UNIVERSITÀ DELLA CALABRIA
DIPARTIMENTO DI **INGEGNERIA DELL'AMBIENTE**

DESIGN OF STRUCTURES IN SEISMIC AREAS

A.A.2020/2021

Denominazione insegnamento	DESIGN OF STRUCTURES IN SEISMIC AREAS	
Codice insegnamento	2706240	
Corso di Studio (CdS)	ENVIRONMENTAL AND TERRITORIAL SAFETY ENGINEERING	
Livello CdS	SECOND	
Codice CdS	0773	
Settore Scientifico Disciplinare (SSD)	ICAR/09	
Crediti Formativi Universitari (CFU)	9	
Tipologia Attività Formativa (TAF)	CARATTERIZZANTE	
Tipo attività formativa	COMPULSORY	
Anno di corso	1	
Periodo didattico	FIRST SEMESTER	
Docente responsabile	FRANCESCO BENCARDINO	
Altri docenti coinvolti	---	
Organizzazione didattica*	***Ore Lezioni***	54
	Ore Esercitazioni	18
	Ore Laboratorio	
	Ore Studio individuale	153
Lingua di insegnamento	ITALIAN	
Propedeuticità	NONE	
Prerequisiti	Good knowledge of the topics covered in the Structural Mechanics course.	
Contenuti	The course provides the basic tools for the design and safety verification of structures in seismic areas. The approach to the project will be developed with reference to National Codes and Eurocodes. The main aspects relating to the following topics will be discussed: Territorial seismic risk, site seismic hazard and conventional seismic action; Static/dynamic linear structural analysis methods; Conception, design and modeling criteria of anti-seismic structures with specific reference to the reinforced concrete structures; Simple models and methods for design/verification of bi-dimensional structures (plates/tanks). The main skills that will be acquired include the ability to design/verify, in terms of ductility, strength and stiffness, an anti-seismic reinforced concrete structure.	
Obiettivi formativi (in termini di risultati di apprendimento attesi)	The course aims to provide the main tools to design buildings and structural elements in seismic areas. The course develops the main topics of seismic design, the conception and design of a reinforced concrete building according to the "capacity design" criteria, as well as some specific aspects related to plates and tanks, and the use of strut-tie models for the solution of particular structural problems. The students must demonstrate that they are able to carry out the analysis and design of a reinforced concrete building in a seismic area, up to section design and verification of some main structural members. At the end of the course, the knowledge acquired will be sufficient and suitable to make the students autonomous, capable of using appropriate language for the correct discussion of the design issues, and they will be also able to setting-up and develop the design of a reinforced concrete structure in seismic areas.	
Programma	**1. LINEAR STRUCTURAL ANALYSIS**. Deflected beams, Equation describing beam deflection shape, shear and bending moment diagrams, elastic deflection and angle of deflection. Flexural and shear stiffness.	

	Consistent deformation method and stiffness method of analysis, stiffness matrix and frame analysis using the stiffness method. Solution of isostatic and hyperstatic beams: cantilever beams, simply supported beams, fixed beams (one or both ends), beam supported with cantilever at the ends, continuous beam, simple and complex frames. 2. **STRUCTURAL DESIGN**. Conceptual basis of structural design. Constructions and structural systems. Structural modeling. Materials/structures and their effectiveness. The shape-structure relationship. Steps of structural design. National and international Codes, Standards and guidelines for design. 3. **STRUCTURAL SAFETY AND ACTIONS**. Structural safety verification methodologies: deterministic and probabilistic approach. Random variables and their properties. The semi-probabilistic limit state methodology. The characteristic and design values of strengths and actions. The ultimate limit state (ULS) and serviceability limit state (SLS). Partial factors for materials and loads. Actions on structures: permanent actions (dead loads), variable actions (live loads), snow loads and wind actions. Characteristic and design values of the actions. Combinations of actions. 4. **GROUND CONDITIONS AND SEISMIC ACTION**. Basic concepts of seismic design. Peak ground acceleration, importance factors and reference return period for seismic action. The basic seismic hazard, the limit states for seismic design, ground conditions. Evaluation of seismic action: horizontal/vertical elastic response spectrum in acceleration and design spectrums. 5. **REINFORCED CONCRETE STRUCTURES.** a. **Materials, durability, bond**. Concrete and steel. Strength classes for concrete, compressive and tensile behavior of concrete and reinforcing steel. Environmental conditions, durability, concrete cover, spacing of bars. Bond stress concrete-steel bars and theoretical models. Anchorage length and overlap length of longitudinal reinforcements. b. **Elastic analysis and serviceability limit states (SLS).** Actions for the SLS, materials and elastic analysis method, SL cracking, SL stress in concrete and steel, SL deformation, verification of sections subjected to flexure and section subjected to flexure and axial load. c. **Ultimate limit states (ULS).** Stress-strain relations (characteristic and design values) for concrete and steel. Flexural strength and strength of member with flexure and axial load: failure modes in reinforced concrete sections, design and strength of single and double reinforced sections. Shear strength of members with and without web reinforcement (stirrups). Torsional strength and strength of members subjected to shear and torsion. Strut-and-tie models for short beams. d. **Design in seismic areas**. Design philosophy in seismic areas. Concept of ductility, stiffness and strength. The ductility: of the materials, of the section, of the structural member. Multistory buildings and "capacity design". Curvature ductility, structural ductility, relationship between local and global ductility. General design criteria: configuration and structural response, mass distribution and lateral

