



Shri Rawatpura Sarkar University, Raipur, Chhattisgarh

Faculty of Engineering

Shri Rawatpura Sarkar University, Raipur



Examination Scheme & Syllabus

for

M.Tech.(Structural Engineering)

Semester-II

**Outcome Based Education (OBE) and Choice Based Credit System
(CBCS)**

(Effective from the Session: 2022-23)



Shri Rawatpura Sarkar University, Raipur, Chhattisgarh

Faculty of Engineering

Two Years M.Tech. Programme

Scheme of Teaching and Examination

M.Tech. Second Semester Structural Engineering

Outcome Based Education (OBE) and Choice Based Credit System (CBCS)

(Effective from the Academic Year 2022-2023)

S.No	Course Code	Course Title	Hours / Week			Credits	Maximum Marks			Sem End Exam Duration (Hrs)
			L	T	P		Continuous Evaluation	Sem End Exam	Total	
1	MENSE201T	Advanced Design of Concrete Structures	3	1	-	4	30	70	100	3
2	MENSE201P	Advanced Design of Concrete Structures	-	-	2	1	15	35	50	-
3	MENSE202T	Earthquake Effects on Structures	3	1	-	4	30	70	100	3
4	MENSE203T	Finite Element Analysis of Structures	3	1	-	4	30	70	100	3
5	MENSE204T	Maintenance and Rehabilitation of Structures	3	1	-	4	30	70	100	3
6	MENSE205T	Elective- II	3	1	-	4	30	70	100	3
7	MENSE206P	Structural Experimentation Lab	-	-	2	1	15	35	50	-
Total Contact Hr Per Week: 24			Total Credit: 22			Grand Total Marks:			600	

L- Lecture T- Tutorial P- Practical

Elective-II

S.NO.	Course Title
1	Advance Foundation Engineering
2	Design of Industrial Structures
3	Fabrication and Erection of Structures



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Course Title	Advanced Design of Concrete Structures				
Course Code	MENSE201T				
Course Credits	L	T	P	TC	
	3	1	-	4	
Prerequisites	Structure Analysis				
Course Objectives	<p>This course will enable students to:-</p> <ul style="list-style-type: none"> • The course Advanced design of concrete structures intend to supplement a basic course of reinforced and prestressed concrete structures and provide a structural specialist level of knowledge. • One of the objectives is to strengthen the capacity of students to design by introducing concepts related to project and construction systems. A particular emphasis is given to the struts and ties model as a general method of design, especially suitable for areas of discontinuity. • This method is applied to the study of structural elements with geometric or mechanical discontinuity, such as corbels, deep beams. In the structural analysis, some aspects are studied such as the effects of prestressing in statically indeterminate structures as well as long term behaviour, nonlinear behaviour, construction effects, and the design of structures partially prestressed, taking into account the service and ultimate limit states. 				
Course Contents	<p>UNIT I Design of Beams Behavior of RCC beams under combined Shear, Torsion and Bending, Modes of Failures, Inter action effects, Analysis and design of beams circular in plan, Design calculation of deflections and crack width.</p> <p>UNIT II Design of Slender Columns Behaviour of slender RCC Columns, Failure modes and Interaction curves, Additional Moment method, Comparison of codal provisions, calculation of design moments for braced and unbraced columns, Principles of Moment magnification method, design of slender columns..</p> <p>UNIT III Design of Special Rc Elements Design and detailing of Concrete walls according to IS code, Classification of shear walls, design principles, design of rectangular shear walls, Analysis of forces, Approximate analysis and design of Grid floors</p> <p>UNIT IV Design of Flat Slabs Design of Flat slabs according to IS method, Shear in Flat Slabs.</p>				



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	<p>UNITV Inelastic Behaviour Inelastic behaviour of concrete beams-moment-rotation curves, moment redistribution, Design of cast-insitu joints in frames. Detailing requirements for ductility, durability and fire resistance</p>
Course Outcomes	<p>After the completion of course:-</p> <ul style="list-style-type: none">• Estimate the crack width and deflection with regard to the serviceability.• Analyse and design a grid floor system.• Analyse and design a flat slab system.• Discuss fire and seismic resistance of concrete structures.• Analyse and design bunkers, silos and chimneys.
Text Books	<ol style="list-style-type: none">1. Advanced Reinforced Concrete Design, Varghese, P.C. Prentice Hall of India.2. Advanced Reinforced Concrete Design Krishna Raju N., CBS Publishers and Distributers.
Reference Books	<ol style="list-style-type: none">1. Reinforced Concrete Structure Structural Elements: Behaviour Analysis and Design, Purushothaman, P, Tata McGraw-Hill.2. Design of Concrete Structures, Arthur H.NilsonTata McGraw-Hill.



