



INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

CIVIL ENGINEERING

COURSE DESCRIPTOR

Course Title	STRUCTURAL HEALTH MONITORING				
Course Code	BSTB07				
Programme	M.Tech				
Semester	I	STE			
Course Type	Professional Elective.				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lectures	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Chief Coordinator	Mr. N. Venkat Rao AssociateProfessor.				
Course Faculty	Mr. N. Venkat Rao, AssociateProfessor.				

I. COURSE OVERVIEW:

The primary objective of this course is to introduce the concept of Rehabilitation as a precise concept, and study how to overcome the defects in regular construction practices, establish their effectiveness in overcoming the problems faced, study their efficiency and memory needs. The course also focuses on structural health and monitoring of structural health. Retrofitting reduces the vulnerability of damage of an existing structure during a future earthquake. It aims to audit structural safety and strengthen a structure to satisfy the requirements of the current codes for seismic design. In this respect, seismic retrofit is beyond conventional repair or even rehabilitation. The principles of seismic retrofit refer to the goals, objectives and steps. The steps encompass condition assessment of the structure, evaluation for seismic forces, selection of retrofit strategies and construction. It also studies various dynamic and static field testing methods. The benefits of retrofitting include the reduction in the loss of lives and damage of the essential facilities, and functional continuity of the life line structures. For an existing structure of good condition, the cost of retrofitting tends to be smaller than the replacement cost. Thus, the retrofitting of structures is an essential component of long term disaster mitigation.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
-	-	-	Concrete Technology	-
-	-	-	Rehabilitation and Retrofitting of Structures	-

III. MARKSDISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Advanced Structural Analysis	70 Marks	30 Marks	100

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✗	Chalk & Talk	✓	Quiz	✓	Assignments	✗	MOOCs
✓	LCD / PPT	✓	Seminars	✓	Mini Project	✓	Videos
✗	Open Ended Experiments						

V. EVALUATION METHODOLOGY:

Each theory course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIE during the semester, marks are awarded by taking average of two sessional examinations.

Semester End Examination (SEE): The SEE shall be conducted for 70 marks of 3 hours duration. The syllabus for the theory courses shall be divided into FIVE units and each unit carries equal weightage in terms of marks distribution. The question paper pattern shall be as defined below. Two full questions with „either“ „or“ choice will be drawn from each unit. Each question carries 14 marks. There could be a maximum of three sub divisions in a question.

The emphasis on the questions is broadly based on the following criteria:

50 %	To test the objectiveness of the concept.
50 %	To test the analytical skill of the concept.
50 %	To test the application skill of the concept.

Continuous Internal Assessment (CIA):

For each theory course the CIA shall be conducted by the faculty/teacher handling the course as given in Table 4. CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Technical Seminar and Term Paper

Table 1: Assessment pattern for Theory Courses

Component	Theory		Total Marks
	CIE Exam	Technical Seminar and Term Paper	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 9th and 17th week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration, consisting of 5 one mark compulsory questions in part-A and 4 questions in part-B. The student has to answer any 4 questions out of five questions, each carrying 5 marks. Marks are awarded by taking average of marks scored in two CIE exams

Technical Seminar and Term Paper: Two seminar presentations are conducted during I year I semester and II semester. For seminar, a student under the supervision of a concerned faculty member, shall identify a topic in each course and prepare the term paper with overview of topic. The evaluation of Technical seminar and term paper is for maximum of 5 marks. Marks are awarded by taking average of marks scored in two Seminar Evaluations.

VI. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (POs)		Strength	Proficiency assessed by
PO 3	Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields.	2	Assignments, Tutorials
PO 4	Apply appropriate techniques, resources, modern engineering and Information Technology (IT) tools including predictions, modeling of complex structural engineering activities.	2	Assignments
PO 5	Able to identify and analyze the impact of Structural Engineering in development projects and find a suitable solution from number of alternatives.	2	Assignments
PO 6	Conceptualize and design civil engineering structures considering various socio-economic factors.	2	Presentation on realworld problems

3 = High; 2 = Medium; 1 = Low

VII. COURSE OBJECTIVES :

The course should enable the students to:	
I	Diagnosis the distress in the structure understanding the causes and factors.
II	Assess the health of structure using static field methods.
III	Assess the health of structure using dynamic field tests.
IV	Suggest repairs and rehabilitation measures of the structure.

