UNIWERSYTET PRZYRODNICZY WE WROCŁAWIU

Computational methods

Educational subject description sheet

Basic information

Field of study Civil engineering **Speciality** - **Department** The Faculty of Environmental Engineering and Geodesy **Study level** Second-cycle (engineer) programme **Study form** Full-time **Education profile** Practical	**Education cycle** 2022/23 **Subject code** ID000000IBU(P)S.MI1BO.0420.22 **Lecture languages** English **Mandatory** optional **Block** major subjects (conducted) in foreign languages **Disciplines** Civil engineering and transport **Subject related to scientific research** No **Subject shaping practical skills** No

Teacher responsible for the subject	Filip Zakęś
Other teachers conducting classes	Filip Zakęś

Period Semester 1	**Examination** exam **Activities and hours** lecture: 30 laboratory classes: 30	**Number of ECTS points** 4.0

Goals

C1	Computer methods applied in the analysis of engineering structures, common features and pros and cons of their application. Concept of discretization and its impact on the results of numerical calculations. Mathematical foundations of Finite Element Method (FEM). Equilibrium equations for single elements and for entire structure. Stiffness matrices for bar and surface elements. Analysis of plate and cover discs with the use of Robot computer system. FEM algorithm in non-linear problems stemming from the application of unilateral constraints modelling collaboration of structure with surface. Solution to own problem within dynamic analysis of surface girders. Integration of equations of motion.

Subject's learning outcomes

Code	Outcomes in terms of	Effects	Examination methods
Knowledge – Student knows and understands:			
W1	One has enhanced theoretical knowledge related to the use of computer methods and in particular methods of finite elements, in the scope of analysis of bar and surface girders.	BU_P7S_WG07	written exam
W2	One knows what discretization of analysed object is and what impact it has on the results of calculations. One knows computer systems (is able to list them) which are applied in	BU_P7S_WG04, BU_P7S_WG05	written exam
Skills – Student can:			
U1	One is able to create calculation model of analysed girders in computer system based on the method of finite elements. One is able to conduct discretization of an analysed object and specify the number of degrees of freedom of the applied finite element.	BU_P7S_UW02, BU_P7S_UW04	project
U2	One understands which parameters are required for description of selected statistical analysis or dynamic analysis. One is able to make a choice of method of solving non-linear problem. One is able to present the results of calculations in graphic form and assess their correctness.	BU_P7S_UW07	project
U3	The student knows English at a level that allows understanding of the content taught.	BU_P7S_UK17	project
Social competences – Student is ready to:			
K1	One appreciates the role of applying computer in engineering calculations and understands the need of increasing his/her qualifications in this scope.	BU_P7S_KK02	project

Balance of ECTS points

Activity form	Activity hours*
lecture	30
laboratory classes	30
project preparation	40

literature study	10
consultations	4
exam / credit preparation	3
exam participation	2

Student workload	**Hours** 119	**ECTS** 4.0
Workload involving teacher	**Hours** 66	**ECTS** 2.4
Practical workload	**Hours** 30	**ECTS** 1.0

* hour means 45 minutes

Study content

No.	Course content	Activities

1.	Purpose of teaching and course subject scope Methods of computer modelling and analysis of structure-short characteristics of the Finite Difference Method (FDM), Finite Element Method (FEM), Boundary Element Method (BEM)-common features, pros and cons and possibilities of application. Bar and surface girders-division and classification in terms of geometric parameters and floor load, characteristic degrees of freedom and voltage status in place. Role of preprocessor, processor and post-processor in computer analysis of structure. Discretisation of geometry, support conditions and loads in FEM. Mathematical foundations of FEM, application of the method of works elaborated for entering equations of static equilibrium to discrete structure according to displacement approach. Compliance conditions of displacements and equilibrium in constraints. Discretisation of surface girder with regular and non-regular shape upon application of rectangular, triangular and parallelogram components. Degrees of freedom of disc, plate and cover elements. Geometric compounds and physical compounds in discs, plates and covers. Introduction to stiffness matrices for disc, plate and cover element. Numerical integration on the surface of elements. Stiffness matrices and vector of external load equivalents for single element-physical interpretation of elements of stiffness matrix. Methods of automated generation of network of surface elements used in computer programmes based on FEM. Impact of discretisation on results of calculations. Density of network of division of elements in areas of anticipated concentration of stresses. Aggregation of stiffness matrices of entire discrete structure, optimum numbering of constraints. Method of introducing conditions for structure support. Storing matrices in computer memory and algorithms of solving simultaneous equations with band and symmetrical matrix of coefficients in case of unknown. Solving non-linear problems with the use of FEM. Geometrical and physical non-linearity of structure. Incremental- iterative methods of solving non-linear problems. Structural non-linearity-concept of unilateral constraints and their use, modelling of contact issues. Elastic foundation of Winkler type with bi and unilateral constraints. Own issue in the analysis of structure stability. Stability criterion applied in numerical calculations. Assigning critical load level and vector of buckling form. Dynamic equilibrium equations for single element and entire structure. Types of vibration damping. Inertia and damping matrices for single element and entire structure. Methods of integration of equation of motion on independent variable representing time. Impact of length of time step and number of steps on the course of solution. Harmonic analysis-defining acceleration amplitude, internal forces and reaction. Modal analysis Methods of solving own issue. Indication of vector of frequency of free vibrations and matrices of forms of such vibrations. Simulation of moving loads for structure. Repertory.	lecture
2.	Familiarizing with the method and stages of modelling bar and surface structures within Robot Structural Analysis system (classes 1, 2). Calculating stiffness matrices for trussed and bar element based on the principle of works elaborated, graphic illustration of the function of shape (classes 3, 4). Automatic generation of division grid into elements within the analysis of surface girders-disc, plate and cover of regular and non-regular shape (classes 5, 6). Solution for surface girders (flat deformation state and stress, bending the disc and the cover) subject to activity of static loads-presentation and interpretation of results of calculations (classes 7, 8). Solution for non-linear issues stemming from the way of structure support and material properties (classes 9, 10). Analysis of stability of bar structure. (classes 11). Dynamic analysis of surface girder-own vibrations, harmonic extortion, motion equations integration (classes 12, 13). Moving loads on bar girder (gantry) and surface girder (vehicle on plate). (classes 14). Passing of classes (classes 15)	laboratory classes

