Program Name : **Civil Engineering Program Group**

Program Code : **CE/CR/CS**

Semester : **Fourth**

Course Title : **Theory of Structures**

Course Code : **22402**

1. RATIONALE

Civil engineering structures are mainly made-up of column, Beam and Slabs and these structures are subjected to axial as well as eccentric loading along with different end conditions. The content on calculations of shear forces, bending moments, bendingstresses, slope and deflections which are developed in various types of beams will be useful in design of these members. Analysis of members for axial forces, slope, deflection, combined direct and bending stresses will be useful in safe design of various structural members.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Analyze structural components using different methods.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Analyze stresses induced in vertical membersubjected to direct and bending loads.
b. Analyze slope and Deflection in beams under different loading conditions.
c. Analyze end moments of fixed beams.
d. Analyse continuous beam under different loading conditions using the principles of Three Moments.
e. Analyze continuous beam using Moment Distribution Method under different loading conditions.
f. Evaluate axial forces in the members of simple truss.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
4	2	-	6	4	70	28	30*	00	100	40	--	--	--	--	--	--

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

***Legends:** **L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** -Practical; **C** – Credit, **ESE** -End Semester Examination; **PA** - Progressive Assessment.*

5. COURSE MAP(with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

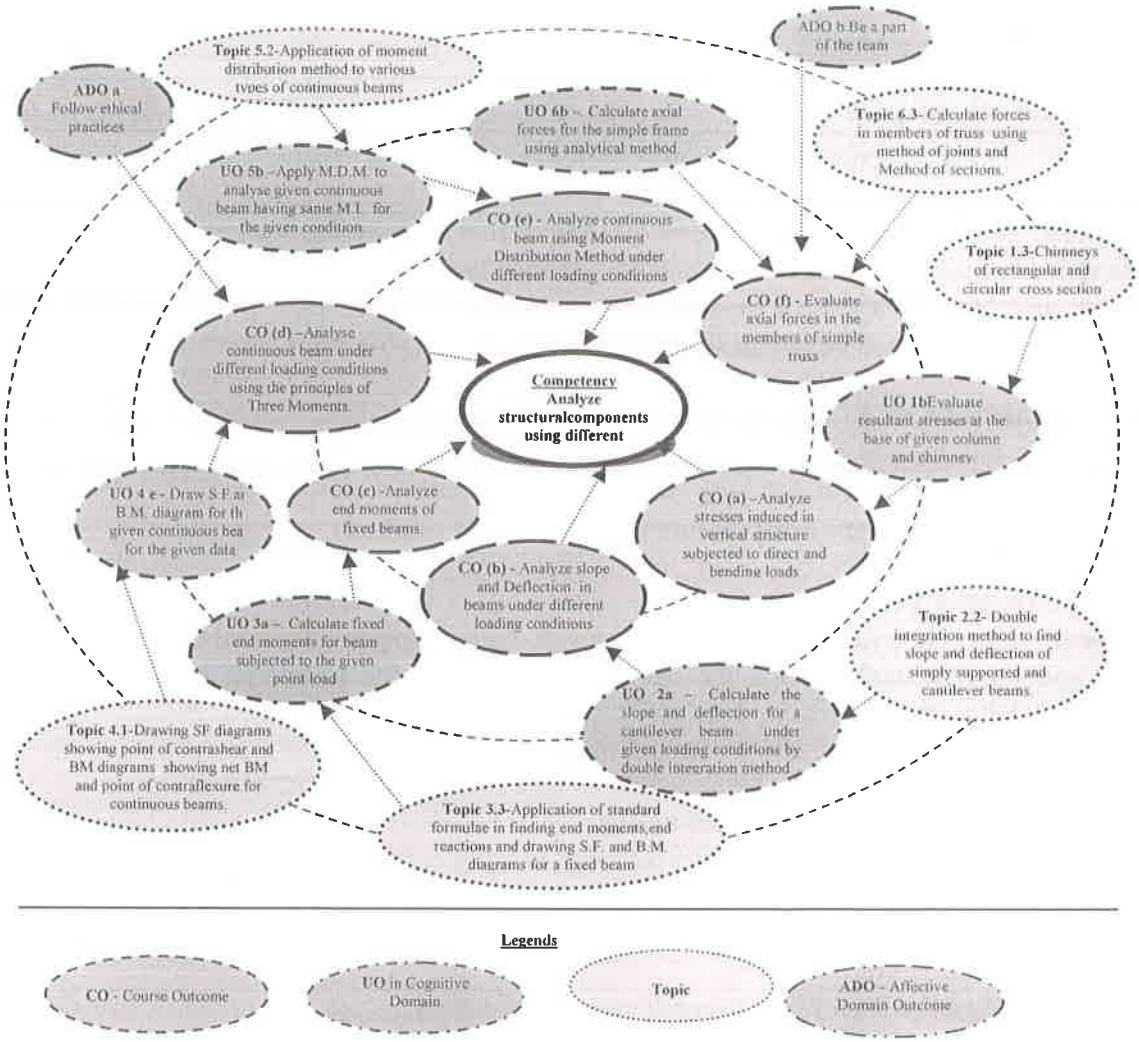

Figure 1 - Course Map

6. UNDERPINNING THEORY COMPONENTS

The following topicsare to betaught and assessed in order to develop the sample UOs given below for achicving thc COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Direct and Bending Stresses in vertical members.	1a. Compare stresses developed due to the axial load and eccentric load in the given situation. 1b. Evaluate resultant stresses at the base of given column and chimney under given loading conditions. 1c. Draw stress distribution diagram	1.1 Introduction toaxial and eccentric loads, Eccentricity about one principal axis only, nature of stresses. Maximum and minimum stresses, resultant stresses and stress distribution diagram. 1.2 Condition for no tension or zero stress at extreme fiber, Limit of eccentricity.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	for the given column and chimney under given loading conditions. 1d. Calculate the limit of eccentricity and core of a given section. 1e. Analyze stresses in a given dam section for given loading conditions. 1f. Draw stress distribution diagram for the given dam section.	core of section for rectangular and circular cross sections, Middle third rule. 1.3 Chimneys of rectangular and circular cross section subjected to wind pressure, coefficient of wind pressure, Maximum and minimum stresses, resultant stresses and stress distribution diagram at base. 1.4 Analysis of dams subjected to horizontal water pressure, conditions of stability, Maximum and minimum stresses, resultant stresses and stress distribution diagram at base.
Unit-II Slope and Deflection	2a. Calculate the slope and deflection for a cantilever beam under given loading conditions by double integration method. 2b. Determine the slope and deflection for a simply supported beam under given loading conditions by double integration method. 2c. Find the slope and deflection for a cantilever beam under given loading conditions by Macaulay's method. 2d. Calculate the slope and deflection for a simply supported beam under given loading conditions by Macaulay's method.	2.1 Concept of slope and deflection, stiffness of beams, Relation among bending moment, slope, deflection and radius of curvature, (no derivation). 2.2 Double integration method to find slope and deflection of cantilever and simply supported beams subjected to concentrated load and uniformly distributed load on entire span. 2.3 Macaulay's method for slope and deflection, application to cantilever and simply supported beam subjected to concentrated and uniformly distributed load on entire span.
