SUBJECT TEACHING GUIDE

586 - Advanced Calculus for Structural Analysis

Master's Degree in civil Engineering, Canal and Port Engineering

Academic year 2024-2025

1. IDENTIFYING DATA					
Degree	Master's Degree in civil Engineering, Canal and Port Engineering			Type and Year	Compulsory. Year 1
Faculty	School of civil Engineering				
Discipline	Advanced Calculation of Structures				
Course unit title and code	586 - Advanced Calculus for Structural Analysis				
Number of ECTS credits allocated	4,5	Term		Semester based (1)	
Web					
Language of instruction	Spanish	English Friendly	No	Mode of delivery	Face-to-face

Department	DPTO. INGENIERIA ESTRUCTURAL Y MECANICA
Name of lecturer	RAFAEL DIEZ ALMAGRO
E-mail	rafael.diez@unican.es
Office	E.T.S. de Ingenieros de Caminos, Canales y Puertos. Planta: + 2. DESPACHO (2065)
Other lecturers	ALVARO GAUTE ALONSO

3.1 LEARNING OUTCOMES
- Understanding of the structural behavior and the response to such behavior of the models and calculation methods that idealize it, for different types of actions. To understand the magnitudes involved in the structural response.
- Understanding of the different loads that can act on a structure (static, kinematic and dynamic) and their correct consideration in models and general structural design softwares.
- Comprehension of the different static and dynamic structural calculation methods, their applications and limitations, and their adaptation to computer software.
- Understanding of the particularities that characterize and distinguish the behavior of a structure under dynamic actions compared to its behavior under static actions.
- Understand the characteristics of seismic actions as a particular case of dynamic actions.
- Statically and dynamically analyze simple structural types, understanding their resistant behavior.
- Critically analyze the results of a static or dynamic structural calculation.
- Apply the regulations and codes (Spanish and Eurocodes) where the different actions, static, kinematic, dynamic, in general, and seismic, in particular, to be considered in the structural design for the analysis of the different limit states are contemplated.
- Use computer programs applied to the general calculation of structures, static or dynamic, knowing the theory that sustains them.

4. OBJECTIVES
-Learn the concepts of structural, static and dynamic actions and systems, and distinguish the particularities that characterize and differentiate them.
- Establishing the equation, static or dynamic, that governs the structural problem and learning to solve it for different types of stresses, using elementary one degree of freedom models.
- Deducing and understanding the concept of stiffness from the resolution of the static equation (bar, cable, beam under bending, beam under torsion); and from the dynamic equation, the concepts of frequency and eigenperiod of vibration, resonance, structural damping and dynamic amplification factor, with their implications and corresponding practical applications.
- To strengthen the knowledge of structural matrix calculation techniques (flexibility and stiffness methods) for the resolution of general structural problems, both for building or industrial structures in its general sense, and for different types of bridges (beam, frame-type, arch, cable-stayed or suspension bridges).
- Learning to solve structural dynamic calculation problems in the time domain by the method of modal superposition, understanding the concepts of frequencies and vibration modes, and orthogonal damping matrix, by using the stiffness calculation matrix technique,
- Likewise, learning the concept of spectrum response for its application to the resolution of a structural design problem under seismic actions, by means of the modal-spectral analysis method. In particular, the response spectra for the Spanish seismic-resistant standard and the Eurocode.
- Finally, in lab practices, and through the resolution of certain examples, the student will be introduced in the use of some of the currently available softwares for general structural calculations (static and dynamic).

