INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**CIVIL ENGINEERING**				
Course Title	**ADVANCED STRUCTURAL ANALYSIS**				
Course Code	BSTD01				
Program	M. Tech (STE)				
Semester	I				
Course Type	CORE				
Regulation	PG - 21				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr. Venu M, Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	ACED06	IV	Theory of Structures
B.Tech	ACED14	V	Structural Analysis

II COURSE OVERVIEW:

This course mainly deals with matrix analysis of structures. It begins with a review of the basic concepts of structural analysis and matrix algebra, and shows how the latter provides an excellent mathematical framework for the former. This is followed by detailed descriptions, and demonstrations through many examples, of how matrix methods can be applied to linear static analysis of skeletal structures (plane and space trusses; beams and grids; plane and space frames) by the stiffness method, and also the flexibility method. Also, it is shown how simple structures can be conveniently solved using a reduced stiffness formulation, involving far less computational effort. Finally, the analysis of elastic instability and second order response is discussed.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Advanced structural analysis	60 Marks	40 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

Semester End Examination (SEE): The SEE shall be conducted for 60 marks of 3 hours duration. The syllabus for the theory courses shall be divided into FIVE modules and each module 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 12 marks. There could be a maximum of two / three sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

50%	To test the objectiveness of the concept
30 %	To test the analytical skill of the concept
20%	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. CIA is conducted for a total of 40 marks, with 30 marks for Continuous Internal Examination (CIE), 05 marks for Assignment and 05 marks for Alternative Assessment Tool (AAT). Two CIE Tests are Compulsory and sum of the two tests, along with the scores obtained in the assignment and AAT shall be considered for computing the final CIA of a student in a given course.
The CIE Tests/Assignment /AAT shall be conducted by the course faculty with due approval from the HOD. Advance notification for the conduction of Assignment/AAT is mandatory and the responsibility lies with the concerned course faculty.

Table 2: Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	**CIA - I**	**CIA - II**	**SEE**	**Total Marks**
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered. The valuation and verification of answer scripts of CIE exams shall be completed within a week after the conduct of the Examination.

Assignment: To improve the writing skills in the course an assignment will be evaluated for 05 marks. Assignment has to submit either at the end of the CIE1 or CIE2 for the questions provided by each course coordinator in that semester. Assignments to be handed in as loose paper collection stapled together at the top left corner. The assignment should be presented as a professional report. It must consist of a cover sheet, content page, and should have an introduction, a body, a conclusion or recommendation, and a reference page.

Quiz: It is online proctor based online examination conducted either at the end of the CIE1 or CIE2. The choice of conduction of Assignment / Quiz in CIE1 or CIE2 is purely choice of course handling faculty.

Alternative Assessment Tool (AAT): In order to encourage innovative methods while delivering a course, the faculty members are encouraged to use the Alternative Assessment Tool (AAT). This AAT enables faculty to design own assessment patterns during the CIA. The AAT enhances the autonomy (freedom and flexibility) of individual faculty and enables them to create innovative pedagogical practices. If properly applied, the AAT converts the classroom into an effective learning center. **The**

AAT may include, Course related term paper, Technical seminar, Term paper, Case Study, Paper presentations conducted by reputed organizations relevant to the course etc.

VI COURSE OBJECTIVES:

The students will try to learn:

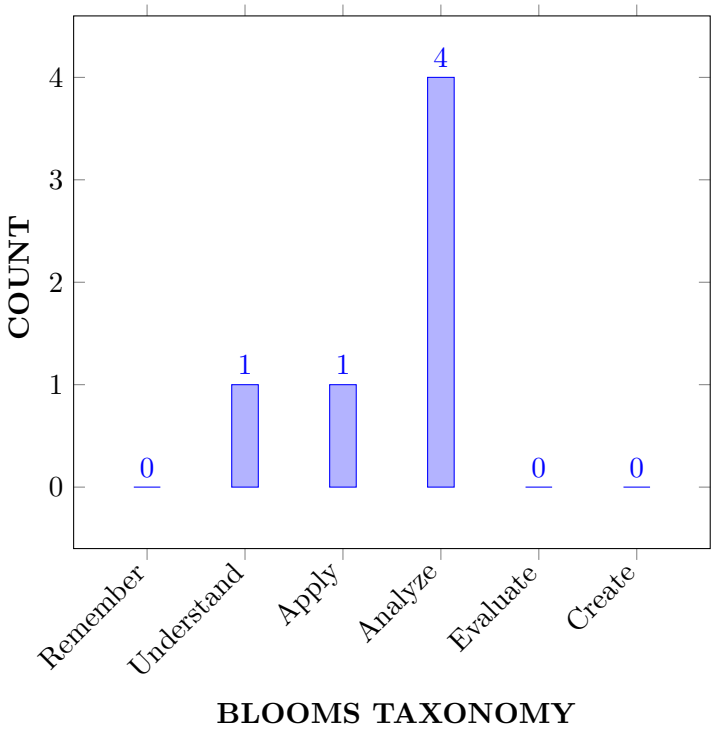
I	The advanced techniques to know the behavior of structural elements subjected to both vertical and horizontal loads which are used for designing all types of structures.
II	The advanced matrix analysis of various structural elements for design purpose.
III	The Design independently civil engineering structures as per the requirements of client and provide detailed design drawings, quality control reports during construction for ensuring quality and economical structures.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	Explain the concepts of the static and kinematic indeterminacy of structures for analyzing the structures courseed to different loads.	Understand
CO 2	Apply the concept of stiffness matrix equations in global coordinate system with boundary condition for analyzing member forces in beams and frame structures.	Apply
CO 3	Analyze continuous beams courseed to different loading conditions using the flexibility method for ensuring structural efficiency.	Analyze
CO 4	Analyze portal frames for the symmetrical and unsymmetrical loading conditions using the force method for the economical design of structures.	Analyze
CO 5	Analyze indeterminate beams and frames with different loading conditions using the Stiffness method for the design purpose.	Analyze
CO 6	Analyze the frames know the maximum shear force and bending moments using approximate methods of analysis.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	An ability to Independently carry out research/investigation and development work to solve practical problems.
PO 2	An ability to Write and present a substantial technical report/document.
PO 3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
PO 4	Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields.
PO 5	Conceptualize and design civil engineering structures considering various socio-economic factors.
PO 6	Engage in life-long learning for continuing education in research-level studies and professional development.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	An ability to Independently carry out research/investigation and development work to solve practical problems.	1	CIE, SEE
PO 3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.	1	CIE, SEE
PO 4	Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields.	2	CIE, SEE

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 5	Conceptualize and design civil engineering structures considering various socio-economic factors.	3	CIE, SEE

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s):

Course Outcomes	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	-	✓	✓	-	-
CO 2	✓	-	-	✓	✓	-
CO 3	-	-	✓	✓	✓	-
CO 4	✓	-	-	✓	✓	-
CO 5	-	-	-	✓	✓	-
CO 6	-	-	✓	✓	-	-

XI JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO3	Analyze the given **problem statement** and find the static and kinematic inderteminacy of structures to establish innovative solutions in structural system and **Interpret the result** on various applications.	2
	PO4	Demonstrate the importance of structural analysis of new innovative structures for solving society relevant problems for applying **knowledge, understanding and demonstrations of structural applications in real time scenario and use creativity to establish innovative solutions to get the solution development and communicate effectively in writing / orally societal problems.**	4
CO2	PO1	Independently carry out research / investigation by **resource identification, implementation and demonstrate the solution** related to a given structure using matrix methods.	2
	PO4	Select the appropriate method for the analysis of different structural elements by applying **knowledge, understanding and demonstrations of structural applications in real time scenario and use creativity to establish innovative solutions to get the solution development and communicate effectively in writing / orally societal problems.**	4
	PO5	Analyse the structural systems for the design of civil engineering structures understanding **experimental design, design process, requirements of engineering activities, legal requirements, safety and risk issues.**	4
CO3	PO3	Analyze the given **problem statement** and find the member forces for different loads to establish innovative solutions in structural system and **Interpret the results.**	2

Course Outcomes	PO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 4	Analyse the member forces due to loads and lack of fit by Selecting the appropriate method for different structural elements by applying **knowledge, understanding and demonstrations of structural applications in real time scenario and use creativity to establish innovative solutions to get the solution development and communicate effectively in writing / orally societal problems.**	4
	PO5	Analyse the structural systems for the design of civil engineering structures understanding **experimental design, design process, requirements of engineering activities, legal requirements, safety and risk issues.**	4
CO4	PO1	Independently carry out research / investigation by **resource identification, implementation and demonstrate the solution** related to a given structure in terms of stiffness matrix in global coordinate system.	2
	PO4	Apply the knowldege of stiffness matrix in global level by applying **knowledge, understanding and demonstrations of structural applications in real time scenario and use creativity to establish solutions.**	2
	PO5	Analyse the structural systems for the design of civil engineering structures understanding **experimental design, design process, requirements of engineering activities, legal requirements, safety and risk issues.**	4
CO5	PO4	Demonstrate the importance of shape functions in analysing the one and two dimensional elements by applying **knowledge, understanding and demonstrations of structural applications in real time scenario and use creativity to establish solutions.**	2
	PO5	Utilize the concepts of shape functions for the analysis and design of civil engineering structures understanding **experimental design, design process, requirements of engineering activities, legal requirements, safety and risk issues.**	4
CO6	PO3	Analyze the given **problem statement** and find the solution of one dimensional boundary value problem using different methods for innovative solutions in structural system and **Interpret the result** on various applications.	2
	PO4	Select the appropriate method for the analysis of one dimensional boundary value problem by applying **knowledge, understanding and demonstrations of structural applications in real time scenario and use creativity to establish innovative solutions to get the solution development and communicate effectively in writing / orally societal problems.**	4

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO MAPPING:

Course Outcomes	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	-	2	4	-	-
CO 2	2	-	-	4	4	-
CO 3	-	-	2	4	4	-
CO 4	2	-	-	2	4	-
CO 5	-	-	-	2	4	-
CO 6	-	-	2	4	-	-

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO

Course Outcomes	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	0.0	0.0	28.5	50.0	0.0	0.0
CO 2	28.5	0.0	0.0	50.0	80.0	0.0
CO 3	0.0	0.0	28.5	50.0	80.0	0.0
CO 4	28.5	0.0	0.0	25.0	80.0	0.0
CO 5	0.0	0.0	0.0	25.0	80.0	0.0
CO 6	0.0	0.0	28.5	50.0	0.0	0.0

XIV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

1 -$5 < C \leq 40\%$ – Low/ Slight

2 - $40\% < C < 60\%$ –Moderate

3 - $60\% \leq C < 100\%$ – Substantial /High

Course Outcomes	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	0.0	0.0	1.0	2.0	0.0	0.0
CO 2	1.0	0.0	0.0	2.0	3.0	0.0
CO 3	0.0	0.0	1.0	2.0	3.0	0.0
CO 4	1.0	0.0	0.0	1.0	3.0	0.0
CO 5	0.0	0.0	0.0	1.0	3.0	0.0
CO 6	0.0	0.0	1.0	2.0	0.0	0.0
Total	2.0	0.0	3.0	10.0	12.0	0.0
Average	1	0	1	2	3	0

XV ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	✓
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	-	Open Ended Experiments	-
Assignments	✓				

XVI ASSESSMENT METHODOLOGY-INDIRECT:

✓	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVII SYLLABUS:

MODULE I	**INTRODUCTION TO MATRIX METHODS OF ANALYSIS**
	Static indeterminacy and kinematic indeterminacy, degrees of freedom, coordinate system, structure idealization, stiffness and flexibility matrices, element stiffness equations, elements flexibility equations, force - displacement equations for truss, beam.
MODULE II	**TECHNIQUES FOR ASSEMBLY OF GLOBAL STIFFNESS MATRIX**
	Assembly of stiffness matrix from element stiffness matrix, direct stiffness method, general procedure, bank matrix, semi bandwidth, computer algorithm for assembly by direct stiffness matrix method.
MODULE III	**FLEXIBILITY METHOD OF ANALYSIS**
	Introduction to flexibility method, flexibility equations. Analysis of continuous beams with different loading conditions and Plane frames with symmetrical and unsymmetrical loads. Analysis of plane truss courseed to axial loads and grids by flexibility methods.
MODULE IV	**STIFFNESS METHOD OF ANALYSIS**
	Introduction to stiffness method, stiffness equations. Analysis of continuous beams with different loading conditions and Plane frames with symmetrical and unsymmetrical loads. Analysis of plane truss courseed to axial loads and grids by stiffness methods.
MODULE V	**APPROXIMATE METHODS OF ANALYSIS**
	Analysis of multi-storey frames for lateral loads: Portal method and cantilever method; Analysis of multistorey frames for gravity (vertical) loads; Substitute frame method.

TEXTBOOKS

1. G. S. Pandit and S.P. Gupta, "Structural Analysis – A Matrix Approach", McGraw Hill Education. 2nd Edition, 2008.
2. C.S. Reddy, "Basic Structural Analysis", McGraw Hill Education, 3rd Edition, 1994
3. Ashok. K. Jain, "Advanced Structural Analysis", Nem Chand & Bros. 3rd Edition, 2010.
4. J. Meek, "Matrix Methods of Structural Analysis", McGraw Hill Education.1st Edition, 2011.
5. S S. Bhavikatti, "Finite Element Analysis", New Age International Pvt. Ltd., Publishers.1st Edition, 2009.

REFERENCE BOOKS:

1. Todd, J.D., "Structural theory and analysis", the mac million press ltd., New York, 1st Edition, 1974.
2. Menon, D., "Advanced structural analysis", narosa publishing house, new delhi, 1st Edition, 2009.
3. McCarmac, J. And Elling, R. E., "Structural analysis: a classical and matrix a approach" , harper and row publishers, 4th Edition, 2007

WEB REFERENCES:

1. https://nptel.ac.in/reviewed-pdfs/105106050/lec1.pdf
2. http://web.iitd.ac.in/ sbhalla/rc717.pdf

XVIII COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: R1:
OBE DISCUSSION			
1	Discussion on OBE, POs and COs of Advanced Structural Analysis		
CONTENT DELIVERY (THEORY)			
1	Introduction	CO1	T1,T2
2	Static indeterminacy and kinematic indeterminacy.	CO1	T1,T2
3	Static indeterminacy and kinematic indeterminacy.	CO1	T1,T2
4	Degrees of freedom and coordinate system.	CO1	T1,T2
5	Degrees of freedom and coordinate system.	CO1	T1,T2
6	Structure idealization.	CO1	T1,T2
7	Structure idealization	CO1	T1,T2
8	Stiffness and flexibility matrices.	CO1	T1,T2
9	Stiffness and flexibility matrices.	CO1	T1,T2
10	Element stiffness equations.	CO1	T1,T2
11	Element stiffness equations.	CO1	T1,T2
12	Elements flexibility equations	CO1	T1,T2
13	Force - displacement equations for truss, beam	CO1	T1,T2
14	Assembly of stiffness matrix from element stiffness matrix	CO2	T1,T2
15	Assembly of stiffness matrix from element stiffness matrix	CO2	T1,T2
16	Direct stiffness method and general procedure.	CO2	T1,T2
17	Direct stiffness method and general procedure.	CO2	T1,T2
18	Band matrix and semi bandwidth.	CO2	T1,T2
19	Band matrix and semi bandwidth.	CO2	T1,T2
20	computer algorithm for assembly by direct stiffness matrix method.	CO2	T1,T2
21	computer algorithm for assembly by direct stiffness matrix method.	CO2	T1,T2
22	Introduction to flexibility method.	CO3	T1,T2
23	Introduction to flexibility method.	CO3	T1,T2
24	Flexibility equations.	CO3	T1,T2
25	Flexibility equations.	CO3	T1,T2
26	Analysis of continuous beams with different loading conditions	CO3	T1,T2
27	Analysis of continuous beams with different loading conditions	CO3	T1,T2
28	Analysis of continuous beams with different support conditions	CO3	T1,T2
29	Analysis of continuous beams with different support conditions	CO3	T1,T2
30	Analysis of continuous beams with support sinking conditions	CO3	T1,T2
31	Analysis of continuous beams with support sinking conditions	CO3	T1,T2
32	Plane frames with symmetrical loads.	CO3	T1,T2
33	Plane frames with symmetrical loads.	CO3	T1,T2
34	Plane frames with symmetrical loads.	CO3	T1,T2
35	Plane frames with unsymmetrical loads.	CO3	T1,T2
36	Plane frames with unsymmetrical loads.	CO3	T1,T2

37	Plane frames with unsymmetrical loads.	CO3	T1,T2
38	Analysis of plane truss subjected to axial loads and grids by flexibility methods.	CO4	T1,T2
39	Analysis of plane truss subjected to axial loads and grids by flexibility methods.	CO4	T1,T2
40	Analysis of plane truss subjected to axial loads and grids by flexibility methods.	CO4	T1,T2
41	Introduction to stiffness method.	CO5	T1,T2
42	Introduction to stiffness method.	CO5	T1,T2
43	Stiffness equations.	CO5	T1,T2
44	Stiffness equations.	CO5	T1,T2
45	Analysis of continuous beams with different loading conditions.	CO5	T1,T2
46	Analysis of continuous beams with different loading conditions.	CO5	T1,T2
47	Analysis of continuous beams with different support conditions.	CO5	T1,T2
36	Analysis of continuous beams with different support conditions.	CO5	T1,T2
48	Plane frames with symmetrical and unsymmetrical loads.	CO5	T1,T2
49	Plane frames with symmetrical and unsymmetrical loads.	CO5	T1,T2
50	Analysis of plane truss courseed to axial loads and grids by stiffness methods.	CO5	T1,T2
51	Analysis of plane truss courseed to axial loads and grids by stiffness methods.	CO5	T1,T2
52	Analysis of multi-storey frames for lateral loads using portal method.	CO6	T1,T2
53	Analysis of multi-storey frames for lateral loads using portal method.	CO6	T1,T2
54	Analysis of multi-storey frames for lateral loads using portal method.	CO6	T1,T2
55	Analysis of multi-storey frames for lateral loads using cantilever method.	CO6	T1,T2
56	Analysis of multi-storey frames for lateral loads using cantilever method.	CO6	T1,T2
57	Analysis of multi-storey frames for lateral loads using cantilever method.	CO6	T1,T2
58	Analysis of multi-storey frames for gravity loads using substitute frame method.	CO6	T1,T2
59	Analysis of multi-storey frames for gravity loads using substitute frame method.	CO6	T1,T2
60	Analysis of multi-storey frames for gravity loads using substitute frame method.	CO6	T1,T2
DISCUSSION ON QUESTION BANK			
1	Static indeterminacy and kinematic indeterminacy, degrees of freedom, coordinate system, structure idealization, stiffness and flexibility matrices, element stiffness equations, elements flexibility equations, force - displacement equations for truss, beam	CO1	T1,T2
2	Assembly of stiffness matrix from element stiffness matrix, direct stiffness method, general procedure, bank matrix, semi bandwidth, computer algorithm for assembly by direct stiffness matrix method.	CO2	T1,T2

3	Introduction to flexibility method, flexibility equations. Analysis of continuous beams with different loading conditions and Plane frames with symmetrical and unsymmetrical loads. Analysis of plane truss courseed to axial loads and grids by flexibility methods.	CO3, CO4,	T1,T2
4	Introduction to stiffness method, stiffness equations. Analysis of continuous beams with different loading conditions and Plane frames with symmetrical and unsymmetrical loads. Analysis of plane truss courseed to axial loads and grids by stiffness methods.	CO5	T1,T2
5	Analysis of multi-storey frames for lateral loads: Portal method and cantilever method; Analysis of multistorey frames for gravity (vertical) loads; Substitute frame method.	CO6	T1,T2

Signature of Course Coordinator **HOD,CE**
Dr. Venu M

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COURSE DESCRIPTION

Department	**CIVIL ENGINEERING**				
Course Title	**ADVANCED SOLID MECHANICS**				
Course Code	BSTB02				
Program	M. Tech (STE)				
Semester	II				
Course Type	CORE				
Regulation	PG -21				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mrs.R.Ramy Swetha , Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	ACEB13	V	Strength of Materials – I
B.Tech	ACEB47	VIII	Structural Analysis

II COURSE OVERVIEW:

This course is sequel to a Strength of Materials Course that already studied in undergraduate. This course introduces the principles of elasticity, components of stresses and strains, differential equations of equilibrium, boundary conditions, compatibility conditions and stress function. This course also covers the two dimensional problems in rectangular coordinates and polar coordinates, Fourier series for two dimensional problems stress distribution symmetrical about an axis, pure bending of curved bars, strain components in polar coordinates, displacements for symmetrical stress distributions, simple symmetric and asymmetric problems, analysis of stress strain in three dimensions, torsion of prismatical bars and plasticity. This course in reached to student by power point presentations, lecture notes, and assignment questions, seminars, previous model question papers, and question bank of long and short answers

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Advanced structural analysis	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	x	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

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 is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
10 %	Understand
30%	Apply
60 %	Analyze
0%	Evaluate
0%	Create

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE), 05 marks for Technical Seminar and Term Paper

Component	Theory		Total Marks
Type of Assessment	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 8^{th} and 16^{th} week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Technical Seminar and Term Paper:

Two seminar presentations and the term paper with overview of topic are conducted during II semester. 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 COURSE OBJECTIVES:

The students will try to learn:

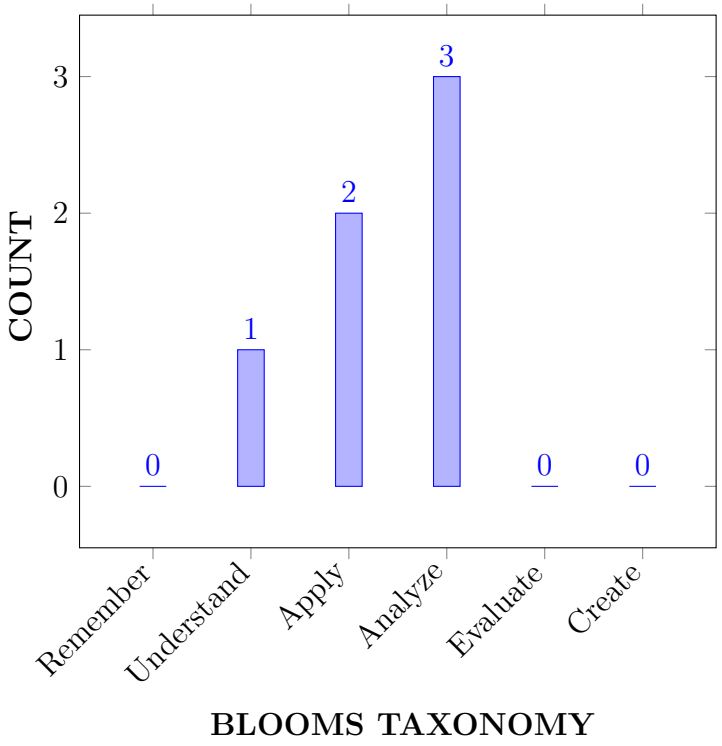
I	Solve advanced solid mechanics problems using classical methods
II	Apply commercial software on select, applied solid mechanics problems.+
III	The concept of local co-ordinate and global co-ordinate system for analyzing frame structures.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Explain** the theory of elasticity including strain/displacement and Hooke's law relationships for linearly elastic solid	Understand
CO 2	**Develop** constitutive relationships between stress and strain for ensuring structural efficiency	Apply
CO 3	**Analyse** the equilibrium equations, Stress-Strain relations for solving the and two-Dimensional Problems in Polar Coordinates.	Analyse
CO 4	**Explain** the Plane Stress and Plane Strain Problems, Airy's stress Function and Two-Dimensional Problems in Polar Coordinates. for analyzing member forces in beams and frame structures.	Apply
CO 5	**Analyze** boundary value problems using various methods for the solution	Analyze
CO 6	**Examine** the properties of ideally plastic solids and apply the concepts of energy methods for solving structural problems.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields.
PO 2	Apply appropriate techniques, resources, modern engineering and Information Technology (IT) tools including predictions, modeling of complex structural engineering activities
PO 3	Conceptualize and design civil engineering structures considering various socio-economic factors.
PO 4	Independently carry out research / investigation and development work to solve practical problems
PO 5	Write and present a substantial technical report / document
PO 6	Engage in life-long learning for continuing education in research-level studies and professional development.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields.	2	CIE, SEE
PO 3	Conceptualize and design civil engineering structures considering various socio-economic factors..	2	CIE,SEE
PO 4	Independently carry out research / investigation and development work to solve practical problems	2	CIE,SEE
PO 5	Write and present a substantial technical report / document	2	CIE,SEE
PO 6	Engage in life-long learning for continuing education in research-level studies and professional development.	1	CIE,SEE

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s):

Course Outcomes	PROGRAM OUTCOMES						
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	✓	-	-	-	-	-	-
CO 2	✓	-	✓	-	✓	-	-
CO 3	✓	-	✓	-	-	-	-
CO 4	✓	-	✓	-	✓	-	-
CO 5	✓	-	✓	-	-	-	-
CO 6	-	-	✓	-	✓	-	-

XI JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Recall the concepts of the static and kinematic indeterminacy of structures (apply)for its behaviour by applying the principles of **mathematics and engineering fundamentals..**	2
CO2	PO1	Recall (knowledge) the continuous beam and portal frames and form the stiffness and flexibility matrices by applying the principles of**mathematics and engineering fundamental.**	2
	PO3	Select the appropriate method for the analysis of structures using **mathematical principles and engineering knowledge** for different loads for the design purpose.	2
	PO5	select the appropriate method for the analysis of structures using **mathematical principal** for desing purpose	1
CO3	PO 1	Understand indeterminate trusses and analyse the same for member forces due to applied loads, lack of fit and temperature change by using ther **mathematical principles** and **engineering fundamentals**	2
	PO3	Use the **mathematical principles** and **engineering fundamentals** in identifying the determinate and indeterminate trusses.	2
CO4	PO1	Recall (knowledge) the continuous beam and portal frames and form the stiffness and flexibility matrices by applying the principles of**mathematics and engineering fundamental.**	2
	PO3	Select the appropriate method for the analysis of structures using **mathematical principles and engineering knowledge** for different loads for the design purpose.	2
	PO5	select the appropriate method for the analysis of structures using **mathematical principal** for desing purpose	1

Course Outcomes	PO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO5	PO1	undderstand the **engineering** concepts of shapes functions to obtain stiffness matrix for two dimensional elements by using the **principles of mathematics and sciences.**	3
	PO3	**Identify the problem, formulate** stiffness matrix for two dimensional elements **for solution development** in reaching substantiated conclusions by the **interpretation of results.**	4
CO6	PO3	Analyze the quantitative techniques for cost management of the engineering projects using **fundamental in mathematics and engineering fundamentals.**	2
	PO5	Make use of galerkin method for solving one dimensional boundary value problmes by applying the principles of **engineering fundamentals.**	1

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO MAPPING:

Course Outcomes	PROGRAM OUTCOMES						
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	2	-	-	-	-	-	-
CO 2	2	2	-	-	1	-	-
CO 3	2	-	2	-	-	-	-
CO 4	2	-	2	-	1	-	-
CO 5	3	-	4	-	-	-	-
CO 6	-	-	2	-	1	-	-

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO

Course Outcomes	PROGRAM OUTCOMES						
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	25	0.0	0.0	0.0	0.0	0.0	0.0
CO 2	25	33.3	0.0	0.0	16.6	0.0	0.0
CO 3	25	0.0	33.3	0	16.6	0.0	0.0
CO 4	25	0.0	50	0.0	100	0.0	0.0
CO 5	37.5	0.0	37.5	0.0	0.0	0.0	0.0
CO 6	0.0	0.0	40	0.0	12.5	0.0	0.0

XIV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.
0 - 0 ≤ C≤ 5% – No correlation
1 -5 <C≤ 40% – Low/ Slight
2 - 40 % <C < 60% –Moderate
3 - 60% ≤ C < 100% – Substantial /High

Course Outcomes	**PROGRAM OUTCOMES**						
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	2	0.0	0.0	0.0	0.0	0.0	0.0
CO 2	2	2	0.0	0.0	1	0.0	0.0
CO 3	2	0.0	2	0.0	0.0	0.0	0.0
CO 4	2	0.0	2	0.0	1	0.0	0.0
CO 5	3	0.0	4	0.0	0.0	0.0	0.0
CO 6	0.0	0.0	2	0.0	1	0.0	0.0
Total	11	2	10	0.0	3	0.0	0.0
Average	3	1	2.5	0.0	1	0.0	0.0

XV ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	✓
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	-
Assignments	✓				

XVI ASSESSMENT METHODOLOGY-INDIRECT:

✓	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVII SYLLABUS:

MODULE I	**INTRODUCTION TO ELASTICITY**
	Displacement, Strain and Stress Fields, Constitutive Relations, Cartesian Tensors and Equations of Elasticity.
MODULE II	**STRAIN AND STRESS FIELD**
	Elementary Concept of Strain, Stain at a Point, Principal Strains and Principal Axes, Compatibility Conditions, Stress at a Point, Stress Components on an Arbitrary Plane, Differential Equations of Equilibrium, Hydrostatic and Deviatoric Components.
MODULE III	**EQUATIONS OF ELASTICITY AND TWO-DIMENSIONAL PROBLEMS OF ELASTICITY**

	Equations of Equilibrium, Stress-Strain relations, Strain Displacement and Compatibility Relations, Boundary Value Problems, Co-axiality of the Principal Directions. Plane Stress and Plane Strain Problems, Airy's stress Function, Two-Dimensional Problems in Polar Coordinates.
MODULE IV	**TORSION OF PRISMATIC BARS**
	Torsion of Prismatic Bars: Saint Venants Method, Prandtls Membrane Analogy, Torsion of Rectangular Bar, Torsion of Thin Tubes.
MODULE V	**PLASTIC DEFORMATION**
	Plastic Deformation: Strain Hardening, Idealized Stress- Strain curve, Yield Criteria, von Mises Yield Criterion, Tresca Yield Criterion, Plastic Stress-Strain Relations, Principle of Normality and Plastic Potential, Isotropic Hardening.

TEXTBOOKS

1. Timoshenko and Goodier , "Theory of Elasticity" , McGraw Hill Publishing Company, 1970.
2. RagabA.R.,BayoumiS.E , "Engineering Solid Mechanics"., CRC Press,1999.
3. Kazimi S. M. A, "Solid Mechanics"., Tata McGraw Hill,1994

REFERENCE BOOKS:

1. SaddM.H , "Elasticity", Elsevier, 2005.
2. Ameen.M, "Computational Elasticity", Narosa, 2005
3. KazimiS. M. A, "Solid Mechanics", Tata McGraw Hill, 1994.
4. SrinathL.S, "Advanced Mechanics of Solids", Tata McGraw Hill, 2000.

