MANIPAL UNIVERSITY JAIPUR
Department of Civil Engineering
M Tech (Structural Engineering)
Batch – 2021-2022

Year	FIRST SEMESTER						SECOND SEMESTER					
	Sub. Code	**Subject Name**	**L**	**T**	**P**	**C**	**Sub. Code**	**Subject Name**	**L**	**T**	**P**	**C**
I	MA6104	Statistics, Probability and Reliability	3	1	0	4	CV6211	Earthquake Engineering	4	0	0	4
	DR6001	Research Methodology	3	0	0	3	CV6212	Bridge Engineering	3	1	1	4
	CV6111	Advanced Structural Analysis	3	1	0	4	CV6213	Structural Dynamics	3	1	1	4
	CV6112	Advanced Design of Reinforced Concrete Structures	4	0	0	4	CV62XX	Program Elective – II	4	0	0	4
	CV6113	Advanced Concrete Technology	4	0	0	4	CV62XX	Program Elective – III	4	0	0	4
	CV61XX	Program Elective – I	3	0	0	3	------	Open Elective	3	0	0	3
	CV6131	Structural Engineering Lab – I	0	0	2	1	CV6231	Structural Engineering Lab - II	0	0	2	1
	CV6180	Minor Project	0	0	2	1	CV6235	Seminar	0	0	2	1
							CV6280	Minor Project	0	0	2	1
			20	2	4	**24**			21	2	6	**26**
	Total Contact Hours (L + T + P)		26				Total Contact Hours (L + T + P) + OE		29			
IV	**THIRD AND FOURTH SEMESTER**											
	CV7080	Dissertation							0	0	0	25
							Total Contact Hours (L + T + P) + OE		0			

Program Elective – I		**Open Elective**	
Sub. Code	**Subject Name**	**Sub. Code**	**Subject Name**
CV6150	Finite Element Method	CV6280	Environmental Management
CV6151	Durability Assessment of Reinforced Concrete Structures		
CV6152	Advanced Solid Mechanics		
CV6153	Design of Industrial Structures		
Program Elective – II			
CV6250	Pre-stressed Concrete Structures		
CV6251	Repair, Rehabilitation and Restoration of Structures		
CV6252	Design of Tall Structures		
CV6253	Design of Hydraulic Structures		
Program Elective – III			
CV6254	Advanced Design of Steel Structures		
CV6255	Plates & Shells		
CV6256	Advanced Foundation Design		
CV6257	Design of Composite Structures		

MANIPAL UNIVERSITY
JAIPUR

Syllabus for M.Tech. Structural Engineering

First Semester

MA6104: STATISTICS, PROBABILITY AND RELIABILITY [3 1 0 4]

Basics of Statistics: Random Variables and its Properties. Applications of Mean, Median, Mode, Standard Deviation, Correlation Coefficient in Analyzing Quality Related Data, Preliminary Analysis of Data by Graphical Representation, Measure of Central Tendency Dispersion, Peakedness in Context with Construction Industry and Quality Control Problems, Dependent Variables, Co-Relation, Co-Relation Coefficient and It's Significance; Basic Probability: Probability of Discrete and Continuous Variables, Probability Mass Function, Probability Density Function, Cumulative Density Function, Discrete and Continuous Standard Probability Distributors and their Properties, Central Limit Theorem, Equivalent Normal Distribution for Non-Normal Distributions, Utilization of Random Events, Measures of Probability Concepts for Quality Control Related Issues, Applications of Frequency Distribution and Probability, Probability Distributors, Continuous And Discrete Distributions in Analyzing Data Related to Process and Quality Control, Goodness of Fit Tests, Chi-Square Test, Kolmogorov-Smirnov Goodness of Fit Test and Two Sample Test, Monte-Carlo Simulation; Reliability Analysis: Concept of Reliability, Risk and Safety Factors. Safety Margin Function, Reliability Index, FOSM Method of Reliability Analysis, Application of FOSM to Linear and Non Linear Safety Margin Functions-Hasofer-Lynd Method.

