STRENGTH OF MATERIALS – I

Subject Code: **CE306ES**
Regulations: R**17 -** JNTUH
Class : II Year B.Tech CE I Semester

Department of Civil Engineering

BHARAT INSTITUTE OF ENGINEERING AND TECHNOLOGY

Ibrahimpatnam - 501 510, Hyderabad

STRENGTH OF MATERIALS – I (CE306ES)
COURSE PLANNER

I. COURSE OVERVIEW:

Civil Engineers are required to design structures like building, beams, dams, bridges, etc. The loads coming onto these structures, along with the self-weight, have to be safely transmitted to the ground. 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 foundational course in civil engineering is intended to introduce to concepts of stress and strain due to external loading on a structural member, and their calculations. For this, the concept and calculations of (a) shear force diagrams and bending moment diagram for different type of beams, (b) bending and shear stresses in beams, (c) slope and deflection of beams using various methods are covered in depth. The important calculations of principal stresses and principal strains and the consequent theory of failures for prediction of the strength of the materials are also discussed. Through this course content engineers can design the structures for safety and serviceability

II. PREREQUISITE(S):

Level	Credits	Periods/Week	Prerequisites
UG	4	4	Engineering Mechanics

III. COURSE OBJECTIVES:

The objective of the teacher is to impart knowledge and abilities to the students to:

i. **Relate** mechanical properties of a material with its behaviour under various load types
ii. **Classify** the types of material according to the modes of failure and stress-strain curves.
iii. **Apply** the concepts of mechanics to find the stresses at a point in a material of a structural member
iv. **Analyze** a loaded structural member for deflections and failure strength
v. **Evaluate** the stresses & strains in materials and deflections in beam members
vi. **Create** diagrams for shear force, bending moment, stress distribution, mohr's circle, elastic curve
vii. **Design** simple beam members of different cross-sections to withstand the loads imposed on them.

IV. COURSE OUTCOMES:

After completing this course the student must demonstrate the knowledge and ability to:

1. **Calculate** the stress and strain developed in any structural member due to applied external load.
2. **Differentiate** the type of beams, and the various loading and support condition upon them.
3. **Apply** the formulae for beams under different loading condition.
4. **Draw** shear force diagram and bending moment diagram for different type of beams.
5. **Derive** the pure bending equation, and on its basis explain the existence of normal stresses and shear stresses in the different layers of the beam.
6. **Explain** the importance of and evaluate the section modulus for various beam cross-sections.
7. **Calculate** the normal and tangential stresses on an inclined section of a bar under uniaxial, biaxial, pure shear and plain stress conditions.
8. **Evaluate** the principal stress and principal strain at a point of a stressed member and draw the Mohr's circle of stresses.
9. **Predict** failure of a material using various theories of failure, and their relative applications.
10. **Calculate** the slope and deflection in beams by using methods like Double integration, Macaulay method, Moment-area method, Conjugate beam, etc.
11. Participate and succeed in competitive examination like GATE,

V. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Level	Proficiency assessed by
PO1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	H	Assignments, Exams
PO2	**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.	H	Assignments, Exams
PO3	**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,	H	Assignments, Exams
PO4	**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.	S	Discussion
PO5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	S	-
PO6	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	H	Exams, Assignment, Discussions
PO7	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	S	Discussions
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	S	Discussions
PO9	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	S	Assignment, Discussions

PO10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	S	Discussions
PO11	**Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary	S	-
PO12	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	S	Discuss

H - Highly Related

N – Not Applicable **S – Supportive**

VI. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program specific outcomes		Level	Proficiency Assessed By
PSO1	**UNDERSTANDING:** Graduates will have an ability to understand, analyze and solve problems using basic mathematics and apply the techniques related to irrigation, structural design, etc.	H	Lectures, Assignments Exams
PSO2	**ANALYTICAL SKILLS:** Graduates will have an ability to design civil structures, using construction components and to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety manufacturability and reliability and learn to work with multidisciplinary teams.	H	Lectures, Assignments, Exams
PSO3	**BROADNESS:** Graduates will have an exposure to various fields of engineering necessary to understand the impact of other disciplines on civil engineering blueprints in a global, economic, and societal context and to have necessary focus for postgraduate education and research opportunities at global level.	S	Lectures, Guest Lectures, Discussions, Industrial visits

VII. SYLLABUS:

UNIT – I

Simple Stresses and Strains: Elasticity and plasticity – Types of stresses and strains – Hooke's law – stress – strain diagram for mild steel – Working stress – Factor of safety –

Lateral strain, Poisson's ratio and volumetric strain – Elastic moduli and the relationship between them – Bars of varying section – composite bars – Temperature stresses. Elastic constants.

Strain Energy: Resilience – Gradual, sudden, impact and shock loadings – simple applications.

UNIT – II

Shear Force and Bending Moment: Definition of beam – Types of beams – Concept of shear force and bending moment – S.F and B.M diagrams for cantilever, simply supported and overhanging beams subjected to point loads, uniformly distributed load, uniformly varying loads and combination of these loads – Point of contra flexure – Relation between S.F., B.M and rate of loading at a section of a beam.

UNIT – III

Flexural Stresses: Theory of simple bending – Assumptions – Derivation of bending equation: $M/I = f/y = E/R$ - Neutral axis – Determination of bending stresses – Section modulus of rectangular and circular sections (Solid and Hollow), I,T, Angle and Channel sections – Design of simple beam sections.

Shear Stresses: Derivation of formula – Shear stress distribution across various beam sections like rectangular, circular, triangular, I, T angle sections.

UNIT – IV

Deflection of Beams: Bending into a circular arc – slope, deflection and radius of curvature – Differential equation for the elastic line of a beam – Double integration and Macaulay's methods – Determination of slope and deflection for cantilever and simply supported beams subjected to point loads, U.D.L, Uniformly varying load-Mohr's theorems – Moment area method – application to simple cases including overhanging beams.

Conjugate Beam Method: Introduction – Concept of conjugate beam method. Difference between a real beam and a conjugate beam. Deflections of determinate beams with constant and different moments of inertia.

