



COURSE DESCRIPTION CARD - SYLLABUS

Course name

Computer design of structures [S2Bud1E-ZBZ>KPK]

Course

Field of study

Civil Engineering

Year/Semester

1/2

Area of study (specialization)

Sustainable construction and management

Profile of study

general academic

Level of study

second-cycle

Course offered in

English

Form of study

full-time

Requirements

compulsory

Number of hours

Lecture

15

Laboratory classes

15

Other

0

Tutorials

0

Projects/seminars

0

Number of credit points

2,00

Coordinators

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Lecturers

Prerequisites

Possesses knowledge of structural mechanics and strength of materials within the scope of the Civil Engineering curriculum. Is familiar with the methods of designing steel, timber, and reinforced concrete structures in accordance with Eurocode standards. Applies basic formulas in the field of structural mechanics and strength of materials. Is able to adopt appropriate structural and technological solutions in the field of corrosion protection and fire protection. Is capable of proposing structural solutions using appropriate calculation procedures and applies building standards regarding loads acting on structures, as well as standards for static calculations and the design of steel structural elements. Understands the need for lifelong learning and is able to cooperate and work in a team, taking on different roles within it. Is aware of the responsibility associated with the profession they are preparing for.

Course objective

The aim of the course is to acquire knowledge and skills in the field of computer modelling, design, and dimensioning of bar and shell structural systems typical for frame and frame-panel building structures. The course also discusses the application of various types of bar elements used in computational models (including truss elements, beam elements with 6 degrees of freedom based on Bernoulli theory, 7DoF elements, and Timoshenko beam elements), as well as the modelling of surface elements such as plates, diaphragms, and shells. During the course, contemporary possibilities in structural design using advanced computational tools will be presented, including numerical wind tunnels for analysing wind load distribution, spatial soil models used to evaluate subsoil stiffness, and various types of global analyses, including nonlinear analyses applied in structural design. In addition, issues related to the integration of architectural and structural models in the computer-aided design process will be discussed, with particular emphasis on the differences between the simplifications used in structural models and the high level of detail present in architectural models.

Course-related learning outcomes

Knowledge:

1. Know in detail the principles of analysing, constructing and dimensioning elements and connections in selected building structures.
2. Have extended and detailed knowledge of material strength, modelling and constructing; have knowledge of theoretical principles of the finite element method as well as general rules of non-linear calculations of engineering structures.
3. Have detailed knowledge in the field of operation algorithms of selected software supporting the analysis and design of building facilities, which are also useful to plan and manage construction projects, including Building Information Modelling (BIM).
4. Have advanced and detailed knowledge of the structure analysis and design of selected building units.

Skills:

1. Can design elements and connections in complex building units, working both individually and in a team.
2. Can perform a classical static and dynamic analysis and stability analysis of statically determinate and non-determinate bar structures (trusses, frames and strands); as well as surface construction (discs, plates, membranes and shells).
3. Use advanced specialized tools in order to search for useful information, communication and in order to obtain software supporting the designer and organizer of building engineering works.

Social competences:

1. Take responsibility for the reliability of working results and their interpretation.
2. Can realise that it is necessary to improve professional and personal competence; are ready to critically evaluate the knowledge and received content.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lecture assessment - test. The test consists of a test part and a practical part in which a given engineering problem must be solved.

Laboratory classes - completion of tasks assigned during the laboratory sessions.

Grading scale:

- 5.0 - the student obtained from 90% to 100% of the points,
- 4.5 - the student obtained from 80% to 89% of the points,
- 4.0 - the student obtained from 70% to 79% of the points,
- 3.5 - the student obtained from 60% to 69% of the points,
- 3.0 - the student obtained from 50% to 59% of the points,
- 2.0 - the student obtained less than 50% of the points.

Programme content

1. The role of computational models in structural design
 - The role of computational models in structural design
 - Types of structural models used in frame and frame-panel construction

