GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3174021
Semester – VII
Subject Name: Repair and Rehabilitation of Structures

Type of course: Professional Elective Course

Prerequisite: Concrete technology, Analysis of structures, Design of structures.

Rationale:

Civil engineering structures have always been the first choice for the construction industry world over. Concrete is composite material has proved its robustness and versatility, however concrete structures are subjected to constant deterioration due to effects of ageing, inadequate maintenance, severe environmental exposure, penetration of catalytic agencies such as moisture, gases like CO2 & oxygen, chloride ions, industrial pollutants, abuse (over-used and misused) etc. This deterioration needs to be timely arrested before it leads to irreversible damage making it imperative to repair and upgrade (retrofit/strengthening) the current stock of deteriorated and deficient structures. This course has been designed with an aim to give the students an insight into the subject of concrete repair, its protection and strengthening. This subject also provides conceptual understanding and applications of repair and retrofitting materials and techniques used in existing undamaged/damaged concrete structures.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
3	1	0	4	70	30	00	00	100

Content:

Sr. No.	Content	Total Hrs
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
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
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	8

	Corrosion Potential Assessment: Cover meter survey, Half-cell potential survey, Resistivity measurement.	
	Fire Damage Assessment: Differential Thermal Analysis (DTA), X-ray Diffraction (XRD) **Structural Integrity/Soundness Assessment**: Radiography, Impact-echo test, Dynamic Testing of Structures **Present condition of structures:** Rating system of the structure.	
4	**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 **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.	**5**
5	**Rehabilitation and retrofitting methods:** Introduction, Repair options, Important factors to be considered for selection of repair methods, Performance requirements of repair systems, Repair stages. **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	**7**
6	**Repair/Rehabilitation Strategies:** Stress reduction, Repair/Strengthening of columns, beams, slabs, cracks, joints, masonry, foundation, base isolation. **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.	**6**
7	**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.	**6**
	Total	**42**

Suggested Specification table with Marks (Theory):

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

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. S. Champion, Failures and repair of concrete structures, John Wiley and Sons, 1961
2. Pankaj Agarwal, Manish Shrikande, "Earthquake resistant design of structures", PHI, 2006.
3. Peter. H. Emmons, Concrete repair and maintenance Illustrated, Galgotia publications Pvt. Ltd., 2001.
4. Noel P. Mailvaganam, Repair and protection of concrete structures, CRC Press, 1991.
5. R. N. Raikar, Diagnosis and treatment of structures in distress, Published by R & D Centre of Structural Designers and Consultants Pvt. Ltd, Mumbai.
6. Handbook on repair and rehabilitation of RCC buildings, CPWD, Government of India
7. Handbook on SEISMIC Retrofit of buildings, CPWD, Government of India
8. A. Chakrabarti et.al, Handbook on seismic retrofit of buildings, Narosa Publishing House, 2010.

Course Outcomes: After studying this subject, students will be able to

Sr. No.	CO statement	Marks % weightage
CO-1	Understand causes of various distress / damages to different structures.	30
CO-2	Assess damage level of structures.	30
CO-3	Select appropriate repair / retrofitting material.	20
CO-4	Select best technique for repair / retrofit the existing structure.	20

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.