UNIT – V

Principal Stresses and Strains: Introduction – Stresses on an inclined section of a bar under axial loading – compound stresses – Normal and tangential stresses on an inclined plane for biaxial stresses – Two perpendicular normal stresses accompanied by a state of simple shear – Mohr's circle of stresses – Principal stresses and strains – Analytical and graphical solutions.

Theories of Failure: Introduction – Various theories of failure - Maximum Principal Stress Theory, Maximum Principal Strain Theory, Maximum shear stress theory- Strain Energy and Shear Strain Energy Theory (Von Mises Theory).

SUGGESTED BOOKS:

TEXT BOOKS:

1. Mechanics of Materials by B. C. Punmia, A. K. Jain and A. K. Jain, Laxmi Publications (P) Ltd, New Delhi.
2. Strength of Materials – A Practical Approach Vol.1 by D. S. Prakash Rao, Universities Press, Hyderabad, India.
3. Mechanics of materials by F. Beer, E. R. Johnston and J. Dewolf (Indian Edition – SI units), Tata McGraw Hill Publishing Co. Ltd., New Delhi

REFERENCES BOOKS:

1. Mechanics of Materials (SI edition) by J.M. Gere and S. Timoshenko, CL Engineering, India
2. Engineering Mechanics of Solids by E. G. Popov, Pearson Education, New Delhi, India

3. Strength of Materials by R. K. Bansal, Laxmi Publications (P) ltd., New Delhi, India.
4. Strength of Materials by S.S.Bhavikatti, Vikas Publishing House Pvt. Ltd.
5. Strength of Materials by R.K Rajput, S.Chand & Company Ltd.
6. Strength of Materials by R. S. Khurmi, S. Chand publication New Delhi, India.
7. Fundamentals of Solid Mechanics by M.L.Gambhir, PHI Learning Pvt. Ltd
8. Strength of Materials by R.Subramanian, Oxford University Press.

NPTEL WEB COURSE:

http://nptel.ac.in/courses/112107147/37

NPTEL VIDEO COURSE:

http://nptel.ac.in/courses/112107147/37#

GATE SYLLABUS:

Bending moment and shear force in statically determinate beams. Simple stress and strain relationship: Stress and strain in two dimensions, principal stresses, stress transformation, Mohr's circle. Simple bending theory, flexural and shear stresses, unsymmetrical bending, shear centre. Thin walled pressure vessels, uniform torsion, buckling of column, combined and direct bending stresses

IES SYLLABUS:

Analysis of determinate structures - different methods including graphical methods.

VIII. COURSE PLAN:

Lecture No	Week	Unit	Topics to be covered	Learning Objective	References
1.	1	1	UNIT - I Elasticity and plasticity – Types of stresses and strains – Hooke's law	Understand the concept of elasticity and plasticity, concept of stress and strain, concept of Hooke's law	T1: 1.1-3, 2.1-5
2.	1	1	Elasticity and plasticity – Types of stresses and strains – Hooke's law	Understand the concept of elasticity and plasticity, concept of stress and strain, concept of Hooke's law	T1: 1.1-3, 2.1-5
3.	1	1	Stress – strain diagram for mild steel – Working stress – Factor of safety	Explain Relation between stress and strain for mild steel. Understand working stress and factor of safety.	T1: 2.4
4.	1	1	Stress – strain diagram for mild steel – Working stress – Factor of safety	Explain Relation between stress and strain for mild steel. Understand working stress and factor of safety.	T1: 2.4
5.	2	1	Bars of varying section	Understand the concept of	T1: 2.6-

				bars for varying section.	14
6.	2	1	Bars of varying section	Understand the concept of bars for varying section.	T1: 2.6-14
7.	2	1	Composite bars – Temperature stresses	Understand the concept of composite bars and temperature stresses.	T1: 2.15-20
8.	2	1	Composite bars – Temperature stresses	Understand the concept of composite bars and temperature stresses.	T1: 2.15-20
9.	3	1	Lateral strain, Poisson's ratio and volumetric strain – Elastic modulii and the relationship between them	Explain lateral strain, Poisson's ratio, volumetric strain, elastic modulii and relation between them	T1: 3.1-.3
10.	3	1	Lateral strain, Poisson's ratio and volumetric strain – Elastic modulii and the relationship between them	Explain lateral strain, Poisson's ratio, volumetric strain, elastic modulii and relation between them	T1: 3.1-.3
11.	3	1	Elastic constants.	Explain Bulk modulus, longitudinal strain, lateral strain and relation between them	T1: 3.5-14
12.	3	1	Elastic constants.	Explain Bulk modulus, longitudinal strain, lateral strain and relation between them	T1: 3.5-14
13.	4	1	Strain Energy, Resilience – Gradual, sudden, impact and shock loadings – simple applications.	Explain resilience, proof resilience, modulus of resilience. Derive strain energy for various loadings and simple	T1: 6.1-5
14.	4	1	Strain Energy, Resilience – Gradual, sudden, impact and shock loadings – simple applications.	Explain resilience, proof resilience, modulus of resilience. Derive strain energy for various loadings and simple	T1: 6.1-5
15.	4	2	**UNIT - II** **Definition of beam** – Types of beams – Concept of shear force and bending moment	Define beam, types of beams. Explain the concept of shear force and bending moment	T1: 9.1-5
16.	4	2	Definition of beam – Types of beams – Concept of shear force and bending moment	Define beam, types of beams. Explain the concept of shear force and bending moment	T1: 9.1-5
17.	5	2	S.F and B.M diagrams for cantilever, subjected to point	Derive and evaluate the shear-force and bending	T1: 9.6-7