References:

1. Blank Leland, *Stastical Procedure for Engineering, Management and Science*, Mc-Graw Hill Series in Industrial Engineering and Management Science, 1982.
2. Angand Tang, *Probability Concepts in Engineering Planning and Design*, Vol. I and II, Wiley International, 1984.
3. N. T. Kottegoda, Rosso Renzo, Statistics, *Probability and Reliability for Civil and Environmental Engineers*, Mc-Graw Hill International, 1998.
4. D. D. Wackerly, W. Mendenhall, R. L. Scheaffer, *Mathematical Statistics with Applications*, 7th Edition, Thomson Brooks/Cole, 2008.
5. K. M. Ramachandran, C. P. Tsokos, *Mathematical Statistics with Applications*, Academic Press, 2009.

DR6001: RESEARCH METHODOLOGY [2 0 0 2]

Meaning of research, type of research, Qualitative and quantitative research, defining research problem, review of literature, formulation of theory & hypothesis, data collection, data analysis: hypothesis testing, ANOVA, regression analysis, reporting research findings. Design of experiments, Full and fractional factorial experiments, randomized block design, latin square design, robust design, taguchi method.

References:

1. C. R. Kothari, *Research methodology: methods and techniques*, New Age International Publication Ltd, 2018
2. J.W. Creswell, *Research Design*, Sage South Asia Edition, 2009
3. D.G. Montgomery, *Design and Analysis of Experiments*, John Willy India Edition, 2016

CV6111: ADVANCED STRUCTURAL ANALYSIS [3 1 0 4]

Matrix Methods in Skeletal Structural Analysis: Force and Displacement Methods; Structure on Elastic Foundation; Direct Stiffness Method: Formation of Member Stiffness Matrix; Transformation of Load Vector and Displacement Vector, Formation of Global Stiffness Matrix, Analysis of Continuous Beams, Plane Frames and Plane Trusses.

References:

1. G. M. Gere, Jr. W. Weaver, *Matrix Analysis of Framed Structures*, D Van Nostrand (1987).
2. J. C. McCormac, J. K. Nelson, *Structural Analysis: A Classical and Matrix Approach,* John Wiley and Sons (1997).
3. G. Pandit, S. Gupta, *Matrix Analysis of Structures*, Tata McGraw Hill Publications (2003) .
4. N. G. R. Iyengar, *Elastic Stability of Structural Elements*, Macmillan India Ltd (1980).
5. B. Madhu B Kanchi, *Matrix Method of Structural Analysis*, Wiley Eastern Ltd. (1993)

CV6112: ADVANCED DESIGN OF REINFORCED CONCRETE STRUCTURES [4 0 0 4]

Analysis and Design of the following Reinforced Concrete Structures: Continuous Beams, Multi-storey Frames, Bunkers and Silos, Overhead water tanks: Rectangular and Intze type water tanks Special Structural Elements: Domes, Deep Beams, Brackets or Corbels, Grid Floor Systems; Flats

Slabs: Advantages and Disadvantages of Flat Slabs, Action of Flat Slab, Preliminary Design of Flat Slabs, Basic Action of Two-Way Slab.Pre-fabricated construction: Requirements for pre-fabricated R.C. members – design and erection of pre-fabricated members – general erection principles – transportation and storage joints in pre-fabricated structures – analysis and design of embedded parts. Yield Line Theory: Introduction, Assumptions, Location of Yield Lines, Methods of Analysis, Analysis of One-way and Two-way Slabs.

