NATIONAL UNIVERSITY OF ENGINEERING
COLLEGE OF CIVIL ENGINEERING
CIVIL ENGINEERING PROGRAM

SYLLABUS - EARTHQUAKE RESISTANT ENGINEERING AND DISASTER PREVENTION

I. GENERAL INFORMATION

CODE	**:**	ES831 Earthquake Resistant Engineering and Disaster Prevention
SEMESTER	**:**	8
CREDITS	**:**	5
HOURS PER WEEK	**:**	6 (Theory – Practice)
PREREQUISITES	**:**	EC211 Structural Analysis I, ES731 Reinforced Concrete I
CONDITION	**:**	Compulsory
DEPARTMENT	**:**	Structures

II. COURSE DESCRIPTION

The course trains students on the principles for the analysis and design of earthquake-resistant structures. Students develop models to analyze the vibrational characteristics of diverse type of structures subject to diverse external perturbations and apply numeric methods to simulate and analyze the time and frequency response of the structure. Focus is given to the seismic characteristics of Peru and its diverse regions applying national norms on earthquake-resistant structures. Students complete a design project and present and defend a report.

III. COURSE OUTCOMES

1. Develop dynamic models of structures and formulate motion equations.
2. Analyze the dynamic response of structures of several degrees-of freedom and determine their vibration modes.
3. Apply Peruvian norms for earthquake resistant design.
4. Understand that the structures' analysis and design must go together in the activity of the civil engineer.
5. Adequately use materials, taking into consideration their characteristics of resistance and deformability.
6. Design earthquake resistant structures.

IV. LEARNING UNITS

1. BASIC CONCEPTS / 18 HOURS
History of anti-seismic engineering / Seismology concepts and definitions / Earthquake definition and characteristics / Earthquake causes and origins / Seismic waves / Earthquake intensity and magnitude / Determination of epicenter / Seismic scales / Tsunamis / Seismic potential and seismic risk studies / Seismic micro-zoning studies.

2. DYNNAMIC SEISMIC RESPONSE OF STRUCTURAL SYSTEMS / 15 HOURS
Principles of earthquake resistant engineering / Damage types / Factors affecting the dynamical response of buildings / Types of dynamic loads / Dynamic models of structural systems / Mass lumping / Lumped mass and point mass systems.

3. DYNAMIC MODELLING / 18 HOURS
Damping in structural systems / Damping types / Viscous damping / Recommended damping values / Determination of lateral rigidity in lateral columns and portico-type structures / Lateral rigidity in reinforced concrete walls / Series and parallel rigidity / Laboratory tests for dynamic analysis / Forced

vibration in damped and non-damped systems / Constant excitation forces / Periodic excitation forces / Resonant systems / Dynamic amplifying factor.

4. ONE-DEGREE-OF-FREEDOM SYSTEMS / 9 HOURS

Motion equations / Free vibration of non-damped systems / Angular frequency, natural frequency and vibration period / Free vibration in viscous damped systems / Amplitude ratio of successive cycles / Forced vibration of damped systems / Resonant systems / Dynamic amplifying factors / Impulse force and arbitrary excitation forces response / Convolution and Duhamel integral / One-degree-of-freedom systems with basement acceleration / Computation of dynamic response through numeric methods / Linear acceleration methods.

5. SPECTRAL RESPONSE / 9 HOURS

Spectral response concepts / Displacement spectral response / Pseudo velocity and pseudo acceleration spectral response / Tripartite spectral response/ Normalized spectral response / Several degrees-of-freedom systems / Motion equations.

6. SEVERAL-DEGREES-OF-FREEDOM SYSTEMS / 5 HOURS

Non-damped systems / Determination of period and vibration modes / Matrix method / Orthogonality and normalization of vibration modes / Iterative methods for determining vibration modes / Stodola method / Dynamic-elastic analysis / Holzer method / Motion equations of damped systems with basement acceleration / Static condensation / Basement displacement motion / Basement rotation motion / Symmetrical and non-symmetrical plant systems / Elastic-dynamic analysis / Spectral modal analysis.

7. PERUVIAN NORMS ON EARTHQUAKE RESISTANT DESIGN / 10 HOURS

Static seismic analysis / Seismic zoning / Geotechnical conditions / Building seismic types / Ground and seismic amplifying factors / Structural configuration / Reduction coefficient / Shear force on basement and height distribution / Torsion effects / Vertical seismic forces / Dynamical analysis / Spectral superposition analysis / Spectral acceleration / Minimum shear stress on basement / Time-history analysis / Lateral displacement / Seismic separation joints / Non-structural elements / Evaluation and reparation of seismic damaged buildings / Instrumentation.

V. METHODOLOGY

The course is carried out in theory and practice sessions. In theory sessions, the instructor introduces the analysis and deduction of theories and methods with student participation either individually or in teams. The instructor exposes and gives examples to complement students' activity. Students' learning is complemented with papers and problems given by the instructor in the classroom. The instructor provides offprints about theory and the solutions to several formulated problems. Students complete a design project and submit and defend a report.

VI. EVALUATION FORMULA

The average grade PF is calculated as follows:

$$PF = 0.3\,EP + 0.3\,EF + 0.3\,PP + 0.1\,TF$$

EP:	Mid-Term Exam	EF:	Final Exam
PP:	Average of six quizzes	TF:	Final project

VII. BIBLIOGRAPHY

1. **NEWMARK N., ROSENBLUETH E.**
   Fundamentals of Earthquake Engineering.
   Prentice Hall Ed., 2003

2. **BUILDING TECHNICAL NORM E.030**
   Earthquake Resistant Design