GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3160621
SUBJECT NAME: EARTHQUAKE ENGINEERING
SEMESTER-VI

Type of course: Professional Elective Course

Prerequisite: Mechanics of Solids, Structural Analysis I, Design of Structure

Rationale: This subject is conceptual applications of principles of dynamics and earthquake resistant design & detailing of RC structures. Some special topics like Earthquake resistant masonry structures, liquefaction, structural controls and seismic strengthening are included aiming students know that these are challenges in this subject. This subject is useful to understand the behaviour of the structure subjected to earthquake forces and earthquake resistant design of the structure.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	**Earthquake Basics**: Interior of Earth, plate tectonics, faults, consequences of earthquake, Basic parameters of earthquake, seismic waves, magnitude & intensity, scales, Seismic zones of India, damages caused during past earthquakes (worldwide).	4	10
2	**Fundamentals of Earthquake Vibrations of buildings** Static load v/s Dynamic load, simplified single degree of freedom system, mathematical modelling of buildings, natural frequency, resonance v/s increased response, responses of buildings to different types of vibrations like free and forced, damped and un-damped vibration, response of building to earthquake ground motion, Response to multi degree (maximum three) of freedom systems up to mode shapes.	11	25
3	**Design Philosophy:** Philosophy of earthquake resistant design, earthquake proof v/s earthquake resistant design, four virtues of earthquake resistant structures (strength, stiffness, ductility and configuration), seismic structural configuration, Introduction to IS: 1893 (Part I) 2016, IS: 875 (Part V). Seismic load: **Seismic Coefficient Method** – base shear and its distribution along height. Introduction to Response spectrum, IS code provisions.	11	25
4	**Lateral Loads on Buildings:** **Lateral Load Distribution (SDOF):** Rigid diaphragm effect, centres of mass and stiffness, torsionally coupled and uncoupled system. **Lateral Load Analysis:** Analysis of frames using approximate methods like portal & cantilever methods	6	15
5	**Ductile Detailing:** Concepts of Ductile Design & Detailing of various structural components as per IS:	5	13

	13920 - 2016 provisions.		
6	**Special topics**: Introduction to Earthquake Resistant Features of un-reinforced & reinforced masonry Structure, Confined Masonry, Soil liquefaction, Structural controls, Seismic strengthening.	5	12

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	**30**	**20**	**20**	**5**	**5**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Manish Shrikhande & Pankaj Agrawal; Earthquake resistant design of structures, PHI Publication, New Delhi
2. S.K.Duggal; Earthquake resistance design of structures; Oxford University Press, New Delhi.
3. A.K.Chopra; Dynamics of structures , Pearson, New Delhi
4. Clough & Penzin; Dynamics of structures
5. Park & Pauly; Behaviour of RC structure
6. John M.Biggs; Introduction to Structural Dynamics
7. C V R Murthy - Earthquake Tips, NICEE
8. IITK-GSDMA EQ26 – V -3.0 Design Example of a Six Storey Building
9. S S Rao; Mechanical Vibration; Pearson, New Delhi.
10. **IS Codes:**

a) Criteria for earthquake resistant design General provision & Building - IS: 1893 (Part I)- 2016
b) Code of Practice for Ductile Detailing of RC Structures - IS: 13920 (2016).
c) Code of Practice for earthquake resistant design & Construction of buildings – IS 4326 (2013).
d) Improving Earthquake Resistance of Earthen Buildings - IS 13827(1993) (R 2006)
e) Guide lines for Improving Earthquake Resistance low strength masonry buildings - IS 13828 (1993) (R2008)

Course Outcome:

After learning the course the students should be able to:

Sr.	**CO statement**	**Marks % weightage**

No.		
CO-1	Identify the causes of damages in structures during earthquake events	10
CO-2	Determine the response of SDOF & MDOF structural system subjected to vibration including earthquake	25
CO-3	Apply the concept of Earthquake Resistant Design & concept of lateral load distribution on buildings in design of RC structures	25
CO-4	Determine the lateral forces generated in the structure due to earthquake.	15
CO-5	Apply the concept of ductile detailing in RC structures & the concepts ERD to Masonry structures with knowledge of advanced technology	25

Term Work :

Term work shall consist of satisfactory completion and submission of following list of Practicals/Tutorials.

List of Experiments:

Following experiments should be carried out in laboratory.
1. Spring Mass model
2. Mode shapes of multi-storey building
3. Response of structure with & without Shear wall and bracing system
4. Response of building with re-entrant corner
5. Behaviour of structure under pounding
6. (a) Liquefaction potential of clayey & sandy soil (b) Response of structure with isolated, raft & pile foundation under liquefaction

Practical examinations shall consist of oral based on the term-work and above course.

Major Equipment:

1. Shake table to simulate earthquake
2. Models required to perform above experiments

List of Open Source Software/learning website:

1. www.**nicee**.org
2. www.**eeri**.org
3. www.**gsdma**.org
4. www.**ndma**.gov.in
5. www.nptel.iitm.ac.in/courses
6. www.nisee.berkeley.edu/elibrary/getpkg?id=NONLIN