INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad -500 043

CIVIL ENGINEERING

COURSE DESCRIPTOR

Course Title	**STRUCTURAL ANALYSIS**				
Course Code	ACE008				
Programme	B.Tech				
Semester	V	CE			
Course Type	Core				
Regulation	IARE - R16				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	4	-	4	-	-
Chief Coordinator	Mr. Suraj Baraik, Assistant Professor				
Course Faculty	Mr. S. Ashok Kumar, Assistant Professor Mr. Suraj Baraik, Assistant Professor,				

I. COURSE OVERVIEW:

Civil Engineers are required to design structures like buildings, dams, bridges, etc. This course is intended to introduce the basic principles to impart adequate knowledge and successfully apply fundamentals of Structural Engineering within their chosen engineering application area. A structural engineer must be able to design a structure in such a way that none of its members fail during load transfer process. This course is intended to introduce analysis of various structural members using different methods. For this, the concept of trusses, arches, determinate and indeterminate structures are covered in depth. Deflections by energy methods of propped cantilevers, fixed and continuous beams under various load combinations. Through this course content engineers can analyze the behavior of various structural members under different loading conditions for design, safety and serviceability.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	ACE004	IV	Strength of material-II	4

III. MARKS DISTRIBUTION:

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

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

v.

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

V. EVALUATION METHODOLOGY:

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

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

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz/Alternative Assessment Tool (AAT).

Table 1: Assessment pattern for CIA

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz/AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part- A shall have five compulsory questions of one mark each. In part-B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination

Two Quiz exams shall be online examinations consisting of 20 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Marks shall be awarded considering the average of two quizzes for every course.

Alternative Assessment Tool (AAT)

This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning centre. The AAT may include seminars, assignments, term paper, open ended experiments, micro projects, five minutes video and MOOCs.

VI. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (POs)		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.	2	Presentation on real-world problems
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	2	Seminar
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	Assignments

3 = High; 2 = Medium; 1 = Low

VII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes (PSOs)		Strength	Proficiency assessed by
PSO 1	**Engineering Knowledge**: Graduates shall demonstrate sound knowledge in analysis, design, laboratory investigations and construction aspects of civil engineering infrastructure, along with good foundation in mathematics, basic sciences and technical communication.	1	Presentation on real-world problems

Program Specific Outcomes (PSOs)		Strength	Proficiency assessed by
PSO 2	**Broadness and Diversity**: Graduates will have a broad understanding of economic, environmental, societal, health and safety factors involved in infrastructural development, and shall demonstrate ability to function within multidisciplinary teams with competence in modern tool usage	-	-
PSO 3	**Self-Learning and Service**: Graduates will be motivated for continuous self-learning in engineering practice and/or pursue research in advanced areas of civil engineering in order to offer engineering services to the society, ethically and responsibly	-	-

3 = High; 2 = Medium; 1 = Low

VIII. COURSE OBJECTIVES :

The course should enable the students to:	
I	Describe the process of analysis of various structures such as beams, trusses, arches and frames.
II	Analyze statically determinate structures using force and displacement methods.
III	Draw the shear force, bending moment and influence diagrams for various structures.
IV	Examine the various structures to calculate critical stresses and deformation.

IX. COURSE OUTCOMES (COs):

COs	Course Outcome	CLOs	Course Learning Outcome
CO 1	Understand the concept of trusses and describe the analysis process of trusses by various methods.	CLO 1	Differentiate between the perfect, imperfect and redundant pin jointed frames.
		CLO 2	Identify the pin jointed frames and rigid joint structures.
		CLO 3	Understand the determinate and indeterminate structures for rigid jointed and pin jointed frames.
		CLO 4	Analysis of determinate pin jointed frames using method of joint, method of section for vertical load.
		CLO 5	Evaluate the determinate pin jointed frames by method of joint, method of section for horizontal and inclined load.
		CLO 6	Analysis of determinate pin jointed frames by tension coefficient method foe vertical, horizontal and inclined loads.
CO 2	Determine stresses and analysis of two hinged and three hinged arches.	CLO 7	Differentiate between three hinged and two hinged arches.
		CLO 8	Analysis of three hinged circular arches at different levels.
		CLO 9	Execute secondary stresses in two hinged arches due to temperature and elastic shortening of rib.
		CLO 10	Analyze the parabolic arches for the shear forces and bending moments.
		CLO 11	Evaluate the shear forces and bending moments in two-hinged arches using energy methods.