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Course Title	Advanced Design of Concrete Structures				
Course Code	MENSE201P				
Course Credits	L	T	P	TC	
	-	-	2	1	
Prerequisites	Structure Analysis-I & II				
Course Objectives	<p>This course will enable students to:-</p> <ul style="list-style-type: none"> • Understand the different techniques for analysis of structures 				
Course Contents	<p style="text-align: center;">List of Experiments</p> <ol style="list-style-type: none"> 1. Introduction to latest version of a Standard Structural Engineering Design Package such as STAAD Pro. 2. Modelling of RCC Frame on latest version of a Standard Structural Engineering Design Package such as STAAD Pro. (including Earthquake and Wind Loads) 3. Analysis and Interpretation of Results of Analysis on RCC Frame on latest version of a Standard Structural Engineering Design Package such as STAAD Pro. 4. Design and Interpretation of Results of Design of RCC Frame on latest version of a Standard Structural Engineering Design Package such as STAAD Pro. 5. Modelling, of Steel Frame on latest version of a Standard Structural Engineering Design Package such as STAAD Pro. (including Earthquake and Wind Loads) 6. Analysis and Interpretation of Results of Analysis on Steel Frame on latest version of a Standard Structural Engineering Design Package such as STAAD Pro. 7. Design and Interpretation of Results of Design of Steel Frame on latest version of a Standard Structural Engineering Design Package such as STAAD Pro. 8. Case Study of design of a RCC Multistory Building / Steel Industrial Building on latest version of a Standard Structural Engineering Design Package such as STAAD Pro. 9. Introduction to latest version of Finite Element Package such as ANSYS. 10. Modeling of a Steel Angle section on ANSYS and viewing the results. 11. Design of Multistory Building for Dead Loads and Live Loads. 12. Design of Multistory Building for Dead Loads, Live Loads and Wind Loads. 13. Design of Multistory Building for Dead Loads, Live Loads and Earthquake Loads. 				



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	14. Modelling of Steel Connections in Finite Element Package ANSYS. 15. Introduction to Non-Linear Finite Element analysis of structures on ANSYS
Course Outcomes	<ul style="list-style-type: none">• Student will be able to analyze various types of statically determinate and indeterminate structures.
Text Books	<ol style="list-style-type: none">1. Users Manuals for STAAD Pro Software.2. Users Manuals for ANSYS Software.



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Course Title	Earthquake Effects On Structures				
Course Code	MENSE202T				
Course Credits	L	T	P	TC	
	3	1	-	4	
Prerequisites	Structure Analysis-I & II				
Course Objectives	<p>This course will enable students to:-</p> <ul style="list-style-type: none"> • Provide a coherent development to the students for the courses in sector of earthquake engineering To present the foundations of many basic engineering concepts related earthquake • Engineering To give an experience in the implementation of engineering concepts which are applied • In field of earthquake engineering To involve the application of scientific and technological principles of planning, analysis, • Design of buildings according to earthquake design philosophy. 				
Course Contents	<p>UNIT I Engineering Seismology Elements of Engineering Seismology, Characterization of ground motion, Earthquake intensity and magnitude, Recording instruments and base line correction, Predominant period and amplification through soil, Earthquake spectra for elastic and inelastic systems, Response Spectrum, Indian Standard Codes on Earthquake Engineering, Seismic Zoning Map of India</p> <p>UNIT II Case Studies Earthquake History, Behaviour of Structures in the past Earthquakes, Case Studies and Remedial Measures.</p> <p>UNIT III Design Concepts Seismic Design Concepts, Cyclic load behaviour of structural elements, Design spectrum, Principles of capacity design.</p> <p>UNIT IV Codal Provisions Idealization of structural systems for low, medium and high rise buildings, Provisions of Seismic Code (IS 1893), Building systems frames, shear walls, Braced Frames. Ductility requirements for framed structures.</p> <p>UNIT V Special Problems Structural Configuration, Seismic performance, Irregular Buildings, Soil</p>				



