DEPARTMENT OF CIVIL ENGINEERING

COURSE STRUCTURE

(1^{ST} – 4^{TH} SEMESTER)

FOR

M. TECH PROGRAMME

SPECIALISATION

IN

STRUCTURAL ENGINEERING

(EFFECTIVE FROM July 2019)

VEER SURENDRA SAI UNIVERSITY OF TECHNOLOGY

(FORMLY, UNIVERSITYCOLLEGE OF ENGINEERING)

BURLA – 768 018, SAMBALPUR, ODISHA

Vision

To emerge as an internationally acclaimed Civil Engineering Department for imparting futuristic technical education and creation of vibrant research enterprise to create quality civil engineers and researchers, truly world class leaders and unleash technological innovations to serve the global society and improve the quality of life.

Mission

The Department of Civil Engineering, VSSUT Burla strives to create values and ethics in its products by inculcating depth and intensity in its education standards and need based research through

- Participative learning in a cross-cultural environment that promotes the learning beyond the class room.
- Collaborative partnership with industries and academia within and outside the country in learning and research.
- Encouraging innovative research and consultancy through the active participation and involvement of all faculty members.
- Facilitating technology transfer, innovation and economic development to flow as natural results of research whereever appropriate.
- Expanding curricula to cater broader perspectives.
- Creation of service opportunities for upliftment of the society at large.

PO

- An ability to independently carry out research /investigation and development work to solve practical problems
- An ability to write and present a substantial technical report/document
- Students should be able to 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
- Ability to apply knowledge of mathematics, science and engineering to solve complex problems in civil engineering
- Ability to identify, formulate, and solve complex civil engineering problems using first principle of mathematics, basic science & engineering
- Ability to design and conduct complex civil engineering experiments as well as to analyze and interpret the experimental data

PEO

- To lead a successful career in industries, pursue higher studies and entrepreneurial endeavors.

- To offer techno-commercially feasible and socially acceptable solutions to real life engineering problems.

- To demonstrate effective communication skill, professional attitude and a desire to learn.

PSO

- Plan, analyse, design, prepare and execute all kinds ofStructural Engineering projects
- Apply latest construction techniques for successful completion of time bound Structural Engineering projects with optimised cost

VSS UNIVERSITY OF TECHNOLOGY BURLA ODISHA

Model Course Structure
for
PG Programmes to be introduced from July 2019
(Structural Engineering)
Semester I

Sl. No.	Core/ Elective	Subject Code	Subject Name	L	T	P	Credits
1	Core-1	MCESE101	Advanced Structural Analysis	3	0	0	3
2	Core-2	MCESE102	Advanced Solid Mechanics	3	0	0	3
3	PE-1			3	0	0	3
4	PE-2			3	0	0	3
5	Common		Research Methodology & IPR	3	0	0	3
6	Lab-1	MCESE103	Computational Lab	0	0	3	2
7	Lab-2	MCESE104	Advanced concrete Lab	0	0	3	2
8	Audit -1						
Total Credits							19

Semester II

Sl. No.	Core/ Elective	Subject Code	Subject Name	L	T	P	Credits
1	Core-3	MCESE201	Finite Element Method	3	0	0	3
2	Core-4	MCESE202	Structural Dynamics	3	0	0	3
3	PE-3			3	0	0	3
4	PE-4			3	0	0	3
5	Common		Mini Project	0	0	3	2
6	Lab-3	MCESE203	Structural Dynamics Lab	0	0	3	2
7	Lab-4	MCESE204	Structural Engineering and Design Lab	0	0	3	2
8	Audit -2						
Total Credits							18

Semester III

Sl. No.	Core/ Elective	Subject Code	Subject Name	L	T	P	Credits
1	PE-5			3	0	0	3
2	OE-1			3	0	0	3
3	Project		Dissertation (Phase-I)	0	0	20	10
Total Credits							16

Semester IV

Sl. No.	Core/ Elective	Subject Code	Subject Name	L	T	P	Credits
1	Project		Dissertation (Phase-II)	0	0	32	16
Total Credits							16

GRAND TOTAL CREDITS: 19+18+16+16= **69**

Sl. No.	Course Code	Programme Elective I
1	MSEPE101	Theory of Thin Plates and Shells
2	MSEPE102	Civil Engineering Material
3	MSEPE103	Theory of Structural Stability
4	MSEPE104	Reliability Analysis of Structures
5	MSEPE105	Construction Management

Sl. No.	Course Code	Programme Elective II
1	MSEPE106	Numerical Methods in Engineering
2	MSEPE107	Structural Health Monitoring
3	MSEPE108	Structural Optimization
4	MSEPE109	Advanced Concrete Technology
5	MSEPE110	Construction Methods and Equipments

Sl. No.	Course Code	Programme Elective III
1	MSEPE201	Advanced Design of Steel Structures
2	MSEPE202	Design of Formwork
3	MSEPE203	Design of High Rise Structures
4	MSEPE204	Design of Masonry Structures
5	MSEPE205	Bridge Engineering

Sl. No.	Course Code	Programme Elective IV
1	MSEPE206	Advanced Reinforced Concrete Design
2	MSEPE207	Advanced Design of Foundations
3	MSEPE208	Soil Structure Interaction
4	MSEPE209	Design of Industrial Structure
5	MSEPE210	Earthquake Analysis and Design
6	MSEPE211	Repair, Rehabilitation and Retrofitting of Structures

Sl. No.	Course Code	Programme Elective V
1	MSEPE301	Prestressed Concrete
2	MSEPE302	Analysis of Laminated Composite Plates
3	MSEPE303	Fracture Mechanics of Concrete Structures
4	MSEPE304	Design of Plates and Shells
5	MSEPE305	Structural Design of Water and Sewerage System
6	MSEPE306	Passive vibration and Control of Structures

Sl. No.	Course Code	Open Elective V
1	MSEOE301	Business Analytics
2	MSEOE302	Industrial Safety
3	MSEOE303	Operations Research
4	MSEOE304	Cost Management of Engineering Projects
5	MSEOE305	Mechanics of Composite Materials
6	MSEOE306	Waste to Energy
7	MSEOE307	Optimization Technique

Audit course 1 & 2

Sl.No.	Course Code	Subject Name
1.	BCAC1001	English for Research Paper Writing
2.	BCAC1002	Disaster Management
3.	BCAC1003	Sanskrit for Technical Knowledge
4.	BCAC1004	Value Education
5.	BCAC2001	Constitution of India
6.	BCAC2002	Pedagogy Studies
7.	BCAC2003	Stress Management by Yoga
8.	BCAC2004	Personality Development through Life Enlightenment Skills.

FIRST SEMESTER

Programme:M.Tech. Structural Engineering	**Semester: 1st**
Professional Core Course	
Subject Name: Advanced Structural Analysis	**(3-0-0) CR-03**
Course Content	
Module-I	
Fundamental concepts: Static and Kinematic indeterminacy, Concepts of stiffness and flexibility, Energy concepts, Principle of minimum potential energy and minimum complementary energy, Development of element flexibility and element stiffness matrices for truss, beam and grid elements, Incorporation of support settlement, temperature change and lack of fit conditions in analysis	
Module-II	
Analysis using Flexibility method: Force transformation matrix using Flexibility method, Development of global flexibility matrix for continuous beams, plane trusses and rigid plane frames (having not more than six co-ordinates – 6x6 flexibility matrix) Analysis of continuous beams, plane trusses and rigid plane frames by flexibility method (having not more than 3 coordinates – 3x3 flexibility matrix.	
Module-III	
Analysis using Stiffness Method: Displacement transformation matrix using Stiffness Method, Development of global stiffness matrix for continuous beams, plane trusses and rigid plane frames (having not more than six co-ordinates – 6x6 stiffness matrix) Analysis of continuous beams, plane trusses and rigid plane frames by stiffness method (having not more than 3 coordinates – 3x3 stiffness matrix).	
Module-IV	
Computer implementation of stiffness method: Basic concept, Solution techniques: Solution techniques including numerical problems for simultaneous equations, Gauss elimination and Cholesky method. Bandwidth considerations, Introduction to static condensation and sub-structuring	
Module-V	
Plastic Analysis of Structures: Plastic moment of resistance, Plastic Modulus, Shape factor, Load factor, Plastic Hinge and mechanism, Analysis of indeterminate beams and frames mechanism method, upper and lower bound theorems	
Text Book:	
1. Pandit .G.S., Gupta .S.P, “Structural Analysis, A Matrix Approach”, 2nd Edition, Tata McGraw-Hill Education, 2010. 2. Bhavikatti, "Matrix Methods of Structural Analysis", IK International Pvt Ltd	
Reference Books:	
1.Sterling Kinney .J, “Indeterminate Structural Analysis”, Narosa PublishingHouse.1987. 2.Jr. William Weaver and James .M.Gere, “Matrix Analysis of Framed Structures”, CBS Publishers and Distributors, Delhi, 1995. 3.Rajasekaran .S and Sankarasubramanian .G., Computational “Structural Mechanics”, Prentice Hall of India, 2006. 4.H.C.Martin," Introduction to Matrix Methods of Structural Analysis. McGraw-Hill 5.M.B.Kanchi, "Matrix Methods of Structural Analysis", New Age International Publishers, New Delhi	
Course Outcomes:	
1.Revise fundamental concepts of matrix methods of structural analysis	
2.Analyze structures using flexibility matrix methods	
3. Applystiffness matrix methodsto analyze structures	
4. Solve structural analysis problems using computer	
5. Use plastic theory and its application in analysis of indeterminate structures	

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**3**	**1**	**3**	**1**	**1**	
CO2	**3**	**2**	**2**	**1**	**1**	
CO3	**3**	**1**	**1**		**3**	**2**
CO4	**2**	**2**	**1**	**2**	**2**	**3**
CO5	**3**	**2**	**3**	**2**	1	**2**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	**3**	**2**	**2**	**1**	**2**	**1**

Programme:M.Tech. Structural Engineering	**Semester: 1st**
Professional Core Course	
Subject Name: Advanced Solid Mechanics	**(3-0-0) CR-03**
Course Content	
Module-I	
Plane stress and plane strain problems.General stress and strain equations (Equilibrium and compatibility equations).Two dimensional problems in rectangular coordinates. Stress and strain components, differential equation, equilibrium equations and compatibility equations in polar coordinate.	
Module-II	
Stress distribution for axisymmetric problems. Pure bending of curved bars, thick walled cylinder. Concentrated force at a point of straight boundary. Force acting on the end of a wedge. Concentrated force acting on a beam. Effect of circular holes on stress distributions in plates.	
Module-III	
Stress and strain in three dimensions: Principles stresses, maximum shearing stress, principal axes of strain. Stretching of prismatic bar by its own axis. Elementary problems of elasticity in three dimensions	
Module-IV	
Torsion of non-circular prismatic bars, Saint Venant's theory, Various analogies, Torsion of hollow and thin section, Application of energy methods	
Module-V	
Introduction to the theory of plasticity, the yield criteria of metals, stress space representation of yield criteria, stress-strain relations plastic potential, flow rules and maximum work hypothesis. Two dimensional plastic flow problems. Incompressible two dimensional flow, stresses in plastic materials in condition of plane strain, equation of equilibrium the simplest slip-line fields.	
Text Book:	
1. S P Timoshenko and J N Goodier, Theory of Elasticity, Mc Graw Hill 2. Hoffman and Sachs, Theory of plasticity	
Reference Books:	
1. N.Filonenko-Borodich, Theory of Elasticity, Mir Publishers,Moscow,1965 2. W. Johnson and P B Meller, Plasticity of Mechanical Engineers 3. C.R. Calladine, 'Plasticity for Engineers', Ellis Herwood, Chichester, U.K., 1985	
Course Outcomes:	
1.Apply the basic knowledge of elasticity and application of the concepts of stresses and strain.	

