COURSE DESCRIPTION CARD - SYLLABUS

Course name
Thin-walled structures [S1MiBM2>KoC]

Course

Field of study
Mechanical Engineering

Year/Semester
3/6

Area of study (specialization)
–

Profile of study
general academic

Level of study
first-cycle

Course offered in
Polish

Form of study
full-time

Requirements
elective

Number of hours

Lecture
15

Laboratory classes
15

Other
0

Tutorials
0

Projects/seminars
0

Number of credit points

2,00

Coordinators

Lecturers

Prerequisites

Basic knowledge of mathematics and other areas of education in the field of study. Structured knowledge of strength of materials. Ability to solve tasks in statics. Ability to solve tasks in mathematics: algebra, mathematical analysis, geometry. Ability to search for necessary information in literature, databases, on the Internet and in indicated sources. The ability to study independently and self-educate. Use of information and communication technology appropriate to engineering tasks.

Course objective

To provide a basic knowledge of the determination of stresses and strains in thin-walled structures such as beams and shells. To present in a concise and understandable form the fundamentals of stability, necessary for the design of safe and reliable structures. Discuss basic models and calculation methods, highlighting the importance of formulating stability conditions. To introduce the finite element method for modelling and analysis of thin-walled structures. To point out the possibilities of solving stability problems with different methods. To draw attention to the risks to the safe operation of machines resulting from loss of stability of their parts or their assemblies. To raise awareness of the complexity of problems, distinguishing between different forms of loss of stability.

Course-related learning outcomes

Knowledge:

1. The student has knowledge and understanding of loss of stability of systems, including structures.
2. The student has a structured knowledge of the determination of geometrical characteristics of open sections of thin-walled beams, including sectional coordinates, centre of transverse forces and sectional moments of inertia.
3. The student knows and understands methods of determining normal and tangential stresses in open sections of thin-walled beams.
4. The student has a structured knowledge of the determination of internal forces and moments and stresses in thin shells.
5. The student understands the basic models and computational methods necessary in the study of structural stability.
6. The student is aware of the importance of stability in the design of safe and reliable structures.
7. The student has knowledge of the basic concepts of structural stability.
8. The student understands of the importance of theory and experiments - experiments in the study of structural stability.
9. The student has knowledge of current issues in global research.

Skills:
1. The student can formulate and solve simple structural stability problems under static loads.
2. The student can formulate the stability conditions for simple structures.
3. The student determines of critical loads for selected structures.
4. The student identifies technical problem - identification of a stability problem.
5. The student is able to define and characterise a thin-walled structure.
6. The student is able to carry out basic strength calculations of simple thin-walled structures using the analytical method.
7. The student is able to prepare a FEM model of a thin-walled structure and carry out strength tests.

Social competences:
1. The student understands the necessity of self-education related to the development of technology.
2. The student is aware the importance of engineering activities.
3. The student is able to make appropriate decisions and to make decisions appropriate to the importance of the problem.
4. The student understands the importance of teamwork.
5. The student understands the importance of computer systems in the design and analysis of thin-walled structures.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Credit for lecture: written in the last class of the semester:
grade 3.0: 50.1%-60%
grade 3.5: 60.1%-70%
grade 4.0: 70.1%-80%
grade 4.5: 80.1%-90%
grade 5.0: 90.1%-100%
Credit for laboratory: ongoing review of learning outcomes and final colloquium in the last class of the semester:
grade 3.0: 50.1%-60%
grade 3.5: 60.1%-70%
grade 4.0: 70.1%-80%
grade 4.5: 80.1%-90%
grade 5.0: 90.1%-100%
Assessment of lecture activity and laboratory engagement included in final grades.

Programme content

Lecture:
1. Introduction
- discussion of basic properties of thin-walled structures
- presentation of examples of thin-walled structures
- introduction of basic concepts of structural stability as deformable body mechanics

- presentation of calculation methods
2. Thin-walled bars
- geometrical properties of open sections, sectional coordinates, sectional moment of inertia, internal forces, moment of inertia
- equation of torsion angle for thin-walled bars
- tangential and normal stresses in non-rotating torsion
3. Bars and bar systems
- stability of compression rods or bar systems
- loss of stability of a stiff column supported by a bar,
- buckling of compression beams with different modes of edge support, buckling of multi-span beams, buckling of beams on elastic foundation,
- buckling of plane frames
4. Stability of plates
- stability of rectangular slabs
- stability of circular slabs
5. Thin-walled rotating shells
- geometrical description of thin-walled rotating shells
- discussion of membrane states
- determination of stresses in rotating shells
- stability of cylindrical shells
6. Application of finite element method in the analysis of thin-walled structures
- principles for modelling thin-walled beams and shells
- selection of finite element and boundary conditions
- analysis of typical load cases.
Laboratory:
1. Application of the Finite Element Method to the determination of critical forces and the form of buckling of members for different attachment conditions.
2. Surface modelling of complex thin-walled structures and strength calculations including connections between members, including welded connections.
3. Strength and stability of a welded I-section. Influence of loading and fixation conditions on the results obtained.
4. Modelling of thin-walled structures with sheet metal.
5. Equivalent parameters of thin-walled structures. Determination of centre of gravity and centre of shear. Effect of embossments on critical load in a compressed column.
6. Modelling of a shaped connection - non-linear analysis of a folded connection.
7. Determination of critical load for compressed rectangular and circular plates and cylindrical shells.

Course topics

none

Teaching methods

Lecture:
- lecture with multimedia presentation including drawings and photographs to support the content presented on the blackboard
- application of the theoretical basis presented to solve simple examples from engineering practice
- during the lecture a discussion is initiated with the students
Laboratory:
- modelling and solving engineering problems using a computer system based on the finite element method

Bibliography

Basic:
1. Magnucki K., Stawecki W., Lewiński J. Modelowanie analityczne i numeryczne podstawowych części konstrukcji pojazdów szynowych, Instytut Pojazdów Szynowych TABOR, Poznań 2021. [in Polish]
2. Magnucki K., Szyc W. Wytrzymałość materiałów w zadaniach. Pręty, płyty i powłoki obrotowe. Wyd. naukowe PWN, Warszawa, 2000. [in Polish]
3. Magnucki K., Stawecki W. Stateczność wynranych części konstrukcji, Instytut Pojazdów Szynowych TABOR, Poznań 2016. [in Polish]

4. Weiss S., Giżejowski M. Stateczność konstrukcji metalowych. Arkady, Warszawa, 1991. [in Polish]
5. Życzkowski M. Stateczność prętów i ustrojów prętowych, s.242-380. M. Życzkowski (red.) Mechanika techniczna. Wytrzymałość elementów konstrukcyjnych. T.IX, PWN, Warszawa, 1988. [in Polish]

Additional:
1. Baľant Z.P., Cedolin L. Stability of structures. Oxford University Press, New York, Oxford,1991.
2. Doyle J.F. Nonlinear analysis of thin-walled structures. Springer Verlag, New York, 2001.
3. Demidowicz B.P. Matematyczna teoria stabilności. Wyd. Naukowo-Techniczne, Warszawa 1972. [in Polish]
4. Murray N.W. Introduction to the Theory of Thin-Walled Structures, Clarendon Press, Oxford 1986.
5. Vlasov V.Z. Thin-Walled Elastic Beams, National Science Foundation, Washington, D.C. 1961

Breakdown of average student's workload

	Hours	ECTS
Total workload	50	2,00
Classes requiring direct contact with the teacher	30	1,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	20	1,00