References:

1. P. C. Varghese, *Limit State Design of Reinforced Concrete*, PHI Learning Publications. (2002)
2. I. C. Syal, A. K. Goel, *Design of Reinforced Concrete Structures*, S. Chand Publications. (2009)
3. M. L. Gambhir, *Fundamentals of Reinforced Concrete Design*, PHI Learning, 2012
4. M. L. Gambhir, *Design of Reinforced Concrete Structures*, PHI Learning, 2012
5. Ramamurtham, R. Narayan, *Design of Reinforced concrete structures*, Dhanpat Rai & Sons. (1981)
6. S. U. Pillai, Devdas Menon, *Reinforced Concrete Design*, Tata McGraw-Hill. (1998)
7. P. M. Ferguron, *Reinforced Concrete Fundamentals*, Wiley Eastern Ltd. (1965)

CV6113: ADVANCED CONCRETE TECHNOLOGY [4 0 0 4]

Microstructural aspects of cement paste; Models of hydrated Portland cement gel; Mechanism, application and specification of chemical admixtures, mineral admixtures and other cement replacement materials; Special cementitious systems, viz., phosphate cement, magnesium oxychloride cement, regulated set cement, high alumina cement etc.; concrete- environment interaction; Marine concrete; Resistance of concrete to Fire and influence of temperature; Extreme weather concreting; Properties and mix proportioning of flyash concrete, silica fume concrete, fibre reinforced concrete, sprayed concrete, high performance concrete, self-compacting concrete and geopolymer concrete.

References:

1. A.M. Neville, *Properties of Concrete*, Pearson Education, 1995
2. M.S. Shetty, *Concrete Technology: Theory and Practices*, S. Chand Publications, 1982
3. A.R. Santha Kumar, *Concrete Technology*, Oxford University Press., 2007

CV6131: STRUCTURAL ENGINEERING LAB – I [0 0 2 1]

Testing of Cement, Aggregate, Steel, Ferro Cement and Mix Design; Test on Permeability Properties of Concrete; Non-destructive Testing of Concrete & Durability Testing of Concrete.

References:

1. A. M Neville, *Properties of Concrete*, Pearson Education, 1995
2. M. S. Shetty, *Concrete Technology: Theory and Practices*, S. Chand Publications, 1982
3. A. R. Santha Kumar, *Concrete Technology*, Oxford University Press., 2007

CV6180: MINOR PROJECT [0 0 2 1]

Students will undertake a project in the domains pertaining to relevant specialization

PROGRAM ELECTIVES- I

CV6150: FINITE ELEMENT METHOD [3 0 0 3]

Brief general description of the method, theory of elasticity - constitutive relationships - plane stress and plane strain. Concept of an element, types of elements, displacement models - compatibility and convergence requirements, displacement models by generalised coordinates, Lagrangian polynomials and Hermitian polynomials. Natural coordinates, formulation of shape functions for different types of elements. Variational method of formulation - Minimization of potential energy approach, formulation of element stiffness and consistent load vector. Application of Finite element method to pin jointed and rigid jointed framed structures. Natural co-ordinates, Isoparametric elements, Numerical Integration. Application to plane stress and plane strain problems.

References:

1. S. S. Bhavikati , *Finite Element Analysis*, New Age International Publishers, New Delhi, 2005
2. C. S. Desai, J. F. Abel, *Introduction to the Finite Element Method: A Numerical Method for Engineering Analysis*, CBS Publisher, 2005
3. R. H. Gallagher, *Finite Element Analysis: Fundamentals*, Prentice Hall, Englewood Cliffs, 1987
4. O. C. Zienkiewicz, R.A. Taylor, *The Finite Element Method*, Butterworth Heinemann (Vol I and Vol II), 2000
5. J. N. Reddy, *An Introduction to the Finite Element Method*, McGraw Hill Inc., 1993

6. C. S. Krishnamoorthy, *Finite Element Analysis, Theory and Programming*, Tata McGraw Hill, 1994
7. K. J. Bathe, *Finite Element Procedures in Engg. Analysis*, Prentice Hall of India, 1996

CV6151: DURABILITY ASSESSMENT OF REINFORCED CONCRETE STRUCTURES [3 0 0 3]