2.Identify, formulate and solve engineering problems withrespect to stress and strain as applied to 2D elements in Cartesian and polar coordinates.
3.Solve engineering problems with respect to stress and strain as applied to 3D elements in Cartesian and polar coordinates.
4. Discus engineering problems asapplied to Torsion of Prismatic bars.
5. Enumerate engineering problems with respect to Plasticity and how exactly applied to the structural systems.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**2**	**3**	**2**	**1**	
CO2	**3**	**1**	**1**	**1**	**1**	
CO3	**2**	**1**	**2**		**3**	**2**
CO4	**3**	**3**	**1**	**2**	**2**	**3**
CO5	**2**	**2**	**3**	**2**	1	**2**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	**3**	**2**	**2**	**1**	**2**	**1**

Programme:M.Tech. Structural Engineering	**Semester: 1st**
Lab	
Subject Name: Computational Lab	**(0-0-3) CR-02**
Course Content	
1. MATLAB Basics: Data Representation in MATLAB, Generating Retrieving the data, Logical expressions and Looping, S MATLAB Script files, MATLAB functions and MATLAB Graphics.	
2. Basics of Finite element Programming: Steps, Writing of functions for estimation of Stiffness matrix for truss, beam, frame and space truss structures	
3. MATLAB Codes for static analysis of linear bar element, 2D and 3D Truss and Plane frame structures.	
4. STAAD Pro Basics: Modeling, specifying Element properties, Boundary Conditions and Loadings, Post processing.	
5. Analysis of a two-storey residential building using STAAD Pro.	
Course Outcomes:	
1. Revise basics of MATLAB programming language	
2. Develop program customized functions for FEM	
3. Write FEM programs for various structures	
4. Practice basics of STAAD Pro	
5. Design a structure using STAAD Pro.	

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**1**	**1**	**2**
CO2	**3**	**2**	**1**	**1**	**2**	**3**
CO3	**3**	**3**	**2**	**3**	**3**	**1**
CO4	**2**	**2**	**1**	**2**	**1**	**3**
CO5	**3**	**3**	**3**	**2**	**2**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	**3**	**2**	**2**	**2**	**2**	**2**

Programme:M.Tech. Structural Engineering	**Semester: 1st**
Lab	
Subject Name: Advanced Concrete Lab	**(0-0-3) CR-02**
Course Content	
1.Mix design of different grades of concrete	
2.Non-Destructive testing of existing concrete members.	
3.Behaviour of Beams under flexure, Shear and Torsion.	
4.Durability properties of concrete	
5.Micro structural properties of concrete	
Reference Books:	
1.Properties of Concrete, Neville A. M., 5th Edition, Prentice Hall, 2012.	
2.Concrete Technology, Shetty M. S., S. Chand and Co., 2006.	
Course Outcomes:	
1.Design high grade concrete and study the parameters affecting its performance	
2.Apply Non Destructive Tests on existing concrete structures	
3.Use engineering principles to understand behaviour of structural/ elements.	
4.Experiment effect of different environmental impact on concrete	
5. Discuss the micro structure of concrete	

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**2**	**1**	**3**	**1**	**1**	**2**
CO2	**3**	**2**	**1**	**1**	**2**	**3**
CO3	**3**	**3**	**2**	**3**	**3**	**1**
CO4	**2**	**2**	**1**	**2**	**1**	**3**
CO5	**3**	**3**	**3**	**2**	**2**	**2**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	**3**	**2**	**2**	**2**	**2**	**2**

Programme:M.Tech. Structural Engineering	**Semester: 1st**
Professional Elective Course (I)	
Subject Name: Theory Of Thin Plates and Shells	**(3-0-0) CR-03**
Course Content	
Module-I	
Introduction: Space Curves, Surfaces, Shell Co-ordinates, Strain Displacement Relations, Assumptions in Shell Theory, Displacement Field Approximations, Stress Resultants, Equation of Equilibrium using Principle of Virtual Work, Boundary Conditions	
Module-II	
Static Analysis of Plates: Governing Equation for a Rectangular Plate, NavierSolution for Simply- Supported Rectangular Plate under Various Loadings, Levy solution for Rectangular Plate with other Boundary Conditions.	

Module-III
Circular Plates: Analysis under Axi- Symmetric Loading, Governing Differential Equation in Polar Co-ordinates. Approximate Methods of Analysis- Rayleigh-Ritz approach for Simple Cases in Rectangular Plates.
Module-IV
Static Analysis of Shells: Membrane Theory of Shells - Cylindrical, Conical and Spherical Shells
Module-V
Shells of Revolution: with Bending Resistance - Cylindrical and Conical Shells, Application to Pipes and Pressure Vessels.Thermal Stresses in Plate/ Shell.
Text Book:
1..Theory of Plates and Shells, Timoshenko S. and KriegerW., McGraw Hill. 2..Stresses in Plates and Shells, UguralAnsel C., McGraw Hill.
Reference Books:
1..Thin Elastic Shells, KrausH., John Wiley and Sons. 2..Theory of Plates, ChandrashekharaK., Universities Press. 3..Design and Construction of Concrete Shells, Ramaswamy G.S.
Course Outcomes:
1. Discuss methods for the solution of thin plates and shells. 2. Use analytical methods for the solution of shells. 3. Apply the numerical techniques and tools for the complex problems in thin plates. 4. Evaluate numerical techniques and tools for the complex problems in shells. 5. Solvecomplex problems in shells using the numerical techniques

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**1**	**1**	
CO2	**3**	**2**	**2**	**1**	**1**	
CO3	**3**	**1**	**1**		**3**	**2**
CO4	**2**	**2**	**1**	**2**	**2**	**3**
CO5	**3**	**2**	**3**	**2**	1	**2**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	**3**	**2**	**2**	**1**	**2**	**1**

Programme:M.Tech.	**Semester: 1st**
Professional Elective Course	
Subject Name: Civil Engineering Material	**(4-0-0) CR-03**
Course Content	
Module-I	
Cement: Portland cement, chemical composition, hydration of cement, structure of hydrated cement, mechanical strength of cement gel, water held in hydrated cement paste and heat of hydration, cements of different types.	
Module-II	

Concrete:Factors affecting the strength of concrete, shrinkage and creep of concrete; durability of concrete, permeability of concrete, chemical attack of concrete, air-entrained concrete and thermal properties of concrete, mechanical test of hardened concrete, light weight and high density concrete.
Module-III
Mix design, statistical quality control
Module-IV
Cement Composites:Types of Cement Composites, Terminology, Constituent Materials and their Properties, Fibre Reinforced Concrete – Ferro cement, SIFCON, Polymer Concretes, Preparation of Reinforcement, Casting and Curing.
Module-V
Mechanical Properties of Cement Composites: Behaviour of Ferro cement, Fiber Reinforced Concrete in Tension, Compression, Flexure, Shear. Durability and Corrosion. Application of Cement Composites:FRC and Ferro cement
Text Book:
1. A.M. Neville, J.J. Brooks, Concrete Technology, Low Priced Edition, Pearson Education, 2004. 2. Ferro cement – Theory and Applications, Pama R. P., IFIC, 1980.
Reference Books:
1. New Concrete Materials, Swamy R.N., 1stEd., Blackie, Academic and Professional, Chapman & Hall, 1983.
Course Outcomes:
1. Enumerate various types of cement and its use in different environment.
2. Evaluate the strength and behaviour of concrete and effect of environmental agencies on the concrete
3. Create different types of concrete for specific jobs.
4. Discussbehaviour of composite materials – Ferro cement, SIFCON and Fibre Reinforced Concrete.
5. List application of cement composites.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**2**	**1**	
CO2	**2**	**2**	**2**	**1**	**2**	
CO3	**3**	**1**	**3**		**3**	**1**
CO4	**3**	**2**	**1**	**3**	**2**	**3**
CO5	**3**	**2**	**2**	**2**	1	**2**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	**3**	**2**	**2**	**2**	**2**	**1**

Programme:M.Tech. Structural Engineering	**Semester: 1st**
Professional Elective Course (I)	
Subject Name: Theory of Structural Stability	**(3-0-0) CR-03**
Course Content	
Module-I	
Criteria for Design of Structures: Stability, Strength, and Stiffness, Classical Concept of Stability of Discrete and Continuous Systems, Linear and nonlinear behaviour	
Module-II	

Stability of Columns: Axial and Flexural Buckling, Lateral Bracing of Columns, Combined Axial, Flexural and Torsion Buckling.
Module-III
Stability of Frames: Member Buckling versus Global Buckling, Slenderness Ratio of Frame Members.
Module-IV
Stability of Beams: lateral torsion buckling. Stability of Plates:axial flexural buckling, shear flexural buckling, buckling under combined loads.
Module-V
Introduction to Inelastic Buckling and Dynamic Stability.
Text Book:
1..Theory of elastic stability, Timoshenko and Gere, Tata Mc Graw Hill,1981 2..Principles of Structural Stability Theory, Alexander Chajes, Prentice Hall, New Jersey.
Reference Books:
1..Structural Stability of columns and plates, Iyengar, N. G. R., Eastern west press Pvt. Ltd. 2.Strength of Metal Structures,Bleich F. Bucking, Tata McGraw Hill, New York.
Course Outcomes:
1. Evaluate stability of columns **2.** Analyze stability of beams and plates **3.** Use stability criteria and concepts for analysing discrete and continuous systems. 4. Discuss the stability of frames 5. Examine the dynamic stability

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**3**	**1**	**3**	**1**	**2**	
CO2	**2**	**2**	**2**	**2**	**1**	
CO3	**3**	**1**	**1**		**3**	**2**
CO4	**2**	**2**	**2**	**2**	**2**	**3**
CO5	**3**	**2**	**3**	**2**	1	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	**3**	**2**	**2**	**1**	**2**	**2**

Programme:M.Tech. Structural Engineering	**Semester: 1st**
Professional Elective Course (I)	
Subject Name: Reliability Analysis of Structures	**(3-0-0) CR-03**
Course Content	
Module-I	
Preliminary Data Analysis: Graphical representation-Histogram, frequency polygon, Measures of central tendency- grouped and ungrouped data, measures of dispersion, measures of asymmetry. Curve fitting and Correlation: Fitting a straight line, curve of the form y = abx, and parabola, Coefficient of correlation.	
Module-II	
Probability Concepts: Random events-Sample space and events, Venn diagram and event space, Measures of probability-interpretation, probability axioms, addition rule, multiplication rule, conditional probability, probability tree diagram, statistical independence, total probability theorem	

and Baye's theorem

Module-III

Random variables: Probability mass function, probability density function, Mathematical expectation, Chebyshev's theorem; Probability distributions: Discrete distributions- Binomial and poison distributions, Continuous distributions- Normal, Log normal distributions.

