

B.E. Semester: VIII
Department of Civil Engineering

Subject Name: Structural Failures and Remedies (CV804-N-A)

Course Category: Program Course Elective – V (PCE)

A. Objectives of the Course:

- To develop understanding and ability to appraise the causes of distress in structures at an early age and in certain cases collapse amongst the students.
- Students will also study the effects of the distresses on the structure and prevention
- Students will learn how to prepare a document through the conditional survey
- Students will also learn various repairing, restrengthening and rehabilitation techniques
- Keeping in mind the causes of failure, the evaluation techniques used for diagnosing the distressed or/and deteriorated structures along with the various materials and systems used for repairing and rehabilitation of the same structures will be comprehended with the emphasis on the role of an engineer at design and construction stage while dealing with such structures.
- Students will get hands on experience of non-destructive testing of concrete structures

B. Teaching & Evaluation Scheme:

Teaching Scheme				Credit	Evaluation Scheme					Total Marks
L hrs	T hrs	P hrs	Total Hrs		Theory		IE	CIA	Pra/Viva	
					Hrs	Marks	Marks	Marks	Marks	
3	0	0	3	3	3	70	30	20	00	120

C. Detailed Syllabus:

Construction Failures

1. Types of Failures:

Safety Failures, Functional Failures, Ancillary Failures

2. Cracks and Distresses in Concrete Elements:

Classification of cracks, Types Cracks with its Root Causes a such as Structural Deficiency, Material Deterioration, Improper Selection of Material, Overloading, Physical Damage, Unskilled Manpower, Violation of Construction Specifications, Improper Reinforcement Detailing and Drafting, and Prevention of Such Distress, Honey Combing, Crazeing etc.,

3. Cracks in Brick Masonry:

Types Cracks with its causes such as Structural Deficiency, Material Deterioration, Overloading, Physical Damage, Violation of Construction Specifications

4. Causes of Construction Failure:

Effect of accidents such as explosion and fire, Effect of Severe Environmental Exposure, Effects of Natural Calamities such as Earthquakes, Wind or Tsunamis, Geotechnical Failures, Formwork Failure, Common Types of Failures in Pre-Cast Concrete Structures and Steel Structures

5. Case Studies of Failure:

The Hyatt Regency Walkway Collapse, Centergy Parking Deck Collapse, Delhi Metro Corbel Failure, Ronnen Point Failure, Collapse at Pittsburgh International Airport Terminal, Airside Building etc.

Restoration of Structures

6. Introduction to Repair, Retrofitting and Restrengthening:

Introduction to Repairs, Strengthening, Retrofitting and restoration, Classification of Repairs Techniques and Retrofitting Techniques and their Importance

7. Repairing Techniques:

Importance of Various repairing Techniques with their Material, Importance and Step wise Procedure of Implementation

8. Retrofitting Techniques:

Importance of Various Retrofitting Techniques with their Material, Importance and Step wise Procedure of Implementation, Under Pining

Conditional Survey and Documentation

9. **Conditional Survey and Documentation:**

Situations Describing Necessity of Conditional Survey, Cost Effective Repairing Strategy, Procedures for Periodic Inspection of Structures

Reconnaissance Survey: General Information about the Structure, Reconnaissance Survey Form

Preliminary Inspection or Visual Inspection: Basic Information and Photographic Records, Preparing Field Documents, Grouping of Members, Damage Classification, Measurement of Nature, Extent and location of Damage, Preparing Condition Survey Report that Includes Field Documents, Basic Information of Structure, Architectural and Structural Drawings, Photographic Records, Member Wise Record of Damage Classification that include Nature, Extent, Location and Probable Root Cause, Recording of Repairs Already Carried Out

Detailed Investigation Non Destructive Tests Evaluation Reports, Detailed Structural Analysis and Design, Prepare Logical Documentation of Defects, Repair Strategy and Legal Documentation

10. **Introduction to Non Destructive Testing:**

Introduction to various Non-Destructive testing Methods such as Rebound Hammer Test, Ultra Sonic Pulse Velocity Tests, Cover Meter, Crack Width Measuring Scale

D. **Lesson Planning:**

Unit No	Title of the Unit	Minimum Hours	Weightage (%)
1	Types of Failures	01	05
2	Cracks and Distresses in Concrete Elements	06	20
3	Cracks in Brick Masonry	02	05
4	Other Causes of Construction Failure	02	05
5	Case Studies of Construction Failure	06	20
6	Introduction to Repair, Retrofitting and Restrengthening	02	05
7	Repairing Techniques	06	10
8	Retrofitting/Restrengthening Techniques	06	10
9	Conditional Survey and Documentation	10	15

