

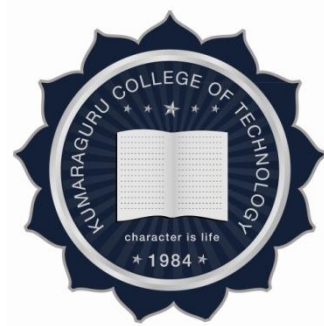
# **KUMARAGURU COLLEGE OF TECHNOLOGY**

An autonomous Institution affiliated to Anna University, Chennai

**COIMBATORE – 641 049.**

## **M.E. STRUCTURAL ENGINEERING**

**REGULATIONS 2018**



**CURRICULUM AND SYLLABI**

**I to IV Semesters**

**Department of Civil Engineering**

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## VISION

Department of Civil Engineering is striving to become as a world class Academic Centre for quality education and research in diverse areas of Civil Engineering, with a strong social commitment.

## MISSION

- Producing highly competent and technologically capable professionals and motivated young academicians
- Providing quality education in undergraduate and post graduate levels, with strong emphasis on professional ethics and social commitment.
- Developing a scholastic environment for the state – of –art research, resulting in practical applications.
- Undertaking professional consultancy services in diverse areas of Civil Engineering.

## PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

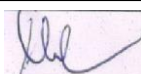
The Program Educational Objectives of Structural Engineering Postgraduate Program are to prepare the students:

- I. To produce students with excellent academic qualities and inculcate the required skills to contribute for the academic and research requirements.
- II. To develop the students as experts in laboratory and experimental work as per recommended standards.
- III. To prepare the students to meet the industrial needs by encouraging them to involve in real time projects.

## PROGRAM OUTCOMES (POs)

Graduates of the Structural Engineering Postgraduate Program should have the ability to:

- PO 1:** Independently carry out research /investigation and work to solve practical problems.
- PO 2:** Write and present a substantial technical report/document.
- PO 3:** Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
- PO 4:** Analyze and solve complex structural engineering problems using the knowledge of mathematics and engineering.
- PO 5:** Use modern/advanced techniques, tools and skills for structural engineering problems and practices.
- PO 6:** Engage in lifelong learning for updating oneself on structural engineering contemporary advancements.



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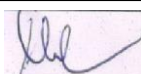
## M.E. STRUCTURAL ENGINEERING CURRICULUM

Semester I								
S.No	Course code	Course Title	Course Mode	L	T	P	J	C
1	P18MAI1201	Applied Numerical Methods for Structural Engineering	Embedded	3	0	2	0	4
2	P18SET1001	Advanced Solid Mechanics	Theory	3	0	0	0	3
3	P18SEI1202	Design of Advanced Concrete Structures	Embedded	3	0	2	0	4
4	P18SEI1203	Advanced Concrete Technology	Embedded	3	0	2	0	4
5	P18_____	Professional Elective I	Theory	3	0	0	0	3
<b>Total Credits</b>								<b>18</b>
<b>Total Contact Hours/week</b>								<b>21</b>

Semester II								
S.No	Course code	Course Title	Course Mode	L	T	P	J	C
1	P18SET2001	Finite Element Method	Theory	3	0	0	0	3
2	P18SEI2202	Structural Dynamics	Embedded	3	0	2	0	4
3	P18SET2003	Advanced Design of Steel Structures	Theory	3	0	0	0	3
4	P18_____	Professional Elective II	Theory	3	0	0	0	3
5	P18SEP2504	Design Studio	Laboratory	0	0	4	0	2
<b>Total Credits</b>								<b>15</b>
<b>Total Contact Hours/week</b>								<b>18</b>

Semester III								
S.No	Course code	Course Title	Course Mode	L	T	P	J	C
1	P18_____	Professional Elective III	Theory	3	0	0	0	3
2	P18_____	Professional Elective IV	Theory	3	0	0	0	3
3	P18SEP3701	In-plant Training*	Project	0	0	0	0	1
4	P18SEP3702	Project Phase I / Industry Project	Project	0	0	0	24	12
* At the end of second semester for 2 weeks								
<b>Total Credits</b>								<b>19</b>
<b>Total Contact Hours/week</b>								<b>30</b>

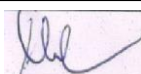
Semester IV								
S.No	Course code	Course Title	Course Mode	L	T	P	J	C
1	P18SEP4701	Project Phase II / Industry Project	Project	0	0	0	36	18
<b>Total Credits</b>								<b>18</b>
<b>Total Contact Hours/week</b>								<b>36</b>



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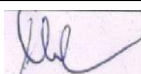
List of Mandatory Audit Courses									Semester Offered
S.No	Course code	Course Title	Course Mode	L	T	P	J	C	
1	P18SEA0001	Disaster Management	Audit	3	0	0	0	0	2

List of Electives									Pre-requisite
S.No	Course code	Course Title	Course Mode	L	T	P	J	C	
1	P18INT0001	Research Methodology and Statistics	Theory	3	0	0	0	3	-----
2	P18SEE0001	Design of Bridges	Theory	3	0	0	0	3	-----
3	P18SEE0002	Design of Pre-Stressed Concrete Elements	Theory	3	0	0	0	3	P18SEI1202
4	P18SEE0003	Earthquake Resistant Design of Structures	Theory	3	0	0	0	3	P18SEI2202
5	P18SEE0004	Smart Materials for Construction	Theory	3	0	0	0	3	-----
6	P18SEE0005	Structural Health Monitoring	Theory	3	0	0	0	3	-----
7	P18SEE0006	Experimental Methods and Model Analysis	Theory	3	0	0	0	3	-----
8	P18SEE0007	Design of Plates, Shells and Spatial Structures	Theory	3	0	0	0	3	-----
9	P18SEE0008	Design of Structures for Dynamic Loads	Theory	3	0	0	0	3	P18SEI2202



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# SEMESTER I



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P18MAI1201

## APPLIED NUMERICAL METHODS FOR STRUCTURAL ENGINEERING

<b>L</b>	<b>T</b>	<b>P</b>	<b>J</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>2</b>	<b>0</b>	<b>4</b>

### Course Outcome

After successful completion of this course, the students should be able to

**CO1:** Solve a set of algebraic equations representing steady state models formed in engineering problems

**CO2:** Fit smooth curves for the discrete data connected to each other or to use interpolation methods over these data tables

**CO3:** Find the trend information from discrete data set through numerical differentiation.

**CO4:** Estimate integrals from discrete data through numerical methods.

**CO5:** Predict the system dynamic behavior through solution of ODEs modeling the system

**CO6:** Solve PDE models representing spatial and temporal variations in physical systems through numerical methods.

**Pre-requisites:** Nil

<b>CO/PO Mapping</b>						
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak						
COs	Programme Outcomes (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1				S		
CO2				M		
CO3				M		
CO4				W		
CO5				M		
CO6				M		

### NUMERICAL SOLUTION OF ALGEBRAIC EQUATIONS

**10 Hours**

Solution of nonlinear equations– Newton’s method, Secant method and Muller method for a single equation. Numerical evaluation of multiple roots: Brent’s algorithm. Solution of non - linear system of equations by Newton’s method.

### INTERPOLATION AND CURVE FITTING

**9 Hours**

Divided differences – Newton’s divided difference formula - Curve fitting – Method of least squares. Spline curves - Bezier curves and B–spline curves - Bezier surfaces and B-spline surfaces - Cubic spline interpolation

### NUMERICAL DIFFERENTIATION AND INTEGRATION

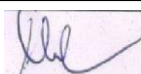
**6 Hours**

Numerical differentiation by using Newton’s divided difference formula – Numerical integration by Trapezoidal and Simpson’s 1/3 and 3/8 rules–Numerical double integration

### NUMERICAL SOLUTION OF BOUNDARY VALUE PROBLEMS

**9 Hours**

Boundary value problems (ODE) – Finite difference methods–Shooting Methods–Collocation Methods



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## **NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS** **11 Hours**

Parabolic equations: explicit and implicit finite difference methods, weighted average approximation - Dirichlet and Neumann conditions–Two dimensional parabolic equations–ADI method; First order hyperbolic equations – method of characteristics, different explicit and implicit methods.

