Course guide
250703 - 250703 - Composite Materials Structures

Last modified: 28/03/2024

Unit in charge: Barcelona School of Civil Engineering
Teaching unit: 751 - DECA - Department of Civil and Environmental Engineering.

Degree: MASTER'S DEGREE IN GEOTECHNICAL ENGINEERING (Syllabus 2015). (Optional subject).
MASTER'S DEGREE IN STRUCTURAL AND CONSTRUCTION ENGINEERING (Syllabus 2015). (Optional subject).

Academic year: 2023 **ECTS Credits:** 5.0 **Languages:** Spanish

LECTURER

Coordinating lecturer: LUCIA GRATIELA BARBU

Others: LUCIA GRATIELA BARBU, JAVIER MARTINEZ GARCIA, PABLO LEONEL SIERRA HERMOSID

TEACHING METHODOLOGY

This course takes place in 12 classes of three hours each. Each class will have about 1:30 hours devoted to theoretical dictates of the same i 0:30 discussions and consultations. Also, 11 hours were devoted to the development of work / problems implementing some topics of the course, and 8 hours of work evaluation.

Support material is used in the form of detailed teaching plan using the virtual campus ATENEA: content, programming and evaluation activities directed learning and literature.

Although most of the sessions will be given in the language indicated, sessions supported by other occasional guest experts may be held in other languages.

LEARNING OBJECTIVES OF THE SUBJECT

Subject to know the behavior and calculation of structures made of composite materials

Capability to design and calculate structures made of composite materials. Ability to interpret results from finite element programs appropriate for non - linear analysis of composite structures

Introduction, definition and use of some composite materials. Anisotropy of the material. Theory of Mixtures : Slide fiber matrix (DFM) . Delamination of laminated composite . Homogenization theory . Reinforced composites inelastic buckling. Fuselage and wing structures tickets compounds and mixed materials (aluminum - composite) . Repair and reinforcement of structures with composite materials

The aim of this course is to get students to acquire extensive information about the behavior and calculation of structures built in composite materials. It is also expected that these studies will allow interpreting results from appropriate programs for non-linear analysis of composite structures finite elements. The study of this subject is discussed under the assumption that the structures can achieve cinematic nonlinear constitutive behavior and / or. To numerically analyze the behavior of structures, two basic theories will be studied: 1) blends theory and its various evolutions and 2) the theory of homogenization and its various forms. Some nonlinear constitutive models will also be remembered for representing the behavior of each basic substance.

STUDY LOAD

Type	Hours	Percentage
Self study	80,0	63.95
Hours small group	9,8	7.83
Hours large group	25,5	20.38
Hours medium group	9,8	7.83

Total learning time: 125.1 h

CONTENTS

Introduction, definition and use of some composite materials

Description:
Use of composite materials: in the automotive industry, in the aircraft industry, in shipbuilding, in civil engineering. Properties of Compounds. Achievable features. Classification of composite materials. Classification by topology. Classification according to its components. Structural Classification.

Full-or-part-time: 4h 48m
Theory classes: 2h
Self study : 2h 48m

Finite Element Method

Description:
Linear elastic MEF
Types of nonlinearity
Resolution of non-linear systems

Full-or-part-time: 7h 11m
Theory classes: 3h
Self study : 4h 11m

Geometric non-linearity

Description:
Yield surface classification

Full-or-part-time: 7h 11m
Theory classes: 3h
Self study : 4h 11m

Mixing Theory

Description:
Classical Mixing Theory mixtures. Modification classical theory. Series-parallel. Model Generalized theory mixtures. Classical theory formulated mixtures large strain. Generalized theory formulated mixtures large strain. Modifying mixing theory for reinforcing short length. Constitutive equation of the composite. Comparison "micropattern" vs. "Theory of Mixtures" with large deformation anisotropy. Application to various engineering problems
Classical Mixing Theory . Modification classical theory. Series-parallel. Model Generalized theory mixtures. Classical theory formulated mixtures large strain. Generalized theory formulated mixtures large strain. Modifying mixing theory for reinforcing short length. Constitutive equation of the composite. Comparison "micromodel" vs. "Theory of Mixtures" with large deformation anisotropy. Application to various engineering problems

Full-or-part-time: 14h 23m
Theory classes: 2h 30m
Practical classes: 1h 30m
Laboratory classes: 2h
Self study : 8h 23m

Anisotropy of the material

Description:
Overview of anisotropic formulation. General definition of explicit criteria orthotropic creep in the benchmark setting. General definition of an orthotropic approach implicit in the reference configuration. Anisotropy in the updated configuration.
Overview of anisotropic formulation. General definition of explicit criteria orthotropic creep in the benchmark setting. General definition of an orthotropic approach implicit in the reference configuration. Anisotropy in the updated configuration.

