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THEORY OF STRUCTURE **Course Code : 315313**

Programme Name/s	**: Civil Engineering/ Civil & Rural Engineering/ Construction Technology/ Civil & Environmental Engineering/**
Programme Code	**: CE/ CR/ CS/ LE**
Semester	**: Fifth**
Course Title	**: THEORY OF STRUCTURE**
Course Code	**: 315313**

I. RATIONALE

Every civil engineering structure need to be design properly for ensuring its stability .Structural members often experience various types of load with different end conditions. However all such design based on some preliminarily analysis of determinate & indeterminate structural element such as Simply supported beam, cantilever beam, fixed beam, continuous beam, portal frame etc. Therefore civil engineer must have knowledge of specialized method for conducting such analysis. This course will develop the basic knowledge among the learners about various analytical technique that are required to solve civil engineering problems.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

•The theoretical principles taught in the course are directly applicable to real-world field situations. By applying these Principles, students learn how to
"Analyze the given structural components using the relevant methods."

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Analyze slope and Deflection in beams under different loading conditions.
- CO2 - Analyze fixed beams under different loading conditions.
- CO3 - Apply the principles of Three Moments to analyze continuous beam under the given situations.
- CO4 - Apply the Moment Distribution Method to analyze continuous beam under different loading conditions.
- CO5 - Evaluate axial forces in the members of simple truss.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
315313	THEORY OF STRUCTURE	TOS	DSC	6	-	-	3	9	3	4	30	70	100	40	-	-	-	-	25	10	125

Total IKS Hrs for Sem. : Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be

declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 10 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Use flexural equation to prepare general differential equation. TLO 1.2 Determine the slope and deflection for the given structural element under specific loading conditions by double integration method. TLO 1.3 Determine the slope and deflection for the given structural element under specific loading conditions by Macaulay's method.	**Unit - I Slope and Deflection** 1.1 Concept of slope and deflection, stiffness of beams, Relation among bending moment, slope, deflection and radius of curvature, (no derivation). 1.2 Double integration method to find slope and deflection of simply supported and cantilever beam subjected to concentrated load and uniformly distributed load on entire span. 1.3 Macaulay's method for slope and deflection, application to simply supported and cantilever beam subjected to concentrated and uniformly distributed load on entire span.	Lecture Using Chalk-Board Collaborative learning Video Demonstrations Site/Industry Visit Presentations
2	TLO 2.1 Explain the effect of fixity in the given beam section. TLO 2.2 Calculate fixed end moments for the fixed beam under specific loading conditions by using first principle. TLO 2.3 Find end moments and reactions for fixed beam under given loading condition by using standard formulae. TLO 2.4 Draw S.F. and B.M. diagrams for the given fixed beam using given data.	**Unit - II Fixed Beam** 2.1 Concept of fixity, effect of fixity, advantages and disadvantages of fixed beam over simply supported beam. 2.2 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. 2.3 Standard formulae to find end moments and end reactions for different loading conditions. 2.4 Shear force and bending moment diagram of fixed beam, point of contra shear and point of contra flexure.	Lecture Using Chalk-Board Video Demonstrations Site/Industry Visit Collaborative learning Presentations
3	TLO 3.1 Draw deflected shape of continuous beam subjected to given load and end conditions by using effect of continuity TLO 3.2 Explain Clapeyron's theorem of three moments used for the analysis of given continuous beam. TLO 3.3 Analyze continuous beam under given loading conditions, using Clapeyrons	**Unit - III Continuous Beam** 3.1 Definition, effect of continuity, nature of moments induced due to continuity, concept of deflected shape, Zero span or imaginary span theory. 3.2 Clapeyron's theorem of three moments (no derivation) Supports at same level, spans having same and different moment of inertia. 3.3 Clapeyron's theorem of three moments to various types of continuous beams subjected to concentrated loads and uniformly distributed load over entire span having same and different moment of inertia,	Lecture Using Chalk-Board Video Demonstrations Site/Industry Visit Collaborative learning Presentations