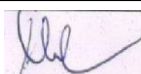
## **PRACTICAL (Computing Lab Component)** **30 Hours**

1. Solving a nonlinear equation using Newton's method, Secant method
2. Solving a system nonlinear equation using Newton's Method
3. Fitting of curves by Method of least squares. Spline curves-Bezier curves
4. Interpolation using Newton divided difference.
5. Numerical differentiation– Newton divided difference.
6. Numerical Integration using Trapezoidal rule, Simpson's rule.
7. Solution of ODE using Shooting Methods.
8. Solution of ODE using Collocation Methods.
9. Solution of PDE using weighted average approximation
10. Solution of PDE using explicit and implicit methods.

<b>Theory: 45</b>	<b>Tutorial: 0</b>	<b>Practical: 30</b>	<b>Project: 0</b>	<b>Total: 75 Hours</b>
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## **REFERENCES**

1. Kendall E. Atkinson, An Introduction to numerical analysis, John Wiley & Sons, second edition, 1990.
2. Conte S.D and Carl de Boor, Elementary Numerical Analysis-An Algorithmic Approach, McGraw-Hill.
3. Steven C. Chapra and Raymond P. Canale, "Numerical Methods for Engineers with Programming and Software Applications", McGraw-Hill, 2004.
4. John H. Mathews and Kurtis D. Fink, "Numerical Methods using Matlab", Prentice Hall of India, 2004.
5. Gerald C.F. and Wheatley P.O, "Applied Numerical Analysis", Pearson Education Asia, New Delhi, 2002.
6. Sastry S.S, "Introductory Methods of Numerical Analysis", Prentice Hall of India Pvt. Ltd, New Delhi, 2003.



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**P18SET1001      ADVANCED SOLID MECHANICS**

<b>L</b>	<b>T</b>	<b>P</b>	<b>J</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Course Outcome**

**After successful completion of this course, the students should be able to**

**CO1:** Formulate equilibrium and compatibility equations for 3D problems

**CO2:** Formulation of boundary value problems in linearized elasticity and solution of 2D problems using Airy's stress functions.

**CO3:** Solution to boundary value problems corresponding to end torsion of prismatic beams

**CO4:** Analyze using plastic theories

**CO5:** Analyze using fracture mechanics

**Pre-requisites:** Nil

<b>CO/PO Mapping</b>						
(S/M/W indicates strength of correlation)    S-Strong, M-Medium, W-Weak						
COs	Programme Outcomes (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	W					
CO2	W					
CO3				M		
CO4				S		
CO5				S		

**INTRODUCTION TO ELASTICITY****12 Hours**

Elasticity approach-Definition and notation of stress - components of stress and strain - generalized Hooke's Law - Transformation of stresses and strains - Stress invariants - Principal stresses and strains for three-dimensional element - Equilibrium equations and compatibility conditions in Cartesian and cylindrical coordinates.

**BOUNDARY VALUE PROBLEMS: FORMULATION****12 Hours**

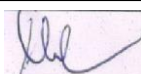
Airy's stress functions for plane stress and strain problems-Bending of a cantilever and simply supported narrow rectangular cross-section under different loads –Asymmetric problems like thick and thin cylinders subjected to internal pressure-Stress concentrations due to circular hole in plate –Non-axisymmetric problems like Flamant approach

**END TORSION OF PRISMATIC BEAMS****8 Hours**

Formulation of the BVP for torsion of beams with solid cross section - warping function and Prandtl stress function approach-Torsion of circular, elliptic, rectangular and triangular cross sections-Membrane analogy-Torsion of thin walled tubes-thin rectangular sections, rolled sections and multiply connected section

**PLASTIC DEFORMATION****9 Hours**

Strain Hardening, Idealized Stress- Strain curve, Yield Criteria, von Mises Yield Criterion, Tresca Yield Criterion, Plastic Stress-Strain Relations, Principle of Normality and Plastic Potential, Isotropic Hardening.



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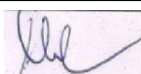
**INTRODUCTION TO FRACTURE MECHANICS****4 Hours**

Failure criteria and fracture toughness– stress intensity factor.

<b>Theory: 45</b>	<b>Tutorial: 0</b>	<b>Practical: 0</b>	<b>Project: 0</b>	<b>Total: 45 Hours</b>
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**REFERENCES**

1. Richard. G. Budynas, Advanced Strength and Applied Stress Analysis, McGraw-Hill, New Delhi, Second Edition, 2011
2. Chakrabarty, Theory of Plasticity, Tata McGraw Hill Book Co., New Delhi, 2012.
3. L.S. Srinath, Advanced Mechanics of Solids, Tata McGraw Hill, 2007.
4. Chwo P.C. and Pagano N.J., Elasticity Tensor, Dyadic and Engineering Applications, D.Van Nastrand and Co., Inco. 2013
5. M.H. Sadd, Elasticity: Theory, Applications and Numeric, Academic Press, 2006.
6. Timoshenko S. and Goodier J.N., Theory of Elasticity, Hill Education., India, Third Edition, 2010.
7. Sadhusingh, Theory of Elasticity, Khanna Publishers, New Delhi, Fourth Edition, 2012.
8. A.R. Ragab and S.E. Bayoumi, Engineering Solid Mechanics: Fundamentals and Applications, CRC Press, 1999.



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**P18SEI1202****DESIGN OF ADVANCED CONCRETE  
STRUCTURES**

<b>L</b>	<b>T</b>	<b>P</b>	<b>J</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>2</b>	<b>0</b>	<b>4</b>

**Course Outcome**

After successful completion of this course, the students should be able to

**CO1:** Calculate short term and long-term deflections for structural elements

**CO2:** Analyze the structure after redistribution of moments

**CO3:** Design and detail deep beams, grid floor and flat slabs in accordance with relevant IS code and standards

**CO4:** Design bunkers and silos.

**Pre-requisites:** Nil

<b>CO/PO Mapping</b>						
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak						
COs	Programme Outcomes (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1			M	S		
CO2		M	S	S		
CO3		M	S	S		
CO4		M	S	S		

**SERVICEABILITY CRITERIA FOR RC BEAMS AND SLABS****9 Hours**

Deflection: Introduction– Short Term and Long-Term Deflection of Beams Slabs, Continuous slabs as per IS456–Deflection due to Imposed Loads. Crack Width: Introduction - Factors affecting Crack width in Beams–Mechanism of Flexural Cracking–Estimation of Crack width in Beams by IS456 and BS8110 – Shrinkage, Creep and Thermal Cracking.

**REDISTRIBUTION OF MOMENTS TO REINFORCED CONCRETE BEAMS****9 Hours**

Introduction – Redistribution of Moments in a Fixed Beam– Plate Theory Concepts - Advantages and Disadvantages of Moment Redistribution - Moment Redistribution for a Two–Span Continuous Beam – Modification of Clear Distance between Bars in Beams (for Limiting Crack width) with redistribution – Moment – Curvature (M - $\Phi$ ) Relation of Reinforced Concrete Sections.

**DESIGN OF REINFORCED CONCRETE DEEP BEAMS****9 Hours**

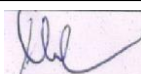
Introduction – Design by IS456– Checking for Local failures– Detailing of Deep Beams – Design of Corbels

**DESIGN OF RIBBED (Voided) SLABS****9 Hours**

Introduction – Specification regarding the slabs – Analysis of the Slabs for Moment and Shears – Ultimate Moment of Resistance – Design of Shear – Deflection– Arrangement of Reinforcements

**DESIGN OF GRID FLOORS AND FLAT SLABS****9 Hours**

Introduction – Analysis and design of Flat Grid Floors – Detailing of Steel in Flat Grids – Analysis and design of Flat slabs.



