GHENT UNIVERSITY

Course Specifications

Valid as from the academic year 2021-2022

Life Cycle Assessment of Materials and Structures (E065480)

Due to Covid 19, the education and evaluation methods may vary from the information displayed in the schedules and course details. Any changes will be communicated on Ufora.

Course size *(nominal values; actual values may depend on programme)*

Credits 3.0 **Study time 90 h** **Contact hrs** 30.0 h

Course offerings and teaching methods in academic year 2022-2023

A (semester 2)	English	Gent	project	10.0 h
			lecture	17.5 h
			excursion	3.75 h
B (semester 2)	Dutch		guided self-study	17.5 h
			project	10.0 h
			excursion	3.75 h

Lecturers in academic year 2022-2023

De Belie, Nele	TW14	lecturer-in-charge
Van den Heede, Philip	TW14	co-lecturer

Offered in the following programmes in 2022-2023	crdts	offering
Bridging Programme Master of Science in Civil Engineering	3	B
Master of Science in Engineering: Architecture (main subject Architectural Design and Construction Techniques)	3	A
Master of Science in Engineering: Architecture (main subject Urban Design and Architecture)	3	A
Master of Science in Civil Engineering	3	B
Master of Science in Civil Engineering	3	A
International Master of Science in Sustainable and Innovative Natural Resource Management	3	A
Exchange Programme Architecture	3	A

Teaching languages

Dutch, English

Keywords

Durability, sustainability, service life prediction, reuse and recycling, life cycle assessment (LCA), environmental impact

Position of the course

Inform the students on the interaction between materials/structures and their environment. Both the effect of a specific environment (subject to one or more deterioration mechanisms) on the technical durability of commonly used building materials (concrete, natural stone, metals, wood, ...) as well as the effect of these materials over their entire life cycle on the environment will be studied in this course. The students will receive the necessary background on probabilistic service life design methods to estimate the (remaining) life span of concrete structures based on experimentally quantifiable durability properties. Through case studies, the students will get acquainted with the major influencing factors in the now available service life prediction models for engineering purposes (e.g. DuraCrete, fib Bulletin 34). In addition, the students will learn more on suitable life cycle assessment methodologies for adequate environmental impact quantification of concrete and other building materials. Attention will be paid to the impact on climate change and a wide range of other environmental issues (acidification, eutrophication, (eco)toxicity, ...). In general, the course contributes to the acquisition of the following competences: durable and sustainable design of structures, creative use of broadening information on various materials to reduce environmental impacts in structural design.

Contents

- Brief recapitulation of the durability issues relevant for steel reinforced concrete
- Overview of the main properties and durability issues of natural stone, metals and wood
- Physical background on the different probabilistic models for service life estimation of concrete exposed to chloride- and carbonation-induced steel corrosion
- Prescription versus performance based structural design
- Introduction to different model codes for service life design (DuraCrete, fib Bulletin 34)
- Sensitivity study of the relevant model input parameters (e.g. concrete cover, critical chloride content, age factor, time of wetness, ...) to the service life prediction models
- Characterization of the different model input parameters in terms of their most suitable probabilistic distribution
- Project work/case studies assessing the remaining service life of existing concrete structures in the software Comrel
- Sustainable development: environmental problems (greenhouse effect, use of non-renewable materials/energy/land, ozone layer depletion, acidification, eutrophication, human toxicity, ecotoxicity, ...), sustainability, factor 20, ...
- Life cycle thinking in accordance with the ISO 14040-14044 standards (the traditional four-step approach with (i) definition of goal and scope, (ii) inventory analysis, (iii) impact analysis and (iv) interpretation, cradle-to-gate/cradle-to-grave/cradle-to-cradle studies, functional unit choice accounting for the strength and service life of the material, mass versus economic allocation of impacts when dealing with industrial by-products, problem versus damage oriented impact assessment, aggregation and weighing of impacts
- Resource conservation, pollution prevention, use of building and demolition waste, waste disposal, recycling and reuse, design for recycling, IFD
- Quantifying the effective sustainability of potentially 'green' building materials using the principles of life cycle assessment
- Eco-labels, environmental product declarations (EPDs), environmental audits, LCA databases (e.g. Ecoinvent)
- Project work/case studies involving the use of the LCA software SimaPro