COs	Course Outcome	CLOs	Course Learning Outcome
		CLO 12	Draw the shear forces and bending moments in three hinged arches using energy methods.
CO 3	Evaluate propped cantilever, fixed beam and continuous beam using various methods of analysis.	CLO 13	Contrast the fixed end moment and deflection formula for propped cantilever and fixed beams.
		CLO 14	Analysis of propped cantilever and fixed beam using the method of consistent deformation for different loading conditions.
		CLO 15	Evaluate of continuous beam using the method of clapeyron's equation of three moment.
		CLO 16	Analysis of continuous beam with sinking support using equation of three moments.
CO 4	Understand the concept of moment distribution method and its application to beams and frame structure.	CLO 17	Contrast between the concept of force and displacement methods of analysis of indeterminate structures.
		CLO 18	Analyze the methods of moment distribution to carry out structural analysis of 2D portal frames with various loads and boundary conditions.
		CLO 19	Apply the methods of slope deflection to carry out structural analysis of 2D portal frames with various loads and boundary conditions.
		CLO 20	Analysis of single storey frames with and without sway using slope deflection and moment distribution method.
CO 5	Comprehend the concept of moving loads and influence line diagram, its application to beams.	CLO 21	Comprehend the concept of moving loads, and its effect on shear force and bending moment on a beam.
		CLO 22	Evaluate the shear force and bending moment at a section of a determinate beam under moving load.
		CLO 23	Understand the concept of influence line diagram for shear force and bending moment.
		CLO 24	Construct the influence line diagram for shear force and bending movement for the entire beam.

X. COURSE LEARNING OUTCOMES (CLOs):

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
ACE008.01	CLO 1	Differentiate between the perfect, imperfect and redundant pin jointed frames.	PO 1	1
ACE008.02	CLO 2	Identify the pin jointed frames and rigid joint structures.	PO 1	2
ACE008.03	CLO 3	Understand the determinate and indeterminate structures for rigid jointed and pin jointed frames.	PO 1	1
ACE008.04	CLO 4	Analysis of determinate pin jointed frames using method of joint, method of section for vertical load.	PO 2	2
ACE008.05	CLO 5	Evaluate the determinate pin jointed frames by method of joint, method of section for horizontal and inclined load.	PO 1, PO 2	2
ACE008.06	CLO 6	Analysis of determinate pin jointed frames by tension coefficient method foe vertical, horizontal and inclined loads.	PO 2, PO 1	3

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
ACE008.07	CLO 7	Differentiate between three hinged and two hinged arches.	PO 1	1
ACE008.08	CLO 8	Analysis of three hinged circular arches at different levels.	PO 2, PO 3	3
ACE008.09	CLO 9	Execute secondary stresses in two hinged arches due to temperature and elastic shortening of rib.	PO 3	2
ACE008.10	CLO 10	Analyze the parabolic arches for the shear forces and bending moments.	PO 2, PO 3	3
ACE008.11	CLO 11	Evaluate the shear forces and bending moments in two-hinged arches using energy methods.	PO3	2
ACE008.12	CLO 12	Draw the shear forces and bending moments in three hinged arches using energy methods.	PO 1, PO 2	3
ACE008.13	CLO 13	Derive the moment equation for propped cantilever and fixed beams under various conditions	PO 2, PO 3	1
ACE008.14	CLO 14	Analysis of propped cantilever and fixed beam using the method of consistent deformation for different loading conditions.	PO 2, PO3	3
ACE008.15	CLO 15	Evaluate of continuous beam using the method of clapeyron's equation of three moment.	PO 2	2
ACE008.16	CLO 16	Analysis of continuous beam with sinking support using equation of three moments.	PO2, PO3	2
ACE008.17	CLO 17	Contrast between the concept of force and displacement methods of analysis of indeterminate structures.	PO 2	2
ACE008.18	CLO 18	Analyze the methods of moment distribution to carry out structural analysis of 2D portal frames with various loads and boundary conditions.	PO 2, PO 3	2
ACE008.19	CLO 19	Apply the methods of slope deflection to carry out structural analysis of 2D portal frames with various loads and boundary conditions.	PO 1, PO 2	3
ACE008.20	CLO 20	Analysis of single storey frames with and without sway using slope deflection and moment distribution method.	PO2	3
ACE008.21	CLO 21	Comprehend the concept of moving loads, and its effect on shear force and bending moment on a beam.	PO 1	1
ACE008.22	CLO 22	Evaluate the shear force and bending moment at a section of a determinate beam under moving load.	PO 2, PO 3	2
ACE008.23	CLO 23	Understand the concept of influence line diagram for shear force and bending moment.	PO1	1
ACE008.24	CLO 24	Construct the influence line diagram for shear force and bending movement for the entire beam.	PO 2, PO 3	2