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**DESIGN OF SPECIAL STRUCTURES****9 Hours**

Introduction - Difference between bunker and silo - Design of Bunkers – Design of Silo – Design of RC walls. – Design of Shear Wall in Framed Building – Design of Slender Columns.

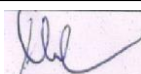
**PRACTICAL****9 Hours**

1. Design of Ribbed Slab.
2. Design of Flat Slab.
3. Design of Grid Floor.
4. Design of Deep Beam.
5. Design of Bunkers.
6. Design of Silo.

<b>Theory: 45</b>	<b>Tutorial: 0</b>	<b>Practical: 30</b>	<b>Project: 0</b>	<b>Total: 75 Hours</b>
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**REFERENCES**

1. P.C. Vargheese, 'Advanced Concrete Design', Prentice Hall of India Pvt. Ltd., 2009
2. Krishnaraju, N. 'Advanced Reinforced Concrete Design', CBS Publishers and Distributors, Delhi, 2013
3. Jain, A.K. 'Reinforced Concrete-Limit State Design', Nem Chand and Bros., Roorkee, 2012
4. Park. R. and Paulay T., 'Reinforced Concrete Structures', John Wiley and Sons, New Delhi, 2009.
5. Sinha, N.C. and Roy S.K., 'Fundamentals of Reinforced Concrete', S. Chand and Company, New Delhi, 2007.
6. B.C. Punmia, A.K.Jain, 'Limit State Design of Reinforced concrete', Firewall media, 2007.
7. S. Unnikrishna Pillai and Devdas Menon, 'Reinforced Concrete Design', TATA McGraw-Hill Education Pvt. Ltd., New Delhi, 2017.



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**P18SEI1203****ADVANCED CONCRETE  
TECHNOLOGY**

<b>L</b>	<b>T</b>	<b>P</b>	<b>J</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>2</b>	<b>0</b>	<b>4</b>

**Course Outcome**

**After successful completion of this course, the students should be able to**

**CO1:** Explain the production process, mineral and chemical admixtures for concrete.

**CO2:** Assess concrete properties.

**CO3:** Design a concrete mix for target strength and suggest advanced methods for concrete manufacture and placement.

**CO4:** Perform tests for permeability and durability properties.

**CO5:** Recommend sustainable materials for concrete production.

**CO6:** Assess behavior of various concrete elements

**Pre-requisites:** Nil

<b>CO/PO Mapping</b>						
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak						
COs	Programme Outcomes (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	S		S		S	
CO2	S		S		S	
CO3	S		S		S	
CO4	S		S		S	
CO5	S		S		S	
CO6	S		S		S	

**CONSTITUENT MATERIALS OF CONCRETE****10 Hours**

Constituent materials of structural concrete, Material types and production - mineral and chemical admixtures.

**CONCRETE PROPERTIES****10 Hours**

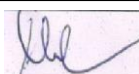
Concrete properties - setting and hardening - transition zone in concrete - Elastic behavior in concrete - creep, shrinkage and thermal properties of concrete. Strength-porosity relationship- Permeability of concrete - pore structure and water transport process

**CONCRETE PRODUCTION, PROCESSES, APPLICATIONS AND CONSTRUCTIONS****8 Hours**

Concrete design mix for higher grades - Advanced methods of concrete manufacture and placement - Ready mix concrete, Pumpable Concrete

**TESTING, QUALITY ASSURANCE, REPAIR AND MAINTENANCE OF CONCRETE****10 Hours**

Durability concept: Rapid Chloride permeability test- water absorption test- Resistance against sulphate attack - Classification and causes of concrete deterioration- Alkali aggregate reactivity- effect of elevated temperature. Nondestructive testing methods - failure modes in concrete-plastic and thermal cracking



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**ECO-FRIENDLY CONCRETE****7 Hours**

Concreting under special circumstances-special materials in construction-Concrete for prefabricated elements - concreting machinery and equipment sustainability in concrete –future trends in concrete technology

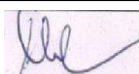
**PRACTICAL****30 Hours**

1. Test on hardened concrete – Study of stress - strain characteristics and determination of Young's modulus- Split tensile strength test.
2. Test on hardened concrete using Non-Destructive Testing Techniques
  - i) Ultrasonic method
  - ii) Rebound hammer method
3. Testing of RC column under axial compression.
4. Testing of RC beam to study the moment rotation behaviour under flexure.
5. Testing of RC beam to study the behaviour under shear failure.
6. Accelerated corrosion test on concrete
7. Rapid Chloride Penetration Test
8. Rebar locator test

<b>Theory: 45</b>	<b>Tutorial: 0</b>	<b>Practical: 30</b>	<b>Project: 0</b>	<b>Total: 75 Hours</b>
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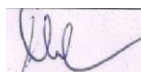
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1. P. Kumar Metha and Paulo J.M.Monteiro, Concrete : Microstructure, Properties and Materials, Mc Graw Hill, Fourth Edition, 2014.
2. Shetty.M.S, Concrete Technology, S.Chand and Company Ltd, New Delhi.
3. John Newman and Ban Seng Choo, Advanced Concrete Technology Part 1 to 4, Butterworth-Heinemann, First Edition 2003.
4. Adam M., Neville, Properties of Concrete , Wiley Publications, Fourth and Final edition ,1996.
5. A.R.Santhakumar, Concrete Technology , Oxford University Press, 2006.



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# SEMESTER II



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**P18SET2001****FINITE ELEMENT METHOD**

<b>L</b>	<b>T</b>	<b>P</b>	<b>J</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Course Outcome**

**After successful completion of this course, the students should be able to**

**CO1:** understand the energy principles and finite element concepts.

**CO2:** formulate shape functions for various elements

**CO3:** determine the stresses and strains for 2D and 3D problems

**CO4:** apply finite element method for the analysis of framed structures

**CO5:** analyze plates and shells using Finite Element Method

**Pre-requisites:** Nil

<b>CO/PO Mapping</b>						
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak						
COs	Programme Outcomes (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	W					
CO2	W					
CO3				M		
CO4				S		
CO5				S		

**INTRODUCTION****9 Hours**

Introduction - Basic Concepts of Finite Element Analysis - Introduction to Elasticity - Steps in Finite Element Analysis

Finite Element Formulation Techniques - Virtual Work and Variational Principle - Galerkin Method - Finite Element Method: Displacement Approach - Stiffness Matrix and Boundary Conditions

**ELEMENT PROPERTIES****9 Hours**

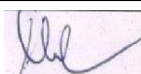
Natural Coordinates - Triangular Elements-Rectangular Elements - Lagrange and Serendipity Elements - Solid Elements - Isoparametric Formulation - Stiffness Matrix of Isoparametric Elements

**ANALYSIS OF FRAME STRUCTURES****9 Hours**

Stiffness of Truss Members-Analysis of Truss-Stiffness of Beam Members-Finite Element Analysis of Continuous Beam-Plane Frame Analysis-Analysis of Grid and Space Frame

**FEM FOR TWO AND THREE-DIMENSIONAL SOLIDS****9 Hours**

Constant Strain Triangle - Linear Strain Triangle - Rectangular Elements- Numerical Evaluation of Element Stiffness - Computation of Stresses, Geometric Nonlinearity and Static Condensation - Axisymmetric Element - Finite Element Formulation of Axisymmetric Element - Finite Element Formulation for 3 Dimensional Elements- Problems



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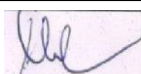
## **FEM FOR PLATES AND SHELLS & ADDITIONAL APPLICATIONS OF FEM** **9 Hours**

Introduction to Plate Bending Problems - Finite Element Analysis of Thin Plate - Finite Element Analysis of Thick Plate - Finite Element Analysis of Skew Plate -Introduction to Finite Strip Method - Finite Element Analysis of Shell