Unit– III Fixed Beam	3a. Explain the effect of fixity in the given beam section. 3b. Calculate fixed end moments for beam subjected to the given point load. 3c. Determine fixed end moments for the given beam subjected to UDL over entire span by first principle. 3d. Find end moments and reactions for fixed beam under given loading condition. 3e. Draw S.F. and B.M. diagrms for the given fixed beam using	3.1 Concept of fixity, effect of fixity, advantages and disadvantages of fixed beam over simply supported beam. 3.2 Principle of superposition, Fixed end moments from first principle for beam subjected to central point load, UDL over entire span, Point load other than mid span. 3.3 Application of standard formulae in finding end moments,end reactions and drawing S.F. diagrams showing point of contrashear and B.M. diagrams showing net BM and point

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	given data.	of contraflexurefor a fixed beam.
Unit– IV Continuous Beam	4a. Explain the effect of continuity in the given situation. 4b. Draw deflected shape of continuos beam subjected to given load and end conditions. 4c. Explain Calpeyron's theorem of three moments used for the analysis of given continuous beam. 4d. Analyse continuous beam under given loading conditions, using Clapeyrons theorem of three moment. 4e. Draw S.F.and B.M. diagram for the given continuous beam using given data.	4.1 Definition, effect of continuity, nature of moments induced due to continuity, concept of deflected shape,practical example. 4.2 Clapeyron's theorem of three moment (no derivation) Application of Clapeyron's theorem maximum up to three spans and two unknown support moment only. Supports at same level, spans having same and different moment of inertia subjected to concentrated loads and uniformly distributed loads over entire span. 4.3 Drawing SF diagrams showing point of contrashear and BM diagrams showing net BM and point of contraflexure for continuous beams.
Unit –V Moment Distribution Method	5a. Explain Moment Distribution Method(M.D.M.) used for analyzing the given indeterrminate beam. 5b. Apply M.D.M. to analyse given continuous beam having same M.I.for the given condition. 5c. Apply M.D.M. to analyse given continuous beam having different M.I.for the given condition. 5d. Plot S.F. and B.M. Diagrams for continuous beam using given data. 5e. Identify the type of given portal frame with justification. 5f. Plot S.F. and B.M. Diagrams for the portal frame using given data.	5.1 Introduction to moment distribution method, sign convention, Carry over factor, stiffness factor, distribution factor. 5.2 Application of moment distribution method to various types of continuous beams subjected to concentrated loads and uniformly distributed load over entire span having same or different moment of inertia, supports at same level, up to three spans and two unknown support moments only. 5.3 Drawing SF diagrams showing point of contrashear and BM diagrams showing net BM and point of contraflexure for continuous beams. 5.4 Introduction to portal frames – Symmetrical and unsymmetrical portal frames with the concept of Bays and stories.(Numericals on Symmetrical portal frames only) 5.5 Drawing SF diagrams and BM diagrams for Symmetrical portal frames only.
Unit–VI Simple Trusses	6a. Select the type of truss for given situation with justification. 6b. Calculate the support rections for the given simple truss using	6.1 Types of trusses (Simple, Fink, compound fink, French truss, pratt truss, Howe truss, North light truss, King post and Queen post truss)

