COMPUTER METHODS IN DESIGN OF ROADS AND BRIDGES

Course code: **11.9-WILŚ- BUD- MKDM- DB02**

Type of course: compulsory

Entry requirements: knowledge of computational methods, strength of materials and structural mechanics, computer system and programming language

Language of instruction: Polish

Director of studies: dr hab. inż. Mieczysław Kuczma prof. UZ Department of Structural Mechanics, dr hab. inż. Adam Wysokowski prof. UZ Department of Road and Bridges

Name of lecturer: dr hab. inż. Mieczysław Kuczma prof. UZ, dr inż. Krzysztof Kula, mgr inż. Arkadiusz Denisiewicz, mgr inż. Artur Juszczyk

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
Full-time studies					4
Lecture	15	1	IV	Grade	
Class					
Laboratory	30	2		Grade	
Seminar					
Workshop					
Project					
Part-time studies					
Lecture	10	1	IV	Grade	
Class					
Laboratory	20	2		Grade	
Seminar					
Workshop					
Project					

COURSE CONTENTS:
Lecture

Minimization of the functional of total potential energy and the equation of virtual work for problems in mechanics. Approximation properties of the finite element method (FEM) for weak formulations of boundary value problems in structural mechanics – approximation error, convergence rate and adaptive FEM. Numerical analysis of plates and plates on foundation by the finite element method – conforming and non-conforming finite elements. Numerical direct and iteration methods for eigenvalue problems of structural dynamics and stability. Problems with unilateral constraints. Unilateral contact of plates with foundation. FEM for cable structures. Linearization of nonlinear problems. Newton-Raphson method and its applications to nonlinear problems in mechanics (cable structures). Finite difference method and numerical integration methods for equations of motion. Conditional and unconditional stability of time integration methods. Introduction to the boundary element method.

Laboratory

1. *Verification of the F. Leonhardt method on a bridge model in the form of a flat grid by the finite element method.*
2. *Determining the influence surface for a plate bridge of complex plane geometry by the finite element method.*
3. *Suspension programme of cables in a cable-stayed bridge for making a pre-set system of internal forces in the deck.*

LEARNING OUTCOMES:

Competence and skill to understand and use (i) the finite element approximation and modelling of systems of any geometry, (ii) the FEM algorithms for advanced structural problems, (iii) contemporary computer methods in engineering practice, and (IV) advanced computer programs (Robot) for engineering calculations.

ASSESSMENT CRITERIA:

Lecture – *to receive a credit for final test.*

Project – *to receive a credit for all projects and tests.*

RECOMMENDED READING:

1. Rakowski G., Kacprzyk Z.: Metoda elementów skończonych w mechanice konstrukcji, Wyd. PW, Warszawa 2005.
2. Zienkiewicz O.C., Metoda elementów skończonych. Arkady, Warszawa 1972.
3. Praca zbiorowa, Mechanika budowli: ujecie komputerowe, t. 2 , t. 3, Arkady, Warszawa 1992, 1995.
4. Łodygowski T., Kąkol W., Metoda elementów skończonych. Politechnika Poznańska, Poznań 1994.
5. Rajche J., Pryputniewicz S., Bryś G., Projektowanie wspomagane komputerem. Cz. II: Metoda elementów skończonych. WSInż., Zielona Góra 1991.
6. Piecha, Programowanie w języku Fortran 90 i 95. Politechnika Warszawska, Warszawa 2000.
7. Robot. Podręcznik użytkownika.

OPTIONAL READING:

1. Kleiber M. (red.), Komputerowe metody mechaniki ciał stałych. PWN, Warszawa 1995.
2. Zienkiewicz O.C., Taylor R., The Finite Element Method. Vol. 1: The Basis, Vol. 2: Solid Mechanics. Oxford: Butterworth-Heinemann, 2000.
3. Wriggers P., Nichtlineare Finite-Element-Methoden. Springer, Berlin 2001.
4. Dahlquist G., Bjoerck A., Numerical methods in Scientific Computing. vol. I, SIAM, Philadelphia 2008.