<b>Theory: 45</b>	<b>Tutorial: 0</b>	<b>Practical: 0</b>	<b>Project: 0</b>	<b>Total: 45 Hours</b>
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### **REFERENCES**

1. Chandrupatla, R.T. and Belegundu, A.D., "Introduction to Finite Elements in Engineering", Prentice Hall of India, 2012.
2. Desai, Y.M., Eldho, T.L. and Shah, A.H., "Finite Element Method", Pearson Education Asia, New Delhi, 2011.
3. Chandrakant S. Desai and John F. Abel 'Introduction to the Finite Element Method' CBS Publishers and Distributors Pvt. Lts., 2005.
4. SS. Bhavikkatti, "Introduction to Finite Element Analysis", New Age International Pvt. Ltd., New Delhi, 2005.
5. Wail N. AL-Rifaie and Ashok. K. Govil, "Finite Element Method for Structural Engineers", New Age International Pvt. Ltd., New Delhi, 2010.
6. Singiresu. S. Rao, "The Finite Element Method in Engineering", Butterworth-Heinemann, India Edition, 2010.
7. Bathe K.J, Finite Elements Procedures in Engineering analysis, Prentice Hall Inc., 2014.
8. Zienkiewicz O.C., Finite Element Method, & Taylor R.L. Vol. I, II & III, Elsevier, 2000.
9. C. Krishnamoorthy, 'Finite Element Analysis: Theory and Programming', Tata McGraw-Hill Education Pvt. Ltd., New Delhi, 2017.



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**P18SEI2202****STRUCTURAL DYNAMICS**

<b>L</b>	<b>T</b>	<b>P</b>	<b>J</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>2</b>	<b>0</b>	<b>4</b>

**Course Outcome**

**After successful completion of this course, the students should be able to**

**CO1:** Understand the importance of mathematical modelling and vibration analysis.

**CO2:** Solve response of the structures to dynamic loads using numerical methods

**CO3:** Study the dynamics response of single degree freedom system using fundamental theory and equation of motion.

**CO4:** Study the dynamics response of Multi degree freedom system using fundamental theory and equation of motion.

**CO5:** Understand the special loads like wind loads, Vibrations due to traffic etc. and the concept of base isolation.

**Pre-requisites:** Nil

<b>CO/PO Mapping</b>						
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak						
COs	Programme Outcomes (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	W					
CO2				S	M	
CO3	W			S		
CO4	W			S		
CO5	W					

**INTRODUCTION****5 Hours**

Objectives, Importance of Vibration Analysis, Nature of Exciting Forces, Mathematical Modelling of Dynamic Systems.

**SINGLE DEGREE OF FREEDOM SYSTEM****9 Hours**

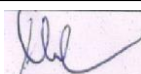
Single Degree of Freedom System: Free and Forced Vibration with and without Damping, Response to Harmonic Loading, Response to General Dynamic Loading using Duhamel's Integral, Fourier Analysis for Periodic Loading, State Space Solution for Response.

**NUMERICAL METHODS****9 Hours**

Numerical Solution to Response using Newmark Method and Wilson Method, Numerical Solution for State Space Response using Direct Integration

**MULTIPLE DEGREE OF FREEDOM SYSTEM (LUMPED PARAMETER)****13 Hours**

Multiple Degree of Freedom System, Inverse Iteration Method for Determination of Natural Frequencies and Mode Shapes, Dynamic Response by Modal Superposition Method, Direct Integration of Equation of Motion. Multiple Degree of Freedom System (Distributed Mass and Load): Single Span Beams, Free and Forced Vibration, Generalized Single Degree of Freedom System



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**SPECIAL TOPICS IN STRUCTURAL DYNAMICS****9 Hours**

Dynamic Effects of Wind Loading, Moving Loads, Vibrations caused by Traffic, Blasting and Pile Driving, Foundations for Industrial Machinery, Base Isolation. (Concepts only)

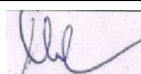
**PRACTICAL****30 Hours**

1. Response of structures and its elements against extreme loading events.
  - a. Impact test on slab specimen
  - b. Cyclic load test on RC beam
  - b. Demonstration on Horizontal and Vertical Shake table.
2. Model Testing:
  - a. Dynamic Response of cantilever steel beam
  - b. Lateral Load testing of G+1 storied steel frame
3. Evaluation of dynamic modulus of concrete.
4. Testing of Shear wall model for lateral load – Stiffness, Energy absorption
5. Vibration Characteristics of RC Beam using FFT analyzer.
6. Study on Vibration isolation.

<b>Theory: 45</b>	<b>Tutorial: 0</b>	<b>Practical: 30</b>	<b>Project: 0</b>	<b>Total: 75 Hours</b>
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**REFERENCES**

1. Clough R. W. and Penzien J., Dynamics of Structures, McGraw Hill.,2007
2. A.K. Chopra, Dynamics of Structures – Theory and Applications of Earthquake Engineering, Pearson Education., 2014.
3. Paz Mario., Structural Dynamics – Theory and Computation, CBS Publication., 5th edition,2006.
4. Shashikant K. Duggal., Earthquake Resistant Design of Structures, Oxford University Press, 2013.
5. Ashok K. Jain., Dynamics of Structures with MATLAB Applications, Pearson Education., 2017.



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**P18SEI2003****ADVANCED DESIGN OF STEEL  
STRUCTURES**

<b>L</b>	<b>T</b>	<b>P</b>	<b>J</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Course Outcome**

**After successful completion of this course, the students should be able to**

**CO1:** design various types of connections for steel structural elements.

**CO2:** analyze and design cold-formed steel structural components.

**CO3:** analyze and design steel towers.

**CO4:** design special structures like steel chimney and bunkers and silos and analyse the structures for wind and earthquake forces for design loads.

**CO5:** Design composite beams, slabs and columns.

**Pre-requisites:** Nil

<b>CO/PO Mapping</b>						
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak						
COs	Programme Outcomes (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1		M	S	S		
CO2		M		S		
CO3		M		S		
CO4		M		S		
CO5		M		S		

**BEHAVIOUR AND DESIGN OF CONNECTIONS****9 Hours**

Connection behavior – Design requirements of bolted and welded connections-unstiffened and stiffened seat connections – framed connections – Connections for force and moment transmission - tee stub and end plate connections - Column stiffeners and other reinforcement – principles of semi-rigid connections.

**ANALYSIS AND DESIGN OF COLD-FORMED STEEL STRUCTURES****9 Hours**

Types of cross sections - concepts of local buckling, and effective width - Design of compression and tension members - concepts of lateral buckling – Design of Beams, deflections of beams and design of beam webs - Combined stresses and connections- Empirical design of Z-purlins with lips and wall studs

**ANALYSIS AND DESIGN OF STEEL TOWERS****9 Hours**

Micro Wave Towers – Transmission line towers – Loads on towers - Shape, Sag and Tension in Uniformly loaded conductors -Analysis of towers – Design of member in towers.

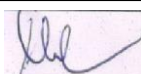
**ANALYSIS AND DESIGN OF SPECIAL STRUCTURES****9 Hours**

Design of self-supporting chimney and guyed steel chimney – Stress due to wind and earthquake forces – Gust factor method – Design concept of bunkers and silos

**COMPOSITE STRUCTURES****9 Hours**

Composite beams – composite slabs – infilled encased columns – uniaxial eccentric composite columns

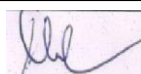
<b>Theory: 45</b>	<b>Tutorial: 0</b>	<b>Practical: 0</b>	<b>Project: 0</b>	<b>Total: 45 Hours</b>
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**REFERENCES**

1. L.S.Jayagopal, D.Tensing, Design of Steel Structures, Vikas Publishing, 2015
2. Dayaratnam, Design of Steel Structures, S. Chand & Company Ltd.,2012
3. S.Ramchandra and Virendra Gehlot,'Design of Steel Structures', Vol.-II, Scientific Publication, New Delhi,2010.
4. INSDAG, 'Teaching Resource for Structural Steel Design', Kolkotta, Version-II
5. Wei Wen Yu, Roger A. LaBoube, Cold Formed Steel Desgin, Wiley Publishers, 2010.
6. Subramanian.N, "Design of Steel Structures", Oxford University press, 2011.



