figure vertical displacement for certain speed

B2 common block: Random vibrations

During the second week of the quarter, the focus shifted to analysing random vibrations caused by unknown excitations. The approach of this subject is purely analytical and based on the probability theory and propagation of inputs through the system. As opposed to the "standard" approach we are here no longer interested in one solution but rather a response spectrum, as the real excitation is unknown.

Student experience

During the module, we got a lot of information about the different courses. The teachers really try to let you think about the different subjects and after a nice start, the tempo increases a bit. The projects were fun to do and there was plenty of support. Although they are a lot of work, I found it nice to work together and get it done. The presentations were very educational, and the questions sometimes were even fun. Because of the projects, I had forgotten a bit about the exam, but in the end it was a nice quarter.

Structural Engineering - B3 Module: Concrete Structures (CIEM5230)

The lectures of this module are given by teachers who are all experts in the field of concrete. All different kinds of topics are discussed in this module, from finite element modelling of concrete structures to concrete bridges and advanced mechanics. But also the more fundamental theory about the concrete science and technology and concrete structures under special loadings are explained.

B3-1: Advanced Modelling of Concrete Structures

This unit focuses on the mechanics which are used for designing concrete structures. Topics such as the plasticity theory, stress fields and fracture mechanics are examples of typical concrete mechanics. You will learn how certain rules in the Eurocode are established, such as the shear force capacity of reinforced and prestressed concrete elements. Lectures in combination with a few examples using software will prepare you for the written exam which is given in combination with unit 2.

B3-2: Concrete science and technology

The second unit of the module will go more in depth on the material science aspect of concrete. The constituents of concrete and the chemistry behind hydration will be taught as well as the microstructure of concrete, creep and strain. Innovative and more sustainable types of concrete will also be touched upon in the lectures and the assessment is done by a written exam in combination with unit 1.

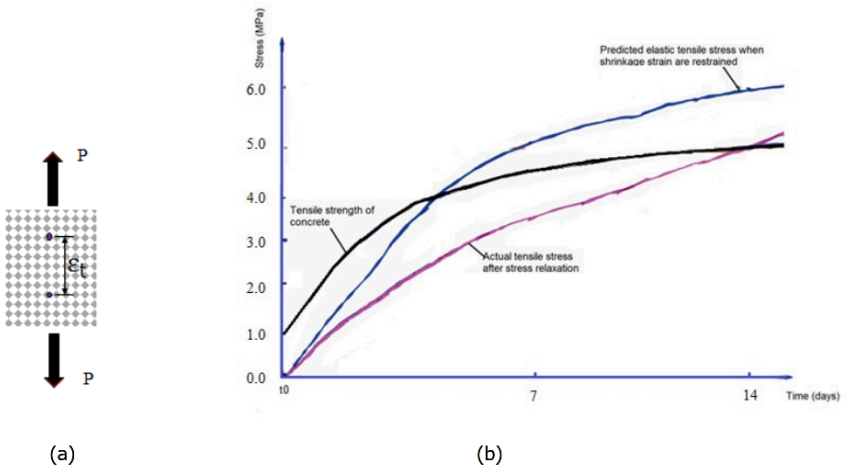


Figure 18: Example exercise: explain influence of shrinkage and creep on concrete cracking potential when concrete is under restraint.

B3-3: Numerical Modelling of Concrete Structures

Numerical modelling of structures is the only unit which runs throughout both halves of the quarter. This unit will teach you how to go from a physical problem, which is schematized by a mechanical model, to a finite element model. Discretizing the physical problem has to be done thoughtfully. Each week consists of lectures about the application of finite element modelling and a workshop to apply this knowledge to some examples. This unit is assessed by modelling a structure from a paper at the end of quarter and an oral exam in which your assignment is discussed and your knowledge about numerical modelling.

B3-4: Concrete structures under special loadings

Unit 4 of the module is all about special loadings such as imposed deformation caused by thermal expansion or loading caused by explosions and collisions. Early age concrete will be presented briefly, which will teach you how to mitigate excessive tensile stresses. Moreover, the construction and loadings of silos will be discussed as well as reservoirs filled with liquids such as water or LNG. Two case studies about silos and an oral exam on imposed deformation will form your final grade.

B3-5: Concrete bridges

The last unit, concrete bridges, is all about the different types of concrete bridges. You learn which type of concrete bridges are viable for which spans and rule of thumbs to dimension all these types of bridges. The standard elements of concrete bridges will be discussed and it is explained how the loading on bridges is determined. Three formative assignments are given which are useful for your final grade which is based upon an oral exam at the end of the quarter.

