GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering (Part time)
Subject Code: 2970602
SUBJECT NAME: Retrofitting of structures
SEMESTER-VII

Type of course: Professional Elective Course

Prerequisite: Concrete technology, Structural Analysis, Design of Reinforced Concrete structures

Rationale: Reinforced concrete structure has always been the first choice for the construction industry world over. This composite material has proved its robustness and versatility, however considering it to be an immortal material and not giving proper attention in the early days resulted into many catastrophic failure which could have been averted with prior precautionary measures. 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 CO_2 & 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.

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
1	**Introduction:** Overview of distress, deterioration in concrete structures, Case studies of distressed structures world over, Need for repairs and upgrading of structures, General introduction to process (Road-map) to a durable concrete repair	03
2	**Deterioration of concrete structures:** Types of deterioration – Signs, causes & symptoms, Mechanism of deterioration – Physical, Mechanical, Chemical, Deterioration due to ageing, Design & construction deficiencies, overloading, water leakage, Fire, Inadequate maintenance, etc.Corrosion of reinforcement (chloride induced, carbonation induced). **Visual deterioration of structures-** Cracking – Types, causes & characteristics of cracking in various structural components like beam, column, slab, masonry walls. Measurement of cracks, interpretation of the cause of particular type of cracking, effects of cover thickness, Provisions in accordance to IS 456 for ensuring durability in structures	10

3	**Conditional assessment / Evaluation of structures:** **Structural assessment:** Conditional evaluation / Structural Appraisal of the structure, Damage assessment procedure, Preliminary & Detailed investigation & Rapid visual screening/ inspection of structures **Damage Assessment allied Tests (Destructive, Semi-destructive, Non-destructive):** Field & laboratory testing procedures for evaluating the structure for strength, corrosion activity, performance & integrity, durability index.Interpretation of the findings of the tests.	**12**
4	**Repairs, rehabilitation & Retrofitting of concrete structures:** **Repair materials** - Criteria for durable concrete repair, Methodology, performance requirements, repair options, selection of repair material, Preparatory stage of repairs, Different types of repair materials & their application, types of repair techniques. **Retrofitting / Strengthening: -** Need for retrofitting, Design philosophy of strengthening structures, Techniques available for strengthening including conventional and innovativetechniques. **Seismic retrofit of concrete structures :**Local & global deficiencies in structure requiring seismic retrofit, Design philosophy, Techniques to enhance the seismic resistance of structures.	**12**
5	**Allied topics:** **Protection & maintenance of structures -** Importance of protection & maintenance,Categories of maintenance, Building maintenance. Corrosion mitigation techniques to protect the structure from corrosion. **Quality control in concrete –**Aim & importance of quality control in concrete construction, measures to assure quality in construction through testing & inspection.	**08**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	**30**	**30**	**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. Concrete microstructure, Properties and materials – P Kumar Mehta and Paulo J.M.Monterio
2. Handbook on Repairs and Rehabilitation of RCC buildings – CPWD, Government of India.

3. Repairs and Rehabilitation of Concrete Structures by Poonam I. Modi and Chirag N. Patel, PHI Publication.
4. Structural Renovation in Concrete - Zongzin Li, Christopher Leung, Yunping XI – Spon Press
5. Appraisal and Repair of Reinforced concrete by R.Holland, Thomas Telford Ltd. London.
6. Concrete Repair and Maintenance Illustrated – Peter H. Emmons, Galgotia Publications.
7. Concrete technology – A.R.Shanthakumar, Oxford University Press, India
8. Maintenance, Repair and Rehabilitation and minor works of buildings – P.C.Varghese, PHI Publication.
9. Structural Condition assessment by Robert T. Ratay.

Course Outcome:

Sr. No.	CO statement	Marks % weightage
CO-1	Identify and define all the terms and concepts associated with deterioration of concrete structures.	20
CO-2	Carry out the damage assessment and Rapid Visual inspection of a building showing signs of deterioration and thus should be able to detect the possible cause /source of deterioration	30
CO-3	Develop a knowhow of the Concrete repair industry equipped with variety of repair materials and techniques.	25
CO-4	Describe and apply the importance of quality control in concrete construction and significance of protection and maintenance of structures.	25

List of Experiments:

1. Take up Conditional Assessment of 5 different structures including Residential, Commercial, Industrial, Government buildings, Private structures (old & new construction both). Prepare Rapid visual inspection data sheets of the same.
2. Prepare a report on the buildings surveyed, to highlight all the defects/deterioration seen through proper resolution photographs. The report must clearly indicate the distress – its source and symptoms.
3. To perform the Non-destructive & Semi-destructive testing on the cast specimens of beams using set-up of Rebound hammer, USPV, Core drilling etc. and thereby prepare a report on the Interpretation of the strength i.e quality of concrete based on NDT test results.
4. To perform experiment to evaluate the Compatibility between the substrate material concrete and any repair material. (For instance comparing the Bond strength of Polymer modified mortar and Conventional Mortar with Concrete).
5. Experiment investigation to carry out the efficacy of repair material/ technique in enhancing the strength of concrete beam post cracking. (For instance, Cast a RCC beam, simulate cracking and then filling the crack with repair material and check the post-repair strength results).

Major Equipment: Compression Testing Machine, Concrete Mixture, NDT equipments like USPV, Rebound Hammer, Corrosion Meter, Rebar Locator, Engineer's inspection Kit.

List of Open Source Software/learning website:

1. **http://www.icri.org**

2. **http://www.nbmcw.com**