



GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering

Subject Code: 3722020

Semester – II

Subject Name: **STRUCTURAL HEALTH MONITORING AND RETROFITTING OF STRUCTURES**

Type of course: PROGRAM ELECTIVE-IV

Prerequisite: Concrete technology, Analysis & Design of reinforced concrete structures, Repairs & rehabilitation of structures

Rationale: Recent structural failures and the increased deterioration of the civil infrastructure, calls for the technology that can help to preserve structural integrity thereby assuring the public safety. Structural Health Monitoring (SHM) is one such technology that helps to assess the in-service performance of the structures located in earthquake zones or remote areas, using a variety of measurement techniques. SHM plays a predominant role in catering to the need of monitoring of innovative designs and materials & better management of existing structures. The proper diagnosis through SHM helps to suggest the most appropriate retrofitting techniques to localize damages at their first occurrence.

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) | |
| 3 | 0 | 2 | 4 | 70 | 30 | 30 | 20 | 150 |

Content:

| Sr. No. | Content | Total Hrs |
|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| 1 | Structural Assessment& Need for retrofitting: Introduction to health assessment of structures, structural damages & failures, Principles of structural assessment, Classification & levels of assessment, Current scenario of infrastructure through case studies | 8 |
| 2 | Introduction to SHM: Introduction to global infrastructure crisis, Definition & Motivation for SHM, SHM versus Non-destructive evaluation, Concept of smart materials & smart structures with SHM, SHM & biomimetics, System components & categories of SHM, Classification of SHM systems, Methodologies and monitoring principles, Local & global Techniques for SHM, Advantages of SHM | 12 |
| 3 | Monitoring techniques of SHM: Static field testing: Behavior tests, Diagnostic tests, Proof tests, Sensors & sensing technology for Structural monitoring, Structural responses | 12 |



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| | Dynamic Field Testing: Stress history tests, Ambient vibration tests, Dynamic Load Allowance tests, Pull back (anchored cable tests) Periodic Monitoring: Field testing, tests to determine changes in structure Continuous monitoring: Active & Passive Monitoring | |
| 4 | Concept of repair & retrofitting of structures: Case studies of structural & foundation failure, performance problems, responsibility & accountability, causes of distress in structural members, design and material deficiencies, factors causing extensive deterioration. Retrofitting of structures: Fundamental of retrofitting, Flow of retrofitting process, Methods of retrofitting, Materials for retrofitting(conventional and smart materials), selection of retrofitting methods | 10 |
| | | |

Suggested Specification table with Marks (Theory): (For BE only)

| Distribution of Theory Marks | | | | | |
|------------------------------|-----------|----------|----------|----------|----------|
| R Level | U Level | A Level | N Level | E Level | C Level |
| 40 | 40 | 5 | 5 | 5 | 5 |

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:

- Structural Health Monitoring, Daniel Balageas, Peter Fritzen, Alfredo Guemes, John Wiley & Sons, 2006.
- Health Monitoring of Structural Materials and Components_Methods with Applications, Douglas E Adams, John Wiley and Sons, 2007.
- Structural Health Monitoring and Intelligent Infrastructure, Vol1, J. P. Ou, H. Li and Z. D. Duan, Taylor and Francis Group, London, UK, 2006.
- Structural Health Monitoring with Wafer Active Sensors, Victor Giurgutiu, Academic Press Inc, 2007.



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Course Outcomes:

| Sr. No. | CO statement | Marks % weightage |
|---------|-------------------------------------------------------------------------------------------|-------------------|
| CO-1 | Diagnose the distress and the cause of distress in the structure. | 30 |
| CO-2 | Detect the changes in the characteristics of the structure | 30 |
| CO-3 | Assess the remaining performance capacity | 10 |
| CO-4 | Choose & apply the appropriate repair and retrofitting techniques for damaged structures. | 30 |

List of Experiments:

1. To determine change in dynamic response of material due to damage : Steel
2. To determine change in dynamic response of material due to damage : Concrete
3. Damage detection using Acoustics/Ultrasonic wave propagation
4. Mapping of reinforcement details of given reinforced concrete element
5. Comparison of core test with destructive testing
6. Testing of rehabilitated beam – Flexure
7. Testing of rehabilitated beam – Shear
8. Testing of rehabilitated column

Major Equipment:

1. Vibration analyzer with sensors
2. Concrete Core cutter
3. Cover meter and rebar locator
4. USPV tester
5. Acoustic tester
6. Reinforced member casting facility
7. Load frame for testing elements

List of Open Source Software/learning website:

- <https://research.csiro.au/data61/structural-health-monitoring>
- <https://beanair.com/conditioning-monitoring-system.html>
- <https://www.hindawi.com/journals/ace/2010/724962/>
- https://www.ndt.net/events/NDTCanada2014/app/content/Slides/40_Tamutus.pdf
- https://cpwd.gov.in/Units/FinalDraftHandbook_Apr2007.pdf