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	performance, Modern Concepts, Base Isolation, Adoptive system
Course Outcomes	<p>After the completion of course:-</p> <ul style="list-style-type: none">• Students will gain an experience in the implementation of Earthquake Engineering on engineering concepts which are applied in field Structural Engineering.• Students will get a diverse knowledge of earthquake engineering practices applied to• Real life problems The students will learn to understand the theoretical and practical aspects of earthquake• Engineering along with the planning and design aspects.• In field of earthquake engineering To involve the application of scientific and technological principles of planning, analysis,
Text Books	<ol style="list-style-type: none">1. Earthquake Resistant Design of Structures, Agrawal P. and Srikhande M., Prentice hall of India Private Limited, New Delhi.2. Indian Standard Codes / Handbooks on Earthquake Engineering.
Reference Books	<ol style="list-style-type: none">1. Dynamics of Structures – Theory and applications to Earthquake Engineering, Chopra A.K., Prentice Hall Inc.2. Proceedings of recent seminars / workshops / conferences, Papers from relevant National and International Journals and Material from NICEE, IIT Kanpur



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Course Title	Finite Element Analysis of Structures				
Course Code	MENSE203T				
Course Credits	L	T	P	TC	
	3	1	-	4	
Prerequisites	Structure Analysis-I				
Course Objectives	<p>This course will enable students to:-</p> <ul style="list-style-type: none"> • Provide the fundamental concepts of the theory of the finite element method: • Develop proficiency in the application of the finite element method (modeling, analysis, and interpretation of results) to realistic engineering problems through the use of a major commercial general-purpose finite element code. 				
Course Contents	<p>UNIT I Basic Concepts Review of solid mechanics, Displacement model, shape functions, Lagrange and Serendipity elements. Element properties, isoperimetric elements, numerical integration technique assemblage of elements and solution technique for static analysis.</p> <p>UNIT II Analysis of Beams Finite Element formulation and Analysis of beams by Finite Element method..</p> <p>UNIT II Analysis of Rigid Jointed Plane Frame Finite Element formulation and Analysis of rigid jointed plane frame by Finite Element method.</p> <p>UNIT IV Analysis of Pin Jointed Plane Frame Finite Element formulation and Analysis of pin jointed plane frame by Finite Element method.</p> <p>UNIT V Introduction To Plate And Shell Elements Analysis of plane stress / strain and ax symmetric solids-triangular, quadrilateral and isoperimetric elements, Analysis of plate bending, basic equations of thin plate theory, Reissinner-Mindlin theory, plate elements and applications. Analysis of shells, degenerated shell elements.</p>				
Course Outcomes	<p>After the completion of course:-</p> <ul style="list-style-type: none"> • Obtain an understanding of the fundamental theory of the FEA method; • Develop the ability to generate the governing FE equations for systems governed by partial differential equations; 				



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	<ul style="list-style-type: none">• Understand the use of the basic finite elements for structural applications using truss, beam, frame, and plane elements; and• Understand the application and use of the FE method for heat transfer problems.• Apply finite element method to solve problems on is parametric element and dynamic Problems.
Text Books	<ol style="list-style-type: none">1. Introduction to Finite Elements in Engineering, Chandrupatla T.R., Belegundu A.D., Prentice Hall of India Private Limited, New Delhi.2. Introduction to the Finite Element Method, Desai C.S., Abel J.F., CBS Publishers & Distributors, Delhi.
Reference Books	<ol style="list-style-type: none">1. Finite Element Analysis – Theory and Programming, Krishanmurthy, C.S., Tata McGraw Hill Publishing Company Limited, New Delhi.2. Finite Element Analysis – Theory and Programming by Cook R.D. et.al., Concepts and Applications of Finite Element Analysis, John Wiley



