

FEM in Structural Engineering

Name of course				Code of course		Year / Semester	
FEM in Structural Engineering <i>Metoda elementów skończonych w konstrukcjach inżynierskich</i>				WB-BUD-D2-MES-02		I	02
Type of course		Profile		Level of qualification			
obligatory		generally academic		stationary second cycle programme – S2			
Rodzaj zajęć						ECTS	
Lecture	Exercises	Laboratory	Projects	Seminar	Exam		
15	15	-	30	-	-	6	
Person leading of course::							
Prof. Piotr Lacki				mail: lacki@bud.pcz.pl			

I.CARD OF COURSE

OBJECTIVE OF THE SUBJECT	
C01	Understanding the course of proceedings in the construction of a numerical model in the finite element method
C02	Acquiring the skills of proper selection of a numerical model based on a physical model.
C03	Acquiring the ability to interpret the results of numerical simulations using the finite element method.
PREREQUISITES FOR KNOWLEDGE, SKILLS AND OTHER COMPETENCE	
1	The basic knowledge of the civil engineering.
2	The basic knowledge of the theoretical mechanics and the strength of materials and the skill to calculate the sections strength parameters.
3	The knowledge of the structural mechanics and the ability to solve the static equilibrium systems.
4	Ability to construct the building dividing walls.
5	Ability to use the standards of the construction loads.
6	The knowledge of the preparing principles of the technical drawings and the ability to read and apply them.
LEARNING OUTCOMES:	
Knowledge: the graduate knows and understands	
EK1	The graduate knows and understands the rules of conducting the analysis using MES.
Skills: the graduate can	
EK2	The graduate can explain the workflow using the finite element method, build a FEM model and optimize the MES model.
Social competence: The student is ready to	
EK3	The student is ready to work in a group and make his/her own decisions related with design metal structures.

II.CONTENTS OF COURSE

Form of teaching - Lectures		Number of hours
W1	Construction of the FEM program. An algorithm for the construction of the FEM model.	1
W2	Numerical model of a truss. One-dimensional elements (1D) of the "truss" type.	1
W3	Numerical model of a truss. Concentrated loads	1
W4	Numerical model of a truss. Implementation of boundary conditions for a truss	1
W5	Numerical model of a truss. Analysis of results for a truss	1
W6	Numerical model of the beam. One-dimensional (1D) "beam" elements	1
W7	Numerical model of the beam. Types of beam loads	1
W8	Numerical model of the beam. Types of boundary conditions for beams	1

W9	Numerical model of the beam. Analysis of results for beams	1
W10	Discussion of the scope of the implemented own project	1
W11	Two-dimensional "shell" elements	1
W12	Analysis of results using elements of the "shell" type	1
W13	Three-dimensional elements (3D Solid).	1
W14	Analysis of results using 3D Solid elements.	1
W15	Final test.	1
TOTAL:		15
Form of teaching – Exercise		Number of hours
Cw1	Discussion of the procedure for modeling MES using an example	1
Cw2	An example of using truss elements for truss modeling	1
Cw3	Discussion of a truss load with concentrated forces on the example	1
Cw4	Discussion of defining complex boundary conditions for a truss example	1
Cw5	Discussion of the analysis of the calculation results for the truss on an example	1
Cw6	The use of beam-like elements for frame modeling.	1
Cw7	Loading of the frames with the examples	1
Cw8	Discussion of defining complex boundary conditions for frames on an example	1
Cw9	Discussion of the analysis of the calculation results for the frames on the example	1
Cw10	Discussing project tasks	1
Cw11	An example of using a two-dimensional "shell" element	1
Cw12	Analysis of the results of the FEM model with the use of "shell" type elements	1
Cw13	An example of using a three-dimensional element "3D Solid"	1
Cw14	Analysis of the results of the FEM model with the use of "3D Solid" elements	1
Cw15	Final assignment.	1
TOTAL:		15
Form of teaching – Project		Number of hours
Pr1	The assumptions of project.	2
Pr2	Creating geometry	5
Pr3	Loads	1
Pr4	Boundary conditions	1
Pr5	Building a FEM model	5
Pr6	Optimizing the FEM model	5
Pr7	Analysis of calculation results	5
Pr8	Creation of the project documentation	6
TOTAL:		30

TOOLS OF TEACHING		
1.	The lecture carried out with the using of audio-visual means.	
2.	The exercises carried out with the using of audio-visual means, PLATON platform, ADINA program	
3.	The materials prepared by the teachers.	
4.	Literature.	

METHODS OF ASSESSMENT: (F - FORMATIVE; P - SUMMARY)		
F01	The assessment of the individual preparation for the exercises.	
P01	The assessment of the knowledge and skills to apply computational procedures according to ULS.	
P02	The assessment of the knowledge and skills to apply computational procedures according to SLS.	
P03	The assessment of the familiarize with the knowledge in the context of the calculation procedures.	

