VEERMATA JIJABAI TECHNOLOGICAL INSTITUTE

(VJTI)

MATUNGA, MUMBAI 400 019

(Autonomous Institute affiliated to University of Mumbai)

Curriculum
(Scheme of Instruction & Evaluation and Course contents)

For
Third Year Syllabus
Bachelor of Technology (B.Tech.) Degree in Civil Engineering

Implemented from the batch admitted in Academic Year 2023-24

[NEP 2020 Based syllabus]

VEERMATA JIJABAI TECHNOLOGICAL INSTITUTE, MUMBAI-400 019.
Civil & Env. Engg. Dept.

Dean-Academics
VJTI MUMBAI

Program Educational Objective

PEO1	Develop a professional to pursue career as a Civil Engineer with adequate technical knowledge and skills while using modern tools for problem solving and exhibiting qualities of communication, team membership, and leadership
PEO2	Develop ability to practice ethically focusing on social relevance, environmental sustainability, optimal solutions and safety of stakeholders.
PEO3	Develop abilities of lifelong learning to continuously strive to enhance decision making abilities to investigate, design and develop complex facilities.

Program Specific Outcomes

PSO1	Able to analyze various Civil Engineering structures and systems by using basic and advanced technologies.
PSO2	Able to design civil engineering facilities and their elements and also use of modern software tools for the same.
PSO3	Able to plan, monitor and supervise construction activities to complete civil engineering facilities satisfactorily.
PSO4	Able to practice as a construction professional through ethical practice while focusing on sustainability and economy.

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Program Outcomes

PO-1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering and technology to the solution of complex mechanical engineering problems.
PO-2	**Problem analysis**: Identify, formulate, review existing literature, and analyze complex engineering problems to reach substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO-3	**Design/Development of solutions**: Design solutions for mechanical engineering problems and design system components or processes that meet the specified needs with appropriate consideration for societal, economical and environmental considerations.
PO-4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO-5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex mechanical engineering activities with an understanding of the limitations.
PO-6	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.
PO-7	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO-8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO-9	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO-10	**Communication**: Communicate effectively with the engineering community and with society at large, including the ability to comprehend, create effective reports, make effective presentations, and give and receive clear instructions.
PO-11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO-12	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

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Credit Framework for UG Programme in Civil Engineering (Level 5.5- B. Voc. or B. Sc. (Tech.)) - Semester - V

Sr.	Course Type	Course Code	Course Name	L	T	P	Hr	Cr	Examination Weightage in %		
									TA	MST	ESE
1	PCC	R5CE3001T	Quantity Survey and Estimation	2	1	0	3	3	20	30	50
2	PCC	R5CE3001L	Quantity Survey and Estimation Laboratory	0	0	2	2	1	ISCE: 60		40
3	PCC	R5SE3001T	Design of Reinforced and Pre-stressed concrete structure	3	0	0	3	3	20	30	50
4	VSEC	R5SE3001L	Design of RCC Laboratory	0	0	2	2	1	ISCE: 60		40
5	PCC	R5CE3002T	Transportation Engineering	3	0	0	3	3	20	30	50
6	PCC	R5CE3002L	Transportation Engineering Laboratory	0	0	2	2	1	ISCE: 60		40
7	PCC	R5CE3003L	Engineering Geology Laboratory	0	0	2	2	1	ISCE: 60		40
8	PCC	R5SE3002T	Geotechnical Engineering	3	0	0	3	3	20	30	50
9	PEC	R5CE3101T*	Programme Elective Course – I	3	1	0	4	4	20	30	50
10	MDM	R5CE3201T*	Multidisciplinary Minor – III	3	0	0	3	3	20	30	50
11	VSEC	R5CE3004L	Disaster Planning and Management	0	0	2	2	1	ISCE: 60		40
			Total	17	2	10	29	24			

Abbreviations: **T** Theory Course, **L** Laboratory Course, **I** Internship, **P** Project, **TA** Teacher Assessment / Term work Assessment, **MST** Mid Semester Test, **ESE** End Semester Written Examination, **ISCE** In-semester Continuous Evaluation, **PCC** Program Core, **MDM** Multi-Disciplinary Minor **VSEC** Vocational and Skill Enhancement Course, **OE** Open Elective, **VEC** Value Education Course

* Relevant Course Code for Program elective, Open Elective, and Multidisciplinary Minor (Sem V) to be used

VEERMATA JIJABAI TECHNOLOGICAL INSTITUTE, MUMBAI-400 019
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Credit Framework for UG Programme in Civil Engineering (Level 5.5- B. Voc. or B. Sc. (Tech.)) - Semester – VI