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
	theorem of three moments. TLO 3.4 Draw S.F.and B.M. diagram for the given continuous beam using given data.	supports at same level, up to three spans and two unknown support moments only. 3.4 Shear force and bending moment diagram of continuous beams, point of contra shear and point of contra flexure.	
4	TLO 4.1 Explain Moment Distribution Method (M.D.M.) used for analyzing the given indeterminate beam. TLO 4.2 Apply M.D.M. to analyse given continuous beam with same M.I. for the given condition. TLO 4.3 Apply M.D.M. to analyze given continuous beam with different M.I. for the given condition. TLO 4.4 Plot S.F. and B.M. Diagrams for continuous beam using given data. TLO 4.5 Identify the type of given portal frame with justification.	**Unit - IV Moment Distribution Method** 4.1 Introduction to moment distribution method, sign convention, Carry over factor, stiffness factor, distribution Factor, Distribution of moment. 4.2 Application of moment distribution method to continuous beams subjected to concentrated loads and uniformly distributed load over entire span having same moment of inertia, supports at same level, up to three spans and two unknown support moments only. 4.3 Application of moment distribution method to continuous beams subjected to concentrated loads and uniformly distributed load over entire span having different moment of inertia, supports at same level, up to three spans and two unknown support moments only. 4.4 Shear force and bending moment diagram of continuous beams, point of contra shear and point of contra flexure. 4.5 Introduction to portal frames – Symmetrical and unsymmetrical portal frames with the concept of Bays and stories.(No Numerical)	Lecture Using Chalk-Board Collaborative learning Video Demonstrations Presentations Site/Industry Visit
5	TLO 5.1 Classify the trusses used in constructions. TLO 5.2 Calculate the support reactions for the given simple truss using analytical method. TLO 5.3 Calculate axial forces for the given simple truss using method of joint and method of section. TLO 5.4 Understand the graphical method for analysis of simple truss.	**Unit - V Simple Trusses** 5.1 Introduction of Truss, Types of trusses (Simple, Fink, compound fink, French truss, Pratt truss, Howe truss, North light truss, King post and Queen post truss), Classification of trusses (perfect and imperfect). 5.2 Support reactions for trusses subjected to point loads at nodal points only. 5.3 Forces in members of truss using method of joints and Method of sections. 5.4 Graphical method of analysis of truss. (No numerical on graphical method of analysis of truss)	Lecture Using Chalk-Board Collaborative learning Model Demonstration Video Demonstrations Site/Industry Visit Presentations

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Apply the knowledge related to slope and deflections to solve the problems /	1	Sample Question's….. (Course teacher will decide the number of numerical as per the time constraint)	4	CO1

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Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
questions in given situation.		A) Draw the neat sketch indicating maximum slope and maximum deflection of cantilever beam subjected to point load at its free end. B) State the suitable boundary conditions for given type of beam to calculate integration constants C1 and C2. C) Prepare the General differential equation for given type of beam for different loading conditions along with the required data. D) Calculate the Slope and Deflection by using Macaulay's method for a simply supported beam and cantilever beam for various loading conditions such as 1. Beam subjected to single point load. 2. Beam subjected to two point loads. 3. Beam subjected to point load and udl. Along with the required data		
LLO 2.1 Apply the knowledge related to fixed beam to solve the problems / questions in given situation.	2	Sample Question's….. (Course teacher will decide the number of numerical as per the time constraint) A) Compare the fixed beam and simply supported beam subjected to same loading conditions. B)Compare the support moments calculated by first principle and standard formula for fixed beam for various loading conditions. C) Draw net BM of fixed beam for given loading conditions along with the required data. D) Draw the SFD and calculate the pt. of contra shear of continuous beam for given support moments and loads along with the required data. E) Calculate pt. of contra flexure for given BMD and pt. of contra shear for given SFD along with the required data.	4	CO2
LLO 3.1 Apply the knowledge related to continuous beam to solve the problems / questions in given situation.	3	Sample Question's….. (Course teacher will decide the number of numerical as per the time constraint) A) Explain the effect of continuity with neat sketch? OR Draw the neat sketch of continuous beam indicating sagging and hogging bending moment when it is subjected to external loading. B) State Clapeyron's theorem of three moment for same and different Moment of Inertia. Also state the meaning of each term involved. C) Calculate the support moments of continuous beam having same moment of inertia and varying moment of inertia for given loading conditions using Clapeyron's three moment theorem. D) Draw the SFD and calculate the pt. of contra shear of continuous beam for given support moments and	4	CO3

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Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
		reactions along with the required data. E) Calculate the Net Bending moment , Max. bending moment and pt. of contra flexure from given BMD and required data of continuous beam.		
LLO 4.1 Apply the knowledge related to continuous beam to solve the problems / questions in given situation.	4	Sample Question's….. (Course teacher will decide the number of numerical as per the time constraint) A) State the distribution of carry over factor for a continuous beam for different support conditions. B) Calculate the stiffness factor and Distribution Factor for diagram such as number of members connecting at same point whose having different support conditions and varying MI. (Diagram should be provided by course teacher) C) Calculate the support moments of continuous beam having same or varying moment of inertia for given loading conditions using moment distribution method. D) Draw the SFD and calculate the pt. of contra shear of continuous beam for given loading conditions and support moments along with the required data . E) Calculate pt. of contra flexure and pt. of contra shear for given BMD and SFD of continuous beam along with the required data.	4	CO4
LLO 5.1 Apply the knowledge related to truss to solve the problems / questions in given situation.	5	Sample Question's….. (Course teacher will decide the number of numerical as per the time constraint) A) Draw a neat sketch of any four types of trusses. B) State the assumptions for analysis of trusses. C) Identify the perfect and imperfect truss from given trusses D) Find the redundancy for given imperfect trusses. E) Calculate the axial forces developed in simple supported truss and cantilever truss subjected to external loading along with the required data.	4	CO5

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Assignment

- (Minimum TWO activities is compulsory for all students under SLH)

1. Collect the data from YouTube/videos showing change in deflected shape due to change in number of supports in a beam.

2. Apply the moment distribution method to analyze the portal frames.
3. Apply the graphical method to analyze the truss.
4. Prepare truss using given number of members and joints to carry given load. (use web tools/ video games available on internet such as X construction)
5. Explain the procedure to calculate maximum & minimum Stress for hollow rectangular chimney.
6. Explain the procedure to calculate maximum & minimum Stress for hollow circular chimney.
7. Write the procedure to calculate Maximum & minimum stress for a trapezoidal Dam section.