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**P18SEP2504****DESIGN STUDIO**

<b>L</b>	<b>T</b>	<b>P</b>	<b>J</b>	<b>C</b>
<b>0</b>	<b>0</b>	<b>4</b>	<b>0</b>	<b>2</b>

**Course Outcome**

**After successful completion of this course, the students should be able to**

**CO1:** design RC structural elements using spread sheets

**CO2:** analyse and design multi-storeyed RC building and trussed steel roof structures for wind and seismic forces

**CO3:** analyse and design various RC and steel structures

**CO4:** develop FEM model for RC elements

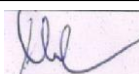
**Pre-requisites:** Nil

<b>CO/PO Mapping</b>						
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak						
COs	Programme Outcomes (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1		W		M	S	
CO2		W			S	
CO3		W			S	
CO4		W	M	M	S	

**LIST OF EXPERIMENTS****60 Hours**

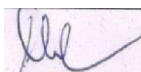
1. Design of simple structural elements of RC structures using Excel spread sheets - (Beam, Column, Slab, Isolated Footing, Retaining wall).
2. Analysis and design of multi-storey RC frame using computer software.
3. Design of steel foot-over bridge with fabrication drawings
4. Design of Industrial Shed with fabrication drawings
5. Design of T-beam bridge for moving load
6. Design of Water tanks
7. Design of Retaining walls
8. Design of Isolated footing
9. Design of Mat foundation
10. FEA of flat slab

<b>Theory: 0</b>	<b>Tutorial: 0</b>	<b>Practical: 60</b>	<b>Project: 0</b>	<b>Total: 60 Hours</b>
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# ELECTIVES



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**P18INT0001****RESEARCH METHODOLOGY AND  
STATISTICS**

<b>L</b>	<b>T</b>	<b>P</b>	<b>J</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Course Outcome**

**After successful completion of this course, the students should be able to**

**CO1:** Understand and apply the concepts of research

**CO2:** Apply statistical and other research tools to analyze and interpret data

**CO3:** Demonstrate skills in writing research topics

**Pre-requisites:** Nil

<b>CO/PO Mapping</b> (S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak						
COs	Programme Outcomes (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	S					S
CO2				S	S	
CO3		S				M

**INTRODUCTION TO RESEARCH METHODS****9 Hours**

Definition and Objectives of Research, Scientific Methods, Various Steps in Scientific Research, Research planning, Selection of a Problem for Research, Formulation of the Selected Problems, Purpose of the Research, Formulation of research objectives, Formulation of research questions, Hypotheses Generation and Evaluation, Literature search, and review, Research abstract.

**INTRODUCTION TO STATISTICS****9 Hours**

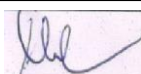
Population and Sample, Sampling and sample size, Population Proportion and Population Mean, Sample Proportion and Sample Mean, Estimation of Standard Error and confidence Interval, Identifying the dependent and independent variables, Introduction to data, Types of data and their importance, Descriptive Statistics and Inferential Statistics, Summarizing and describing data, Measures of Central Tendency and Measures of Dispersion, Mean, Median, Mode, Range, Variance, Standard Deviation

**STATISTICAL MODELING AND ANALYSIS****12 Hours**

Probability Distributions, Normal, Binomial, Poisson, Fundamentals of Statistical Analysis and Inference, Hypothesis Testing, Confidence interval, Test of Significance, Comparison of Means (T test, Z test), Analysis of variance (ANOVA), Measures of association/Relationship, Chi-square test, Simple Regression Analysis, Multiple Regression analysis, Correlation, Data visualization techniques

**RESEARCH DESIGN/PLAN****6 Hours**

Types and Methods of Research, Classification of Research, Research Ethics, Sampling Techniques, Methods of Collecting Primary Data, Use of Secondary Data, Experimentation, Design of Experiments, Survey Research and Construction of Questionnaires, Pilot Studies and Pre-tests, Data Collection methods, Processing of Data, Editing, Classification and Coding, Transcription, Tabulation, Validity and Reliability



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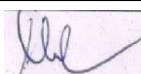
**RESEARCH REPORTS****9 Hours**

Structure and Components of Research Report/thesis, Types of Report, Planning of Report/thesis Writing, Research Report Format, Layout of Research Report, Presentation of data and Data Analysis Reporting, Mechanism of writing a research report, Principles of Writing, Writing of Report

<b>Theory: 45</b>	<b>Tutorial: 0</b>	<b>Practical: 0</b>	<b>Project: 0</b>	<b>Total: 45 Hours</b>
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**REFERENCES**

1. C.R. Kothari, Research Methodology Methods and Techniques, 3/e, New Age International Publishers, 2014.
2. Ranjit Kumar, Research Methodology A Step-by-Step Guide for Beginners, 4th Edition, Sage Publishing, 2014
3. R. Pannerselvam, Research Methodology, 2nd edition, Prentice Hall India, 2014
4. Devore, J.L., Probability and statistics for Engineering and the Sciences, Cengage Learning, ebook, 8th edition, 2010.



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**P18SEE0001****DESIGN OF BRIDGES**

<b>L</b>	<b>T</b>	<b>P</b>	<b>J</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Course Outcome**

After successful completion of this course, the students should be able to

**CO1:** Calculate loads for different types of Bridges.

**CO2:** Design short span and long span bridges.

**CO3:** Design bearings and substructure for bridges.

**Pre-requisites:** Nil

<b>CO/PO Mapping</b>						
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak						
COs	Programme Outcomes (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1		M	M	S		
CO2		M	M	S		
CO3		M	M	S		

**INTRODUCTION****9 Hours**

Classification, investigations and planning, choice of type, I.R.C. specifications for road bridges, standard live loads, other forces acting on bridges, general design considerations.

**SHORT SPAN BRIDGES****9 Hours**

Load distribution theories, analysis and design of slab bridge, box culverts and tee beam bridges.

**LONG SPAN GIRDER BRIDGES****9 Hours**

Design principles of balanced cantilever bridges – Design of articulation - continuous bridges - box girder bridges.

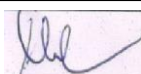
**DESIGN OF PRESTRESSED CONCRETE BRIDGES****9 Hours**

Design of prestressed concrete bridges – Preliminary dimensions – Design of girder section - Maximum and minimum prestressing forces-Eccentricity-Live load and dead load shear forces – cable zone in girder - Short term and long-term deflections.

**BEARINGS, SUB-STRUCTURES AND FOOTINGS FOR BRIDGES****9 Hours**

Design of bearings – Foundation for bridges – Well and caisson foundation – Design of pier cap - Design of pier.

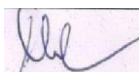
<b>Theory: 45</b>	<b>Tutorial: 0</b>	<b>Practical: 0</b>	<b>Project: 0</b>	<b>Total: 45 Hours</b>
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**REFERENCES**

1. Krishnaraju, N., 'Design of Bridges', Oxford and IBH Publishing, 2010.
2. Ponnuswamy, S., 'Bridge Engineering', Tata McGraw-Hill, 2007.
3. N. Rajagopalan, 'Bridge Superstructure', Alpha Science Intl. Ltd, 2006.
4. Raina V.K. 'Concrete Bridge Practice', Tata McGraw-Hill Publishing Company, New Delhi, 1994.
5. Bakht, B. and Jaegar, L.G., 'Bridge Analysis Simplified', McGraw-Hill, 1985.
6. Derrick Beckett, 'An introduction to Structural Design of Concrete Bridges', Surrey University Press, Henley Thomes, Oxford Shire, 1973.
7. Taylor, F.W., Thomson, S.E., and Smulski E., 'Reinforced Concrete Bridges', John Wiley and Sons, New York, 1955.
8. Edwin H. Gaylord Jr., Charles N. Gaylord, James, E., Stallmeyer 'Design of Steel Structures' McGraw-Hill International Editions, 1992.
9. D. Johnson Victor, 'Essentials of Bridge Engineering', Oxford and IBH Publishing, 2010.