VIII. COURSE OUTCOMES (COs):

COs	Course Outcome	CLOs	Course Learning Outcome
CO 1	Know the causes of Distress in structures, factors effecting structural health, need of regular maintenance of structures.	CLO 1	Understand deterioration and distress in structures.
		CLO 2	Identify the condition of structures.
		CLO 3	Identify the type of deterioration and method of correction.
		CLO 4	Understand the general causes of distress.
CO 2	Understand the concept of structural health monitoring and various methods applied for monitoring of structures and structural	CLO 5	Evaluate causes and prevention methods for structural health monitoring.
		CLO 6	Understand the concepts for structural health monitoring.
		CLO 7	Understand various measures in structural health

COs	Course Outcome	CLOs	Course Learning Outcome
	safety.		monitoring.
		CLO 8	Understand the safety of structures in structural health monitoring.
		CLO 9	Identify the importance of structural audit.
CO 3	Understand the importance of structural audit and Assessment of Health Structure, Collapse and Investigation, Investigation Management, SHM Procedures	CLO 10	Analyze structural health monitoring.
		CLO 11	Analyze inspection and testing of concrete.
		CLO 12	Identify symptoms and diagnosis of distress.
		CLO 13	Understand the damage assessment.
		CLO 14	Understand the procedure of structural health monitoring.
		CLO 15	Importance of Investigation Management.
CO 4	Know The Importance of Static field testing, Types of Static Tests, Simulation and Loading Methods, sensor systems and hardware requirements, Static Response Measurement.	CLO 16	Understand Simulation and Loading Methods in static field.
		CLO 17	Understand the sensor systems in structural health monitoring.
		CLO 18	Recognize the importance of Static Response Measurement.
		CLO 19	Understand health monitoring of structures by Dynamic Response Method.
CO 5	Understand the Dynamic Field testing, stress History Data, Dynamic Response Methods, Hardware for Remote Data Acquisition systems, Remote Structural Health Monitoring. Introduction to Repairs and Rehabilitations of Structures impedance (EMI) technique, Adaptations of EMI technique.	CLO 20	Analyze Data Acquisition Systems in dynamic field testing methods.
		CLO 21	Understand building instrumentation.
		CLO 22	Recognize the behavior of sensors.
		CLO 23	Understand piezo– electric materials and other smart materials in structural health monitoring.

IX. COURSE LEARNING OUTCOMES (CLOs):

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
BSTB07.01	CLO 1	Understand deterioration and distress in structures.	PO 3	2
BSTB07.02	CLO 2	Identify the condition of structures.	PO 3	2
BSTB07.03	CLO 3	Identify the type of deterioration and method of correction.	PO 3, PO 4	1
BSTB07.04	CLO 4	Understand the general causes of distress.	PO 3	2
BSTB07.05	CLO 5	Evaluate causes and prevention methods for structural health monitoring.	PO 3	2
BSTB07.06	CLO 6	Understand the concepts for structural health monitoring.	PO 5, PO 6	1
BSTB07.07	CLO 7	Understand various measures in structural health monitoring.	PO 3	1
BSTB07.08	CLO 8	Understand the safety of structures in structural health monitoring.	PO 3, PO 4	2
BSTB07.09	CLO 9	Identify the importance of structural audit.	PO 3	1

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
BSTB07.10	CLO 10	Analyze structural health monitoring.	PO 3, PO 4	1
BSTB07.11	CLO 11	Analyze inspection and testing of concrete.	PO 3, PO 4, PO 5	2
BSTB07.12	CLO 12	Identify symptoms and diagnosis of distress.	PO 3, PO 4, PO 6	1
BSTB07.13	CLO 13	Understand the damage assessment.	PO 3, PO 6	2
BSTB07.14	CLO 14	Understand the procedure of structural health monitoring.	PO 3, PO 4	2
BSTB07.15	CLO 15	Importance of Investigation Management.	PO 3	2
BSTB07.16	CLO 16	Understand Simulation and Loading Methods in static field.	PO 3	2
BSTB07.17	CLO 17	Understand the sensor systems in structural health monitoring.	PO 3, PO 4, PO 5, PO 6	1
BSTB07.18	CLO 18	Recognize the importance of Static Response Measurement.	PO 3, PO 6	2
BSTB07.19	CLO 19	Understand health monitoring of structures by Dynamic Response Method.	PO 3, PO 5	2
BSTB07.20	CLO 20	Analyze Data Acquisition Systems in dynamic field testing methods.	PO 3, PO 4, PO 5, PO 6	2
BSTB07.21	CLO 21	Understand building instrumentation.	PO 3, PO 4	1
BSTB07.22	CLO 22	Recognize the behavior of sensors.	PO 3, PO 4, PO 6	2
BSTB07.23	CLO 23	Understand piezo– electric materials and other smart materials in structural health monitoring.	PO 3, PO 5, PO 6	2

3= High; 2 = Medium; 1 = Low

X. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

Course Outcomes (COs)	Program Outcomes (POs)			
	PO 3	PO 4	PO 5	PO 6
CO 1	2	1		
CO 2	2	2	2	1
CO 3	2	2	2	1
CO 4	2	1	2	1
CO 5	2	2	1	2

3 = High; 2 = Medium; 1 = Low

XI. MAPPING COURSE LEARNING OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES

(CLOs)	Program Outcomes (POs)						
	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CLO 1			2				

