COURSE DESCRIPTION CARD - SYLLABUS

Course name
LIGHTWEIGHT MULTI-LAYERED SHELLS FOR MODERN STRUCTURAL APPLICATIONS [S5IMECH>LPW]

Course

Proposed by Discipline
–

Year/Semester
2/3

Level of study
Doctoral School

Course offered in
English

Form of study
full-time

Requirements
elective

Number of hours

Lecture
8

Laboratory classes
0

Other
0

Tutorials
0

Projects/seminars
0

Number of credit points

2,00

Coordinators

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Lecturers

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Prerequisites

A student should have a basic knowledge of mathematics, mechanics, the strength of materials, and materials science. He should know how to apply his knowledge of geometry, trigonometry, and calculus to model and solve problems related to the mechanics of structures. Basic knowledge related to the stress analysis, the mechanical properties of engineering materials, and the geometrical description of structural members is essential.

Course objective

The aim of the course is to present of the latest trends in the design and analysis of lightweight shell structures, including multilayered structures, used in the design of aircraft fuselages and skins, submersibles, and pressure vessels. The potential applications of shell structures in the construction of state-of-the-art structures, such as spacecraft, deep-sea exploration submersibles, underwater bases, and space stations, will also be discussed.

Course-related learning outcomes

Knowledge
- student will become familiar with the current trends in mechanical and biomechanical engineering regarding the design and analysis of thin-walled and multi-layered shells and membranes (P8S_WG/

SzD_W01, P8S_WG/SzD_W02)
- student will understand the possible modern applications and advantages of thin-walled and multi-layered structures (P8S_WK/SzD_W06, P8S_WK/SzD_W05)
- student will know the basic procedures and computer software for designing and analysing of thin-walled structures (P8S_WG/SzD_W03)

Skills
- student will be able to define the geometric parameters describing thin-walled and multi-layered shells (P8S_UW/SzD_U01)
- student will be able to select the correct type of analysis and software to determine the behaviour of thin-walled structures (P8S_UW/SzD_U01)
- student will be able to analyse the results of stress and stability analyses of shell structures in order to identify their weak points and improve load-bearing performance (P8S_UW/SzD_U02, P8S_UK/SzD_U05)
- student will be able to select a proper shape, cross-section and material to design a thin-walled structural member for a given application (P8S_UW/SzD_U02, P8S_UK/SzD_U04)

Social competencies
- student is aware of the importance of non-technical aspects and the results of engineering activities, including their environmental impact, and recognises their responsibility for the decisions made (P8S_KK/SzD_K01)
- student understands the impact of a designer's work on the functioning and shaping of society (P8S_KO/SzD_K04, P8S_KR/SzD_K07)
- student understands the importance of aesthetics in structural design (P8S_KK/SzD_K02)
- student is aware of the need for optimisation in the field of structural design and the importance of using structural components with reduced material consumption (P8S_KK/SzD_K03)

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Learning outcomes presented above are verified as follows:
An individual work, in the form of a written assignment, designed to assess students' understanding of the topics covered in the lecture as well as their ability to apply this knowledge when defining and solving problems relating to the modelling, manufacture and use of modern shell structures.
The assignment should take the form of a project proposal containing the following elements:
- the goal of the project,
- a literature review related to the state of the art in the area of interest,
- justification for undertaking the research project and its significance,
- the research concept and plan,
- research methodology,
- a bibliography of the subject.

The work should be about five pages long (excluding the title page) and may include graphics.
The work is rated as follows:
over 50% - 60,0%: 3,0
over 60% - 70,0%: 3,5
over 70% - 80,0%: 4,0
over 80% - 90,0%: 4,5
over 90% - 100%: 5,0

Programme content

1. Definition and examples of shell structure applications.
2. The characteristics of shells as a load-bearing elements.
3. Examples and analysis of modern structural solutions related to shells.
4. Tools for analysing the strength and stability of shells.
5. The behaviour of selected shell structures under load (case study).
6. The application of shell-like structures in biomedical engineering.
7. Examples of potential applications in the engineering of the future.

Course topics

1. Shell structures in engineering applications - definition of a shell as a structural element; exemplary structures; advantages and drawbacks.
2. The characteristics of shells as a load-bearing elements: geometrical description of a shell of revolution, load bearing mechanisms in shells - membrane forces, failure by the loss of stability - buckling and post-buckling behaviour of shells.
3. Analysis of exemplary structures made of single- and multi-layered shell structures in mechanics and biomechanics: geometry, materials, behaviour under the load.
4. Analytical, numerical and experimental analysis of the strength and stability of shells: introduction to the theory of shells, membrane theory, the finite element method, laboratory tests.
5. Example of a shell structure analysis in mechanics and biomechanics: geometric description; finite element modelling; analysis of stress distribution; buckling analysis; post-buckling analysis - equilibrium path.
6. Modelling and analysis of shells made of hyperelastic materials - membranes; application of shells in biomedical engineering.
7. Examples of potential applications in the engineering of the future – space technology, deep-sea exploration, space and the deep-sea bases. Identifying problems and challenges in terms of manufacturing, materials, and operation.

Teaching methods

- lecture with a multimedia presentation containing figures and pictures supported by examples presented on the blackboard;
- the theory is presented in close relation to practical applications; working examples are provided with the use of computer software
- different aspects of the presented problems are included, such as engineering, safety, economics, ecology, social issues, etc.;
- during the lecture, discussions with students are initiated;

Bibliography

Basic
Calladine C.R. Theory of Shell Structures, Cambridge University Press, Cambridge, 1988
Alfutov N.A., Stability of Elastic Structures, Springer-Verlag, Berlin, 2000
Fluegge W., Stresses in Shells, 2nd ed., Springer-Verlag, Berlin, 1973
Singiresu S., The finite element method in engineering, Elsevier Butterworth-Heinemann, New York, 2014

Additional
Ventsel E., Krauthammer T. Thin Plates and Shells. Theory, Analysis, and Applications, CRC Press, Boca Raton, 2001
Timoshenko S., Woinowsky-Krieger S. Theory of Plates and Shells, 2nd ed., McGraw-Hill, New York, 1987
Bazant Z.P., Cedolin L. Stability of Structures. Elastic, Inelastic, Fracture, and Damage Theories, Dover Publications, INC., New York, 1991
Kurowski P., Finite element analysis for design engineers, 2nd ed., SAE International, 2017

Breakdown of average student's workload

	Hours	ECTS
Total workload	50	2,00
Classes requiring direct contact with the teacher	8	0,00
Doctoral student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests/exam, project preparation)	42	2,00