			loads, uniformly distributed load, uniformly varying loads and combination of these loads – Point of contra flexure	moment for cantilever beam for various types of loading and solved problems	
18.	5	2	S.F and B.M diagrams for cantilever, subjected to point loads, uniformly distributed load, uniformly varying loads and combination of these loads – Point of contra flexure	Derive and evaluate the shear-force and bending moment for cantilever beam for various types of loading and solved problems	T1: 9.6-7
19.	5	2	S.F and B.M diagrams for cantilever, subjected to point loads, uniformly distributed load, uniformly varying loads and combination of these loads – Point of contra flexure	Derive and evaluate the shear-force and bending moment for cantilever beam for various types of loading and solved problems	T1: 9.6-7
20.	5	2	S.F and B.M diagrams simply supported subjected to point loads, uniformly distributed load, uniformly varying loads and combination of these loads – Point of contra flexure	Derive and evaluate the shear-force and bending moment for simply supported beam for various types of loading and solved problems	T1: 9.6-7
21.	6	2	S.F and B.M diagrams simply supported subjected to point loads, uniformly distributed load, uniformly varying loads and combination of these loads – Point of contra flexure	Derive and evaluate the shear-force and bending moment for simply supported beam for various types of loading and solved problems	T1: 9.6-7
22.	6	2	S.F and B.M diagrams simply supported subjected to point loads, uniformly distributed load, uniformly varying loads and combination of these loads – Point of contra flexure	Derive and evaluate the shear-force and bending moment for simply supported beam for various types of loading and solved problems	T1: 9.6-7
23.	6	2	S.F and B.M diagrams for overhanging beams subjected to point loads, uniformly distributed load, uniformly varying loads and combination of these loads – Point of contra flexure	Derive and evaluate the shear-force and bending moment for overhanging beam for various types of loading and solved problems	T1: 9.6-7
24.	6	2	S.F and B.M diagrams for overhanging beams subjected to point loads, uniformly distributed load, uniformly varying loads and	Derive and evaluate the shear-force and bending moment for overhanging beam for various types of loading and solved	T1: 9.6-7

			combination of these loads – Point of contra flexure	problems	
25.	7	2	S.F and B.M diagrams for overhanging beams subjected to point loads, uniformly distributed load, uniformly varying loads and combination of these loads – Point of contra flexure	Derive and evaluate the shear-force and bending moment for overhanging beam for various types of loading and solved problems	T1: 9.6-7
26.	7	2	Relation between S.F., B.M and rate of loading at a section of a beam.	Explain the relation between shear force and bending moment and rate of loading at a section for beams	T1:9.6-11
27.	7	3	**UNIT -III** **FLEXURAL STRESSES:** Theory of simple bending – Assumptions – Derivation of bending equation: M/I = f/y = E/R	Explain the concept of simple bending with assumptions and derive the bending equation	T1: 10.1-5
28.	7	3	Theory of simple bending – Assumptions – Derivation of bending equation: M/I = f/y = E/R	Explain the concept of simple bending with assumptions and derive the bending equation	T1: 10.1-5
29.	8	3	Neutral axis – Determination of bending stresses	Define neutral axis and determine the bending stresses for various conditions	T1: 10.5-7
30.	8	3	Neutral axis – Determination of bending stresses	Define neutral axis and determine the bending stresses for various conditions	T1: 10.5-7
31.	8	3	Section modulus of rectangular and circular sections (Solid and Hollow), I,T, Angle and Channel sections	Derive the section modulus for rectangular, circular, I, T sections and solved problems	T1: 10.7
32.	8	3	Section modulus of rectangular and circular sections (Solid and Hollow), I,T, Angle and Channel sections	Derive the section modulus for rectangular, circular, I, T sections and solved problems	T1: 10.7
33.	9	3	Design of simple beam sections.	Solve problems for design of simple beams	T1: 10.7
34.	9	3	Design of simple beam sections.	Solve problems for design of simple beams	T1: 10.7

35.	9	3	SHEAR STRESSES: Derivation of formula – Shear stress distribution across various beam sections like rectangular, circular, triangular, I, T angle sections.	Derive the formula for shear stress and evaluate the shear stress distribution across various beam sections like rectangular, circular, triangular, I, T angle sections.	T1: 11.1-7
36.	9	3	Derivation of formula – Shear stress distribution across various beam sections like rectangular, circular, triangular, I, T angle sections.	Derive the formula for shear stress and evaluate the shear stress distribution across various beam sections like rectangular, circular, triangular, I, T angle sections.	T1: 11.1-7
37.	10	3	Derivation of formula – Shear stress distribution across various beam sections like rectangular, circular, triangular, I, T angle sections.	Derive the formula for shear stress and evaluate the shear stress distribution across various beam sections like rectangular, circular, triangular, I, T angle sections.	T1: 11.1-7
38.	10	3	Derivation of formula – Shear stress distribution across various beam sections like rectangular, circular, triangular, I, T angle sections.	Derive the formula for shear stress and evaluate the shear stress distribution across various beam sections like rectangular, circular, triangular, I, T angle sections.	T1: 11.1-7
39.	10	4	UNIT-IV PRINCIPAL STRESSES AND STRAINS: Introduction – Stresses on an inclined section of a bar under axial loading – compound stresses	Define principal stresses and strains. Explain the stresses on a inclined section of a bar under axial loading and explain the concept of compound stresses	T1: 4.1
40.	10	4	Normal and tangential stresses on an inclined plane for biaxial stresses – Two perpendicular normal stresses accompanied by a state of simple shear - Mohr's circle of stresses, Principal stresses	Evaluate Normal and tangential stresses on an inclined plane for biaxial stresses and evaluate stresses for two perpendicular normal stresses accompanied by a state of simple shear	T1: 4.2 - 4.11
41.	11	4	Normal and tangential stresses on an inclined plane for biaxial stresses – Two	Evaluate Normal and tangential stresses on an inclined plane for biaxial	T1: 4.2 - 4.11

