



# GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Branch: Civil (Structural Engineering)

Course / Subject Code :ME01000101

Course / Subject Name :Repairs and Retrofitting of Structures

w. e. f. Academic Year:	2024-25
Semester:	1 <sup>st</sup> Semester
Category of the Course:	PEC

<b>Prerequisite:</b>	Concrete technology, Structural Analysis and Design of RCC structures
<b>Rationale:</b>	Repairs and retrofitting of structures plays an important role for the successful functioning of the crucial infrastructure segment considered to be life line of any establishment. It is therefore essential for any civil engineer to understand the different factors that are involved in affecting the integrity and durability of the built structures and structures under construction. The successful functioning of structure over its designed life can be ensured by taking proper care of these factors during the design, pre-construction and construction stages itself. In some cases it become imperative to carry out the repair and retrofitting of structures due to effects of ageing, inadequate maintenance, constant deterioration due to environmental exposure, penetration of catalytic agencies such as moisture, obnoxious gases, industrial pollutants etc. Keeping this in view, this subject has been designed to give the students an insight into the assessment of the deteriorated structures, repair and retrofitting of infrastructure using the advance methodologies and repair materials.

## Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes
01	Identify and define all the terms and concepts associated with deterioration of concrete structures.
02	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.
03	Develop a knowhow of the Concrete repair industry equipped with variety of repair materials and techniques.
04	Describe and apply the importance of quality control in concrete construction and significance of protection and maintenance of structures.



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## Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
L	T	PR	C	Theory		Tutorial / Practical		
				ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
3	0	2	4	70	30	20	30	150

## Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	<b>Introduction:</b> 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	04	5
2.	<b>Deterioration of concrete structures:</b> 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	12	30
3.	<b>Conditional assessment / Evaluation of structures:</b> Structural assessment: Conditional evaluation / Structural Appraisal of the structure, Damage assessment procedure, Preliminary & Detailed investigation & Rapid visual screening/ inspection of structures	12	25



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	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.		
4.	<b>Repairs &amp; Retrofitting of concrete structures:</b> 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 such as Repairs to overcome low member strength, deflection, cracking, chemical disruption, weathering, under water repairs, types of repair techniques.  Retrofitting / Strengthening: - Need and design philosophy for retrofitting, Techniques available for strengthening including conventional and innovative techniques, beam shear capacity strengthening, shear transfer strengthening between members, stress reduction techniques, column strengthening, flexural strengthening, connections stabilization and strengthening, crack stabilization	12	30
5..	<b>Allied Topics:</b> Maintenance of structures – Categories of maintenance, corrosion mitigation techniques. Overview of defects in steel members – Crevice corrosion, pitting, stress corrosion cracking, corrosion fatigue Guidelines for safety evaluation of Bridges and Dams and High rise buildings.	05	10
<b>Total</b>		<b>45</b>	<b>100</b>

### 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	5	5

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)



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## References/Suggested Learning Resources:

### (a) 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.
10. Forensic Structural Engineering Handbook, 2<sup>nd</sup> Edition by Robert T. Ratay.

### (b) Open source software and website:

1. <http://www.icri.org>
2. <http://www.nbmcw.com>

## List of Laboratory/Learning Resources Required:

### Suggested Project List:

1. Students in a group of 2 to take up Condition assessment of 3 different structures and prepare a comprehensive Rapid Visual Inspection data sheet and Preliminary Investigation report based on observations.
2. Students in a group of 2 to perform experiment to evaluate the Compatibility between the substrate material concrete and any repair material, to carry out the efficacy of repair material/ technique in enhancing the strength of concrete beam post cracking.

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