6. SUBJECT PROGRAM	
CONTENTS	
1	1. LINEAR AND NONLINEAR STRUCTURAL ANALYSIS 1.1. Concepts of linearity and nonlinearity in structural design. Linearity conditions. Linear and nonlinear calculation under static actions. 1.2. Concept of static and dynamic actions and structural systems and their characteristics. Types of actions: static, quasi-static, kinematic and dynamic actions. Types of vibrations. Discretization methods.
2	2. ENERGY THEOREMS 2.1. Energy theorems in structural analysis. Main principles and derived theorems. Practical applications in conventional structural analyses. 2.2. Application of the energy theorems to the indirect formula of the dynamic equation in 1 degree of freedom systems as an alternative to the equilibrium method. Generalized 1 DOF systems. Rigid elements. Plates. 2.3.Solving the dynamic equation: free vibrations. Fundamental frequency and vibration eigenperiod concepts. Structural damping and logarithmic decrement. Harmonic forced vibrations: resonance concept. Dynamic amplification factor. Periodic, impulsive and arbitrary forced vibrations. Duhamel's integral.
3	3. MATRIX METHODS OF EQUILIBRIUM AND FLEXIBILITY 3.1. Equilibrium matrices in statically-determined structural systems. 3.2. Flexibility matrices in statically-indetermined structural systems. 3.3. Practical applications to conventional structural design. 3.4. Indirect calculation of a structure's stiffness matrix from the flexibility matrix.
4	4. STIFFNESS MATRIX METHOD 4.1. Direct calculation of a structure's stiffness matrix. Loading vectors. Practical application for the resolution of general structural problems. 4.2. Application of the stiffness matrix method to the calculation of N DOF dynamic systems. Orthogonal mass and damping matrices. General approach of the dynamic matrix equation. Free vibrations. Obtaining of frequencies and modes. Modal coordinates. Modal matrix. 4.3. Forced vibrations. Transformation to modal coordinates. Dynamic response in the time domain. Modal superposition method. 4.4. Practical applications.
5	5. TYPES OF ACTIONS IN THE REGULATIONS. SOFTWARE 5.1. Definition of actions in structural design calculations. Types of static and kinematic actions in Spanish standards and Eurocode, and their combinations for the verification of limit states. 5.2. Extraordinary actions of seismic nature: Fundamental aspects of seismic actions. Response spectrum concept and its consideration in the standards. 5.3. Obtaining the structural response under seismic actions in 1 DOF and N DOF systems: Spectral modal analysis. Concept of ductility. Practical applications and construction recommendations. 5.4. Characteristics and practical use of commercial software in static and dynamic design of structures.

7. ASSESSMENT METHODS AND CRITERIA

Description	Type	Final Eval.	Reassessn	%
The follow-up practice will consist of two practical or theoretical-practical exercises. It will have the character of a eliminatory for those students who pass it.	Others	No	Yes	30,00
The ordinary exam will consist of 2-4 practical or theoretical-practical exercises, 1-2 corresponding to blocks 3 to 5, common for all students, and the other 1-2 recovery exercises for those students who have not passed the practice of follow-up	Written exam	Yes	Yes	40,00
Individual practices will address all teaching blocks and will be carried out and delivered throughout the course.	Work	No	No	20,00
Laboratory practices will be carried out at the end of blocks 2 and 5.	Laboratory evaluation	No	No	10,00
TOTAL				100,00

Observations

In relation to the agreements adopted in the ordinary session of the School Board held on June 10, 2010, it is established that, with respect to evaluation activities that have a recoverable nature, as a general criterion and except that in this guide specifies something different, a student may only take the retake of those activities that he has not passed, that is, in which he has not obtained a minimum grade of five out of ten.
As a general criterion and unless otherwise specified in this guide, in the period of recovery, the evaluation procedure for an activity will be the same as that of the activity that originates it.
Note: According to royal decree RD 1125/2003 on the European credit system and the grading system in official university degrees valid throughout the national territory, the results obtained by the student in each of the subjects of the plan The studies will be graded based on the following numerical scale from 0 to 10, with a decimal expression, to which the corresponding qualitative grade may be added:
0,0-4,9: Suspenso (SS).
5,0-6,9: Aprobado (AP).
7,0-8,9: Notable (NT).
9,0-10: Sobresaliente (SB).

Only for duly justified reasons (e.g. health restrictions) can evaluation tests be organized remotely, with prior authorization from the Center Management.

Observations for part-time students

Students enrolled part-time may take the entire subject in the ordinary or extraordinary exams, meeting the requirements demanded of the rest of the students in said exams.

8. BIBLIOGRAPHY AND TEACHING MATERIALS

BASIC

CÁLCULO MATRICIAL DE ESTRUCTURAS. Avelino Samartín Quiroga y José Ramón González de Cangas. Ed. Colegio de Ingenieros de Caminos, Canales y Puertos (2001). ISBN-84-380-0179-3.

INTRODUCCIÓN AL CÁLCULO DINÁMICO DE ESTRUCTURAS. Juan Miquel Canet y Alex H. Barbat. CIMNE, Barcelona, 2015.

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