			perpendicular normal stresses accompanied by a state of simple shear - Mohr's circle of stresses, Principal stresses	stresses and evaluate stresses for two perpendicular normal stresses accompanied by a state of simple shear	
42.	11	4	Normal and tangential stresses on an inclined plane for biaxial stresses – Two perpendicular normal stresses accompanied by a state of simple shear - Mohr's circle of stresses, Principal stresses	Evaluate Normal and tangential stresses on an inclined plane for biaxial stresses and evaluate stresses for two perpendicular normal stresses accompanied by a state of simple shear	T1: 4.2 - 4.11
43.	11	4	Principal Strains – Analytical and graphical solutions.	Explain the concept of Mohr's circle of stresses and derive the principal stresses and strains using analytical and graphical method.	T1: 5.1-8
44.	11	4	Principal Strains – Analytical and graphical solutions.	Explain the concept of Mohr's circle of stresses and derive the principal stresses and strains using analytical and graphical method.	T1: 5.1-8
45.	12	4	Principal Strains – Analytical and graphical solutions.	Explain the concept of Mohr's circle of stresses and derive the principal stresses and strains using analytical and graphical method.	T1: 5.1-8
46.	12	4	Introduction – Various theories of failure - Maximum Principal Stress Theory	Explain Maximum Principal Stress Theory and evaluate failure criteria	T1: 7.1-3
47.	12	4	Introduction – Various theories of failure - Maximum Principal Stress Theory	Explain Maximum Principal Stress Theory and evaluate failure criteria	T1: 7.1-3
48.	12	4	Maximum Principal Strain Theory, Strain Energy and Shear Strain Energy Theory (Von Mises Theory).	Explain Maximum Principal Strain Theory, Strain Energy and Shear Strain Energy Theory (Von Mises Theory) and evaluate failure criteria	T1: 7.4-7
49.	13	4	Maximum Principal Strain Theory, Strain Energy and	Explain Maximum Principal Strain Theory,	T1: 7.4-7

			Shear Strain Energy Theory (Von Mises Theory).	Strain Energy and Shear Strain Energy Theory (Von Mises Theory) and evaluate failure criteria	
50.	1 3	5	Bending into a circular arc – slope, deflection and radius of curvature – Differential equation for the elastic line of a beam	Derive relation between slope, deflection and radius of curvature and derive the differential equation for the elastic line of a beam	T1: 12.1-3
51.	1 3	5	Bending into a circular arc – slope, deflection and radius of curvature – Differential equation for the elastic line of a beam	Derive relation between slope, deflection and radius of curvature and derive the differential equation for the elastic line of a beam	T1: 12.1-3
52.	1 3	5	Bending into a circular arc – slope, deflection and radius of curvature – Differential equation for the elastic line of a beam	Derive relation between slope, deflection and radius of curvature and derive the differential equation for the elastic line of a beam	T1: 12.1-3
53.	1 4	5	Double integration and Macaulay’s methods – Determination of slope and deflection for cantilever and simply supported beams subjected to point loads, U.D.L, Uniformly varying load	Determine slope and deflection for cantilever and simply supported beams subjected to point loads, U.D.L, Uniformly varying load using Double integration and Macaulay’s methods	T1: 12.4-11
54.	1 4	5	Double integration and Macaulay’s methods – Determination of slope and deflection for cantilever and simply supported beams subjected to point loads, U.D.L, Uniformly varying load	Determine slope and deflection for cantilever and simply supported beams subjected to point loads, U.D.L, Uniformly varying load using Double integration and Macaulay’s methods	T1: 12.4-11
55.	1 4	5	Double integration and Macaulay’s methods – Determination of slope and deflection for cantilever and simply supported beams subjected to point loads, U.D.L, Uniformly varying load	Determine slope and deflection for cantilever and simply supported beams subjected to point loads, U.D.L, Uniformly varying load using Double integration and Macaulay’s methods	T1: 12.4-11
56.	1 4	5	Double integration and Macaulay’s methods – Determination of slope and	Determine slope and deflection for cantilever and simply supported	T1: 12.4-11

			deflection for cantilever and simply supported beams subjected to point loads, U.D.L, Uniformly varying load	beams subjected to point loads, U.D.L, Uniformly varying load using Double integration and Macaulay's methods	
57.	15	5	Mohr's theorems – Moment area method – application to simple cases including overhanging beams.	Explain mohr's theorem and moment area method and apply it to simple beams.	T1: 13.1-9
58.	15	5	Mohr's theorems – Moment area method – application to simple cases including overhanging beams.	Explain mohr's theorem and moment area method and apply it to simple beams.	T1: 13.1-9
59.	15	5	Mohr's theorems – Moment area method – application to simple cases including overhanging beams.	Explain mohr's theorem and moment area method and apply it to simple beams.	T1: 13.1-9
60.	15	5	Mohr's theorems – Moment area method – application to simple cases including overhanging beams.	Explain mohr's theorem and moment area method and apply it to simple beams.	T1: 13.1-9
61.	16	5	Conjugate Beam Method: Introduction – Concept of conjugate beam method. Difference between a real beam and a conjugate beam.	Explain conjugate beam method and differentiate between real beam and a conjugate beam.	T1: 14.1-8
62.	16	5	Conjugate Beam Method: Introduction – Concept of conjugate beam method. Difference between a real beam and a conjugate beam.	Explain conjugate beam method and differentiate between real beam and a conjugate beam.	T1: 14.1-8
63.	16	5	Conjugate Beam Method: Introduction – Concept of conjugate beam method. Difference between a real beam and a conjugate beam.	Explain conjugate beam method and differentiate between real beam and a conjugate beam.	T1: 14.1-8
64.	16	5	Conjugate Beam Method: Introduction – Concept of conjugate beam method. Difference between a real beam and a conjugate beam.	Explain conjugate beam method and differentiate between real beam and a conjugate beam.	T1: 14.1-8

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

CourseObjectives	**ProgramOutcomes**	**ProgramSpecific Outcomes**

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PS O2	PS O3
I	H	H	H	S	S	S	S	S	S	S	S	S	H	H	S
II	H	H	H	S	S	S	S	S	S	S	S	S	H	H	S
III	H	H	H	S	S	S	S	S	S	S	S	S	H	H	S
IV	H	H	H	S	S	S	S	S	S	S	S	S	H	H	S
V	H	H	H	S	S	S	S	S	S	S	S	S	H	H	S
VI	H	H	H	S	S	S	S	S	S	S	S	S	H	H	S
VII	H	H	H	S	S	S	S	S	S	S	S	S	H	H	S

X. QUESTION BANK: (JNTUH)

DESCRIPTIVE QUESTIONS: (WITH BLOOMS PHRASES)