III.WORKLOAD OF STUDENT

O.n.	Activity	Average number of hours/ECTS to complete the activity
		[hours]
1. Contact hours with the teacher:		
1.1	Hours of classes organized by the universities – lecture	15
1.2	Hours of classes organized by the universities – exercise	15
1.3	Hours of classes organized by the universities – laboratory	0
1.4	Hours of classes organized by the universities – project	30
1.5	Consultations	15
1.6	Exam	0
Total contact hours with the teacher:		75
2. Student's own work		
2.1	Preparing for the practices and for the final assignment	20
2.2	Preparation for the laboratory, execution of individual test reports	0
2.3	Preparing own project	15
2.4	Preparation for the final test from the lecture	5
2.5	Preparation for the exam	0
2.6	Get acquainted with the indicated literature	5
Total hours of student work:		45
General workload of the student:		120
TOTAL NUMBER OF ECTS FOR SUBJECT:		
The number of ECTS which the student receives in a course requiring direct teacher involvement:		3.75
The number of ECTS which the student receives in a practical course, including laboratory and project classes:		2.25

IV.LITERATURA PODSTAWOWA I UZUPEŁNIAJĄCA

Literatura podstawowa:	
1.	Zienkiewicz O. C.: Metoda elementów skończonych, Arkady, Warszawa 1972.
2.	Klaus-Jürgen Bathe: Finite element procedures Prentice Hall, 1996.
3.	Rakowski G., Kacprzyk Z.: Metoda elementów skończonych w mechanice konstrukcji, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa 2005.
4.	Grzegorz Dzierżanowski, Marta Sitek: Samouczek Metody Elementów Skończonych dla studentów Budownictwa. Oficyna Wydawnicza Politechniki Warszawskiej Warszawa 2012.
5.	Szmelter J., Dacko M., Dobrociński S., Wieczorek M.: Metoda elementów skończonych w statyce konstrukcji, Arkady, Warszawa 1979
6.	Sieczkowski J.M.: Podstawy komputerowego modelowania konstrukcji budowlanych, Oficyna wydawnicza Politechniki Wrocławskiej, Wrocław 2001
7.	Starosolski W.: Wybrane zagadnienia z komputerowego modelowania konstrukcji inżynierskich, Wydawnictwo Politechniki Śląskiej, Gliwice 2001
Literatura uzupełniająca:	
1.	Bogucki W., Żybertowicz M.: Tablice do projektowania konstrukcji metalowych, Arkady, Warszawa 2008
2.	PN-EN 1993-1-1:2006 Eurokod 3. Projektowanie konstrukcji stalowych. Część 1-1: Reguły ogólne i reguły dotyczące budynków.
3.	PN-EN 1993-1-5:2008 Eurokod 3. Projektowanie konstrukcji stalowych. Część 1-5: Blachownice.
4.	PN-EN 1993-1-3:2008 Eurokod 3. Projektowanie konstrukcji stalowych. Część 1-3: Reguły ogólne - reguły uzupełniające dla konstrukcji z kształtowników i blach profilowanych na zimno.

V.MATRIX OF IMPLEMENTATION EFFECTS OF EDUCATION FOR DIRECTION

The effect of learning	The reference to the effect of learning defined for the entire program	Reference of the effect to characteristics of I and II PRK		Objectives of the course	Program content	Tools of teaching	Method for assessing
		universal	In technical sciences and leading to engineering competencies				
EK1	K1_W08 K1_W10	P6U_W	P6S_WG	C01 C02 C03	W1-W12 C1-C14	1, 2, 3, 4	F01, P03
EK2	K1_U05 K1_U16	P6U_U	P6S_UW	C01 C02 C03	W1-W14 C2-C14	1, 2, 3, 4	F01, P01, P03, P03
EK3	K1_K01 K1_K02 K1_K03	P6U_K	P6S_KK	C01 C02 C03	W1 W14 C1-C14	1, 2, 3, 4	P03

VI.METHODS ASSESSMENT - DETAILS

MARKS	LEARNING OUTCOME
EK1	
2,0	The graduate does not know and does not understand how to conduct the analysis using MES.
3,0	The graduate knows the basic concepts related to FEM modeling. He can solve a simple issue using FEM.
4,0	The graduate knows the concepts related to FEM modeling. He can solve a problem using FEM, and apply complex boundary conditions and loads. Moreover, the student is able to analyse the results of calculations during the design process.
5,0	The graduate knows and understands the method of conducting the analysis using FEM. He can solve a complex issue using FEM. Moreover, the student completed the information given in the standards of knowledge given in the books.
EK2	
2,0	The graduate can not explain the workflow using the finite element method
3,0	The graduate can draw up a flow chart for the FEM model. He can build a simple numerical FEM model
4,0	The graduate can draw up a flow chart for the FEM model. He can build a numerical FEM model and interpret the results of calculations accordingly..
5,0	The graduate is able to draw up a scheme of procedure for modeling using the finite element method, build a numerical model of FEM, and interpret the results of calculations accordingly. He can optimize the numerical model of FEM
EK3	
2,0	The student performs the tasks assigned to him carelessly.
3,0	The student performs the tasks carefully, but he does not subject their results to discussion. Moreover, the student notes the need to discuss the result, but he cannot formulate the problem properly.
4,0	The student formulates the problem correctly, but he cannot perform the discussions about the result. The student can discuss the result using the appropriate criteria.
5,0	Moreover, the student is able to assess the impact of changes of particular criteria on the final result.
<p>Half score 3.5 is given in the case of a full assessment of the learning outcomes for grade 3.0, but the student has not fully absorbed the learning outcomes for grade 4.0.</p> <p>Half-score 4.5 is given in the case of a full assessment of the learning outcomes for grade 4.0, but the student has not fully absorbed the learning outcomes for grade 5.0</p>	

VII.OTHER USEFUL INFORMATIONS ABOUT THE COURSE

1.	Information where the student can see the presentations to classes, support materials and literature: <i>According to the type of materials - in the classes didactic, in the room of teacher, in the library of the university and faculty.</i>
2.	Information on the place of event classes: <i>Showcased at the Faculty of Civil Engineering, Faculty of Civil Engineering website.</i>
3.	Information on the date of the course (day of week / time): <i>Showcased at the Faculty of Civil Engineering, Faculty of Civil Engineering website.</i>

4.	<p>Information on the consultation (hours + location):</p> <p><i>Schedule of consultation on the website of Faculty of Civil Engineering and on the door of the worker's room.</i></p>
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