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**P18SEE0002****DESIGN OF PRE-STRESSED  
CONCRETE ELEMENTS**

<b>L</b>	<b>T</b>	<b>P</b>	<b>J</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Course Outcome**

**After successful completion of this course, the students should be able to**

**CO1:** Understand different methods of pre-stressing techniques

**CO2:** Design pre-stressed concrete structures for flexure and shear

**CO3:** Analyze and design the anchorage zone.

**CO4:** Design pre-stressed concrete pipes and tanks

**CO5:** Analyze composite and indeterminate pre-stressed concrete structures

**Pre-requisites:** Design of Advanced Concrete Structures

<b>CO/PO Mapping</b>						
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak						
COs	Programme Outcomes (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	S					
CO2		S	M	S		
CO3				S		
CO4		S	M	S		
CO5				S		

**PRINCIPLES AND ANALYSIS FOR FLEXURE****9 Hours**

Principles of Pre-stressing – Types of pre-stressing systems – Materials – Systems and devices– Analysis and design for flexure – Components of tendons – Behaviour of pre-stressed concrete elements – General concept of pre-stress – Force transmitted by pre-tensioned and post-tensioned systems – deflection – crack width - losses in prestress – analysis for Ultimate strength – Comparison of codal provisions

**DESIGN FOR FLEXURE****8 Hours**

Concept of Limit State design – Limit state of Collapse and serviceability – Design using allowable stresses – Stress range approach-Lin's approach – Magnel's approach – Analysis of Ultimate Strength

**DESIGN FOR SHEAR, TORSION AND ANCHORAGE ZONE****8 Hours**

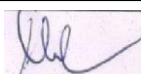
Principal stresses – Shear resistance in beams – Design for shear in rectangular and flanged beams – Behaviour under torsion – Modes of failure - Design for torsion, shear and bending Anchorage Zone – analysis and design of pre-tensioned and post tensioned end blocks

**STATICALLY INDETERMINATE STRUCTURES****7 Hours**

Analysis of indeterminate structures – Continuous beams – linear transformations - Concept of concordance – Choice of cable profiles – deflection of pre-stressed members.

**SPECIAL STRUCTURES****7 Hours**

Partial pre-stressing – Principles, analysis and design concepts - Concept of circular prestressing – Design of pre-stressed concrete pipes and cylindrical water tanks - Composite construction- types, behaviour, flexural stresses, longitudinal shear transfer, transverse shear–Compression members–Design of poles, piles and sleepers – Post tensioning systems – Precast elements.



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**DESIGN FOR TENSION**

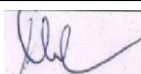
Design of tension members

**6 Hours**

<b>Theory: 45</b>	<b>Tutorial: 0</b>	<b>Practical: 0</b>	<b>Project: 0</b>	<b>Total: 45 Hours</b>
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**REFERENCES**

1. N. Krishnaraju, 'Prestressed Concrete', Tata McGraw-Hill Publishing Company, 4th Ed 2012
2. N. Rajagobalan, 'Prestressed Concrete', Norosa Publishing House, 2014
3. T.Y. Lin & Ned Bhurns, 'Design of Prestressed Concrete Structures', 3rd edition, John Wiley & Sons, 1982
4. N.C. Sinha & S.K. Roy, 'Fundamentals of Prestressed Concrete' S. Chand & Co, New Delhi, 2011.



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**P18SEE0003****EARTHQUAKE RESISTANT DESIGN  
OF STRUCTURES**

<b>L</b>	<b>T</b>	<b>P</b>	<b>J</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Course Outcome**

**After successful completion of this course, the students should be able to**

**CO1:** Acquire knowledge on earthquake and theory of vibration.

**CO2:** Understand response of the structures to dynamic loads and capacity design.

**CO3:** Understand the code provisions for seismic analysis of structures.

**CO4:** Design RC elements of frame system as per code provision.

**CO5:** Understand Retro-fitting of existing damaged buildings and vibration control measures

**Pre-requisites:** Structural Dynamics

<b>CO/PO Mapping</b>						
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak						
COs	Programme Outcomes (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	W					
CO2	W					
CO3	S		S			
CO4		M	M	S		
CO5	S					S

**INTRODUCTION****9 Hours**

Elements of Seismology – Definitions of magnitude – Intensity – Epicenter etc.- General features of tectonics of seismic regions– Seismographs and Accelerographs. Theory of Vibrations - Free vibrations of single degree – Two degree and multiple degree freedom systems.

**EARTHQUAKE RESPONSE****9 Hours**

Load path – Effect of irregularities and plan configuration – Torsion in Structural systems - Cyclic Behaviour of PCC, RCC, Steel and PSC Elements, Earthquake Response to Elastic and Inelastic Buildings – Response Spectrum Theory – Design spectrum – Design principles, Capacity based design, Strong column – weak beam concept, Ductility – Definition, Types, Importance and Requirements

**BIS SPECIFICATIONS & SEISMIC ANALYSIS****9 Hours**

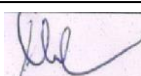
Code Provisions of Design of Buildings as per IS1893 and IS4326 – Behaviour and Design of Masonry Structures as Per IS 13827 and IS13828. Methods of Seismic Analysis: Equivalent static analysis – Response Spectrum method – Time history method – Pushover Analysis

**DUCTILE & DESIGN DETAILING****9 Hours**

Code Provisions of Ductile Detailing of Structures as per IS13920 – Design of RC beams, columns, Beam-column joints and shear walls – Ductility of Moment Resisting Frames and Braced Frames.

**SPECIAL TOPICS****9 Hours**

Base isolation technique, Active and passive control devices, Seismic retro-fitting strategies for RC and masonry buildings. Soil Liquefaction.

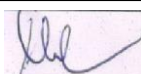


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<b>Theory: 45</b>	<b>Tutorial: 0</b>	<b>Practical: 0</b>	<b>Project: 0</b>	<b>Total: 45 Hours</b>
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**REFERENCES**

1. Pankaj Agarwal, Earthquake Resistant Design of Structures, Prentice – Hall of India Pvt. Ltd., New Delhi, 2006.
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3. Duggal S.K., Earthquake Resistant Design of Structures, Prentice Hall of India, New Delhi, 2013.
4. Bungale S. Taranath, Wind and Earthquake Resistant Buildings: Structural Analysis and Design, CRC Press, 2004.



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**P18SEE0004****SMART MATERIALS FOR  
CONSTRUCTION**

<b>L</b>	<b>T</b>	<b>P</b>	<b>J</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Course Outcome**

**After successful completion of this course, the students should be able to**

**CO1:** choose a suitable concrete admixture

**CO2:** design steel-concrete composite elements

**CO3:** design fiber reinforced concrete mix as per ACI standards

**CO4:** suggest composition of geopolymer and ferrocement

**Pre-requisites:** Nil

<b>CO/PO Mapping</b>						
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak						
COs	Programme Outcomes (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M		S			
CO2		M		S		
CO3		M		S		
CO4	M	M	S			

**CONCRETE ADMIXTURES****9 Hours**

Mineral (pozzolanic materials and fillers) – Chemical (accelerators, retarders, plasticizers, super plasticizers, air entraining agent, viscosity modifier, corrosion inhibitors and water repellent) – Dosage – Compatibility

**STEEL CONCRETE COMPOSITE****9 Hours**

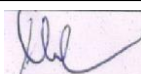
Introduction to steel-concrete composite structures, Anatomy of a composite building, Construction of composite structures, Design of composite beam and column, Shear connectors, Design strength of shear connectors, Load resisting systems, connections, Analysis procedures of buildings for gravity and lateral loads

**FIBER REINFORCED CONCRETE****9 Hours**

Fibre materials, mix proportioning, distribution and orientation, interfacial bond, properties in fresh state, strength and behaviour in tension, compression and flexure of steel fibre reinforced concrete, mechanical properties, crack arrest and toughening mechanism – Applications of FRC – Design as per ACI 544.4R-18 – Case study

**GEO-POLYMER CONCRETE****9 Hours**

Characterisation – activating solution – structure of geopolymers – accelerated curing – durability – design – Engineering properties – applications – case study



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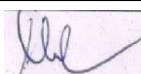
**FERROCEMENT****9 Hours**

Ferro cement: Ferrocement materials, mechanical properties, cracking of ferrocement, strength and behaviour in tension, compression and flexure, Design of ferrocement in tension, ferrocement constructions, durability, and applications.