10	Introduction to Non Destructive Testing	04	05
Total:		45	100

E. Assignments:

- Presentation on cracks with their causes, prevention and cure
- Presentation on each Cause of Construction/Structural Failures with Case Study
- Presentation on each Repairing Technique with Case Study
- Presentation on each Retrofitting/Restrengthening Technique with Case Study
- Minimum 2 Theoretical Questions from Each Topic

Note: Students will have to submit the theoretical questions in one spiral bound of A4 Blank Pages

F. Instructional Method and Pedagogy (Continuous Internal Assessment Scheme CIA):

- At the start of course, the course delivery pattern, prerequisite of the subject will be discussed.
- Lecture may be conducted with the aid of multi-media projector, black board, OHP etc.
- Attendance is compulsory in lectures, practical and Tutorial which carries 05 Marks.
- At regular intervals assignments is given. In all, a student should submit all assignments of 05 marks each.
- Classroom participation and involvement in solving the problems in Tutorial rooms carries 05 Marks.
- Viva Voce will be conducted at the end of the semester of 05 Marks.
- One internal exam of 30 marks is conducted as a part of Mid Semester evaluation.

G. Students Learning Outcomes:

On the successful completion of this course

- The students will be able to understand the fundamentals of construction failures
- The students will be able to understand various cracks in concrete and brick along with the root causes of them

- Students will be able to understand various repairing and retrofitting techniques and application steps of each techniques
- Students will be able to carry out conditional survey and documentation
- Students will get hands on experience of non-destructive testing of concrete structures in the laboratory.

H. Recommended Study Materials:

a. Text book & Reference Books:

1. Jacob Feld and Kenneth L. Carper, Construction Failure, Wiley Series of Practical Construction Guides Book 78
2. Advanced Composites in Bridge Construction and Repair, Yail J. Kim, Woodhead Publishing
3. Concrete Repair, A practical Guide, Michael G. Grantham, Spoon Press
4. Concrete Structures – Protection, Repair and Rehabilitation, R. Dooge Woodson, Butterworth-Heinemann Publisher
5. Failure and Distress and Repair of Concrete Structures, Norbert Delatte, CRC Publication
6. Rehabilitation of Metallic Civil Infrastructure using Fiber Reinforced Polymer Composites, Vistasp M. Karbhari, Woodhead Publishing
7. “External Repair of Cracked Grain Silos” By M. P. Colins, P. Adebar, D. Kuchma and P. Sacre
8. Precast Concrete Element Failure Patterns, Highlighting the Beam Collapse at Pittsburgh International Airport Terminal, Airside Building
9. The Hyatt Regency walkway collapse by American Society of Civil Engineers report
10. Centergy Parking Deck Collapse report by Occupational Safety and Health Administration (OSHA)
11. Handbook for the repair of cracks by Govt. of India
12. “Rapid Visual Screening of RCC Buildings” by Dr. Anand s. Arya
13. Earthquake Tips – IIT Kanpur
14. Structural Rehabilitation of Old Buildings. Costa, Aníbal., João Miranda. Guedes, and Humberto. Varum, Heidelberg: Springer Berlin Heidelberg, 2014.
15. Structural Health Monitoring for Advanced Composite Structures, Aliabadi, M. H., editor; Sharif-Khodaie, Z. (Zahra), editor.

16. Structural Condition Assessment, Ratay, Robert T.; Structural Engineering Institute.; American Society of Civil Engineers
17. Rehabilitation of Concrete Structures with Fiber-Reinforced Polymer, Riyadh Al-Mahaidi and Robin Kalfat

b. Web Materials:

1. <http://www.nptel.iitm.ac.in/courses.php?branch=Civil>
2. <https://careertrend.com/info-12000568-modal-response.html>

c. Indian Codes of Practice and Other Standards:

1. IS 9012 (1978) “Recommended practice for Shotcreting”
2. IS 6433 (1972) “Specification for Guniting Equipments”
3. ACI 506.2-95 “Specification for Shotcrete”
4. ACI 506R-16 “Guide to Shotcrete”
5. Guide for Conducting a Visual Inspection of Concrete in Service reported by ACI Committee 201
6. Guidelines for Forensic Engineering Practice – Second Edition –Published by American Society of Civil Engineering
7. NSPE Position Statement No. 10-1748-NSPE-NAFE Joint Position on Forensic Engineering
8. The NSPE Code of Ethics Applied to Forensic Engineering
9. “Guide for Evaluation of Concrete Structures Prior to Rehabilitation” reported by ACI committee 364
10. “Periodic Structural Inspection of Existing Buildings – Guidelines for Structural Engineers” by Building and Construction Authority
11. IS 456 (2000): Plain and Reinforced Concrete Code of Practice [CED 2: Cement and Concrete]

