Reinforced concrete modelling - BMEEOHSDT81

I. Subject Specification

1. Basic Data

1.1 Title

Reinforced concrete modelling

1.2 Code

BMEEOHSDT81

1.3 Type

Module with associated contact hours

1.4 Contact hours

Type	Hours/week / (days)
Lecture	2

1.5 Evaluation

Exam

1.6 Credits

3

1.7 Coordinator

name	István Sajtos, PhD
academic rank	Associate professor
email	sajtos.istvan@epk.bme.hu

1.8 Department

Department of Structural Engineering

1.9 Website

https://epito.bme.hu/BMEEOHSDT81
https://fiek2.mywire.org/course/view.php?id=2541

1.10 Language of instruction

english

1.11 Curriculum requirements

Ph.D.

1.12 Prerequisites

There are no subject prerequisites. Students participating in the course must be proficient in the design and analysis of reinforced concrete structures. The students should know the design principles and analysis methods of load-bearing structures based on Eurocode, and the basis of the finite element method. Intermediate English language knowledge is expected.

1.13 Effective date

1 September 2022

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2. Objectives and learning outcomes

2.1 Objectives

The aim of the PhD course is to gain knowledge on fracture mechanics based numerical modelling of concrete and reinforced concrete structures. The course will introduce the elements of reinforced concrete numerical modelling with the practical application possibilities and limitations. The effects of concrete constituents on capacity and ductility and their possible numerical models will be discussed The fracture mechanics-based models of reinforced concrete are also introduced (linear elastic-, and non-linear fracture mechanics models). Students who complete the course gain knowledge in the following topics:

- numerical modelling possibilities of reinforced concrete structures;
- linear and non-linear behaviour of concrete structures;
- numerical models of cracks;
- models of secondary effects; strain softening, dowel action; creep and shrinkage; size effect; aggregate interlock;
- effect of concrete constituents on capacity and ductility of concrete,
- models of cracks based on linear elastic fracture mechanics;
- models of cracks based on nonlinear fracture mechanics;
- models of crack propagation.

2.2 Learning outcomes

Upon successful completion of this subject, the student:

A. Knowledge

1. knows numerical modelling techniques,
2. knows linear and nonlinear behaviour of concrete structures,
3. knows numerical modelling possibilities of cracks,
4. knows the secondary effects: strain softening, dowel action; creep and shrinkage; size effect; aggregate interlock,
5. knows the effects and modelling possibilities of concrete constituents on strength and ductility of concrete,
6. knows linear elastic fracture mechanics models of cracks,
7. knows nonlinear fracture mechanics models of cracks,
8. knows the criteria of crack propagation.

B. Skills

1. able to apply numerical modeling techniques in practice,
2. able to design reinforced concrete structures based on a numerical model, selecting the appropriate model level and creating the numerical model,
3. able to carry out the designing of reinforced concrete structures based on the results of the numerical model, evaluate the results from a theoretical point of view,
4. able to model cracks in reinforced concrete structures and determine their effect on load-bearing

capacity.

C. Attitudes

1. cooperates with the teacher and fellow students during the expansion of knowledge,
2. open to using numerical tools,
3. pursue to use of advanced design methods,
4. strives for accurate and error-free task solutions,

D. Autonomy and Responsibility

1. independently performs numerical modeling problems and designing of structures based on calculation results,
2. accepts and considers new designing procedures, their principles, and correctness with an open mind.

2.3 Methods

Lectures, practical analysis, communication in writing and orally, using IT tools and techniques.