(CLOs)	Program Outcomes (POs)						
	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CLO 2			2				
CLO 3			2	1			
CLO 4			2				
CLO 5			2				
CLO 6					2	1	
CLO 7			1				
CLO 8			2	2			
CLO 9			1				
CLO 10			2	1			
CLO 11			2	2	2		
CLO 12			1	2		1	
CLO 13			2			2	
CLO 14			2	2			
CLO 15			2				
CLO 16			2				
CLO 17			2	1	2	1	
CLO 18			2			2	
CLO 19			2		2		
CLO 20			2	2	1	2	
CLO 21			1	2			
CLO 22			2	2		2	
CLO 23			2		2	2	

3 = High; 2 = Medium; 1 = Low

XII. ASSESSMENT METHODOLOGIES–DIRECT:

CIE Exams	PO3, PO4, PO5, PO6	SEE Exams	PO3, PO4, PO5, PO6	Assignments	PO3, PO4, PO5, PO6	Seminars	-
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	-						

XIII. ASSESSMENT METHODOLOGIES–INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
✗	Assessment of Mini Projects by Experts		

XIV. SYLLABUS

UNIT-I	STRUCTURAL HEALTH
Definition, Principles, significance of SHM, Factors affecting Health of Structures, Causes of Distress, Regular Maintenance.	
UNIT-II	STRUCTURAL HEALTH MONITORING
Concepts, Use of Sensors, Building Instrumentation, Various Measures, Structural Safety in Alteration.	
UNIT-III	STRUCTURAL AUDIT AND STATIC FIELD TESTING
Assessment of Health of Structure, Collapse and Investigation, Investigation Management, SHM Procedures. State-of-Art damage identification and pattern reorganization methods.	
Types of Static Tests, Simulation and Loading Methods, sensor systems and hardware requirements, Static Response Measurement	
UNIT-IV	DYNAMIC FIELD TESTING
Types of Dynamic Field Test, Stress History Data, Dynamic Response Methods, Hardware for Remote Data Acquisition Systems, Remote Structural Health Monitoring.	
UNIT-V	INTRODUCTION TO REPAIRS AND REHABILITATIONS OF STRUCTURES
Case Studies (Site Visits), piezo-electric materials and other smart materials, electro–mechanical impedance (EMI) technique, Adaptations of EMI technique	
Text Books:	
1. Daniel Balageas, Claus_PeterFritzen, Alfredo Güemes , “Structural Health Monitoring”, John Wiley and Sons, 2006. 2. Douglas E Adams, “Health Monitoring of Structural Materials and Components_Methods with Applications”, John Wiley and Sons, 2000.	
Reference Books:	
1. J. P. Ou, H. Li and Z. D. Duan , “Structural Health Monitoring and Intelligent Infrastructure”, Voll, Taylor and Francis Group, London, UK, 2006. 2. Victor Giurgutiu, “Structural Health Monitoring with Wafer Active Sensors”, Academic Press Inc, 2007.	

XV. COURSE PLAN:

Lecture No.	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
1-2	Introduction to Structural Health	CLO 1	T1:1.1
3-5	Factors affecting health of structures.	CLO 2	T1:1.4
6-8	Causes of Distress.	CLO 3	T2:6.6
9	Types of Distress.	CLO 4	T1:3.1
10	Maintenance of structures.	CLO 5	T2:3.15
11	Introduction to Structural Health monitoring.	CLO 6	T1:3.3

Lecture No.	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
12-13	Concepts Of health monitoring.	CLO 7	T1:3.8
14-15	Various measures in health monitoring.	CLO 8	T1:3.9
16-17	Structural safety in alteration.	CLO 9	T1:4.3
18-20	Introduction to Structural Audit, Importance of structural audit	CLO 10	T1:5.9
21	Assessment of structural health.	CLO 11	T1:5.4
22-24	Investigation of structural health.	CLO 12	T1:5.4.1
25-26	Investigation Types.	CLO 13	T1:5.6
27-28	Investigation management.	CLO 14	T1:5.8
29	Procedure to practice Structural Health monitoring.	CLO 15	T1:6.9 to 6.10
30	Introduction to Static field testing in SHM.	CLO 16	T1:6.5
31	Types of static tests.	CLO 17	T1:6.3 to 6.3
32-33	Simulation and Loading Methods.	CLO 18	T1:7.22
34-35	Sensor systems and hardware requirements,	CLO 19	T1:7.22
36-39	Static Response Measurement.	CLO 20	T1:12.3.2
40-41	Introduction to dynamic field testing, Types of dynamic field tests, Dynamic response methods.	CLO 21	T1:12.6.1
42-44	Remote Structural Health Monitoring	CLO 22	T1:12.6.2
45	Introduction to Repairs and Rehabilitations of Structures	CLO 23	T: 7.22

XVI. GAPS IN THE SYLLABUS-TO MEET INDUSTRY / PROFESSION REQUIREMENTS:

S. No	Description	Proposed Actions	Relevance with Pos
1	Understand deterioration and distress in structures	Seminars / Guest Lectures / NPTEL	PO 3, PO 4, PO 5, PO 6
2	Inspection and testing of concrete	Seminars / Guest Lectures / NPTEL	PO 5, PO 6
3	Health monitoring of structures	Seminars/NPTEL	PO 3, PO 6

Prepared by:

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