Concrete and the environment - interaction; Physical mechanisms of concrete degradation - shrinkage, thermal cracking, freeze–thaw attack, abrasion and erosion; Chemical mechanisms of concrete degradation - sulphate attack, alkali–aggregate reactions, acid attack; Corrosion of steel reinforcement in concrete - corrosion of steel in concrete, chloride ingress into concrete, carbonation; Specification and design of durable concrete - concrete as a permeable medium, cement, aggregates, admixtures, fibers, specifying durable concrete, concrete mix design, special concrete; Tests for measuring durability - permeability, RCPT, shrinkage, heat of hydration and resistivity tests; Construction of durable concrete structures - surface of concrete, curing, surface protection systems, cathodic protection; Serviceability, repair and maintenance of concrete structures - serviceability of structures, appraisal of structures, in situ testing, laboratory testing, concrete repair products, repair methods, rehabilitation of concrete structures – general principles.

References:

1. P. Dayaratnam, R. Rao, *Maintenance and Durability of Concrete Structures*, University Press, India, 1997.
2. P. Kumar Mehta, Paulo. J. M.Monteiro, *Concrete micro structure properties and materials*, Mc Graw hill Education (India) private Limited, NewDelhi, 2013.
3. Marios Soutsos, *Concrete Durability: A Practical Guide to the Design of Durable Concrete Structures*, Thomas Telford Publisher, 2010.
4. H. Emmons Peter, *Concrete Repair and Maintenance Illustrated*, Galgotia Publications pvt. Ltd., 2001.
5. R. N. Raikar, Learning from failures - Deficiencies in Design, Construction and Service – R and Centre (SDCPL), Raikar Bhavan, Bombay, 1987.
6. A. R. Santha kumar, *Concrete Technology*, Oxford University Press, Printed in India by Radha Press, New Delhi, 110 031, 2007.
7. Dyer Thomas, *Durable Concrete*, 1st edition, CRC Press, 2014.

CV6152: ADVANCED SOLID MECHANICS [3 0 0 3]

Introduction: General Modes of Failure of Members, Direct Stress, Flexure, Torsion Formula and their Limitations; Failure Analysis: Significance and Applications; Shear Centre: Significance, Determination of Its Location for Different Sections; Unsymmetrical Bending: Analysis of Beams, Location and Direction of Neutral Axis, Determination of Stresses; Curved Flexural Members: Circumferential Stress at any Point, Equivalent Area Method, Radial Stresses and Deflections in Curved Beams; Torsion: Torsional Resistance of Bars of Rectangular Section, Elastic Membrane Analogy, Formulae Obtained from Mathematical Analysis, Torsion of Sections Composed of Narrow Rectangles; Beams on Elastic Foundation: Analysis for Concentrated and Uniformly Distributed Loads.

References:

1. F. B. Seely, J. O. Smith, *Advanced Mechanics of Materials*, John Wiley & Sons Ltd., 1952
2. Y. C. Fung, *Fundamentals of Continuum Mechanics*, Prentice Hall, Englewood Cliffs, 1969
3. P. Karasudhi, *Fundamentals of Solid Mechanics*, Kluwer Academy Boston, 2007
4. I. H. Shames, Cozzarelli, *Elastic and Inelastic Stress Analysis*, Taylor and Francis, 1997
5. R. Subramanian, *Strength of Materials*, Oxford University Press, 2012.

CV6153: DESIGN OF INDUSTRIAL STRUCTURES [3 0 0 3]

Design of Single and Multi Bay Industrial Structures in Steel and Concrete, Tubular Trusses and Space Frames; Bunkers and Silos, Pressure Vessels and Chimneys, Communication Towers, Cooling Towers, Suspended Roof Structures, Large Span Roof Structures, Structural Aspects of Machine Foundations.