Initial competences

Final competences

1 To be able to define relevant concepts: Technical durability, chloride- and carbonation-induced steel corrosion, corrosion initiation, corrosion propagation, Fick's first and second law of diffusion, probabilistic service life prediction, first order reliability method, Monte Carlo analysis, remaining service life, sustainability, life cycle assessment, functional unit, system boundaries, cradle-to-gate/cradle-to-grave/cradle-to-cradle, life cycle inventories (LCIs), environmental product declarations (EPDs), life cycle impact assessment (LCIA), problem and damage oriented impact methods, environmental impact, climate change, abiotic depletion, acidification, eutrophication, human toxicity, ecotoxicity, ozone layer depletion, chain management, eco-labels, recycling, reuse, ...

2 Explain how basic material properties like mechanical strength and service life of a material can have a major effect on its environmental impact when considering the full life cycle of the material.

3 Elaborate in how the outcome of service life prediction can vary significantly with the assumed model input.

4 Show the importance of choosing a proper unit for environmental impact quantification which accounts for all the relevant functionalities of the material.

5 Explain the advantages and disadvantages of different allocation principles (mass versus economic allocation) and impact methods (problem versus damage oriented impact assessment).

6 Being aware of the different material properties to consider when using a building material in an environment with specific exposure conditions.

7 Being able to make a proper material choice for a specific building application.

8 Being able to perform an adequate service life prediction for steel reinforced concrete and evaluate the uncertainty on this service life estimation based on a thorough sensitivity analysis in the software Comrel.

9 Being able to consequently quantify the environmental impact of potentially 'green' construction materials using common LCA principles in the software SimaPro.

Conditions for credit contract

Access to this course unit via a credit contract is determined after successful competences assessment

Conditions for exam contract

This course unit cannot be taken via an exam contract

Teaching methods

Guided self-study, excursion, lecture, project

Extra information on the teaching methods

Due to Covid19, the education methods may differ from the information displayed in the schedules and course details. Any changes will be communicated on Ufora.

Learning materials and price

Course notes (English) (around 15 Euro)

References

- Fernando Pacheco-Torgal, Luisa F. Cabeza, João Labrincha, Aldo Giuntini de Magalhaes (editors). (2013). Eco-efficient Construction and Building Materials. Life Cycle Assessment (LCA), Eco-Labelling and Case Studies. Woodhead Publishing. Electronic ISBN 9780857097729.
- Kathib J.M. (ed.) (2016). Sustainability of construction materials. CRC Press, Boca Raton. eBook ISBN: 9780081003916, Hardcover ISBN: 9780081009956
- Rodriguez-Robles, D., Van Den Heede, P., De Belie, N. (2019). Life Cycle Assessment applied to recycled aggregate concrete. In: De Brito J., Agrela F. (eds.) New Trends in Eco-Efficient and Recycled Concrete. Woodhead Publishing, Elsevier, Duxford, UK, p. 207-256. ISBN: 978-0-08-102480-5 (print), ISBN: 978-0-08-102481-2 (online).
- Alexander, M., Bertron, A., De Belie, N. (Eds.) (2012). Performance of cement-based materials in aggressive aqueous environments. State-of-the-Art Report, RILEM TC 211 – PAE. Springer, 449 p., ISBN 978-94-007-5412-6.
- DuraCrete (2000). Probabilistic performance based durability design of concrete structures: General guidelines for durability design and redesign. Document BE95-1347/R15. Gouda: CUR.
- fib Bulletin 34 (2006). Model code for service life design. Lausanne: fib.

Course content-related study coaching

Before and after lectures or after making an appointment

Evaluation methods

end-of-term evaluation and continuous assessment

Examination methods in case of periodic evaluation during the first examination period

Oral examination

Examination methods in case of periodic evaluation during the second examination period

Oral examination

Examination methods in case of permanent evaluation

Report

Possibilities of retake in case of permanent evaluation

examination during the second examination period is possible in modified form

Extra information on the examination methods

During the examination period: oral closed book exam, written preparation
Evaluation of a report concerning a project work on service life prediction and life cycle assessment

Calculation of the examination mark

The oral examination counts for 60% and the report on service life prediction and life cycle assessment for 40% of the points.
If one does not participate in one of the parts of the evaluation, it is not possible to pass for this course. In case the final score would still be 10 or more on 20, this will be reduced to the highest no-pass score (9/20).
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