

# GUJARAT TECHNOLOGICAL UNIVERSITY

**BRANCH NAME: APPLIED MECHANICS**

**SUBJECT NAME: REPAIRS & REHABILITATION OF CONCRETE STRUCTURES**

**SUBJECT CODE: 2180607**

**B.E. SEMESTER-VIII**

**Type of course: DEPARTMENT ELECTIVE**

**Prerequisite:** Concrete technology, Structural Analysis, Design of Reinforced Concrete structure, Earthquake Engineering

**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 taking it for granted has 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<sub>2</sub> & 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 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

ESE-End Semester Exam, PA-Progressive Assessment, E-External, M-Mid semester, V-Viva (External), I-Internal, ALA-Active Learning Assignment, OEP-Open Ended Problem

**Content:**

Sr. No.	Content	Total Hrs	% Weightage
1	<b>Introduction:</b> Overview of distress, deterioration in concrete structures, Scenario of distressed structures world over, Need for repairs and upgrading of structures, General introduction to process (Road-map) to a durable concrete repair	04	5
2	<b>Deterioration of concrete structures:</b> Types of deterioration – Signs, causes & symptoms, Mechanism of deterioration, contributing factors like permeability, inadequate durability & micro-structure of concrete. Physical deterioration due to moisture, temperature, shrinkage, freeze-thaw, abrasion, erosion, cavitation, crystallization of salts, Efflorescence, exposure to severe environment like marine exposure. Chemical deterioration due to corrosion of reinforcement (chloride induced, carbonation induced), Alkali-silica reaction, sulphate attack, Acid attack.	10	25

	<p>Deterioration due to water leakage, fire – detection &amp; mitigation of the same. Deterioration due to ageing, inadequate maintenance, Design &amp; construction deficiencies, overloading etc.</p> <p><b>Visual deterioration of structures-</b> Types of cracks, causes &amp; characteristics of cracking in various structural components like beam, column, slab, masonry walls. Measurement of cracks, interpretation of the cause of particular type of crack.</p>		
<b>3</b>	<p><b>Conditional/damage assessment &amp; Evaluation of structures:</b></p> <p><b>Structural assessment:</b> Conditional evaluation / Structural Appraisal of the structure – Importance, objective &amp; stages, Conditional/damage assessment procedure, Preliminary &amp; Detailed investigation – Scope, Objectives, Methodology &amp; Rapid visual inspection of structures</p> <p><b>Damage Assessment allied Tests (Destructive, Semi-destructive, Non-destructive):</b> Field &amp; laboratory testing procedures for evaluating the structure for strength, corrosion activity, performance &amp; integrity, durability. Interpretation of the findings of the tests.</p>	<b>10</b>	25
<b>4</b>	<p><b>Repairs, rehabilitation &amp; Retrofitting of concrete structures:</b></p> <p><b>Repair materials</b> - Criteria for durable concrete repair, Methodology, performance requirements, repair options, selection of repair materials, Preparatory stage of repairs, Different types of repair materials &amp; their application, types of repair techniques.</p> <p><b>Retrofitting/Strengthening:</b> Need for retrofitting, Design philosophy of strengthening structures, Techniques available for strengthening including conventional and advanced techniques.</p> <p><b>Seismic retrofit of concrete structures :</b>Deficiencies in structure requiring seismic retrofit, Design philosophy, Techniques to enhance the seismic resistance of structures, advanced techniques for making seismic resistant structures</p>	<b>12</b>	25
<b>5</b>	<p><b>Allied topics:</b></p> <p><b>Protection &amp; maintenance of structures</b> - Importance of protection &amp; maintenance, Categories of maintenance, Building maintenance. Corrosion mitigation techniques to protect the structure from corrosion.</p> <p><b>Long term health monitoring / Structural health monitoring (SHM)–</b> Definition and motivation for SHM, Basic components of SHM and its working mechanism, SHM as a tool for proactive maintenance of structures.</p>	<b>06</b>	15

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

<b>Distribution of Theory Marks</b>					
R Level	U Level	A Level	N Level	E Level	C Level
<b>20</b>	<b>30</b>	<b>30</b>	<b>10</b>	<b>10</b>	<b>-</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. 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. Concrete technology – A.R.Shanthakumar, Oxford University Press, India
4. Concrete Technology by M.L.Gambhir, Tata McGraw-Hill Education, Third Edition
5. Appraisal and Repair of Reinforced concrete by R.Holland, Thomas Telford Ltd. London.
6. J.H.Bungey, S.G.Millard & M.G.Grantham , Testing of Concrete in Structures, 4<sup>th</sup> Edition, Taylor & Francis, London & New York, 2006.
7. V. M. Malhotra, Nicholas J. Carino 2004 “Handbook on Nondestructive Testing of Concrete”
8. “Repair and Strengthening of Concrete structures” , FIP guide, Thomas Telford, London.
9. Concrete Structures, Protection, Repair and Rehabilitation by R.Dodge Woodson.
10. Structural Condition assessment by Robert T. Ratay.
11. Repairs and rehabilitation of concrete structures by P. I. Modi & C. N. Patel, PHI Publication.

**Course Outcome:**

After learning the course the students should be able to:

1. Identify and define all the terms and concepts associated with deterioration of concrete structures.
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.
3. Develop a knowhow of the Concrete repair industry equipped with variety of repair materials and techniques.
4. Describe and apply the importance of quality control in concrete construction and significance of protection and maintenance of structures.

**List of Experiments:**

1. To perform a non-destructive and semi-destructive testing on the cast specimens of the beams using set up of Rebound hammer, UPSV, Core drilling etc. and there by prepare a report on the interpretation of the strength i.e quality of concrete based on NDT test results.
2. Take up Conditional Assessment of 5 different structures including Residential, Commercial, Industrial, and Government buildings, Private structures (old & new construction both). Prepare Rapid visual inspection data sheets of the same.
3. 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.
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>

**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.