2.4 Course outline

Week	**Topics of lectures and/or exercise classes**
1.	Introduction: micro-, meso-, macro models of concrete, reinforced concrete
2.	Models of reinforced concrete - linear elastic models
3.	Models of reinforced concrete - nonlinear behaviour models (discrete crack model, smeared crack model)
4.	Models of reinforced concrete - nonlinear models (secondary effects: softening for tension and compression, the effect of confinement, tension stiffening, aggregate interlock, shear friction, dowel action, size effect, creep and shrinkage)
5.	Structure of cement and concrete and its effect on the strength and ductility - uniaxial compression
6.	Structure of cement and concrete and its effect on the strength and ductility - uniaxial tension
7.	Structure of cement and concrete and its effect on the strength and ductility - shearing
8.	Structure of cement and concrete and its effect on the strength and ductility - multiaxial stress state
9.	Fracture mechanics of reinforced concrete - linear elastic models
10.	Fracture mechanics of reinforced concrete - nonlinear models

11.	Fracture mechanics of reinforced concrete - approximate non-linear fracture models

The above programme is tentative and subject to changes due to calendar variations and other reasons specific to the actual semester. Consult the effective detailed course schedule of the course on the subject website.

2.5 Study materials

a) Books:

- S. Kumar - S.V. Barai: Concrete Fracture Models and Applications, Springer-Verlag, Berlin, 2011.
- J.G.M. van Mier: Fracture Processes of Concrete, CRC Press, 1997.
- B.L. Karihaloo: Fracture Mechanics of Concrete, Addison-Wesely Longman Ltd., 1995.
- A.R. Ingraffea: Computational Fracture Mechanics, Chp.11 in: ed. E Stein et al: Encyclopaedia of Computational Mechanics, Vol.2: Solids and Structures, John Wiley and Sons, 2004.
- R. Lackner et al: Computational Concrete Mechanics, Chp.15 in: ed. E Stein et al: Encyclopaedia of Computational Mechanics, Vol.2: Solids and Structures, John Wiley and Sons, 2004.
- Structural Concrete: Journal of the fib

b) Downloadable materials:

- Slides of lecture materials
- Kármán T.: Mitől függ az anyag igénybevétele? Magyar Mérnök és Építészegylet Közlönye, 44 (10), 1910, p.212-226.

2.6 Other information

2.7 Consultation

Appointments for consultation:

according to the announcement on the department’s web page, or

asking for an appointment in e-mail; e-mail: sajtos.istvan@epk.bme.hu

This Subject Datasheet is valid for:

Inactive courses

II. Subject requirements

Assessment and evaluation of the learning outcomes

3.1 General rules

The evaluation of the learning outcomes stated in point 2.2 is done on the basis of a project task (report) and the result shown in the exam.

3.2 Assessment methods

Evaluation form	Abbreviation	Assessed learning outcomes
Homework – project task (report)	HW	A.1-A.8; B.1-B.4; C.1-C.4; D.1-D.2
Exam (performance evaluation)	E	A.1-A.8; B.1-B.4; C.1-C.4; D.1-D.2

The time of the evaluations held during the semester is in the "Semester schedule", which is available on the subject's website.
The dates of deadlines of assignments/homework can be found in the detailed course schedule on the subject's website.

3.3 Evaluation system

Abbreviation	Score
HW	20%
Sum during the semester	**20%**
E	80%
Sum	**100%**

The condition for passing the subject is that the student achieves 50% of the scores on the homework.
Insufficient performance in the exam will result in a fail grade.

3.4 Requirements and validity of signature

The condition for obtaining the signature is that, according to point 3.3, the student achieves at least 50% of the points that can be obtained during the semester on the homework.
Mid-semester results previously obtained from the subject, which can be taken into account when determining the exam grade, can be accepted for up to 6 semesters.

3.5 Grading system

The grades of those who meet the attendance requirements are determined according to the following criteria:
The final grade is calculated based on the weighted average of the homework and the exam according to point 3.3:

Grade	Points (P)
excellent (5)	80<=P
good (4)	70<=P<80%
satisfactory (3)	60<=P<70%
passed (2)	50<=P<60%
failed (1)	P<50%

3.6 Retake and repeat

According to the Study Rules.

3.7 Estimated workload

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Activity	Hours/semester
attendance of the lectures	12×2=24
preparing project task	36
self- learning of written course material	6
preparing for exam	24
Sum	**90**

3.8 Effective date

1 September 2022

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Inactive courses