SUBJECT TEACHING GUIDE

M1445 - Advanced Calculation of Structures

Master's Degree in Civil Engineering

Academic year 2019-2020

1. IDENTIFYING DATA					
Degree	Master's Degree in Civil Engineering			Type and Year	Compulsory. Year 1
Faculty	School of civil Engineering				
Discipline	Advanced Calculation of Structures				
Course unit title and code	M1445 - Advanced Calculation of Structures				
Number of ECTS credits allocated	3	Term		Semester based (2)	
Web					
Language of instruction	Spanish	English Friendly	No	Mode of delivery	Face-to-face

Department	DPTO. INGENIERIA ESTRUCTURAL Y MECANICA
Name of lecturer	JOSE RAMON GONZALEZ DE CANGAS
E-mail	ramon.gonzalez@unican.es
Office	E.T.S. de Ingenieros de Caminos, Canales y Puertos. Planta: + 2. DESPACHO (2040)
Other lecturers	GUILLERMO CAPELLAN MIGUEL RAFAEL DIEZ ALMAGRO

3.1 LEARNING OUTCOMES

- LEARNING OUTCOMES

1.- Comprehension of structural behaviour and how stuctural models and calculation methods reproduce this behaviour under the action of different loads. Comprehension of the magnitudes involved in a structural analysis.
2.- Comprehension of the real loads acting on a structure (static, kinematic and dynamic) and their idealisation for using in structural models and computer programs.
3.- Comprehension of the different methods of static and dynamic analysis of structures, their applications and limitations, and their adaptation to the existing computer programs.
4.- Comprehension of the particularities characterising and differentiating the structural behaviour under dynamic actions compared to the static response.
5.- Comprehension of the characteristics of seismic actions as a particular case of dynamic loads.
6.- Capability for the analysis (static and dynamic) of simple structural models and comprehension of their resistant behaviour.
7.- Capability for the critical analysis of the results of a structural calculation, static or dynamic.
8.- Knowledge of the Spanish standards and Eurocodes dealing with the different kinds of real loads, static, kinematic and dynamic (earthquakes included), and their consideration in the analysis of the structural limit states.
9.- Capability for using some basic computer programs for general analysis of structures (static and dynamic) and knowledge of the theory they are based on.

4. OBJECTIVES

OBJECTIVES

1.- On the one hand, the main objectives of the subject are aimed at learning the concepts of actions and structural systems, either static or dynamic, as well as the particularities characterising and differentiating them. By considering elementary structural models with one degree of freedom, the student will establish the static or dynamic equation governing the problem and will learn to solve it for different kinds of actions. By solving the static equation, the student will learn the concept of stiffness, and from the dynamic one, the concepts of frequency and period of vibration, resonance, structural damping and dynamic magnification factor, as well as their implications and practical applications.
On the other hand, the student will consolidate the knowledge of the most common matrix methods of structural analysis (flexibility and stiffness methods) and their applications in practical general static problems.
By means of the stiffness matrix method, the student will learn to solve general problems of dynamics of structures in the time domain, by applying the superposition modal method. He will learn the concepts of frequencies and vibration modes, and ortogonal damping matrix. The student will also learn the concept of response spectrum and its application to calculate a structure under seismic actions by means of the modal-spectral method. Response spectra defined in Spanish standards and Eurocodes will be known.
Finally, the student will be introduced to the use of some of the existing computer programs for general analysis of structures (static and dynamic) by solving specific problems in practical applications carried out at the laboratory.

6. COURSE ORGANIZATION	
CONTENTS	
1	1. LINEAR AND NON-LINEAR ANALYSIS 1.1. Concepts of linearity and non-linearity in structural analysis. Linear analysis under static actions. 1.2. Concepts of actions and structural systems, static and dynamic. Types of actions (static, kinematic and dynamic). Types of vibrations. Discretization methods.
2	2. ENERGY THEOREMS 2.1. Energy theorems in structural analysis. Fundamental principles and drived theorems. Practical applications in conventional structural analysis under static loads. 2.2. Energy methods applied to the indirect formulation of the dynamic equation in 1 DOF systems, as an alternative to the direct equilibrium method. Generalised 1 DOF systems. Rigid elements: Plates. 2.3. Resolution of dynamic equation: Free vibrations. Concepts of frequency and vibration period. Structural damping and logarithmic decrement. Forced harmonic vibrations: Concept of resonance. Dynamic magnification factor. Periodic, impulse and arbitrary dynamic loads. Duhamel´s integral.
3	3. EQUILIBRIUM AND FLEXIBILITY MATRIX METHODS 3.1. Equilibrium matrix in statically determinate structural systems. 3.2. Flexibility matrix in statically indeterminate structural systems. 3.3. Practical applications in conventional structural analysis. 3.4. Indirect calculation of the stiffness matrix through the flexibility method .
4	4. STIFFNESS-MATRIX METHOD 4.1. Direct calculation of the stiffness matrix of a structure. Loading vectors. Practicqal applications in conventional struuctural analysis. 4.2. Application of the stiffness-matrix method to the analysis of multi-degree-of-freedom (NOF) dynamic systems. Mass and ortogonal damping matrices. General approach to the dynamic equation. Free vibrations. Frequencies and vibration modes. Modal coordinates. Modal matrix. 4.3. Forced vibrations: Modal coordinates transformation. Dynamic response through the time domain: Superposition modal method. Practical applications.
5	5. TYPES OF LOADINGS AND THEIR CONSIDERATUION IN THE CODES. COMPUTER PROGRAMS. 5.1. Definition of loads in structural analysis. Types of actions (static, kinematic and dynamic) in Spanish standards and Eurocodes. Load combinations for the analysis of limit states. 5.2. Extraordinary actions due to earthquakes. Fundamentals of seismic actions. Concept of response spectrum and its consideration in the codes. 5.3. Structural response under seismic actions in one-degree and multi-degree-of-freedom systems. Modal-spectral analysis. Concept of ductility. Practical applications and constructive recommendations. 5.4. Characteristics and practical use of some existing computer programs for static or dynamic structural analysis.

7. ASSESSMENT METHODS AND CRITERIA

Description	Type	Final Eval.	Reassessn	%
Mid-term exam consists of two exercises, practical or theoretical-practical, corresponding to the first two blocks of the subject. Students not having passed this exam have to retake it in the final exam.	Written exam	No	Yes	40,00
Final exam consists of four exercises, practical o theoretical-practical, two of them corresponding to the second part of the subject (blocks 3, 4 and 5) and two corresponding to the first part (blocks 1 and 2), only for students that have failed the mid-	Written exam	Yes	Yes	60,00
TOTAL				100,00

Observations

As a general criterion and unless otherwise specified in this guide, a student can only apply for the recovery of those activities that have not passed, that is, in which he has not obtained a minimum score of five out of ten.

Observations for part-time students

Students enrolled on a part-time basis may examine the whole subject in the final exam, meeting the requirements demanded of the rest of the students in said exam.

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, 2015.

NORMA DE CONSTRUCCIÓN SISMORRESISTENTE NCSE 02