	stiffness distribution, structural regularity, structural types and behavior factor for horizontal seismic actions, ductility classes and hierarchy of resistance. **e. Analysis methods.** Structural modeling and modeling criteria. Static and dynamic linear analysis methods. **f. Design and verification of the structural elements**. Selection criteria for designing. The structural elements: decks and seismic-resistant structures. Slabs: types of slab and design methods. Section design of one-way spanning ribbed slab with hollow blocks. Design procedure of beams and columns/pillars. Lateral overhangs and corner overhangs: modeling, section and steel reinforcements design. Holes in the slabs: modeling, analysis and arrangement of reinforcement. Vertical connections: stair with sloping one-way spanning slab, stair with knee beam and cantilever steps. **g. Foundation structures.** Types of foundations: shallow and deep foundations. Bearing capacity of shallow foundations. Isolated/pad footing, piles, group of piles and pile cap/pad footing. Continuous strip footing (rigid and/or elastic beam) on Winkler ground: analysis, section design (width and height) and steel reinforcements design (longitudinal bars and stirrups). Structural modeling and analysis. **6. DESIGN OF BUILDINGS IN SEISMIC AREA.** Essentials of structural systems for seismic resistance. Structural modeling of reinforced concrete multistory buildings. Structural analysis and design by using a specific software. Recommended details for reinforced concrete construction in seismic area. **7. BI-DIMENSIONAL FLAT STRUCTURAL ELEMENTS (PLATE)**. Geometry, behavior and intuitive considerations. The rectangular plates orthogonally loaded to their surface: the plates supported and/or fixed along the edges. The rectangular plate subjected to: uniformly distributed load and hydrostatic load. Rectangular reinforced concrete plates: internal steel reinforcements, anchorage and overlapping of the bars, joints. The analysis methods of Grashof and Marcus. Punching shear: modeling, analysis and solution. **8. PRESTRESSED CONCRETE.** Basic principle of prestressing. Methods of prestressing (Pre- and post- tensioning technology). Prestressed concrete structures: general design criteria. Prestress loss: immediate losses and time dependent losses. Response of prestressed members subjected to axial load and subjected to flexure. Elastic analysis of prestressed concrete sections in flexure: stress limits.
Modalità di erogazione	FRONT.
Metodologie didattiche	Lectures in the classroom (with the aid of a projector and blackboard), exercises, individual and group project activities.
Metodi e criteri di valutazione dell'apprendimento	The exam will be carried out through an oral test and consists in a discussion of the project documents prepared by the student with specific questions on the topics covered during the course. The evaluation criteria will be: completeness of information, quality and graphic clarity of the project; degree of understanding, reasoning ability, quality of exposure, methodological rigor and terminology used in the