UNIT-I

SHORT ANSWER QUESTIONS

S.No	Question	Blooms Taxonomy Level	Programme Out come
1	Distinguish between the terms (a) Elasticity and (b) Plasticity with examples.	Remembering	1
2	Define the following properties of engineering materials: (a) Ductility (b) Brittleness (c) Malleability	Remembering	1
3	Define the following properties of engineering materials: (a) Toughness (b) Hardness (c) Strength	Remembering	1
4	Define Stress at a point in a material, and mention its units.	Remembering	1
5	Distinguish between different types of stress using illustrations	Remembering	1
6	Define Strain in a material and give its units	Remembering	1
7	State Hooke's law and give its equation	Remembering	1
8	Distinguish between different types of strain	Remembering	1
9	Define modulus of elasticity and give its units.	Remembering	1
10	Draw stress-strain diagram for mild steel indicating all critical points	Understanding	1
11	Define longitudinal strain and lateral strain.	Remembering	1
12	Define Poisson's ratio and its range of values	Remembering	1

LONG ANSWER QUESTIONS

S. No	Question	Blooms Taxonomy Level	Programme Out come
1.	Explain with illustrations and stress-strain diagrams, the phenomenon of strain-hardening.	Understanding	1
2.	Explain with illustrations and stress-strain diagrams, the phenomenon of necking.	Understanding	1
3.	Define and explain the terms: slip and creep.	Understanding	1
4.	Explain the off-set method of locating the yield point for a material on its stress-strain curve.	Understanding	1
5.	Explain the concept of fatigue failure. Define endurance limit and fatigue limit.	Understanding	1
6.	A tensile test was conducted on a mild steel bar. The following data was obtained from the test:Diameter of steel bar = 2.5 cm; Gauge length of the bar = 24 cm;Diameter of the bar at rupture = 2.35 cm; Gauge length at rupture = 24.92mmDetermine (a) percentage elongation (b) percentage decrease in area	Applying	1,2
7.	A tensile test was conducted on a mild steel bar. The following data was obtained from the test:Diameter of steel bar = 3cm; Gauge length of the bar = 20cmLoad at elastic limit = 250kN; Extension at load of 150kN = 0.21mmMaximum load = 380kN; Determine: (a) Young's modulus (b) Yield strength (c) Ultimate Strength (d) Strain at the elastic limit	Applying	1,2
8.	Derive the constitutive relationship between stress and strain for three dimensional stress systems.	Applying	1,2
9.	A rod whose ends are fixed to rigid supports, is heated so that rise in temperature is To C. Derive the expression for thermal strain and thermal stresses set up in the body if α is co-efficient of thermal expansion.	Applying	1,2
10.	Derive the expression for volumetric strain of a body in terms of its linear strains in orthogonal directions.	Applying	1,2

UNIT-II
SHORT ANSWER QUESTIONS

S.No	Question	Blooms Taxonomy Level	Programme Out come
1	What are the different types of beams?	Remembering	2
2	Differentiate between a simply supported beam and a cantilever.	Remembering	2
3	Differentiate between a fixed beam and a cantilever.	Remembering	2
4	Show by proper diagram, positive and negative shear forces at a section of a beam.	Remembering	2
5	Draw shear force diagrams for a cantilever of length L carrying a point load W at the free end.	Applying	2,4
6	Draw shear force diagrams for a cantilever of length L carrying a point load W at the mid-span.	Applying	2,4
7	Draw shear force diagram for a cantilever of length L carrying a uniformly distributed load of w per unit length over its entire span.	Applying	2,4
8	Draw shear force diagrams for a simply supported beam of length L carrying a point load W at its mid-span.	Applying	2,4
9	Draw shear force diagram for a simply supported beam of length L carrying a uniformly distributed load of w per unit length over its entire span.	Applying	2,4
10	Explain what information we obtain from shear force diagram and bending moment diagram.	Understanding	2,4

LONG ANSWER QUESTIONS

S. No	Question	Blooms Taxonomy Level	Programme Out come
1	Derive the relation between rate of loading, shear force and bending moment for a beam carrying a uniformly distributed load of w per unit length over whole span.	Understanding	2,3,4
2	Derive the shear force and bending moment	Understan	2,3,4

	diagrams for a cantilever beam carrying a uniformly distributed load of w per unit run over half its span staring from the free-end.	ding	
3	Draw the shear force diagrams for a cantilever beam of length 12 m carrying a uniformly distributed load of 12 kNm-1 over half its span staring from the free-end.	Applying	2,3,4
4	Draw the bending moment diagrams for a cantilever beam of length 12 m carrying a uniformly distributed load of 12 kNm-1 over half its span staring from the free-end.	Applying	2,3,4
5	Derive the shear force and bending moment diagrams for a cantilever beam carrying a uniformly varying load from zero at free end to w per unit length at the fixed end.	Applying	2,3,4
6	Draw the shear force and bending moment diagrams for a cantilever beam of length 4 m if two anti-clockwise moments of 15 kNm and 10 kNm are applied at the mid-span and the free end, respectively.	Applying	2,3,4
7	Draw the shear force and bending moment diagrams for a cantilever beam of length 7 m with a uniformly varying load from zero at fixed-end to 10 kN/m at 4m from the fixed end.	Applying	2,3,4
8	Draw the shear force and bending moment diagrams for a simply supported beam of length 12 m with an eccentric point load at a distance '3 m' from the left end and at a distance of '4m' from the right end.	Applying	2,3,4
9	Derive the shear force and bending moment diagrams for a simply supported beam with an eccentric point load at a distance 'a' from left end and at a distance 'b' from right end.	Applying	2,3,4
10	Derive the shear force and bending moment diagrams for a simply supported beam carrying a uniformly distributed load of *w* per unit run over whole span.	Applying	2,3,4

UNIT-III

SHORT ANSWER QUESTIONS

S.No	Question	Blooms Taxonomy Level	Programme Out come
1	Define bending stress in a beam with a diagram.	Understanding	5
2	Define pure bending and show an example by a figure.	Understanding	5

3	Define neutral axis and where is it located in a beam.	Understanding	5
4	What are the assumptions made in theory of simple bending?	Remembering	5
5	Write the bending equation, defining all the terms in the equation	Remembering	5
6	Explain the terms: moment of resistance and section modulus	Remembering	5,6
7	Explain the role of section modulus in defining the strength of a section.	Understanding	5,6
8	Write the section modulus for a solid rectangular section.	Applying	5,6
9	Write the section modulus for a hollow rectangular section.	Applying	5,6
10	Write the section modulus for a solid circular section.	Applying	5,6

