

# GUJARAT TECHNOLOGICAL UNIVERSITY

**BRANCH NAME: Civil Engineering**  
**SUBJECT NAME: Earthquake Engineering**  
**SUBJECT CODE: 2170612**  
**B.E. 7<sup>th</sup> SEMESTER**

**Type of course:** Applied Mechanics

**Prerequisite:** Mechanics of Solids, Structural Analysis I & II, Design of Reinforced Concrete 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 behavior of the structure subjected to earthquake forces and earthquake resistant design of the structure.

## Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks						Total Marks
L	T	P		Theory Marks			Practical Marks			
				ESE (E)	PA (M)		ESE (V)		PA (I)	
					PA	ALA	ESE	OEP		
3	1	0	4	70	20	10	30	0	20	150

### Content:

Sr. No.	Content	Total Hrs	% Weightage
1	<b>Earthquake Basics:</b> Interior of Earth, plate tectonics, faults, consequences of earthquake, Basic parameters of earthquake, magnitude & intensity, scales, Seismic zones of India, damages caused during past earthquakes (worldwide).	3	10
2	<b>Fundamentals of Earthquake Vibrations of buildings</b> Static load v/s Dynamic load (force control and displacement control), 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	<b>Design Philosophy:</b> Philosophy of earthquake resistant design, earthquake proof v/s earthquake resistant design, four virtues of earthquake resistant	11	25

	structures (strength, stiffness, ductility and configuration), seismic structural configuration, Introduction to IS: 1893 (Part I), IS: 875 (Part V). Seismic load: <b>Seismic Coefficient Method</b> – base shear and its distribution along height. Introduction to Response spectrum, IS code provisions.		
<b>4</b>	<b>Lateral Loads on Buildings:</b> <b>Lateral Load Distribution (SDOF):</b> Rigid diaphragm effect, centers of mass and stiffness, torsionally coupled and uncoupled system. <b>Lateral Load Analysis:</b> Analysis of frames using approximate methods like portal & cantilever methods	6	15
<b>5</b>	<b>Ductile Detailing:</b> Concepts of Detailing of various structural components as per IS: 13920 provisions.	5	10
<b>6</b>	<b>Special topics:</b> Introduction to Earthquake Resistant Features of un-reinforced & reinforced masonry Structure, Confined Masonry, Soil liquefaction, Structural controls, Seismic strengthening.	6	15

**Suggested Specification table with Marks (Theory):**

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
<b>20</b>	<b>30</b>	<b>20</b>	<b>20</b>	<b>5</b>	<b>5</b>

**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:

- Criteria for earthquake resistant design General provision & Building - IS: 1893 (Part I)- 2002
- Code of Practice for Ductile Detailing of RC Structures - IS: 13920 (1993).
- Code of Practice for earthquake resistant design & Construction of buildings – IS 4326 (1993).
- Improving Earthquake Resistance of Earthen Buildings - IS 13827(1993)
- Guide lines for Improving Earthquake Resistance low strength masonry buildings - IS 13828 (1993)

## Course Outcome:

After learning the course the students should be able to:

1. Determine the response of SDOF & MDOF structural system subjected to vibration including earthquake.
2. Apply the concept of Earthquake Resistant Design & concept of lateral load distribution on buildings.
3. Determine the lateral forces generated in the structure due to earthquake.
4. Apply the concept of ductile detailing in RC structures.

## Term Work:

Term work shall consist of laboratory works and following:

1. At least 25 problems based on the syllabus of Earthquake Engineering which are uniformly distributed & graded from each of the topic
2. Seminar/project assigned by the faculty member.

## Design based Problems (DP)/Open Ended Problem: (This may be considered as a part of term work)

1. Site visit of real life structures to understand the irregularities. (Take Photographs)
2. Site visit of construction site to understand ductile detailing. (Take Photographs)
3. Model preparation to understand the behavior of structures under earthquake forces.

## List of Experiments:

Following experiments should be carried out in laboratory.

1. Spring Mass model
2. Mode shapes of three 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

### **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](http://www.nicee.org)
2. [www.eeri.org](http://www.eeri.org)
3. [www.gsdma.org](http://www.gsdma.org)
4. [www.ndma.gov.in](http://www.ndma.gov.in)
5. [www.nptel.iitm.ac.in/courses/](http://www.nptel.iitm.ac.in/courses/)
6. [www.nisee.berkeley.edu/elibrary/getpkg?id=NONLIN](http://www.nisee.berkeley.edu/elibrary/getpkg?id=NONLIN)

### **ACTIVE LEARNING ASSIGNMENTS:**

Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.

1. Presentation on study of past Indian & International Earthquakes one each
2. Presentation of any one earthquake tip & every student will participate in Quiz based on Earthquake Tips.