References:

1. A. L. Ajmani, A. S. Arya, *Design of Steel Structures*, Nem Chand and Brothers, 2000.
2. C. W. Dunham, *Planning of Industrial Structures*, John Wiley and Sons, 2001.
3. W. Gary, *Steel Designer's Manual*, Prentice Hall, 2008
4. F. Glower, *Structural Pre-cast Concrete*, Oxford Publishers, 2008
5. I. C. Syal, A. K. Goel, *Design of Reinforced Concrete Structures*, S. Chand Publications, 2009

Second Semester

CV6211: EARTHQUAKE ENGINEERING [4 0 0 4]

Past Earthquakes: Review of Damage in Past Earthquakes, Earthquake Response of Structures, Idealization of Structures, Response Spectrum Analysis, Equivalent Lateral Force Concepts, Torsionally Coupled Systems, Orthogonal Effects, Nonlinear, Pushover and Time History Analysis; Philosophy of Earthquake Resistant Design: Ductility, Redundancy & Over Strength, Damping, Base Isolation Supplemental Damping, Codal Provisions; Seismic Behaviour of Structures: Concrete Structures, Steel and Masonry Structures, Material Properties, Analysis of Members Under Cyclic Loads, Detailing Provisions, Concepts of Structural Control; Effects of Soil-Structure Interaction.

References:

1. W. Ray Clough, J. Penzien, *Dynamics of Structures*, McGraw-Hill, 1975.
2. J. P. D. Hartog, *Mechanical Vibrations*, McGraw Hill Book Co., 1989.
3. S. P. Timoshenko, *Vibration Problems in Engineering*, D. Van Nostrand Company Inc., 2007.
4. P. Aggarwal, M. Shrikhande, *Earthquake Resistant Design of Structures*, McGraw-Hill, 2003.

CV6212: BRIDGE ENGINEERING [3 1 0 4]

General: Bridge System, Considerations in Alignment, Planning, Economic Consideration, Aesthetics and Selection of Type of Bridge (Review); Loading Standards: Standards Followed in U.K., U.S.A. and Europe; Super Structure Analysis: Bridge Deck Analysis Using Different Methods, Load Distribution Theories – Carbon Specifications for Loading, Geometrical Proportioning of Road, Rail-Cum-Road Bridges, Indian Road Congress (IRC) and Indian Railway Loading Standards; Limit Analysis: Design of Bridge Decks; Connections: Design of Different Connections, Bearings and Joints; Substructure Analysis and Design: Piers, Abutments, Wing Walls and Other Appurtenant Structures; Foundations: Well Foundations and Pile Foundation, Design and Construction and Field Problems; Construction & Maintenance: Erection of Bridge Super Structure, Maintenance, Rating and Strengthening of Existing Bridges; Dynamics Behaviour: Behaviour of Bridges Under Dynamic Loads, Discussion of Code Provisions for Design of Bridges for Wind and Earthquake Forces; Long Span Bridges: General Discussion of Suspension and Cable Stayed Bridges.

References:

1. B. Bakht, L.G. Jaeger, *Bridge Analysis Simplified,* McGraw-Hill Book Company, 1985.
2. A. R. Cusens, R.P. Parma, *Bridge Deck Analysis*, John Wiley & Sons Ltd, 1975.
3. E. C. Hambly, *Bridge Deck Behaviour*, Chapman and Hall, 1991.
4. N. Krishna Raju, *Design of Bridges*, Oxford and IBH Publications, 1998.
5. R. Ponnuswamy, *Bridge Engineering*, Tata McGraw Hill, 1997
6. V. K. Raina, *Concrete Bridge Practice*, Tata McGraw Hill Publications, 1991.
7. T. R. Jagdeesh, M. A. Jayaram, *Design of Bridge Structures*, PHI Learning Publications, 2009

CV6213: STRUCTURAL DYNAMICS [3 1 0 4]