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Course Title	Maintenance And Rehabilitation of Structures			
Course Code	MENSE204T			
Course Credits	L	T	P	TC
	3	1	-	4
Prerequisites	Structure Analysis-II			
Course Objectives	<p>This course will enable students to:-</p> <ul style="list-style-type: none"> • The course seeks to recognize the mechanisms of degradation of concrete structures, provide the students with the knowledge of available techniques and their application for strengthening or upgrading existing structural systems. • It also provides how to conduct field monitoring and non-destructive evaluation of concrete structures. 			
Course Contents	<p>UNIT I Quality Assurance Quality assurance for Concrete and Steel construction, Properties such as strength, permeability, thermal properties and cracking. Corrosion prevention.</p> <p>UNIT II Influence On Serviceability And Durability Effects due to climate, temperature, chemicals, wear and erosion, Design and construction errors, corrosion mechanism, Effects of cover thickness and cracking, methods of corrosion protection, corrosion inhibitors, corrosion resistant steels, coatings, cathodic protection.</p> <p>UNIT III Maintenance And Repair Strategies Definitions: Maintenance, repair and rehabilitation, Facets of Maintenance importance of Maintenance Preventive measures on various aspects Inspection, Assessment procedure for evaluating a damaged structure causes of deterioration - testing techniques.</p> <p>UNIT IV Materials For Repair Special concretes and mortar, concrete chemicals, special elements for accelerated strength gain, Expansive cement, polymer concrete, Sulphur infiltrated concrete, ferro cement, Fiber reinforced concrete.</p> <p>UNIT V Techniques For Repair Rust eliminators and polymers coating for rebar's during repair foamed concrete, mortar and dry pack, vacuum concrete, Guniting and Shotcrete Epoxy injection, Mortar repair for cracks, shoring and underpinning.</p>			



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Course Outcomes	<p>After the completion of course:-</p> <ul style="list-style-type: none">• Understand the properties of fresh and hardened concrete.• Know the strategies of maintenance and repair.• Get an idea of repair techniques.• Understand the properties of repair materials• Understand the retrofitting strategies and techniques
Text Books	<ol style="list-style-type: none">1. Concrete Structures, Denison Campbell, Allen and Harold Roper, Materials, Maintenance and Repair, Longman Scientific and Technical UK, 1991.2. Repair of Concrete Structures, R.T.Allen and S.C.Edwards, Blakie and Sons, UK, 1987
Reference Books	<ol style="list-style-type: none">1. Concrete Technology - Theory and Practice, M.S. Shetty, S. Chand and Company, New Delhi, 1992.2. Learning from failures - Deficiencies in Design, Raikar, R.N., Construction and Service - R & D Centre (SDCPL), Raikar Bhavan, Bombay, 1987.



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Course Title	Advance Foundation Engineering				
Course Code	MENSE205T (Elective-II)				
Course Credits	L	T	P	TC	
	3	1	-	4	
Prerequisites	Steel Structure-I&II				
Course Objectives	<p>This course will enable students to:-</p> <ul style="list-style-type: none"> • Build upon knowledge acquired in CIV331 • Develop deeper understanding of foundation analyses • Develop understanding of choice of design parameters • Learn about advanced topics of foundation design and analyses 				
Course Contents	<p>UNIT I Principles Of Foundation Engineering Functions of foundations, Types of foundations, Principal modes of failure, Estimation of allowable bearing pressures, calculation of ultimate bearing capacity by theoretical and empirical methods, settlement of foundations, Factors to be considered in foundation design.</p> <p>UNIT II Soil Structure Interaction Introduction to soil-foundation interaction problems – Soil behaviour, Foundation behaviour, Interface behaviour, Scope of soil foundation interaction analysis, Soil response models, Elastic continuum, two parameter elastic models, Elastic plastic behaviour, Time dependent behaviour</p> <p>UNIT III Beams On Elastic Foundation Infinite beam, two parameters, Isotropic elastic half-space, Analysis of beams of finite length, Classification of finite beams in relation to their stiffness.</p> <p>UNIT IV Pile Foundations Purpose/Uses of pile foundations, Classification of piles, Concrete and Steel Piles, their advantages and disadvantages, behaviour of pile and pile groups under load, interaction analysis, Estimation of carrying capacity of piles and pile groups. Load deflection prediction for laterally loaded piles.</p> <p>UNIT V Special Considerations Improvement of foundation soils - Purpose, Improvement of Granular Soils, Improvement of Cohesive soils, Grouting, Geosynthetics, Specific Applications.</p>				



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Course Outcomes	<p>After the completion of course:-</p> <ul style="list-style-type: none">• Determine suitable soil parameters.• Perform geotechnical design of shallow and deep foundations.• Analyse and design pile foundations.• Understand limitations and uncertainties in geotechnical design.• Synthesize the concepts of allowable stress design, appropriate factors of safety, margin of safety, and reliability;
Text Books	<ol style="list-style-type: none">1. Foundation Analysis and Design, Bowles J.E., Mc-Graw Hill International Edition.2. Foundation Engineering, Varghese P.C., Printice Hall of India Private Limited.
Reference Books	<ol style="list-style-type: none">1. Foundation Design and Construction, ELBS Longman, 1996.2. Soil Engineering in Theory and practice, A. Singh & G.R. Chowdhry, CBS Publishers, 1990.