Student experience

The quarter is divided in two parts, where the first part focuses on concrete science and technology and advanced concrete mechanics. Where concrete mechanics is given in a flipped classroom type, which was executed very well. Concrete science and technology is given in a more classical teaching style. Both units are combined in one exam which was given in week 5. After week 5 the focus shifts to concrete bridges and concrete structures under special loadings. For both units multiple assignments were given and an oral exam is conducted in week 10. During the entire quarter we had workshops and lectures about finite element modelling of concrete structures, where small assignments were conducted in the first half of the quarter, and one bigger assignment is conducted in the second half. This bigger assignment is also the preparation for the oral exam which is conducted in week 10. (It could be that the order of the units might change in 2023-2024 compared to 2022-2023.)

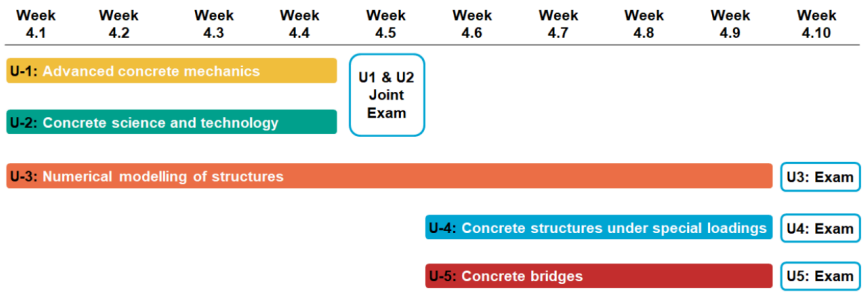


Figure 19: weekly schedule B3 module

Structural Engineering - B4 Module: Steel and Composite Structures (CIEM5240)

B4-1: Strength and durability of steel and composite structures and joints

This Unit consists of the topics Joints (30%), Fatigue (40%) and Modelling (30%). Joint design and fatigue are some of the most important design aspects of structural steel, no matter the application. Along with the innovations in modelling and it's importance, these three topics encompass the general understanding of design of steel structures which would be applicable to all engineering cases today. Even though this unit spans the entire quarter, the lectures are well-devised to cover theory in the most lucid manner, followed by comprehensive practice sessions for numerical applications. No two topics within the unit are covered at the same time, ensuring that it doesn't become confusing or heavy to grasp. The examinations mostly have numerical/application-based questions, similar to the assignments. The Modelling unit had lectures on its real-life applications by professors and PhD scholars, which made it interesting and fun, along with workshop sessions to work on the ABAQUS software.

B4-2: Heavy-duty steel and composite structures

This Unit consists of the topics Bridges (60%) and Energy (40%). As the name suggests, this unit covers some of the specific applications of steel. The Bridges topic covers the design and analysis of steel and hybrid bridges, along with few of its modelling aspects, while the Energy topic covers the design and analysis of wind towers and their connections. The lectures for this unit, especially Bridges, are mixed mode, since there are pre-recorded video lectures to watch along with in-person lectures. The study hours have been clearly divided between lectures and numerical discussion sessions, which gives a good overview into the type of questions which can be expected for the exams, along with the assignments. The exams were a mix of theory and application-based questions, which was sometimes tricky, in case of Bridges especially, since the lecture mode was new to us. Nevertheless, keeping track of all reading material and updating yourself with it helped a lot. Since these topics were covered parallel to the first unit, we could clearly understand the interplay of various topics in the overall design of these structures. The lectures were also accompanied by frequent lab visits, which made few weeks lighter, more fun and interesting to see the theory come into life.

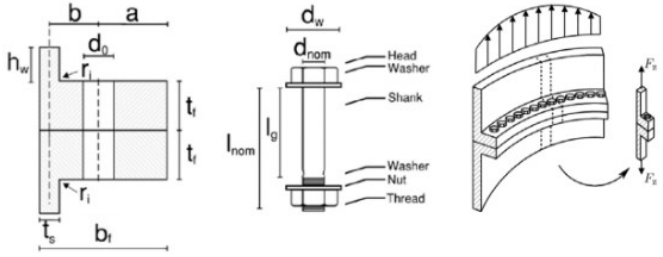


Figure 20: Example assignment

B4-3: Lightweight steel and composite structures

This Unit consist of the topics Stability (40%) and Composites (60%). Stability covers subjects such as buckling analysis of thin plates and the design and analysis of cold formed steel sections, while Composites covers the design using innovative fibre-reinforced polymeric composites. Arranged in similar fashion to previous units, the lectures for Composites

are in mixed-mode, with lectures from industry leaders and researchers. Since both topics are relatively new but easy to understand, they have a good repository of reading materials. A good number of solved examples and assignments reinforce the theoretical knowledge gained. The exams are also relatively simple because of the same, but with a more emphasis on the application aspect, compared to Unit 1. The arrangement of field trips and company visits were really fun and great for networking.