Introduction: Objectives, dynamic loading, types of dynamic problems. Formulation of equations of motion: a) D'Alembert's principle b) Principle of virtual work c) Variational approach. Single Degree of Freedom Systems: Components of the system, un-damped and damped free vibrations, and logarithmic decrement. Forced vibrations due to harmonic excitation – steady state and transient response, transmissibility, vibration isolation, evaluation of damping – half power band width method. Forced vibrations due to general dynamic loading – Duhamel's integral, response of SDOF system to impulsive loading, numerical methods – direct integration (constant and linear acceleration) of Duhamel's integral, trapezoidal rule and simpson's rule: Response to periodic loading – Fourier Analysis. Multi-Degree of Freedom Systems: Equations of motion, un-damped and damped free vibration, eigenvalues and eigen vectors, orthogonality conditions. Free vibration of shear buildings with and without damping. (Harmonic and impulse loads only), Approximate methods for the analysis of multi-degree of freedom un-damped systems – Raleigh's method, improved Raleigh's method, Dunkerley's method, Raleigh - Ritz method, matrix iteration method. Continuous Systems: Free longitudinal vibration of bars, flexural vibration of single span beams, forced vibration of beams.

References:

1. M. Paz, *Structural Dynamics – Theory and Computation*, C.B.S. Publishers & Distributor, 2004
2. R. W. Clough, J. Penzin, *Dynamics of Structures*, McGraw Hill International Editions, 1993
3. S. R. Damodarasamy, S. Kavitha, *Basics of Structural Dynamics and Aseismic Design,* PHI Learning, 2012.

CV6231: STRUCTURAL ENGINEERING LAB - II [0 0 2 1]

Programming for Structural Analysis, Software for Analysis, Introduction to Standard Software for Structural, Geo-technical engineering and Introduction to Soft Computing Skills.

References:

1. www.bently.com

CV6235: SEMINAR [0 0 2 1]

Students will present a seminar on topic related to relevant specialization.

CV6280: MINOR PROJECT [0 0 2 1]

Students will undertake a project in the domains pertaining to relevant specialization.

PROGRAM ELECTIEVES- II

CV6250: PRE-STRESSED CONCRETE STRUCTURES [4 0 0 4]

Review: Basic Principles, External and Internal Pre-Stressing, Systems of Pre-Stressing, Partial Pre-Stressing, Loss of Pre-Stress, Materials Used, Advantages and Disadvantages; Working Stress Design of Simple Beams: Design Procedure Based on Flexure, Minimum Weight Design, Cable Layout and Profile of Tendons, Design by Load Balancing Method; Pre-Stressed Concrete Composite Beams: Allowable Stress Considerations, Shrinkage Stresses; Continuous Beams: Two Span Continuous Beams and their Analysis; Pre-Stressed Concrete Slabs: One-way and Two-way Slabs, Beam and Slab Construction, Flat Slab; Shear and Bond in Pre-Stressed Concrete: Principal Stresses, Failure Due to Shear, Combined Bending and Shear, Bond in Pre-Tensioned Construction, Bond in Post Tensioned Construction; Limit State Design : Introduction, Strength Limit State in Flexure, Limit State of Strength in Shear, Torsion, Limit State Strength at Transfer Condition, Limit State of Serviceability, Durability Limit State, Partially Pre-Stressed Concrete Beams, Design Examples.

References:

1. G. S. Pandit, S. P. Gupta, *Prestressed Concrete,* CBS Publishers and Distributers, 2009
2. T. Y. Lin, *Design of Pre-stressed Concrete Structures*, John Wiley and Sons, 2012
3. N. Krishna Raju, *Pre-stressed Concrete,* Tata McGraw Hill, 2015
4. A. H. Nilson, *Design of Pre-stressed Concrete*, John Wiley, 2010
5. S. Ramamurtham, *Pre stressed cement concrete*, Dhanpat Rai.& Sons, 2012

CV6251: REPAIR, REHABILITATION AND RESTORATION OF STRUCTURES [4 0 0 4]

Performance of construction materials and components in services; Causes of deterioration; preventive measurements and maintenance, principles of assessment of weathering and durability Deterioration process in concrete structures, Construction and design defects Diagnostic methods, Load testing and non-destructive testing. Causes and prevention of cracks in masonry structures, Corrosion in structures, process and prevention, Fire damage of buildings. Repair materials, cement aggregate, polymer and construction chemicals Management of concrete for durability. Damage assessment and restoration techniques, case studies of restoration works, buildings, bridges, water retaining structures, marine structures. Special repairs, maintenance inspection and planning, Budgeting and management.