Module-IV

Reliability Analysis: Measures of reliability-factor of safety, safety margin, reliability index, performance function and limiting state. Reliability Methods-First Order Second Moment Method (FOSM), Point Estimate Method (PEM), and Advanced First Order Second Moment Method (Hasofer-Lind's method).

Module-V

System reliability: Influence of correlation coefficient, redundant and non-redundant systems series, parallel and combined systems, Uncertainty in reliability assessments- Confidence limits, Bayesian revision of reliability. Simulation Techniques: Monte Carlo simulation- Statistical experiments, sample size and accuracy, Generation of random numbers random numbers with standard uniform distribution, continuous random variables, discrete random variables.

Text Book:

1. Papoulis A.Probability, Random Variables and Stochastic Processes, McGraw-Hill, New York, USA, 1991.
2. Ayyub B M, McCuen R H.Probability,Statistics and Reliability for Engineers and Scientists, Chapman & Hall, Florida, USA, 2000.

Reference Books:

1..Ranganathan R.Structural Reliability Analysis & Design. Jaico Publishing House, Mumbai, India, 1999.
2.. Melchers R E.StructuralReliability:Analysis and Prediction, John Wiley, Chichester, 1999.
3. Ang A H S & Tang W H.Probability Concepts in Engineering Planning and Design, Vol II, John Wiley, New York, 1984.
4. Madsen H O,Krenk S and Lind N C. Methods of Structural Safety,Prentice-Hall, Inc, Englewood Cliffs, USA, 1986.
5. Choi S K, Grandhi R V and Canfield R A. Reliability Based Structural Design,SpringerVerlag, London, UK, 2007.
6. Haldar A & Mahadevan S. Reliability Assessment Using Stochastic Finite Element Analysis, John-Wiely& Sons Inc., New York, USA, 2000.
7. RackwitzR,Augusti G and BorriA. Reliability and Optimization of Structural Systems, Chapman & Hall, London, UK, 1995.
8. Waarts P H.Structural Reliability Using Finite Element Methods, Delft Univ.Press, Netherland, 2000.
9. Bucher C. ComputationalAnalysis of Randomness in Structural Mechanics, CRC Press, London, UK, 2009.
10. Breitung K W. Lecture Notes in Mathematics,Springer-Verlag,Berlin, Germany, 1994.

Course Outcomes:

1. Examine mathematical tools required for preliminary data analysis.
2. Discuss various probability concepts
3. List random variables
4. Assess mathematical tools required for reliability analysis.
5. Explain various aspects of system reliability

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**3**	**3**	**2**	**1**	**1**	
CO2	**2**	**2**	**2**	**1**	**1**	
CO3	**3**	**2**	**3**		**3**	**2**
CO4	**2**	**2**	**1**	**2**	**2**	**3**
CO5	**3**	**1**	**3**	**2**	1	**1**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	**3**	**2**	**2**	**1**	**2**	**1**

Programme:M.Tech. Structural Engineering	**Semester: 1st**
Professional Elective Course (I)	
Subject Name: Construction Management	**(3-0-0) CR-03**

Course Content

Module-I

Introduction: Foundations of Project Management, Project Life Cycle, the Project Environment, Project Selection, Project Proposal, Project Scope, Work Breakdown Structure.

Module-II

Network Scheduling, Critical Path Method, Program Evaluation & Review Technique, Planning and Scheduling of Activity Networks, Assumptions in PERT Modeling, Time-cost Trade-offs, Linear Programming and Network Flow Formulations, PERT/COST Accounting

Module-III

Scheduling with limited resources, Resource Planning, Resource Allocation, Project Schedule Compression, Project Scheduling Software,

Module-IV

Precedence Diagrams, Decision CPM, Generalized Activity Networks, GERT.

Module-V

Estimation of Project Costs, Earned Value Analysis, Monitoring Project Progress, Project Appraisal and Selection, Recent Trends in Project Management.

Text Book:

1. R.L. Peurify, 'Construction planning, Equipments and Methods', Tata Mc Grawhill
2. B. Sengupta & H Guha, 'Construction management and planning', Tata Mc Grawhill

Reference Books:

1. M Verma, 'Construction planning and management'
2. L.S. Srinath, 'PERT & CPM', East-West Press
3. S.S. Rao, 'Optimization', Tata McGrawhill

Course Outcomes:

1. Identify different aspects of project management
2. Estimate the cost and time of a Project by using CPM & PERT Techniques
3. Discuss resources in a project
4. Describe material procurement method and control for a project
5. Select the suitable equipments and materials required for the execution of a project.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**2**	**1**	**3**	**2**	**1**	
CO2	**3**	**2**	**2**	**1**	**1**	
CO3	**3**	**1**	**1**		**3**	**3**
CO4	**2**	**2**	**1**	**2**	**2**	**3**
CO5	**3**	**2**	**3**	**3**	1	**2**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	**3**	**2**	**2**	**2**	**2**	**2**

Programme:M.Tech. Structural Engineering	**Semester: 1st**
Professional Elective Course (II)	
Subject Name: Numerical Methods in Engineering	**(3-0-0) CR-03**

Course Content

Module-I

Introduction to digital computers and programming-an overview, Errors-polynomial approximation ,interpolation: finite differences, Newton's formula for interpolation ,central difference interpolation formulae, interpolation with unevenly spaced points, divided difference and their properties, inverse interpolation and double interpolation

Module-II

Numerical differentiation: errors in numerical differentiation, differentiation formula with function values.
Numerical integration: Trapezoidal rule, Simpson's 1/3rd & 3/8th rule, Romberg integration, newton cote's integration formula, Euler-maclaurin formula, Gaussian integration, numerical double integration

Module-III

Solution of linear system - Gaussian elimination and Gauss-Jordan methods, necessity for pivoting, LU decomposition methods, Jacobi and Gauss-Seidel iterative methods sufficient conditions for convergence, Power method to find the dominant Eigen value and eigenvector Diagonal dominance, condition number, ill conditioned matrices, singularity and singular value decomposition. Banded matrices, storage schemes for banded matrices, skyline solver.
Solution of nonlinear equation - Bisection method - Secant method - Regula falsi method - Newton-Raphson method

Module-IV

Approximate solution technique, static condensation, Rayleigh-Ritz method, subspace iteration, Application of finite difference method, solution of equilibrium equations in dynamics, direct method, central difference method, Houbolts method, Wilson θ method, Newmarks method

Module-V

Numerical Solution of Ordinary Differential Equations- Euler's method - Euler's modified method Taylor's method and Runge-Kutta method for simultaneous equations and 2nd order equations - Multistep methods - Milne's and Adams' methods
Partial differential equations: Finite difference solution two dimensional Laplace equation, Finite difference explicit method for wave equation.

Text Book:

1.Numerical methods for Scientists and Engineers by M.K. Jain, S.R. Iyengar & R.K. Jain, Wiley Eastern Ltd.
2.Numerical methods in engineering and science, Grewal, B.S., Khanna Publishers, Delhi.

Reference Books:

1.Introductory methods in Numerical Analysis by S.S. Sastry, Prentice Hall of India.
2.Theory and problems in Numerical Methods by T. Veeranjan and T. Ramachandran, Tata McGrawHill Publishing Company, New Delhi-2004.
3.Numerical Methods for Mathematics Sciences and Engineering 2nd ed. By John H. Mathews, Prentice Hall of India, New Delhi 2003.

Course Outcomes:

1. Discuss numerical interpolation and approximation of functions
2. Compare numerical integration and differentiation
3. Apply numerical solutions of nonlinear equations in a single variable

4. Develop approximate solution technique for a differential equation.
5. Use numerical solution of ordinary differential equations and Partial differential equations.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**3**	**2**	**3**	**1**	**1**	
CO2	**3**	**2**	**2**	**1**	**2**	
CO3	**3**	**1**	**1**		**3**	**1**
CO4	**2**	**2**	**1**	**3**	**2**	**3**
CO5	**2**	**3**	**3**	**2**	1	**2**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	**3**	**2**	**2**	**1**	**2**	**1**

Programme:M.Tech. Structural Engineering	**Semester: 1st**
Professional Elective Course (II)	
Subject Name: Structural Health Monitoring	**(3-0-0) CR-03**

Course Content

Module-I

Structural Health: Factors affecting Health of Structures, Causes of Distress, Regular Maintenance.Structural Health Monitoring:Concepts,Various Measures, Structural Safety in Alteration.

Module-II

Structural Audit: Assessment of Health of Structure, Collapse and Investigation, Investigation Management, SHM Procedures.

Module-III

Static Field Testing: Types of Static Tests, Simulation and Loading Methods, sensor systems and hardware requirements, Static Response Measurement.

Module-IV

Dynamic Field Testing: Types of Dynamic Field Test, Stress History Data, Dynamic Response Methods, Hardware for Remote Data Acquisition Systems, Remote Structural Health Monitoring.

Module-V

Introduction to Repairs and Rehabilitations of Structures: Case Studies (Site Visits), piezo–electric materials and other smart materials, electro–mechanical impedance (EMI) technique, adaptations of EMI technique..

Text Book:

1.Structural Health Monitoring, Daniel Balageas, Claus_Peter Fritzen, Alfredo Güemes, John Wiley and Sons, 2006.
2..Health Monitoring of Structural Materials and Components_Methods with Applications, Douglas E Adams, John Wiley and Sons, 2007.

Reference Books:

1.Structural Health Monitoring and Intelligent Infrastructure, Vol1, J. P. Ou, H. Li and Z. D. Duan, Taylor and Francis Group, London, UK, 2006.
2..Structural Health Monitoring with Wafer Active Sensors, Victor Giurglutiu, Academic Press Inc, 2007

Course Outcomes:
1. Describe the distress in the structure understanding the causes and factors. **2.** Assess the health of structure using static field methods. **3.** Apply dynamic field teststo evaluates the health of structure. **4.** Discuss repairs and rehabilitation measures of the structure **5.** AnalyzeCase studies

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**2**	**1**	**3**	**1**	**1**	
CO2	**3**	**2**	**2**	**1**	**1**	
CO3	**3**	**1**	**1**		**3**	**2**
CO4	**3**	**2**	**1**	**2**	**2**	**3**
CO5	**3**	**2**	**3**	**2**	1	**2**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	**3**	**2**	**2**	**1**	**2**	**1**

Programme:M.Tech. Structural Engineering	**Semester: 1st**
Professional Elective Course (II)	
Subject Name: Structural Optimization	**(3-0-0) CR-03**
Course Content	
Module-I	
Introduction: Simultaneous Failure Mode and Design, Classical External Problems.	
Module-II	
Calculus of Variation: Variational Principles with Constraints.	
Module-III	
Linear Programming, Integer Programming, Nonlinear Programming, Dynamic Programming.	
Module-IV	
Geometric Programming andStochastic Programming.	
Module-V	
Applications: Structural Steel and Concrete Members, Trusses and Frames. **Design:** Frequency Constraint, Design of Layouts.	
Text Book:	
1..Elements of Structural Optimization, Haftka, Raphael T., Gürdal, Zafer, Springer. 2..Variational methods for Structural optimization, Cherkaev Andrej, Springer	
Course Outcomes:	
1. Use Variational principle for optimization 2. Apply optimization techniques to structural steel and concrete members. 3. Evaluate using frequency constraint. 4. Analyse the structure using programming 5. Design the various structures	