	discussion of the topics discussed. The evaluation will be based on five questions, three concerning to the proposed project and two concerning the topics covered in the program. The duration of the test will be about one hour and it depends on the student's level of knowledge. The test is passed if the student shows sufficient mastery and skill on the topics related to the project carried out.
Testi di riferimento ed eventuali letture consigliate	FONDAMENTI DI TECNICA DELLE COSTRUZIONI*, a cura di M. Mezzina*, Città Studi Edizioni. STRUTTURE IN CEMENTO ARMATO - Basi della Progettazione, *E. Cosenza, G. Manfredi, M. Pecce*, HOEPLI Editore Milano. PROGETTAZIONE STRUTTURALE ANTISISMICA, *Marco Boscolo Bielo*, GRAFILL. CALCOLO EDIFICI IN C.A. con il software EdiSAP – Analisi progettazione strutturale e disegno di edifici tridimensionali multipiano in calcestruzzo armato in zona sismica, *Angelo Longo*, GRAFILL.
Peer review	*Prof. Giuseppe Mendicino, Prof. Beniamino Sirangelo, Prof. Alfonos Senatore, Ing. M. De Biase*
Orario delle lezioni	*http://diam.unical.it*
Calendario degli esami	*http://diam.unical.it*
Commissione d'esame	*http://diam.unical.it*

* Educational Organization

AVERAGE WORKLOAD FOR A STUDENT ENGAGED IN FULL-TIME ACADEMIC ACTIVITIES				
	Lecture [Ore]	Practice [Ore]	Laboratory [Ore]	Individual study [Ore]
1. LINEAR STRUCTURAL ANALYSIS FONDAMENTI DI TECNICA DELLE COSTRUZIONI, a cura di M. Mezzina, Città Studi Edizioni.	6	3		15
2. STRUCTURAL DESIGN FONDAMENTI DI TECNICA DELLE COSTRUZIONI, a cura di M. Mezzina, Città Studi Edizioni. PROGETTAZIONE STRUTTURALE ANTISISMICA, *Marco Boscolo Bielo*, GRAFILL.	2			4
3. GROUND CONDITIONS AND SEISMIC ACTION FONDAMENTI DI TECNICA DELLE COSTRUZIONI, a cura di M. Mezzina, Città Studi Edizioni. PROGETTAZIONE STRUTTURALE ANTISISMICA, *Marco Boscolo Bielo*, GRAFILL.	3			6
4. STRUCTURAL SAFETY AND ACTIONS FONDAMENTI DI TECNICA DELLE COSTRUZIONI, a cura di M. Mezzina, Città Studi Edizioni. STRUTTURE IN CEMENTO ARMATO - Basi della Progettazione, *E. Cosenza, G. Manfredi, M. Pecce*, HOEPLI Editore Milano.	6			12
5. REINFORCED CONCRETE STRUCTURES FONDAMENTI DI TECNICA DELLE COSTRUZIONI, a cura di M. Mezzina, Città Studi Edizioni. STRUTTURE IN CEMENTO ARMATO - Basi della Progettazione, *E. Cosenza, G. Manfredi, M. Pecce*, HOEPLI Editore Milano.	20	9		49
6. DESIGN OF BUILDINGS IN SEISMIC AREA FONDAMENTI DI TECNICA DELLE COSTRUZIONI, a cura di M. Mezzina, Città Studi Edizioni. PROGETTAZIONE STRUTTURALE ANTISISMICA, *Marco Boscolo Bielo*, GRAFILL. CALCOLO EDIFICI IN C.A. con il software EdiSAP – Analisi progettazione strutturale e disegno di edifici tridimensionali multipiano in calcestruzzo armato in zona sismica, *Angelo Longo*, GRAFILL	10	6		26
7. BI-DIMENSIONAL FLAT STRUCTURAL ELEMENTS (PLATES) Appunti delle lezioni.	4			8
8. PRESTRESSED CONCRETE STRUCTURES FONDAMENTI DI TECNICA DELLE COSTRUZIONI, a cura di M. Mezzina, Città Studi Edizioni.	5			10
Ore riservate allo sviluppo delle competenze trasversali *(possono essere previste anche ore di lezione frontale)*				
Tesine/altri homework				5
Ulteriori ore da dedicare alla preparazione dell'esame *(es. ore che gli studenti dedicano allo svolgimento di precedenti*				18

tracce d'esame)				
TOTALE *(Attenzione: i totali devono coincidere con le ore inserire dall'ufficio)*	**54**	**18**		**153**
ORE COMPLESSIVE	✓ **225**			