GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Branch: Civil Engineering

Subject Code: ME02065091

Subject Name: Structural Health Evaluation and Retrofitting of Structure

w. e. f. Academic Year:	2024-2025
Semester:	2
Category of the Course:	Professional Elective Course

Prerequisit:	Concrete Technology
Rationale :	Concrete buildings have certain useful life depending on the specifications adopted. Concrete structures are subjected to constant deterioration due to age, aggressive natural environment/ industrial pollution, overloading/misuse of buildings, inadequate maintenance etc. Simple and superficial repair to buildings does not restore the lost strength; it only hides the cracks, leaving the building in a weakened state. 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. The proper diagnosis through Structural Evaluation helps to suggest the most appropriate retrofitting techniques to localize damages.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
01	Identify and define all the terms and concepts associated with the deterioration of concrete structures.	R, U
02	Execute 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.	A, E
03	Illustrate and apply Repair Materials, Repairs and retrofitting processes.	U, A, C
04	Interpret and apply the importance of quality control in concrete construction and the significance of protection and maintenance of structures.	U, A
05	Identify and define all the terms and concepts associated with the deterioration of concrete structures.	R, U

**Revised Bloom's Taxonomy (RBT)*

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	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.	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, health assessment of Structures. Definition & Motivation for Structural Health Monitoring (SHM), System components & categories of SHM, Classification of SHM systems	02	5
2.	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. Durability of concrete: Factors affecting durability of concrete, Corrosion of reinforcements in concrete, Carbonation, Chloride ingress, Alkali-silica reaction, Freeze-thaw effects, Chemical attack, Abrasion, erosion and cavitation, Weathering and efflorescence.	08	20

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	25
4.	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 innovative techniques. Methods for repairs, rehabilitation and retrofitting including surface preparation, Study of failures of buildings and lesson learnt.	13	25
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, Methodologies and monitoring principles, Local & global Techniques for SHM, Advantages of SHM. Sensors & sensing technology for Structural monitoring	10	25
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
20	**20**	**20**	**20**	**20**	

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

References/Suggested Learning Resources:

(a) Books:

1. Concrete Microstructures, properties and materials - P Kumar Mehta and Paulo J. M. Monterio
2. Properties of concrete - A. M. Neville
3. Structural condition assessment - Robert T. Ratay
4. Handbook of retrofitting earthquake damaged buildings- CPWD, Government of India.
5. Repairs and Rehabilitation of Concrete Structures by Poonam I. Modi and Chirag N. Patel, PHI Publication.
6. Structural Renovation in Concrete - Zongzin Li, Christopher Leung, Yunping XI – Spon Press
7. Appraisal and Repair of Reinforced concrete by R. Holland, Thomas Telford Ltd. London.
8. Concrete Repair and Maintenance Illustrated – Peter H. Emmons, Galgotia Publications.
9. Concrete technology – A. R. Shanthakumar, Oxford University Press, India
10. Maintenance, Repair and Rehabilitation and minor works of buildings – P. C. Varghese, PHI Publication.
11. Structural Health Monitoring, Daniel Balageas, Peter Fritzen, Alfredo Guemes, John Wiley & Sons,
    2006.

(b) Open source software and website:

https://nptel.ac.in/courses/105105213
https://nptel.ac.in/courses/105104189
http://www.nbmcw.com
http://www.icri.org

Suggested Course Practical List: If any

1. Study of rehabilitation/retrofitting of RCC/Masonry buildings covering (a) damage assessment by visual inspection and using various techniques including NDT (b) one/two alternatives for rehabilitation/retrofitting (considering strength criteria & serviceability criteria).
2. Case study of construction and design failures.
3. Market survey for material for repairs.
4. Case study of repairing/rehabilitation structures and retrofitting of EQ damage/deficit structure.
5. Presentations / finding engineering applications /preparation of learning material based on the syllabus

List of Laboratory/Learning Resources Required:

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

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