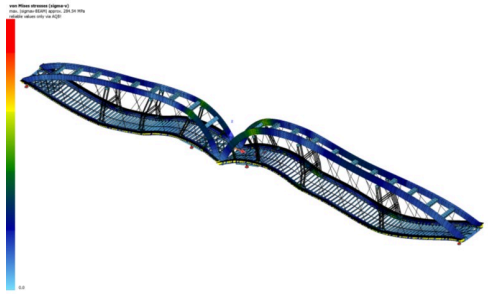


Figure 21: screenshot calculation steel structure

Student experience

I found this module thoroughly interesting, in the way it is curated and delivered. The application of knowledge gained in this module can be found in major infrastructure companies and research organisations today. The delivery of lectures and assignments are clearly aligned to this idea, and I personally found this the right way to comprehend the needs of the industry today, and how we can provide solutions. What makes the courses stand out is how flexible the delivery and testing in the coursework is, and the teachers can effectively deliver content in any way the students are comfortable. With the module having a comfortable number of students, the lectures are generally more conversational, making it effective in delivery and for the clarification of questions. Graded group assignments proved very helpful in the preparation of examinations, and the higher weightage to the assignments gives us ample opportunity to work throughout the quarter, reducing the pressure on exams. The course framework was perfect since the units were covered parallel to each other, reinforcing our understanding in each of the units. Overall, I had a wonderful time learning and discovering various aspects within this module.

Structural Engineering - B5 Module: Building Engineering (CIEM5250)

Building Engineering will focus on the engineering of buildings as complex systems in which many facets need to be aligned in an integrated interdisciplinary design process. The three units are taught through lectures and workshops and the knowledge is then applied to an overarching design challenge. Furthermore, the knowledge is tested through one exam per unit.

B5-1: Architecture, Building Physics and Façades

This unit will provide you with specific building-related background knowledge that is not directly structural engineering: contemporary and 19th-century architectural styles, façade design/detailing, building physics (heat transport, acoustics, wind flow) as well as building services (heating, ventilation, air-conditioning, vertical transport, water).

B5-2: Building Structures, Construction Methods and Foundations

You will learn about the flow of forces in regular building structures and stability in various typologies of buildings. The use and re-use of various building materials and structures will be addressed, as well as the interaction with the subsoil via foundation and construction pit. Working on a design exercise of a realistic building will allow students to experience the consequences (limitations, options and uncertainties) of available design and construction methods and receive feedback from professional building engineers.

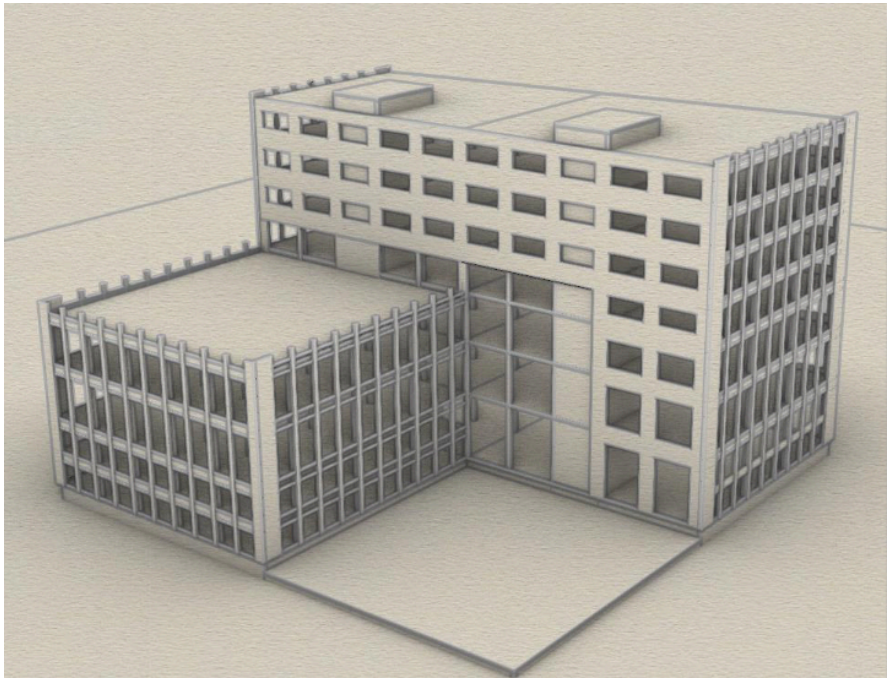


Figure 22: Project example

B5-3: Design of Spatial Structures

This is an advanced course in the field of special and spatial building structures, their design process, structural mechanics, structural behaviour and performance, computational modelling, combined with practical use of design- and analysis tools for structural engineering. Topics include structures in nature, biomimetics, plates, shells and vaults, membrane and pneumatic structures, cable-nets, tensegrity, (space) frames, grid structures and domes, adaptive and deployable structures.