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**2**	**3**	**3**	**1**	**1**	
CO2	**3**	**2**	**2**	**1**	**1**	
CO3	**3**	**1**	**1**		**3**	
CO4	**3**	**2**	**1**	**2**	**1**	**3**
CO5	**2**	**2**	**3**	**2**	**1**	**2**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	**3**	**2**	**2**	**1**	**1**	**1**

Programme:M.Tech. Structural Engineering	**Semester: 1st**
Professional Elective Course (II)	
Subject Name: Advanced Concrete Technology	**(3-0-0) CR-03**
Course Content	
Module-I	
Introduction: Rheological modeling of fresh concrete, constitutive equations, nonlinear elasticity, plasticity, viscoelasticity	
Module-II	
fracture mechanics of hardened concrete, confinement and ductility, moisture diffusion, drying shrinkage	
Module-III	
Solid and structural mechanics of reinforced concrete	
Module-IV	
Skew bending, modified compression field and unified theories of RC beams under bending, shear and torsion, bond slip and phenomenon of cracking in reinforced concrete	
Module-V	
Static and dynamic analysis of RC structures, Trends	
Text Book:	
1. P. Kumar Mehta and Paulo J. M. Monteiro, 2006. *Concrete* - Microstructure, Properties, and Materials, 3rd Edition, McGraw-Hill, 2. M L Gambhir, *Concrete Technology*, 2009, 4th Ed., McGraw-Hill	
Reference Book:	
1. Paul and Pama, 1978, Ferro Cement, AIT, Bangkok 2. Neville, A.M. 1995. Properties of Concrete, 4th ed. Addison Wesley Longman 3.Fafat Siddique, 2000, *Special Structural concrete*, Galgotia Publications	
Course Outcomes:	
1. Revise the knowledge microstructure of concrete 2. Discuss the influence of microstructure on the strength and behavior of concrete and effect of environmental agencies on the concrete. 3. Enumerate of advances that is taking place in the concrete technology 4. Give examples on solid and structural mechanics of reinforced concrete 5. Compare Static and dynamic analysis of RC structures, Trends	

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**3**	**1**	**2**	**3**	**1**	
CO2	**2**	**2**	**1**	**1**	**1**	
CO3	**3**	**1**			**3**	**1**
CO4	**3**	**2**	**2**	**2**	**2**	**3**
CO5	**3**	**2**	**3**	**2**	**1**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	**3**	**2**	**2**	**2**	**2**	**1**

Programme:M.Tech. Structural Engineering	**Semester: 1st**
Professional Elective Course (II)	
Subject Name: . Construction Methods and Equipments	**(3-0-0) CR-03**
Course Content	
Module-I	
Factors affecting selection of equipments-technical and economic	
Module-II	
Construction engineering fundamentals	
Module-III	
Analysis of production outputs and costs,	
Module-IV	
Characteristics and performances of equipments for earth moving, erection, material transport, pile driving, dewatering	
Module-V	
Concrete construction (including batching, mixing, transport and placement) and tunneling	
Text Book:	
1. Robertwade Brown, Practical foundation engineering hand book, McGraw Hill Publications, 1995 2. Patrick Powers .J, Construction Dewatering: New Methods and Applications John Wiley & Sons, 1992	
Reference Book:	
1. Jerry Irvine, Advanced Construction Techniques CA Rockers, 1984 2. Peurifoy, R.L., Ledbetter, W.B. and Schexnayder.C, Construction Planning Equipment and Methods, McGraw Hill. Singapore 1995 3. Sharma S.C. Construction Equipment and Management, Khanna Publishers, Delhi, 1988 4. Deodhar, S.V. Construction Equipment and Job Planning Khanna Publishers Delhi, 1988 5. Dr. Mahesh Varma, Construction Equipment and its planning and application, Metropolitan Book Company, New Delhi 1983	
Course Outcomes:	
1. List the equipment necessary for construction engineering 2. Discuss construction engineering fundamentals 3. Analyze production outputs and costs 4. Evaluate the performance of equipment for earth moving 5. Enumerate the batching, mixing, transport and placement of concrete	

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**3**	**3**	**2**	**3**	**2**	
CO2	**3**	**2**	**1**	**1**	**1**	
CO3	**3**	**1**	**2**	**2**	**3**	**3**
CO4	**2**	**2**	**1**	**2**	**1**	**2**
CO5	**3**	**2**	**3**	**2**	**2**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	**3**	**2**	**2**	**2**	**2**	**2**

SECOND SEMESTER

Programme:M.Tech. Structural Engineering	**Semester: 2nd**
Professional Core Course	

Subject Name: Finite Element Method	**(3-0-0) CR-03**

Course Content

Module-I

The Continuum, Equations of Equilibrium, Boundary Conditions, Strain displacement relations, Stress strain Relations, Plane stress and plane Strain problems, Different methods of structural analysis including numerical methods. Basics of finite element method (FEM), different steps involved in FEM, Different approaches of FEM, Direct method, Energy approach, Weighted residual Method.

Module-II

One and Two Dimensional Problems: Detail formulation including shape functions, stress strain relations, strain displacement relations and derivation of stiffness matrices using energy approach, Assembling of element matrices, application of displacement boundary conditions, Numerical solution of one dimensional problems using bar, truss, beam elements and frames. Derivation of shape function using Lagrange's interpolation, Pascal's triangle, Convergence criteria, Finite Element modeling of two dimensional problems using Constant strain Triangle (CST) elements, Stress strain relations for isotropic and orthotropic materials, Four nodded rectangular elements, axisymmetric solids subjected to axisymmetric loading.

Module-III

Isoparametric Elements: Natural coordinates, isoparametric elements, four node, eight node elements. Numerical integration, order of integration

Module-IV

Plate Bending: Bending of plates, rectangular elements, triangular elements and quadrilateral elements, Concept of 3D modeling.

Module-V

Dynamic Considerations: General Equation of motion, Lagrange's approach, mass matrix, lumped and consistent mass matrices, Evaluation of eigenvalue and eigenvectors, stability problems.

Text Book:

1. C.S. Desai and J.F. Abel, Introduction to the Finite Element Method: CBS Publishers
2. R. D. Cook., Concepts and Applications of Finite Element Analysis, Wiley.

Reference Books:

1. Logan, D. L., A First Course in the Finite Element Method, PWS Publishing, Boston,
2. O. C Zienkiewicz .and R. L. Taylor, Finite Element Method, Mc Graw Hill

Course Outcomes:

1. Revise the basic knowledge of mathematics, science and engineering in the areas of finite element analysis related to structural engineering.
2. Identify, formulate and solve engineering problems of structural engineering related to one and two dimensional structures.
3. Analyze structures using isoperimetric elements
4. Solve plate bending problems
5. Discuss structures subjected to dynamic loads

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**

CO1	**2**	**3**	**3**	**1**	**1**	
CO2	**3**	**2**	**1**	**1**	**1**	
CO3	**3**	**1**	**2**	**3**	**3**	
CO4	**2**	**3**	**1**	**2**	**2**	**3**
CO5	**3**	**2**	**3**	**2**	**1**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	**3**	**2**	**2**	**2**	**2**	**1**

Programme:M.Tech. Structural Engineering	**Semester: 2nd**
Professional Core Course	
Subject Name: Structural Dynamics	**(3-0-0) CR-03**
Course Content	
Module-I	
Oscillatory motion; harmonic motion, periodic motion, vibration terminology, Single degree of freedom system; equation of motion, damped and undamped free vibration, response to harmonic and periodic loads	
Module-II	
Response to impulse load using Duhamel's integral for single degree of freedom system, Fourier Analysis for Periodic Loading, Numerical Solution to Response using Newmark Method and Wilson Method, vibrating measuring instruments.	
Module-III	
Multi-degrees of freedom system: equation of motion, free vibration analysis, dynamic response and modal analysis.	
Module-IV	
Multiple Degree of Freedom System (Distributed Mass and load):Vibrating strings, longitudinal and torsional vibration of rods, Flexural vibration for uniform beams, Natural frequencies and mode shapes of uniform beams for different end conditions.	
Module-V	
Special Topics in Structural Dynamics (Concepts only): Dynamic Effects of Wind Loading, Moving Loads, Vibrations caused by Traffic, Blasting and Pile Driving, Foundations for Industrial Machinery, Base Isolation. Introduction to random vibrations: random phenomena, time averaging and expected value, frequency response function.	
Text Book:	
1. WT Thomsen, 'Theory of vibration', CBS Publications 2. M. Paz, 'Structural Dynamics- Theory and Computation', Van Nostrand, 1985	
Reference Books:	
1. R.W. Clough and J. Penzien, 'Dynamics of Structures', McGraw-HillInc 2. A.K. Chopra, 'Dynamics of Structures: Theory and Applications to Earthquake Engineering, Printice Hall of India 3. M. Mukhopadhyay, 'Structural Dynamics Vibrations & Systems, Ane Books India. Dynamics ofStructures, Hart and Wong. 4 .Vibration ofStructures - Application in Civil Engineering Design, Smith J. W., Chapman and Hall. 5. Dynamics of Structures, Humar J. L., Prentice Hall.	
Course Outcomes:	
1. Develop the equations of motion for vibratory systems and solving for the free and forced response for single degree of freedom system	
2 Analyze and study dynamics response of single degree freedom system subjected to impulse load	

3. Interpret dynamics response of Multi degree freedom system with lumped mass using fundamental theory and equation of motion.
4. Discuss dynamics response of Multi degree freedom system with distributed mass using fundamental theory and equation of motion
5. Revise concepts for dynamic effects for different loading

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**3**	**1**	**3**	**1**	**1**	
CO2	**3**	**2**	**1**	**1**	**2**	
CO3	**3**	**1**			**3**	
CO4	**3**	**3**	**1**	**2**	**1**	**2**
CO5	**2**	**2**	**3**	**2**	**1**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	**3**	**2**	**2**	**1**	**2**	**1**

Programme:M.Tech. Structural Engineering	**Semester: 2nd**
Lab	
Subject Name: Structural Dynamics Lab	**(0-0-3) CR-02**
Course Content	
1.. Response of structures and its elements against extreme loading events.	
2.. Model Testing: Testing of plates, shells, and frames models.	
3.. Model Testing: Free and forced vibrations, Evaluation of dynamic modulus.	
4.. Beam vibrations, Vibration isolation, Shear wall building model, Time and frequency-domain study, Vibration Characteristics of RC Beams using Piezoelectric Sensors etc.	
Course Outcomes:	
1.Evaluate the response of structures	
2.Prepare the models	
3.Discuss model testing for dynamic loading	
4.Analyze model testing for free and forced vibrations	
5.Predict beam vibration	

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**3**	**1**	**3**	**1**	**1**	**2**
CO2	**2**	**2**	**1**	**1**	**1**	
CO3	**3**	**3**		**3**	**3**	**1**
CO4	**3**	**2**	**1**	**2**	**1**	**3**
CO5	**3**	**2**	**3**	**2**	**2**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	**3**	**2**	**2**	**2**	**2**	**2**