WEB REFERENCES:

1. https://www.youtube.com/watch?v=4meZNc2wB4s&t=1464s

COURSE WEB PAGE:

XVIII COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Discussion on OBE, CO's and CLO's of subject Cost Management of Engineering Projects		
CONTENT DELIVERY (THEORY)			
1	Introduction	CO1	T1:1, W1:2 W2:2
2-3	Displacement, Strain and Stress Fields	CO1	W1:3
4	Constitutive Relations, Cartesian Tensors and Equations of Elasticity.	CO1	W1:3
5	Elementary Concept of Strain.	CO1	W1:3
6	Stain at a Point, Principal Strains and Principal Axes, Compatibility Conditions	CO2	T1:2.5, W1:Pg118
7	Differential Equations of Equilibrium	CO2	W3:1
8	Hydrostatic and Deviatoric Components	CO2	W2:2
9-11	Equations of Equilibrium	CO2	T1,T2
12-13	Stress-Strain relations, Strain Displacement and Compatibility Relations	CO2	T1,T2
14	Boundary Value Problems	CO3	T1,T2
15	Co-axiality of the Principal Directions	CO3	T1,T2
16	Plane Stress and Plane Strain Problems	CO3	T1,T2
17	Airy's stress Function	CO3	T1,T2
18	Two-Dimensional Problems in Polar Coordinates.	CO3	T1,T2
19	Torsion of Prismatic Bars: Saint Venans Method	CO4	T1,T2
20	Prandtl's Membrane Analogy	CO4	T1,T2
21	Torsion of Rectangular Bar	CO4	T1,T2
22	Torsion of Thin Tubes	CO4	T1,T2
23	Plastic Deformation: Strain Hardening	CO5	T1,T2
24	Idealized Stress- Strain curve	CO5	T1,T2
25	Yield Criteria, von Mises Yield Criterion	CO5	T1,T2
26	Tresca Yield Criterion	CO5	T1,T2
27	Plastic Stress-Strain Relations	CO6	T1,T2
28-29	Principle of Normality and Plastic Potential	CO6	T1,T2
30	Isotropic Hardening	CO6	T1,T2
PROBLEM SOLVING/ CASE STUDIES			
1	Problems on Strain and Stress Fields, Constitutive Relations	CO 1	T1,T2
2	Problems on Boundary Value	CO 1	T1,T2
3	Problems on Principal Strains and Principal Axes	CO 2	T1,T2
4	Problems on Differential Equations of Equilibrium	CO 2	T1,T2

5	Problems on Equations of Equilibrium, Stress-Strain relations	CO 3	T1,T2
6	Problems on Boundary Value	CO 4	T1,T2
7	Problems on Two-Dimensional Problems in Polar Coordinates.	CO 4	T1,T2
8	Formulation of general one dimensional equilibrium problem.	CO 5	T1,T2
9	Problems on Plastic Stress-Strain Relations.	CO 6	T1,T2
10	Problems on Idealized Stress- Strain curve	CO 6	T1,T2
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Strain and Stress Fields ensors and Equations of Elastthe icity	CO 1	T1,T2
2	Stress Components on an Arbitrary Plane	CO2	T1,T2
3	Saint Venants Method	CO3	T1,T2
4	Idealized Stress- Strain curve	CO4	T1,T2
5	Principle of Normality and Plastic Potential,	CO5	T1,T2
DISCUSSION OF QUESTION BANK			
1	Explain Strain and Stress Fields and also discuss the Constitutive Relations	CO1	T1,T2
2	Explain Stress-Strain relations, Strain Displacement and Compatibility Relations	CO2	T1,T2
3	Prandtl's Membrane Analogy	CO3,	T1,T2
4	Tresca Yield Criterion, Plastic Stress-Strain Relations	CO4	T1,T2
5	Isotropic Hardening	CO6	T1,T2

Signature of Course Coordinator **HOD,CE**
Mrs.S. Ramya Swetha

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**CIVIL ENGINEERING**				
Course Title	**Theory of Plates and Shells**				
Course Code	BSTD07				
Program	M. Tech (STE)				
Semester	I				
Course Type	Professional Core Elective				
Regulation	PG - 21				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr.Gude Ramakrishna, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
M.Tech	-	-	-

II COURSE OVERVIEW:

Plates and shells exhibit two dimensional structural actions that result in stronger, thinner and lighter structures and therefore, have economic advantage. This has opened the scope for the wide use of such elements in all fields of engineering due to significant increase of strength/weight ratio. The exposure to this course and its completion are very essential in understanding the behaviour of thin structures for their applications in design.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Theory of Plates and Shells	60 Marks	40 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	x	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	✓	Videos
x	Others						

V EVALUATION METHODOLOGY:

Each theory course will be evaluated for a total of 100 marks, out of which 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE).

Semester End Examination (SEE): The SEE shall be conducted for 60 marks of 3 hours duration. The syllabus for the theory courses shall be divided into FIVE modules and each module 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 12 marks. There could be a maximum of two / three sub divisions in a question.

The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

50 %	To test the objectiveness of the concept
30 %	To test the analytical skill of the concept
20%	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. CIA is conducted for a total of 40 marks, with 30 marks for Continuous Internal Examination (CIE), 05 marks for Assignment and 05 marks for Alternative Assessment Tool (AAT). Two CIE Tests are Compulsory and sum of the two tests, along with the scores obtained in the assignment and AAT shall be considered for computing the final CIA of a student in a given course. The CIE Tests/Assignment /AAT shall be conducted by the course faculty with due approval from the HOD. Advance notification for the conduction of Assignment/AAT is mandatory and the responsibility lies with the concerned course faculty.

Activity	CIA-I	CIA-II	SEE	Total Marks
Continuous Internal Examination (CIE)	10 Marks	10 Marks	-	20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks	-	10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	-	100 Marks

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectivelyy for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered. The valuation and verification of answer scripts of CIE exams shall be completed within a week after the conduct of the Examination.

Assignment:

To improve the writing skills in the course an assignment will be evaluated for 05 marks. Assignment has to submit either at the end of the CIE1 or CIE2 for the questions provided by each course coordinator in that semester. Assignments to be handed in as loose paper collection stapled together at the top left corner. The assignment should be presented as a professional report. It must consist of a cover sheet, content page, and should have an introduction, a body, a conclusion or recommendation, and a reference page.

Quiz:

It is online proctor based online examination conducted either at the end of the CIE1 or CIE2. The choice of conduction of Assignment / Quiz in CIE1 or CIE2 is purely choice of course handling faculty.

Alternative Assessment Tool (AAT):
In order to encourage innovative methods while delivering a course, the faculty members are encouraged to use the Alternative Assessment Tool (AAT). This AAT enables faculty to design own assessment patterns during the CIA. The AAT enhances the autonomy (freedom and flexibility) of individual faculty and enables them to create innovative pedagogical practices. If properly applied, the AAT converts the classroom into an effective learning center. The AAT may include, Course related term paper, Technical seminar, Term paper, Case Study, Paper presentations conducted by reputed organizations relevant to the course etc.

VI COURSE OBJECTIVES:

The students will try to learn:

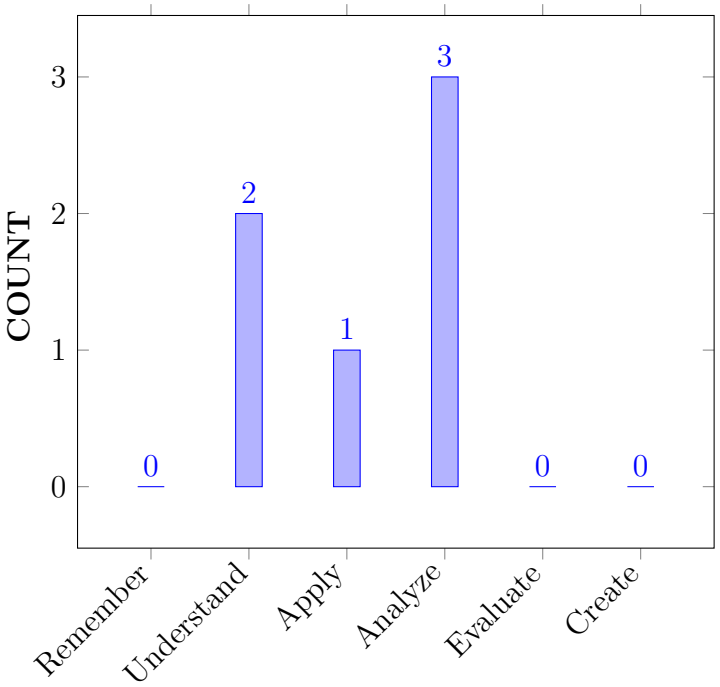
I	The Formulation of differential equations for bending of thin rectangular and circular plates.
II	The theory of large deflection of plates for efficient and economical design.
III	The numerical techniques and tools for the complex problems in thin plates.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Explain** the Concept of of governing differential equation, and solution of Navier and Levy type, large plate loaded at equidistant points by concentrated forces.	Understand
CO 2	**Explain** about annular plate, rotationally symmetric loading, eccentric concentrated load, simultaneous bending and stretching of circular plates.	Understand
CO 3	**Solve** the governing differential equation for Plates on an elastic foundations.	Apply
CO 4	**Understand** the general theory in bending of cylindrical shell, for simplified method of cylindrical shell.	Analyze
CO 5	**Analysis** of governing equation for bending of plate under the action of lateral loads.	Analyze
CO 6	**Examine** the buckling of rectangular plates by compressive forces acting in one and two directions in the middle plane of plate.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



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VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	An ability to Independently carry out research / investigation and development work to solve practical problems.
PO 2	An ability to Write and present a substantial technical report/document.
PO 3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
PO 4	Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields.
PO 5	Conceptualize and design civil engineering structures considering various socio-economic factors.
PO 6	Engage in life-long learning for continuing education in research-level studies and professional development.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	An ability to Independently carry out research / investigation and development work to solve practical problems.	3	CIE/ SEE
PO 4	Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields.	2	CIE/SEE
PO 5	Conceptualize and design civil engineering structures considering various socio-economic factors.	3	CIE/SEE

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s):

Course Outcomes	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	-	-	✓	-	-
CO 2	✓	-	-	✓	✓	-
CO 3	-	-	-	-	-	-
CO 4	✓	-	-	✓	-	-
CO 5	✓	-	-	-	✓	-
CO 6	-	-	-	✓	✓	-

XI JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 4	Recall the concepts of the static and kinematic indeterminacy of structures (apply)for its behaviour by applying the principles of **mathematics and engineering fundamentals..**	2
CO2	PO1	Recall (knowledge) the continuous beam and portal frames and form the stiffness and flexibility matrices by applying the principles of**mathematics and engineering fundamental.**	2
	PO4	Select the appropriate method for the analysis of structures using **mathematical principles and engineering knowledge** for different loads for the design purpose.	2
	PO5	select the appropriate method for the analysis of structures using **mathematical principal** for desing purpose	1
CO3	PO 1	Understand indeterminate trusses and analyse the same for member forces due to applied loads, lack of fit and temperature change by using ther **mathematical principles** and **engineering fundamentals**	2
	PO4	Use the **mathematical principles** and **engineering fundamentals** in identifying the determinate and indeterminate trusses.	2
CO4	PO1	Recall (knowledge) the continuous beam and portal frames and form the stiffness and flexibility matrices by applying the principles of**mathematics and engineering fundamental.**	2
	PO4	Select the appropriate method for the analysis of structures using **mathematical principles and engineering knowledge** for different loads for the design purpose.	2
	PO5	select the appropriate method for the analysis of structures using **mathematical principal** for desing purpose	1

Course Outcomes	PO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO5	PO1	undderstand the **engineering** concepts of shapes functions to obtain stiffness matrix for two dimensional elements by using the **principles of mathematics and sciences.**	3
	PO4	**Identify the problem, formulate** stiffness matrix for two dimensional elements **for solution development** in reaching substantiated conclusions by the **interpretation of results.**	4
CO6	PO4	Analyze the quantitative techniques for cost management of the engineering projects using **fundamental in mathematics and engineering fundamentals.**	2
	PO5	Make use of galerkin method for solving one dimensional boundary value problmes by applying the principles of **engineering fundamentals.**	1

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO MAPPING:

Course Outcomes	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	-	-	2	-	-
CO 2	2	-	-	2	1	-
CO 3	2	-	-	2	-	-
CO 4	2	-	-	2	1	-
CO 5	3	-	-	4	-	-
CO 6	-	-	-	2	1	-

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO

Course Outcomes	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	0.0	0.0	0.0	50	0.0	0.0
CO 2	66.66	0.0	0.0	50	100	0.0
CO 3	66.66	0.0	0.0	50	0.0	0.0
CO 4	66.66	0.0	0.0	50	100	0.0
CO 5	100	0.0	0.0	25	0.0	0.0
CO 6	0.0	0.0	0.0	50	100	0.0

XIV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.
0 - 0 ≤ C≤ 5% – No correlation
1 -5 <C≤ 40% – Low/ Slight
2 - 40 % <C < 60% –Moderate
3 - 60% ≤ C < 100% – Substantial /High

Course Outcomes	**PROGRAM OUTCOMES**					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	0.0	0.0	0.0	2	0.0	0.0
CO 2	3	0.0	0.0	2	3	0.0
CO 3	3	0.0	0.0	2	0.0	0.0
CO 4	3	0.0	0.0	2	3	0.0
CO 5	3	0.0	0.0	1	0.0	0.0
CO 6	0.0	0.0	0.0	2	3	0.0
Total	12	0.0	0.0	11	9	0.0
Average	3	0.0	0.0	2	3	0.0

XV ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	✓
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	-	Open Ended Experiments	-
Assignments	✓				

XVI ASSESSMENT METHODOLOGY-INDIRECT:

✓	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVII SYLLABUS:

MODULE I	**THIN RECTANGULAR PLATES**
	Bending of thin plates, assumptions, governing differential equations in cartesian coordinate system, Boundary conditions, analytical solutions for rectangular plates by Navier and Levy s methods, distributed and concentrated loads.
MODULE II	**CIRCULAR PLATES**
	Circular plates: Governing differential equations in polar coordinate system, annular plate, rotationally symmetric loading, eccentric concentrated load, simultaneous bending and stretching of thin plates, introduction to large deflection theory of plates.
MODULE III	**PLATES ON ELASTIC FOUNDATIONS**

	Plates on elastic foundations, governing differential equation and deflection of uniformly loaded simply supported rectangular plate. Navier and Levy type solutions, large plate loaded at equidistant points by concentrated forces.
MODULE IV	**SHELS**
	Shells: Shells, geometry and classifications, stress resultants, membrane theory and its applications to shells of surface of revolutions, membrane theory for cylindrical shell, general theory in bending of cylindrical shell, simplified method for cylindrical shell.
MODULE V	**BUCKLING OF THIN PLATES**
	Buckling of plates: Governing equation for bending of plate under the combined action of inplane loading and lateral loads, buckling of rectangular plates by compressive forces acting inone and two directions in the middle plane of plate.

TEXTBOOKS

1. Timoshenko S. and Krieger, "Theory of Plates and Shells", W. McGraw Hill, 1959.
2. Chandra shekhara. K, "Theory of Plates", Universities Press, 2001.
3. Timoshenko ,"Theory of Plates and Shells" , Tata MC Graw Hill, 1959.

REFERENCE BOOKS:

1. UguralAnselC,"Stresses in Plates and Shells", McGraw Hill, 2009.
2. Kraus.H, "Thin Elastic Shells", John Wiley and Sons, 1998.
3. Rama swamy.G.S., "Design and Construction of Concrete Shells", 2001.

WEB REFERENCES:

1. https://pdfs.semanticscholar.org/presentation/ce6d/b61238325d60d3f6dc0f1fbe7af33e3972c1.pdf

COURSE WEB PAGE:

XVIII COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Discussion on OBE, CO's and CLO's of subject Theory of Plates and Shells		
CONTENT DELIVERY (THEORY)			
1	Introduction	CO1	T1,T2
2	Assumptions, governing differential equations.	CO1	T1,T2
3	Strain displacement relatioin.	CO1	T1,T2
4	Governing differential equations in Cartesian coordinate system, Boundary conditions .	CO1	T1,T2
5	Analytical solutions for rectangular plates.	CO1	T1,T2
6	Strain Energy in Pure Bending of Plates.	CO1	T1,T2
7	Derivation for the relations between bending moments and curvature in pure bending of plates	CO1	T1,T2
8	Distinguish between thin plate with small deflection and thin plate with large deflection	CO1	T1,T2
9	Analytical solutions for rectangular plates by Navier method.	CO1	T1,T2
10	analytical solutions for rectangular plates by Levy's method.	CO1	T1,T2
11	Navier method for distributed and concentrated loads.	CO1	W2:2
12	Levy's methods, for distributed and concentrated loads.	CO1	T1,T2
13	Differential equations of cylindrical bending of uniformly loaded rectangular plates with simply supported edges.	CO1	T1,T2
14	Deflection and internal moments of simply supported rectangular support plate of size a x b.	CO1	T1,T2
15	General expressions for deflection and bending moment of a rectangular plate a x b simply supported at the edges is subjected to sinusoidal loading using the Navier solution.	CO1	T1,T2
16	Differential equation for plate subjected to cylindrical bending.	CO1	T1,T2
17	Derivation for differential equations of cylindrical bending of uniformly loaded rectangular plates will simply supported edges.	CO1,CO2	T1,T2
18	Maximum deflection for uniform loaded solid circular plate with radius 'a' has its edges simply supported. expressions for the	CO1,CO2	T1,T2
19	Governing differential equations in polar coordinate system	CO1,CO2	T1,T2
20	Deflection equation equation for a plate subjected to hydrostatic pressure use Levy's basic equation for calculating deflection	CO1,CO2	T1,T2
21	Differential equations in polar coordinate system, annular plate, rotationally symmetric loading	CO2	T1,T2
22	Differential equation for eccentric concentrated load	CO2	T1,T2

16	Circular Plate with a Circular Hole at the Center.	CO2	T1,T2
23	Differential equation simultaneous bending and stretching of thin plates	CO2	T1,T2
24	Differential equation simultaneous bending and stretching of thin plates	CO2	T1,T2
25	Introduction to large deflection theory of plates	CO2	T1,T2
26	Differential equations of cylindrical bending of uniformly loaded rectangular plates with built in edges.	CO2	T1,T2
27	Introduction to Plates on elastic foundations	CO3	T1,T2
28	Governing differential equation and deflection of uniformly loaded simply supported rectangular plate	CO3	T1,T2
29	Derivation for the moment curvature in the case of pure bending of plates.	CO3	T1,T2
30	Deflection equation equation for a plate subjected to hydrostatic pressure by Levy's solution.	CO3	T1,T2
31	Levy type solutions for plates on elastic foundation	CO3	T1,T2
32	Navier and Levy type solutions for large plate loads	CO3	T1,T2
33	Navier and Levy type solutions for plates on elastic foundation by concentrated forces	CO3	T1,T2
34	Plate with clamped edge under a uniform load Po.	CO3	T1,T2
35	Circular Plates on elastic foundation.	CO3	T1,T2
36	Derivation for the general equations for axisymmetric shells of revolution.	CO3	T1,T2
37	Shells, geometry and classifications	CO3	T1,T2
38	stress resultants, membrane theory and its applications to shells of surface of revolutions	CO4	T1,T2
39	Derive an expression for all round simply supported rectangular plate by Navier solution.	CO 6	T1,T2
40	Membrane theory for cylindrical shell.	CO4	T1,T2
41	Bending of Circular Plates by Moments Uniformly Distributed along the Edge	CO4	T1,T2
42	Axisymmetric Bending of Circular Plates	CO4	T1,T2
43	Maximum deflections and bending moment of a uniform loaded solid circular plate with radius 'a ' at its edges simply suppored.	CO4	T1,T2
44	General theory in bending of cylindrical shells shell	CO4	T1,T2
45	Theory of simplified method for cylindrical shell	CO4	T1,T2
46	Introduction to Buckling of plates	CO4	T1,T2
47	Introduction to Buckling of plates	CO4	T1,T2
48	Introduction to Buckling of plates	CO4	T1,T2
49	Governing equation for bending of plate under the action of in plane loading	CO5	T1,T2
50	Derivation of geometrical relations for shells of double curvature.	CO5	T1,T2
51	Governing equation for bending of plate under the action of lateral loads	CO5	T1,T2

52	Bending and membrane theories for analysis of shells.	CO5	T1,T2
53	Plate Bending by Approximate and Numerical Methods	CO5	T1,T2
54	buckling of rectangular plates	CO5	T1,T2
55	Modified galerkin method for one-dimensional	CO5	T1,T2
56	Buckling of plate by compressive forces acting in one and two directions	CO6	T1,T2
57	Buckling of sanewich plate .	CO6	T1,T2
59	Classical stability analysis of thin elastic plates.	CO6	T1,T2
60	Buckling of rectangular plates by compressive forces acting in one and two directions in the middle plane of plate	CO6	T1,T2
DISCUSSION OF QUESTION BANK			
1	What are the assumptions in pure bending.	CO1	T1,T2
2	Deflection and bending moments for circular plate loaded at center.	CO2	T1,T2
3	Expression for rigidity of corrugated sheet.	CO3,	T1,T2
4	Explain about the advantages and disadvantages of the shells.	CO4	T1,T2
5	Buckling of rectangular plates by compressive force acting in two directions .	CO6	T1,T2

Signature of Course Coordinator **HOD,CE**
Mr.Gude Ramakrishna.

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**CIVIL ENGINEERING**				
Course Title	**ADVANCED CONCRETE TECHNOLOGY**				
Course Code	BSTD04				
Program	M.Tech (STE)				
Semester	I				
Course Type	Core				
Regulation	PG - 21				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr.A Rajesh, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
-	-	-	-

II COURSE OVERVIEW:

Concrete is the most versatile construction material used all around the world. The study of concrete has become indispensable to the Civil engineering graduates to learn fundamental properties of fresh concrete, hardened concrete, strength and durability. Concrete technology provides a comprehensive coverage of the theoretical and practical aspects of the subject and includes the latest developments in the field of concrete construction. It incorporates the latest Indian standard specifications and codes of practices for regulating concrete construction. The properties of concrete and its constituent materials, the role of various admixtures in modifying these properties to suit specific requirements and situations are also be studied. The course also provides the knowledge on mix design for producing most economical and durable concrete, it also enables the students to acquire knowledge on special and new generation concrete with their applications.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Fluid Dynamics	60 Marks	40 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

Each theory course will be evaluated for a total of 100 marks, out of which 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE).

Semester End Examination (SEE): The SEE shall be conducted for 60 marks of 3 hours duration. The syllabus for the theory courses shall be divided into FIVE modules and each module 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 12 marks. There could be a maximum of two / three sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
33%	Understand
33%	Apply
33%	Analyze
0%	Create

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 40 marks, with 20 marks for continuous internal examination (CIE) and 10 marks for Definitions and Terminology / Quiz and 10 marks for Tech Talk / Assignment.

Component		Marks	Total Marks
CIA	Continuous Internal Examination – 1 (Mid-term)	10	40
	Continuous Internal Examination – 2 (Mid-term)	10	
	AAT-1	10	
	AAT-2	10	
SEE	Semester End Examination (SEE)	60	60
Total Marks			100

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered. The valuation and verification of answer scripts of CIE exams shall be completed within a week after the conduct of the Examination.

Assignment: To improve the writing skills in the course an assignment will be evaluated for 05 marks. Assignment has to submit either at the end of the CIE1 or CIE2 for the questions provided by each course coordinator in that semester. Assignments to be handed in as loose paper collection stapled together at the top left corner. The assignment should be presented as a professional report. It must consist of a cover sheet, content page, and should have an introduction, a body, a conclusion or recommendation, and a reference page.

Quiz: It is online proctor based online examination conducted either at the end of the CIE1 or CIE2. The choice of conduction of Assignment / Quiz in CIE1 or CIE2 is purely choice of course handling faculty.

Alternative Assessment Tool (AAT): In order to encourage innovative methods while

delivering a course, the faculty members are encouraged to use the Alternative Assessment Tool (AAT). This AAT enables faculty to design own assessment patterns during the CIA. The AAT enhances the autonomy (freedom and flexibility) of individual faculty and enables them to create innovative pedagogical practices. If properly applied, the AAT converts the classroom into an effective learning center. **The AAT may include**, Course related term paper, Technical seminar, Term paper, Case Study, Paper presentations conducted by reputed organizations relevant to the course etc.

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

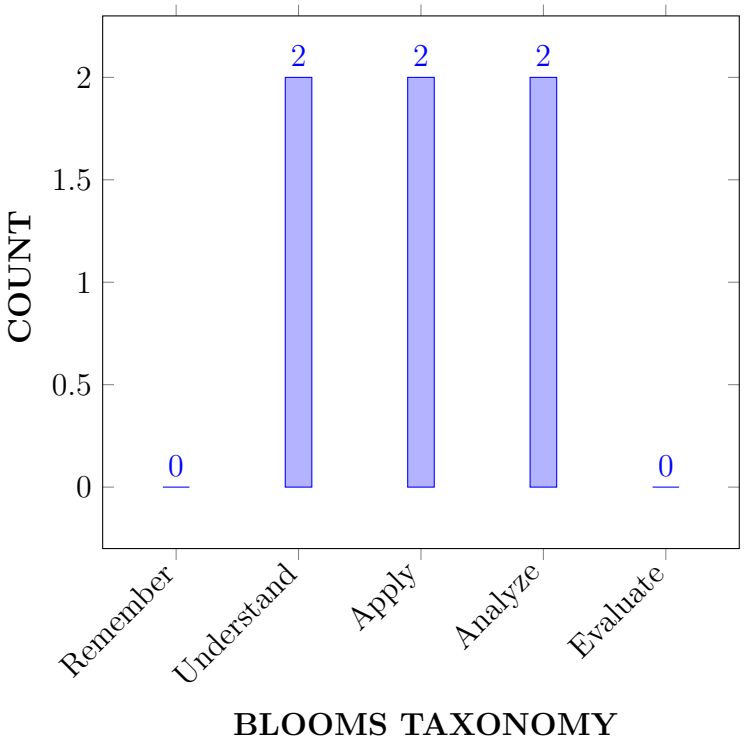
I	The fundamental properties of construction materials such as cement, aggregates and admixtures based on laboratory and filed tests for identifying material quality.
II	The factors influencing workability and methods involved in measuring workability of fresh concrete.
III	The application of special and new generation concrete by replacing traditional concrete for improving structural performance in real time.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Explain** the basic physical and chemical properties of construction materials for determining quality of concrete.	Understand
CO 2	**Outline** the workability and manufacturing process of concrete for obtaining economical and durable concrete	Understand
CO 3	**Inspect** the impact of water/cement ratio on strength and durability of concrete by measuring its hardened strength.	Analyze
CO 4	**Identify** the materials and technics of repair for rehabilitation and retrofitting of structures.	Apply
CO 5	**Develop** the most economical and eco-friendly concrete mix based on standard methods for producing quality of concrete.	Apply
CO 6	**Examine** special concretes and new generation concrete for satisfying the future needs of industry in real time.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields.
PO 2	Apply appropriate techniques, resources, modern engineering and Information Technology (IT) tools including predictions, modeling of complex structural engineering activities.
PO 3	Conceptualize and design civil Engineering structures considering various socio-economic factors.
PO 4	Independently carry out research / investigation and development work to solve practical problems.
PO 5	Write and present a substantial technical report / document.
PO 6	Engage in life-long learning for continuing education in research-level studies and professional development.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields.	1.5	CIE, SEE, AAT

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 2	Apply appropriate techniques, resources, modern engineering and Information Technology (IT) tools including predictions, modeling of complex structural engineering activities.	2	CIE, SEE, AAT
PO 3	Conceptualize and design civil engineering structures considering various socio-economic factors.	3	CIE, SEE, AAT

3 = High; 2 = Medium; 1 = Low

X JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO1	PO 1	**Interpret** the quality of concrete after gaining **knowledge** of basic physical and chemical properties **in the structural applications.**	2
	PO 3	**Experiment** with Physical and chemical properties in the process of **designing civil engineering structures** in the context of **sustainable development.**	3
CO 2	PO 1	**Develop** the **formulate solutions to problems** by applying the knowledge of manufacturing process of concrete and workability concept hence to **design innovative products** in the **real-time constructions.**	5
	PO 2	**Determine** the workability of concrete and understand **various techniques** in manufacturing of concrete helping to **develop solutions** in the **construction projects.**	2
	PO 3	Identify the condition of fresh concrete based on **Experimental** work to **evaluate** the **economical product**.	3
CO 3	PO 1	Determine various engineering properties like compressive strength, tensile strength and flexural strength of concrete by applying different **own and interdisciplinary engineering practices.**	3
CO 4	PO 1	**Inspect** the structural components of building and apply the**knowledge** of techniques of repairs and retrofitting in the **structural applications** in reaching substantiated conclusions by the **interpretation of results.**	4
	PO2	**Apply** the knowledge of repair an rehabilitation in the **complex structural activities** using **tools** to **interpret the performance.**	4
CO 5	PO 1	**Design** the quality concrete mix based on standards after gaining **knowledge** of mix design **in the structural applications.**	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	**Experiment** with concrete mix design in the process of **designing civil engineering structures** in the context of **economical point of view.**	3
CO 6	PO 1	**Understand** about the new generation concretes to **design innovative products** solutions to problems by **formulating real-time constructions.**	3
	PO 3	**Experiment** on new concrete materials and **design** special concretes to solve various **environmental problems** helping the **sustainable civil engineering.**	3

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

Course Outcomes	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓	-	✓	-	-	-
CO 2	✓	✓	✓	-	-	-
CO 3	✓	-	✓	-	-	-
CO 4	✓	✓	-	-	-	-
CO 5	✓	✓	-	-	-	-
CO 6	✓	-	✓	-	-	-

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO MAPPING:

Course Outcomes	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	-	3	-	-	-
CO 2	5	2	3	-	-	-
CO 3	3	-	4	-	-	-
CO 4	3	4	-	-	-	-
CO 5	4	3	-	-	-	-
CO 6	3	-	3	-	-	-

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO

Course Outcomes	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	25	-	60	-	-	-
CO 2	65	33	60	-	-	-
CO 3	40	-	80	-	-	-
CO 4	40	66	-	-	-	-
CO 5	50	50	-	-	-	-
CO 6	40	-	60	-	-	-

XIV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.
0 - 0 ≤ C≤ 5% – No correlation
1 -5 <C≤ 40% – Low/ Slight
2 - 40 % <C < 60% –Moderate
3 - 60% ≤ C < 100% – Substantial /High

Course Outcomes	**PROGRAM OUTCOMES**					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	1	-	3	-	-	-
CO 2	3	1	3	-	-	-
CO 3	1	-	3	-	-	-
CO 4	1	3	-	-	-	-
CO 5	2	2	-	-	-	-
CO 6	1	-	3	-	-	-
Total	9	6	12	-	-	-
Avarage	1.5	2	3	-	-	-

XV ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	✓
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	-
Assignments	✓				

XVI ASSESSMENT METHODOLOGY-INDIRECT:

✓	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVII SYLLABUS:

MODULE I	**MATERIALS FORMING CONCRETE**
	Concrete making materials: cement, bogues compounds, hydration Process, types of cement, aggregates, gradation charts, combined aggregate, alkali silica reaction, admixtures, chemical and mineral admixtures.
MODULE II	**TESTS ON FRESH AND HARDENED CONCRETE**
	Fresh and hardened Concrete: Fresh Concrete workability tests on concrete setting times of fresh concrete, segregation and bleeding. Hardened concrete: Abram's law, gel space ratios, maturity concept, stress behaviour, creep and shrinkage, durability tests on concrete, nondestructive testing of concrete.
MODULE III	**HIGH STRENGTH AND HIGH-PERFORMANCE CONCRETES**
	High strength concrete, micro structure, manufacturing and properties, design of HSC using erintroyshaklok method, ultra-high strength concrete. High performance concrete, requirements and properties of high-performance concrete, design considerations.