3= High; 2 = Medium; 1 = Low

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

Course Outcomes (COs)	Program Outcomes (POs)			
	PO 1	PO 2	PO 3	PSO1
CO 1	2	2		2
CO 2	2	3	2	1
CO 3		2	2	1

Course Outcomes (COs)	Program Outcomes (POs)			
	PO 1	PO 2	PO 3	PSO1
CO 4	3	2	2	1
CO 5	2	2	1	1

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XII. MAPPING COURSE LEARNING OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Learning Outcomes (CLOs)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CLO 1	1												2		
CLO 2	2												2		
CLO 3	1												2		
CLO 4		2											2		
CLO 5	2	2											1		
CLO 6	3	3											2		
CLO 7	1												2		
CLO 8		3	3										2		
CLO 9			2										1		
CLO 10		3	3										1		
CLO 11			2										2		
CLO 12	3	3											2		
CLO 13		1	1										2		
CLO 14		3	3										1		
CLO 15		2											2		
CLO 16		2	2										1		
CLO 17		2											1		
CLO 18		2	2										1		
CLO 19	3	3											2		
CLO 20		3											1		

Course Learning Outcomes (CLOs)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CLO 21	1												2		
CLO 22		2	1										2		
CLO 23	1												2		
CLO 24		2	2										1		

3 = High; 2 = Medium; 1 = Low

XIII. ASSESSMENT METHODOLOGIES – DIRECT

CIE Exams	PO1, PO2, PO3,PSO1	SEE Exams	PO1, PO2, PO3,PSO1	Assignments	PO3	Seminars	PO2
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	-						

XIV. ASSESSMENT METHODOLOGIES - INDIRECT

✔	Early Semester Feedback	✔	End Semester OBE Feedback
✘	Assessment of Mini Projects by Experts		

XV. SYLLABUS

UNIT - I	ANALYSIS OF PIN-JOINTED FRAMES (TRUSSES)
Types of frames, perfect, imperfect and redundant. Pin jointed frames (trusses), analysis of determinate pin jointed frames , analysis of determinate pin jointed frames using method of joints, method of sections and tension coefficient method for vertical loads, horizontal loads and inclined loads.	
UNIT - II	**ARCHES**
Introduction, types of arches, comparison between three hinged and two hinged arches; Normal thrust and radial shear in an arch; Geometrical properties of parabolic and circular arch; Three hinged circular arch at different levels; Absolute maximum bending moment diagram for a three hinged arch; Two hinged arches: Introduction, classification of two hinged arches, analysis of two hinged parabolic arches, secondary stresses in two hinged arches due to temperature and elastic shortening of rib.	
UNIT - III	**FORCE METHOD OF ANALYSIS OF INDETERMINATE BEAMS**
Analysis of propped cantilever and fixed beams using the method of consistent deformation, including the beams with varying moments of inertia, subjected to uniformly distributed load, central point load, eccentric point load, number of point loads, uniformly varying load, couple and combination of loads, shear force and bending moment diagrams for propped cantilever and fixed beams, deflection of propped cantilever and fixed beams; effect of rotation of a support. Continuous beams. Clapeyron's theorem of three moments, analysis of continuous beams with constant and variable moments of inertia with one or both ends fixed, continuous beams with overhang. Effects of sinking of supports.	

UNIT - IV	DISPLACEMENT METHOD OF ANALYSIS: SLOPE DEFLECTION AND MOMENT DISTRIBUTION
Derivation of slope, deflection equation, concept of moment distribution method, application of the methods to continuous beams with and without settlement of supports. Shear force and bending moment diagrams, elastic curve, application of the methods to single bay, single storey frames with and without sway.	
UNIT - V	**MOVING LOADS AND INFLUENCE LINES**
Introduction, maximum shear force, and bending moment; At a given section and absolute maximum shear force and bending moment due to various load cases, focal length; Definition of influence line for shear force, influence line for bending moment, load position for maximum SF at a section, load position for maximum BM at a section, for various loads.	
Text Books:	
1. Devadas Menon , "Structural Analysis Vol.1 ", Narosa Publishers, New Delhi, 2010. 2. S. S. Bhavikatti, "Structural Analysis Vol.1", Vikas Publishing House, New Delhi, 2010. 3. R. C. Hibbler, "Structural Analysis", Pearson Education, India, 2008.	
Reference Books:	
1. T. S. Thandavamoorthy, "Structural Analysis", Oxford Higher Education, India, 2011. 2. C. S. Reddy , "Basic Structural Analysis", McGraw Hill Education (India), Delhi, 2000. 3. C. K. Wang, "Intermediate Structural Analysis", McGraw Hill Education (India), Delhi, 2010.	