LONG ANSWER QUESTIONS

S. No	**Question**	**Blooms Taxonomy Level**	**Programme Out come**
1	Derive the bending equation for a beam.	Understanding	5
2	For a given stress, compare the moments of resistance of a beam of a square section, when placed (i) with its two sides horizontal and (ii) with its diagonal horizontal. Which is more suitable?	Understanding	5,6
3	Three beams have the same length, the same allowable stress and the same bending moment. The cross-section of the beams are a square, a rectangle with depth twice the width and a circle. If all the three beams have the same flexural resistance capacity, then find the ratio of the weights of the beams. Which beam is most economical?	Understanding	5,6
4	A rectangular beam 60 mm wide and 150 mm deep is simply supported over a span of 6 m. If the beam is subjected to central point load of 12 kN, find the maximum bending stress induced in the beam section.	Applying	5,6
5	A rectangular beam 300 mm deep is simply supported over a span of 4 m. What uniformly distributed load the beam may carry, if the bending stress is not to exceed 120 MPa. Take I = 225 x 106 mm4 .	Applying	5,6
6	A cantilever beam is rectangular in section having 80	Applying	5,6

	mm width and 120 mm depth. If the cantilever is subjected to a point load of 6 kN at the free end and the bending stress is not to exceed 40 MPa, find the span of the cantilever beam.		
7	A hollow square section with outer and inner dimensions of 50 mm and 40 mm respectively, is used as a cantilever of span 1 m. How much concentrated load can be applied at the free end, if the maximum bending stress is not exceed 35 MPa?	Applying	5,6
8	A cast iron water pipe of 500 mm inside diameter and 20 mm thick is supported over a span of 10 m. Find the maximum stress in the pipe metal, when the pipe is running full. Take density of cast iron as 70.6 kN/m3, and that of water as 9.8 kN/m3.	Applying	5,6
9	Two wooden planks 150 mm x 50 mm each are connected to form a T-section of a beam. If a moment of 6.4 kNm is applied around the horizontal neutral axis, find the bending stresses at both the extreme fibres of the cross-section.	Applying	5,6
10	Prove that maximum shear stress in a circular section of beam is 4/3 times the average shear stress.	Applying	5,6

UNIT-IV
SHORT ANSWER QUESTIONS

S.No	Question	Blooms Taxonomy Level	Programme Out come
1	Define principal planes and principal stresses	Understanding	7,8
2	Why is it important to determine principal stresses and planes?	Understanding	7,8
3	What are the methods used to determine the stresses on oblique section?	Remembering	7,8
4	Draw the representation of biaxial state of stress at a point in a material.	Understanding	7,8
5	Draw the representation of the state of pure shear stress at a point in a material.	Understanding	7,8
6	Explain the condition of plane stress.	Understanding	7,8
7	Write the expression for normal and tangential stresses on an inclined plane for a material element subjected to combined biaxial and shear stress.	Understanding	7,8
8	Give the expression for principal stresses for the case of combined bi-axial and shear stress (plan stress condition).	Understanding	7,8

9	Give the expression for maximum shear stress for the case of combined bi-axial and shear stress (plan stress condition).	Understanding	7,8
10	Explain Mohr's circle of stresses using an example.	Understanding	7,8

LONG ANSWER QUESTIONS

S.No	Question	Blooms Taxonomy Level	Programme Out come
1	Derive an expression for the major and minor principal stresses on an oblique plane, when the body is subjected to direct stresses in two mutually perpendicular directions accompanied by a shear stress.	Applying	7, 8
2	Define and explain he theories of failure: (i) Maximum principal stress theory (ii) Maximum principal strain theory	Understanding	7, 8, 9
3	Define and explain he theories of failure: (i) Maximum shear stress theory (ii) Maximum shear strain energy theory	Understanding	7, 8, 9
4	A body is subjected to direct stresses in two mutually perpendicular principal tensile stresses accompanied by a simple shear stress. Draw the Mohr's circle of stresses and explain how you will obtain the principal stresses and strains.	Applying	7, 8
5	A body is subjected to direct stresses in two mutually perpendicular directions. How will you determine graphically the resultant stresses on an oblique plane when (i) the stresses are unequal and unlike; (ii) the stresses are unequal and like.	Applying	7, 8
6	In a two dimensional stress system, the direct stresses on two mutually perpendicular planes are 100 MN/mm2. These planes also carry a shear stress of 25 MN/mm2. If the factor of safety on elastic limit is 2.5, then find: (i) the value of stress when shear strain energy is minimum; (ii) elastic limit of material in simple tension.	Applying	7, 8
7	Determine the diameter of a bolt which is subjected to an axial pull of 18 kN together with a transverse shear force of 9 kN, when	Applying	7, 8, 9

	the elastic limit in tension is 350 N/mm2, factor of safety = 3 and μ = 0.3 using (i) Maximum principal stress theory (ii) Maximum principal strain theory (iii) Maximum shear stress theory (iv) Maximum strain energy theorem (v) Maximum shear strain energy theory		
8	A bolt is under an axial thrust of 10 kN together with a transverse shear force of 4 kN. Calculate the diameter of bolt according to (i) Maximum principal stress theory (ii) Maximum shear stress theory (iii) Maximum strain energy theorem Take elastic limit in simple tension = 225 N/mm2, factor of safety = 3, μ = 0.3.	Applying	7, 8, 9
10	The principal stresses at a point in a elastic material are 30 N/mm2 (tensile), 120 N/mm2 (tensile) and 50 N/mm2 (compressive). If the elastic limit in simpletension is 250 N/mm2 and μ = 0.3, then determine whether the failure of material will occur or not according to (iii) Maximum principal stress theory (iv) Maximum principal strain theory (v) Maximum shear stress theory (vi) Maximum strain energy theorem (vii) Maximum shear strain energy theory	Applying	7, 8, 9