- Assumptions, simplifications, and limitations of numerical models
- 2. Bar elements in computational structural models
 - Truss elements
 - Beam elements with 6 degrees of freedom based on Bernoulli beam theory
 - 7DoF elements
 - Beam elements based on Timoshenko beam theory
- 3. Modelling of surface structural elements
 - Plates, diaphragms, and shells in numerical models
 - Discretization and finite element meshes
 - Differences in modelling plate and shell elements
- 4. Modelling of frame and frame-panel structures
 - Development of the global structural model
 - Static schemes and representation of connections
 - Interaction between bar and surface elements
- 5. Advanced structural analyses in computer-aided design
 - Linear and nonlinear analysis
 - Second-order analysis
 - Stability and buckling analysis of structures
- 6. Modelling environmental actions and soil-structure interaction
 - Numerical wind tunnels and wind load analysis
 - Spatial models of soil subgrade
 - Influence of subsoil stiffness on structural behaviour
- 7. Integration of architectural and structural models in the design process
 - Cooperation of BIM models
 - Differences between architectural and structural models
 - Simplifications in computational models
 - Interdisciplinary coordination in digital design

Course topics

1. The role of computational models in structural design
2. Bar elements in computational structural models
3. Modelling of surface structural elements
4. Modelling of frame and frame-panel structures
5. Advanced structural analyses in computer-aided design
6. Modelling environmental actions and soil-structure interaction
7. Integration of architectural and structural models in the design process

Teaching methods

During the course, diverse teaching methods will be applied, aimed at developing students' analytical and design skills. The primary form of instruction will be a problem-oriented lecture, during which real design issues related to the modelling and analysis of building structures will be discussed. During the lectures, examples of practical applications of computational methods in the design of frame and frame-panel structures will be presented, allowing theoretical concepts to be linked with engineering practice.

An important component of the course will also include case studies and the analysis of computational examples. These activities will enable students to understand the process of developing computational models, interpreting analysis results, and identifying key factors influencing structural behaviour. The teaching process will also incorporate elements of Problem Based Learning (PBL), involving the solution of specific engineering problems related to structural modelling. Working individually or in small teams, students will analyse assigned design tasks, propose modelling solutions, and discuss their correctness and limitations.

Additionally, part of the course will be conducted in a "design - implement - analyse" format. Within this framework, students will independently develop structural models, perform numerical analyses using specialised software, and interpret the obtained results. Such activities will foster the development of practical skills in computer-based structural modelling, critical evaluation of calculation results, and formulation of engineering conclusions.

Bibliography

Basic:

1. Oñate, E. (2013). Structural Analysis with the Finite Element Method. Linear Statics. Volume 2: Beams, Plates and Shells. Dordrecht: Springer. ISBN: 978-1-4020-8733-2.
2. Werkle, H. (2021). Finite Elements in Structural Analysis. Cham: Springer. ISBN: 978-3-030-49839-9.
3. Trahair, N. S.; Bradford, M. A.; Nethercot, D. A.; Gardner, L. (2008). The Behaviour and Design of Steel Structures to EC3. London: Taylor & Francis. ISBN 978-0415418669.
4. Eastman, C.; Teicholz, P.; Sacks, R.; Liston, K. (2018). BIM Handbook: A Guide to Building Information Modeling for Owners, Designers, Engineers, Contractors, and Facility Managers. 3rd ed. Hoboken: John Wiley & Sons.

Additional:

5. Chen, W. F.; Lui, E. M. (2005). Structural Stability: Theory and Implementation. Amsterdam: Elsevier. ISBN 978-0444514882
6. Macleod, I. A. (2012). Advanced Structural Analysis with MATLAB. Oxford: Butterworth-Heinemann. ISBN 978-0080969121.
7. EC3: EN 1993-1-1, EN 1993-1-14
8. EC2: EN 1992-1-1
9. EC5: EN 1995-1-1
10. EC0: EN 1990
11. Kawa, O.; Studziński, R. (2025). Assessment of the distribution of external pressure coefficients on a flat roof with a photovoltaic panels, Advances in Steel and Steel-Concrete Composite Structures-Lorenc et al. (Eds.). <http://dx.doi.org/10.1201/9781003534464-29>
12. Ciesielczyk, K.; Studziński, R.; Chybiński, M.; Ścigałło, J.; Szymkuć, W.; Grabski, J. K.; Marciniak, T.; Polus, Ł. (2025). An Assessment of the Behaviour of Ceiling Beams of Different Structure. Applied Sciences, 15(21), 11543. <https://doi.org/10.3390/app152111543>
13. Studziński, R.; Ścigałło, J.; Ratajczak, M.; Ciesielczyk, K. (2024). Impact of Heterogeneous Soil Conditions on the Life Cycle Assessment of a Multi-Storey Reinforced Concrete Structure. Sustainability, 16(16), 6771. <https://doi.org/10.3390/su16166771>

Breakdown of average student's workload

	Hours	ECTS
Total workload	60	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)	30	1,00