XVI. COURSE PLAN:

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

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
1	Types of frames- Perfect.	CLO 1	T1:1.1-3
2	Imperfect and Redundant pin jointed frames.	CLO 2	T1:1.13
3-4	Problems on determinate pin jointed frames using method of joints for vertical loads,	CLO 2	T1: 2.4, R 1:5-7
5	Problems on determinate pin jointed frames using method of joints for horizontal loads and inclined loads.	CLO 5	T1, T2 : 2.4
6	Problems on determinate pin jointed frames using method of sections	CLO 5	T1: 2.6-14
7	Problems of determinate pin jointed frames for vertical loads.	CLO 5	T1: 2.6-14
8	Problems of determinate pin jointed frames for inclined loads and horizontal loads.	CLO 5	T1: 2.6-14
9	Problems on determinate pin jointed frames using for tension coefficient method using vertical loads, inclined loads and horizontal loads.	CLO 5	T1:2.15-20, R1:5.7
10	Introduction to arches, types of arches, comparison between three hinged and two hinged arches	CLO 7	T1: 3.1-.3
11-12	Problems on three hinged and two hinged arches, Geometrical properties of parabolic and circular arch	CLO 8	T1: 3.1-.3
13	Problems on parabolic and circular arch	CLO 10	T1: 3.5-14
14	Three hinged circular arch	CLO 10	T1: 6.1-5
15	Three hinged circular arch at different levels.	CLO 10	T2: 6.1-5
16	Introduction to two hinged arches	CLO 11	T1: 9.1-5
17	Classification of two hinged arches. Analysis of two hinged parabolic arches. Analysis of two hinged parabolic arches.	CLO 11	T1:9.1 R:1:7.3
18	Analysis of two hinged parabolic arches. Problems on secondary stresses in two hinged arches	CLO 11	T1: 9.2-3

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
20	Problems on secondary stresses in two hinged arches due to temperature and elastic shortening of rib.	CLO 11	T1: 9.4-5
21	Analysis of propped cantilever and fixed beams using the method of consistent deformation, including the beams with varying moments of inertia for different loading conditions.	CLO 11	T1: 9.6-7 R1: 8.1-2
22	Draw the shear force and bending moment diagrams for propped cantilever and fixed beams. Introduction to cantilever and fixed beam.	CLO 13	T1: 9.6-7 R1: 3.8.6
23	Deflection of propped cantilever and fixed beams. Deflection of propped cantilever and fixed beams, effect of rotation of a support.	CLO 13	T1: 9.6-7
24-25	Derive the Clapeyron's theorem of three moments for continuous beams. Problems on continuous beam using Clapeyron's equation of three moments. Problems on continuous beams with constant and variable moments of inertia	CLO 13	T1: 9.6-7
26-27	Problems on continuous beams with one or both ends fixed. Problems on continuous beams with overhang. Effects of sinking of supports.	CLO 15	T2: 9.6-7
28-30	Derivation of slope deflection equation application of the methods to continuous beams with and without settlement of supports.	CLO 16	T1:9.6-11, R 1:7.6.3
31-32	Deflection of propped cantilever and fixed beams. Deflection of propped cantilever and fixed beams, effect of rotation of a support.	CLO 13	T1: 9.6-7
33-34	Problems on continuous beams with one or both ends fixed. Problems on continuous beams with overhang. Effects of sinking of supports.	CLO 15	T2: 9.6-7 R2:7.1-1
35-36	Derivation of slope deflection equation application of the methods to continuous beams with and without settlement of supports.	CLO 17	T1: 10.1
37-38	Understand the concept of moment distribution method. Problems on application of the methods to continuous beams with and without settlement of supports.	CLO 17	T1: 10.2-3
39-40	Shear force and bending moment diagrams, elastic curve, application of the methods to single bay, single storey frames with and without sway.	CLO 18	T1: 10.4-5 R 1:10.3.6
41-42	Understand the concept of influence line and moving load, **a**t a given section and absolute maximum shear force and bending moment due to various load cases, focal length Understand the concept of influence line and moving load.	CLO 19	T1: 10.5-6
43-44	Definition of influence line for shear force, influence line for bending moment, load position for maximum SF at a section, load position for maximum BM at a section, for various loads.	CLO 19	T1: 10.6-7
45	Problems on influence line method.	CLO 20	T2: 10.7

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

S No	Description	Proposed actions	Relevance With POs	Relevance With PSOs
1	Analysis of Arches with elastic shortening of rib.	Assignment	PO 2	PSO 1
2	Application of continuous beam with settlement support.	Guest Lectures	PO 2, PO3	PSO 1

S No	Description	Proposed actions	Relevance With POs	Relevance With PSOs
3	Application of ILD for single frame method.	Seminars	PO 2, PO 3	PSO 1

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