MODULE IV	**QUALITY CONTROL OF CONCRETE**
	Concrete mix design: Quality control, quality assurance, quality audit, mix design method - BIS method
MODULE V	**SPECIAL CONCRETES**
	Self-compacting concrete, polymer concrete, Fiber reinforced concrete-Requirements and Guidelinesadvantages and applications, Light weight concrete, bacteria concrete, geo polymer concrete, self-curing concrete, recycled aggregate concrete.

TEXTBOOKS

1. Shetty, M.S., "Concrete Technology, Theory & Practice", S. Chand and Co,2004
2. Gambhir, M.L., "Concrete Technology", Tata McGraw Hill,2004.
3. A. M. Neville, "Properties of Concrete", ELBS publications, 2012.

REFERENCE BOOKS:

1. V.N.Vazirani&S.P.Chandola, Ed. by Vineet Kumar," Concrete technology", 6th edition reprint.
2. Santakumar A.R., "Concrete Technology", Oxford University Press, New Delhi,2007.
3. Rajat Siddique, "Special Structural Concretes", Galgotia Publications, 2004.
4. N. Krishna Raju, "Design of Concrete Mixes", CBS Publications, 1996.
5. P. K. Mehta, "Concrete: Micro Structure", ICI, Chennai, 2007.

WEB REFERENCES:

1. http://nptel.ac.in/courses/112104160/3
2. http://nptel.ac.in/downloads/112104160/
3. https://books.google.co.in/books?id=DXOsGoqtiggC printsec=frontcoverv=onepage q false
4. https://www.researchgate.net/publication/273059503 Introduction to Structural Health Monitoring

COURSE WEB PAGE:

1. Course Template
2. Tutorial Question Bank
3. Assignments
4. Model Question Paper – I
5. Model Question Paper - II
6. Lecture Notes
7. Power point presentation

XVIII COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Course objectives, Course outcomes, Program Outcomes and CO-PO Mapping		
CONTENT DELIVERY (THEORY)			
2	Portland cement :chemical composition Hydration, setting of cement.	CO 1	T1: 1.8-1.9, T1: 2.28-2.28.2
3	structure of hydrate cement, Test on physical properties	CO 1	T1: 1.13-1.1
4	Different grades of cement	CO 1	T1:2.1-2.6, T1: 2.18, R2:5.1
5	Admixtures: Mineral and chemical admixtures.	CO 1	T1: 5.1-5.3
6	Admixtures-properties, dosage, effects usage.	CO 1	T1: 5.4-5.5
7	Aggregates: Classification of aggregate, particle shape & texture bond	CO 1	T1: 3.2-3.4, R2:6.3
8	strength and other mechanical properties of aggregate	CO 1	T1: 3.7-3.9
9	specific gravity, bulk density, porosity, adsorption & moisture content of aggregate	CO 1	T1: 3.15-3.18, R2:6.5
10	Bulking of sand,Deleterious substance in aggregate, Soundness of aggregate	CO 1	T1:3.26-3.27, T1:3.19-3.20, T2 :3.50
11	Alkali aggregate reaction, thermal properties	CO 1	T2 :3.6-3.7, R1:7.1
12	Sieve analysis, fineness modulus,Grading curves	CO 1	T2:3.8-3.9
13	grading of fine & coarse aggregates, gap graded aggregate, maximum aggregate size	CO 2	T2:3.9-3.11, R1:7.5
14	Workability :factors affecting workability , measurement of workability by different tests	C02	T2: 6.1-6.4, R2:7.2
15	setting times of concrete, effect of time and temperature on workability	CO 2	T1:6.3-6.36
16	segregation & bleeding, mixing and vibration of concrete	CO 2	T1:6.6, R1:3.5
17	steps in manufacture of concrete, quality of mixing water.	CO 2	T1: 6.6, R1:8.4
18	Water / Cement ratio: Abram's Law, Gel space ratio	CO 2	T1: 6.4-6.5, R1:8.5
19	Nature of strength of concrete, Maturity concept	CO 3	T1: 6.7.1-6.7.7.15
20	Strength in tension & compression, factors affecting strength, relation between compression & tensile strength curing	CO 3	T1: 6.7-6.8
21	Testing of hardened concrete: compression tests, tension tests	CO 3	T1: 4.2-4.3
22	Factors affecting strength, flexure tests, splitting tests	CO 3	T1: 7.2, R1:8.6

23	Non-destructive testing methods, codal provisions for NDT	CO 3	T1: 7.3, R1:8.8
24	Elasticity, creep & shrinkage, modulus of elasticity, dynamic modulus of elasticity, Poisson's ratio	CO 3	T1: 7.4
25	creep of concrete, factors influencing creep, relation between creep & time, nature of creep, effects of creep	CO 3	T1: 7.6, R1:9.1.4
26	shrinkage, types of shrinkage	CO5	T1: 7.8
27	Factors in the choice of mix proportions	CO 5	T1: 7.7 R2:9.2.1
28	Durability of concrete & tensile strength, curing	CO 5	T1: 7.8 R1: 6.8-6.9
29	Quality Control of concrete	CO 5	T1: 10.1-10.2, R1:4.2.3
30	Statistical methods, Acceptance criteria	CO 5	T1:10.7-10.9
31	Proportioning of concrete mixes by various methods	CO5	T1:10.8-10.11, R1: 10.1-10.2
32	Proportioning of concrete mixes by various methods	CO 5	T1:8.1-8.3
33	BIS method of mix design	CO 5	T1:8.1.1-8.1.4
34	BIS method of mix design	CO 5	T1:8.2
35	Light weight aggregates, polymer concrete	CO 6	T1:8.3
36	cellular concrete , no fines concrete, high density concrete	CO 5	T1:11.3
37	fiber reinforced concrete, different types of fibers	CO 6	R1:9.2
38	factors affecting properties of F.R.C, applications	CO 6	R1:11.5
39	high performance concrete	CO 6	R1:11.5-11.7
40	high performance concrete	CO 6	T1:11.9
41	self-consolidating concrete, SIFCON	CO 6	T1:11.13
PROBLEM SOLVING/ CASE STUDIES			
1	Design the concrete mix for grade M30 with suitable conditions	CO 4	T1:11.13-11.14
2	Design the concrete mix for grade M35 with suitable conditions	CO 4	R2:14.2-14.3
3	Design the concrete mix for grade M 40 with suitable conditions	CO 4	R2:14.15
4	Design the concrete mix for grade M45 with suitable conditions	CO 4	R1:12.8
5	Design the concrete mix for grade M50 with suitable conditions	CO 4	T1:12.10
6	Design of concrete mix for grade M20 with suitable conditions.	CO 4	R1:12.10.2
7	Design the concrete mix for grade M55 with suitable conditions.	CO 4	R1:12.13
8	Design the concrete mix for grade M60 with suitable conditions.	CO 4	R1:12.13.2
9	Fineness modulus of aggregates	CO 1	R2:16.1-16.9
10	Setting time of cement	CO 1	T1:13.1-13.4

11	Affect of gel space ratio on properties of hardened concrete	CO 5	R2:14.2
12	relationship between time and creep	CO 5	R2:14.2-14.3
13	Compressive strength of hardened concrete.	CO 6	R2:14.15
14	creep affect on hardened concrete	CO 6	R1:12.8
15	Effect of water cement ratio on the properties of hardened concrete	CO 6	T1:12.10
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Cement admixtures and aggregates	CO 1	R1:12.10.2
2	Fresh concrete	CO 2	R2:14.2-14.3
3	Hardened concrete and its testing	CO 3	R2:14.15
4	Mix design	CO 4	R2:14.2-14.3
5	Special concrete	CO 5	R2:14.15
DISCUSSION OF QUESTION BANK			
1	Cement admixtures and aggregates	CO 1	R1:12.8
2	Fresh concrete	CO 2	T1:12.10
3	Hardened concrete and its testing	CO 3	R1:12.10.2
4	Mix dsesign	CO 4	R2:14.2-14.3
5	Special concrete	CO 5	R2:14.2-14.3

Signature of Course Coordinator **HOD,CE**

Mr. A. Rajesh, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

ADVANCED CAD LABORATORY
COURSE TEMPLATE

1	Department	**CIVIL ENGINEERING**			
2	Course Title	**ADVANCED CAD LABORATORY**			
3	Course Code	BSTD11			
4	Program	M.Tech			
5	Semester	I Semester			
6	Regulation	PG-21			
7	Structure of the course	Practical			
		Tutorial Hours		Practical Hours	
		1		2	
8	Course Offered	Odd Semester ✓		Even Semester ×	
9	Course Coordinator	Dr. M.Maheswara Rao			
10	Date Approved by BOS	25/08/2023			
11	Course Webpage	www.iare.ac.in/—-/—-			
12	Course Prerequistes	**Level**	**Course Code**	**Semester**	**Prerequisites**
		-	-	-	-
		-	-	-	-

13. COURSE OVERVIEW

This course deals with the drawing of various structural elements related to reinforced concrete structures using software package. This will help the students to expose the new software and also minute detailing of the structures. This will also help how to study the existing drawing and incorporate the improvements in the drawings as and when required.

14. EMPLOYABILITY SKILLS

1. **Technical Proficiency in Structural Design Software::** Students gain practical experience in designing structural elements such as slabs, beams, columns, footings, and staircases using Excel. This enhances their ability to work efficiently with spreadsheet tools for structural analysis and detailing.
2. **Computer-Aided Design (CAD) and 3D Modeling Skills:** Through modules involving geometry creation, command input, and 3D model development, students learn to visualize and process structural designs using CAD tools. These skills are essential for roles in structural engineering and contribute to proficiency in modern design workflows.

15.RELEVANCE TO SUSTAINABILITY GOALS

Write brief description about the course and how its relevance to SDGs.

X		
X		
X		
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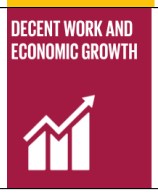
X		

✓		**Industry, Innovation, and Infrastructure:** By teaching the use of modern tools like Excel, STAAD.Pro, and AutoCAD Civil 3D for structural design, the course fosters innovation in infrastructure development, promoting efficient, durable, and smart construction practices.
X		
✓		**Sustainable Cities and Communities:** Students learn to design safe and resilient structural components, essential for developing sustainable buildings and infrastructure in urban environments.
✓		**Responsible Consumption and Production:** The software-based design and simulation approach minimizes material waste, supports optimized resource usage, and encourages life-cycle thinking in structural engineering.
✓		**Climate Action:** The emphasis on energy-efficient and accurate design using digital tools reduces the environmental impact of construction processes, contributing to climate-resilient infrastructure planning.
X		
X		
X		

X		

16. CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES

✓	 Day to Day lab evaluation	✓	 Demo Video	✓	 Expected Viva Voce questions	✓	 Open Ended Experiments
X	 Competitions	X	 hackathons	✓	 Certifications	✓	Probing Further Questions

17. EVALUATION METHODOLOGY

Each laboratory will be evaluated for a total of 100 marks consisting of 40 marks for internal assessment and 60 marks for semester end lab examination. Out of 40 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance including viva voce, 10 marks for the final internal lab assessment and remaining 10 marks for The remaining 10 marks are for Laboratory Report/Project and Presentation, which consists of the Design (or) Software / Hardware Model Presentation (or) App Development (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 40 marks (Table 1), with 20 marks for continuous lab assessment during day-to-day performance including viva voce, 10 marks for final internal lab assessment and remaining 10 marks for Laboratory Report / Project and Presentation.

Table 2: CIA marks distribution

Component				
Type of Assessment	Day to Day performance and viva voce examination	Final internal lab assessment	Laboratory Report / Project and Presentation	Total Marks
CIA marks	20	10	10	40

Continuous Internal Examination (CIE): One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

Table 3: Experiment based

Objective	Analysis	Design	Conclusion	Viva voce	Total
					20

Table 4: Programming based

Objective	Analysis	Program	Results	Viva voce	Total
4	4	6	4	2	20

Semester End Examination:
The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which will be decided by the Head of the institution.
In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

18. COURSE OBJECTIVES

The students will try to learn:

I	The use of various software tools for drafting of typical structures.
II	The Design and drawings of the structural detailing of the RC elements.
III	The structural drawings of various elements in the structures for preparing quantities.

19. COURSE OUTCOMES

After successful completion of the course, students should be able to:

CO 1	Design basic structural elements like slabs, beams, columns and stair cases etc. for construction purpose.
CO 2	Analyze technical drawings using both CAD and basic manual tools.
CO 3	Develop the drawings of structural elements for different applications.
CO 4	Build the different stages of the structure from scratch using engineering graphics techniques such as sectional projections, dimensioning and computer-generated drawings.
CO 5	Make use of software packages for creating different structural Geometry.
CO 6	Apply principles of technical drawings for producing different 3D models.

20. SYLLABUS

CO 1	**DESIGN OF BASIC STRUCTURAL ELEMENTS**
	1. Program for design of slabs using Excel and detailing 2. Program for design of beams using Excel and detailing 3. Program for design of column using Excel and detailing 4. Program for design of footing using Excel and detailing 5. Program for design of footing using Excel and detailing
CO 2	**STRUCTURAL SYSTEMS and COMMAND INPUTS**
	1. General Description-Type of structure, Unit systems, structure geometry and Co-ordinate system. 2. Commands- Using Edit Input-Command Formats-Text Input.
CO 3	**Developing Geometry and Dimensioning**
	1. PRE- Graphical Input Generation-Library- Geometry Generation – Dimensioning
CO 4	**Develop and build structure with drawings**

	1. PRE- Graphical Input Generation-Library- Geometry Generation – Dimensioning 2. Commands- Using Edit Input-Command Formats-Text Input.
CO 5	**Make use of software packages for structural geometry**
	1. Introduction to analysis and design software's
CO 6	**Apply principles for producing 3D models**
	1. POST - Graphical Post Processing - Animation - Icons - Isometric View Zooming-Results of Analysis and Design – Query reports.

Note: One Course Outcome may be mapped to multiple number of experiments.

Text Books

1. Terence M. Shumaker, David A., Madsen AutoCAD and its Applications: Advanced AutoCAD, Good heart-Wilcox, 12th edition, 2005

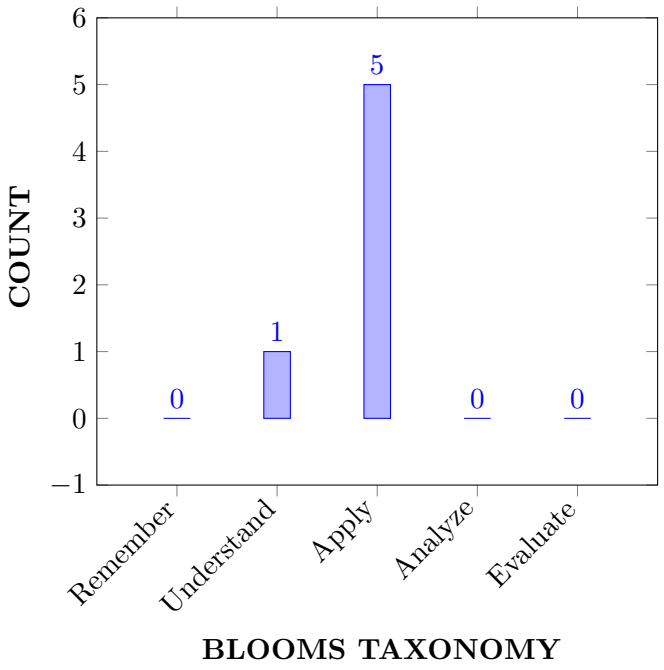
Reference Books

1. Dr M.N. Sesha Prakash and Dr. G.S. Servesh, "Computer Aided Design Laboratory", Laxmi Publications, 1st edition, 2016.
2. Omura, George, and Brian C. Benton. Mastering AutoCAD 2018 and AutoCAD LT 2018. John Wiley & Sons, 2017.

Materials Online

1. https://structuralbd.com/dwg-file-sample
2. https://dwgmodels.com/construction_details

21. COURSE KNOWLEDGE COMPETENCY LEVEL



22. PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES

Program Outcomes	
PO 1	An ability to Independently carry out research/investigation and development work to solve practical problems
PO 2	An ability to Write and present a substantial technical report/document.
PO 3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
PO 4	Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields.
PO 5	Conceptualize and design civil engineering structures considering various socio-economic factors.
PO 6	Engage in life-long learning for continuing education in research-level studies and professional development.

23. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
PO 1	An ability to Independently carry out research/investigation and development work to solve practical problems. problems.	1	LAB PRO-GRAMS/CIE/SEE

PO 2	An ability to Write and present a substantial technical report/document.		
PO 3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.	3	LAB PROGRAMS/CIE/SEE

24. MAPPING OF EACH CO WITH PO(s):

COURSE OUTCOME	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	✓	✓	✓	-	-	-	-	-	-	-	-	-	-
CO 2	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	✓	✓	✓	-	-	-	-	-	-	-	-	-	-
CO 4	-	✓	✓	✓	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	-	✓	-	✓	✓	-	-	-	-	-	-	-	-	-
CO 6	-	-	✓	-	✓	✓	-	-	-	-	-	-	-	-	-

25. JUSTIFICATIONS FOR CO – PO MAPPING - DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Apply knowledge of structural design (e.g., slabs, beams, staircases) by utilizing core engineering fundamentals to address real-world construction needs.	3
	PO 3	Demonstrate mastery in basic structural element design above undergraduate level with deeper understanding of construction application.	3
	PO 4	Apply multidisciplinary engineering knowledge to solve practical structural design challenges.	3
	PO 5	Consider socio-economic and functional aspects while designing basic structures.	3

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 2	PO 1	Analyze and interpret construction drawings using both manual and CAD tools, applying core structural engineering knowledge.	3
	PO 2	Prepare technical documents and detailed drawings for project communication.	3
	PO 4	Use integrated engineering knowledge in understanding different drawing standards and conventions.	3
CO 3	PO 3	Demonstrate advanced skill in developing application-oriented drawings of structural elements using latest tools.	3
	PO 4	Apply cross-functional knowledge for varied structural drawing needs in real-life applications.	3
	PO 5	Conceptualize the design intent in drawing form for different civil engineering structures.	3
CO 4	PO 2	Communicate technical aspects of structure development using accurate drafting and documentation. —	3
	PO 3	Apply advanced drawing techniques and representation strategies above undergraduate level.	3
	PO 4	Understand, design and analyze computer programs in the areas related to Algorithms, System Software, Web design, Big data, Artificial Intelligence, Machine Learning and Networking.	3
CO 5	PO 3	Show competence in using structural design software for modeling and drawing generation.	3
	PO 5	Create structural geometries that reflect practical considerations like space planning and economy.	3
	PO 6	Engage with evolving tools and technologies for continuous professional growth in structural design.	3
CO 6	PO 3	Apply technical drawing principles for advanced 3D visualization and modeling of structures.	3
	PO 5	Model structures based on realistic and sustainable civil engineering practices.	3
	PO 6	Continue adapting to new 3D design tools for lifelong learning and improvement in professional capabilities.	3

26. TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	3	3	3	-	-	-	-	-	-	-	-	-	-
CO 2	3	3	-	3	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	3	3	3	-	-	-	-	-	-	-	-	-	-
CO 4	-	3	3	3	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	-	3	-	3	3	-	-	-	-	-	-	-	-	-
CO 6	-	-	3	-	3	3	-	-	-	-	-	-	-	-	- -

27. PERCENTAGE OF KEY COMPETENCIES FOR CO – PO:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	25	-	25	25	25	-	-	-	-	-	-	-	-	-	-
CO 2	33.3	33.3	-	33.3	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	33.3	33.3	33.3	-	-	-	-	-	-	-	-	-	-
CO 4	-	33.3	33.3	33.3	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	-	33.3	-	33.3	33.3	-	-	-	-	-	-	-	-	-
CO 6	-	-	33.3	-	33.3	33.3	-	-	-	-	-	-	-	-	-

28. COURSE ARTICULATION MATRIX (PO MAPPING):

CO'S and PO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - 0≤ C≤ 5% – No correlation

2 - 40 % <C < 60% –Moderate

1-5 <C≤ 40% – Low/ Slight

3 - 60% ≤ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	1	-	1	1	1	-	-	-	-	-	-	-	-	-	-
CO 2	1	1	-	1	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	1	1	1	-	-	-	-	-	-	-	-	-	-
CO 4	-	1	1	1	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	-	1	-	1	1	-	-	-	-	-	-	-		-
CO 6	-	-	1	-	1	1	-	-	-	-	-	-	-	-	-
TOTAL	2	2	5	4	4	2	-	-	-	-	-	-	-	-	-
AVERAGE	1	1	1	1	1	1	-	-	-	-	-	-	-	-	-

29. ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Laboratory Practices	✓
Certification	-	Student Viva	✓	Open Ended Experiments	-

30. ASSESSMENT METHODOLOGY INDIRECT:

x	Assessment of Mini Projects by Experts	✓	End Semester OBE Feedback

31. COURSE PLAN

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's
1	Program for design of slabs using Excel and detailing	CO 1
2	Program for design of beams using Excel and detailing	CO 1
3	Program for design of column using Excel and detailing	CO 1
4	Program for design of footing using Excel and detailing	CO 1
5	Program for design of footing using Excel and detailing	CO 1
6	Introduction to analysis and design software's	CO 5
7	General Description-Type of structure, Unit systems, structure geometry and Co-ordinate system.	CO 2
8	Commands- Using Edit Input-Command Formats-Text Input.	CO 2, CO4
9	PRE- Graphical Input Generation-Library- Geometry Generation – Dimensioning	CO3, CO 4
10	POST – Graphical Post Processing – Animation – Icons – Isometric View – Zooming-Results of Analysis AND Design – Query reports.	CO6

Experiments for enhanced learning (EEL):

S.No	Design Oriented Experiments
1.	STAAD.Pro: Introduce students to structural analysis and design using STAAD.Pro for real-time modeling, analysis, and validation of concrete and steel structures.
2.	AutoCAD Civil 3D: Train students in using Civil 3D for civil infrastructure design, focusing on transportation, land development, and water projects through dynamic modeling and documentation.

Approved by: Board of Studies in the meeting conducted on ——————————.

Signature of Course Coordinator **HOD,CSE**
Dr. M.Maheswara Rao, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal - 500 043, Hyderabad, Telangana

COURSE OUTLINE DESCRIPTION

SECTION 1: General Information about the Course	
Course Title	**ADVANCED CONCRETE LABORATORY**
Course Code	BSTE12
Course Start	First Semester
Course Type	Core
Regulation	IARE – PG 21
Prerequisite Courses	-
Department	Civil Engineering (Structural Engineering)
Number of Credits	1.5 Credit hours
Academic Year	2025-26
Method(s) of Instruction	Laboratory
Course Coordinator's Name	**Mr. K. Anand Goud, Assistant,** Professor of Aeronautical Engineering IARE10537 **k.anandgoud@iare.ac.in**
Prior Learning Assessment and Recognition (PLAR)	Students interested in PLAR pathways for open learning can register one semester prior to the start of semester. Students will receive the necessary contact information one semester in advance.
Open Learning Faculty Member Information	Open Learning Faculty (OLF) is available to assist students. Students will receive the necessary contact information at the start of the course.
Course Webpage	https://akanksha.iare.ac.in/index?route=course/details&course_id=1242
Course Description	Advanced concrete laboratory provides a comprehensive coverage of the theoretical and practical aspects of the subject and includes the latest developments in the field of concrete construction. It incorporates the latest Indian standard specifications and codes regulating concrete construction. The properties of concrete and it constituent materials and the role of various admixtures in modifying these properties to suit specific requirements, such as ready mix concrete, reinforcement detailing, disaster-resistant construction, and concrete machinery have been treated exhaustively the and also special concrete in addition to the durability maintenance and quality control of concrete structure.
Course Objectives	**The students will try to learn:** a. The mechanical behavior of concrete under various loading conditions such as compression, tension, flexure, shear, and torsion. b. How to establish correlations among different strength parameters such as cube strength, cylinder strength, split tensile strength, and modulus of rupture. c. To assess the quality and durability of concrete using non-destructive testing methods and permeability tests, and interpret their relevance in structural evaluation. d. The influence of material composition and mix parameters (such as water–cement ratio and workability) on the strength and performance of both conventional and self-compacting concrete.
Text and Reference Books	**Textbooks**

	1. Hemanth Sood and L.N. Mittal, "Laboratory Manual on Concrete Technology," CBS Publishers Pvt. Ltd., New Delhi, 2nd Edition, 2013. 2. Khanna S.K. and Justo C.E.G., "Pavement Materials and Testing," Tata McGraw Hill Education, 2012. **Reference Books** 1. Malik R.S. and Meo, G.S., "Laboratory Manual on Concrete Technology," Computech Publication Ltd New Asian, 2009. 2. Sikka, V.B., "Laboratory Manual on Concrete Technology," S. K. Kataria & Sons, 2013.
Learning and Teaching Strategies	Online material will provide the foundation of the learning resources, requiring the students to log in and engage regularly throughout the sixteen weeks of the course. There will be a mix of suggested readings, discussions and video content containing embedded digital content and undertake the assessment tasks.

DELIVERY / INSTRUCTIONAL METHODOLOGIES:							
✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

SECTION 2: Teaching Learning Scheme

At least 48 lecture hours of scheduled laboratories activities (TLA) will be delivered in person,

Notional Study Time: 48 Hours (Laboratory Exercises)

TLA Code	Teaching and Learning Activities	Number	Duration (Hours)	Total Workload
TLA 1	Lectures	-	-	-
TLA 2	Tutorials	-	-	-
TLA 3	Case Study	-	-	-
TLA 4	Problem Solving	-	-	-
TLA 5	Demonstration	-	-	-
TLA 6	Scheduled revision sessions	-	-	-
TLA 7	Guided independent study: Directed viewing of video materials / PPTs	-	-	-
TLA 8	Independent private study	-	-	-
TLA 9	Laboratory Exercises	48	01	48
TLA 10	Homework assignments / Programming assignments	-	-	-
TLA 11	Placement / work based learning or Specific practical training	-	-	-
TLA 12	Presentation / Seminar Preparation	-	-	-
TLA 13	Course Project / Preparation for Complex Problem Solving	-	-	-
TLA 14	Technical visit	-	-	-
TLA 15	Field activities	-	-	-
			Total study hours	**48**
			Expected total study hours	**48**

SECTION 3A: Course Outcomes		
After successfully completing this course, the student will be able to:		
Outcome Number	**Course Outcomes**	**Learning Domain**
CO1	Construct the stress–strain curve of high-strength concrete to analyze its mechanical behavior for use in RC design.	Analyze
CO2	Develop the correlation between cube and cylinder strengths to interpret variations in strength parameters as per different code provisions.	Evaluate
CO3	Determine the relationship between compressive and split tensile strengths to evaluate the tensile performance of concrete.	Analyze
CO4	Identify the relationship between compressive strength and modulus of rupture to understand the flexural behavior of concrete members.	Analyze
CO5	Perform non-destructive tests (Rebound Hammer and UPV) to assess the quality, uniformity, and integrity of concrete structures.	Evaluate
CO6	Explain the behavior of beams under flexure, shear, and torsion to apply the concepts in the design of reinforced concrete elements.	Apply

SECTION 3B: Cognitive Levels	
Blooms Taxonomy Level	**Cognitive Level in Percentage (%)**
Remember	0
Understand	0
Apply	17
Analyse	50
Evaluate	33
Create	0

SECTION 4: Concrete Materials laboratory	
CO1	**Construct the stress–strain curve of high-strength concrete to analyze its mechanical behavior for use in RC design.**
	• Enables students to understand the fundamental properties of cement and aggregates. • Builds skills to analyze different physical properties such as fineness, consistency, and specific gravity. • Develops an understanding of how these properties affect the performance of concrete in construction. • Prepares students to identify the suitability of materials for different concrete applications.
CO2	**Develop the correlation between cube and cylinder strengths to interpret variations in strength parameters as per different code provisions.**
	• Helps students understand how to assess the quality of cement. • Builds skills in determining properties such as setting time, soundness, and compressive strength. • Teaches how cement properties influence the strength and durability of concrete. • Prepares students to select suitable cement types for various construction needs.
CO3	**Determine** the **relationship between compressive and split tensile strengths** to **evaluate the tensile performance of concrete**.
	• Helps students understand the importance of specific gravity in mix design. • Builds skills in performing specific gravity tests for accurate material proportioning. • Teaches how variations in cement composition affect mix design calculations. • Prepares students to optimize concrete mixes for strength and durability.
CO4	**Identify the relationship between compressive strength and modulus of rupture to understand the flexural behavior of concrete members.**
	• Helps students understand the grading of fine and coarse aggregates.

	• Builds skills in determining the fineness modulus and bulking of sand. • Teaches how aggregate properties impact concrete workability and strength. • Prepares students to select appropriate aggregates for different construction projects.
CO5	**Perform non-destructive tests (Rebound Hammer and UPV) to assess the quality, uniformity, and integrity of concrete structures.**
	• Helps students understand the factors influencing workability. • Builds skills in performing slump tests, compaction factor tests, and flow table tests. • Teaches how workability affects placement, compaction, and finishing of concrete. • Prepares students to modify mix proportions for improved concrete performance.
CO6	**Explain the behavior of beams under flexure, shear, and torsion to apply the concepts in the design of reinforced concrete elements.**
	• Perform compressive strength tests on concrete cubes/cylinders using a Compression Testing Machine (CTM) as per IS standards. • Evaluate results against IS 456:2000 acceptance criteria to determine if the concrete mix meets required strength. • Use test data for quality control, acceptance decisions, and mix adjustments in real-world construction practices.

SECTION 5: Complex Engineering Problem Solving- NA
.