Full-or-part-time: 9h 36m
Theory classes: 2h
Practical classes: 1h
Laboratory classes: 1h
Self study : 5h 36m

Fiber-matrix debounding

Description:
Stress distribution along the reinforcing fiber. Interaction between cracks and fibers. Constitutive models for composite materials with "DFM". Implementation. Lagrangian formulation "Total" and "Update". Implementation of mixing theory and anisotropy in the context of "MEF". Phenomenon "DFM" micropattern blends theory and anisotropy.
Fiber-matrix debounding (DFM) (Class 1.5)

Full-or-part-time: 4h 48m
Theory classes: 1h
Practical classes: 1h
Self study : 2h 48m

Delamination of laminated composites

Description:
Identification of the phenomenon. Defining the formulation. Coupling with the formulation of the theory of mixtures in small and large deformations.
Delamination in laminated composites (Class 1.5)

Full-or-part-time: 4h 48m
Theory classes: 1h
Practical classes: 1h
Self study : 2h 48m

Inelastic buckling reinforced composites

Description:
Introduction. Description of the phenomenon. Euler critical load. Model of Rosen. Micro-mechanical models. Finite element formulation. Simplified formulation. Models of mechanical damage. Loss model buckling stiffness of the compounds with long fibers. General definition for fiber reinforced composites. Definition of variable stiffness loss buckling: Participation of the fiber matrix participation. Energy dissipation.
Inelastic buckling in reinforced composites (class 1.5)

Full-or-part-time: 4h 48m
Theory classes: 1h
Practical classes: 1h
Self study : 2h 48m

Homogenization Theory

Description:
Introduction and state of knowledge. Averages methods. Theory asymptotic expansion. Extension of the "average method" and "Asymptotic Expansion Method" to the nonlinear problem. Other issues related to standardization. Boundary conditions and implementation. Two scales solution elastic problem. Challenges to the theory of homogenization and use of adaptive methods and "multi-grid". Homogenization by Voronoi Finite Element Method. Theory based on "Local Recurrence" homogenization. Concepts on the periodic structure. Local Frequency of variables. Effect of periodic field trips. Homogenization of the strain tensor. The homogenized voltage and the equilibrium equation. Fundamentals of elastic problem in the micro-macro scales. Micro-Macro structural coupling. Influence of local effects. Application to various problems: reinforced laminates, masonry, etc.
Theory homogenisation (Class 2.0)

Full-or-part-time: 13h 12m
Theory classes: 3h 30m
Practical classes: 2h
Self study : 7h 42m

Strengthening and repair of structures with composite materials

Description:
Introduction. Possible solutions for structural reinforcement of beams and concrete frames. Repair and effectiveness of possible solutions. Calculation and evaluation of reinforcements and repairs.
Theory and examples

Full-or-part-time: 4h 48m
Theory classes: 2h
Self study : 2h 48m

Fatigue in Composite Materials

Description:
Introduction, fatigue modeling, examples

Full-or-part-time: 3h 35m
Theory classes: 1h 30m
Self study : 2h 05m

Nonlinear FE exercise

Description:
Se utiliza software desarrollado en el Departamento

Full-or-part-time: 28h 47m
Laboratory classes: 12h
Self study : 16h 47m

GRADING SYSTEM

The course grade is obtained from continuous assessment grades and measurable practical work on each of the topics.

The rating of the asignutura results from the average of the marks of the papers presented.

Work will be done using tools like MathCad and/or Matlab and/or using Finite Element programs that provide students

EXAMINATION RULES.

If any or practical work continuous assessment in the scheduled period is performed it shall be considered as zero score.

BIBLIOGRAPHY

Basic:
- Oller, S. Numerical simulation of mechanical behavior of composite materials [on line]. Barcelona: International Center for Numerical Methods in Engineering (CIMNE) : Springer, 2014 [Consultation: 20/04/2020]. Available on: http://dx.doi.org/10.1007/978-3-319-04933-5. ISBN 9783319049328.
- Jones, Robert M. Mechanics of composite materials. 2nd ed. New York, NY: Taylor & Francis, cop. 1999. ISBN 9781560327127.
- Christensen, Richard M. Mechanics of composite materials. Nova York: Dover, cop. 2005. ISBN 048644239X.
- Barbero, Ever J. Introduction to composite materials design [on line]. 2nd ed. Boca Raton: Taylor & Francis, cop. 2011 [Consultation: 18/02/2021]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=1446773. ISBN 9781420079159.
- Tsai, Stephen W; Hahn, H. Thomas. Introduction to composite materials. Westport: Technomic Publishing, cop. 1980. ISBN 0877622884.
- Mallick, P.K. Fiber-reinforced composites : materials, manufacturing, and design. 3th ed. New York [etc.]: CRC, 2008. ISBN 9780849342059.
- Chawla, Krishan Kumar. Composite materials : science and engineering. 3rd ed. New York [etc.]: Springer, 2012. ISBN 9780387743646.

Complementary:
- Miravete, A. [et al.]. Materiales Compuestos [on line]. Zaragoza: Antonio Miravete De Marco, 2000 [Consultation: 20/01/2021]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=3429381. ISBN 8492134976.
- Sanchez-Palencia E., Zaoui A. Homogenization Techniques for Composite Media. Spring-Verlag, 1987.