Programme:M.Tech. Structural Engineering	**Semester: 2nd**
Lab	
Subject Name: Structural Engineering and Design Lab	**(0-0-3) CR-02**
Course Content	
Instruments, Properties of fresh & hardened concrete - Concrete mix design Tests on RC beam, Prestressed beam, RC slabs, RC column, Steel beam, Steel column; NDTS - Application of acoustic emission instrument, ultrasonic test. Biaxial and multiaxial testing, Steel-concrete composite, Tests on fibre reinforced concrete composites, Individual/group projects	
Course Outcomes:	
1. Analyzethe fresh and hardened properties of various types of concrete. 2. Interpret how modern instruments helpful for the experimenting the strength ofconcrete. 3. Discuss the importance of experiments in behavioral aspect of ingredients of concrete. 4. Examine field application of properties of concrete and implementation of it at site 5. Evaluate Nondestructive techniques	

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**3**	**1**	**3**	**1**	**1**	**2**
CO2	**2**	**2**	**1**	**1**	**1**	
CO3	**3**	**3**		**3**	**3**	**1**
CO4	**3**	**2**	**1**	**2**	**1**	**3**
CO5	**3**	**2**	**3**	**2**	**2**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	**3**	**2**	**2**	**2**	**2**	**2**

Programme:M.Tech. Structural Engineering	**Semester: 2nd**
Professional Elective Course (III)	
Subject Name: Advanced Design of Steel Structures	**(3-0-0) CR-03**
Course Content	
Module-I	
Structural Steel: Mechanical Properties, Hysteresis, Ductility. **Hot Rolled Sections:** compactness and non-compactness, slenderness, residual stresses	
Module-II	

Loadings and Load Combinations: Dead load, live load, wind load, earthquake load, impact load, Accidental load, Inelastic bending curvature, Introduction to plastic design, plastic moment
Module-III
Stability criteria: stability of beams – local buckling of compression flange & web, lateral-torsional, buckling.**Stability of columns** -slenderness ratio of columns, local buckling of flanges and web, bracing of column about weak axis**.**
Module-IV
Strength criteria: ***beams*****-**flexure, shear, torsion, ***columns*** – moment magnification factor, effective length, P-M interaction, bi-axial bending, joint panel zones
Module-V
Drift criteria:P-Δ effect, deformation-based design; beam, column, Connections: types – welded, bolted, location –beam column, column-foundation, splices.
Text Book:
1. N Subramanian, 'Design of steel structures', Oxford University Press
Reference Book:
2. M Bill Wong, 'Plastic analysis and design of steel structures', 3. M Bruneau, CM Uang and SER Sabelli, 'Ductile design of steel structures'
Course Outcomes:
1. Assess structural steelHot rolled sections and its different properties
2. Survey different type of loads in structural steel elastic and plastic design
3. Analyze the beam and column of real-life structures on stability point of view.
4. Examine the beam and column of steel structures on basis of strength
5. Interpret the beam and column of different types of steel structures and connections on drift

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**1**	**1**	
CO2	**3**	**2**	**1**	**1**	**1**	
CO3	**3**	**1**			**3**	
CO4	**3**	**2**	**1**	**2**	**1**	**3**
CO5	**3**	**2**	**3**	**2**	**1**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	**3**	**2**	**2**	**1**	**1**	**1**

Programme:M.Tech. Structural Engineering	**Semester: 2nd**
Professional Elective Course (III)	
Subject Name: . Design of Formwork	**(3-0-0) CR-03**
Course Content	
Module-I	
Introduction: Requirements and Selection of Formwork. Formwork Materials- Timber, Plywood, Steel, Aluminium, Plastic, and Accessories. Horizontal and Vertical Formwork Supports.	
Module-II	
Formwork Design: Concepts, Formwork Systems and Design for Foundations, Walls,	

Columns, Slab and Beams.
Module-III
Formwork Design for Special Structures: Shells, Domes, Folded Plates, Overhead WaterTanks, Natural Draft Cooling Tower, Bridges.
Module-IV
Flying Formwork: Table Form, Tunnel Form, Slip Form, Formwork for Precast Concrete,Formwork Management Issues –Pre- and Post-Award.
Module-V
Formwork Failures: Causes and Case studies in Formwork Failure, Formwork Issues in Multi-Story Building Construction.
Text Book:
1..Formwork for Concrete Structures, Peurify, Mc Graw Hill India, 2015. 2..Formwork for Concrete Structures, Kumar NeerajJha, Tata McGraw Hill Education, 2012.
Reference Book:
1.. IS 14687: 1999, False workfor Concrete Structures - Guidelines, BIS
Course Outcomes:
1. Select proper formwork, accessories and material. 2. Explain the form work for Beams, Slabs, columns, Walls and Foundations. 3. Design the form work for Special Structures. 4. Discuss the working of flying formwork. 5. Judge the formwork failures through case studies.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**3**	**1**	**3**	**1**	**1**	
CO2	**3**	**2**	**1**	**2**	**1**	
CO3	**3**	**1**			**3**	
CO4	**3**	**2**	**3**	**2**	**1**	**3**
CO5	**2**	**2**	**2**	**2**	**1**	**2**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	**3**	**2**	**2**	**1**	**1**	**1**

Programme:M.Tech. Structural Engineering	**Semester: 2nd**
Professional Elective Course (III)	
Subject Name: Design of High Rise Structures	**(3-0-0) CR-03**
Course Content	
Module-I	
Design of transmission/ TV tower, Mast and trestles: Configuration, bracing system, analysis and design for vertical transverse and longitudinal loads.	
Module-II	
Analysis and Design of RC and Steel Chimney, Foundation design for varied soil strata.	
Module-III	
Tall Buildings: Structural Concept, Configurations, various systems, Wind and Seismic loads,	
Module-IV	

Dynamic approach, structural design considerations and IS code provisions. Fire fighting design provisions.
Module-V
Application of software in analysis and design.
Text Book:
1.Structural Design of Multi-storeyed Buildings, Varyani U. H., 2nd Ed., SouthAsian Publishers, New Delhi, 2002. 2..Structural Analysis and Design of Tall Buildings, Taranath B. S., Mc Graw Hill, 1988..
Reference Book:
1.Illustrated Design of Reinforced Concrete Buildings(GF+3storeyed), Shah V. L. &Karve S. R., Structures Publications, Pune, 2013. 2.Design of Multi Storeyed Buildings, Vol. 1 & 2, CPWD Publications, 1976. 3.Tall Building Structures, Smith Byran S. and Coull Alex, Wiley India. 1991. 4.High Rise Building Structures, Wolfgang Schueller, Wiley., 1971. 5.Tall Chimneys, Manohar S. N., Tata Mc Graw Hill Publishing Company, New Delhi
Course Outcomes:
1. Analyze, design and detail Transmission/ TV tower, Mast and Trestles with different loading conditions. 2. Distinguish design and detailingof the RC and Steel Chimney. 3. Discuss tall buildings subjected to different loading conditions using relevant codes. 4.. Evaluate dynamic structural design 5.. Apply software in analysis and design

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**2**	**1**	**3**	**1**	**1**	
CO2	**3**	**2**	**2**	**2**	**1**	
CO3	**3**	**1**	**1**		**3**	
CO4	**2**	**2**	**3**	**2**	**1**	**3**
CO5	**3**	**2**	**2**	**2**	**1**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	**3**	**2**	**2**	**1**	**1**	**1**

Programme:M.Tech. Structural Engineering	**Semester:2nd**
Professional Elective Course (III)	
Subject Name: Design of Masonry Structures	**(4-0-0) CR-03**
Course Content	
Module-I	
Introduction: Historical Perspective, Masonry Materials, MasonryDesign Approaches, Overview of Load Conditions, Compression Behaviour of Masonry, Masonry Wall Configurations, Distribution ofLateral Forces.	
Module-II	
Flexural Strengthof Reinforced Masonry Members: In plane and Out-of-plane Loading.	
Module-III	

Interactions: Structural Wall, Columns and Pilasters, Retaining Wall, Pier and Foundation.**Shear Strength**and Ductility of Reinforced Masonry Members.
Module-IV
Prestressed Masonry - Stability of Walls, Coupling of Masonry Walls, Openings, Columns, Beams.
Module-V
Elastic and Inelastic Analysis, Modeling Techniques, Static Push Over Analysis and use of Capacity Design Spectra.
Text Book:
1. Design of Reinforced Masonry Structures, Narendra Taly, ICC, 2nd Edn, 2. Masonry Structures: Behavior and Design, Hamid Ahmad A. and Drysdale Robert G., 1994.
Reference Books:
1 Mechanics of Masonry Structures, Editor: Maurizio Angelillo, 2014. 2. Earthquake-resistant Design of Masonry Buildings,Toma_evi_Miha, Imperial College Press, 1999
Course Outcomes:
1. Describe the masonry design approaches.
2. Analyze Reinforced Masonry Members.
3. Compare interactions between members.
4. Evaluate shear strength and ductility of Reinforced Masonry members.
5. Discuss elastic and Inelastic analysis of masonry walls.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**3**	**1**	**3**	**2**	**1**	
CO2	**3**	**2**	**2**	**1**	**1**	
CO3	**2**	**1**		**2**	**3**	
CO4	**3**	**2**	**1**	**2**	**1**	**3**
CO5	**3**	**2**	**3**	**2**	**1**	**2**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	**3**	**2**	**2**	**2**	**1**	**1**

Programme:M.Tech. Structural Engineering	**Semester: 2nd**
Professional Elective Course (III)	
Subject Name: Bridge Engineering	**(3-0-0) CR-03**
Course Content	
Module-I	
Introduction: classification and components of a standard bridge, Engineering and aesthetic requirements, introduction to bridge codes. Investigation for bridge: Site selection, data drawing, design discharge linear water way, economical span, location of piers and abutments, vertical clearance above HFL, scour depth and choice of bridge type. Standard Loadings for Road Bridges: Dead load, Live loads, Impact effect, Wind load, Longitudinal forces, Centrifugal forces, Horizontal forces due to water current, Buoyancy effect, Earth pressure, Deformation stresses, Erection stresses, Temperature effects, and Seismic force.	

Module-II

Foundation and substructures: Types of foundation (open, pile, well and caisson), design of piers, abutments, wing wall and bed blocks. Design of Culverts: Design of Pipe culverts (hydraulics and structural), Analysis and design of right, skew and curved slab culvert; design of single vent rectangular box culvert.

Module-III

Design of Girders: Design and detailing T-beam bridge (without footpath), load distribution, design and orthographic plate analysis of bridge deck. Bearings: Bearings for slab bridges and girder bridges, design of elastomeric bearing. Joints: Design and construction of expansion joints.

Module-IV

Introduction to long span bridges: Cantilever bridges, Arch bridges, Cable stayed bridges, suspension bridges, Pre-stressed concrete bridge (pre-tensioned and post-tensioned) and steel bridges.

Module-V

Bridge Launching: Methods of erection of concrete, steel, pre-stressed and composite bridges Inspection and Maintenance of Bridges: Types of inspection (routine inspection, principal inspection and special inspection), Types of maintenance (Ordinary maintenance and specialized maintenance).