SECTION 6A: Assessment Methods – Direct			
Item	**Evaluation Components**	**Week in / out**	**Marks**
1	Day to day evaluation	Every week	20
2	Internal examination and Viva-voce	10 +10	20
3	Semester end examination (External)	Week – 17	60
		Total Marks	**100**
Department's Late Submission Policy: 1. 1 – 24 hours: 25% of the mark will be deducted 2. > 24 hours: Not accepted			
SECTION 6B: Assessment Methods –Indirect			
Course End Survey (End Semester OBE Feedback)			✓

SECTION 8: Engineering Competencies (ECs) Focused: NA
Please tick (✓) relevant engineering competency profile covered

EC Number	Attributes	Profiles	(✓)
EC1	Depth of knowledge required (CP)	Ensures that all aspects of an engineering activity are soundly based on fundamental principles - by diagnosing, and taking appropriate action with data, calculations, results, proposals, processes, practices, and documented information that may be ill-founded, illogical, erroneous, unreliable or unrealistic requirements applicable to the engineering discipline	✓
EC2	Depth of analysis required (CP)	Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models.	✓
EC3	Design and development of solutions (CA)	Support sustainable development solutions by ensuring functional requirements, minimize environmental impact and	-

		optimize resource utilization throughout the life cycle, while balancing performance and cost effectiveness.	
EC4	Range of conflicting requirements (CP)	Competently addresses complex engineering problems which involve uncertainty, ambiguity, imprecise information and wide-ranging or conflicting technical, engineering and other issues.	✓
EC5	Infrequently encountered issues (CP)	Conceptualizes alternative engineering approaches and evaluates potential outcomes against appropriate criteria to justify an optimal solution choice.	✓
EC6	Protection of society (CA)	Identifies, quantifies, mitigates and manages technical, health, environmental, safety, economic and other contextual risks associated to seek achievable sustainable outcomes with engineering application in the designated engineering discipline.	✓
EC7	Range of resources (CA)	Involve the coordination of diverse resources (and for this purpose, resources include people, money, equipment, materials, information and technologies) in the timely delivery of outcomes	-
EC8	Extent of stakeholder involvement (CP)	Design and develop solution to complex engineering problem considering a very perspective and taking account of stakeholder views with widely varying needs.	-
EC9	Extent of applicable codes, legal and regulatory (CP)	Meet all level, legal, regulatory, relevant standards and codes of practice, protect public health and safety in the course of all engineering activities.	✓
EC10	Interdependence (CP)	High level problems including many component parts or sub-problems, partitions problems, processes or systems into manageable elements for the purposes of analysis, modelling or design and then re-combines to form a whole, with the integrity and performance of the overall system as the top consideration.	✓
EC11	Continuing professional development (CPD) and lifelong learning (CA)	Undertake CPD activities to maintain and extend competences and enhance the ability to adapt to emerging technologies and the ever-changing nature of work.	✓
EC12	Judgement (CA)	Recognize complexity and assess alternatives in light of competing requirements and incomplete knowledge. Require judgement in decision making in the course of all complex engineering activities.	✓

SECTION 9: Employability Skills

Example: Communication skills / Programming skills / Project based skills

The study of Aerodynamics and Propulsion Laboratory equips students with a range of practical, hands-on skills that are highly valued in the aerospace industry. These skills are particularly important in the design, testing, and optimization of aerodynamic systems and propulsion technologies.

Employability Skills:

- Problem-Solving Skills: Ability to analyze and solve real-world material quality and concrete mix design issues through experimentation and testing.
- Analytical and Critical Thinking: Expertise in interpreting laboratory test data, identifying trends, and making informed decisions to optimize material selection.
- Proficiency in Testing Equipment: Skilled in handling laboratory equipment such as vicat apparatus, slump cones, compression testing machines, and permeability testers.
- Optimization Skills: Ability to adjust concrete mix proportions to achieve desired workability, strength, and durability.
- Knowledge of Concrete Technology: Strong understanding of cement, aggregates, admixtures, and their role in concrete performance.
- Teamwork and Collaboration: Effective communication and teamwork in conducting experiments and analyzing results with peers.

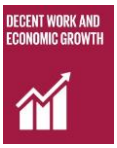
- Adaptability: Ability to adapt to evolving construction material technologies and industry best practices.

Project Management Skills:

- Planning and Organizing: Ability to design and manage laboratory experiments efficiently.
- Resource Allocation: Proficiency in managing laboratory materials, equipment, and personnel.
- Collaboration and Communication: Clear communication of experimental goals, procedures, and results across various teams.
- Risk Identification and Mitigation: Identifying potential risks in material testing and taking proactive measures to ensure accuracy and safety.
- Testing and Validation: Conducting rigorous testing and validation of concrete materials to ensure compliance with industry standards.

SECTION 10: Relevance to Sustainability goals

Brief description about the course and its correlation with Sustainability Development Goal (SDGs).

SDG Goals		Correlation with SDG
4		**Quality Education:** This course prepares students for modern construction challenges by enhancing their understanding of concrete materials, ensuring high-quality infrastructure development.
8		**Decent Work and Economic Growth:** The course equips students with industry-relevant skills, increasing employability in the civil engineering and construction sectors.
9		**Industry, Innovation, and Infrastructure:** Supports innovation in concrete technology, promoting sustainable material selection and efficient construction techniques.
11		**Sustainable Cities and Communities:** Encourages the use of durable, high-performance concrete for sustainable urban infrastructure development.
12		**Responsible Consumption and Production:** Enhances awareness about optimizing raw material use in concrete production to minimize waste and environmental impact.

SECTION 11A: Mapping between COs and POs / PSOs

Course Outcomes	Program Outcomes (POs)					
	1	2	3	4	5	6
CO1	✓			-	-	
CO2	✓	✓		✓		✓
CO3	✓	✓	✓		✓	-
CO4	✓			✓		-
CO5		✓	✓			✓
CO6					✓	

Outcomes		WKS and Indicators of attainment and Justification for mapping (students will be able to)																																									IAsCoUnt
COs	POs	WK 1	WK 2								WK 3			WK 4			WK 5						WK 6			WK 7				WK 8							WK 9						
		A	a	b	c	D	e	f	g	h	a	b	c	a	b	c	a	b	c	d	e	f	a	b	c	a	b	c	d	a	b	c	d	e	f	g	a	b	c	d	e	f	
CO 1	PO 1	•	•	•	•	•	•	•				•	•	•	•																												11
CO 2	PO 1	•	•	•	•	•	•	•			•	•	•	•	•																												11
	PO 2	•	•	•	•	•	•	•				•	•	•	•		•	•	•	•			•	•	•																		7
	PO 4	•	•	•	•	•	•	•			•	•	•	•	•																												11
	PO 6	•	•	•	•	•	•	•				•	•	•	•																												
CO 3	PO 1	•	•	•	•	•	•	•			•	•	•	•	•																												11
	PO 2																•	•	•	•			•	•	•					•	•		•	•	•								7
	PO 3	•	•	•	•	•	•	•			•	•	•	•	•																												11
	PO 5	•	•	•	•	•	•	•				•	•	•	•																												
CO 4	PO 1	•	•	•	•	•	•	•				•	•	•	•																												11
	PO 4	•	•	•	•	•	•	•				•	•	•	•																												11
CO 5	PO 2	•	•	•	•	•	•	•			•	•	•	•																•	•			•	•	•							11
	PO 3																•	•	•	•			•	•	•					•	•			•	•	•							7
	PO 6	•	•	•			•	•			•	•	•	•	•																												11
CO 6	PO 1	•	•	•	•	•	•					•	•	•	•																												11

SECTION 10B: Indicators of Attainment with COs to POs and PSOs

Course Outcomes	Percentage of Indicators of Attainments (IA) with POs					
	PO					
	1	2	3	4	5	6
CO1	78	-	-	-	-	-
CO2	78	74	-	73	-	72
CO3	73	73	78		74	-
CO4	73	-	-	73	-	-
CO5	-	73	78	-	-	73
CO6	-	-	-	-	72	-

SECTION 11C: Course Articulation Matrix of COs to POs

0 No Contribution (0-5%)	1 Low (≥5 - <40%)	2 Moderate (≥40 - <60%)	3 High (≥60%)

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

CO1	3	-				-
CO2	3	3		3		3
CO3	3	3	3		3	-
CO4	3	-		3		-
CO5	-	3	3			-
CO6	-	-			3	3
Total	12	9	6	6	6	6
Average	3	3	3	3	3	3

SECTION 11D: Level of Contribution of the COs to POs and PSOs			
Number	**Programme Outcomes**	**Proficiency Assessed by**	**Contribution Level (from 1 to 3)**
PO 1	Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in **WK1 to WK4** respectively to develop to the solution of **complex engineering problems**.	CIE / SEE	**3**
PO 2	Identify, formulate, review research literature and analyse **complex engineering problems** reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4).	CIE / SEE	**3**
PO 3	Design creative solutions for **complex engineering problems** and design / develop systems / components/ processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5)	CIE / SEE	**3**
PO 4	Conduct investigations of **complex engineering problems** using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8)	CIE / SEE	**3**
PO 5	Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve **complex engineering problems**. (WK2 and WK6).	CIE / SEE	**3**
PO 6	Analyze and evaluate societal and environmental aspects while solving **complex engineering problems** for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7)	CIE / SEE	**3**

2.1 SECTION 12: Course Content	
WEEK- I	**STRESS STRAIN CURVE FOR CONCRETE**
	Study of stress-strain curve of high strength concrete
WEEK- 2	**CORRELATION BETWEEN CUBE STRENGTH AND CYLINDER STRENGTH**
	Correlation between cube strength and cylinder strength
WEEK- 3	**DETERMINTION OF SPLIT TENSILE STRENGTH OF CONCRETE**
	Split tensile strength.
WEEK- 4	**DETERMINTION OF MODULUS OF RUPTURE OF CONCRETE**
	Modulus of rupture.
WEEK- 5	**RELATION BETWEEN COMPRESSIVE STRENGTH AND SPLIT TENSILE STRENGTH**
	Correlation between compressive strength and cylinder strength
WEEK- 6	**RELATION BETWEEN COMPRESSIVE STRENGTH AND MODULUS OF RUPTURE**
	Effect of cyclic loading on steel.
WEEK- 7	**NON – DESTRUCTIVE TEST (NDT)**
	Non-Destructive testing (rebound hammer) of existing concrete members.
WEEK- 8	**PERMEABILITY OF CONCRETE TEST**
	Permeability of concrete test.
WEEK- 9	**SHEAR STRENGTH TEST**
	Behavior of Beams under Shear.
WEEK- 10	**TORSION STRENGTH TEST**
	Behavior of steel under Torsion
WEEK- 11	**WORKABILITY TEST ON SELF COMPACTING CONCRETE**
	Determine the workability of self-compacting concrete by using L-box, U-box, V-Funnel and J-ring.
WEEK- 12	**QUALITY OF CONCRETE USING NDT**
	Determine the uniformity of concrete using Ultra sonic pulse velocity.
WEEK-13	**STRENGTH OF SCC WITH DIFFERENT W/C RATIOS**
	Determine the strength of Self compacting concrete with different W/C ratios.
WEEK-14	**DURABILITY OF CONCRETE**
	Determine the durability of concrete

SECTION 13: Tentative Schedule of Instructions		
Week Number	**Topics**	**Duration (Hours)**
1	1.1 Stress–strain curve of high-strength concrete	3
2	2.1 Correlation between cube strength and cylinder strength	3
3	3.1 Determination of split tensile strength of concrete	3
4	4.1 Determination of modulus of rupture of concrete	3

5	5.1 Relation between compressive strength and split tensile strength	3
6	6.1 Relation between compressive strength and modulus of rupture	3
7	7.1 Non-destructive testing of concrete members using Rebound Hammer	3
8	8.1 Permeability of concrete test	3
9	9.1 Shear strength test of beams	3
10	10.1 Torsion strength test of steel / concrete	3
11	11.1 Workability tests on fresh self-compacting concrete (L-box, U-box, V-funnel, J-ring)	3
12	12.1 Quality assessment of concrete using Ultrasonic Pulse Velocity (UPV)	3
13	13.1 Strength of SCC with different W/C ratios	3
14	14.1 Durability assessment of concrete	3
	Total	**48**

SECTION 14: Specific Goals for the Course

The following table shows the knowledge and skills covered by the unit outcomes:

Knowledge	Skills
Learners should understand:	**Learners can:**
• Fundamental properties of cement, aggregates, and admixtures used in concrete. • Factors affecting workability and methods for measuring it in fresh concrete. • The significance of the water/cement (W/C) ratio and its effect on concrete strength. • Quality control measures in concrete mix design. • Non-destructive and destructive testing methods for concrete durability assessment. • The role of admixtures in modifying concrete properties. • The environmental impact of concrete production and sustainability considerations. • Advanced testing techniques for evaluating concrete performance. • The importance of curing methods and their influence on concrete strength. • The effects of aggregate properties on concrete performance.	• Conduct laboratory tests to assess material properties such as fineness, consistency, and setting time. • Perform workability tests like slump test, compaction factor test, and flow table test. • Analyze the impact of different W/C ratios on compressive strength through experimental data. • Design concrete mixes using IS code methods for different applications. • Perform permeability tests and non-destructive testing techniques like rebound hammer and ultrasonic pulse velocity. • Evaluate the effects of chemical and mineral admixtures on workability, setting time, and strength. • Implement sustainable practices in concrete mix designs by optimizing material proportions. • Use laboratory equipment like compression testing machines, permeability meters, and air entrainment apparatus. • Conduct curing techniques, including accelerated curing, to assess early strength development. • Determine the fineness modulus of fine and coarse aggregates and assess bulking of sand.

EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S. No	Design Oriented Experiments
1	Simulation of workability and strength variations in concrete with different water-cement ratios.
2	Influence of admixtures on the setting time and strength development of concrete.
3	Optimization of aggregate grading for enhanced durability and performance in concrete mix design.

4	Non-destructive evaluation of hardened concrete using ultrasonic pulse velocity and rebound hammer tests.

Administrative Information

SECTION 15: History of changes		
Regulations	**Description of change**	**BOS Date**
PG 21	**Changes from R16 to R18 regulation** • **No change in syllabus**	17.11.2020
MT 23	**Changes from R18 to UG 20 regulation** **Incorporated the following additions in UG 20 regulations** • Studies on Non-Destructive test on concrete	21.08.2023
MT 25	**Incorporated the following additions in BT 23 regulations** • Air entrainment test on fresh concrete • Permeability of concrete • Non-destructive testing of concrete • Test for compressive strength of cement concrete • Accelerated curing of concrete • Influence of w/c ratio on strength and aggregate / cement ratio on workability and strength • Marsh cone test • Workability tests on fresh self-compacting concrete	1.09.2025

Course Outline Approvals	
Course Coordinator Name: Mr. K. Anand Goud Signature: Date:	**Head of the Department** Name: Dr. R. Ramya Swetha Signature: Date:
Dean of Outcome Based Teaching and Learning Name: Dr. Srinivasulu Signature: Date:	**Dean of Academics** Name: Dr. GVR. Sheshagiri Rao Signature: Date:

Check List		
Section	**Description**	**Please tick (✓)**
1	General Information about the Course	
2	Notional Study Time	
3	A. Course Outcomes	
	B. Cognitive Levels	
4	Content and Context of the Course	
5	Complex Engineering Problem Solving	
6	A. Assessment Methods – Direct	
	B. Assessment Methods – Indirect	
7	Content Delivery / Instructional Methodologies	
8	Engineering Competencies (ECs) Focused	
9	Employability Skills	
10	Relevance to Sustainability goals	
11	A. Mapping between COs and POs / PSOs	
	B. Indicators of Attainment with COs to POs and PSOs	
	C. Course Articulation Matrix of COs to POs	
	D. Level of Contribution of the COs to POs and PSOs	
12	Syllabus	
13	Tentative Schedule of Instructions	
14	Specific Goals for the Course	
15	History of Changes	

Signature of Course Coordinator **HOD, CE**

Mr. K. Anand Goud, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**Civil Engineering**				
Course Title	**Finite Element Analysis**				
Course Code	BSTD13				
Program	M. Tech (ST)				
Semester	II				
Course Type	Core				
Regulation	PG - 21				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr.Gude Ramakrishna, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
M.Tech	BSTD01	I	Advanced Structural Analysis

II COURSE OVERVIEW:

The Finite Element Method (FEM) is widely used in industry for analyzing and modelling structures and continua, whose physical behavior is described by ordinary and partial differential equations. The FEM is particularly useful for engineering problems that are too complicated to be solved by classical analytical methods. The main objective of this course is to introduce the mathematical concepts of the Finite Element Method for obtaining an approximate solution of ordinary and partial differential equations. In this course you will attend lectures on the fundamentals of the Finite Element Method. The learning process will be enhanced by completing assignments using mathematical software. You will also be introduced to a commercial Finite Element software package–ANSYS during lectures with computer laboratories providing opportunities to practice on, and to complete practical assignments, using ANSYS.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Finite Element Analysis	60 Marks	40 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	x	Assignments	x	MOOC
x	Open Ended Experiments	✓	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). Out of 40 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 60 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 12 marks. There could be a maximum of two 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
30%	To test the analytical skill of the concept
20%	To test the application skill of the concept

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE), 05 marks for Technical Seminar and Term Paper Outline of the Continuous Internal Assessments (CIA – 1 and CIA – 2) and SEE

Activities	CIA - I	CIA - II	SEE	Total Marks
Continuous Internal Examination(CIE)	10 Marks	10 Marks	-	20 Marks
Assignment / Quiz	05 Marks	05 Marks	-	10 Marks
Alternative Assessment Tool (AAT)	05 Marks	05 Marks	-	10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	-	100 Marks

Continuous Internal Examination (CIE):

CIA is conducted for a total of 40 marks, with 30 marks for Continuous Internal Examination (CIE), 05 marks for Assignment and 05 marks for Alternative Assessment Tool (AAT). Two CIE Tests are Compulsory and sum of the two tests, along with the scores obtained in the assignment and AAT shall be considered for computing the final CIA of a student in a given course.

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 COURSE OBJECTIVES:

The students will try to learn:

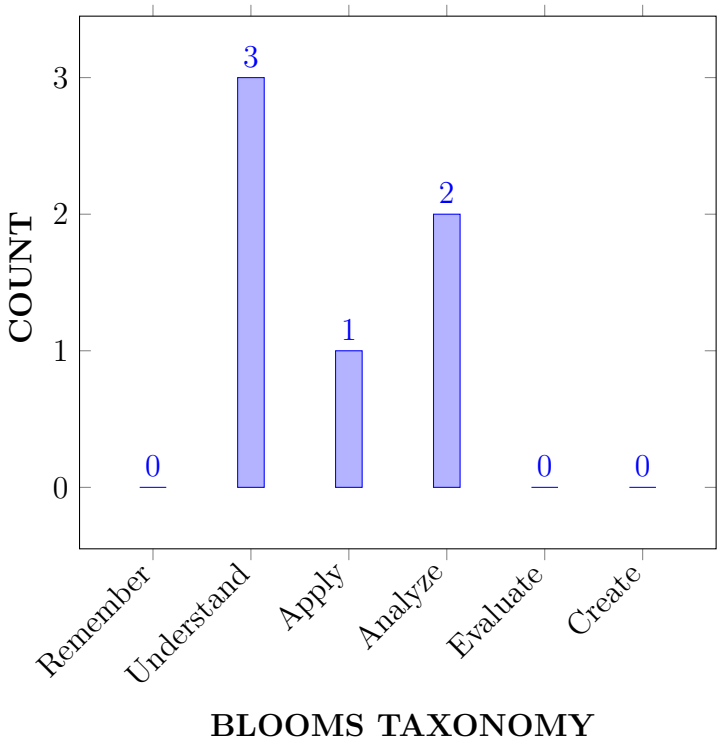
I	The Use of Finite Element Method for structural analysis.
II	The Execution of the Finite Element Program by using Software tools.
III	The continuum problems using finite element analysis

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Explain** the concepts of matrix analysis of structures for understanding the Finite Element Analysis.	Understand
CO 2	**Develop** the concepts of elasticity, plane stress and plane strain conditions for the design purpose.	Apply
CO 3	**Analyze** the one- and two-dimensional structures elements	Analyze
CO 4	**Explain** the concepts of iso-parametric elements for the analysis of Structures.	Understand
CO 5	**Analyze** the plates like slabs using plate elements.	Analyze
CO 6	**Summarize** the concepts of iso-parametric elements for analyzing the real world situations	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	An ability to Independently carry out research/investigation and development work to solve practical problems.
PO 2	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
PO 3	An ability to Write and present a substantial technical report/document.
PO 4	Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields.
PO 5	Conceptualize and design civil engineering structures considering various socio-economic factors.
PO 6	Engage in life-long learning for continuing education in research-level studies and professional development.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.	3	CIE, SEE
PO 4	Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields.	2	CIE,SEE
PO 5	Conceptualize and design civil engineering structures considering various socio-economic factors.	3	CIE,SEE

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s):

Course Outcomes	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	-	-	✓	-	-
CO 2	-	-	✓	✓	✓	-
CO 3	-	-	✓	✓	-	-
CO 4	-	-	✓	✓	✓	-
CO 5	-	-	✓	✓	-	-
CO 6	-	-	-	✓	✓	-

XI JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 4	Recall the concepts of of FEM, steps involved and understand **structural applications** for its behaviour by **analyze and design** the structure.	2
CO2	PO3	Develop procedure to **understand** different elements stress and stran values and stiffness matrix to slove problems and **solution developed** for particular condition and check for **validation of results.**	3
	PO4	Apply the appropriate method to **understand**mathematical concept of **analysis and design**of the structural members es for **Interpretation of results**.	3
	PO5	Select the appropriate method for **design and analysis** of problems in structural engineering and allied fields for **Interpretation of results and Validation**.	2
CO3	PO 3	Understand the application of **Problem formulation** of finite 3-D elements and **design process and evaluate outcomes** of member forces and applied loads.	2
	PO4	Use and **create** the finite elements and **obtain Solution and implimentation on** beam,bar and isoperimetric elements.	2
CO4	PO3	Recall (knowledge) the principles of membrane and bending analysis and form the stiffness and flexibility matrices by applying the principles of**to manage the design process** for the buckling of plates and shells to obtain **interpretation of results and validation**.	2
	PO4	Select the appropriate method for the bulking analysis of plate elements using **analyze and design principles** for different loadimg condition **interpretation of results** of plate and shel elements.	2
	PO5	Select the appropriate method for finite element analysis of structures using **requirements of engineering activities** for desing purpose	1
CO5	PO3	Undderstand the **experimental design** concepts of shapes functions to obtain stiffness matrix for shell elements by using **modern tools.**	2
	PO4	**Identify the problem, formulate** stiffness matrix for plate and shell elements **for solution development** to get substantiated conclusions by the **interpretation of results.**	3
CO6	PO3	**Understanding and demonstrations** of basic engineering non linear analysis.	1
	PO5	Make use of non linear analysis for the **requirement of engineering activities to promote sustainable development** in finite element analysis.	1

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO MAPPING:

Course Outcomes	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	-	-	2	-	-
CO 2	-	-	3	3	2	-
CO 3	-	-	2	2	-	-
CO 4	-	-	2	2	1	-
CO 5	-	-	2	3	-	-
CO 6	-	-	1	-	1	-

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO

Course Outcomes	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	-	-	25	-	-
CO 2	-	-	42.85	37.50	40	-
CO 3	-	-	28.57	25	-	-
CO 4	-	-	28.57	25	100	-
CO 5	-	-	28.57	37.5	-	-
CO 6	-	-	15	-	12.70	-

XIV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.
0 - $0 \leq C \leq 5\%$ – No correlation
1 -$5 < C \leq 40\%$ – Low/ Slight
2 - $40\% < C < 60\%$ –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

Course Outcomes	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	-	-	2	-	-
CO 2	-	-	3	3	3	-
CO 3	-	-	3	2	-	-
CO 4	-	-	3	2	3	-
CO 5	-	-	2	3	-	-
CO 6	-	-	1	-	3	-
Total	-	-	12	12	9	-
Average	-	-	3	2	3	–

XV ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	✓
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	-
Assignments	✓				

XVI ASSESSMENT METHODOLOGY-INDIRECT:

✓	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVII SYLLABUS:

MODULE I	**INTRODUCTION TO FEM AND PRINCIPLES OF ELASTICITY**
	Introduction: Concepts of FEM, steps involved merits and demerits, energy principles, discrimination, raleigh, ritz method of functional approximation. Principles of Elasticity: Stress equations, strain displacement relationships in matrix form plane stress, plane strain and axi-symmetric bodies of revolution with axi-symmetric loading.
MODULE II	**1D AND 2D FEM**
	One dimensional FEM: Stiffness matrix for beam and bar elements, shape functions foe ID elements.Two dimensional FEM: Different types of elements for plane stress and plane strain analysis, displacement models, generalized coordinates, shape functions, convergent and compatibility requirements, geometric invariance, natural coordinate system, area and volume coordinates, generation of element stiffness and nodal load matrices.
MODULE III	**DIFFERENT FORMULATIONS AND 3D FEM**
	Iso-parametric formulation: Concept, different iso-parametric elements for 2D analysis, formulation of 4- noded and 8-noded isoperimetric quadrilateral elements, lagrange elements, serendipity elements. Axi Symmetric Analysis: Bodies of revolution, axi symmetric modeling, strain displacement relationship, formulation of axi symmetric elements. Three dimensional FEM: Different 3-D elementsstrain, displacement relationship, formulation of hexahedral and isoparametric solid element.
MODULE IV	**ANALYSIS OF PLATES**
	Introduction to finite element analysis of plates: Basic theory of plate bending, thin plate theory, stress resultants, mindlin's approximations, formulation of 4-noded isoperimetric quadrilateral plate element, shell element. .
MODULE V	**NON-LINEAR ANALYSIS**
	Introduction to non linear analysis: basic methods, application to special structures.

TEXTBOOKS

1. Seshu P, "Finite Element Analysis", Prentice-Hall of India, 1st Edition, 2003.
2. Cook R. D, "Concepts and Applications of Finite Element Analysis", Wiley J., New York, 4 th Edition, 2001.
3. Krishnamoorthy C.S, "Finite Elements Analysis - Theory and Programming", Tata McGraw Hill publishing company limited, New Delhi, 2nd Edition, 2017.

REFERENCE BOOKS:

1. Hutton David, "Fundamentals of Finite Element Analysis", McGraw Hill, 2nd Edition, 2017.
2. Zienkiewicz O.C. and Taylor R.L, "Finite Element Method",. Vol. I, II and III, Elsevier, 3rd Edition, 2000
3. Buchanan G.R, "Finite Element Analysis, McGraw Hill Publications, New York, 1st Edition, 1995.
4. Belegundu A.D., Chandrupatla, "Finite Element Methods in Engineering", T.R., Prentice Hall, India, 1st Edition, 1991.

WEB REFERENCES:

1. https://nptel.ac.in/courses/105106051
2. http:// nptel.ac.in/courses/1051050

XVIII COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1, T2
OBE DISCUSSION			
1	Discussion on OBE, CO's and CLO's of subject Finite Element Analysis		
CONTENT DELIVERY (THEORY)			
1	Introduction, Concepts of FEM, steps involved merits and demerits	CO1	T1,T2
2	Energy principles.	CO1	T1,T2
3	Discrimination.	CO1	T1,T2
4	Raleigh, ritz method of functional approximation.	CO1	T1,T2
5	Principles of Elasticity: Stress equations, strain displacement relationships in matrix form plane stress	CO1	T1,T2
6	Direct Stiffness Method.	CO1	T1:2.5,
7	One dimensional FEM: Stiffness matrix for beam and bar elements. shape functions for ID elements	CO1	T1,T2
8	Beam and bar element.	CO2	T1,T2
9	Different types of elements for plane stress and plane strain.	CO2	T1,T2
10	Analysis different types of elements .	CO2	T1,T2
11	Displacement models.	CO2	T1,T2

12	Geometric invariance, natural coordinate system.	CO2	T1,T2
13	Area and volume coordinates	CO2	T1,T2
14	Element Load Vector.	CO2	T1,T2
15	Isoparametric formulation: Concept, different iso-parametric elements for 2D analysis.	CO2	T1,T2
16	stiffness matrix for global coordinates	CO2	T1,T2
17	concepts on solution of stiffness matrix equations	CO3	T1,T2
18	calculation of reactions and member forces	CO3	T1,T2
19	Step by step procedure for stiffness method	CO3	T1,T2
20	stiffness method for beams	CO3	T1,T2
21	Problem solving for beams by stiffness method	CO3	T1,T2
22	Problem solving for cantilever beams by stiffness method	CO3	T1,T2
23	Problem solving for continunous beams by stiffness method	CO3	T1,T2
24	Problem solving for continunous beams with settelment by stiffness method	CO3	T1,T2
25	Problem solving for portal frame by stiffness method	CO3	T1,T2
26	stiffness method for plane trusses	CO3	T1,T2
27	flexibilty method	CO4	T1,T2
28	flexibilty method for beam	CO4	T1,T2
29	flexibilty method for beamdifferent shapes	CO4	T1,T2
30	Problem solving for beams by stiffness method and flexibilty method	CO4	T1,T2
31	Analysis, axi symmetric modeling, strain displacement relationship. frames.	CO4	T1,T2
32	formulation of grid structures	CO4	T1,T2
33	CST Element, Plane Strain Rectangular Element.	CO5	T1,T2
34	Introduction to Isoperimetric Formulation of the Plane Quadrilateral Element, Axi- Symmetric element.	CO5	T1,T2
35	classification of element : One dimensional elements, Two dimensional elements, Axi-symmetric elements and Three dimensional elements.	CO5	T1,T2
36	Different boundary conditions	CO5	T1,T2
37	solutions for boundary value problems	CO5	T1,T2
38	Introduction to non linear analysis	CO6	T1,T2
39	Importanance of non linear analysis	CO6	T1,T2
40	Non linear analysis methods.	CO6	T1,T2
41	The matrix formulation of the modified galerkin method.	CO6	T1,T2
42	Explain procedure for modified galerkin method.	CO6	T1,T2
43	Non linear analysis.	CO6	T1,T2
44	Application to special structures.	CO6	T1,T2
45	Problem solving on Non linear analysis.	CO6	T1,T2
46	Problems on static indeterminacy and Kinematic Indeterminacy of Structures	CO 5	T1,T2
47	Problems on continuous beam by stiffness matrix method	CO 2	T1,T2
47	Problems on truss by stiffness matrix method	CO 6	T1,T2

49	Problems on rigid frame by flexibilty and stiffness matrix method	CO 6	T1,T2
50	Develop the stiffness matrix for global coordinates for boundary conditions.	CO 4	T1,T2
51	Problems on plane rigid jointed frames by flexibilty and stiffness matrix method	CO 4	T1,T2
52	Problems on boundary value problems	CO 5	T1,T2
53	Formulation of general one dimensional equilibrium problem.	CO5	T1,T2
54	Problems on shape functions for linear elements.	CO 6	T1,T2
55	Problems on modified galerkin method	CO 6	T1,T2
56	degree of freedom, statically indeterminate structure ,static indeterminacy and Kinematic Indeterminacy of Structures	CO 5	T1,T2
57	local and global coordinates, stiffness matrix	CO6	T1,T2
58	Distinction between flexibilty method and stiffness method	CO5	T1,T2
59	shape function, one and two diamensional element	CO6	T1,T2
60	Explain the Analysis Software based on the structure of a FEA program.	CO6	T1,T2
61	Explain about material nonlinearity	CO5	T1,T2
62	Minimum Potential Energy, the Variation Principle	CO6	T1,T2
63	Differentiate Between Linear and Nonlinear Analysis	CO6	T1,T2
DISCUSSION OF QUESTION BANK			
1	What is static indeterminacy and Kinematic Indeterminacy of Structures? solutionn for indeterminacy .	CO1	T1,T2
2	stiffness matrix problem solution for beam, truss and rigid frames	CO2	T1,T2
3	force method and displacement method	CO6,	T1,T2
4	shape function for one diamensional element	CO4	T1,T2
5	solution for modified galerkin method	CO5	T1,T2

Signature of Course Coordinator **HOD,CE**
Mr.Gude Ramakrishna.

