

GUJARAT TECHNOLOGICAL UNIVERSITY

CIVIL AND INFRASTRUCTURE ENGINEERING (40) REPAIR AND REHABILITATION OF BUILDINGS SUBJECT CODE: 2184011

BE 8th SEMESTER

Type of course: Department Elective

Prerequisite: Fundamental knowledge of concrete technology, design of reinforced concrete structure, design of steel structure.

Course Objective:

- To understand the failure mechanisms of Infrastructure projects
- To understand the importance of maintenance of structures
- To check the status of damage of buildings through various tests
- To study the various types and properties of repair materials
- To evaluate the appropriate repair or retrofitting process for different structures

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P		Theory Marks		Practical Marks				
			ESE (E)	PA (M)	PA (V)		PA (I)			
		ESE			OEP	PA	RP			
3	2	0	5	70	30	20	10	10	10	150

Content:

Sr. No	Topics	Teaching Hrs.	Module Weightage
1.	Introduction: Introduction of health monitoring of civil structures, Need and objectives of condition assessment of structures, Overview of various evaluation techniques for evaluating performance of structures. Introduction of performance indices or rating system of the structures.	4	10%
2	Durability and serviceability of structures: Construction materials characteristics and properties, Quality assurance criterion of construction materials and construction practices, Factors influencing durability and serviceability of the structures. Stages of distress in structures.	6	15%
3	Condition assessment of structures: Condition Survey: Preliminary Inspection, Planning of condition assessment of the structure, Visual Inspection, Field/Laboratory Testing, damage rating system of the structures, considerations for repair strategy. Evaluation techniques for condition assessment: Concrete Strength Assessment: Rebound hammer test, Ultrasonic pulse velocity test, Penetration resistance, Pullout test, Core sampling and testing. Chemical Tests: Carbonation test, Chloride content, Sulphate attack test	7	17.5%

	<p>Corrosion Potential Assessment: Cover meter survey, Half-cell potential survey, Resistivity measurement.</p> <p>Fire Damage Assessment: Differential Thermal Analysis (DTA), X-ray Diffraction (XRD)</p> <p>Structural Integrity/Soundness Assessment: Radiography, Impact-echo test, Dynamic Testing of Structures</p> <p>Present condition of structures: Rating system of the structure.</p>		
4	<p>Selection of repair materials for concrete: Essential parameters for repair materials, Criteria for material selection, Methodology of selection, Health and safety precautions for handling and applications of repair materials</p> <p>Materials for repair: Premixed cement concrete/mortars, Polymer modified mortars and concrete, Epoxies and epoxy systems including epoxy mortars/concretes, Polyester resins, Surface coatings, Grouting materials, Bonding agents.</p>	5	12.5%
5	<p>Rehabilitation and retrofitting methods: Introduction, Repair options, Important factors to be considered for selection of repair methods, Performance requirements of repair systems, Repair stages.</p> <p>Repair Methods: Repairs using mortars, Dry pack and epoxy bonded dry pack, Pre-placed aggregate concrete (PAC), Shotcrete, Concrete replacement, Epoxy bonded concrete, Silica fume concrete, Polymer concrete system, Strengthening concrete by surface impregnation using vacuum methods, Thin polymer overlays, Thin epoxy overlay, Resin/polymer modified cement slurry injection, Protective seal coats on the entire surface, Ferro-cement, Plate bonding, RCC jacketing, Propping and supporting, Fiber wrap technique, Foundation rehabilitation methods, Chemical and electro-chemical methods of repair</p>	7	17.5%
6	<p>Repair/Rehabilitation Strategies: Stress reduction, Repair/Strengthening of columns, beams, slabs, cracks, joints, masonry, foundation, base isolation.</p> <p>Structural repair work and its specifications: General, Surface preparation, Crack/Honeycomb area repair, Bonding coats, Structural repair items, Curing, Water proofing & protective coatings, Masonry repairs, Chhajja/sunshades repair, Testing of materials and Pre /Post repair testing of structure.</p>	6	15%
5	<p>Strengthening of Earthquake damaged buildings. Condition assessment of buildings, Retrofit of non-engineered buildings, Retrofit of masonry buildings, Retrofit of historical and heritage structures, Retrofit of steel buildings, Retrofit of foundations, efficiencies in structure requiring seismic retrofit, Design philosophy, Techniques to enhance the seismic resistance of structures, Advanced techniques for making seismic resistant structures.</p>	5	10%
		40	100

Reference/Books:

- Failures and repair of concrete structures by S.Champion, John Wiley and Sons, 1961
- “Earthquake resistant design of structures” by Pankaj agarwal, Manish shrikande, PHI, 2006.
- Concrete repair and maintenance Illustrated by Peter.H.Emmons, Galgotia publications Pvt. Ltd., 2001.

- Repair and protection of concrete structures by Noel P.Mailvaganam, CRC Press, 1991.
- Diagnosis and treatment of structures in distress by R.N.Raikar Published by R & D Centre of Structural Designers and Consultants Pvt.Ltd, Mumbai.
- Handbook on repair and rehabilitation of RCC buildings, CPWD, Government of India
- Handbook on SEISMIC Retrofit of buildings, CPWD, Government of India
- Handbook on seismic retrofit of buildings, A. Chakrabarti et.al, Narosa Publishing House, 2010.

Course outcomes

By the end of this course students will have the capability/knowledge of

- Understanding causes of various distress / damages to different structures
- How to assess damage level of structures
- Selecting appropriate repair / retrofitting material
- Selecting best technique for repair / retrofit the existing structure

Open Ended Projects:

A group of students will take up conditional assessment of different structures such as residential, commercial, industrial, and government buildings, private structures (old & new construction both) etc. Prepare a detailed report of Structural Audit of respective structures, which includes buildings surveyed, visual inspection data sheets, highlighting all the defects/deterioration seen through photographs, proposed repair or strengthening or rehabilitation strategies and its implementation procedures.

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N	E Level	C
10	15	20	20	25	10

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above

List of Open Source Software/learning website: www.nptel.iitm.ac.in/courses/

Active learning Assignments (AL) : 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.