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Course Title	Design of Industrial Structures				
Course Code	MENSE205T (Elective-II)				
Course Credits	L	T	P	TC	
	3	1	-	4	
Prerequisites	Steel Structure				
Course Objectives	<p>This course will enable students to:-</p> <ul style="list-style-type: none"> • Be able to perform analysis and design of reinforced concrete members and connections. • Be able to identify and interpret the appropriate relevant industry design codes. 				
Course Contents	<p>UNIT I Planning And Functional Requirements Classification of Industries and Industrial structures - planning for Layout Requirements regarding Lighting, Ventilation and Fire Safety - Protection against noise and vibration - Guidelines from Factories Act.</p> <p>UNIT II Industrial Buildings Roofs for Industrial Buildings, Trusses and domes, Gantry Girders, Machine Foundations.</p> <p>UNIT III Bunkers And Silos Analysis and Design of Bunkers and Silos.</p> <p>UNIT IV Power Plant Structures Chimneys and Cooling Towers, High Pressure boilers and piping design, Nuclear containment structures.</p> <p>UNIT V Power Transmission Structures Cables, Transmission Line Towers, Substation Structures, Tower Foundations, Testing Towers.</p>				
Course Outcomes	<p>After the completion of course:-</p> <ul style="list-style-type: none"> • Students will understand the general mechanical behavior of reinforced concrete. • Students will be able to analyze and design reinforced concrete flexural members. • Student will be able to analyze and design reinforced concrete compression members. 				



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	<ul style="list-style-type: none">• Students will be able to analyze and design for vertical and horizontal shear in reinforced concrete.• Students will be able to analyze transfer and development length of concrete reinforcement.
Text Books	<ol style="list-style-type: none">1. Indian Standard Codes and Handbooks on Industrial Structures2. Relevant Publications from Institute for Steel Development and Growth, Kolkata
Reference Books	<ol style="list-style-type: none">1. Handbook of Machine Foundations, P. Srinivasulu and C.V. Vaidyanathan, Tata McGraw-Hill 1976.2. Design and Construction, S.N. Manohar, Tall Chimneys – Tata McGraw-Hill, 1985.3. Transmission Line Structures, A.R. Santhakumar and S.S. Murthy, Tata McGraw-Hill 1992.4. Dr. K. Rajagopalan – Storage Structures – Oxford IBH Publishing Company Ltd.



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Course Title	Fabrication And Erection of Structures				
Course Code	MENSE205T (Elective-II)				
Course Credits	L	T	P	TC	
	3	1	-	4	
Prerequisites	Structure Analysis				
Course Objectives	<p>This course will enable students to:-</p> <ul style="list-style-type: none"> • Term used in context of Quality Assurance, qualitative or quantitative information, record or statement of fact, pertaining to quality of an item or service which is based on observation, measurement or test and which can be verified 				
Course Contents	<p>UNIT I General Various slopes, size and properties of rolled steel sections, tubes and hollow rectangular sections: Chemical composition, physical properties and weld ability of various types of structures steel, their suitability for various purposes. Various operations like interpretation of drawings, shop-floor operations, fastenings, assembling, finishing and shipping, sub-assemblies and main assemblies..</p> <p>UNIT II Fabrication Drawings Structural connections, their classification, symbols for their representation, layout of an industrial building, preparation of fabrication drawing and detailing for columns, trusses, beams and cladding, detailing of truss joints, column bases, beam to beam and column to beam connection</p> <p>UNIT III Erection Process Principle of erection, Erection organization, Preparation and reading of erection drawing, Assembly marks, common types of structures to be erected, erection of tackle and false work equipment's for lifting and rigging, Code provisions for erection. Methods of erection, leveling and alignment, setting out and grouting, allowable tolerances for plumbing, leveling and alignment.</p> <p>UNIT IV Tools For Erection Miscellaneous small tools for erection like drifts, shackles and grips, erection of shed type buildings, portal frames, multi-storeyed buildings, prefabricated tanks, towers and chimneys.</p> <p>UNIT V Inspection, Quality Control And Safety Code provisions for tolerances and deviations, Inspection of welds, radiographic</p>				