UNIT-V
SHORT ANSWER QUESTIONS

S.No	Question	Blooms Taxonomy Level	Programme Out come
1	Define deflection and slope of a beam.	Remembering	10
2	Write the differential equation for the beam	Remembering	10
3	List the different methods for finding slope and deflection of a beam.	Remembering	10

4	Explain the concept of double-integration method to obtain the deflections of a beam	Understanding	10
5	Give the relation between the load, shear force and bending moment at a section of a beam.	Remembering	10
6	What is Macaulay's method? How is it different from the general double integration method?	Understanding	10
7	What is meant by flexural rigidity? Give its expression.	Remembering	10
8	Give the slope and deflection of a cantilever beam, with flexural rigidity EI, and length L, carrying a point load W at its free end?	Remembering	10
9	Give the slope and deflection of a simply supported beam, with flexural rigidity EI, and length L, carrying a point load W at its mid-span?	Remembering	10
10	State and explain the first theorem of Mohr.	Understanding	10

LONG ANSWER QUESTIONS

S.No	**Question**	**Blooms Taxonomy Level**	**Programme Out come**
1	Derive an expression for slope and deflection of a beam subjected to uniform bending moment.	Applying	10
2	Prove that the relation where M is the bending moment and E is modulus of elasticity and I is moment of inertia of the beam section.	Applying	10
3	Prove that the deflection at centre of a simply supported beam, carrying a point load at centre, is given by	Applying	10
4	Derive the slope at supports and deflection at centre for a simply supported beam carrying uniformly distributed load of *w* per unit length over the entire span.	Applying	10
5	Use Moment-Area method to find the slope and deflection of a simply supported beam carrying a point load at the centre.	Applying	10
6	Use Moment-Area method to find the slope and deflection of a simply supported beam carrying a uniformly distributed load over the entire span.	Applying	10
7	Derive slope and deflection of a cantilever	Applying	10

	carrying uniformly distributed load over whole length using Macaulay's method.		
8	Derive slope and deflection of a cantilever carrying uniformly distributed load over a length 'a' from the fixed end by double integration method.	Applying	10
9	Derive slope and deflection of a cantilever carrying uniformly distributed load over a length 'a' from the fixed end by Moment-Area method.	Applying	10
10	Derive slope and deflection relations for a cantilever carrying a gradually varying load from zero at the free end to *w* per metre run at the fixed end.	Applying	10

XI. OBJECTIVE QUESTIONS: JNTUH

UNIT 1

1. A material obey's Hooke's law up to
   (a) Plastic limit (b) Elastic limit (c) Yield point (d) Limit of proportionality
2. The intensity of stress which causes unit strain is called
   (a) Unit stress (b) Modulus of rigidity (c) Bulk modulus (d) Modulus of elasticity
3. With in elastic limit stress is
   (a) Inversely proportional to strain (b) Directly proportional to strain
   (c) Square root of strain (d) Equal to strain
4. A bar when subjected to an axial pull P
   (a) Decrease in length and width and increase in thickness
   (b) Decrease in length and increase in width and thickness
   (c) Increase in length and decrease in Width and thickness
   (d) Increase in length, width and thickness.
5. Poissons's ratio is the ratio of
   (a) Stress and strain (b) Modules of elasticity and strain
   (c) Lateral strain and longitudinal strain (d) None of these
6. If all the dimensions of a prismatic bar are doubled, then the maximum stress produced in it under its own weight will
   a) decrease b) remain unchanged c) increase to two times d) increase to four times
7. The elongation of a conical bar under its own weight is equal to
   a) that of a prismatic bar of same length
   b) one half that of a prismatic bar of same length
   c) one third that of a prismatic bar of same length
   d) one fourth that of a prismatic bar of same length
8. If a material has identical properties in all directions, it is said to be
   a) homogeneous b) isotropic c) elastic d) orthotropic
9. Two bars of different materials are of the same size and are subjected to same tensile forces. If the bars have unit elongations in the ratio of 4 : 7, then the ratio of moduli of elasticity of the two materials is
   a) 7:4 b) 4:7 c) 4:17 d) 16 :49

10. If a composite bar of steel and copper is heated, then the copper bar will be under
    a) tension b) compression c) shear d) torsion

UNIT 2

1. The shape of cantilever for uniformly distributed load will be
   (a) Straight line (b) Parabolic (c) Parabolic (d) Elliptical
2. A point of contraflexure occurs in a
   (a) Simply supported beam (b) Fixed beam (c) Cantilever (d) None of the above
3. Shear force diagram for a cantilever beam carrying a uniformly distributed load over its length is a
   (a) Triangle (b) Rectangle (c) Hyperbola (d) Parabola
4. Maximum bending moment in a beam occurs where
   a) deflection is zero b) shear force is maximum
   c) shear force is minimum d) shear force changes sign
5. Rate of change of bending moment is equal to
   a) shear force b) deflection c) slope d) rate of loading
6. The diagram showing the variation of axial load along the span is called
   a) shear force diagram b) bending moment diagram
   c) thrust diagram d) influence line diagram
7. The variation of the bending moment in the portion of a beam carrying linearly varying load is a) linear b) parabolic c) cubic d) constant
8. The maximum bending moment due to a moving load on a fixed ended beam occurs
   a) at a support b) always at the midspan
   c) under the load only d) none of the above

UNIT 3

1. In I-section, the bending moment is resisted mainly by
   (a) Flanges only (b) Web only (c) Both by flanges and web (d) None of the above
2. The 'plane section remains plane' assumption in bending theory implies:
   (a) strain profile is linear (b) stress profile is linear
   (c) both strain and stress profiles are linear (d) shear deformations are neglected
3. Beams of uniform strength are better as comapred to beams of uniform cross section as they are Economical
   (a) For short spans (b) For large spans
   c) For heavy weight beams (d) For light weight beams
4. The square root of the ratio of moment of inertia of the cross section to its cross sectional area is called
   a)Second moment of area b)Slenderness ratio
   c)Section modulus d)Radius of gyration
5. In T-section
   (a) Both flange and web resists in the ratio of the their areas of cross-section
   (b) Only flanges resists shear (c) Most of the shear is resisted by web only
   (d) None of these
6. Shear stress in a rectangular beam exhibits a
   (a) Parabolic variation (b) Linear variation (c) Cubic variation (d) None of the above
7. A beam of rectangular cross-section is 100 mm wide and 200 mm deep. If the section is subjected to a shear force of 20 kN, then the maximum shear stress in the section is
   a) 1 N/mm2 b) 1.125 N/mm2 c) 1.33 N/mm2 d) 1.5 N/mm2