Student experience

For students that are interested in building buildings, this module is great. It refreshed and deepened knowledge on building structures and touched upon new topics within building physics. The design assignment, in which a design for a new university building was made with groups of three students, was really challenging, but a good way to put the newly gained knowledge into practice. There are a lot of teachers involved in this module, which makes it sometimes a bit chaotic, but does give you enough opportunity to learn from experts from all directions.

Structural Engineering - B6 Module: Transportation Infrastructures (CIEM5260)

B6-1: Design and construction of new transportation infrastructures

In this unit, knowledge related to the design and construction of new transport infrastructure is introduced. It discusses the process and method of transportation infrastructure construction and how to evaluate the design of transportation infrastructure. The pavement part introduces several design methods in detail, and introduces the design of bitumen, asphalt and other different layers. The railway part detailly introduces some knowledge such as the conventional track, non-conventional track, rail vehicle design, maintenance and static design of railway track and transition zone.

B6-2: Dynamics and degradation of transportation infrastructures

In this unit, the dynamics and degradation (D&D) of transportation infrastructure is introduced, including the consequences, mechanisms, modelling and solutions of D&D. In this unit, ANSYS workbench software and ANSYS APDL software are applied to evaluate the long-term performance of the transportation infrastructure and the impact of D&D on it.

B6-3: Monitoring and maintenance of transportation infrastructure

In this unit, a number of state-of-art monitoring solutions for transportation infrastructure are introduced, including AI and other data-based solutions. In addition, this module also discusses how to make better maintenance decisions for transportation infrastructure. It also analyses the knowledge of asset management of transportation infrastructure.

Student experience

I think this module is essential for students aiming to become transportation infrastructure engineers. I had the opportunity to visit an asphalt plant and the rail centre, which helped me connect theoretical knowledge with real projects. This module also contains two experiments, one related to pavement and one related to railway, which gave me a deeper understanding of the knowledge learned.
Modelling of transportation infrastructure by software is a very important part of this module. Five types of software are used in this module, which are BitProps, 3D Move, VI Rail, ANSYS ADPL, and ANSYS workbench, which is important to learn because it is used in the field. Furthermore, all lecturers in this module (including the PhD students who provided help) are very responsible and deliver very high-quality lectures. They will give timely feedback to students' suggestions and difficulties.

B6: Project 1 – Trnsportation infrastructures project design

This project focuses on upgrading the transportation infrastructure around Rotterdam-The Hague Airport to optimize aircraft flow and improve connectivity.

The project has the following tasks.

- Designing durable, eco-friendly pavement (Figure X) for the airport's entrance, exit, and the A20 Motorway, with considerations for climate impact, traffic loads, and long-term maintenance.
- Provide advisory support for optimizing railway networks (Figure X), particularly addressing the challenges of transition zones where trains pass over canals. The goal is to enhance investment decisions, system performance, and innovation in transportation infrastructure.

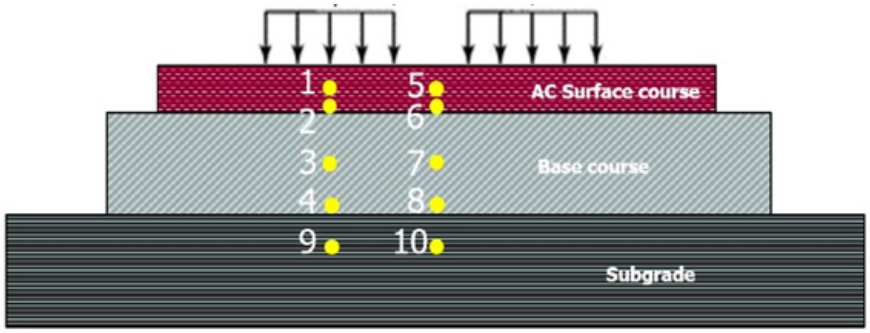


Figure X: Example of Pavement Design (Schematic pavement layer structure)