<b>Theory: 45</b>	<b>Tutorial: 0</b>	<b>Practical: 0</b>	<b>Project: 0</b>	<b>Total: 45 Hours</b>
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**REFERENCES**

1. A.M Paillere, “Applications of Admixtures in Concrete”, Taylor & Francis, 2007.
2. D. J. Oehlers and M. A. Bradford, “Composite Steel and Concrete Structural Members: Fundamental Behaviour”, Pergamon, 1995.
3. Harvinder Singh, “Steel Fiber Reinforced Concrete”, Springer, 2017
4. J. L. Provis and J. S. J. van Deventer, “Geopolymers: Structures, Processing, Properties and Industrial Applications”, CRC Press, 2009
5. Stanley Abercrombie, “Ferrocement: Building with cement, sand, and wire mesh”, Hill Family Books, 2008



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**P18SEE0005****STRUCTURAL HEALTH  
MONITORING**

<b>L</b>	<b>T</b>	<b>P</b>	<b>J</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Course Outcome**

**After successful completion of this course, the students should be able to**

**CO1:** Diagnose for serviceability and durability aspects of concrete.

**CO2:** Suggest the materials and techniques used for repair of structures.

**CO3:** Decide the appropriate repair, strengthening, rehabilitation and retrofitting technique required for a case study building

**CO4:** Recommend an appropriate health monitoring technique and demolition technique

**Pre-requisites:** Nil

<b>CO/PO Mapping</b>						
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak						
COs	Programme Outcomes (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	S					M
CO2	S	S				S
CO3	S	S				S
CO4	S	S				M

**INTRODUCTION TO STRUCTURAL HEALTH MONITORING****9 Hours**

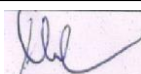
Definition of structural health monitoring (SHM), Motivation for SHM, SHM as a way of making materials and structures smart, SHM and biomimetics, Process and pre-usage monitoring as a part of SHM, SHM as a part of system management, Passive and active SHM, NDE, SHM and NDECS, Variety and multi-disciplinary: the most remarkable characters of SHM, Birth of the SHM Community.

**VIBRATION-BASED TECHNIQUES FOR SHM****9 Hours**

Basic vibration concepts for SHM, Local and global methods, Damage diagnosis as an inverse problem, Model-based damage assessment, Mathematical description of structural systems with damage, General dynamic behavior, State-space description of mechanical systems, Modelling of damaged structural elements, Linking experimental and analytical data, Modal Assurance Criterion (MAC) for mode pairing, Modal Scaling Factor (MSF), Co-ordinate Modal Assurance Criterion (COMAC), MECE error localization technique.

**FIBER-OPTIC SENSORS****9 Hours**

Classification of fiber-optic sensors, Intensity-based sensors, Phasemodulated optical fiber sensors, or interferometers, Wavelength based sensors, Photoelasticity in a plane stress state, Orientation of the optical fiber with respect to the reinforcement fibers, Ingress/egress from the laminate, Measurement of strain and stress variations, Measurement of spectral perturbations associated with internal stress release resulting from damage spread, Examples of applications in civil engineering, Stiffened panels with embedded fiber Bragg gratings, Concrete beam repair



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**SHM WITH PIEZOELECTRIC SENSORS****9 Hours**

The use of embedded sensors as acoustic emission (AE) detectors, Algorithms for damage localization, Algorithms for damage characterization, Available industrial AE systems, New concepts in acoustic emission, Sensor technology, Acousto-ultrasonic signal and data reduction methods, Available industrial acousto-ultrasonic systems with piezoelectric sensors, Electromechanical impedance, E/M impedance for defect detection in metallic and composite parts, The piezoelectric implant method applied to the evaluation and monitoring of viscoelastic properties.

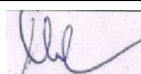
**SHM USING ELECTRICAL RESISTANCE****9 Hours**

Composite damage, Electrical resistance of unloaded composite, Percolation concept, Anisotropic conduction properties in continuous fiber reinforced polymer, Influence of temperature, Composite strain and damage monitoring by electrical resistance, 0° uni-directional laminates, Multidirectional laminates, Randomly distributed fiber reinforced polymers, Damage localization.

<b>Theory: 45</b>	<b>Tutorial: 0</b>	<b>Practical: 0</b>	<b>Project: 0</b>	<b>Total: 45 Hours</b>
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**REFERENCES**

1. Daniel Balageas, Claus-Peter Fritzen, Alfredo Güemes, Structural Health Monitoring, Wiley ISTE, 2006.
2. Douglas E Adams, Health Monitoring of Structural Materials and Components-Methods with Applications, John Wiley and Sons, 2007.
3. J.P. Ou, H.Li and Z.D. Duan, Structural Health Monitoring and Intelligent Infrastructure, Vol-1, Taylor and Francis Group, London, U.K, 2006.
4. Victor Giurgutiu, Structural Health Monitoring with Wafer Active Sensors, Academic Press Inc, 2007.



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**P18SEE0006****EXPERIMENTAL METHODS AND  
MODEL ANALYSIS**

<b>L</b>	<b>T</b>	<b>P</b>	<b>J</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>3</b>

After successful completion of this course, the students should be able to

**CO1:** demonstrate the various force and strain measuring equipment.

**CO2:** choose various data indicating and recording instruments.

**CO3:** perform model analysis.

**Pre-requisites:** Nil

<b>CO/PO Mapping</b>						
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak						
COs	Programme Outcomes (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1					S	
CO2	S					
CO3				S	S	

**FORCE AND STRAIN MEASUREMENTS****9 Hours**

Basic Concept in Measurements – Types of strain gauges – Hydraulic jacks – pressure gauges – proving rings – electronic load cells – Calibration of Testing Machines

**DATA RECORDING****9 Hours**

Strain gauge circuits – Potentiometer and Wheatstone bridge – use of lead wires switches etc., - Use of electrical resistance strain gauges in transducer applications – LVDT - Indicating and recording devices - Static and dynamic data recording –Data (Digital and Analogue) acquisition and processing systems.

**VIBRATION MEASUREMENT****9 Hours**

Strain analysis methods – Rosette analysis. Static and dynamic testing techniques. - Equipment for loading - Moire's techniques - Transducers for velocity and acceleration measurements - vibration meter - Seismographs - vibration analyzer - Cathode Ray Oscilloscope

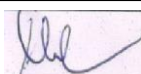
**NON-DESTRUCTIVE TESTING TECHNIQUES (NDT)****9 Hours**

Non-destructive testing techniques - Load testing of structures, Buildings, bridges and towers -Acoustic emission - holography - use of laser for structural testing.