8. A prismatic bar when subjected to pure bending assumes the shape of
   a) catenary b) cubic parabola c) quadratic parabola d) arc of a circle

UNIT 4

1. Slope and deflection at a point in a loaded cantilever beam carrying several loads can be found out by the
   (a) Principle of least work (b) Moment area method
   (c) Double integration method (d) Macualay's method
2. If the depth of a rectangular beam is halved the deflection for a beam carrying a mid point load shall be
   (a) Halved (b) Doubled (c) Four times (d) Eight times
3. A cantilever of length L, carries a point load W at the free end. The downward deflection at the free end is given by ________.
4. A cantilever of length L, carries a point load W at the free end. The slope at the free end is given by ________.
5. A cantilever of length L, carries a udl w per unit length over the whole length. The downward deflection at the free end is given by ________.

UNIT 5

1. Principal planes are planes having
   (a) Maximum shear stress (b) No shear stress
   (c) Minimum shear stress (d) None of the above
2. At the principal planes
   (a) Normal stress is maximum or minimum and the shear stress is zero
   (b) Tensile and compressive stresses are zero
   (c) Tensile stress is zero and the shear stress is maximum.
   (d) No stress acts
3. Mohr's circle can be used to determine following stress on inclined surface
   (a) Principal stress (b) Normal stress
   (c) Tangential stress (d) Maximum shear stress (e) All of the above
4. The radius of Mohr's circle for two equal unlike principal stresses of magnitude p is
   a) p b) p/2 c) zero d) none of these
5. Shear stress on principal planes is
   a) zero b) maximum c) minimum d) none of these
6. The major and minor principal stresses at a point are 3MPa and -3MPa respectively. The maximum shear stress at the point is a) Zero b)3MPa c)6MPa d)9MPa
7. The plane which have no shear stress are known as _______.
8. The stresses acting on principal planes are known as _________.
9. When a member is subjected to a simple shear stress, then the normal stress on an oblique plane is given as ________.
10. When a member is subjected to a simple shear stress, then the tangential stress on an oblique plane is given as ________.

XII. GATE QUESTIONS:

1. The shape of cantilever for uniformly distributed load will be
   (a) Straight line (b) Parabolic (c) Parabolic (d) Elliptical
2. A point of contraflexure occurs in a
   (a) Simply supported beam (b) Fixed beam
   (c) Cantilever (d) None of the above

3. Shear force diagram for a cantilever beam carrying a uniformly distributed load over its length is a
   (a) Triangle (b) Rectangle (c) Hyperbola (d) Parabola
4. Maximum bending moment in a beam occurs where
   a) deflection is zero b) shear force is maximum
   c) shear force is minimum d) shear force changes sign
5. Rate of change of bending moment is equal to
   a) shear force b) deflection c) slope d) rate of loading
6. The diagram showing the variation of axial load along the span is called
   a) shear force diagram b) bending moment diagram
   c) thrust diagram d) influence line diagram
7. The variation of the bending moment in the portion of a beam carrying linearly varying load is a) linear b) parabolic c) cubic d) constant
8. The maximum bending moment due to a moving load on a fixed ended beam occurs
   a) at a support b) always at the midspan
   c) under the load only d) none of the above
9. A cantilever beam AB of length 1 carries a concentrated load W at its midspan C. If the free end B is supported on a rigid prop, then there is a point of contraflexure
   a) between A and C b) between C and B
   c) one between A and C and other between C and B d) no where in the beam
10. A prismatic beam fixed at both ends carries a uniformly distributed load. The ratio of bending moment at the supports to the bending moment at mid-span is
    a) 0.5 b) 1.0 c) 1.5 d) 2.0

A beam of overall length 1 with equal overhangs on both sides carries a uniformly distributed load over the entire length. To have numerically equal bending moments at

XIII. WEBSITES:

1. http://www.asce.org
2. http://www.icivilengineer.com
3. http://www.construction-guide.in

XIV. EXPERT DETAILS:

- Prof. SATISH C . SHARMA Department of Mechanical & Industrial Engineering Indian Institute of Technology Roorkee
- Prof.M.S.Sivakumar Department of Applied Mechanics , IIT Madras. email: mssiva@iitm.ac.in
- Prof. S.K. Bhattacharyya, Department of Civil Engineering, IIT Kharagpur.
- Dr. Satish C Sharma (IITR)
- LS Ramachandra & SK Barai (IITKGP)

XV. JOURNALS:

0970-1141	Thesis Digest on civil Engineering	1987
0973-8061	International Engineering and Technology Journal of Civil and Structure	2007
0975-5314	International journal of civil engineering	2009
0975-6744	Journal of information knowledge and research in civil engineering	2009
0976-6308	International journal of civil engineering and technology	2010

2249-426X	International Journal of Civil Engineering and Applications	2011
2249-8753	Recent Trends in Civil Engineering and Technology	2011
2277-5986	World Research Journal of Civil Engineering	2011
2277-7032	International Journal of Structural and Civil Engineering	2012
2278-9987	International Journal of Civil Engineering (IJCE)	2012
2319-6009	International Journal of Structural and Civil Engineering Research	2012
2320-723X	International Journal of Advanced Research in Civil, Structural, Environmental and Infrastructure Engineering and Developing	2013

XVI. LIST OF TOPICS FOR STUDENT SEMINARS:

1. Stresses and strain
2. Types of beam
3. Bending stress and shear stress
4. Mohr's circle
5. Principle stresses and strain
6. Slope and Deflection of beam
7. Concept of Bending Equation
8. Important role of Strength of Materials

XVII. CASE STUDIES / SMALL PROJECTS:

1. The length of a broad -gauge railway sleeper such that it has the minimum bending moment.