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	<p>and ultrasonic techniques, Various stages of inspection, Quality control departments, methods of rectification of defects. Accidents and their causes, Various unsafe acts and precautions for their prevention, Rules for safety for cranes, winches, etc. Safety during electrical operations and while using X-ray equipment's, Maintenance of erected structures, surface treatment against corrosion, etc.</p>
Course Outcomes	<p>After the completion of course:-</p> <ul style="list-style-type: none">• Graduates will demonstrate knowledge of mathematics, science and engineering.• Graduates will demonstrate an ability to identify, formulate and solve engineering problems.• Graduate will demonstrate an ability to design and conduct experiments, analyze and interpret data.• Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.• Graduates will demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks.• Graduate will demonstrate skills to use modern engineering tools, software and equipment to analyze problems.
Text Books	<ul style="list-style-type: none">• Structural Steel Fabrication and Erection – S.K. Saxena and R.B. Asthane (Somaiya Publications, 172, Mumbai Marathi Granth, Sangrahalaya Marg, Dadar, Bombay-14)• Guide Book for Fabrication and Erection of Steel Structures, Institute for Steel Development and Growth, Kolkata
References Books	<ul style="list-style-type: none">• Structural Steel Drafting and Detailing, Shivagunde R.B. and Asthana R.B Somaiya Publications, New Delhi. Steel Designer's Manual: Edited by Graham• W. Owens & Peter R. Knowles, 5th Edition, Blackwell Scientific Publications, London.



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Course Title	Structural Experimentation Lab				
Course Code	MENSE206P				
Course Credits	L	T	P	TC	
	-	-	2	1	
Prerequisites	Designing & Structure-I & II				
Course Objectives	<p>This course will enable students to:-</p> <ul style="list-style-type: none"> Realistic engineering problems through the use of a major commercial general-purpose finite element code. 				
Course Contents	<p style="text-align: center;">List of Experiments</p> <ol style="list-style-type: none"> Study of Strain gauges – Principles and applications, mechanical, optical and electrical strain gauges, Study of Strain recording instruments. Study the response of RCC Beams using dial gauges, load cells etc. on a loading Frame. Study the response of structural members RCC Columns using dial gauges, load cells etc. on a loading Frame. Study the response of Steel Beams using dial gauges, load cells etc. on a loading Frame. Study the response of Steel Columns using dial gauges, load cells etc. on a loading Frame. Study the response of Steel Trusses using dial gauges, load cells etc. on a loading Frame. Testing and recording of stress strain curve of steel specimens on Universal Testing Machine. Testing of steel connections to demonstrate single shear / Double shear failure of bolts on Universal Testing Machine. Use of static and dynamic data recording and processing systems. Comparison of behaviour of steel beam (laterally supported and laterally unsupported) on a loading frame Load carrying capacity of RCC Columns of various cross-sections such as plus shape, circular shape, etc. Preparation of moment-rotation curves for framed steel connections. Preparation of moment-rotation curves seated steel connections. Preparation of moment-rotation curves for moment-resistant connection 				
Course Outcomes	<p>After the completion of course:-</p> <ul style="list-style-type: none"> Understand analysis of indeterminate structures and adopt an appropriate 				



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	structural analysis technique <ul style="list-style-type: none">• Determine response of structures by classical, iterative and matrix methods
Text Books	<ol style="list-style-type: none">1. Experimental stress analysis, Dally J.W. and Riley W.F., McGraw-Hill Inc., New York.2. Instrumentation-Devices & Systems, Rangan Csetal, Tata McGraw Hill Publishing Co. Ltd., New Delhi.
Reference Books	<ol style="list-style-type: none">1. Finite Element Analysis – Theory and Programming, Krishanmurthy, C.S. Tata McGraw Hill Publishing Company Limited, New Delhi.2. Finite Element Analysis – Theory and Programming by Cook R.D. et.al., Concepts and Applications of Finite Element Analysis, John Wiley