EARTHQUAKE RESISTANT DESIGN OF STRUCTURES
(Professional Elective – V)

Course Code: 20CE1169

L	T	P	C
3	0	0	3

Pre-requisites: Strength of Materials, Building Materials and Concrete Technology, Design of Reinforced Concrete Structures

Course Outcomes:

At the end of the course, the student will be able to:

CO1: Discuss the equations of motion for undamped free vibrations for SDOF and 2DOF systems

CO2: Explain the engineering seismology including causes and effects of earthquakes

CO3: Analyse amulti-storeyed structure using Equivalent Static Method and Response Spectrum methods

CO4: Assess various irregularities in buildings

CO5: Apply the provisions of IS:13920 and IS: 4326 to building structures

UNIT-I **(10 Lectures)**

STRUCTURAL DYNAMICS:

Introduction – Physical and Mathematical Modelling – Discrete and continuum Modelling. Laws of Equilibrium – Newton's Law of Motion – D'Alembert's Principle and Principle ofvirtual displacement. - Types of Dynamic Loading.

Single Degree of Freedom System (SDOF) – Undamped Free Vibrations – Damped FreeVibrations (concept only).

Two Degree of Freedom System (2DOF) – Undamped Free Vibrations – Determination of Natural frequencies and Mode shapes.

Learning outcomes:

1. Apply the principles of structural dynamics for building models (L3)
2. Demonstrate the equation of motion for a single degree of freedom system structure (L3)
3. Formulate two degrees of freedom system structure and obtain natural frequencies (L2)

UNIT-II **(10 Lectures)**

ENGINEERING SEISMOLOGY:

Introduction- Internal structure of earth – Chemical properties – Physical properties – Continental drift theory – Plate tectonics – Movement of plate Boundaries – Movement of Indian plate – Faults – Types of faults – Elastic Rebound theory.

Earthquakes – Earthquake terminology – Classification of Earthquakes – Causes and effects of Earthquakes –Earthquake waves – Quantification of Earthquakes – Intensity and Magnitude – Recording Earthquakes.

Learning outcomes:

1. Describe the earthquake terminology (L2)
2. Explain how the earthquakes will occur (L2)
3. Compare various methods of measurement of earthquakes (L4)

UNIT-III **(10 Lectures)**

EARTHQUAKE RESISTANT DESIGN:

Reviews of latest I.S : 1893 (Part 1) provisions for buildings - General principles and design criteria – Assumptions – Design Acceleration spectrum – Horizontal seismic coefficient – Design acceleration – Seismic zones of India – Importance factor – Response reduction factor – Design lateral force – Design imposed loads for Earthquake force calculation – Seismic weight – Analysis by Equivalent Static Method and Dynamic Method (Response Spectrum Method) – Storey drift limitation.

Learning outcomes:

1. Discuss the earthquake loads following the provisions of IS 1893 (Part 1)(L2)
2. Analyse the Structure using Equivalent Static Method (L4)
3. Apply the provisions in the Response Spectrum method for analysing the structure (L3)

UNIT-IV **(10 Lectures)**

BUILDING CONFIGURATIONS:

Introduction – Regular and Irregular Buildings.
Plan Irregularities – Torsion Irregularity – Re-entrant corners - Floor slabs having excessive cut-outs or openings- Out of plane offsets in Vertical Elements – Non-parallel Lateral Force system.
Vertical Irregularities – Stiffness Irregularity (soft storey) – Mass Irregularity – Vertical Geometric Irregularity – In-plane discontinuity in Vertical Elements resisting lateral force – strength Irregularity (weak storey) – Floating or stub columns – Irregular Modes of Oscillation in two Principle Plan Directions.

Learning outcomes:

1. Differentiate regular and irregular buildings (L2)
2. Illustrate the plan irregularities in buildings (L3)
3. Illustrate the vertical irregularities in buildings (L3)

UNIT-V **(10 Lectures)**

DUCTILE DESIGN AND DETAILING:

Review of Latest IS: 13920 provisions
General specifications – Beams – Columns – Shear walls.
Special confining reinforcement.
Review of Latest IS: 4326 provisions - General principles – Special Construction features relating to separations of structures (above ground only).

Learning outcomes:

1. Apply the ductile design and detailing provisions to beam, columns and shear walls (L3)
2. Demonstrate the special confining reinforcement provisions in structural members (L3)
3. Discuss about special construction features (L2)

TEXT BOOKS:

1. A.K. Jain "Dynamics of Structures with Mat Lab Applications" Pearson India Education Series Pvt.Ltd., Delhi, 2016
2. Pankaj Agarwal & Manish Shrikhande, "Earthquake Resistant Design of Structures", 5th Edition Prentice Hall of India, New Delhi, 2011.
3. S.K.Duggal, "Earthquake Resistant Design of Structures", Oxford University Press, 1st Edition, 2012.

REFERENCES:

1. Chopra A.K., "Dynamics of Structures", 5th Edition, Pearson Education, Indian Branch, Delhi, 2007.
2. Mario Paz, "Structural Dynamics - Theory and Computations", 6th Edition, Pearson Education, 2005.
3. IS 456: 2000 Indian Standard Plain and Reinforced Concrete – Code of Practice, Bureau of Indian Standard, New Delhi. (or latest).
4, IS 1893 (Part 1): 2016, Indian Standard "Criteria for Earthquake Resistant Design of Structures, Part 1, General provisions and Buildings (six revision) Bureau of Indian Standard, New Delhi. (or latest).
5. IS 13920: 2016 Indian Standard "Ductile Design and Detailing of Reinforced Concrete Structures, subjected to Seismic forces - Code of Practice, Bureau of Indian Standard, New Delhi. (or latest).
6. IS 4326: 2013 Indian Standard "Earthquake Resistant Design and Construction of Buildings - Code of Practice, Bureau of Indian Standard, New Delhi. (or latest).