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

STRUCTURAL DYNAMICS
COURSE TEMPLATE

1	Department	**CIVIL ENGINEERING (STRUCTURAL ENGINEERING)**				
2	Course Title	**STRUCTURAL DYNAMICS**				
3	Course Code	BSTD14				
4	Program	M. Tech (STE)				
5	Semester	II Semester				
6	Regulation	PG - 21				
7	Structure of the course	Theory			Practical	
		Lecture	Tutorials	Credits	Lab	Credits
		3	0	3	-	-
8	Type of course (**Tick type of course**)	Core	Professional Elective	Open Elective	VAC	MOOCs
		✓	-	-	-	-
9	Course Offered	Odd Semester X		Even Semester ✓		
10	**Total lecture, tutorial and practical hours for this course (16 weeks of teaching per semester)**					
	Lectures: ..... hours		Tutorials: ..... hours		Practical: ..... hours	
11	Course Coordinator	Dr. BDY Sunil				
12	Date Approved by BOS	DD/MM/YYYY				
13	Course Webpage	www.iare.ac.in/—-/—-				
14	Course Prerequistes	**Level**	**Course Code**	**Semester**	**Prerequisites**	
		B.Tech		I	Matrices and Calculus	
		B.Tech		I	XXXX	

15. COURSE OVERVIEW:

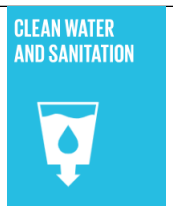
Structural Dynamics is of utmost importance for understanding the analysis and design consideration of structures subjected to dynamic loading. This course introduces the basic concepts of dynamic loading and the response of structures to such loads, and then uses these concepts to illustrate applications in practical structures. It begins with the derivation of the basic equations of motion for an ideal single degree-of-freedom structure using various approaches, and the solution of these equations for different types of loading. Further, the development of equations for multi-degree-of-freedom structures is considered, with multi-storied buildings as the example structures, and free and forced vibration response analysis of these multi-storied buildings shall be discussed.

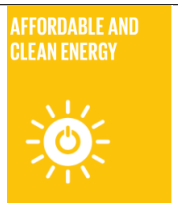
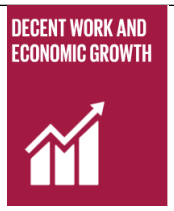
16. Employability Skills

Example: Communication skills / Programming skills / Project based skills /
Analytical skills / Problem-solving skills / Structural analysis skills
Mathematical modeling skills / Engineering judgment skills
STechnical communication skills / Project-based learning skills

17. Relevance to Sustainability goals

Write brief description about the course and how its relevance to SDGs.

1		
2		
3		
4		**Quality Education:**Enhancing technical knowledge and employability skills through engineering education.
5		
6		

7		
8		Developing problem-solving and project-based skills to increase employability and entrepreneurship opportunities.
9		Promoting innovation through mathematical modeling, structural analysis, and numerical methods to improve engineering practices.
10	10.png	
11		Applying engineering skills to design and maintain sustainable and resilient structures and communities.
12		
13		

14		
15		
16		
17		

18. Content Delivery / Instructional Methologies:

✓	 Power Point Pressentation	✓	 Chalk & Talk	✓	20.png Assignments	x	 MOOC
x	 Open Ended Experiments	x	 Seminars	x	 Mini Project	✓	 Videos

19. Evaluation Methodology:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), and and 05 marks for each Definitions and Terminology / Quiz and remaining 10 marks for Tech Talk / Assignments.

Table 2: Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	**CIA - I**	**CIA - II**	**SEE**	**Total Marks**
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 12 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
35%	Understand
55%	Apply

20. COURSE OBJECTIVES:

The students will try to learn:

I	The dynamics response of single and multi-degree freedom systems using fundamental theory and equations of motion.
II	The numerical solution of structural responses of different loading conditions for the design of structures.
III	The responses of structures subjected to earthquakes and blasts for the efficient and economic design of structures.

21. COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Explain** the concepts response of a system under vibrations on the structures for understanding the behavior of structures.	Understand
CO 2	**Outline** the concept of damped vibrations of single degree freedom systems for the analysis of structures subjected to dynamic loads.	Understand
CO 3	**Develop** the expressions for response of single degree freedom systems based on loading functionfor the response of structure used in design.	Apply
CO 4	**Develop** the equations of structural response to dynamic loads using Duhamel's integral and fourier analysis.	Apply
CO 5	**Analyse** the two-degree freedom systems subjected to free and forced vibrations for the design purpose.	Analyse
CO 6	**Analyse** the multiple degree of freedom systems to know the natural frequencies, modes and mode shapes using orthogonality and normality principles and superposition method.	Analyse

****
****

22. Topic Learning Outcome (TLOs):

TLO No	Topic Learning Outcome's	Course Outcome:	Blooms Level
TLO 1	Explain elasticity and stress-strain relationships.	CO 1	Understand
TLO 2	Analyze plane stress and plane strain conditions.	CO 1	Apply
TLO 3	Derive the equations of equilibrium in elasticity.	CO 1	Apply
TLO 4	Identify compatibility conditions in 2D stress fields.	CO 2	Understand
TLO 5	Solve boundary value problems in elasticity.	CO 2	Apply
TLO 6	Formulate Airy's stress function for 2D problems.	CO 2	Analyze
TLO 7	Apply St. Venant's principle in elasticity problems.	CO 2	Apply
TLO 8	Derive displacement equations from stress-strain relations.	CO 3	Apply
TLO 9	Solve for deflections in simple beams.	CO 3	Apply
TLO 10	Understand theory of vibrations and dynamic loading.	CO 1	Understand
TLO 11	Analyze free vibrations of undamped SDOF systems.	CO 1	Apply
TLO 12	Analyze damped vibrations of SDOF systems.	CO 2	Apply
TLO 13	Develop solutions for harmonic excitation problems.	CO 2	Apply
TLO 14	Derive response to periodic loads using Fourier series.	CO 3	Analyze
TLO 15	Apply Duhamel's integral to find system response.	CO 3	Analyze
TLO 16	Analyze free vibrations of undamped 2DOF systems.	CO 4	Analyze
TLO 17	Analyze forced vibrations of damped 2DOF systems.	CO 4	Analyze
TLO 18	Develop vibration isolation methods.	CO 5	Apply
TLO 19	Derive natural frequencies and mode shapes for MDOF.	CO 5	Analyze
TLO 20	Apply orthogonality principle in mode shapes.	CO 6	Analyze
TLO 21	Analyze superposition in MDOF systems.	CO 6	Analyze
TLO 22	Understand damping characteristics and measurements.	CO 2	Understand
TLO 23	Derive equivalent stiffness for combined systems.	CO 1	Apply
TLO 24	Solve differential equations using Laplace transforms.	CO 3	Analyze
TLO 25	Evaluate influence of gravitational forces in dynamic systems.	CO 1	Understand

23. SYLLABUS:

MODULE I	**THEORY OF VIBRATIONS**
	Introduction, basic concepts of vibration, dynamic loading, comparison of static loading and dynamic loading, causes od dynamic effects, basic definitions types of vibration, response of the system, degrees of freedom, SHM, Consequences of vibration. Introduction to undamped vibrations, vibration analysis, free vibration of undamped SDOF system, derivation of equation of motion, solution of the equation of motion, equivalent stiffness of spring combinations, natural frequency, time period, influence of gravitational force.
MODULE II	**DAMPED VIBRATIONS OF SDOF SYSTEM**

	Introduction types of damping, measurement of damping. Introduction to harmonic excitation, undamped harmonic excitation, damped harmonic excitation, characteristics curves, measurement of damping, vibration measuring instruments, vibration isolation.
MODULE III	**RESPONSE TO PERODIC AND IMPULSIVE LOADING**
	Introduction to periodic loading, Fourier series and analysis and response, derive an expression for the response of an SDOF system for the given loading function. Introduction to impulsive loading, differential equation method, Duhamel's integral.
MODULE IV	**TWO DEGREE OF FREEDOM SYSTEM**
	Introduction, concept of shear building, free vibrations of undamped system, damped free vibration, forced vibrations of undamped system, forced vibrations of damped system.
MODULE V	**MULTIPLE DEGREE OF FREEDOM SYSTEM**
	Introduction, Free vibration analysis, undamped system, natural frequencies and normal modes, orthogonality and normality principles, damped systems, decoupling of equations, superposition method, forced vibration.

TEXTBOOKS

1. S. Kavita and S. R. Damodaraswamy, "Basics of structural Dynamics and Aseismic Design", PHI Learning Pvt. Ltd., 1st Edition, 2012.
2. Clough R. W. and Penzien J, "Dynamics of Structures", 1st Edition, McGraw Hill, 1993.
3. Chopra A. K, "Structural Dynamics and Introduction to Earthquake Engineering", illustrated, Prentice Hall, 4th Edition, 2012.
4. Smith J. W, "Vibration of Structures - Application in Civil Engineering Design", Chapman and Hall, 1st Edition, 1988.

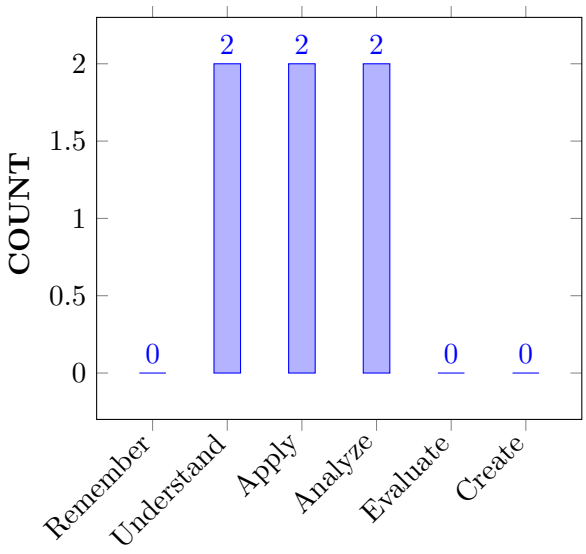
REFERENCE BOOKS:

1. Humar J. L., "Dynamics of Structures", Prentice Hall, 2nd Edition, 2002.
2. Paz Mario, "Structural Dynamics Theory and Computation", CBS Publication, 5th Edition, 2002.
3. Hart and Wong, "Dynamics of Structures", John Wiley, 1st Edition, 1999.

WEB REFERENCES:

1. http://nptel.ac.in/courses/105101006/

24. COURSE KNOWLEDGE COMPETENCY LEVEL



25. PROGRAM OUTCOMES:

Program Outcomes	
PO 1	An ability to Independently carry out research/investigation and development work to solve practical problems.
PO 2	An ability to Write and present a substantial technical report/document.
PO 3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
PO 4	Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields.
PO 5	Conceptualize and design civil engineering structures considering various socio-economic factors.
PO 6	Engage in life-long learning for continuing education in research-level studies and professional development.

26. HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	An ability to Independently carry out research/investigation and development work to solve practical problems.	1	CIE, SEE

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.	1	CIE, SEE
PO 4	Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields.	2	CIE, SEE
PO 5	Conceptualize and design civil engineering structures considering various socio-economic factors.	3	CIE, SEE

3 = High; 2 = Medium; 1 = Low

27. MAPPING OF EACH CO WITH PO(s):

Course Outcomes	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	-	✓	✓	-	-
CO 2	✓	-	-	✓	✓	-
CO 3	✓	-	✓	✓	✓	-
CO 4	✓	-	-	✓	✓	-
CO 5	-	-	✓	✓	✓	-
CO 6	-	-	✓	✓	-	-

28. JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO3	Analyze the given **problem statement** and find the response of the structures to establish innovative solutions in structural system and **Interpret the result** on various applications.	2
	PO4	Demonstrate the importance of structural response for solving society relevant problems for applying **knowledge, understanding and demonstrations of structural applications in real time scenario and use creativity to establish innovative solutions to get the solution development and communicate effectively in writing / orally societal problems.**	4

Course Outcomes	PO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO2	PO1	Independently carry out research / investigation by **resource identification, implementation and demonstrate the solution** related to a given structure using damped vibrations.	2
	PO4	Analyse the single degree freedom system with damped vibrations for the analysis of different structural elements by applying **knowledge, understanding and demonstrations of structural applications in real time scenario and use creativity to establish innovative solutions to get the solution development and communicate effectively in writing / orally societal problems.**	4
	PO5	Analyse the structural systems for the design of civil engineering structures understanding **experimental design, design process, requirements of engineering activities, legal requirements, safety and risk issues.**	4
CO3	PO1	Independently carry out research / investigation by **resource identification, implementation and demonstrate the solution** related to a given structure in terms of response for a given loading function.	2
	PO3	Analyze the given **problem statement** and find the structural response for different loading function to establish innovative solutions in structural system and **Interpret the results.**	2
	PO 4	Analyse the structural repsonse of a gien loading function by Selecting the appropriate method for different structural elements by applying **knowledge, understanding and demonstrations of structural applications in real time scenario and use creativity to establish innovative solutions to get the solution development and communicate effectively in writing / orally societal problems.**	4
	PO5	Analyse the structural systems for the design of civil engineering structures understanding **experimental design, design process, requirements of engineering activities, legal requirements, safety and risk issues.**	4
CO4	PO1	Independently carry out research / investigation by **resource identification, implementation and demonstrate the solution** related to a given structure and develop the structural reponse using duhamel's integration.	2

Course Outcomes	PO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO4	Apply the knowldege of duhamel's integration to get the response of a structure by applying **knowledge, understanding and demonstrations of structural applications in real time scenario and use creativity to establish solutions.**	2
	PO5	Analyse the structural systems for the design of civil engineering structures understanding **experimental design, design process, requirements of engineering activities, legal requirements, safety and risk issues.**	4
CO5	PO3	Analyze the given **problem statement** and find the response of a two degree freedom system subjected to free and forced vibrations to establish innovative solutions in structural system and **Interpret the results.**	2
	PO4	Demonstrate the importance of response of structure in analysing the two degree freedom system by applying **knowledge, understanding and demonstrations of structural applications in real time scenario and use creativity to establish solutions.**	2
	PO5	Utilize the concepts of response of structure for the analysis and design of civil engineering structures understanding **experimental design, design process, requirements of engineering activities, legal requirements, safety and risk issues.**	4
CO6	PO3	Analyze the given **problem statement** and find the solution of multiple degree freedom system for frequencies, modes and mode shapes using different methods for innovative solutions in structural system and **Interpret the result** on various applications.	2
	PO4	Analyse the multiple degree freedom systems for frequncies, modes and mode shapes by applying **knowledge, understanding and demonstrations of structural applications in real time scenario and use creativity to establish innovative solutions to get the solution development and communicate effectively in writing / orally societal problems.**	4

29. TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO MAPPING:

Course Outcomes	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	-	2	4	-	-
CO 2	2	-	-	4	4	-
CO 3	2	-	2	4	4	-

Course Outcomes	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 4	2	-	-	2	4	-
CO 5	-	-	2	2	4	-
CO 6	-	-	2	4	-	-

30. PERCENTAGE OF KEY COMPETENCIES FOR CO – PO

Course Outcomes	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	0.0	0.0	28.5	50.0	0.0	0.0
CO 2	28.5	0.0	0.0	50.0	80.0	0.0
CO 3	28.5	0.0	28.5	50.0	80.0	0.0
CO 4	28.5	0.0	0.0	25.0	80.0	0.0
CO 5	0.0	0.0	28.5	25.0	80.0	0.0
CO 6	0.0	0.0	28.5	50.0	0.0	0.0

31. COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.
0 - $0 \leq C \leq 5\%$ – No correlation
1 -$5 < C \leq 40\%$ – Low/ Slight
2 - $40\% < C < 60\%$ –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

Course Outcomes	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	0.0	0.0	1.0	2.0	0.0	0.0
CO 2	1.0	0.0	0.0	2.0	3.0	0.0
CO 3	1.0	0.0	1.0	2.0	3.0	0.0
CO 4	1.0	0.0	0.0	1.0	3.0	0.0
CO 5	0.0	0.0	1.0	1.0	3.0	0.0
CO 6	0.0	0.0	1.0	2.0	0.0	0.0
Total	2.0	0.0	3.0	10.0	12.0	0.0
Average	1	0	1	2	3	0

32. ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	✓
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	-	Open Ended Experiments	-
Assignments	✓				

33. ASSESSMENT METHODOLOGY-INDIRECT:

✓	Assessment of mini projects by experts	✓	End Semester OBE Feedback

34. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: R1:
OBE DISCUSSION			
1	Discussion on OBE, POs and COs of Structural Dynamics		
CONTENT DELIVERY (THEORY)			
1	Introduction	CO1	T1,T2
2	Basic concepts of vibration	CO1	T1,T2
3	Dynamic loading	CO1	T1,T2
4	Comparison of static loading and dynamic loading	CO1	T1,T2
5	Causes od dynamic effects	CO1	T1,T2
6	Basic definitions types of vibration	CO1	T1,T2
7	Degrees of freedom, SHM	CO1	T1,T2
8	Consequences of vibration	CO1	T1,T2
9	Introduction to undamped vibrations	CO1	T1,T2
10	Vibration analysis	CO1	T1,T2
11	Free vibration of undamped SDOF system	CO1	T1,T2
12	Derivation of equation of motion	CO2	T1,T2
13	Solution of the equation of motion	CO2	T1,T2
14	Equivalent stiffness of spring combinations	CO2	T1,T2
15	Natural frequency, time period	CO2	T1,T2
16	Influence of gravitational force	CO2	T1,T2
17	Introduction types of damping	CO2	T1,T2

18	Measurement of damping	CO2	T1,T2
19	Introduction to harmonic excitation	CO2	T1,T2
20	Undamped harmonic excitation	CO2	T1,T2
21	Damped harmonic excitation	CO2	T1,T2
22	Characteristics curves	CO2	T1,T2
23	Measurement of damping	CO3	T1,T2
24	Vibration measuring instruments	CO3	T1,T2
25	Vibration isolation	CO3	T1,T2
26	Introduction to periodic loading	CO3	T1,T2
27	Fourier series and analysis and response	CO3	T1,T2
28	Derive an expression for the response of an SDOF system for the given loading function	CO3	T1,T2
29	Derive an expression for the response of an SDOF system for the given loading function	CO3	T1,T2
30	Introduction to impulsive loading	CO4	T1,T2
31	Differential equation method	CO4	T1,T2
32	Duhamel's integral	CO4	T1,T2
33	Concept of shear building	CO5	T1,T2
34	Free vibrations of undamped system	CO5	T1,T2
35	Damped free vibration	CO5	T1,T2
36	Forced vibrations of undamped system	CO5	T1,T2
37	Forced vibrations of damped system	CO5	T1,T2
38	Free vibration analysis	CO6	T1,T2
39	Undamped system	CO6	T1,T2
40	Natural frequencies and normal modes	CO6	T1,T2
41	Orthogonality and normality principles	CO6	T1,T2
42	Damped systems, decoupling of equations	CO6	T1,T2
43	Superposition method	CO6	T1,T2
44	Forced vibration	CO6	T1,T2
45	Forced vibration examples	CO6	T1,T2
PROBLEM SOLVING/ CASE STUDIES			
1	Problems on equation of motion	CO 1	T1,T2
2	Problems on equivalent stiffness	CO 2	T1,T2
3	Problems on natural frequency and time period	CO 2	T1,T2
4	Problems on measurement of damping	CO 2	T1,T2
5	Problems on hormonic excitation of system	CO 2	T1,T2
6	Problems on fourier series and respose analysis	CO 3	T1,T2
7	Problems on response of single degree freedom system	CO 3	T1,T2

8	Problems on impulsive loading	CO 4	T1,T2
9	Problems on differential equation method	CO 4	T1,T2
10	Problems on duhamel's integral	CO 4	T1,T2
11	Problems on free and forced vibration undamped system	CO 5	T1,T2
12	Problems on free and forced vibration damped system	CO 5	T1,T2
13	Problems on natural frequencies and normal modes	CO 6	T1,T2
14	Problems on superposition method	CO 6	T1,T2
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Concepts of vibration, dynamic loading, comparison of static loading and dynamic loading, causes od dynamic effects, basic definitions types of vibration, response of the system, degrees of freedom, SHM, Consequences of vibration. Introduction to undamped vibrations, vibration analysis, free vibration of undamped SDOF system, derivation of equation of motion, solution of the equation of motion, equivalent stiffness of spring combinations, natural frequency, time period, influence of gravitational force	CO 1	T1,T2
2	Types of damping, measurement of damping. Introduction to harmonic excitation, undamped harmonic excitation, damped harmonic excitation, characteristics curves, measurement of damping, vibration measuring instruments, vibration isolation	CO2	T1,T2
3	Fourier series and analysis and response, derive an expression for the response of an SDOF system for the given loading function. Introduction to impulsive loading, differential equation method, Duhamel's integral.	CO3, CO4	T1,T2
4	Concept of shear building, free vibrations of undamped system, damped free vibration, forced vibrations of undamped system, forced vibrations of damped system.	CO5	T1,T2
5	Free vibration analysis, undamped system, natural frequencies and normal modes, orthogonality and normality principles, damped systems, decoupling of equations, superposition method, forced vibration.	CO6	T1,T2
DISCUSSION OF QUESTION BANK			
1	Concepts of vibration, dynamic loading, comparison of static loading and dynamic loading, causes od dynamic effects, basic definitions types of vibration, response of the system, degrees of freedom, SHM, Consequences of vibration. Introduction to undamped vibrations, vibration analysis, free vibration of undamped SDOF system, derivation of equation of motion, solution of the equation of motion, equivalent stiffness of spring combinations, natural frequency, time period, influence of gravitational force	CO1	T1,T2

2	Types of damping, measurement of damping. Introduction to harmonic excitation, undamped harmonic excitation, damped harmonic excitation, characteristics curves, measurement of damping, vibration measuring instruments, vibration isolation	CO2	T1,T2
3	Fourier series and analysis and response, derive an expression for the response of an SDOF system for the given loading function. Introduction to impulsive loading, differential equation method, Duhamel's integral.	CO3, CO4,	T1,T2
4	Concept of shear building, free vibrations of undamped system, damped free vibration, forced vibrations of undamped system, forced vibrations of damped system.	CO5	T1,T2
5	Free vibration analysis, undamped system, natural frequencies and normal modes, orthogonality and normality principles, damped systems, decoupling of equations, superposition method, forced vibration.	CO6	T1,T2

Signature of Course Coordinator **HOD,CE**
Dr. Venu M

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**CIVIL ENGINEERING**				
Course Title	**ADVANCED REINFORCED CONCRETE DESIGN**				
Course Code	BSTC15				
Program	M. Tech (STE)				
Semester	II				
Course Type	Elective				
Regulation	PG21				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Ms. Praveena Rao				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
			Reinforced Concrete Structures Design and Drawing

II COURSE OVERVIEW:

The Design of Advanced Concrete Structures course is designed for students to gain advanced knowledge and practical skills in the analysis and design of complex reinforced concrete structures. The course delves into the theoretical and applied aspects of designing reinforced concrete members under various loading conditions, including flexure, shear, torsion, and serviceability limits. It also explores the design of specialized concrete systems such as ribbed and flat slabs, deep beams, corbels, and the integration of advanced methods for analyzing the behavior of structures, including limit analysis and yield line theory. The course provides an in-depth understanding of designing reinforced concrete structures for real-world applications, such as chimneys, bunkers, and silos, while addressing key challenges such as wind loads, temperature changes, and the effect of material properties on structural behavior.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Design of Advanced Concrete Structures	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

Each theory course will be evaluated for a total of 100 marks, out of which 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE).

Semester End Examination (SEE): The SEE shall be conducted for 60 marks of 3 hours duration. The syllabus for the theory courses shall be divided into FIVE modules and each module 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 12 marks. There could be a maximum of two / three sub divisions in a question.

The emphasis on the questions is broadly based on the following criteria given in below Table.

50%	To test the objectiveness of the concept
30 %	To test the analytical skill of the concept
20%	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. CIA is conducted for a total of 40 marks, with 30 marks for Continuous Internal Examination (CIE), 05 marks for Assignment and 05 marks for Alternative Assessment Tool (AAT). **Two CIE Tests are Compulsory** and sum of the two tests, along with the scores obtained in the assignment and AAT shall be considered for computing the final CIA of a student in a given course.

The CIE Tests/Assignment /AAT shall be conducted by the course faculty with due approval from the HOD. Advance notification for the conduction of Assignment/AAT is mandatory and the responsibility lies with the concerned course faculty.

Component		Marks	Total Marks
CIA - 1	Continuous Internal Examination	10	20
	Assignment or Quiz	5	
	Alternative Assessment Tool (AAT)	5	
CIA - 2	Continuous Internal Examination	10	20
	Assignment or Quiz	5	
	Alternative Assessment Tool (AAT)	5	
SEE	Semester End Examination (SEE)	60	60
Total Marks			100

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8 th and 16 th week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered. The valuation and verification of answer scripts of CIE exams shall be completed within a week after the conduct of the Examination.

Assignment: To improve the writing skills in the course an assignment will be evaluated for 05 marks. Assignment has to submit either at the end of the CIE1 or CIE2 for the questions provided by each course coordinator in that semester. Assignments to be handed in as loose paper collection stapled together at the top left corner. The assignment should be presented as a professional report. It must consist of a cover sheet, content page, and should have an introduction, a body, a conclusion or recommendation, and a reference page.

Quiz: It is online proctor based online examination conducted either at the end of the CIE1 or CIE2. The choice of conduction of Assignment / Quiz in CIE1 or CIE2 is purely choice of course handling faculty.

Alternative Assessment Tool (AAT): In order to encourage innovative methods while delivering a course, the faculty members are encouraged to use the Alternative Assessment Tool (AAT). This AAT enables faculty to design own assessment patterns during the CIA. The AAT enhances the autonomy (freedom and flexibility) of individual faculty and enables them to create innovative pedagogical practices. If properly applied, the AAT converts the classroom into an effective learning center. The AAT may include, Course related term paper, Technical seminar, Term paper, Case Study, Paper presentations conducted by reputed organizations relevant to the course etc.

VI COURSE OBJECTIVES:

The students will try to learn:

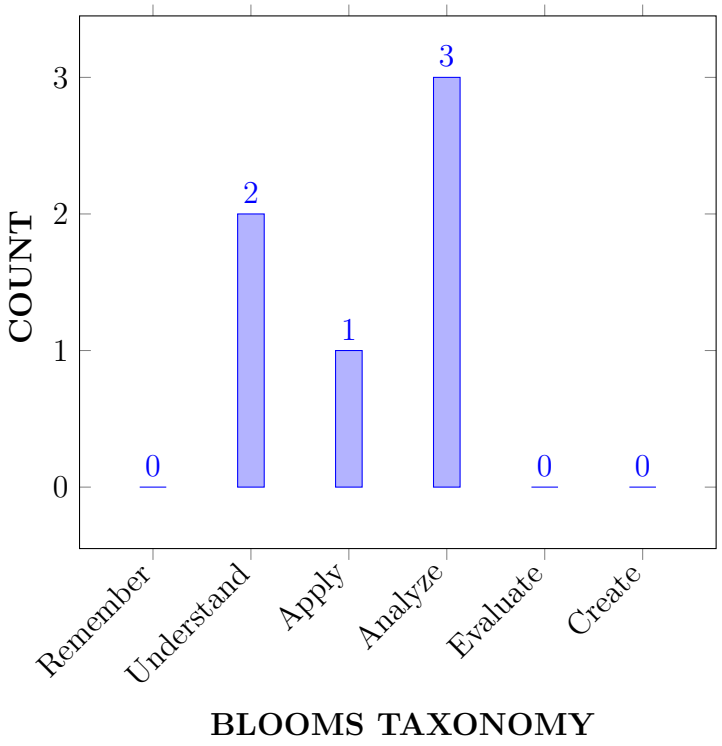
I	The design concepts of complex reinforced concrete structural elements, including beams, slabs, deep beams, and corbels based on limit state design principles.
II	The limit analysis and yield line theory, for assessing the behavior of complex reinforced concrete structures in compliance with IS code provisions for safety, serviceability, and sustainability.
III	The design of specialized concrete structures such as ribbed and flat slabs, chimneys, bunkers, and silos for like shear, torsion and deflection control.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Explain** the behaviour of reinforced concrete under flexure and shear for designing beams, slabs and columns under various load condition.	Understand
CO 2	**Explain** the concepts of plastic hinge and plastic moment for understanding the redistribution of moments and moment rotation characteristics of reinforced concrete members.	Understand
CO 3	**Analyse** flat and ribbed slabs under given loading for designing and obtaining thereinforcement detailing in end and middle strips of the slab.	Analyze
CO 4	**Analyze** the load distribution in deep beams for designing and fixing of reinforcement details in deep beams.	Analyze
CO 5	**Develop** the concept of axial, uni-axial and bi-axial loading on compression members for designing the same to meet the safety and serviceability conditions.	Apply
CO 6	**Analyse** the soil properties for designing various types of footings for transferring the superimposed loads safely to the soil beneath.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	An ability to Independently carry out research/ investigation and development work to solve practical problems.
PO 2	An ability to write and present a substantial technical report/ document.
PO 3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
PO 4	Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields.
PO 5	Conceptualize and design civil engineering structures considering various socio-economic factors.
PO 6	Engage in life-long learning for continuing education in research-level studies and professional development.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	An ability to Independently carry out research/investigation and development work to solve practical problems.	1	CIE, SEE
PO 3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.	1	CIE, SEE

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 4	Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields.	2	CIE, SEE
PO 5	Conceptualize and design civil engineering structures considering various socio-economic factors.	3	CIE, SEE

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s):

Course Outcomes	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓	-	-	✓	✓	-
CO 2	-	-	-	✓	✓	-
CO 3	✓	-	✓	✓	✓	-
CO 4	✓	-	✓	✓	✓	-
CO 5	-	-	✓	✓	✓	-
CO 6	-	-	✓	✓	✓	-

XI JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO1	Analyze the given **problem statement** for design of singly reinforced, doubly reinforced rectangular sections and flanged beams and **Interpret the result** for various applications.	2
	PO4	Demonstrate the importance of design of singly reinforced, doubly reinforced rectangular sections and flanged beams for solving society relevant problems for applying **knowledge, understanding and demonstrations of structural applications in real time scenario and use creativity to establish innovative solutions to get the solution development and communicate effectively in writing / orally societal problems.**	4
	PO5	Demonstrate the importance of design of singly reinforced, doubly reinforced rectangular sections and flanged beams problems for applying **knowledge, understanding and demonstrations of structural applications in real time scenario and use creativity to establish innovative solutions to get the solution development and communicate effectively in writing / orally societal problems.**	4