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	analytical method. 6c. Calculate axial forces for the given simple truss using method of joint and method of section. 6d. Calculate axial forces for the given simple truss using graphical method.	6.2 Calculate support reactions for trusses subjected to point loads at nodal points only. 6.3 Calculate forces in members of truss using method of joints and Method of sections. 6.4 Graphical method of analysis of truss. (No numerical on graphical method of analysis of truss)

***Note**:To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'.*

7. SUGGESTED SPECIFICATION TABLE FORQUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Direct And Bending Stresses	12	02	04	08	14
II	Slope And Deflection	10	02	04	06	12
III	Fixed Beam	10	00	04	04	08
IV	Continuous Beam	12	02	04	06	12
V	Moment Distribution Method	10	02	04	06	12
VI	Simple Trusss	10	02	04	06	12
Total		**64**	**10**	**24**	**36**	**70**

***Legends:** R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
***Note**: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

8. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Collect the data of existing structures where direct and bending stresses have a predominant role(for example: Leaning Tower Of Pisa)
b. Study the deflected shape and measure maximum deflection in a simply supported beam in laboratory.Check the results using analytical method.
c. Compare Fixed Beam with Simply Supported Beam of same span and loading.
d. Analyse given continuous beam using different methods and compare the results.
e. Collect the data from YouTube/videos showing change in deflected shape due to change in number of supports in a beam.
f. Prepare truss using given number of members and joints to carry given load(use webtools/ video games available on internet such as Xconstruction)

9. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects
f. Use Flash/Animations to explain various theorems in circuit analysis
g. Assign unit wise tutorials to group of 4 to 5 students for solving problems unit wise.
h. Assign micro projects to group of 4 to 5 students and let them prepare and present the project through PPT. Group shall submit a report which is limited to 5 pages.
i. Use of video animation films to explain concept, Facts and applications related to Theory of Structures.
j. In respect of item 10 below teacher needs to ensure to create opportunity and provisions for such co curricular activities.

10. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a. Prepare a model to demonstrate effect of eccentricity.
b. Prepare a chart showing values of maximum slope and deflection in a fixed beam and simply supported beam, under various loading conditions.
c. Collect photographs of fixed beams from actual site.
d. Collect information of continuous beams on actual sites and study the reinforcement provided.
e. Collect information and photographs of simple truss, its span and type. Prepare a chart based on the information.
f. Prepare models of different trusses.
g. Compare member forces in different type of trusses of same span,rise and loading.

11. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Theory of Structures	Ramanrutham, S.	Dhanpatrai& Sons, Delhi ISBN : 978-93-84378-10-3
2	Theory of Structures	Khurmi, R. S.	S. Chand and Co., New Delhi, 2006 ISBN:978-81-21905-20-6
3	Structural Analysis Vol-1	Bhavikatti, S S	Vikas Publishing House PvtLtd.New Delhi; ISBN: 978-81-25927-90-7
4	Mechanics of structures, Volume-I and II	Junnarkar, S. B.	Charotar Publishing House,Anand ISBN:978-93-80358-99-4
5	Theory of Structures	Pandit, G.S. and Gupta, S.P.	Tata McGraw Hill, New Delhi, 2006 ISBN :978-00-74634-93-6

12. SUGGESTEDSOFTWARE/LEARNING WEBSITES

a. nptel.ac.in/courses/112107146/lects%20&%20picts/.../lecture30%20and%2031.htm
b. www.nptel.ac.in/courses/105101085/downloads/lec-32.pdf
c. www.facweb.iitkgp.ernet.in/~baidurya/CE21004/online_lecture_notes/m2l12.pdf
d. https://en.wikipedia.org/wiki/Theorem_of_three_moments
e. https://en.wikipedia.org/wiki/Moment_distribution_method
f. www.facweb.iitkgp.ernet.in/~baidurya/CE21004/online_lecture_notes/m3l19.pdf
g. www.bgstructuralengineering.com/BGSMA/ContBeams/BGSMA_CB_0201.htm
h. www.facweb.iitkgp.ernet.in/~baidurya/CE21004/online_lecture_notes/m3l19.pdf
i. www.civilprojectsonline.com › Building Construction
j. www.mathalino.com/reviewer/engineering.../method-sections-analysis-simple-trusses

13. COURSE CURRICULUM DEVELOPMENT COMMITTEE

MSBTE Resource Persons

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