FACULTY OF CIVIL ENGINEERING

SUBJECT CARD

Name in English: **Effective properties of composites – introduction to micromechanics**

Name in Polish: **Właściwości efektywne kompozytów –wprowadzenie do mikromodelowania**

Main field of study (if applicable): *Civil Engineering*

Specialization (if applicable): Civil Engineering

Level and form of studies: ~~1st /~~ 2nd level*, fuLl-time ~~/ part-time~~*

Kind of subject: ~~obligatory~~ / optional / ~~university-wide~~*

Subject code: CEB006863

Group of courses: ~~YES~~ / NO*

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	**15**		**15**		
Number of hours of total student workload (CNPS)	**30**		**60**		
Form of crediting	~~Examination~~ / crediting with grade *	Examination / crediting with grade *	~~Examination~~/ crediting with grade *	Examination / crediting with grade *	Examination / crediting with grade *
For group of courses mark (X) final course					
Number of ECTS points	**1**		**2**		
including number of ECTS points for practical (P) classes			**2,0**		
including number of ECTS points for direct teacher-student contact (BK) classes	**0,6**		**0,6**		

* delete as appropriate

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES
1. The student has knowledge regarding continuous mechanics.
2. The student has knowledge and skills in the field of strength of materials.

SUBJECT OBJECTIVES
C1. Learning the methodology of multiscale modelling of composite materials.
C2. Learning the methodology of composite effective properties determination.
C3. Gaining an in-depth knowledge of continuous media mechanics and strength of materials..
C4. Strengthening the ability to work on the task entrusted to and awareness of the need to seek new theoretical and practical solutions.

SUBJECT EDUCATIONAL EFFECTS
Relating to knowledge:
PEK_W01   The student has an in-depth knowledge of multiscale modelling.
PEK_W02   The student knows theoretical method of composite materials analysis
Relating to skills:
PEK_U01   The student can perform upscaling using the multiscale technique.
PEK_U02   The student can estimate and determine effective properties of composite materials.
Relating to social competences:
PEK_K01   The student is able to work on the implementation of tasks independently or in a team (individual preparation of reports and cooperative problem solving in the classroom)
PEK_K02   The student is aware of the need to increase knowledge in the field of composite theory.

PROGRAMME CONTENT	
Form of classes - lecture	**Number of hours**
Lec1	Introduction. Principles of micro-macro approach	2
Lec2	Continuous micromechanics. Method of volume and weight averaging.	2
Lec3	Analytical methods of effective properties estimation. Single inclusion problem in diffusion and heat conduction problems.	2
Lec4	Maxwell, Mori-Tanaka and self-consistent estimation schemes.	2
Lec5	Solution of single inclusion problem in elasticity.	2
Lec6	Analytical effective properties estimation schemes for linearly elastic composites.	2
Lec7	Estimation of composite effective properties form digital image of its microstructure	2
Lec8	Final test	1
	Total hours	**15**

Form of classes - class	**Number of hours**
Cl1		
...		
	Total hours	

Form of classes - laboratory		**Number of hours**
Lab1	Introductory information. Presentation of basic feature of the FlexPDE software. Solving of simple examples.	2
Lab2	Solving diffusion problem in simple structure of periodic composite. Estimation of effective properties.	2
Lab3	Individual work of students. Performing own numerical calculation.	2
Lab4	Individual work of students. Preparation of laboratory reports.	2
Lab5	Numerical determination of Mori-Tanaka and Self-consistent estimates of effective properties.	2
Lab6	Individual work of students. Performing own numerical calculation.	2
Lab7	Individual work of students. Preparation of laboratory reports.	2
Lab8	The final verification of laboratory reports.	1
	Total hours	**15**

Form of classes - project		Number of hours
Proj1		
…		
	Total hours	

Form of classes - seminar		Number of hours
Sem1		
…		
	Total hours	

TEACHING TOOLS USED
N1. Classic lecture. Multimedial presentation.
N2. Laboratory: classic and multimedial presentation regarding laboratory, presentation of computer software, examples of problem solution with computer software.

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT		
Evaluation (F – forming (during semester), P – concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
F1(laboratory)	PEK_U01, PEK_U02, PEK_K01	Laboratory report.
F2(laboratory)	PEK_U01, PEK_U02, PEK_K01	Laboratory report.
P (laboratory) = P = 0,4xF1+0,4xF2+0,2xParticipation (Laboratory)		
P (lecture)	PEK_W01, PEK_W02, PEK_K02	Final test.

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE:
[1] Milton G. W.: The Theory of Composites, Cambridge Univ. Press, 2002.
[2] Torquato S.: Random heterogeneous materials, Springer, 2000.
[3] Hornung U.: Homogenization and porous media, Springer, 1997.
[4] Łydżba D.: Effective properties of composites, Wrocław, 2011.
SECONDARY LITERATURE:
[1] Cherkaev A.: Variational methods for structural optimization, Springer, 2000.

SUBJECT SUPERVISOR (NAME AND SURNAME, DIVISION, E-MAIL ADDRESS)
dr. hab. inż. Dariusz Łydżba, prof. PWr; Katedra Geotechniki, Hydrotechniki, Budownictwa Podziemnego i Wodnego, Dariusz.Lydzba@pwr.edu.pl
MEMBERS OF TEH EDUCATIONAL TEAM (NAME AND SURNAME, E-MAIL ADDRESS)
Katedra Geotechniki, Hydrotechniki, Budownictwa Podziemnego i Wodnego:
dr inż. Irena Bagińska, Irena.Baginska@pwr.edu.pl
dr inż. Andrzej Batog, Andrzej.Batog@pwr.edu.pl
dr inż. Janusz Kaczmarek, Janusz.Kaczmarek@pwr.edu.pl
dr inż. Marek Kawa, Marek.Kawa@pwr.edu.pl

dr Joanna Stróżyk, Joanna.Strozyk@pwr.edu.pl
dr inż. Adrian Różański, Adrian.Rozanski@pwr.edu.pl
mgr inż. Matylda Tankiewicz, Matylda.Tankiewicz@pwr.edu.pl
mgr inż. Maciej Sobótka, Maciej.Sobotka@pwr.edu.pl
mgr inż. Damian Stefaniuk, Damian.Stefaniuk@pwr.edu.pl
mgr inż. Magdalena Rajczakowska, Magdalena.Rajczakowska@pwr.edu.pl

MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT
Effective properties of composites – introduction to micromechanics
AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY *Civil Engineering*
AND SPECIALIZATION **Civil Engineering**

Subject educational effect	Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)**	Subject objectives ***	Programme content ***	Teaching tool number ***
Knowledge				
PEK_W01	K2_W02, K2S_CEB_W22	C1, C3, C4	Lec1 – Lec7	N1
PEK_W02	K2_W05, K2S_CEB_W22	C1, C3, C4	Lec4 – Lec7	N1
Skills				
PEK_U01	K2_U16, K2S_CEB_U23	C1, C2	Lab1 – Lab7,	N2
PEK_U02	K2_U16, K2S_CEB_U23	C1, C2	Lab1 – Lab7	N2
Social competence				
PEK_K01	K2_K03	C4	Lab3, Lab4, Lab6, Lab7	N2
PEK_K02	K2_K01	C4	Lec1 - Lec7	N1

** - enter symbols for main-field-of-study/specialization educational effects
*** - from table above