Course Outcomes	PO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 2	PO4	Analyse plastic hinge and plastic moment for **the knowledge, understanding and demonstrations of structural applications in real time scenario and use creativity to establish innovative solutions to get the solution development and communicate effectively in writing / orally societal problems.**	4
	PO5	Analyse the plastic hinge and plastic moment for redistribution of moments and moment rotation for **experimental design, design process, requirements of engineering activities, legal requirements, safety and risk issues.**	4
CO3	PO1	Independently carry out research / investigation by **resource identification, implementation and demonstrate the solution** for flat and ribbed slabs under given loading for designing.	2
	PO3	Analyze the given **problem statement** for designing flat and ribbed slabs under given loading to establish innovative solutions in structural system and **Interpret the results.**	2
	PO 4	Analyze flat and ribbed slabs under given loading for designing and obtaining **knowledge, understanding structural applications in real time scenario and use creativity to establish innovative solutions to get the solution development and communicate effectively in writing / orally societal problems.**	4
	PO5	Analyze the structural systems for the design of civil engineering structures understanding **experimental design, design process, requirements of engineering activities, legal requirements, safety and risk issues.**	4
CO4	PO1	Independently carry out research / investigation by **resource identification, implementation and demonstrate the solution** the load distribution in deep beams for designing.	2
	PO3	Independently carry out research / investigation by **resource identification, implementation and demonstrate the solution** designing and fixing of reinforcement details in deep beams.	2
	PO4	Apply the knowledge of load distribution in deep beams for designing and reinforcement detailing **knowledge and demonstrations of structural applications in real time scenario and use creativity to establish solutions.**	2
	PO5	Analyze the structural systems for the design of civil engineering structures understanding **experimental design, design process, requirements of engineering activities, legal requirements, safety and risk issues.**	4

Course Outcomes	PO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO5	PO3	Analyze the given **problem statement** and design the corbels, nibs and curved beams by following the provisions stated in IS 456 establish to find innovative solutions in structural system and **Interpret the results.**	2
	PO4	Demonstrate the importance of corbels, nibs and curved beams to obtain **knowledge, understanding and demonstrations of structural applications in real time scenario and use creativity to establish solutions.**	2
	PO5	Utilize the design concepts for corbels, nibs and curved beams by following the provisions stated in IS 456 for addressing local failure checks for **experimental design, design process, requirements of engineering activities, legal requirements, safety and risk issues.**	4
CO6	PO3	Analyze the given **problem statement** and find the design solution for specialized concrete structures such as chimneys, bunkers, and silos **Interpret the result** on various applications.	2
	PO4	Analyse specialized concrete structures such as chimneys, bunkers, and silos for self-weight, wind load, temperature differences using the **knowledge, understanding and demonstrations of structural applications in real time scenario and use creativity to establish innovative solutions to get the solution development and communicate effectively in writing / orally societal problems.**	4
	PO5	Analyse specialized concrete structures such as chimneys, bunkers, and silos and apply the **knowledge, understanding and demonstrations of structural applications in real time scenario and use creativity to establish innovative solutions to get the solution development and communicate effectively in writing / orally societal problems.**	4

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO MAPPING:

Course Outcomes	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	-	4	4	-	-
CO 2	-	-	-	4	4	-
CO 3	2	-	2	4	4	-
CO 4	2	-	2	2	4	-
CO 5	-	-	2	2	4	-
CO 6	-	-	2	4	4	-

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO

Course Outcomes	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	50	-	-	67	80	-
CO 2	-	-	-	67	80	-
CO 3	50	-	25	67	80	-
CO 4	50	-	25	33.34	80	-
CO 5	-	-	25	33.34	80	-
CO 6	-	-	25	67	80	-

XIV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.
0 - $0 \leq C \leq 5\%$ – No correlation
1 -$5 < C \leq 40\%$ – Low/ Slight
2 - $40\% < C < 60\%$ –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

Course Outcomes	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	-	-	3	3	-
CO 2	-	-	-	3	3	-
CO 3	2	-	1	3	3	-
CO 4	2	-	1	1	3	-
CO 5	-	-	1	1	3	-
CO 6	-	-	1	3	3	-
Total	6.0	0.0	4.0	14.0	18.0	0.0
Average	2	0	1	2.33	3	0

XV ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	✓
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	-	Open Ended Experiments	-
Assignments	✓				

XVI ASSESSMENT METHODOLOGY-INDIRECT:

✓	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVII SYLLABUS:

MODULE I	**BASIC DESIGN CONCEPTS**
	Behavior in flexure, design of singly reinforced rectangular sections, design of doubly reinforced rectangular sections, design of flanged beams, design of shear, design for torsion, Limit state of serviceability: Deflections of reinforced concrete beams and slabs, short term deflection and long-term deflection, estimation of crack width in RCC members, calculation of crack widths.
MODULE II	**LIMIT ANALYSIS OF R.C. STRUCTURES**
	Rotation of a plastic hinge, redistribution of moments, moment rotation characteristics of RC member, I.S. code provisions, applications for fixed and continuous beam. Yield line analysis for slabs: Upper bound and lower bound theorems, yield line criterion, virtual work and equilibrium methods of analysis for square and circulars labs with simple and continuous end conditions.
MODULE III	**DESIGN OF RIBBED SLABS, FLAT SLABS**
	Analysis of the slabs for moment and shears, ultimate moment of resistance, design for shear, deflection, arrangement of reinforcements. Flat slabs: Direct design method, distribution of moments in column strips and middle strip moment. Shear transfer from slabs to columns, shear in flat slabs, check for one way and two-way shears, introduction to equivalent frame method. Limitations of direct design method, distribution of moments in column strips and middle strip.
MODULE IV	**DESIGN OF REINFORCED CONCRETE DEEP BEAMS & CORBELS**
	Steps of designing deep beams, design by IS 456, checking for local failures, detailing of deep beams, design of curved beams, analysis of forces in a corbel, design of procedure of corbels, design of nibs.
MODULE V	**DESIGN OF COMPRESSION MEMBERS**
	Estimation of effective length of a column, code requirements on slenderness limits, design of short columnsunder axial compression, design of short columns with uni-axial bending, design of short columns under biaxialbending, design of slender columns. Design of combined footings, distribution of soil Pressure, geometry oftwo Column combined footing, design considerations in combined footing for two, columns.

TEXTBOOKS

1. Pillai S. U. and Menon D, Reinforced Concrete Design", Tata McGraw-Hill, 3rd edition, 1999.
2. Reinforced concrete design by S. Unnikrishna Pillai & Menon, Tata McGraw Hill, 3rd edition, 2009.
3. Park R. and Paulay T, "Reinforced Concrete Structures", John Wiley & Sons, 1995.

REFERENCE BOOKS:

1. Varghese P. C, "Advanced Reinforced Concrete Design", Prentice Hall of India, New Delhi, 1995.
2. Hsu T. T. C. and Mo Y. L, "Unified Theory of Concrete Structures", John Wiley & Sons, 2010.
3. Salmon C. G., Johnson J. E. and Malhas F. A. "Steel Structures Design and Behavior Emphasizing Load and Resistance Factor Design", Pearson Education, 5th Edition, 2009.

4. Ramchandra, “Design of Steel Structures”, Vol. II, Standard Book House, Delhi, 1999.

WEB REFERENCES:

1. https://lecturenotes.in/course/179/design-of-advanced-concrete-structures-dacs
2. http://nptel.ac.in/downloads/105105104/

COURSE WEB PAGE:

XVIII COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: R1:
OBE DISCUSSION			
1	Discussion on OBE, POs and COs of Advanced Reinforced Concrete Design		
CONTENT DELIVERY (THEORY)			
1	Introduction to bending in reinforced concrete. Study of stress-strain behavior in concrete and reinforcement.	CO1	T1,T2
2	Types of beams, their classification, and bending moments. Moment-curvature relationship.	CO1	T1,T2
3	Introduction to singly reinforced beams.	CO1	T1,T2
4	Assumptions in flexural design.	CO1	T1,T2
5	Calculation of moment of resistance. Design procedure for singly reinforced sections.	CO1	T1,T2
6	Design of Doubly Reinforced Rectangular Sections. Differences between singly and doubly reinforced beams.	CO1	T1,T2
7	Moment-curvature and ultimate strength considerations.	CO1	T1,T2
8	Design procedure for doubly reinforced sections.	CO1	T1,T2
9	Design of Flanged Beams and Types of flanged beams.	CO1	T1,T2
10	Analysis and design considerations of flanged beams.	CO1	T1,T2
11	Flanged beam cross-sections: Wider flanges vs. narrow flanges.	CO1	T1,T2
12	Design for flanged beams according to IS 456.	CO2	T1,T2
13	Design for Shear. Shear stress distribution in reinforced concrete beams.	CO2	T1,T2
14	Shear strength and shear reinforcement design.	CO2	T1,T2
15	Design of shear reinforcement (stirrups, ties, etc.).	CO2	T1,T2
16	Design for Torsion. Introduction to torsion in reinforced concrete beams.	CO2	T1,T2
17	Torsional stress distribution. Design procedure for torsion in beams and slabs.	CO2	T1,T2
18	Limit State of Serviceability. Deflections in reinforced concrete beams and slabs.	CO2	T1,T2
19	Introduction to Short-term and long-term deflections.	CO2	T1,T2
20	Calculating crack widths and their significance in design.	CO2	T1,T2
21	Case study analysis on design of beams and serviceability checks.	CO2	T1,T2
22	Rotation of Plastic Hinge and Moment Redistribution. Introduction to plastic hinges.	CO2	T1,T2
23	Understanding moment redistribution in R.C. structures.	CO3	T1,T2
24	Moment-Rotation Characteristics of RC Members.	CO3	T1,T2
25	Moment-curvature diagrams and their implications.	CO3	T1,T2

26	Moment rotation characteristics for different R.C. members.	CO3	T1,T2
27	Application to design and analysis of continuous beams.	CO3	T1,T2
28	IS Code Provisions for Limit Analysis and provisions for limit analysis of RC structures.	CO3	T1,T2
29	Understanding the yield line theory and its applications.	CO3	T1,T2
30	Analysis of fixed and continuous beams based on IS code.	CO4	T1,T2
31	Yield Line Analysis for Slabs (Upper and Lower Bound Theorems).	CO4	T1,T2
32	Virtual Work and Equilibrium Methods for Slabs.	CO4	T1,T2
33	Analysis and Design of Continuous and Simple Slabs.	CO5	T1,T2
34	Solving problems involving yield line analysis of slabs.	CO5	T1,T2
35	Analysis of Ribbed Slabs for Moment and Shears. Introduction to ribbed slabs.	CO5	T1,T2
36	Ultimate moment capacity and its calculation.Reinforcement detailing for ribbed slabs.	CO5	T1,T2
37	Steps of designing deep beams, design by IS 456.	CO5	T1,T2
38	checking for local failures, detailing of deep beams.	CO6	T1,T2
39	Analysis and design of curved beams.	CO6	T1,T2
40	Analysis of forces in a corbel, design of procedure of corbels.	CO6	T1,T2
41	Design of chimneys: parts of chimney, design factors	CO6	T1,T2
42	Stresses in RC shafts due to self-weight, wind load and reinforcement details.	CO6	T1,T2
43	Design of bunkers and silos: Difference between bunker and silo.	CO6	T1,T2
44	Analysis and design of square or rectangular bunkers.	CO6	T1,T2
45	design of circular bunkers, design of silos: Design concepts and IS code provisions.	CO6	T1,T2
PROBLEM SOLVING/ CASE STUDIES			
1	Problems on design of singly reinforced rectangular beams	CO 1	T1,T2
2	Problems on design of doubly reinforced rectangular beams	CO 2	T1,T2
3	Problems on design of flanged beams	CO 2	T1,T2
4	Problems on design of shear and torsion	CO 2	T1,T2
5	Problems on Deflections of reinforced concrete beams and slabs	CO 2	T1,T2
6	Problems on short term and long-term deflection	CO 3	T1,T2
7	Problems on estimation of crack width in RCC members	CO 3	T1,T2
8	Problems on rotation of a plastic hinge	CO 4	T1,T2
9	Problems on Yield line analysis for slabs	CO 4	T1,T2
10	Problems on Analysis of the slabs for moment, shears and ultimate moment of resistance	CO 4	T1,T2
11	Problems on designing deep beams IS 456 and checking for local failures	CO 5	T1,T2
12	Problems on Flat slabs by direct design method	CO 5	T1,T2
13	Problems on Design of chimneys	CO 6	T1,T2
14	Problems on Design of bunkers and silos	CO 6	T1,T2

DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Objectives of the design of reinforced concrete structure.	CO 1	T1,T2
2	Types of reinforcements used to resist shear? Explain the action of different types of shear steel.	CO2	T1,T2
3	Considerations that govern thickness of one way and two way slabs.	CO3, CO4	T1,T2
4	Role of transverse steel ties in reinforced concrete columns.	CO5	T1,T2
5	Design of different types of shear reinforcements.	CO6	T1,T2
DISCUSSION OF QUESTION BANK			
1	Find out the ultimate moment of resistance of a rectangular beam 300 mm x 550 mm. the area of tension and compression reinforcement are 250mm2 and 400 mm2 respectively. Take effective cover as 50 mm. Assume M 25 grade of concrete and Fe 415 steel	CO1	T1,T2
2	Calculate the moment of resistance of a existing Tbeam bf= 740 mm and effective depth d= 400 mm, width of web bw=240 mm, Df= 100 mm. 5 No of 20 mm dia bars is inserted in beam. Use M15 grade concrete and Fe 415 bars.	CO2	T1,T2
3	Design an interior panel of a flat slab with 4 m x 5 m dimensions, for a superimposed load of 7.75 kN/m2. Provide two-way reinforcement. Use M15 concrete.	CO3, CO4,	T1,T2
4	Design a continuous deep beam having more than 3 spans and loaded a UDL of 180KN/m inclusive of self weight for the beam the clear span 5 mts. width of supports 300 mm beam thickness 250 mm. Overall thickness of beam is 3.5 mts. The material used are M20 HYSD bars of 415.	CO5	T1,T2
5	Design the reinforcement in a column of size 450 mm 600 mm, subject to an axial load of 2000 kN under service dead and live loads. The column has an unsupported length of 3.0 m and is braced against sideway in both directions. Use M 20 concrete and Fe 415 steel	CO6	T1,T2

Signature of Course Coordinator **HOD,CE**
Ms. Praveena Rao

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

REHABILITATION & RETROFITTING OF STRUCTURES COURSE TEMPLATE

1	Department	**CIVIL ENGINEERING (STRUCTURAL ENGINEERING)**				
2	Course Title	**REHABILITATION & RETROFITTING OF STRUCTURES**				
3	Course Code	BSTD22				
4	Program	M. Tech (STE)				
5	Semester	II Semester				
6	Regulation	PG - 21				
7	Structure of the course	Theory			Practical	
		Lecture	Tutorials	Credits	Lab	Credits
		3	0	3	-	-
8	Type of course (**Tick type of course**)	Core	Professional Elective	Open Elective	VAC	MOOCs
		✓	-	-	-	-
9	Course Offered	Odd Semester X		Even Semester ✓		
10	**Total lecture, tutorial and practical hours for this course (16 weeks of teaching per semester)**					
	Lectures: ..... hours		Tutorials: ..... hours		Practical: ..... hours	
11	Course Coordinator	Dr. BDY Sunil				
12	Date Approved by BOS	DD/MM/YYYY				
13	Course Webpage	www.iare.ac.in/—-/—-				
14	Course Prerequistes	**Level**	**Course Code**	**Semester**	**Prerequisites**	
		B.Tech		I	Matrices and Calculus	
		B.Tech		I	XXXX	

15 COURSE OVERVIEW:

The main purpose of this course is to introduce the concept of Rehabilitation, retrofitting and study how to overcome the defects in regular construction practices, establish their effectiveness in overcoming the problems faced, study their efficiency. The course covers the Retrofitting components in addition to adapting new techniques in construction practices. Retrofitting aims to 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 applications include different types of buildings, industrial structures, bridges, urban transport structures, marine structures and earth retaining structures. 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. Some of the applications of this course are restoring the structural integrity and performance,modifying the geometry, configuration, or functionality of existing structures to suit changing needs or demands.

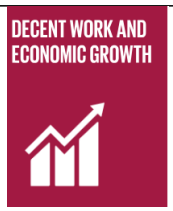
16. Employability Skills

Example: Communication skills / Programming skills / Project based skills /
Analytical skills / Problem-solving skills / Structural analysis skills
Mathematical modeling skills / Engineering judgment skills
STechnical communication skills / Project-based learning skills

17. Relevance to Sustainability goals

Write brief description about the course and how its relevance to SDGs.

1		
2		
3		
4		**Quality Education:**Enhancing technical knowledge and employability skills through engineering education.
5		

6		
7		
8		Developing problem-solving and project-based skills to increase employability and entrepreneurship opportunities.
9		Promoting innovation through mathematical modeling, structural analysis, and numerical methods to improve engineering practices.
10		
11		Applying engineering skills to design and maintain sustainable and resilient structures and communities.
12		

13		
14		
15		
16		
17		

18. Content Delivery / Instructional Methologies:

✓	 Power Point Pressentation	✓	 Chalk & Talk	✓	 Assignments	x	 MOOC
x	 Open Ended Experiments	x	 Seminars	x	 Mini Project	✓	 Videos

19. Evaluation Methodology:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), and and 05 marks for each Definitions and Terminology / Quiz and remaining 10 marks for Tech Talk / Assignments.

Table 2: Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	CIA - I	CIA - II	SEE	Total Marks
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 12 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
35%	Understand
55%	Apply

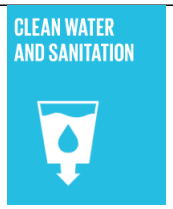
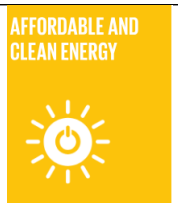
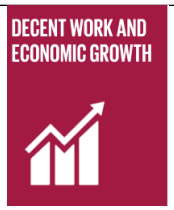
16. Employability Skills

Example: Communication skills / Programming skills / Project based skills /
Analytical skills / Problem-solving skills / Structural analysis skills
Mathematical modeling skills / Engineering judgment skills
STechnical communication skills / Project-based learning skills

17. Relevance to Sustainability goals

Write brief description about the course and how its relevance to SDGs.

1		
2		

3		
4		**Quality Education:**Enhancing technical knowledge and employability skills through engineering education.
5		
6		
7		
8		Developing problem-solving and project-based skills to increase employability and entrepreneurship opportunities.
9		Promoting innovation through mathematical modeling, structural analysis, and numerical methods to improve engineering practices.

10		
11		Applying engineering skills to design and maintain sustainable and resilient structures and communities.
12		
13		
14		
15		
16		

17		

18. Content Delivery / Instructional Methologies:

✓	 Power Point Pressentation	✓	 Chalk & Talk	✓	 Assignments	x	 MOOC
x	 Open Ended Experiments	x	 Seminars	x	 Mini Project	✓	 Videos

19. Evaluation Methodology:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), and and 05 marks for each Definitions and Terminology / Quiz and remaining 10 marks for Tech Talk / Assignments.

Table 5: Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	**CIA - I**	**CIA - II**	**SEE**	**Total Marks**
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 12 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	**Blooms Taxonomy Level**
10%	Remember
35%	Understand
55%	Apply

20. COURSE OBJECTIVES:

The students will try to learn:

I	The basic concepts of degradation, damage grades in civil structures for evaluating Structural performance by using rehabilitation and retrofitting methods.
II	The knowledge on structural maintenance, repairs and rehabilitation for obtaining assessment of damage in construction failure.
III	The mechanism of corrosion and surface deterioration in structures for preventing structural damage.
IV	The application of special materials for improving the performance of the traditional structures.
V	The application of modern techniques in existing structures for strengthening and demolition in real time situations.

21 COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Explain** the damage mechanism and preventive measures for protecting the structure from damages.	Understand
CO 2	**Interpret** the importance and facets of maintenance for scheduling regular inspection of residential and industrial structures.	Understand
CO 3	**Summarize** corrosion protection methods of steel and deterioration of materials for protecting structures from rusting and fatigue failures.	Understand
CO 4	**Identify** the materials and technics of repair for rehabilitation and retrofitting of structures.	Remember
CO 5	**Make use of** non-destructive testing procedures, demolition methods for assessing and improving the performance of structures.	Apply
CO 6	**Select** uitable engineered and non-engineered techniquesin existing structures for strengthening and demolition.	Apply

22. Topic Learning Outcome (TLOs):

TLO No	Topic Learning Outcome's	Course Outcome:	Blooms Level
TLO 1	Elasticity, notation for forces and stresses, components of stresses, components of strain, Hooke's law.	CO 1	Understand
TLO 2	Constitutive relationships for stress and strain in linear elastic solids.	CO 1	Create
TLO 3	Plane stress and plane strain analysis.	CO 1	Analyze
TLO 4	Differential equations of equilibrium and compatibility conditions.	CO 1	Understand
TLO 5	Airy's stress function and boundary conditions.	CO 2	Apply
TLO 6	Solution of two-dimensional problems in rectangular coordinates.	CO 2	Apply
TLO 7	Solution of two-dimensional problems in polar coordinates.	CO 2	Analyze
TLO 8	Principal stresses, principal strains, and stress invariants.	CO 2	Analyze
TLO 9	Stress distribution in beams under bending.	CO 3	Analyze
TLO 10	Stress distribution in beams under shear.	CO 3	Apply
TLO 11	Torsion of circular shafts and thin-walled tubes.	CO 3	Understand
TLO 12	Torsion of non-circular sections.	CO 3	Analyze
TLO 13	Strain energy and energy methods in elasticity.	CO 4	Understand
TLO 14	Castigliano's theorems and applications to beams and frames.	CO 4	Apply
TLO 15	Introduction to stiffness method for elasticity problems.	CO 4	Create
TLO 16	Differential equations for displacement and stresses in elasticity.	CO 4	Apply
TLO 17	Finite element basics for stress and deformation analysis.	CO 5	Understand
TLO 18	Torsion of prismatic bars with different cross-sections.	CO 5	Analyze
TLO 19	Stress concentration factors and their significance.	CO 5	Analyze
TLO 20	Introduction to plasticity: concepts and assumptions.	CO 6	Understand
TLO 21	Ideally plastic solids and yield criteria.	CO 6	Analyze
TLO 22	Strain hardening and plastic potential surfaces.	CO 6	Analyze
TLO 23	Flow rule and stress-strain relations in plasticity.	CO 6	Analyze
TLO 24	Multi-axial loading and yield surface evolution.	CO 6	Analyze
TLO 25	Application of different yield criteria to engineering problems.	CO 6	Analyze

23. SYLLABUS:

MODULE- I	**INTRODUCTION**
	Deterioration of structures; distress in structures; causes and prevention, mechanism of damage; types of damage; damage under accidental and cyclic loads, cracking in structures, evaluation of damage.
MODULE- II	**MAINTENANCE AND DIAGNOSIS OF FAILURE**
	Maintenance, repair and rehabilitation, facets of maintenance, importance of maintenance, various aspects of inspection; Assessment procedure for evaluating a damaged structure; Diagnosis of construction failures.
MODULE- III	**DAMAGES AND THEIR REMEDIES**
	Corrosion damage of reinforced concrete, methods of corrosion protection, corrosion inhibitors, corrosion resistant steels, cathodic protection, rust eliminators. Causes of deterioration of concrete, steel, masonry and timber structures, surface deterioration, efflorescence, causes and preventive measures; coatings for embedded steel and set concrete.
MODULE- IV	**MATERIALS AND TECHNIQUES OF REPAIR**
	Special concrete and mortar, concrete chemicals, expansive cement, polymer concrete sulphur infiltrated concrete, ferro cement, fiber reinforced concrete, methods of repair in concrete, steel, masonry and timber structures. Gunite and shotcrete, epoxy injection.

MODULE- V	**STRENGTHENING AND DEMOLITION ASPECT**
	Strengthening of existing structures; repairs to overcome low member strength, deflection, cracking, chemical disruption, weathering, wear, fire, leakage, marine exposure, use of non-destructive testing techniques for evaluation, load testing of structure; demolition of structures using engineered and non-engineered techniques; case studies.

TEXTBOOKS

1. Shetty .M.S., "Concrete, Technology", Theory and Practice, S.Chand and Company, New Delhi 2010.
2. 2. Allen .R.T. and Edwards .S.C., "Repair of Concrete Structures" Blakie and Sons, UK 1987.

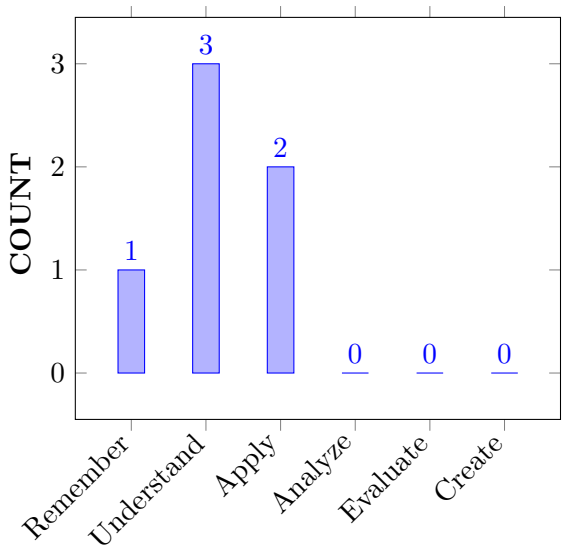
REFERENCE BOOKS:

1. Raiker .R.N. "Learning from Failures, Deficiencies in Design, Construction and Service", R&D Centre (SDCPL), RaikarBhavan, Bombay 1987.
2. "Repair & Rehabilitation" "Compilation from The Indian Concrete Journal", - ACC - RCD Publication 2001.
3. Revision compbell, Allen and Itarold Roper, "Concrete Structures Materials Maintenance and Repair" Longman Scientific and Technical UK 1991.

WEB REFERENCES:

1. http://nptel.ac.in/courses/105102088/
2. http://nptel.ac.in/courses/105101088/

24. COURSE KNOWLEDGE COMPETENCY LEVEL



BLOOMS TAXONOMY

25. PROGRAM OUTCOMES:

Program Outcomes	
PO 1	An ability to Independently carry out research/investigation and development work to solve practical problems.
PO 2	An ability to Write and present a substantial technical report/document.
PO 3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
PO 4	Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields.
PO 5	Conceptualize and design civil engineering structures considering various socio-economic factors.
PO 6	Engage in life-long learning for continuing education in research-level studies and professional development.

26. HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	Engineering knowledge: Apply the knowledge of mathematics, science, engineeringfundamentals, and an engineering specialization to the solution of complex engineering problems.	2	CIE/SEE/AAT

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 2	Problem analysis: Identify, formulate, review research literature, and analyze complexengineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	1	CIE/SEE/AAT
PO 3	Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	1	CIE/SEE/AAT
PO 4	Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	CIE/SEE/AAT
PO 5	Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations.	3	CIE/SEE/AAT

3 = High; 2 = Medium; 1 = Low

27. MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	-	-	-	-	-	-	-	-	✓	-	-
CO 2	-	-	✓	✓	-	-	-	-	-	-	-	-	✓	✓	-
CO 3	✓	✓	-	✓	-	-	-	-	-	-	-	-	✓	✓	-
CO 4	✓	-	✓	-	✓	-	-	-	-	-	-	-	-	✓	-
CO 5	-	-	-	✓	✓	-	-	-	-	-	-	-	-	-	-
CO 6	-	-	-	✓	✓	-	-	-	-	-	-	-	✓	-	-

28. JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of key competencies matched.
CO 1	PO 1	Explain the mechanism of damages involved in the deterioration by using **engineering fundamentals and principles of science.**	2
	PO 2	**Identify** the damages based on the symptoms and develop the solutions to prevent the **deterioration of structures**	2
	PSO 1	Explain the mechanism of damages caused due to **environmental impacts** on residential, industrial buildings, **water treatment and distribution systems** based on **material knowledge** to **ensure the quality of structures** and to improve efficiency of **retrofitting techniques.**	5
CO 2	PO 3	Describe the importance of **aesthetics** and **maintenance** of structure by developing the **solutions** to avoid the **environmental** effects and safety issues.	4
	PO 4	Understand the importance and facets of maintenance by appropriate **codes of practices and industry standards** with the **knowledge of material characteristics** and processes to **improve the quality of structures**	3
	PSO 1	Supervise sub-structures, superstructures, and identify the performance of structures using **codes of practices, material knowledge** by **regular inspection** and remediation measures for **quality assurance.**	4
	PSO 2	Focus on improving performance of structures with Reference to **safety & serviceability** and sustainable green building technology by assessment procedures.	2
CO 3	PO 1	Explain the damages and their remedies involved in the deterioration by using **engineering fundamentals and principles of science.**	2
	PO 2	Identify the corrosion damage and explain the mechanism of corrosion which is involved in the **deterioration of structures and develop the solutions** to prevent the corrosion.	2
	PO 4	Understand industry standards with the knowledge of **material characteristics and processes** to improve the quality of structures.	2

	PSO 1	Explain Corrosion protection methods of residential, industrial building, **Water treatment and distribution systems** based on **material knowledge, codes of practices** to ensure the quality of structure and to improve efficiency of **retrofitting techniques.**	5
	PSO 2	Focus on protection methods of corrosion for improving performance of structures with reference to **safety, serviceability.**	2
CO 4	PO 1	Identify the materials for repair and rehabilitation of structures by understanding the characteristics and applications with the basic knowledge of **engineering fundamentals.**	1
	PO 3	Identify the materials to establish **innovative solutions** for rehabilitation of structure by considering **environmental and sustainability limitations.**	3
	PO 5	Make use of different techniques for structural retrofitting.Select and apply appropriate techniquesfor retrofitting of structures by **understanding the limitations.**	1
	PSO 2	Focus on protection methods of corrosion for **improving performance** of structures with reference to **safety,serviceability**	3
CO 5	PO 4	Perform non-destructive testing on existing structures by understanding the **industry standards and technical literature**	2
	PO 5	Select and apply appropriate non-destructive technique to know the durability of structure by **understanding the limitations**	1
CO 6	PO 4	Choose suitable demolition techniques due to the quality issues of structures with the knowledge of characteristics of **particular materials, equipment**, processes and understanding the contexts in which **engineering knowledge** can be applied.	3
	PO 5	Select and apply appropriate **demolition technique** by understanding the effect of damage of structure.	1
	PSO 1	Explain engineered and non-engineered **techniques of strengthening**, demolition and supervise sub-structures and superstructures for residential and public buildings for **safety**.	2

29. TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	2	-	-	-	-	-	-	-	-	-	-	5	-	-
CO 2	-	-	4	3	-	-	-	-	-	-	-	-	4	2	-
CO 3	2	2	-	2	-	-	-	-	-	-	-	-	5	2	-
CO 4	1	-	3	-	1	-	-	-	-	-	-	-	-	3	-
CO 5	-	-	-	2	1	-	-	-	-	-	-	-	-	-	-
CO 6	-	-	-	3	1	-	-	-	-	-	-	-	2	-	-

30. PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.7	20	-	-	-	-	-	-	-	-	-	-	50	-	-
CO 2	-	-	40	27.3	-	-	-	-	-	-	-	-	40	66.7	-
CO 3	66.7	20	-	18.2	-	-	-	-	-	-	-	-	50	66.7	-
CO 4	33.3	-	30	-	100	-	-	-	-	-	-	-	-	100	-
CO 5	-	-	-	18.2	100	-	-	-	-	-	-	-	-	-	-
CO 6	-	-	-	27.3	100	-	-	-	-	-	-	-	66.7	-	-

31. COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - 0≤ C≤ 5% – No correlation

1-5 <C≤ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

3 - 60% ≤ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	1	-	-	-	-	-	-	-	-	-	-	2	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 2	-	-	1	1	-	-	-	-	-	-	-	-	1	3	-
CO 3	3	1	-	1	-	-	-	-	-	-	-	-	2	3	-
CO 4	1	-	1	-	3	-	-	-	-	-	-	-	-	3	-
CO 5	-	-	-	1	3	-	-	-	-	-	-	-	-	-	-
CO 6	-	-	-	1	3	-	-	-	-	-	-	-	2	-	-
TOTAL	7	2	2	4	9	-	-	-	-	-	-	-	7	9	-
AVERAGE	2	1	1	1	3	-	-	-	-	-	-	-	2	3	-

32. ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	Concept Video	✓	Open Ended Experiments	-
Assignments	✓	Tech talk	✓		

33. ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

34. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Course objectives, Course outcomes, Program Outcomes and CO-PO Mapping		
CONTENT DELIVERY (THEORY)			
2	Introduction to Rehabilitation and Retrofitting of Structures.	CO 1	T2:26.3 R2: 3.1
3	Deterioration of structures.	CO 1	T2:2.2.2

4	Causes for deterioration of structures	CO 1	T2:2.2.2 R3:3.7
5	Mechanism of damage	CO 1	T2:2.2.2
6	types of damage.	CO 1	T1:8.1
7	damage under accidental loads	CO 1	T1:7.1 R2: 1.2
8	damage under cyclic loads	CO 1	T2:3.2.3 R2: 1.3
9	cracking in structures	CO 2	T2:4.2.3
10	cracking in structures	CO 2	T2:4.5.2
11	evaluation of damage	CO 2	T2:4.7.9
12	Defibitions of Maintenance, repair and rehabilitation	CO 2	T2:5.2.1 R2: 6.4
13	facets of maintenance	CO 3	T2:5.4
14	importance of maintenance	CO 3	T2:5.5.3
15	various aspects of inspection.	CO 3	T2:6.2.2
16	Assessment procedure for evaluating a damaged structure.	CO 3	R1:2.5 R2: 8.2
17	Diagnosis of construction failures.	CO 3	R2:2.2.5 R2: 9.2
18	Corrosion damage of reinforced concrete	CO 3	R3:5.6.2
19	methods of corrosion protection	CO 3	R3:5.4.8 R2: 9.6
20	corrosion inhibitors	CO 4	T2:8.1.2
21	corrosion resistant steels	CO 4	T2:8.3.5 R2: 5.3
22	cathodic protection	CO 4	T2:8.5
23	rust eliminators	CO 4	T2:8.9.2
24	Causes of deterioration of concrete	CO 4	T2:9.2 R3: 4.6
25	Causes of deterioration of steel, masonry and timber structures	CO 5	T2:9.5.3
26	surface deterioration	CO 6	T2:9.6.2
27	efflorescence,	CO 6	T2:9.7.5 R3: 8.12
28	causes and preventive measures.	CO 6	T2:9.6.2
29	coatings for embedded steel and set concrete.	CO 6	T2:9.6.2
30	Special concrete and mortar	CO 6	T2:9.6.2

31	concrete chemicals	CO 6	T2:9.6.2
32	polymer concrete.	CO 6	T2:9.6.2
33	sulphurinfiltrated concrete	CO 6	T2:9.6.2
34	ferro cement	CO 6	T2:9.6.2
35	fiber reinforced concrete	CO 6	T2:9.6.2
36	methods of repair in concrete	CO 6	T2:9.6.2
37	methods of repair in steel, masonry and timber structures	CO 6	T2:9.6.2
38	Gunite and shotcrete, epoxy injection	CO 6	T2:9.6.2
39	Strengthening of existing structures	CO 6	T2:9.6.2
40	repairs to overcome low member strength, deflection	CO 6	T2:9.6.2
41	repairs to overcome cracking, chemical disruption	CO 6	T2:9.6.2
42	weathering, wear, fire, leakage, marine exposure	CO 6	T2:9.6.2
43	use of non-destructive testing techniques for evaluation	CO 6	T2:9.6.2
44	load testing of structure	CO 6	T2:9.6.2
45	demolition of structures using engineered and non-engineered techniques	CO 6	T2:9.6.2
46	case studies	CO 6	T2:9.6.2
PROBLEM SOLVING / CASE STUDIES			
1	Rehabilitation and Retrofitting of Structures.	CO 1	T2:26.3 R2: 3.1
2	Damage of structures	CO 1	T1:8.1
3	Mechanism of damage and types of damage.	CO 1	T2:2.2.2
4	Facets of maintenance	CO 2	T2:26.3 R2: 3.1
5	various aspects of inspection.	CO 2	T2:26.3 R2: 3.1
6	Assessment procedure for evaluating a damaged structure.	CO 2	T2:5.2.1 R2: 6.4
7	Different methods of corrosion protection.	CO 3	T2:26.3 R2: 3.1
8	Different causes and preventive measures of surface deterioration and efflorescence.	CO 3	T2:26.3 R2: 3.1
9	different methods of repairs in concrete, steel, masonry and timber structures.	CO 4	T2:26.3 R2: 3.1
10	strengthening techniques for existing structures.	CO 4	T2:26.3 R2: 3.1

11	Various repair works to overcome low member strength, deflection, cracking, chemical disruption, weathering, wear, fire, leakage, marine exposure.	CO 4	T2:9.2 R3: 4.6
12	Non –destructive techniques for evaluation.	CO 5	T2:26.3, R2: 3.1
13	Gunite and shotcrete, epoxy injection	CO 5	T2:26.3 R2: 3.1
14	demolition of structure using engineered technique.	CO 6	T2:26.3 R2: 3.1
15	Non-engineered techniques used for demolition of structures.	CO 6	T2:26.3 R2: 3.1

DISCUSSION OF DEFINATION AND TERMINOLOGY			
1	Introduction	CO 1	R4:2.1
2	Maintenance and diagnosis of failure	CO 2	T4:7.3
3	Damages and their remedies	CO 3	R4:5.1
4	Materials and techniques of repair	CO 4	T1:7.5
5	Strengthening and demolition aspect	CO 5,6	T1: 4.1
DISCUSSION OF QUESTION BANK			
1	Introduction	CO 1	R4:2.1
2	Maintenance and diagnosis of failure	CO 2	T4:7.3
3	Damages and their remedies	CO 3	R4:5.1
4	Materials and techniques of repair	CO 4	T1:7.5
5	Strengthening and demolition aspect	CO 5, 6	T1: 4.1

Signature of Course Coordinator **HOD,CE**
Dr. M.Maheswara Rao, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

CIVIL ENGINEERING
COURSE DESCRIPTION

Course Title	STRUCTURAL DESIGN LABORATORY				
Course Code	BSTD23				
Program	M.Tech				
Semester	II				
Course Type	Laboratory				
Regulation	PG - 21				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	4	2
Course Coordinator	Gude Ramakrishna Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	-	-	-

II COURSE OVERVIEW:

Structural Design Laboratory will summarize the key engineering, operational, safety, and sustainability considerations for the design of RC framed buildings. Introduces the design and behavior of large-scale structures and structural materials. This course emphasizes the development of structural form and the principles of structural design. This Laboratory used to solve structural problems by building and testing simple mathematical models. STAAD.Pro is one of the most widely used structural analysis and design software products worldwide. It can be used for analysis and design of all types of structural projects from buildings, bridges to towers, tunnels, metro stations, water/wastewater treatment plants and more.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Structural Design Laboratory	60 Marks	40 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 40 marks forinternal assessment and 60 marks for semester end lab examination. Out of 30 marks ofinternal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner, both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

SEE	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component	**Laboratory**		**Total Marks**
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

VI COURSE OBJECTIVES:

The students will try to learn:

I	The basic elements with different loading type and supports with the aid of STAAD Pro software.
II	The Analysis and design of 2D Frame and multi-storey buildings with different load sets.
III	The Modeling and analysis of steel structures like beams and columns.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	Explain the basic commands of STADD Pro software for analysis and design of structural elements.	Understand
CO 2	Analyse the trusses courseed to different loading conditions using Indian standard specifications.	Apply
CO 3	Analyse the rigid jointed frames courseed to different loading conditions using Indian standard specifications.	Analyze
CO 4	Design of steel 2D and 3D trusses for industrial and bridge structures.	Analyze
CO 5	Design of reinforced concrete rigid frames for multistoried structures.	Create
CO 6	Make use of latest tools for analysis and design of sub-structures	Create

VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	An ability to Independently carry out research/investigation and development work to solve practical problems.
PO 2	An ability to Write and present a substantial technical report/document.
PO 3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
PO 4	Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields.
PO 5	Conceptualize and design civil engineering structures considering various socio-economic factors.
PO 6	Engage in life-long learning for continuing education in research-level studies and professional development.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.	2	CIE

PO4	Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields.	3	CIE
PO5	Conceptualize and design civil engineering structures considering various socio-economic factors.	2	CIE

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO3	Engage in life-long learning for continuing education in research-level studies and professional development.	2	SEE

3 = High; 2 = Medium; 1 = Low

XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES			PSO'S
	PO 3	PO 4	PO 5	PSO 3
CO 1	-	3	2	-
CO 2	2	-	-	-
CO 3	3	2	2	1
CO 4	-	-	-	-
CO 5	-	2	3	3
CO 6	2	-	-	-

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

WEEK I	**INTRODUCTION TO STAAD SOFTWARE**
	Introduction
WEEK II	**STRUCTURAL SYSTEMS**
	General Description-Type of structure, Unit systems, structure geometry and Co-ordinate systems.
WEEK III	**COMMAND INPUTS**
	STAAD Pro –Commands- Using Edit Input-Command Formats-Text Input.
WEEK IV	**DEVELOPING GEOMETRY AND DIMENSIONING**
	Pre- Graphical Input Generation-Library- Geometry Generation – Dimensioning in STAAD Pro.
WEEK V	**3D MODEL DEVELOPMENT**
	Graphical Post Processing – Animation – Icons – Isometric View – Zooming-Results of Analysis and Design – Query reports in STAAD Pro.
WEEK VI	**ASSIGNING DIFFERENT LOAD PARAMETERS**
	Member Load, Element Load, Joint Load, Floor Load, Self-weight Command, Load case no, Load Combination.
WEEK VII	**ANALYIS CONTINUOUS BEAM**
	Analysis of continuous Beams using STAAD Pro.
WEEK VIII	**ANALYIS OF TRUSS**
	Analysis of 2D Truss using STAAD Pro
WEEK IX	**ANALYIS OF RIGID FRAMES**
	Analysis of 2D and 3D rigid frames using STAAD Pro.
WEEK X	**DESIGN OF RC BEAMS AND COLOMUNS**
	Design of RC framed structures (Beams, columns) using STAAD Pro.
WEEK XI	**DESIGN OF SLABS**
	Design of RC slabs using STAAD Pro.
WEEK XII	**DESIGN OF FOOTINGS**
	Design of RC footing STAAD Pro.
WEEK XIII	**DESIGN OF CIRCULAR WATER TANKS**
	Design of circular water tanks using STAAD Pro.
WEEK XIV	**ANALYSIS AND DESIGN OF STEEL STRUCTURES**
	Analysis and Design of steel structures (Beams, columns)

TEXTBOOKS

1. T.S.Sarma, "Staad.Pro v8i for beginners" Notion press, 2014.

2. Siva kumar Naganathan, "Learn Yourself Staad Pro V8i", Lap Lambert Academic Publishing GmbH KG, 2012.

REFERENCE BOOKS:

1. Subramanian N., "Design of Steel Structures", Oxford Publication, 4th edition, 2008.

XV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	What role does lighting play in your 3D modeling process, and how do you incorporate it.	CO1	T1: 2.4 R1:3.6
2	Structural Systems	CO1	T2: 3.7 R1:5.3
3	Command Inputs	CO2	T2: 4.10 R1:3.15
4	GauDeveloping Geometry and Dimensioning	CO2	T2: 1.15 R1:1.16
5	3D Model Development	CO3	T2: 1.19 R1:1.13.3
6	Assigning Different Load Parameters	CO3	T2:7.3 R1:2.8
7	Analysis of continuous Beam	CO5	T2:6.5 R1:2.6.2
8	Analysis of Truss	CO1	T2:7.5,7.6 R1:2.9.2
9	Analysis of rigid frames	CO4	T2:7.7 R1:2.10
10	Design of RC Beams and Column	CO4	T2:7.7 R1:2.10
11	Design of RC slabs	CO5	T2:7.11 R1:2.10.2
12	Design of RC footing	CO2	T2:15.7 R1:8.3.3
13	Design of circular water tank	CO6	T2:2.1 R1:7.9.2
14	Analysis and design of steel structures	CO6	T2:2.2 R1:7.9.1

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Analysis and design of a flexural member using STAAD Pro.
2	Analysis and design of a simple RCC frame one-bay two storey using STAAD Pro.
3	Analysis of Continuous Beam.
4	Analysis of single storey frame using STAAD Pro.
5	What role does lighting play in your 3D modeling process, and how do you incorporate it

Signature of Course Coordinator **HOD,CE**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

CIVIL ENGINEERING
COURSE DESCRIPTION

Course Title	NUMERICAL ANALYSIS LABORATORY				
Course Code	BSTD24				
Program	M.Tech				
Semester	II				
Course Type	Laboratory				
Regulation	PG - 21				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	4	2
Course Coordinator	K.Anand Goud				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	-	-	-

II COURSE OVERVIEW:

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
NUMERICAL ANALYSIS LABORATORY	60 Marks	40 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 40 marks forinternal assessment and 60 marks for semester end lab examination. Out of 30 marks ofinternal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner, both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component	**Laboratory**		**Total Marks**
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

VI COURSE OBJECTIVES:

The students will try to learn:

I	The Roots of non-linear equations by Bisection method and Newton's metho
II	The system of Linear Equations using Gauss - Elimination/ Gauss - Seidal Iteration/Gauss - Jorden Method.
III	The integrations numerically using Trapezoidal and Simpson's rules

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	Analyze the roots of non-linear equation using bisection and newton's method.	Understand
CO 2	Evaluate the curve fitting by using method of least squares approximations.	Apply
CO 3	Determine the linear system of equations using Gauss elimination, Gauss Seidal and gauss Jordan methods.	Analyze
CO 4	Solve the integrations numerically using trapezoidal and Simpson's rule.	Analyze
CO 5	Explain the numerical solution of ordinary differential equations using Euler's Method.	Create
CO 6	Analyze the numerical solution of ordinary differential equations by using Runge- Kutta Method.	Create

VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	An ability to Independently carry out research/investigation and development work to solve practical problems.
PO 2	An ability to Write and present a substantial technical report/document.
PO 3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
PO 4	Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields..
PO 5	Conceptualize and design civil engineering structures considering various socio-economic factors.
PO 6	Engage in life-long learning for continuing education in research-level studies and professional development.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO1	Anability to Independently carryout research/investigation and development work to solve practical problems.	2	CIE
PO2	Anability to Write and present a substantial technical report/document.	3	CIE

PO6	Engage in life-long learning for continuing education in research-level studies and professional development.	2	CIE

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO3	Engage in life-long learning for continuing education in research-level studies and professional development.	2	SEE

3 = High; 2 = Medium; 1 = Low

XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES			PSO'S
	PO 1	PO 3	PO 5	PSO 3
CO 1	2	-	-	-
CO 2	-	2	-	-
CO 3	3	2	3	1
CO 4	-	-	2	-
CO 5	-	3	2	3
CO 6	2	-	-	-

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

WEEK I	**BISECTION METHOD**
	Find the Roots of Non-Linear Equation Using Bisection Method
WEEK II	**NEWTON'S METHOD**
	Find the Roots of Non-Linear Equation Using Newton's Method.
WEEK III	**CURVE FITTING**
	Curve Fitting by Least Square Approximations.
WEEK IV	**GAUSS ELIMINATION METHOD**
	Solve the System of Linear Equations Using Gauss - Elimination Method.
WEEK V	**GAUSS SEIDAL ITERATION METHOD**
	Solve the System of Linear Equations Using Gauss - Seidal Iteration Method.
WEEK VI	**GAUSS JORDEN METHOD**
	Solve the System of Linear Equations Using Gauss - Jorden Method
WEEK VII	**TRAPEZIODIAL RULE**
	Integrate numerically using Trapezoidal Rule.
WEEK VIII	**SIMPSON'S RULE**
	Integrate numerically using Simpson's Rules.
WEEK IX	**EULER'S METHOD**
	Numerical Solution of Ordinary Differential Equations by Euler's Method.
WEEK X	**RUNGE KUTTA METHOD**
	Numerical Solution of Ordinary Differential Equations by Runge- Kutta Method.
WEEK XI	**NEWTON – RAPHSON METHOD**
	Numerical Solution of Ordinary Differential Equations Newton – Raphson Method
WEEK XII	**SECANT METHOD**
	Numerical Solution of Ordinary Differential Equations secant method
WEEK XIII	**BRENT'S METHOD**
	Numerical Solution of Ordinary Differential Equations Brent's method
WEEK XIII	**MULLER'S METHOD**
	Numerical Solution of Ordinary Differential Equations Muller's method.

TEXTBOOKS

1. Steven Chapra and Raymond Canale, "Numerical Methods for Engineers", McGraw Hill, 7th edition, 2015.

REFERENCE BOOKS:

1. K. Sankara Rao, "Numerical Methods for Scientists and Engineers", PHI Learning, 4th edition, 2018.

XV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Bisection Method	CO1	T1: 2.1 R1:3.9
2	Newton's Method	CO1	T2: 1.7 R1:1.12.3
3	Curve Fitting	CO2	T2: 1.10 R1:1.15
4	Gauss - Elimination Method	CO3	T2: 1.15 R1:1.16
5	Gauss - Seidal Iteration Method.	CO3	T2: 1.19 R1:1.13.3
6	Gauss - Jorden Method	CO3	T2:7.3 R1:2.8
7	Trapezoidal Rule	CO4	T2:6.5 R1:2.6.2
8	Simpson's Rules	CO1	T2:7.5,7.6 R1:2.9.2
9	Euler's Method	CO4	T2:7.7 R1:2.10
10	Runge- Kutta Method	CO4	T2:7.7 R1:2.10
11	Newton – Raphson Method	CO5	T2:7.11 R1:2.10.2
12	Secant method	CO5	T2:15.7 R1:8.3.3
13	Brent's method	CO6	T2:2.1 R1:7.9.2
14	Muller's method	CO6	T2:2.2 R1:7.9.1

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Discuss the importance of choosing an appropriate model function in curve fitting.
2	Discuss situations where using Laplace Transform might be advantageous or disadvantageous compared to other methods.
3	Explain the concept of finite differences and its role in the Secant method.
4	How does Brent's Method handle functions with multiple roots or sharp turns.
5	Discuss scenarios where Muller's Method might outperform Brent's or the Secant method.

Signature of Course Coordinator **HOD,**

COURSE OUTLINE DESCRIPTION

SECTION 1: General Information about the Course	
Course Title	**DESIGN OF PRESTRESSED CONCRETE STRUCTURES**
Course Code	BSTD26
Course Start	III
Course Type	Professional Elective
Regulation	IARE - PG 21
Prerequisite Courses	Reinforced Concrete Structures Design and Drawing
Department	Civil Engineering
Number of Credits	3 Credit hours
Academic Year	2025-26
Method(s) of Instruction	Theory
Course Administrator	**Dr. U. Vamsi Mohan** Professor of Civil Engineering IARE10660 **u.vamshimohan@iare.ac.in**
Course Coordinator's Name	**Dr. Praveena Rao** Assistant Professor of Civil Engineering IARE10485 praveenarao@iare.ac.in
Prior Learning Assessment and Recognition (PLAR)	Students interested in PLAR pathways for open learning can register one semester prior to the start of semester. Students will receive the necessary contact information one semester in advance.
Open Learning Faculty Member Information	Open Learning Faculty (OLF) is available to assist students. Students will receive the necessary contact information at the start of the course.
Course Webpage	https://akanksha.iare.ac.in/index?route=course/details&course_id=1604
Course Description	A prestressed concrete structure is different from a conventional reinforced concrete structure due to the application of an initial load on the structure prior to its use. In prestressed concrete high strength concrete and high strength steel are combined such that the full section is effective in resisting tension and compression. This is an active combination of the two materials. This subject provides students an understanding and ability to analyse and design prestressed concrete structural elements. The primary topics includes the concept and principles of prestressing, methods of prestressing concrete, stress limits, losses of prestress, selection of section, serviceability and strength requirements. Students will also be able to complete analysis and design procedure of simply supported prestressed concrete non-composite and composite beams.
Course Objectives	**The students will try to learn:** a. The concepts of prestressed concrete structures and the behaviour of these structures subjected to loads for the design purpose. b. The design of structural elements necessary for creating efficient and economic prestressed concrete structures. c. The design and drawing of multi storeyed industrial and residential structures including bridges for creating high performance and durable structures.

Text and Reference Books	**Text Books** 1. N. Krishna Raju, "Pre-stressed Concrete", Tata McGraw Hill Book Education Pvt. Ltd, 6th Edition, 2018. 2. N. Rajagopalan, "Prestressed Concrete", Alpha Science International Ltd, 2nd edition, 2005. **Reference Books** 1. 1. T.Y. Lin and Burn, "Design of Pre-stress Concrete Structures", John Wiley, New York. 2. 2. S. Ramarnrutham, "Prestressed Concrete", Dhanpat Rai & Sons, Delhi.
Learning Resources	**Course full stack** is made available in IARE learning management portal – Akanksha, which includes lecture notes, tutorial question bank, definition and terminology, tech-talk topics, assignments, Model question papers (2 sets), complex engineering problem solving statements, power point presentations (PPTs) and ELRV lecture recordings at: • https://www.youtube.com/watch?v=TnAsK6H4O7Q
Supplemental Materials	**Readings, Videos, and Links** 1. https://nptel.ac.in/courses/105106118 2. https://odp.inflibnet.ac.in/index.php/module details?course=prestressed%20concrete %20structures&source=swayam&subsource=NPTEL
Learning and Teaching Strategies	Online material will provide the foundation of the learning resources, requiring the students to log in and engage regularly throughout the sixteen weeks of the course. There will be a mix of suggested readings, discussions and video content containing embedded digital content and undertake the assessment tasks.

SECTION 2: Teaching Learning Scheme

At least 48 lecture hours of scheduled teaching and learning activities (TLA) will be delivered in person, with the remaining hours for scheduled and self-scheduled teaching and learning activities delivered either in person or online.

Notional Study Time: 90 Hours (Lecture hours: 48, Tutorial hours: 8, Guided independent study hours: 10, Homework / Programming assignment hours: 9, Course project / Preparation for complex problem solving hours: 15)

TLA Code	Teaching and Learning Activities	Number	Duration (Hours)	Total Workload
TLA 1	Lectures	48	01	48
TLA 2	Tutorials	08	01	08
TLA 3	Case Study			
TLA 4	Problem Solving			
TLA 5	Demonstration			
TLA 6	Scheduled revision sessions			
TLA 7	Guided independent study: Directed viewing of video materials / PPTs			10
TLA 8	Independent private study			
TLA 9	Laboratory Exercises			
TLA 10	Homework assignments / Programming assignments			9
TLA 11	Placement / work based learning or Specific			

	practical training			
TLA 12	Presentation / Seminar Preparation			
TLA 13	Course Project / Preparation for Complex Problem Solving			15
TLA 14	Technical visit			
TLA 15	Field activities			
			Total study hours	**90**
			Expected total study hours	**90**

SECTION 3A: Course Outcomes		
After successfully completing this course, the student will be able to:		
Outcome Number	**Course Outcomes**	**Learning Domain**
CO1	**Explain the concept of methods of pre and post tensioning and the systems of prestressing for the designing of prestressed concrete structural elements.**	Understand
CO2	**Estimate the losses in the prestress and post tensioned members for the efficient design of prestressed concrete structures.**	Analyse
CO3	**Analyse prestressed concrete structural elements subjected to flexure for the design purpose.**	Analyse
CO4	**Design prestressed concrete structural elements subjected to shear using Indian standard code method.**	Apply
CO5	**Apply the concepts of transfer of prestress in pre and post tensioned members through bond for effective utilisation of prestressing force.**	Apply
CO6	**Design the composite prestressed concrete structural elements subjected to flexure and shear for designing multi storied structures.**	Apply

SECTION 3B: Cognitive Levels	
Blooms Taxonomy Level	**Cognitive Level in Percentage (%)**
Remember	**0**
Understand	16.67
Apply	50
Analyse	33.33
Evaluate	0
Create	0

SECTION 4: Content and Context of Engineering Surveying	
CO1	**Explain the concept of methods of pre and post tensioning and the systems of prestressing for the designing of prestressed concrete structural elements.**
	Prestressed concrete is a type of reinforced concrete where internal stresses are intentionally introduced to counteract the tensile stresses that occur during service. This improves the structural capacity and performance of concrete, especially in elements like beams, slabs, and bridges. 1. **General principles of pre-stressing pre-tensioning and post tensioning:** The general principles of prestressing, whether by pre-tensioning or post-tensioning, are based on the concept of introducing internal compressive forces in a concrete structural element to counteract external tensile stresses. This significantly improves the structural performance of concrete, which is strong in compression but weak in tension. 2. **Advantages and limitations of Prestressed concrete:** Prestressed members require smaller cross-sections, reducing the overall dead weight of the structure and saving on material costs. Prestressed concrete can resist higher loads compared to conventional reinforced concrete due

	to the introduction of compressive stresses that counteract tensile forces. 3. **Classification and types of pre-stressing:** Prestressing is a technique used to improve the performance of concrete by introducing internal compressive stresses to counteract external tensile stresses. It can be classified based on various factors such as the method of application, type of construction, and extent of prestressing. 4. **Pre-tensioning and Post-tensioning methods:** There are two primary methods of prestressing, In the pre-tensioning method, the steel tendons (wires or strands) are tensioned before the concrete is cast. Once the concrete sets and gains strength, the tendons are released, transferring stress to the concrete. In the post-tensioning method, the steel tendons are tensioned after the concrete has been cast and gained strength. The prestressing force is applied using hydraulic jacks and is transferred to the concrete through end anchorages.
CO2	**Estimate the losses in the prestress and post tensioned members for the efficient design of prestressed concrete structures.**
	In prestressed concrete, prestress losses refer to the reduction in the initial prestressing force over time due to several factors. Accurately estimating these losses is critical to ensure that the structure performs as intended during its service life. 1. **Loss of pre-stress in pre-tensioned:** In pre-tensioned concrete, tendons (typically high-strength steel wires or strands) are tensioned before the concrete is cast. After the concrete hardens, the tendons are released, and the prestressing force is transferred to the concrete through bond. However, over time, part of the initial prestressing force is lost due to several factors, which must be accounted for in design to ensure safety and serviceability. 2. **Loss of pre-stress in post-tensioned members:** In post-tensioned concrete, the tendons are placed inside ducts before concrete casting and are tensioned after the concrete has hardened. While transferring and maintaining the prestressing force, several losses occur due to physical and time-dependent factors. These prestress losses must be accurately estimated during the design phase to ensure structural efficiency and durability. 3. **Frictional losses:** Frictional losses refer to the reduction in the prestressing force along the length of a post-tensioned tendon due to friction between the tendon and its surrounding duct during the tensioning process. These losses occur only in post-tensioning systems (not in pre-tensioning), particularly when the tendons are stressed from one or both ends.
CO3	**Analyse prestressed concrete structural elements subjected to flexure for the design purpose.**
	Prestressed concrete members are primarily designed to resist flexural stresses caused by bending moments. The analysis aims to ensure that the concrete and prestressing steel together safely carry the applied loads while controlling deflections and cracking. 1. **Analysis of sections for flexure:** Prestressed concrete sections are specially designed to resist bending moments by inducing a prestressing force that counteracts tensile stresses caused by external loads. The analysis of such sections for flexure ensures that stresses in concrete and prestressing steel remain within permissible limits and the section achieves the required strength and serviceability. 2. **Beams pre-stressed with straight, concentric, eccentric, bent and parabolic tendons:** Prestressing tendons can be arranged in various profiles within beams to optimize structural performance by controlling the stress distribution due to bending. The shape and position of the tendons directly affect how the prestressing force counteracts applied loads. 3. **Elastic design of PSC beams of rectangular and I section**: The elastic design approach involves analyzing prestressed concrete beams assuming linear elastic behavior of materials under service loads. This design ensures that stresses in concrete and prestressing steel remain within permissible limits during service to avoid cracking and excessive deflections.
CO4	**Design prestressed concrete structural elements subjected to shear using Indian standard code method.**
	Prestressed concrete (PSC) members are subjected to shear forces along with bending moments. The

	design for shear ensures that the member can safely resist these forces without shear failure, which is often sudden and brittle. 1. **General considerations for shear design:** Shear design in prestressed concrete (PSC) beams is a critical aspect of structural safety and serviceability. Shear failure can be sudden and brittle, so proper design ensures the beam safely carries shear forces along with bending moments. 2. **Design of shear reinforcements**: Shear reinforcement is essential in prestressed concrete (PSC) elements to resist shear forces exceeding the concrete's inherent shear capacity and to control crack widths. Proper design ensures safety, ductility, and durability of the structure. 3. **Improving shear resistance of concrete:** Shear resistance is a critical factor in the design and safety of prestressed concrete (PSC) elements. Since shear failure can be sudden and brittle, improving the shear capacity of the concrete portion of PSC members enhances overall structural reliability and performance.
CO5	**Apply the concepts of transfer of prestress in pre and post tensioned members through bond for effective utilisation of prestressing force.**
	In prestressed concrete (PSC) members, the transfer of prestressing force from the prestressing tendons (steel strands or wires) to the concrete is a critical step to ensure that the concrete benefits fully from the applied prestress. This transfer is achieved primarily through bond between the steel and concrete. 1. **Transmission of pre-stressing force by bond:** In prestressed concrete members, the transmission of pre-stressing force by bond refers to how the tensile force applied to the prestressing steel (tendons or strands) is gradually transferred to the surrounding concrete through the interface between steel and concrete. This process is essential for the effective functioning of prestressed concrete elements. 2. **Transmission length and flexural bond stresses:** Transmission length is a fundamental concept in prestressed concrete design. It represents the length along the prestressing tendon over which the prestressing force is gradually transferred from the tendon to the surrounding concrete through bond action. 3. **Stress distribution in end block:** When prestressing tendons are anchored, the force is transferred from the small cross-sectional area of the steel to the relatively larger concrete area. This sudden transfer results in non-uniform, high compressive stresses and tensile stresses (due to bursting forces) in the end block. 4. **Anchorage zone reinforcement:** Reinforcement in anchorage zone is usually arranged as closed ties or hoops around the prestressing tendons. Ties prevent the concrete from splitting due to radial tensile stresses. Stirrups are placed closely near anchorage and spaced progressively wider away from the anchorage.
CO6	**Design the composite prestressed concrete structural elements subjected to flexure and shear for designing multi storied structures.**
	Composite prestressed concrete elements combine prestressing with composite action (often involving steel and concrete or different concrete types) to optimize strength and serviceability. In multi-storied structures, these elements often carry large flexural and shear loads and must be designed carefully to ensure safety, durability, and economy. 1. **Analysis of composite beams:** Composite beams combine two or more materials (commonly concrete and steel) to act as a single structural element. In prestressed concrete composite beams, prestressing tendons are used to enhance the flexural capacity and control deflections, while composite action (e.g., between a prestressed concrete slab and a steel beam) provides additional strength and stiffness. 2. **Types of composite beams - Propped and Unpropped:** Composite prestressed concrete beams are widely used in construction to combine the advantages of prestressing with composite action, often involving a concrete slab and steel beam. Based on the support conditions during construction and loading, these beams are classified as Propped or Unpropped.

