

Repair and Maintenance of Structures

01CI1511

Objective of the Course:

- To give insight into the subject of concrete repair, its protection and strengthening
- Study of the 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, overused and misused concrete structure
- To generate awareness about various types of repair materials and techniques used in structural repair.
- To learn about the different types of maintenance strategies for structures

Credit Earned: 03

Student's learning outcomes:

After successful completion of the course, it is expected that students will be able to,

1. Identify type of distress in deteriorated concrete structures
2. Estimate the extent of damage level in concrete structures using Non-Destructive Testing
3. Implement various retrofitting and strengthening techniques using various innovative materials in structures.
4. Understand the importance of structural assessment and its applications in the maintenance of structures.

Teaching and Examination Scheme

Teaching Scheme (Hours)			Credits	Theory Marks			Tutorial/ Practical Marks		Total Marks
Theory	Tutorial	Practical		ESE (E)	IA (M)	CSE (I)	Viva (V)	Term Work (TW)	
03	00	00	03	50	30	20	25	25	150

Detailed Syllabus:

Sr. No	Topic name	Hours
1	Introduction to Structural Repair and Maintenance	4
	Introduction to repair and maintenance, retrofitting, rehabilitation. Causes of structural deterioration, Maintenance and its classifications, Necessity, objectives and importance of maintenance and repair, Types of maintenance, Factors influencing, advantages and limitations of maintenance and repairs.	
2	Deterioration of Concrete Structure	8
	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), Corrosion mechanism, alkali-silica reaction, sulphate attack, Acid attack. Cracks: Cracks in concrete, type, pattern, quantification, measurement & preventive measures.	
3	Condition Assessment & Evaluation of structures	8
	Necessity and importance of structural audit and assessment, Distress survey and detailed inspection of structures, Steps involved in structure assessment and audit, Format preparation for structural audit including general information of structures, structure data. Overview of rules and regulations of structure assessment by public work department. Nondestructive test methods for concrete including Rebound hammer, Ultrasonic pulse velocity, Rebar locator, Corrosion meter, Penetration resistance and pull-out test, Core cutting- Corrosion: Methods for corrosion measurement and assessment including half-cell potential and resistivity, Mapping of data.	
4	Repair Materials	10
	Repair materials:- Various repair materials, Criteria for material selection, Methodology of selection, Health and safety precautions for handling and applications of repair materials Special mortars and concretes Polymer Concrete and Mortar, Quick setting compounds Grouting materials Gas forming grouts, Sulfalumate grouts, Polymer grouts Bonding agents Latex emulsions, Epoxy bonding agents. Protective coatings Protective coatings for Concrete and Steel Fiber Reinforced Polymers: Types, properties and application Other Repair materials for concrete, steel and masonry	

5	Maintenance, Repair and Retrofitting Techniques	12
	<p>Critical locations of cracks in RCC elements, various causes of failure, Causes of dampness in roof slab and its repair techniques, Various types of repair methods like epoxy injection, grooving & sealing, stitching, grouting, shotcrete, and gunniting, etc. Repairs methods for honeycombing and larger voids. Repair and retrofitting of corroded RCC elements, Corrosion mitigation techniques to protect the structure from corrosion.</p> <p>Introduction to retrofitting and strengthening, Need and importance of retrofitting and strengthening, Design philosophy of strengthening structures, Techniques available for retrofitting & strengthening including conventional and innovative techniques. Strengthening of existing structures; repairs to overcome low member strength, deflection, cracking.</p> <p>Jacketing: Jacketing, Column jacketing, Beam jacketing, Beam Column joint jacketing, reinforced concrete jacketing, Steel jacketing, FRP jacketing.</p> <p>Strengthening: Strengthening, Beam shear strengthening, Flexural strengthening</p>	
	Total	42

Suggested Theory Distribution

The suggested theory distribution as per Bloom's taxonomy is as per follows. This distribution serves as guidelines for teachers and students to achieve an effective teaching-learning process

Distribution of Theory for course delivery and evaluation					
Remember	Understand	Apply	Analyze	Evaluate	Create
15%	25%	20%	20%	10%	10%

Instructional Method and Pedagogy:

1. Prerequisite of the course and its pattern shall be discussed on the commencement of the course.
2. Lectures shall be conducted in class room using various teaching aids.
3. Presence in all academic sessions is mandatory which shall carry 5% marks of the total internal evaluation.
4. At the end of each unit/topic an assignment based on the course content shall be given to the students which shall carry 5% weightage for timely completion and submission of the assigned work.

Recommended Study Material

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, 4th Edition, Taylor & Francis, London & New York, 2006.
7. V. M. Malhotra, Nicholas J. Carino 2004 “Handbook on Nondestructive Testing of Concrete”
8. M. Palanisamy, A. J. Thoriya, H. M. Rangwala, M. S. Rawat, Maintenance, Repair and Rehabilitation of Structures.
9. Repair and Strengthening of Concrete structures, FIP guide, Thomas Telford, London.
10. Concrete Structures, Protection, Repair and Rehabilitation by R.Dodge Woodson
11. Structural Condition assessment by Robert T. Ratay.
12. Repairs and rehabilitation of concrete structures by P. I. Modi & C. N. Patel, PHI Publication