IPS Instituto Politécnico de Setúbal
Escola Superior de Tecnologia do Barreiro

Curriculum Unit Sheet

Structural Mechanics

Academic Year:

2018/2019

Course: Master's degree in Civil Engineering

Scientific Area: Structures

ECTS Credits	6.5	**Curriculum Unit code**	MEC134	**Year**	1	**Semester**	1	**Type**	Compulsory

Prerequisites:

Contact Hours

Lecture Sessions	15	**Lecture-Practical Sessions**	30	**Practical and Laboratory Sessions**	
Tutorial	7.5	**Placement**		**Seminar**	
Fieldwork		**Other**	7.5	**Autonomous Study**	115.5

Responsible: Miguel Filipe Sério Passos Lourenço — **Position**: Adjunct Professor

Lecturers: — **Position**:

Learning Outcomes

The Structural mechanics discipline is presented here using a modern approach, giving the student a global and integrated vision of formal and practical aspects of structural discretization, both directly and indirectly, allowing the student to develop discrete models for the various physical systems, whose solution requires the application of the finite element method. These physical systems will focus mainly on problems of elasticity of linear elastic behaviour. In terms of the material behaviour the plastic limit analysis of beam-column systems and slabs is an adequate complement for previous training. Finally, it will be focused problems geometrically nonlinear framed structures. During the training the student will also can verify the occurrence of modelling errors and other common error types in the use of software.

Syllabus

Two-dimensional elasticity: introduction to elasticity. Flat States of stress and strain; Finite element method: introduction to the method. Linear and Bi-linear elements. Matrix formulation. Approximation functions. Flat Elasticity. Elastic supports. Settlements and support reactions. Inclined supports. Formulation for slab elements; Plastic Limit analysis: basic concepts: Critical Sections. Mechanisms. Conditions of transfer, disposal and parity. Admissibility statics and kinematics. Theorems of limit analysis. Statically and cinematically admissible solutions. Matrix formulation. Multiple and partial mechanisms. Solicitation interaction. Application in framed structures and slabs; Geometrically nonlinear analysis and bifurcational Instability: Limit point instability. Nonlinear geometrical analysis of planar framed structures. Critical load. Equilibrium trajectories. Newton-Raphson method and the Secant Array Method.

Teaching Methodologies

Lessons will be presented using PowerPoint slides, which are provided at the beginning of the week in pdf file type to the students. The theoretical presentation of each theme is followed by exemplification with an exercise already solved. Resolution of other exercises using the programs; Scilab, Q7Q8Q9-stress and strain plain states (developed by one of the teachers) and SAP2000. Attribution of evaluation work at the beginning of the semester to each working group, supported by tutorial lectures.

Evaluation

The continuous evaluation will consist of 2 individual tests with a minimum grade of 7.5 on each one and 10 on their average. The tests are fundamentally theoretical and may eventually contain problems solving questions simple and immediate.

Evidence of the syllabus coherence with the curricular unit's intended learning outcomes

The student introduction to the generic concepts of three dimensional elasticity is fundamental to the use of the finite element method, namely the interaction between the kinematic relationships, balance relations and constitutive relations of material. Later it is made the introduction to finite element method in a progressive manner starting with one-dimensional elements (beam, truss bar, column bar and beam-column bar), up to 2-dimensional elements (stress and strain plain states, slab elements, and zero-thickness elements). Choice, for each one of the elements, of the appropriate approximation functions, gradually evolving to more complex functions, presenting its particularities, constitutive relations depending on the physical problem concerned, and applying the principle of virtual works to obtain the nodal equilibrium of the system.
The whole approach will be done using matrix formulation which has a greater versatility among the various types of finite elements covered here. Of course it will also be discussed the boundary conditions, rigid and elastic, the various types of action will be modelled after (boundary and continuum loading, support settlement, initial stress and temperature states). The student will be introduced to refinement methods: h, p, r and autoadapting. The student will be alerted to the various types of errors: approximation, physical modelling, etc, and of software use. The used finite elements exhibit a linear elastic behaviour. In addition it will be covered the plastic analysis of framed structures and slabs, the cinematic, static and theorems of uniqueness, the identification of critical sections, load and providing the various mechanisms of collapse (global or partial).
The matrix formulation will be also presented as a good systematization of methods. Geometrically nonlinear analysis and bifurcacional Instability will be presented exclusively for application in framed structures. Determination of critical load and balance paths, using the Newton-Raphson iterative method or the Secant Method.
The curriculum structure of this unit is consistent, given that there is an evolution in the topics presented at the level of element complexity, material behaviour and geometric behaviour. With this course, the student will be equipped with the skills required for the use of the finite element method, and plastic limit analysis in other disciplines within the course option of theory of structures and structural design.

Evidence of the teaching methodologies coherence with the curricular unit's intended learning outcomes

After a preliminary review of the topics associated with solid mechanics, an introduction to plain elasticity will be presented, in particular to the calculation of displacements, deformations and stresses, for stress and strain plain state analysis. Relations are established for equilibrium, compatibility and constitutive.
Later, the introduction to the finite element method, at the level of elementary types, followed by the formulation itself, at the matrix level. The use of approximation functions with SciLab program will be presented, allowing the student to graphical view. H and p refinements will be used. in addition to loading and displacement will be taught to students in the analysis of the effect of temperature action and supporting settlements. After the apprehension by the student, of the different types of linear and bilinear elements, it will be presented the formulation for thin and thick slab elements, through the formulation of Reissner-Mindlin and Kirchhoff.
The basics of plastic analysis with determining the location of critical sections and possible mechanisms will be presented to the student. Problem solving in application to practical works on framed structures using SciLab program, the Q7Q8Q9 program in the case of walls and SAP2000 program in case of slabs. In addition to teaching, the student will develop a practical work, with application of the syllabus, with questions for e-learning and tutorial. The final subject is composed of geometric nonlinearity analysis with bifurcational instability and instability by limit point. It will also be taught the determination of critical load and balance paths, using the Newton-Raphson methods and matrix Secant.

Bibliography

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Richard L. Burden, J. Douglas Faires, Numerical Analysis, Brooks/Cole, 1997;
Heitor Pina, Métodos Numéricos, McGraw-Hill, 1995;
Steven C. Chapra; Raymond Canale, Numerical Methods for Engineers, McGraw-Hill, 1990;
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Observations