References:

1. Peter H. Emmons, *Concrete Repair and Maintenance Illustrated*, Galgotia Publications Pvt. Ltd., New Delhi, 2001.
2. R. T. L. Allen, S. C. Edwards, *The Repair of Concrete Structures*, Blackie &Sons Ltd., Glasgow, London, 1987.
3. Tedkay, *Assessment and Renovation of Concrete Structures*, Longman SCVntific & Technical, Harlow, England, 1992.
4. R Jagadisa, *Structural Failures- Case Histories*, Goford & IBH Publishing Co. Ltd., New Delhi, 1995.
5. R. N. Raikar, *Diagnosis and Treatment of Structures in Distress*, R & D centre Structural Designers & Consultants Pvt. Ltd., Vashi, New Bombay, 1994.

CV6252: DESIGN OF TALL STRUCTURES [4 0 0 4]

Basic Concepts: Structural Systems for Tall Buildings; Analysis of Frames: Moment Resistant Frames, Braced Frames, Eccentrically Braced Frames; Shear Walls: Coupled Shear Walls, Frame Shear Wall Interaction; Tubular Structures: Approximate and Matrix Oriented Methods of Design, Foundations: Design of Pile and Raft Foundation for Tall Buildings.

References:

1. B. S. Smith, A. Coull, “Tall Building Structures: Analysis and Design”, John Wiley and Sons, 2002
2. B. S. Taranath, “Analysis and Design of Tall Buildings”, Tata McGraw-Hill Limited, 1998

CV6253: DESIGN OF HYDRAULIC STRUCTURES [4 0 0 4]

Dams, Design and Construction of Gravity Dams, Buttress and Arch Dams, Embankment Dams, Canals and Canal Structures, Coastal Structures

References:

1. R. S. Varshney, *Concrete dams*, Oxford & IBH Publications, 1978
2. S. Sathyanarayana Murthy, *Design of Minor Irrigation & Canal structures*, New Age Publications, 1990.
3. W. P. Justin, J. D. Hinds, J. Creager, *Engineering for Dams* (all volumes) Wiley India Publications.
4. S. K. Garg, *Irrigation Engineering*, Khanna Publications, 2013.

PROGRAM ELECTIEVES- III

CV6254: ADVANCED DESIGN OF STEEL STRUCTURES [4 0 0 4]

Limit State Design: Design of Tension, Compression and Flexural Members, Post Buckling Behaviour of Compression Members, Design of Beam Columns; Plastic Design: Flexure of Beams, Analysis for Ultimate Load, Analysis and Design of Continuous Beams and Portal Frames; Light- gauge Cold Formed Steel Design: Materials used, Strength of their Elements and Design Criteria, Flexural Members, Compression Members, Design as per IS: 701, Use of IS: 711 and SP 6(5).

References:

1. N. Subramanium, *Design of Steel structures*, Oxford University Press, 2008
2. N. Subramanium, *Steel structures: Design and Practices*, Oxford University Press, 2010
3. L. S. Beedle, *Plastic design of steel frames*, John Wiley and Sons Inc., 1998
4. W. W. Yu, *Cold-framed steel design*, John Wiley and Sons Inc., 2000
5. I. C. Syal, S. Singh, *Design of Steel Structures*, Standard Publishers & Distributers, 2000
6. V. K. Menieka Selvam, *Fundamentals of Limit Analysis of Structures*, Dhanpat Rai & Sons, 1986
7. B. S. Krishnamachar, D.A. Sinha, *Design of steel structures*, Tata Mc Graw Hill, 1978
8. K. M. Ghosh, *Analysis and Design: Practice of Steel Structures*, PHI Learning Pvt Ltd. 2010.

