31083 EARTHQUAKES ENGINEERING (ELECTIVE THEORY II)

DETAILED SYLLABUS

Unit I INTRODUCTION TO EARTH QUAKE

Objective of earthquake engineering - Engineering Seismology - Structure of the earth - Temperatures and Pressures with respect to depth - Plate Tectonics - Evolution of Indian Sub-Continent - Seism tectonics of India - Severe earthquakes in Indian sub-continent - Causes of earthquake - Definition of terms : Fault line, Active Fault, Focus or Hypo centre, Epicentre, Epicentre distance, Focal depth, Peak ground acceleration, Foreshocks, Aftershocks, Aseismic, Isoseismic, Seismic gap - Ground shaking - Seismic waves Body waves - P-waves and S-waves - Surface waves - Rayleigh and Love waves – Earthquake Intensity - Earthquake size - Magnitude - Wave magnitude, Duration magnitude, Moment magnitude - Energy released - Classification of Earthquake based on magnitude - Consequences of earthquake - Ground motion, Ground rupture, Liquefaction, Landslides, Fire, Tsunamis, etc.- Seismic Zoning Map of India (2002) - Earthquake frequency - Prediction of Earthquake risk -Measurement of Earthquake - Instruments used - Various scales - Richter's Magnitude Scale .

Unit II SEISMIC EFFECTS ON STRUCTURES

Nature of ground motion - Effects of source, path and site - Ground shaking effect on structures - Effects of Amplitude, Duration and Distance of Earth quake - Damage potential of earthquakes -Effects of Inertia forces, Seismic load, Deformations in structures, Horizontal and Vertical shaking of structures, Transfer of inertia forces from top to bottom - Effects of Soil - Influence of ground condition on earthquake motion - Causes for Seismic damages in buildings: Soft storey failure, Floating columns, Plan irregularity, Vertical irregularity, Lack of confinement of concrete, Long cantilevers with heavy dead loads, Insufficient shear reinforcements in columns, Poor quality construction, Poor quality materials, Corrosion of reinforcement, Pounding of adjacent buildings - Short column effect - Effects of size and shape of buildings - Horizontal and vertical layout of buildings - Effect of shifting of filler wall locations from floor to floor, non-uniform rigidity distribution - Ductility and flexibility of buildings.

Unit III BEHAVIOUR OF STRUCTURES DURING EARTHQUAKES

Characteristics of buildings affecting their behaviour - Symmetry, regularity, stiffness, flexibility, strength time period, damping, ductility, materials and method of construction - Ductile, Brittle and Fatigue fractures - Behaviour of structures on sloped ground - Behaviour of Structures with load bearing walls – Brick / Stone /Mud

masonry - Large inertia forces due to heavy weight, Very low tensile / shear strengths and brittleness of walls, Stress concentration at corners of openings, Unsymmetrical openings, Poor mortars, Free standing masonry walls, Wall enclosures without roof – Cracks in load bearing walls due to flexure and shear caused by earthquake – Improvements in the behaviour of reinforced masonry structures - Behaviour of RCC Structures – Framed / Shear wall / Dual structures - Shear failure of columns - Types of damages in beams - Functions of stirrups in seismic beams - Outward bulging of concrete and buckling of compression reinforcement of beams - Effect of joints on the ductile behaviour of RCC / Steel members - Behaviour of Steel structures - Types of joints, Joint collapse, Joint ductility - Behaviour of Non-structural elements in buildings during earthquakes - Behaviour of brittle elements - Behaviour of structural members under cyclic loading - Soil characteristics and its impact on various types of structures during earth quake – Twisting of buildings

Unit IV CONCEPTS OF DESIGN OF EARTHQUAKE RESISTING BUILDINGS

Earthquake proof building - Earthquake resisting building - Acceptable damages to building elements under minor and frequent earth quakes, moderate and occasional earthquakes, and strong but rare earth quakes - General requirements of structures for earthquake resistance and structural safety - Concepts of ductility, deformability and damageability - Concept of base isolation - Ductile performance of structures - Reinforcement detailing for ductility of RC structures - Flexible building elements - Special requirements for RC columns and beams to resist earthquake - Confining steel in columns - Special confining reinforcement for Short columns - Maximum spacing of ties and minimum lapping length of main bars in columns - Ductile detailing of RC buildings - Joints of framed structures – Reinforcements in Beam Column Joints - Providing Shear walls – Arrangement of shear walls - Boundary elements of shear walls – Reinforcements for shear walls - Advantages of shear walls in stilt floors of RC buildings - Earthquake resistant features for masonry buildings - Protection of openings in masonry walls - Masonry bond - Horizontal bands or Ring beams at plinth / lintel / roof levels in masonry - Horizontal / Vertical reinforcements in masonry walls - Framing of thin load bearing walls – Reinforcement for hollow block masonry - Reduction of earthquake effects - Base isolation technique - Types - Seismic dampers - Types of Dampers: Viscous, Friction, Yielding dampers – Seismic vibration control.

Unit V RETROFITTING OF BUILDINGS

Evaluation, Repair, Restoration and Seismic Strengthening of Buildings: Assessment of structural and non-structural damages caused by earthquakes, major and minor damages, Feasibility study for retrofitting – Structural level retrofitting method and Member level retrofitting method - Repair materials: Shot Crete,

Epoxy resins, Epoxy mortar, Gypsum Cement mortar, Quick setting mortars, Mechanical Anchors - Techniques to restore original strength: Repair of minor and medium cracks, Repair of major cracks , crushed concrete and fractured / excessively yielded / buckled reinforcement - Seismic strengthening techniques: Modification of roofs or floors, Insertion of new slab, Stiffening existing slab, Anchoring the slab to supporting walls / beams - Inserting new walls - Strengthening existing walls: Grouting, Use of wire mesh, Connecting the walls, Pre stressing, Providing buttress - Strengthening of RC members: Reinforced concrete rings around existing columns, Jacketing the existing weak beams, Welding new steel to the old steel and replacing the cover, Pre stressing of old beams - Introduction of additional load bearing elements in the structure - Strengthening of Foundations : Improving drainage, Providing apron, Adding RC strips with keys – Strengthening of soft or weak stories of Existing buildings - Bracing of roof truss frames, Anchoring of roof trusses to supporting walls .

Reference Book: 1. Earthquake Resistant Design of Structures by Pankaj Agarwal and Manish Shrikhande (2010) PHI Learning Pvt Ltd

2. Guidelines for Earthquake Resistant Non Engineered Construction by The Associated Cement Companies Ltd

3. Criteria for Earthquake Resistant Design of Structures - General Provisions and Buildings, IS: 1893 (Part 1) – 2002

4. Code of practice for ductile detailing of RC structures subjected to Seismic forces, IS:13920-1993.

5. Earthquake Tips by C.V.R.Murty, IIT, Kanpur, Sponsored by BMTPC, New Delhi.

6. Geotechnical Earthquake Engineering Hand Book by Robert W.Day – McGRAW – HILL

7. Introduction to Earthquake Engineering by Shunzo Okamoto – University of Tokyo Press

8. Repair and Seismic strengthening of buildings - Guidelines, IS:13935 – 2002

9. Dr Kamalesh Kumar, “Basic Geotechnical Earthquake Engineering”, New Age International Publications, New Delhi, 2009

10. Robert W. Day, “Geotechnical Earthquakes Engineering Hand Book, Tata McGraw-Hill, New Delhi, 2002