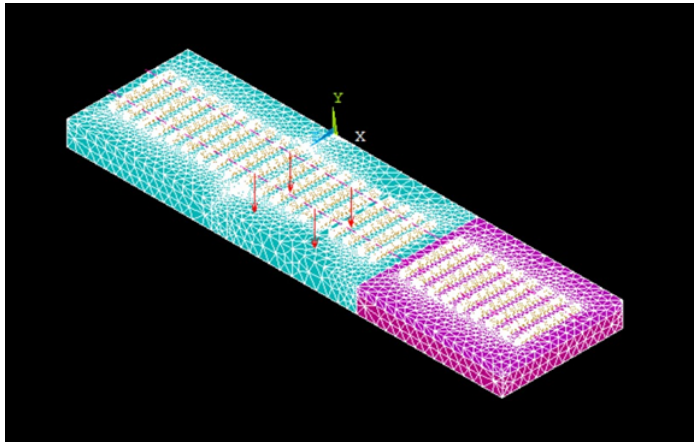


Figure X: ANSYS FEM model of the reference transition zone

Please note that the final deliverable is a report containing two parts, where one is related to Unit1 and the other is related to Unit2. This assessment maintains the balance of learning objectives from the first two units.

Please note that the final deliverable is a report containing two parts, where one is related to Unit1 and the other is related to Unit2. This assessment maintains the balance of learning objectives from the first two units.

B6: Project II – literature Report assignment

This project focuses on a literature report assignment on Monitoring and Maintenance of Transportation Infrastructures. Students are required to individually select an asset from transportation infrastructure, such as roads or railways, and conduct a detailed analysis. The report must cover the asset's functionality, common failures, key performance indicators, maintenance strategies, and monitoring techniques. Additionally, students will evaluate current approaches, provide analysis, and propose improvements or future research areas. The assignment includes both a draft presentation and a final report submission, aiming to enhance understanding of transportation asset management and infrastructure maintenance.

Please note that the final deliverable is the literature study, focusing on the learning objective of unit 3.

U-BASE Study Association

Whilst you're putting in your best efforts to obtain your degree, it is important to not only be occupied with studies and frequently take time off to relax. By becoming a member of U-BASE, you will be given the opportunity to partake in many fun activities among fellow students.

U-BASE is an abbreviation for "United Building and Structural Engineering Association" and it is the student association for master students of Construction Materials and Structural Engineering at the Civil Engineering faculty of the Delft University of Technology. U-BASE was established in September 2015 and was the result of a merger between three former MSc study associations, namely: U-dispuut, CST-dispuut and Betondispuut. At U-BASE we aim to make your time as an MSc student unforgettable. We are here to bring you in contact with your fellow students so that studying is easier, but mainly so you will make a whole lot of new friends. Also bringing students and teachers closer together and improving education is one of our goals. And finally bringing students and companies together for future job opportunities is important to us.

We offer our members a wide range of activities throughout the year. To bring students and companies together we organise excursions, lunch lectures and a yearly recruitment dinner. U-BASE also organises social activities throughout the year, a short U-BASE trip in fall and an international trip during summer break. In order to bring students and teachers closer together, we organise Coffee and Cake Breaks where they can exchange information about courses, exams, graduation or research. Also, course evaluation and improvement are one of our core activities regarding education.

Committees

Committees form the heart of U-BASE. As a member, you're given the opportunity to join a wide range of committees. A committee is a group of students that helps out the association by creating fun and interesting content and activities for other students to participate in. During the Committee Interest Drinks (Wednesday 4th of October), an overview of all committees U-BASE contains will be given. After these drinks, we hope you have a general impression and can make a well informed choice on whether or not to join a committee of your liking. Already interested about joining a committee? Take a look at our website: https://u-base.org/about-us/committees/current-committees for more information!

The BASE

Our office (called 'BASE') can be found in the Stevinlab II (room S2.1.35) of the Civil Engineering faculty. Here students can relax between lectures and meet up with their fellow students. Upcoming events and company information are also shared here. Our door is always open for students, teachers and companies to come by for a visit. So if you are interested in becoming a member or have any questions in general, don't hesitate to come by and say hi!

Other Useful Links

U-BASE website : https://www.u-BASE.org/

Study guide (offers information about each module) :
https://www.studiegids.tudelft.nl/

Teaching and Examination Regulations (TER) and Rules and Guidelines Board of Examiners (R&G) :
https://www.tudelft.nl/studenten/faculteiten/citg-studentenportal/onderwijs/onderwijsinformatie/educational-rules-and-regulations

Academic Year calendar :
https://filelist.tudelft.nl/Studentenportal/Centraal/Onderwijs/Academische%20Jaarindeling/Academische%20Jaarindeling%202023-2024.pdf

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