**MODEL ANALYSIS****9 Hours**

Laws of similitude - model materials – model testing – testing large scale structures – holographic techniques – Photoelasticity – optics of photoelasticity – Polariscopes – Isoclinics and Isochromatics - methods of stress separation – wind tunnel and its use in structural analysis

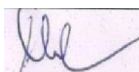
<b>Theory: 45</b>	<b>Tutorial: 0</b>	<b>Practical: 0</b>	<b>Project: 0</b>	<b>Total: 45 Hours</b>
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**REFERENCES**

1. Dally J W and Riley W.F, 'Experimental stress Analysis', McGraw-Hill Inc. New York, 1991.
2. Sadhu Singh, 'Experimental Stress Analysis', Khanna Publishers, New Delhi, 2009.
3. Rangan C S et al., 'Instrumentation – Devices and Systems', Tata McGraw-Hill Publishing Co., Ltd., New Delhi, 2017.
4. Srinath L S et al, 'Experimental Stress Analysis', Tata McGraw-Hill Publishing Co., Ltd., New Delhi, 1984.
5. D.E.Bray and R.K.Stanley, "Non-Destructive Evaluation", McGraw Hill Publishing Co., New York, 1997.



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**P18SEE0007****DESIGN OF PLATES, SHELLS AND SPATIAL STRUCTURES**

<b>L</b>	<b>T</b>	<b>P</b>	<b>J</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Course Outcome**

After successful completion of this course, the students should be able to

**CO1:** analyze various shapes of plates using various methods

**CO2:** analyze and design circular and cylindrical shells

**CO3:** analyze and design space frame

**Pre-requisites:** Nil

<b>CO/PO Mapping</b>						
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak						
COs	Programme Outcomes (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1				S		
CO2				S		
CO3				S		

**SYMMETRICAL BENDING OF PLATES****11 Hours**

Equation of equilibrium and deformation of plates – Bending of rectangular plates and circular plates – Post buckling behaviour.

**NUMERICAL METHODS****9 Hours**

Energy method, finite difference and finite element methods for solution of plate bending problems. Principles of design of folded plates

**SHELLS****9 Hours**

Geometry of shells – Classification of Shells – membrane theory of circular and cylindrical shells – Detailed Analysis and design of cylindrical shells – Detailing of Reinforcement in shells, edge beams and transfer beam

**INTRODUCTION TO SPACE FRAMES****8 Hours**

Space frames – configuration – types of nodes – general principles of design Philosophy – Behaviour.

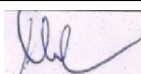
**ANALYSIS OF SPACE FRAMES****8 Hours**

Analysis of space frames – Formex Algebra, FORMIAN – detailed design of space frames.

<b>Theory: 45</b>	<b>Tutorial: 0</b>	<b>Practical: 0</b>	<b>Project: 0</b>	<b>Total: 45 Hours</b>
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**REFERENCES**

1. Ramasamy, G.S. 'Design and Construction of Concrete shells roofs', CBS Publishers, 2005.
2. Timoshenko, S. 'Theory of plates and Shells', McGraw-Hill, 2017
3. Principles of space structures by Dr.N. Subramanian – 1999, Wheeler Publishing Co.
4. Proceedings of International Conference on Space structures, Anna University, November 1997.
5. Szllard, R. Theory of Analysis of Plates, Prentice Hall Inc, 1973.



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**P18SEE0008****DESIGN OF STRUCTURES FOR  
DYNAMIC LOADS**

<b>L</b>	<b>T</b>	<b>P</b>	<b>J</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Course Outcome**

After successful completion of this course, the students should be able to

**CO1:** explain the behavior of structures under dynamic loads

**CO2:** design structures for earthquake, blast and impact loads

**CO3:** perform ductile detailing

**Pre-requisites:** Structural Dynamics

<b>CO/PO Mapping</b> (S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak						
COs	Programme Outcomes (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1			S			
CO2				S		
CO3			S			

**INTRODUCTION****9 Hours**

Factors affecting design against dynamic loads - Behaviour of concrete, steel, masonry and soil under impact and cyclic loads - Recap of Structural dynamics with reference to SDOF, MDOF and continuum systems - Ductility and its importance

**DESIGN AGAINST EARTHQUAKES****9 Hours**

Earthquake characterization - Static and Dynamic response - Response spectra - seismic coefficient and response spectra methods of estimating loads - Response of framed, braced frames and shear wall buildings - Design as per BIS codes of practice - Ductility based design.

**DESIGN AGAINST BLAST AND IMPACT****9 Hours**

Characteristics of internal and external blast - Impact and impulse loads - Pressure distribution on buildings above ground due to external blast - underground explosion - Design of buildings for blast and impact as per BIS codes of practice.

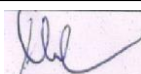
**DESIGN AGAINST WIND****9 Hours**

Characteristics of wind - Basic and Design wind speeds - Effect of permeability of the structure – pressure coefficient - Aeroelastic and Aerodynamic effects - Design as per BIS code of practice including Gust Factor approach - tall buildings, stacks and chimneys.

**SPECIAL CONSIDERATIONS****9 Hours**

Energy absorption capacity – Ductility of the material and the structure – Detailing for ductility – Passive and active control of vibrations – New and favourable materials.

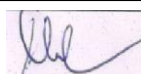
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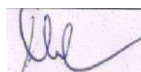
**REFERENCES**

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2. Paulay, T. and Priestly, M.N.J., 'A seismic Design of Reinforced Concrete and Masonry building', John Wiley and Sons, 2013.
3. Dowling, C.H., 'Blast vibration - Monitoring and Control', Prentice Hall Inc., Englewood Cliffs, 1985.
4. Kolousek, .V. et al., 'Wind effects on Civil Engineering Structures', Elsevier, 1984.
5. Synthesis Report CEB, 'Concrete Structures under Impact and Impulsive Loading', Lousanne, Germany, 1988.



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# AUDIT COURSES



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**P18SEA0001****DISASTER MANAGEMENT**

<b>L</b>	<b>T</b>	<b>P</b>	<b>J</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>

**Course Outcome**

After successful completion of this course, the students should be able to

**CO1:** prepare disaster mapping using GIS.

**CO2:** assess disaster vulnerability of a location.

**CO3:** prepare disaster management plan

**Pre-requisites:** Nil

<b>CO/PO Mapping</b>						
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak						
COs	Programme Outcomes (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1		M				
CO2	M					
CO3		M				

**NATURAL DISASTERS****9 Hours**

Cyclones, Floods, Drought and Desertification - Earthquake, Tsunami, Landslides and Avalanche.

**MAN MADE DISASTERS****9 Hours**

Chemical industrial hazards, major power breakdowns, traffic accidents, Fire, War, Atom bombs, Nuclear disaster- Forest Fire-Oil fire –accident in Mines.

**GEOSPATIAL TECHNOLOGY****9 Hours**

Remote sensing, GIS and GPS applications in real time disaster monitoring, prevention and rehabilitation- disaster mapping.

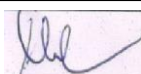
**RISK ASSESSMENT AND MITIGATION****9 Hours**

Hazards, Risks and Vulnerabilities. -Disasters in India, Assessment of Disaster Vulnerability of a location and vulnerable groups- Preparedness and Mitigation measures for various Disasters Mitigation through capacity building -Preparation of Disaster Management Plans

**DISASTER MANAGEMENT****9 Hours**

Legislative responsibilities of disaster management- Disaster management act 2005- post disaster recovery & rehabilitation, Relief & Logistics Management; disaster related infrastructure development- Post Disaster, Emergency Support Functions and their coordination mechanism.

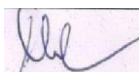
<b>Theory: 45</b>	<b>Tutorial: 0</b>	<b>Practical: 0</b>	<b>Project: 0</b>	<b>Total: 45 Hours</b>
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**REFERENCES**

1. Khanna B K, "All You Wanted to Know About Disasters", New India Publishing Agency, New Delhi, 2005.
2. Ramana Murthy, "Disaster Management", Dominant, New Delhi, 2004.
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5. Murthy D B N, "Disaster Management: Text and Case Studies", Deep and Deep Publications (P) Ltd., New Delhi, 2007.
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