CV6255: PLATES & SHELLS [4 0 0 4]

Plate Equation: Behaviour of Thin Plates in Cartesian, Polar and Skew Coordinates; Curvilinear Coordinates and Coordinate Transformation; Isotropic and Orthotropic Plates: Bending and Twisting of Plates; Navier and Levy Solutions and Energy Methods: Rectangular, Circular Plates and Plates with Variable Rigidity in Cartesian and Polar Coordinates, Numerical Solutions; Shells: Shell Behaviour, Shell Surfaces and Characteristics, Classifications of Shells, Equilibrium Equations in Curvilinear Coordinates, Force Displacement Relations; Membrane Analysis: Shells of Revolution and Cylindrical Shells Under Different Loads, Shallow Shells; Concept of Pseudo Stresses: Membrane Solution of Elliptic Paraboloids and Hyperboloids, Solutions of Typical Problems.

References:

1. S. Timoshenko, Goodier, *Plates and Shells,* McGraw-Hill, 1994
2. IS. : 2210-1982: Indian Standard Criteria for the Design of R.C.C. Shell Structures and Folded Plates, 1982
3. G. S. Ramaswamy, *Design Construction Concrete Shell Roofs*, CBS Publishers, 1998

CV6256: ADVANCED FOUNDATION DESIGN [4 0 0 4]

Bearing capacity: Bearing capacity of shallow foundation in layered soils, Footings on slopes, Foundation with uplift or tension forces. Settlements: Settlement Analysis of shallow foundations in sand, clay, and layered deposits, Reliability of settlement calculations, Structural tolerances. Design of rectangular footings, combined footings and mat foundations. Deep foundations: Pile foundations under vertical and lateral loads, Negative skin friction of piles; Uplift capacity of piles and anchors, Well foundations. Foundations on expansive soils; Introduction to soil dynamics and machine foundation

References:

1. J. E. Bowels, *Foundation Analysis & Design*, Mc Graw Hill, 2006
2. B. M. Das, *Principles of Foundation Engineering*, PWS Publishing, 2004

CV6257: DESIGN OF COMPOSITE STRUCTURES [4 0 0 4]

FRP composites, Types, Mechanics, behaviour, properties, application; Steel & Concrete composite structures, design philosophy, shear connectors, beams, girders and slabs, Concrete & Prestressed concrete composite structures.

References:

1. R. P.Johnson, *Composite structure of steel and concrete*, Willey Publication, 2004

2. M. Mukhopadhay, *Mechanics of composite material and structure*, Cambridge University press, 2004
3. D. Hull, *An Introduction to Composite Material*, Cambridge University Press, 2006

OPEN Elective

CV6280: Environmental Management [3 0 0 3]
Environmental Economics: Introduction, Economic Tools for Evaluation, Cleaner Development Mechanisms (CDM) and their Applications; Environmental Laws and Policies: Water Act, Air Act, Environment Protection Acts, Solid Waste Management Rules, Hazardous and Biomedical Waste Rules; Environmental Audit: Methods, Procedure, Reporting and Case Studies; Environmental Management System and Techniques: Environmental Safety and ISO 14000 Standards, ISO 14001 Standards, Environmental Management Systems, (EMS) Total Quality Management (TQM) and Total Safety Management (TSM), ISO 9000 and ISO 18000 Standards.

References:

1. A. R. N. Sankar, *Environmental Management*, Oxford University Press, New Delhi, 2015.
2. M. M. Sulphey, *Introduction to Environmental Management*, PHI Learning, New Delhi, 2013.
3. MOEF, Government of India, "*Carrying Capacity Based Developmental Planning Studies for the National Capital Region"*, 1995-96.
4. *Environmental Laws* - MOEF, Government of India.

Third and Fourth Semester

CV7080: DISSERATION [0 0 0 25]
Students will undertake a project in the domains pertaining to relevant specialization.