Text Book:

1. Essentials of Bridge Engineering, by DJ Victor, Oxford IBH.

Reference Book:

1. Design of Bridge Structures, by T. R. Jagadeesh, PHI.
2. Principles and Practice of Bridge Engineering, SP Bindra, Dhanpat Rai Publications

Course Outcomes:

1. Revise the basic knowledge of mathematics, science and engineering in the design of various types of bridges.
2. Identify, formulate and solve engineering problems in design of bridges subjected to flexure, shear and torsion.
3. Show the procedural knowledge to design a system, component or process as per needs and specifications of slab culvert, box culvert, T beam bridges, PSC bridges and balanced cantilever bridges slabs subjected to various load combinations with different boundary conditions subjected to various load combinations with different boundary conditions.
4. Practice the culture of professional and ethical responsibilities by following codal provisions in the analysis, design and detailing of advanced design of bridges for strength and durability.
5. Evaluate the impact of engineering solutions on the society and also will be aware of contemporary issues regarding failure of structures due to wrong design, use of poor quality of materials and faulty construction methods. To provide factual knowledge on analysis and design of various types of bridges

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**1**	**1**	
CO2	**3**	**2**	**1**	**2**	**1**	
CO3	**3**	**1**			**3**	
CO4	**3**	**2**	**1**	**2**	**1**	**3**
CO5	**3**	**2**	**3**	**2**	**1**	**2**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	**3**	**2**	**2**	**1**	**1**	**1**

Programme:M.Tech. Structural Engineering	**Semester: 2nd**
Professional Elective Course (IV)	
Subject Name: Advanced Reinforced Concrete Design	**(3-0-0) CR-03**

Course Content

Module-I

Design of reinforced concrete structures: Methods of design, working stress design (WSD) and limit state design (LSD)
Review in brief of LSD-flexure, axial-flexure, shear and torsion,

Module-II

Serviceability requirement: Estimation of crack width and deflection of reinforced concrete beams.

Module-III

Analysis and design of building frames subjected to wind load; Earthquake forces and structural response.

Module-IV

Ductility of reinforced structures; material ductility-steel and concrete, section ductility, member ductility, structural ductility, ductile detailing of reinforced concrete frames for seismic forces.

Module-V

Design of deep beams, Design of concrete shear walls

Text Book:

1. A.K. Jain, "Reinforced Concrete: Limit State Design", Nemchand and Bros, 1999

Reference Book:

1. R Park and T Paulay," Reinforced Concrete Structures", John Wiley & Sons
2 P.C. Varghese, "Advanced Reinforced Concrete Design", PHI, 2nd Edition, 2002

Course Outcomes:

1. Differentiate various design philosophies
2. Analyze the structural long term deformations including crack width
3. Design building frames subjected to wind load and Earthquake forces
4. Evaluate various ductility including the detailing of RC frames
5. Discuss design of deep beam and shear wall

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**3**	**1**	**3**	**2**	**1**	
CO2	**3**	**2**	**1**	**1**	**1**	
CO3	**2**	**1**		**1**	**3**	
CO4	**3**	**2**	**2**	**2**	**1**	**3**
CO5	**3**	**2**	**3**	**2**	**1**	**2**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	**3**	**2**	**2**	**2**	**1**	**1**

Programme:M.Tech. Structural Engineering	**Semester: 2nd**
Professional Elective Course (IV)	
Subject Name: Advanced Design of Foundations	**(3-0-0) CR-03**

Course Content

Module-I

Planning of Soil Exploration for Different Projects, Methods of Subsurface Exploration, Methods of Borings along with Various Penetration Tests.

Module-II

Shallow Foundations, Requirements for Satisfactory Performance of Foundations, Methods of Estimating Bearing Capacity, Settlements of Footings and Rafts, Proportioning of Foundations using Field Test Data, Pressure - Settlement Characteristics from Constitutive Laws.

Module-III

Pile Foundations, Methods of Estimating Load Transfer of Piles, Settlements of Pile Foundations, Pile Group Capacity and Settlement, Laterally Loaded Piles, Pile Load Tests, Analytical Estimation of Load- Settlement Behaviorof Piles, Proportioning of Pile Foundations, Lateral and Uplift Capacity of Piles.

Module-IV

Well Foundation, IS and IRC Code Provisions, Elastic Theory and Ultimate Resistance Methods. T**unnels** and Arching in Soils, Pressure Computations around Tunnels.

Module-V

Open Cuts, Sheeting and Bracing Systems in Shallow and Deep Open Cuts in Different Soil Types. **Coffer Dams**, Various Types, Analysis and Design, Foundations under uplifting loads, Soil-structure interaction

Text Book:

1.. Design of foundation system, N.P. Kurian, Narosa Publishing House

Reference Book:

1..Foundation Analysis and Design, J. E. Bowles, Tata McGraw Hill New York
2..Analysis and Design of Substructures, Sawmi Saran, Oxford and IBH Publishing Co. Pvt. Ltd, New Delhi.

Course Outcomes:

1. Decide the suitability of soil strata for different projects.
2. Design shallow foundations deciding the bearing capacityof soil.
3. Analyze and design the pile foundation.
4. Discuss methods for well foundation.
5. List various types of coffer dams

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**2**	**1**	**3**	**1**	**1**	
CO2	**3**	**3**	**2**	**1**	**1**	
CO3	**2**	**1**	**2**	**3**	**3**	
CO4	**3**	**2**	**1**	**2**	**1**	**3**
CO5	**3**	**2**	**3**	**2**	**1**	**2**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	**3**	**2**	**2**	**2**	**1**	**1**

Programme:M.Tech. Structural Engineering	**Semester: 2nd**
Professional Elective Course (IV)	
Subject Name: Soil Structure Interaction	**(3-0-0) CR-03**
Course Content	
Module-I	
Critical Study of Conventional Methods of Foundation Design, Nature and Complexities of Soil Structure Interaction.	
Module-II	
Application of Advanced Techniques of Analysis such as FEM and Finite Difference Method. Relaxation and Interaction for the Evaluation of Soil Structure Interaction for Different Types of Structure under various Conditions of Loading and Subsoil Characteristics.	
Module-III	
Relaxation and Interaction for the Evaluation of Soil Structure Interaction for Different Types of Structure under various Conditions of Loading and Subsoil Characteristics.	
Module-IV	
Preparation of Comprehensive Design Oriented Computer Programs for Specific Problems, Interaction Problems based on Theory of Sub Grade Reaction Such as Beams, Footings, Rafts Etc.	
Module-V	
Analysis of Different Types of Frame Structures Founded on Stratified Natural Deposits with Linear and Non-Linear Stress-Strain Characteristics. Determination of Pile Capacities and Negative Skin Friction, Action of Group of Piles Considering Stress-Strain Characteristics of Real Soils, Anchor Piles and Determination of Pullout Resistance.	
Text Book:	
1.. Analytical and Computer Methods in Foundation, Bowels J.E.,McGraw Hill Book Co., New York, 1974. 2.Numerical Methods in Geotechnical Engineering, Desai C.S. and Christian J.T., McGraw Hill Book Co., New York.	
Reference Book:	
1.Soil Structure Interaction - The real behaviour of structures, Institution of Structural Engineers. 2.Elastic Analysis of Soil Foundation Interaction, Developments in Geotechnical Engg. Vol-17, Elsevier Scientific Publishing Company. 3..Elastic Analysis of Soil-Foundation Interaction, Selvadurai A.P.S., Elsevier Scientific Publishing Company. 4.Analysis & Design of substructures, Swami Saran, Oxford & IBH Publishing Co. Pvt. Ltd. 5..Design of Foundation System- Principles & Practices, Kurian N. P., Narosa Publishing	
Course Outcomes:	
1. Discuss soil structure interaction concept and complexities involved. 2. Evaluate soil structure interaction for different types of structure under various conditions	

of loading and subsoil characteristics.
3. Prepare comprehensive design oriented computer programs for interaction problems based on theory of sub grade reaction such as beams, footings, rafts etc.
4. Analyze different types of frame structure founded on stratified natural deposits with linear and non-linear stress-strain characteristics.
5. Describe action of group of piles considering stress-strain characteristics of real soils.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**2**	**1**	**3**	**1**	**1**	
CO2	**3**	**2**	**1**	**1**	**2**	
CO3	**2**	**1**	**2**		**3**	
CO4	**3**	**2**	**1**	**2**	**1**	**3**
CO5	**3**	**2**	**3**	**2**	**1**	**2**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	**3**	**2**	**2**	**1**	**2**	**1**

Programme:M.Tech. Structural Engineering	**Semester: 2nd**
Professional Elective Course (IV)	
Subject Name: Design of Industrial Structure	**(3-0-0) CR-03**
Course Content	
Module-I	
Steel Gantry Girders – Introduction, loads acting on gantry girder, permissible stress, types of gantry girders and crane rails, crane data, maximum moments and shears, construction detail, design procedure.	
Module-II	
Portal Frames – Design of portal frame with hinge base, design of portal frame with fixed base - Gable Structures – Lightweight Structures	
Module-III	
Steel Bunkers and Silos – Design of square bunker – Jansen's andAiry's theories – IS Code provisions – Design of side plates – Stiffeners – Hooper – Longitudinal beams Design of cylindrical silo – Side plates – Ring girder – stiffeners.	
Module-IV	
Chimneys – Introduction, dimensions of steel stacks, chimney lining, breech openings and access ladder, loading and load combinations, design considerations, stability consideration, design of base plate, design of foundation bolts, design of foundation. **Water Tanks** – Design of rectangular riveted steel water tank – Tee covers – Plates – Stays – Longitudinal and transverse beams –Design of staging – Base plates – Foundation and anchor bolts .	
Module-V	
Design of pressed steel water tank – Design of stays – Joints – Design of hemispherical bottom water tank – side plates – Bottom plates – joints – Ring girder –Design of staging and foundation.	
Text Book:	
1.. Design of Steel Structure, Punmia B. C., Jain Ashok Kr., Jain Arun Kr., 2nd Ed., Lakshmi	

Publishers, 1998.
Reference Book:
1.Design of Steel Structures, Ram Chandra, 12th Ed., Standard Publishers, 2009. 2.Design of Steel Structures, Subramaniyam.
Course Outcomes:
1. Design of Steel Gantry Girders. 2. Explain Steel Portal, Gable Frames. 3. Analyze Steel Bunkers and Silos. 4. Discuss Chimneys and Water Tanks. 5. Solve pressed steel water

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**3**	**1**	**3**	**1**	**1**	
CO2	**2**	**3**	**1**	**1**	**2**	
CO3	**2**	**1**			**3**	
CO4	**3**	**2**	**2**	**2**	**1**	**3**
CO5	**2**	**2**	**3**	**2**	**1**	**1**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	**2**	**2**	**2**	**1**	**2**	**1**

Programme:M.Tech. Structural Engineering	**Semester: 2nd**
Professional Elective Course (IV)	
Subject Name: Earthquake Analysis and Design	**(3-0-0) CR-03**
Course Content	
Module-I	
Engineering Seismology: Introduction to Seismic hazard, Earthquake Phenomenon, Seismotectonics and Seismic Zoning of India, Earthquake Monitoring and Seismic Instrumentation, Characteristics of Strong Earthquake Motion, Estimation of Earthquake Parameters.	
Module-II	
Design Loads: Response Spectra, Estimation of Earthquake Forces as per IS 1893 (Part 1): Equivalent lateral force method, response spectrum method, time history method; torsional force, load combinations.	
Module-III	
Guidelines for Earthquake Resistant Design: Causes of Damage, earthquake design philosophy, planning Considerations, continuous load path, overall form, simplicity and symmetry, shape, twisting, ductility, framing system, choice of construction materials. Behavior of masonry building under earthquake, behavior of infill walls, improving seismic behaviors of masonry building	
Module-IV	
Earthquake Resistant Design of R.C.C. Buildings: concept of ductile design, ductile detailing of concrete members: beams, columns, joints, special confined reinforcement, and Shear wall.	
Module-V	