Micro project

- (Minimum ONE activity is compulsory for all students under SLH)

1. Prepare the chart of maximum slope and deflection for standard cases of simply supported beam and cantilever beam.
2. Prepare chart of free bending moments for standard cases of simply supported beam and fixed end moments for standard cases of fixed beam.
3. Collect information of three continuous beams having different support conditions on actual sites and study the reinforcement provided.
4. Compare the results of manual analysis and software analysis of continuous beam by using open source software. (Such as https://platform.skyciv.com/login)
5. Compare the results of manual analysis and software analysis of Single bye single story portal frame by using open source software.
(Such as https://platform.skyciv.com/login)
6. Prepare models of any one type of truss.
7. Collect information and photographs of any three types of simple trusses.
8. Compare the results of manual analysis and software analysis of truss by using open source software.
(Such as https://platform.skyciv.com/login)

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Open Source software used for Analysis Such as https://platform.skyciv.com/login	All

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Slope and Deflection	CO1	12	2	4	8	14

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Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
2	II	Fixed Beam	CO2	8	2	4	4	10
3	III	Continuous Beam	CO3	14	2	8	6	16
4	IV	Moment Distribution Method	CO4	16	2	4	12	18
5	V	Simple Trusses	CO5	10	2	4	6	12
Grand Total				**60**	**10**	**24**	**36**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two-unit tests of 30 marks each will be conducted and average of two-unit tests to be considered. Under SLA : Assignment, Microproject (60% Weightage to process and 40% weightage to product), Question and Answer

Summative Assessment (Assessment of Learning)

- Pen and Paper Test (Written Test)

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	3	3	2	1	-	-	2			
CO2	3	3	2	1	-	-	3			
CO3	3	3	2	1	-	-	3			
CO4	3	3	2	1	-	-	3			
CO5	3	3	2	1	-	-	3			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Ramanrutham S.	Theory of Structures	Dhanpatrai & Sons, Delhi ISBN : 978-93-84378-10-3
2	Khurmi R. S.	Theory of Structures	S. Chand and Co., New Delhi, 2006 ISBN:978-81-21905-20-6
3	Bhavikatti S. S.	Structural Analysis Vol-1	Vikas Publishing House Pvt.Ltd. New Delhi; ISBN: 978-81-25927-90-7

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Sr.No	Author	Title	Publisher with ISBN Number
4	Junnarkar S. B.	Mechanics of structures, Volume-I and II	Charotar Publishing House, Anand ISBN:978-93-80358-99-4
5	Pandit G.S. and Gupta S.P.	Theory of Structures	Tata McGraw Hill, New Delhi, 2006 ISBN :978-00-74634-93-6

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://youtu.be/oa5ojjGEUSw?si=nNu8rSHo9YYquTmB	Introduction and Need of Structural Analysis Prof. Amit Shaw, Department of Civil Engineering, I.I.T. Kharagpur.
2	https://sa2-iitd.vlabs.ac.in/exp/slope-deflection-method-1-beams/simulation.html	Virtual Lab for slope-deflection-method beams/simulation, Virtual Labs by IIT Delhi
3	https://www.youtube.com/watch?v=GUOKSExdjq8	Lecture Series on deflection of beam by Prof. S.K. Bhattacharya, Department of Civil Engineering, I.I.T. Kharagpur.
4	https://www.youtube.com/watch?v=vi0tjfDSjNY	Lecture Series on deflection of beam by Prof. S.K. Bhattacharya, Department of Civil Engineering, I.I.T. Kharagpur.
5	https://bsa-iiith.vlabs.ac.in/exp/continuous-beams/index.html	Virtual Lab for Continuous beams/simulation, Virtual Labs by IIT Delhi
6	https://bsa-iiith.vlabs.ac.in/exp/portal-frames/index.html	Virtual Lab for Portal Frame/simulation, Virtual Labs by IIT Delhi
7	https://bsa-iiith.vlabs.ac.in/exp/retaining-walls/theory.html	Virtual Lab for Retaining wall or Dam/simulation, Virtual Labs by IIT Delhi
8	https://youtu.be/yyxRHt62WFo?si=4rF9ds2SedQ77NR4	Analysis of Truss: Method of Sections Prof. Amit Shaw, Department of Civil Engineering, I.I.T. Kharagpur.
9	https://youtu.be/5gExoUfZoBY?si=9bB5Z71ECZAbBbRL	Analysis of Truss: Method of Joints Prof. Amit Shaw, Department of Civil Engineering, I.I.T. Kharagpur.

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students

MSBTE Approval Dt. 24/02/2025 **Semester - 5, K Scheme**