Mechanics of Materials and Structures

Department:	DARTE
Degree course:	Architecture
Class:	LM-4
Training activities:	Characterizing
Subject area:	Civil Engineering
Scientific-disciplinal field:	ICAR/08
Number of ECTS credits:	12
Mandatory prerequisites:	Mathematics
Year:	II
Semester:	I and II
Number of hours of lessons:	120
Exam mode:	The exam will consist of a written test and an oral interview

Instructor
Adolfo Santini, Full Professor

Course objectives
By the end of this course, the student will be able to:
- determine the behaviour of elastic materials subjected to two-dimensional stress states, including the 2D elastic constitutive relationships and Mohr's Circle for stress and strain transformation in 2D;
- determine the deflected shape of beams under a variety of loads;
- analyse two dimensional truss structures and determine their deflection;
- understand the concept of structural redundancy and analyse simple statically indeterminate structures;
- apply the von Mises and Tresca failure criteria for 2D and 3D stress conditions;
- evaluate how a simple column will buckle under a variety of end restraints, and demonstrate understanding of buckling in real structures.

Course outline

Kinematic analysis of beam systems (1.5 ECTS credits) Kinematics of rigid bodies. Degrees of freedom of rigid bodies and generalized displacements. Infinitesimal rigid displacements. Principle of superposition. Planar rigid displacements. Centre of rotation. External constraints: kinematics classification. Linearized boundary conditions. Constraint settlements. Centre of relative rotation among rigid bodies. Kinematic classification of planar beam systems. Fundamental theorems of kinematics. Graphical kinematics.
Static analysis of beam systems (1.5 ECTS credits) Force systems. Equilibrium equations. External constraints: static classification. Static classification of planar beam systems. Statically determined beam structures. Evaluation of the forces transmitted by constraints. Equilibrium equations of beams. Truss analysis using the method of sections and the method of joints. Centroid of an area. Moments of Inertia. Parallel-axis theorem for moment of inertia of a finite area, radius of gyration, principal moments of inertia. Stresses in Beams (axial and shear forces, bending

moments).
Stress analysis (1.00 ECTS credit) The continuum of Cauchy. Stress tensor. Principal stresses and directions. Plane and axial stress. Stress transformations in 2D using Mohr's circle. Equilibrium equations.
Strain analysis (1.00 ECTS credit) Infinitesimal displacements and deformations. Strain tensor. Principal strains and directions. Plane and axial strain. Strain gauge rosettes. Compatibility equations.
Elastic constitutive relationships (1.0 ECTS credit) Experimental tests. Elastic behaviour of materials. Fragile and ductile failure. Elastic constitutive relationships for isotropic materials. Elastic constants. Deformation energy. Von Mises and Tresca failure criteria in 2D and 3D.
Beam analysis (3.0 ECTS credits) The differential equation for bending. Discontinuities of loading. Boundary conditions. Elastic and inelastic constraint settlements. Thermal effects. Elastic displacement of statically determined structures. The virtual work principle. Analysis of statically indeterminate structures. Compatibility in simple beams. Elastic displacement of statically indeterminate structures.
De Saint Venant's problem (2.5 ECTS credits) Axial loading. Bending moment. Unsymmetrical beam bending. Torsion in circular sections. Approximate solutions for thin-walled sections. Shear stresses in beams. Approximate theory for shear stresses in beams: the Jourawsky formula. Shear centre. Combined stresses. Shear stresses in thin-walled sections.
Euler buckling (0.5 ECTS credits) Stable and unstable equilibrium. Support conditions, effective length, slenderness ratio, major and minor axis buckling. Evaluation of buckling load of simple beams.

References

Guagenti E., Buccino F., Garavaglia E., Novati G., *Statica 3/ed - Fondamenti di meccanica strutturale - Metodi di analisi di strutture reali,* McGraw-Hill Libri Italia, Milano, 2009.

Comi C., Corradi Dell'Acqua L., *Introduzione alla meccanica strutturale*, McGraw-Hill Libri Italia, Milano, Seconda edizione, 2007.

Viola E., *Esercitazioni di Scienza delle Costruzioni Voll. 1, 2 e 3*, Pitagora Editrice, Bologna, 1993.