Mathematical modeling of multistoried RC Buildings; Introduction to pushover analysis; Vibration Control: Principles and application of Tuned Mass Dampers, Seismic retrofitting strategies for RC and masonry buildings, Basic Concept of Seismic Base Isolation: various Systems, Case Studies, Important structures
Text Book:
1. Earthquake Resistant Design of Structures, S.K. Duggal, Oxford Intl. 2. Earthquake Resistant Design: Shrikhandee & Agarwal-PHI Publ
Reference Book:
1.. Earthquake-Resistant Design of Building Structures, Vinod Hosur, Willy
Course Outcomes:
1. Discuss fundamental concepts of engineering seismology 2. Estimate design lateral loads on structures 3. Compile general guidelines on earthquake resistance design 4. Employ ductile detailing of reinforced concrete structures 5. Assess concepts of pushover analysis, vibration control and seismic retrofitting of structures.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**2**	**1**	**3**	**1**	**1**	
CO2	**3**	**2**	**1**	**1**	**1**	
CO3	**2**	**1**			**3**	
CO4	**3**	**2**	**1**	**2**	**1**	**3**
CO5	**3**	**2**	**3**	**2**	**1**	**1**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	**3**	**2**	**2**	**1**	**1**	**1**

Programme:M.Tech. Structural Engineering	**Semester: 2nd**
Professional Elective Course (IV)	
Subject Name: Repair, Rehabilitation and Retrofitting of Structures	**(3-0-0) CR-03**
Course Content	
Module-I	
General Aspects: Performance of construction materials and components in services for strength permeability, thermal properties and cracking effects due to climate, temperature, chemicals, wear and erosion, Design and construction errors, Effects of cover thickness	
Module-II	
Maintenance and Diagnosis of Failure: Definitions**:** Maintenance, Repair and rehabilitation, Facets of Maintenance, Importance of Maintenance, Preventive measures based on various aspects of inspection, Assessment procedure for evaluating a damaged structure; Diagnosis of construction failures.	
Module-III	
Damages and Their Remedies: Corrosion damage of reinforced concrete, methods of corrosion protection, corrosion inhibitors, corrosion resistant steels, coatings, cathodic protection, rust eliminators; Causes of deterioration of concrete, steel, masonry and timber	

structures, surface deterioration, efflorescence, causes, prevention and protection.
Module-IV
Materials and Techniques of Repair Special concrete and mortar, concrete chemicals, expansive cement, polymer concrete, sulphur infiltrated concrete, Ferro cement, fiber reinforced concrete; Methods of repair in concrete, steel, masonry and timber structures. Gunite and shotcrete, expoxy injection
Module-V
Strengthening and Demolition Aspect Strengthening of existing structures, repairs to overcome low member strength, deflection, cracking, chemical disruption, weathering, wear, fire, leakage, marine exposure, coatings for set concrete and steel reinforcement, use of non-destructive testing techniques for evaluation, load testing of structure; Demolition of structures using engineered and non-engineered techniques, case studies.
Text Book:
1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services. 2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
Course Outcomes:
1. Enumerate reasons for damage and performances of construction material 2. Discuss maintenance and diagnosis of failure 3. Evaluate damage and their solution 4. Apply appropriate materials and techniques for repair. 5. Describe appropriate technique to retrofit and strengthening a structure

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**1**	**1**	
CO2	**3**	**2**	**1**	**1**	**1**	
CO3	**3**	**2**		**3**	**2**	
CO4	**3**	**2**	**1**	**2**	**1**	**3**
CO5	**2**	**3**	**3**	**2**	**1**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	**3**	**2**	**2**	**2**	**1**	**1**

THIRD SEMESTER

Programme:M.Tech. Structural Engineering	**Semester: 3rd**
Professional Elective Course (V)	
Subject Name: Prestressed Concrete	**(3-0-0) CR-03**

Course Content

Module-I

Introduction to prestressed concrete: types of prestressing, systems and devices, materials. Analysis of PSC flexural members: basic concepts, stresses at transfer and service loads, ultimate strength in flexure, code provisions.

Module-II

Losses in pre tensioned and post tensioned members. Deflection of prestressed concrete structures- short term as well as long term deflections of uncracked and cracked members

Module-III

Statically determinate PSC beams: design for ultimate and serviceability limit states for flexure, analysis and design for shear and torsion, code provisions.

Module-IV

Anchorage zone stresses for post tensioned Members;Magnel's method, Guyon's method, Rowe's method and IS code method of design.

Module-V

Indeterminate structures- Principles of design of prismatic continuous beams of two equal, unequal spans with same and variable moments of inertia, Analysis and design -continuous beams, choice of cable profile, linear transformation and concordancy of cable profile.

Text Book:

1. N Krishnaraju, 'Prestressed concrete', Tata Mc-Grawhill, New Delhi- 2004
2. SK Mallik & AP Gupta, 'Prestressed concrete', Oxford & IBH, New Delhi 1988

Reference Book:

1. EW Bennet,'Prestressed concrete theory & design', Chapman & Hall, London-1962
2. TY Lin & H Burns Ned, 'Design of prestressed concrete structures', John Wiley & Sons, New York, 1982

Course Outcomes:

1. Revise basic aspects of prestressed concrete fundamentals, including pre and post-tensioning processes and determine the prestressing force required in beam for a prestressing systems.
2. Evaluate losses and deflections in the prestressed concrete.
3. Compute the Flexural Strength, Shear strength & Torsional Resistance of prestressed Concrete Members.
4. Design of end blocks for prestressed members.
5. Analyze and design statically indeterminate prismatic continuous beams.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**1**	**1**	
CO2	**3**	**2**	**1**	**3**	**1**	
CO3	**3**	**1**	**2**		**3**	
CO4	**2**	**2**	**1**	**2**	**1**	**3**
CO5	**3**	**2**	**3**	**2**	**1**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	**3**	**2**	**2**	**2**	**1**	**1**

Programme:M.Tech. Structural Engineering	**Semester: 3rd**
Professional Elective Course (V)	
Subject Name: Analysis of Laminated Composite Plates	**(3-0-0) CR-03**
Course Content	
Module-I	
Introduction to Composite Materials	
Module-II	
Classical Theory of Laminated Composite Plates	
Module-III	
First-Order Theory of Laminated Composite Plates	
Module-IV	
Analytical Solutions of Rectangular Laminated Plates Using classical laminated plate theory	
Module-V	
Analytical Solutions of Rectangular Laminated Plates Using shear laminated plate theories	
Text Book:	
J.N. Reddy, Mechanics of Laminated Plates and Shells, Boca Raton 2004 M.W. Hyer, Stress Analysis of Fiber Reinforced Composite Materials, McGrawhill Book Co, 1997	
Course Outcomes:	
1. Revise the basic of composite materials 2. Evaluate classical theory of laminated composite plates 3. Recall knowledge of first order theory of laminated composite plates 4. Solve the problems on laminated composite plates using classical plate theory 5. Discuss problems on laminated composite plates using shear plate theory	

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**3**	**1**	**3**	**1**	**1**	
CO2	**2**	**2**	**1**	**1**	**1**	
CO3	**3**	**1**	**2**		**3**	
CO4	**3**	**2**	**1**	**2**	**1**	**3**
CO5	**3**	**2**	**3**	**2**	**1**	**2**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	**3**	**2**	**2**	**1**	**1**	**1**

Programme:M.Tech. Structural Engineering	**Semester: 3rd**
Professional Elective Course (V)	

Subject Name: Fracture Mechanics of Concrete Structures	**(3-0-0) CR-03**
Course Content	
Module-I	
Introduction: Basic Fracture Mechanics, Crack in a Structure, Mechanisms ofFracture and Crack Growth, Cleavage Fracture, Ductile Fracture, Fatigue Cracking, Environment assisted Cracking, Service Failure Analysis.	
Module-II	
Stress at Crack Tip: Stress at Crack Tip, Linear Elastic Fracture Mechanics, Griffith's Criteria, Stress Intensity Factors,	
Module-III	
Crack Tip Plastic Zone, Erwin's Plastic Zone Correction, R curves, Compliance, J Integral, Concept of CTOD and CMD.	
Module-IV	
Material Models: General Concepts, Crack Models, Band Models, Models based on Continuum Damage Mechanics,	
Module-V	
Applications to High Strength Concrete, Fibre Reinforced Concrete, Crack Concepts and Numerical Modeling.	
Text Book:	
1.. Fracture Mechanics, Suri C. T. and Jin Z.H., 1st Edition, Elsevier Academic Press, 2012. 2.. Elementary Engineering Fracture Mechanics, BroekDavid, 3rd Rev. Ed. Springer, 1982.	
Reference Book:	
1.Fracture Mechanics of Concrete Structures – Theory and Applications, Elfgreen L., RILEM Report, Chapman and Hall, 1989. 2..Fracture Mechanics – Applications to Concrete, Victor, Li C., Bazant Z. P., ACI SP 118, ACI Detroit, 1989	
Course Outcomes:	
1. Identify and classify cracking of concrete structures based on fracture mechanics. 2. Consider stress intensity factor for notched members 3. Apply fracture mechanics models to high strength concrete and FRC structures. 4. Compute J-integral for various sections understanding the concepts of LEFM. 5. Compare Models based on Continuum Damage Mechanics,	

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**1**	**3**	
CO2	**3**	**3**	**2**	**1**	**1**	
CO3	**3**	**1**		**2**	**3**	
CO4	**3**	**2**	**1**	**2**	**1**	**3**
CO5	**3**	**2**	**3**	**2**	**1**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	**3**	**2**	**2**	**2**	**2**	**1**

Programme:M.Tech. Structural Engineering	**Semester: 3rd**
Professional Elective Course (V)	
Subject Name: Design Of Plates and Shells	**(3-0-0) CR-03**
Course Content	
Module-I	
Introduction: Space Curves, Surfaces, Shell Co-ordinates, Strain Displacement Relations, Assumptions in Shell Theory, Displacement Field Approximations, Stress Resultants, Equation of Equilibrium using Principle of Virtual Work, Boundary Conditions	
Module-II	
Design of Plates Under Static Loading: Governing Equation for a Rectangular Plate, Navier Solution for Simply- Supported Rectangular Plate under Various Loadings, Levy solution for Rectangular Plate with other Boundary Conditions.	
Module-III	
Circular Plates: Design of plates under Axi- Symmetric Loading, Governing Differential Equation in Polar Co-ordinates. Approximate Methods of Design- Rayleigh-Ritz approach for Simple Cases in Rectangular Plates.	
Module-IV	
Design of Shells: Membrane Shells Design - Cylindrical, Conical and Spherical Shells	
Module-V	
Design of Shells of Revolution: with Bending Resistance - Cylindrical and Conical Shells, Application to Pipes and Pressure Vessels.Thermal Stresses in Plate/ Shell.	
Text Book:	
1.Theory of Plates and Shells, Timoshenko S. and KriegerW., McGraw Hill. 2.Stresses in Plates and Shells, UguralAnsel C., McGraw Hill.	
Reference Books:	
1..Thin Elastic Shells, KrausH., John Wiley and Sons. 2..Theory of Plates, ChandrashekharaK., Universities Press. 3..Design and Construction of Concrete Shells, Ramaswamy G.S.	
Course Outcomes:	
1. Describe methods to design thin plates 2. Discuss methods to design shells. 3. Apply design tools for the complex design in thin plates. 4. Evaluate tools for the complex design in shells. 5. Compare the tools for the design of shells of Revolutions	

