

**Structural Health Monitoring & Retrofitting of Structures.**
**01ST1212 (PEC)**

**Objective of the Course:** Objectives of introducing this subject at first year level in Masters of structural engineering are:

- To understand the structural health monitoring for structures.
- To understand the conditional assessment & techniques for strengthening and retrofitting of structures.

**Credit Earned: 3**

**Students learning outcomes:**

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

1. Identify suitable Sensors & Instruments required in SHM for in-service performance of structures.
2. Assess the health of structures using different techniques of SHM.
3. Identify suitable technique for structural condition assessment.
4. Decide the appropriate strengthening & retrofitting techniques to regain the structural strength.

**Teaching and Examination Scheme**

Teaching Scheme (Hours)			Credits	Theory Marks			Tutorial/ Practical Marks		Total Marks
Theory	Tutorial	Practical		ESE (E)	CSE (I)	IA (M)	Viva (V)	Term Work (TW)	
3	0	0	3	50	20	30	25	25	150

**Detailed Syllabus**

Sr No.	Title of the unit	Number of hours
<b>1</b>	<b>Introduction of Structural Health Monitoring</b> Need of Structural Health Monitoring, Definition & Concept of SHM, SHM & Biomimetic Comparison of SHM with NDT, Types & Components of SHM, Procedure of SHM, Objectives & Operational Evaluations of SHM, Advantages of SHM. <b>Instrumentation &amp; Sensors for SHM</b> Basics of Instrumentations & Measurements, Various Types of	<b>10</b>

	<p>Instruments for SHM, Data Acquisition Systems-Types, Hardware &amp; It's Components.</p> <p>Basics of Sensors, Transducers &amp; Actuators, Classification of Sensors, and Characteristics &amp; Working Principles of Various Types of Sensors like Strain Gauges, LVDT, and Accelerometers etc.</p> <p>Concept of Smart Materials &amp; Smart Structures with SHM, Basics of Smart Materials like Piezoelectric, Shape Memory Alloys, ER &amp; MR Fluids etc.</p>	
<b>2</b>	<p><b>Methods of SHM</b></p> <p>Methodologies and Monitoring Principles, Local &amp; Global Techniques for SHM, Static &amp; Dynamic Field Testing, Short &amp; Long-Term Monitoring, Active &amp; Passive Monitoring.</p> <p>Vibration Based SHM Techniques - Use &amp; Demonstration of Dynamic Properties of Structures for Damage Detection &amp; SHM, Ambient Vibration Test, Acoustic Emission Technique, Electromechanical Impedance Technique, Wave Propagation Based Techniques, Fibre Optics Based Techniques, Remote &amp; Wireless SHM Techniques, IoT Application in SHM, Artificial Intelligence &amp; Machine Learning in SHM.</p>	<b>14</b>
<b>3</b>	<p><b>Retrofitting of Structures</b></p> <p>Introduction to deterioration of structures, Case studies of structural damages &amp; failures, Need of Retrofitting, Current scenario of infrastructure through case studies.</p> <p><i>Concept of Repair &amp; Retrofitting of Structures:</i> Case studies of structural &amp; foundation failure, performance problems, causes of distress in structural members, design and material deficiencies, factors causing extensive Deterioration.</p> <p><i>Structural Assessment:</i> Conditional Evaluation, Damage Assessment Procedure, Principles of structural assessment, Classification &amp; levels of assessment. Field &amp; Laboratory Test for Assessment.</p> <p><i>Retrofitting of structures:</i> Fundamental of retrofitting, Flow of retrofitting process, Design Philosophy, Local &amp; Global Level Methods of retrofitting, Materials for retrofitting (conventional and smart materials), selection of retrofitting methods.</p>	<b>18</b>

**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 effective teaching-learning process

Distribution of Theory for course delivery and evaluation					
Remember	Understand	Apply	Analyze	Evaluate	Create
5%	5%	20%	25%	25%	20%

**Instructional Method and Pedagogy:**

1. Use of Learning Management system like canvas
2. Demonstration through ppt and videos and lectures
3. Brainstorming and group discussion sessions
4. Collaborative learning

**Recommended Study Material:****Reference Book:**

1. Structural Health Monitoring, Daniel Balageas, Peter Fritzen, Alfredo Guemes, John Wiley & Sons,2006.
2. Health Monitoring of Structural Materials and Components Methods with Applications, Douglas E
3. Adams, John Wiley and Sons, 2007. □Structural Health Monitoring and Intelligent Infrastructure, Voll, J. P. Ou, H. Li and Z. D. Duan, Taylor and Francis Group, London, UK, 2006.
4. Structural Health Monitoring with Wafer Active Sensors, Victor Giurgutiu, Academic Press Inc,2007.
5. Bhattacharjee, J. (2017), Concrete Structures Repair Rehabilitation And Retrofitting, CBS Publishers & Distributors, New Delhi.
6. Repair of concrete structures R.T.Allen and S.C.Edwards, Blakie and Son UK 1987
7. Emmons, P.H., "Concrete Repair and Maintenance", Galgotia Publication
8. Bungey, S., Lillard, G. and Grantham, M.G., "Testing of Concrete in Structures", Taylor and Francis.
9. Malhotra, V.M. and Carino, N.J., "Handbook on Non-destructive Testing of Concrete", CRC Press
10. CPWD Handbook on Repair and Rehabilitation of RCC buildings", Govt of India Press, New Delhi, 2014
11. IS 15988: 2013 Seismic Evaluation and Strengthening of Existing Reinforced Concrete Buildings -Guidelines

**MOOC Course****Structural health Monitoring-NPTEL Course**

<https://nptel.ac.in/courses/114/106/114106046/>

**Web Resources**

- <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://www.ndt.net/events/NDTCanada2014/app/content/Slides/40_Tamutus.pdf)
- [https://cpwd.gov.in/Units/FinalDraftHandbook\\_Apr2007.pdf](https://cpwd.gov.in/Units/FinalDraftHandbook_Apr2007.pdf).

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