Course advanced

Teaching methods:

computer lab/laboratory, lecture

Activities	Examination methods	Percentage in subject assessment

Activities	Examination methods	Percentage in subject assessment
lecture	written exam	50%
laboratory classes	project	50%

Literature

Obligatory

1. M. Dacko, W. Borkowski, St. Dobrociński, T. Niezgoda, M. Wieczorek: Metoda elementów skończonych w mechanice konstrukcji, Arkady, Warszawa 1994.
2. Z. Z. Kączkowski: Płyty, Obliczenia statyczne, Arkady, 1980.
3. Praca zbiorowa pod redakcją - M. Kleibera: Komputerowe metody mechaniki ciał stałych, tom 9, Mechanika techniczna, PWN, Warszawa 1995.
4. P. Konderla, T. Kasprzak: Metody komputerowe w teorii sprężystości, Część. I, Metoda elementów skończonych, Dolnośląskie Wydawnictwo Edukacyjne, Wrocław 1997.
5. J. Pietrzak, G. Rakowski, K. Wrześniowski: Macierzowa analiza konstrukcji, PWN, Warszawa-Poznań 1979.

Optional

1. G. Rakowski, Z. Kacprzyk: metoda elementów skończonych w mechanice konstrukcji, Oficyna Wydawnicza Politechniki Warszawskiej,
2. Praca zbiorowa pod kierunkiem - G. Rakowskiego: Mechanika budowli - ujęcie komputerowe, Arkady, Warszawa 1991, t. l i 2.
3. J. Szmelter: Metody komputerowe w mechanice konstrukcji, PWN, Warszawa 1980.

Effects

Code	Content
BU_P7S_KK02	Absolwent jest gotów do uznawania znaczenia wiedzy w rozwiązywaniu problemów poznawczych i praktycznych oraz zasięgania opinii ekspertów w przypadku trudności z samodzielnym rozwiązaniem problemu;
BU_P7S_UK17	Absolwent potrafi przygotować i przedstawić opracowanie naukowe w języku polskim i obcym, przedstawiające wyniki badań naukowych lub prezentację dotyczącą szczegółowych zagadnień z zakresu budownictwa;
BU_P7S_UW02	Absolwent potrafi w środowisku Metody Elementów Skończonych, poprawnie zdefiniować model obliczeniowy i przeprowadzić zaawansowaną analizę w zakresie liniowym, złożonych konstrukcji inżynierskich oraz stosować techniki obliczeń nieliniowych na poziomie podstawowym.
BU_P7S_UW04	Absolwent potrafi wykonać klasyczną analizę statyczną, dynamiczną i stateczności ustrojów prętowych (kratownic, ram i cięgien) statycznie wyznaczalnych i niewyznaczalnych oraz konstrukcji powierzchniowych (tarcz, płyt, membran i powłok).
BU_P7S_UW07	Absolwent potrafi wybrać narzędzia (analityczne bądź numeryczne) do rozwiązywania problemów inżynierskich;
BU_P7S_WG04	Absolwent zna i rozumie w pogłębionym stopniu zagadnienia wytrzymałości materiałów, modelowania materiałów i konstrukcji, teoretycznych Metody Elementów Skończonych oraz ogólnych zasad prowadzenia nieliniowych obliczeń konstrukcji inżynierskich;
BU_P7S_WG05	Absolwent zna i rozumie w pogłębionym stopniu zasady analizy i optymalizacji konstrukcji oraz projektowania złożonych systemów konstrukcyjnych;
BU_P7S_WG07	Absolwent zna i rozumie w pogłębionym stopniu klasyfikację i zakres stosowania programów komputerowych wspomagających analizę i projektowanie konstrukcji oraz przydatnych do planowania przedsięwzięć budowlanych;