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**2**	**1**	**3**	**1**	**3**	
CO2	**3**	**2**	**2**	**1**	**1**	
CO3	**3**	**1**			**3**	
CO4	**3**	**2**	**1**	**2**	**1**	**3**
CO5	**3**	**2**	**2**	**2**	**1**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	**3**	**2**	**2**	**1**	**2**	**1**

Programme:M.Tech. Structural Engineering	**Semester: 3rd**
Professional Elective Course (V)	
Subject Name: Structural Design of Water and Sewerage System	**(3-0-0) CR-03**
Course Content	
Module-I	
Elements of Water supply and sewerage treatment system: Intake structures; pipe materials; treatment system: aeration, coagulation, flocculation, sedimentation, filtration systems. Design principles.	
Module-II	
Structural design of pipes: Design of concrete; pre-stressed concrete, steel, cast iron piping mains; sewerage tanks design; anchorage for pipes, massive outfalls, structural design and laying, manufacturing of pipes.	
Module-III	
Design of concrete roofing systems: Design of concrete roofing systems: Cylindrical, Spherical, Conical shapes using membrane theory and design of various types of folded plates for roofing with concrete.	
Module-IV	
Analysis and design of water tanks: IS Codes for the design of water retaining structures; Design of circular, rectangular, spherical and Intze type of tanks using concrete.; Design of pre-stressed concrete cylindrical tanks.	
Module-V	
Analysis and design of water supply elements: Underground reservoirs and swimming pools; Intake towers; Structural design including foundation of water retaining structures such as settling tanks clarifloculators; aeration tanks etc.; effect of earth pressure and uplift considerations; selection of materials of construction.	
Text Book:	
Reference Book:	
Course Outcomes:	
1. Measure various elements of water supply and sewerage treatment system 2. Analyze and design pipes 3. Design concrete roofing system for of water storage system 4. Examine design of water tanks 5. Solve and design water supply elements, intake towers, clarofloculators etc.	

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**2**	**1**	**3**	**1**	**2**	
CO2	**3**	**2**	**1**	**1**	**1**	
CO3	**3**	**1**			**3**	
CO4	**3**	**2**	**1**	**2**	**1**	**3**
CO5	**3**	**2**	**1**	**2**	**3**	**2**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	**3**	**2**	**1**	**1**	**2**	**1**

Programme:M.Tech. Structural Engineering	**Semester: 3rd**
Professional Elective Course (V)	
Subject Name: Passive vibration and Control of Structures	**(3-0-0) CR-03**

Course Content

Module-I

Overview of Vibration Control: Introduction, Quantitative Description of Vibration, Methods of Vibration Control, Basic System Parameters. **Vibration Reduction at the Source**: Introduction, Balancing, Balancing of Rigid Rotors, Balancing Machines, Field Balancing, Balancing of Flexible Rotors, Vortex Induced Vibration, Detuning and Decoupling

Module-II

Vibration Control by Structural Design: Damping Models and Measures, Origin of Structural Damping, Damping-Stress Relationship, Selection Criteria for Linear Hysteretic Materials, Combined Fatigue-Strength Damping Criteria, Design for Enhanced Material Damping

Module-III

Viscoelastic Materials for Vibration Damping: Standard Linear Solid – constitutive models, Stress-strain relationship, Complex Modulus, Frequency temperature dependence of complex modulus, Representation of Complex Stiffness, Free Layer Damping, Constrained Layer Damping, Viscoelastic Joints, Bonded Rubber Springs

Module-IV

Dynamic Vibration Absorbers: Introduction, Dynamic Vibration Neutralizers, Self-tuned Pendulum Neutralizer, Optimum Design of Damped Absorbers, Auxiliary Mass with Damper, Gyroscopic Absorber, Impact Absorber, Absorbers attached to Continuous Systems, Special types of Absorbers, Applications of DVA

Module-V

Vibration Isolators: Introduction, Isolators with Complex Stiffness, Isolators with Coulomb Damping, Three Element Isolators, Two-stage Isolators, Suspension systems, Applications of Isolators. **Active Vibration Control**: Introduction to Closed Loop Control, Classical Control System, Piezoelectric Sensors and Actuators, Vibration Control of Flexible Beam, Energy Harvesting System

Text Book:

1. Active and Passive Vibration Control, Mallik and Chatterjee, 2014
2. Mechanical Vibrations, Den Hartog, 1956

Reference Book:

1. Moheimani and Fleming – Piezoelectric Translators for Vibration Control and Damping, Spiringer
2. L. Meirovitch, Dynamics and Control of Structures
3. Preumont, Vibration Control of Active Structures : An Introduction, Kluwer Academic
4. D. J. Inman, Vibration with Control, Wiley

Course Outcomes:

1. Revise background basic concepts of vibration control.
2. Design structures for vibration control
3. Choose viscoelastic materials and its application for vibration control
4. List dynamic vibration absorbers for vibration control
5. Compare vibration isolators, and concert of active vibration control

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**2**	**1**	**3**	**1**	**1**	
CO2	**3**	**2**	**1**	**1**	**1**	
CO3	**3**	**1**			**3**	
CO4	**2**	**2**	**1**	**3**	**1**	**3**
CO5	**3**	**2**	**3**	**2**	**1**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	**3**	**2**	**2**	**1**	**1**	**1**

Programme:M.Tech. Structural Engineering	**Semester: 3rd**
Open Elective Course (I)	
Subject Name: Operations Research	**(3-0-0) CR-03**
Course Content	
Module-I	
Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models	
Module-II	
Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming	
Module-III	
Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT	
Module-IV	
Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.	
Module-V	
Competitive Models,Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation	
Text Book:	
1. H.A. Taha, Operations Research, An Introduction, PHI, 2008 2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.	
Reference Book:	
1. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008 2. Hitler Libermann Operations Research: McGraw Hill Pub. 2009 3. Pannerselvam, Operations Research: Prentice Hall of India 2010 4. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010	
Course Outcomes:	
1. Apply the dynamic programming to solve problems of discreet andcontinuous variables. 2. Revise the concept of non-linear programming 3. Evaluate sensitivity analysis 4. Define the real world problem and simulate it. 5. Assess the concept of dynamic programming	

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**3**	**1**	**3**	**1**	**1**	
CO2	**2**	**2**	**1**	**1**	**1**	
CO3	**3**	**1**			**3**	
CO4	**3**	**2**	**1**	**2**	**1**	**2**
CO5	**3**	**2**	**2**	**3**	**1**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	**3**	**2**	**1**	**1**	**1**	**1**

Programme:M.Tech. Structural Engineering	**Semester: 3rd**
Open Elective Course (I)	
Subject Name: Mechanics of Composite Materials	**(3-0-0) CR-03**
Course Content	
Module-I	
Classification and characteristics of Composite Materials, advantages and limitations, Basic Concepts and characteristics: Homogeneity and Heterogeneity, Isotropy, Orthotropy and Anisotropy;	
Module-II	
Characteristics and configurations of lamina, laminate, micromechanics and macromechanics, Constituent materials and properties.	
Module-III	
Elastic behavior of unidirectional lamina, Strength of unidirectional lamina, Macromechanical failure theories: Maximum stress theory, maximum strain theory, Deviatoric strain energy theory (Tsai-Hill), Interactive tensor polynomial theory (Tsai-Wu).	
Module-IV	
Elastic Behaviour of multidirectional laminates: Basic assumptions, Stress-strain relations, load deformation relations, symmetric and balanced laminates, laminate engineering properties.	
Module-V	
Bending of laminated plates: Governing equations, Deflection of simply supported rectangular symmetric angle-ply, specially orthotropic, antisymmetric cross-ply laminates.	
Text Book:	
1. RM Jones, 'Mechanics of Composite Materials', McGraw-Hill Book Company 2. IM Daniel and O Ishai, 'Engineering mechanics of composite materials,' Oxford university press	
Reference Book:	
1. PK Mallick, 'Fiber-reinforced composites', Marcel Dekker inc 2. D Hull and TW Clyne, 'An introduction to composite materials', Cambridge University Press 3. JN Reddy, 'Mechanics of laminated composite plates and shells: theory and analysis', CRC Press.	
Course Outcomes:	
1. Reproduce the basic knowledge of mathematics, science and engineering in the areas of Composite materials, classifications and applications.	

2. Explain the mechanical behavior of layered composites compared to isotropic materials.
3. Apply constitutive equations of composite materials and understand mechanical behavior at micro and macro levels.
4. Analyze a laminated plate in bending, including finding laminate properties from lamina properties
5. Identify simple laminated structural elements ply-stress and strain, lamina failure theories first fly failure, vibration and buckling analysis.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**3**	**2**	**3**	**1**	**1**	
CO2	**3**	**1**	**1**	**1**	**1**	
CO3	**3**	**1**			**3**	
CO4	**3**	**2**	**1**	**2**	**1**	**3**
CO5	**3**	**2**	**3**	**2**	**1**	**2**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	**3**	**2**	**2**	**1**	**1**	**1**

Programme:M.Tech. Structural Engineering	**Semester: 3rd**
Open Elective Course (I)	
Subject Name: Optimization Technique	**(3-0-0) CR-03**
Course Content	
Module-I	
Linear Programming: Introduction and formulation of models; Convexity; simplex method; Two phase method; Degeneracy, non - existent and unbounded solutions; Duality in L.P.P. Dual simplex method, Sensitivity analysis; Revised simplex method; transportation and assignment problems.	
Module-II	
Non-Linear Programming: Classical optimisation methods; Equality and inequality constraints; Lagrange multipliers; & Kuhn Tucker conditions; Quadratic forms; Quadratic programming	
Module-III	
Search Methods: One dimensional optimisation; Fibonacci search; multi dimensional search methods.	
Module-IV	
Univariate search; gradient methods; steepest descent/ascent methods; Conjugate Gradient method; Penalty function approach.	
Module-V	
Dynamic Programming: Principle of optimality; Recursive relations; solution of L.P.Problem; simple examples. Integer Linear Programming: travelling salesman problem	
Text Book:	
1. Optimisation Theory and Applications - S.S.Rao; Wiley Eastern Ltd., New Delhi	
Reference Book:	
1. Introduction to Optimisation - J.C.Pant; Jain Brothers; New Delhi. 2. Optimisation Method - K.V.Mital; Wiley Eastern Ltd. New Delhi.	
Course Outcomes:	

1. Formulate optimization problem.
2. Solve the problem using the methods of linear programming
3. Evaluate the problem using the methods of nonlinear programming
4. Measure the various search methods
5. Assess the problem using the dynamic programming method

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**2**	**1**	**1**	
CO2	**3**	**2**	**1**	**1**	**2**	
CO3	**3**	**1**			**3**	
CO4	**3**	**2**	**1**	**2**	**1**	**2**
CO5	**3**	**2**	**3**	**2**	**1**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	**3**	**2**	**1**	**1**	**2**	**1**