	3. **Importance of control of deflections:** Deflection refers to the vertical displacement or bending of a beam under load. In prestressed concrete beams, controlling deflections is crucial for the structural performance, serviceability, and durability of the structure. 4. **Short term and long term deflections:** Deflections in prestressed concrete (PSC) beams occur over time due to applied loads and material behavior. These deflections are broadly classified into short-term deflections that occur immediately or shortly after the application of loads. Long-term deflections develop gradually over time due to sustained loads and time-dependent effects of materials.

SECTION 5: Complex Engineering Problem Solving

Complex engineering problem solving projects

There is one piece of assessed coursework, involving a mixture of theoretical work and practical work. We encourage to use the laboratory for practical purpose. For the calculation part in the project, they have to develop the programme code in java or python.

Error analysis and adjustment techniques: The core surveying curriculum typically focuses on fundamental measurement techniques and calculations. However, real-world surveys are subject to various errors. Therefore, an introduction to error analysis and adjustment techniques will be incorporated into the course.

SECTION 6A: Assessment Methods – Direct

Item	Evaluation Components	Week in / out	Marks
AAT: 1 - 1	Tech-Talk	Week – 2 / 5	05
AAT: 1 - 2	Assignments	Week – 4 / 7	05
AAT: 2 - 1	Complex Engineering Problem Solving	Week – 9 / 12	05
AAT: 2 - 2	Definitions and Terminology	Week – 12 / 15	05
CIE - 1	2 hours - Answer 4 out of 5 questions	Week - 9	10
CIE - 2	2 hours - Answer 4 out of 5 questions	Week - 17	10
SEE	3 hours - Answer 1 from each module	Week - 18	60
		Total Marks	**100**

Department's Late Submission Policy:

1. 1 – 24 hours: 25% of the mark will be deducted
2. > 24 hours: Not accepted

SECTION 6B: Assessment Methods –Indirect

Course End Survey (End Semester OBE Feedback)	✓

SECTION 7: Engineering Competencies (ECs) Focused

Please tick (✓) relevant engineering competency profile covered

EC Number	Attributes	Profiles	(✓)
EC1	Depth of knowledge required (CP)	Ensures that all aspects of an engineering activity are soundly based on fundamental principles - by diagnosing, and taking appropriate action with data, calculations, results, proposals, processes, practices, and documented information that may be ill-founded, illogical, erroneous, unreliable or unrealistic requirements applicable to the engineering discipline	✓
EC2	Depth of analysis	Have no obvious solution and require abstract thinking,	✓

	required (CP)	originality in analysis to formulate suitable models.	
EC3	Design and development of solutions (CA)	Support sustainable development solutions by ensuring functional requirements, minimize environmental impact and optimize resource utilization throughout the life cycle, while balancing performance and cost effectiveness.	-
EC4	Range of conflicting requirements (CP)	Competently addresses complex engineering problems which involve uncertainty, ambiguity, imprecise information and wide-ranging or conflicting technical, engineering and other issues.	✓
EC5	Infrequently encountered issues (CP)	Conceptualizes alternative engineering approaches and evaluates potential outcomes against appropriate criteria to justify an optimal solution choice.	-
EC6	Protection of society (CA)	Identifies, quantifies, mitigates and manages technical, health, environmental, safety, economic and other contextual risks associated to seek achievable sustainable outcomes with engineering application in the designated engineering discipline.	-
EC7	Range of resources (CA)	Involve the coordination of diverse resources (and for this purpose, resources include people, money, equipment, materials, information and technologies) in the timely delivery of outcomes	✓
EC8	Extent of stakeholder involvement (CP)	Design and develop solution to complex engineering problem considering a very perspective and taking account of stakeholder views with widely varying needs.	-
EC9	Extent of applicable codes, legal and regulatory (CP)	Meet all level, legal, regulatory, relevant standards and codes of practice, protect public health and safety in the course of all engineering activities.	✓
EC10	Interdependence (CP)	High level problems including many component parts or sub-problems, partitions problems, processes or systems into manageable elements for the purposes of analysis, modelling or design and then re-combines to form a whole, with the integrity and performance of the overall system as the top consideration.	✓
EC11	Continuing professional development (CPD) and lifelong learning (CA)	Undertake CPD activities to maintain and extend competences and enhance the ability to adapt to emerging technologies and the ever-changing nature of work.	✓
EC12	Judgement (CA)	Recognize complexity and assess alternatives in light of competing requirements and incomplete knowledge. Require judgement in decision making in the course of all complex engineering activities.	-

SECTION 8: Employability Skills

Example: Communication skills / Programming skills / Project based skills

Studying Prestressed concrete structures equips the students with a range of employability skills that are highly valued in industries.

Communication skills:

- Effectively convey complex technical information to both technical and non-technical stakeholders.
- Actively listen to clients and colleagues to understand their needs and perspectives.
- Prepare clear and concise written reports, proposals, and presentations.
- confidently present findings and recommendations to diverse audiences.
- Collaborate effectively with team members from various disciplines.
- Negotiate and resolve conflicts constructively.

Project-based skills

- Ability to analyze beams and slabs for bending moments, shear forces, and stresses considering prestressing effects.
- Designing composite prestressed beams and slabs combining steel and concrete.
- Applying Indian Standards (IS 1343, IS 456) or relevant international codes for safe and economical designs.

- Hands-on experience with structural analysis software capable of modeling prestressed concrete elements.

SECTION 9: Relevance to Sustainability goals

Brief description about the course and its correlation with Sustainability Development Goal (SDGs).

SDG Goals		Correlation with SDG
4		**Quality Education:** This course provides high-quality technical education and equips students with essential skills to analyze and design safe, efficient, and sustainable materials and structures.
9		**Industry, Innovation, and Infrastructure:** Prepares students to design and maintain resilient infrastructure by understanding material behavior, promoting innovation in material use, and ensuring structural safety.
11		**Sustainable Cities and Communities:** Enhances the ability to create sustainable buildings and urban infrastructure by selecting appropriate materials and designs that ensure durability and minimize environmental impact.
12		**Responsible Consumption and Production:** Encourages efficient use of materials through optimization and design, reducing waste and promoting responsible material selection in engineering projects.
13		**Climate Action:** Supports the development of climate-resilient infrastructure and promotes the use of materials that minimize environmental impact in changing climate conditions.

SECTION 10A: Mapping between COs and POs / PSOs

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-
CO2	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	✓	✓	-	-	✓	-	-	-	-	-	-	✓	-	-
CO4	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-
CO5	✓	-	-	-	-	-	-	-	-	-	-	✓	-	-
CO6	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-

Outcomes		WKS and Indicators of attainment and Justification for mapping(students will be able to)									IAs Count
COs	POs	WK 1	WK 2	WK 3	WK 4	WK 5	WK 6	WK 7	WK 8	WK 9	

		a	a	b	c	d	e	f	g	h	a	b	c	a	b	c	a	b	c	d	e	f	a	b	c	a	b	c	d	a	b	c	d	e	f	g	a	b	c	d	e	f	
CO 1	PO 1	•	•	•	•	•	•	•			•	•	•	•																														11
	PO 2	•	•	•	•	•	•	•			•	•	•	•																														11
CO 2	PO 1	•	•	•	•	•	•	•			•	•	•	•																														11
CO 3	PO 1	•	•	•	•	•	•	•			•	•	•	•																														11
	PO 2	•	•	•	•	•	•	•			•	•	•	•																														11
	PO 5		•	•	•		•	•	•	•													•	•	•																		10
	PSO 1	•		•			•	•	•	•																•	•	•																9
CO 4	PO 1	•	•	•	•	•	•	•			•	•	•	•																														11
	PO 2	•	•	•	•	•	•	•			•	•	•	•																														11
CO 5	PO 1	•	•	•	•	•	•	•			•	•	•	•																														11
	PSO 1	•		•			•	•	•	•																•	•	•																9
CO 6	PO 1	•	•	•	•	•	•	•			•	•	•	•																														11
	PO 2	•	•	•	•	•	•	•			•	•	•	•																														11

SECTION 10B: Indicators of Attainment with COs to POs and PSOs

Course Outcomes	Percentage of Indicators of Attainments (IA) with POs and PSOs													
	PO											PSO		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	73	73	-	-	-	-	-	-	-	-	-	-	-	-
CO2	73	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	73	73	-	-	90	-	-	-	-	-	-	69	-	-
CO4	73	73	-	-	-	-	-	-	-	-	-	-	-	-
CO5	73	-	-	-	-	-	-	-	-	-	-	69	-	-
CO6	73	73	-	-	-	-	-	-	-	-	-	-	-	-

SECTION 10C: Course Articulation Matrix of COs to POs

0	1	2	3
No Contribution (0-5%)	Low (≥5 - <40%)	Moderate (≥40 - <60%)	High (≥60%)

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3	3	-	-	-	-	-	-	-	-	-	-	-	-
CO2	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	3	3	-	-	3	-	-	-	-	-	-	3	-	-
CO4	3	3	-	-	-	-	-	-	-	-	-	-	-	-
CO5	3	-	-	-	-	-	-	-	-	-	-	3	-	-
CO6	3	3	-	-	-	-	-	-	-	-	-	-	-	-
Total	18	12	-	-	3	-	-	-	-	-	-	6	-	-
Average	**3**	**3**			**3**							**3**		

SECTION 10D: Level of Contribution of the COs to POs and PSOs

Number	Programme Outcomes	Proficiency Assessed by	Contribution Level (from 1 to 3)

PO 1	Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in **WK1 to WK4** respectively to develop to the solution of **complex engineering problems**.	CIE / SEE / AAT:1 – 2 Assignments / Open-ended problems	**3**
PO 2	Identify, formulate, review research literature and analyse **complex engineering problems** reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4).	CIE / SEE / AAT:1 – 2	**3**
PO 5	Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognising their limitations to solve **complex engineering problems**. (WK2 and WK6).	CIE / SEE / AAT:2 – 2	**3**
PSO 1	Design and supervise sub-structures and super structures for residential and public buildings, industrial structures, irrigation structures, power houses, highways, railways, airways, docs and harbours.	AAT: 1 – 1 Tech-Talk	**3**

SECTION 11: Course Content	
MODULE - I	**INTRODUCTION**
	Historic development- General principles of pre-stressing pre-tensioning and post tensioning- Advantages and limitations of Prestressed concrete- General principles of PSC- Classification and types of pre-stressing Materials- high strength concrete and high tensile steel their characteristics. Methods and Systems of prestressing: Pre-tensioning and Post-tensioning methods and systems of prestressing like Hoyer system, Magnel Blaton system, Freyssinet system and Gifford- Udall System- Lee McCall system.
MODULE - II	**LOSSES OF PRE-STRESS**
	Loss of pre-stress in pre-tensioned and post-tensioned members due to various causes like elastic shortage of concrete, shrinkage of concrete, creep of concrete, relaxation of stress in steel, slip in anchorage, frictional losses.
MODULE - III	**FLEXURE**
	Analysis of sections for flexure, beams pre-stressed with straight, concentric, eccentric, bent and parabolic tendons- stress diagrams, Elastic design of PSC beams of rectangular and I section Kern line, Cable profile and cable layout. Shear: General Considerations, Principal tension and compression, improving shear resistance of concrete by horizontal and vertical pre-stressing and by using inclined or parabolic cables, Analysis of rectangular and I beam for shear, Design of shear reinforcements- Bureau of Indian Standards (BIS) Code provisions.
MODULE - IV	**TRANSFER OF PRE-STRESS IN PRE-TENSIONED MEMBERS**
	Transmission of pre-stressing force by bond, Transmission length, Flexural bond stresses, IS code provisions, Anchorage zone stresses in post tensioned members, stress distribution in End block, Analysis by Guyon, Magnel, Zielinski and Rowe's methods, Anchorage zone reinforcement, BIS Provisions.
MODULE - V	**COMPOSITE BEAMS AND DEFLECTIONS**
	Different Types: Propped and Unpropped, stress distribution, Differential shrinkage, Analysis of composite beams, General design considerations. Deflections: Importance of control of deflections, Factors influencing deflections, short term deflections of uncracked beams, prediction of longtime deflections, BIS code requirements.

SECTION 12: Tentative Schedule of Instructions

Week Number	Topics	Duration (Hours)
1	1.1 Historic development of pre-stressing technology. 1.2 General principles of pre-tensioning and post-tensioning. 1.3 Advantages and limitations of pre-stressed concrete.	3
2	2.1 General principles of PSC. 2.2 classifications and types of pre-stressing methods. 2.3 Pre-stressing Materials.	3
3	3.1 High strength concrete and high tensile steel. 3.2 Advantages of pre-stressed concrete. 3.3 Limitations of pre-stressed concrete.	3
4	4.1 Characteristics of pre-stressed concrete. 4.2 Methods and Systems of pre-stressing. 4.3 Pre-tensioning methods.	3
5	5.1 Post-tensioning methods. 5.2 Hoyer system of pre-stressing. 5.3 Magnel Blaton system of pre-stressing.	3
6	6.1 Freyssinet system of pre-stressing. 6.2 Gifford- Udall System of pre-stressing. 6.3 Lee McCall system of pre-stressing.	3
7	7.1 Nature of loss of prestress. 7.2 Loss of prestress in pre-tensioned. 7.3 Loss of prestress in post-tensioned members.	3
8	8.1 Loss of prestress due to elastic deformation. 8.2 Loss of prestress due to shrinkage. 8.3 Loss of prestress due to creep.	3
CONTINUOUS INTERNAL EXAMINATION (CIE- I)		
9	9.1 Loss of prestress due to Relaxation of stress in steel. 9.2 Loss of prestress due to Slip in anchorage. 9.3 Loss of prestress due to frictional losses.	3
10	10.1 Analysis of sections for flexure. 10.2 Beams prestressed with straight tendon and concentric tendon. 10.3 Beams prestressed with eccentric tendon, bent and parabolic tendons.	3
11	11.1 Stress diagrams for stress distribution. 11.2 Elastic design of PSC beams of rectangular section and I section 11.3 Kern line concept of analysis.	3
12	12.1 Analysis for cable profile and cable layout. 12.2 General Considerations for shear design. 12.3 Principal tension and compression.	3
13	13.1 Analysis of rectangular beam for shear. 13.2 Analysis of I - beam for shear analysis. 13.3 Design of shear reinforcements as per Code provisions.	3
14	14.1 Improving shear resistance of concrete by horizontal prestressing 14.2 Transmission length, Flexural bond stresses 14.3 Anchorage zone stresses in post tensioned members	3
15	15.1 Stress distribution in End block 15.2 Analysis by Guyon, Magnel, Zielinski and Rowe's methods, Anchorage zone reinforcement 15.3 Composite Beams: Different Types, Propped and Unpropped	3
16	16.1 Differential shrinkage, Analysis of composite beams. 16.2 Importance of control of deflections, Factors influencing deflections 16.3 Short term deflections of uncracked beams and Prediction of long-term deflections	3
	Total	**48**

SECTION 13: Specific Goals for the Course
The following table shows the knowledge and skills covered by the unit outcomes:

Knowledge	Skills
Learners should understand: • General principles of Prestressed Concrete • Classifications and types of pre-stressing • Advantages and limitations of pre-stressed concrete • Pre-tensioning and Post-tensioning methods • Systems of pre-stressing like Hoyer system, Magnel Blaton system, Freyssinet system and Gifford- Udall System and Lee McCall system • Loss of prestress in pre-tensioned and post-tensioned members • Analysis of sections for flexure • Design of shear reinforcements • Transmission of prestressing force by bond • Analysis by Guyon, Magnel, Zielinski and Rowe's methods • Different Types, Propped and Unpropped • Importance of control of deflections	**Learners can:** • Ability to analyze prestressed concrete beams, slabs, and other structural members for different stages • Proficiency in designing prestressed concrete elements for flexure (bending), shear, bond, deflection control and crack width limitation • Familiarity with design codes such as IS: 1343, IRC, or ACI codes related to prestressed concrete • Ability to interpret and apply code-based limit state and working stress methods. • Skill in using load balancing method and cable profile optimization. • Knowledge of construction techniques, equipment used, and detailing of prestressing tendons. • Evaluating long-term deflections, crack control, and durability aspects of prestressed structures. • Ability to compare alternatives and select the most economical and safe design solution. • Skill in preparing design reports, drawings, and technical documentation.

Administrative Information

SECTION 15: History of changes		
Regulations	**Description of change**	**BOS Date**
R 16	No Changes R15 JNTUH, Hyderabad to R16 IARE regulations	15.12.2016
R 18	No Changes from R16 to R18 regulation	10.07.2018
UG 20	No Changes from R18 to UG 20 regulation	17.11.2020
BT 23	No Changes from UG 20 to BT 23 regulation	21.08.2023

Course Outline Approvals	
Course Coordinator Name: Dr. Praveena Rao Signature: Date: 18.8.2025	**Head of the Department** Name: Dr. R. Ramya Swetha Signature: Date: 18.8.2025
Course Outline Approvals: The course outline description approved by Outcome Based Teaching Learning (OBTL) committee on *date* in meetings *IARE - OBTL – COD /104/25*	
Dean of Outcome Based Teaching and Learning Name: Dr. Ch. Srinivasulu Signature: Date: 18.8.2025	**Dean of Academics** Name: Dr. G. Chandra Sekhar Signature: Date: 18.8.2025

Check List

Section	Description	Please tick (✓)
1	General Information about the Course	✓
2	Notional Study Time	✓
3	A. Course Outcomes	✓
	B. Cognitive Levels	✓
4	Content and Context of the Course	✓
5	Complex Engineering Problem Solving	✓
6	A. Assessment Methods – Direct	✓
	B. Assessment Methods – Indirect	✓
7	Content Delivery / Instructional Methodologies	✓
8	Engineering Competencies (ECs) Focused	✓
9	Employability Skills	✓
10	Relevance to Sustainability goals	✓
11	A. Mapping between COs and POs / PSOs	✓
	B. Indicators of Attainment with COs to POs and PSOs	✓
	C. Course Articulation Matrix of COs to POs	✓
	D. Level of Contribution of the COs to POs and PSOs	✓
12	Syllabus	✓
13	Tentative Schedule of Instructions	✓
14	Specific Goals for the Course	✓
15	History of Changes	✓

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**CIVIL ENGINEERING**				
Course Title	**RESEARCH METHODOLOGY AND IPR**				
Course Code	BHSD01				
Program	M.Tech(ST)				
Semester	III Semester				
Course Type	Core				
Regulation	PG - 21				
Structure of the Course	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	2	0	2	-	-
Course Coordinator	Mr Gude Ramakrishna, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
-	-	-	-

II COURSE OVERVIEW:

This course imparts research methodology and philosophy of intellectual property rights, including basic concepts employed in quantitative and qualitative research methods, Patents, Copyrights, and Trademarks. It provides the research framework, research methodology research design, and formulation hypothesis, sampling techniques, data analysis and report writing. It implies on research skills and intellectual property rights to encourage new creations, including technology, artwork, and inventions, that might increase economic growth.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks

Design of Advanced Concrete Structures	60 Marks	40 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	✓	Chalk & Talk	x	Assignments	x	MOOC
x	Open Ended Experiments	✓	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 60 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 12 marks. There could be a maximum of two sub divisions in a question.

The expected percentage of cognitive level of the questions is broadly based on the criteria .

50%	To test the objectiveness of the concept
30 %	To test the analytical skill of the concept
20 %	To test the application skill of the concept

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE), 05 marks for Technical Seminar and Term Paper Outline of the Continuous Internal Assessments (CIA– 1 and CIA– 2) and SEE

Activities	CIA- I	CIA- II	SEE	Total Marks
Continuous Internal Examination(CIE)	10 Marks	10 Marks	-	20 Marks
Assignment / Quiz	05 Marks	05 Marks	-	10 Marks
Alternative Assessment Tool (AAT)	05 Marks	05 Marks	-	10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	-	100 Marks

Continuous Internal Examination (CIE):
100 Marks CIA is conducted for a total of 40 marks, with 30 marks for Continuous Internal Examination (CIE), 05 marks for Assignment and 05 marks for Alternative Assessment Tool (AAT). Two CIE Tests are Compulsory and sum of the two tests, along with the scores obtained in the assignment and AAT shall be considered for computing the final CIA of a student in a given course.
Technical Seminar and Term Paper:
Twoseminar 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. Page

VI COURSE OBJECTIVES:

The students will try to learn:

I	The Knowledge on formulate the research problem, characteristics of a good research and interpretation of collected data.
II	The importance of research ethics while preparing literature survey and writing thesis to achieve plagiarism free report.
III	The intellectual property rights such as patent, trademark, geographical indications and copyright for the protection of their invention done.

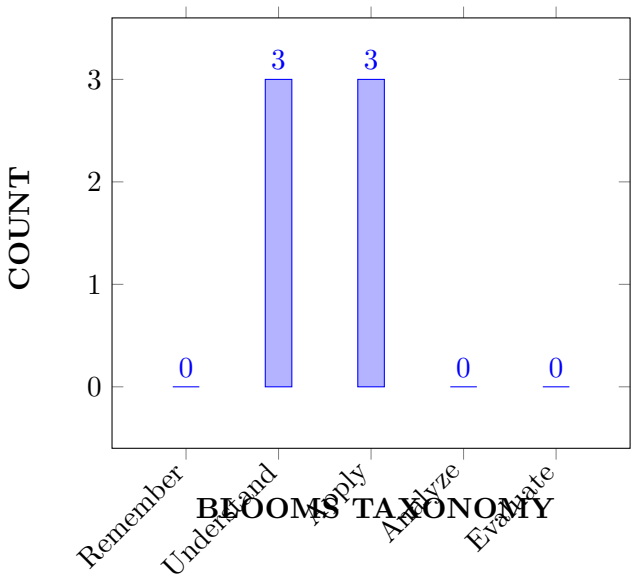
VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Interpret** the technique of determining a research problem for a crucial part of the research study.	Understand
CO 2	**Examine** the way of methods for avoiding plagiarism in research.	Apply

CO 3	**Apply** the feasibility and practicality of research methodology for a proposed project.	Apply
CO 4	**Make** use of the legal procedure and document for claiming patent of invention.	Understand
CO 5	**Identify** different types of intellectual properties, the right of ownership and scope of protection to create and extract value from IP.	Apply
CO 6	**Defend** the intellectual property rights throughout the world with the involvement of world intellectual property organization.	Remember

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

	ProgramOutcomes
PO 1	Anability to Independently carry out research/investigation and developmen twork to solve practical problems.
PO 2	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program.The mastery should be at a level higher than the requirements in the appropriate bachelor program.
PO 3	An ability to Write and present a substantial technical report/document.
PO 4	Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields.
PO 5	Conceptualize and design civil engineering structures considering various socio-economic factors.
PO 6	Engagein life-long learning for continuing education in research-level studies and professiona ldevelopment.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE,SEE
PO 2	Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	1	CIE,SEE
PO 3	Design/Development of Solutions: Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	1	CIE,SEE
PO 5	Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	2	CIE,SEE

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Synthesize and analyze aircraft structures, propulsion, production technologies and computer aided engineering in aeronautical systems including air traffic controls standards	3	CIA,SEE

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s):

Course Outcomes	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓	-	-	-	-	-
CO 2	✓	✓	✓	-	✓	-
CO 3	✓	✓	✓	-	-	-
CO 4	✓	✓	✓	-	✓	-
CO 5	✓	✓	✓	-	-	-
CO 6	-	✓	-	-	-	-

XII JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Apply the knowledge of Mathematics, Sciences and Engineering fundamentals principlesto classify various rocket propulsion systems and missiles	3
	PO 2	Identify the problem statement (mission requirement), select the appropriate missile required for destroying target by reviewing the literature (information and data collection) suitable to mission requirement	2
CO 2	PO 1	Apply the knowledge of Mathematics, Sciences and Engineering fundamentals principlesand derive the rocket thrust equation under different flight conditions	3
	PO 2	Analyze the performance parameters of rocket and various forces acting on a rocket using first principles of Mathematics and engineering sciences.	2
CO 3	PO 1	Identify various chemical rocket propulsion systemsand its propellants using principles of mathematics, science, and engineering fundamentals.	3
CO 4	PO 1	Apply the knowledge of different forces (scientific Principles and mathematical principles) for chemical rocket engine and describe different performance parameters.	3
	PO 2	Determine the grain parameters and rocket performance parameters using first principles and Mathematics and Engineering sciences.	2

	PO 5	Illustrate Thrust vs time graph of solid rocket motor using modern Engineering and IT tools (Matlab) to solve complex engineering problems.	1
CO 5	PO 1	Understand the advantages of solid propellant, monopropellant and Bi-propellant to determine the desirable properties of oxidizer, Inert gas and fuel using the fundamentals of engineering and mathematical equations	3
CO 6	PO 1	Analyze different Engine cycles used for propulsion system of a chemical rocket engine using fundamentals of science &and engineering fundamentals.	3
	PO 2	Categorize the concept of Pyrotechnics based on its physical state and its usage in complex engineering problems.	3
	PO 3	Investigate and define a problem and identify constraints of Pyrotechnics including environmental and sustainability limitations, health and safety and risk assessment issues when dealing with performance of gaseous mixtures and their application on real world problems	2
CO 7	PO 1	Understand (knowledge) different combustion instabilities w.r.t time for various chemical rocket engines during flight by applying the knowledge of sciences and Engineering fundamentals principles	3
	PSO 1	Synthesize and analyze different combustion systems for non-air breathing engines to provide thrust for the Rockets and missiles	2
CO 8	PO 1	Describe (Knowledge) different guidance phases and guidance systems for a cruise and ballistic missile using principles of mathematics, natural science, and engineering fundamentals.	3
	PSO 2	Extend the focus to understand the innovative and dynamic challenges involve the guidance system of rocket and missiles for specific role.	1
CO 9	PO 1	Evaluate the performance characteristics of single stage and multistage rocket using the basic understanding of engineering science and mathematical equations	3
	PO 2	Identify the problem statement (mission requirement), select the number of stages required for placing a payload into the orbit by reviewing the literature (information and data collection) suitable to mission requirement	2
CO 10	PO 1	Apply the knowledge of engineering fundamentals to test the prototype of rockets and various safety measures that should be taken while testing.	3

CO 11	PO 1	Apply the knowledge of Sciences and Engineering fundamentals for design and development of TVC mechanism and cooling systems for rocket propulsion system.	3
	PO 2	Identify the proper cooling system and TVC mechanism for a chemical rocket engine (complex system) using first principle of natural sciences and Engineering sciences.	2
CO 12	PO 1	Apply the knowledge of sciences and Engineering fundamentals principles to design a prototype of different rocket components.	3
	PO 5	Make use of computational/ Experimental tools to synthesize and analyze rocket aerodynamics by application of Modern tools.	1
	PO 12	Make use of broad knowledge of propellant composition in innovative, dynamic challenging environment for design and development of new products.	4

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO MAPPING:

Course Outcomes	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	-	-	-	-	-
CO 2	3	3	3	-	2	-
CO 3	2	2	2	-	-	-
CO 4	2	2	2	-	1	-
CO 5	3	2	2	-	-	-
CO 6	-	-	1	-	1	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO

Course Outcomes	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	25	-	-	-	-	-
CO 2	37.50	28.57	42.85	-	40	-
CO 3	25	42.85	28.57	-	-	-
CO 4	100	37.5	28.57	-	28.5	-
CO 5	37.50	25	28.57	-	-	-
CO 6	-	-	15	-	12.70	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.
0 - 0 ≤ C≤ 5% – No correlation
1 -5 <C≤ 40% – Low/ Slight
2 - 40 % <C < 60% –Moderate
3 - 60% ≤ C < 100% – Substantial /High

Course Outcomes	**PROGRAM OUTCOMES**					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	-	-	-	-	-
CO 2	3	2	3	-	3	-
CO 3	2	3	3	-	-	-
CO 4	2	2	3	-	3	-
CO 5	3	3	2	-	-	-
CO 6	-	-	1	-	3	-
Total	12	10	12	-	9	-
Average	2	2	3	-	3	–

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	✓
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	-
Assignments	✓				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

✓	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**INTRODUCTION**
	Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations.
MODULE II	**RESEARCH ETHICS**
	Effective literature studies approaches, analysis Plagiarism and Research ethics.
MODULE III	**RESEARCHPROPOSAL**
	Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.
MODULE IV	**PATENTING**
	Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.
MODULE V	**PATENT RIGHTS**
	Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

TEXTBOOKS

1. Panneerselvam, Ramasamy. Research methodology. PHI Learning Pvt. Ltd., 2014.
2. Goddard, Wayne, and Stuart Melville. Research methodology: An introduction. Juta and Company Ltd, 2004.
3. Ranjit Kumar, "Research Methodology: A Step-by-Step Guide for beginners". 2nd edition, 2007

REFERENCE BOOKS:

1. Halbert, "Resisting Intellectual Property", Taylor and Francis Ltd, 2007.
2. Correa, Carlos M. Intellectual property rights, the WTO and developing countries: the TRIPS agreement and policy options. Zed books, 2000.
3. Niebel, "Product Design", McGraw Hill, 1974.

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	**Topics to be covered**	**CO's**	**Reference T1: 4.1**
1-2	Explanation of research problem	CO 1	T2: 1.1-1.5,
3-4	Sources of research problem	CO 1	T2: 2.1-2.2,
5-6	Criteria Characteristics of a good research problem	CO 1	T2: 2.3-2.4
7-8	Errors in selecting a research problem	CO 2	T2: 2.5-2.6,
9-10	Scope and objectives of research problem	CO 4	T2: 3.3
11-12	Approaches of investigation of solutions for research problem	CO 3	T2: 3.4
13-14	Data collection, analysis, interpretation, Necessary instrumentations.	CO 5	T2: 3.3
15-18	analysis Plagiarism and Research ethics.	CO 3	R2: 4.2
19-20	Effective technical writing.	CO 6	T2: 5.2
21-24	How to write report, Paper Developing a Research Proposal.	CO 3	T2: 4.5
25-26	, s, Format of research proposal, presentation and assessment.	CO 5	T1: 4.2
27-28	Patents, Designs, Trade and Copyright.	CO 4	T1: 4.3
29-30	Process of Patenting and development, technological research.	CO	T2: 5.2
31-32	innovation, patenting, development. International Scenario.	CO 2	T2: 5.2
33-34	Scope of Patent Rights. Licensing and transfer of technology.	CO 6	T2: 5.2
35-36	Patent information and databases. Geographical Indications.	CO 5	R3: 7.2
37	Administration of Patent System.	CO 5	T1: 7.5
38-39	IPR of Biological Systems, Computer Software etc., Traditional knowledge Case Studies, IPR and IITs.	CO 6	R2:7.5

Signature of Course Coordinator **HOD,CE**