Sr.	Course Type	Course Code	Course Name	L	T	P	Hr	Cr	Examination Weightage in %		
									TA	MST	ESE
1	PCC	R5SE3003T	Design of Steel Structures	3	0	0	3	3	20	30	50
2	PCC	R5SE3003L	Design of Steel Structures Laboratory	0	0	2	2	1	ISCE: 60		40
3	PCC	R5CE3005T	Pavement Engineering	3	0	0	3	3	20	30	50
4	HSSM	R5CE3006T	Construction Management	3	0	0	3	3	20	30	50
5	HSSM	R5CE3006L	Construction Management Laboratory	0	0	2	2	1	ISCE: 60		40
6	HSSM	R5CE3007T	Infrastructure Development Planning	2	0	0	2	2	ISCE: 60		40
7	PEC	R5CE3201T*	Programme Elective Course – II	3	1	0	4	4	20	30	50
8	MDM	R5CE3204T*	Multidisciplinary Minor – IV	3	0	0	3	3	20	30	50
9	OE	R5CE3301T*	Open Elective – I	3	1	0	4	4	20	30	50
			Total	20	2	4	26	24			

Abbreviations: **T** Theory Course, **L** Laboratory Course, **I** Internship, **P** Project, **TA** Teacher Assessment / Term work Assessment, **MST** Mid Semester Test, **ESE** End Semester Written Examination, **ISCE** In-semester Continuous Evaluation, **PCC** Program Core, **MDM** Multi-Disciplinary Minor **VSEC** Vocational and Skill Enhancement Course, **OE** Open Elective, **VEC** Value Education Course

*Relevant Course Code for Program elective, Open Elective, and Multidisciplinary Minor (Sem VI) to be used

List of Exit Courses after completion of Semester V and VI

1. Exit option is available for students those who have earned the total 128 credits at the End of Sixth Semester.
2. Student who wants to avail the exit option after third year have to earn additional 6-8 credits from the list of courses shown below.
3. These courses student have to complete within summer vacation after 3rd Year.
4. After fulfilment as mentioned in 1 to 3 above, Students can earn B. Voc. or B. Sc. (Tech.) and same will be issued by the Institute.

List of Exit Courses after completion of Semester V and VI: Civil Engineering

Sr.	Course Type	Course Code	Course Name	L	T	P	Hr	Cr	Examination Weightage in %		
									TA	MST	ESE
1	EC	R5CE3901I	Internship (6-8 weeks)					6	ISCE: 60		40
2	EC	R5CE3902P	Project / Mini-Project	0	0	12	12	6	ISCE: 60		40
3	EC	R5CE3903T	Health and Safety Management	3	0	0	3	3	20	30	50
4	EC	R5CE3904T	Sustainable and green construction	3	0	0	3	3	20	30	50
5	EC	R5CE3905T	Water Resource Management	2	0	0	2	2	20	30	50
6	EC	R5CE3905L	Water Resource Management Laboratory	0	0	2	2	1	ISCE: 60		40
7	EC	R5CE3906T	Introduction and Application of AI, ML and IOT for Civil Engineering	3	0	0	3	3	20	30	50
8	EC	R5CE3907T	Formwork Engineering	3	0	0	3	3	20	30	50
9	EC	R5CE3908T	Tunnel Engineering	3	0	0	3	3	20	30	50

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PROGRAM ELECTIVES TRACK

	Elective-1 (Sem V)	Elective-2 (Sem VI)	Elective-3 (Sem VII)	Elective-4 (Sem VII)
Structural Engineering I	Advanced structure analysis	Introduction to Non-Linear Analysis of structures.	Structural health monitoring	Advanced design of concrete and steel structure
Structural Engineering II	Bridge engineering	Repair, Retrofitting, and strengthening of structure	Advanced Concrete Technology	Earthquake Engineering and structural dynamics
Construction Engineering and Management	Advanced Construction Techniques	Construction Equipment and Resource Management	Construction Contract Management	Rehabilitation of Buildings
Geotechnical Engineering	Advanced Foundation Engineering	Earth Pressure and Retaining Structures	Soil Dynamics and Machine Foundation	Geosynthetic Engineering
Geo Informatics	Satellite Image Processing	Remote Sensing	Hydrographic surveying	Digital Terrain Analysis
Environmental Engineering	Environmental Legislation and Management	Environmental Impact Assessment and Audit	Unit Operations and Processes in Environmental Engineering	Solid and Hazardous Waste Management
Transportation Engineering	Intelligent Transportation Systems for smart cities	Pavement Management System	Transportation Economics	High Speed Rail Engineering

Hydrology & Water Resources Engineering	Watershed Conservation and Management	Dam and Hydropower Engineering	Groundwater Engineering	Water Resources System Planning and Management
Hydraulics	River Engineering	Stormwater Management	Computational Fluid Dynamics	Design of hydraulic structures/Irrigation Engineering

Course Codes for Program Electives (PEC)

Sr. No.	Course Code	Program Elective I (Sem V)	Name of the Program Elective track
1	R5SE3101T	Advanced Structure Analysis	Structural Engineering I
2	R5SE3102T	Bridge Engineering	Structural Engineering II
3	R5CE3101T	Advanced Construction Techniques	Construction Engineering and Management
4	R5SE3103T	Advanced Foundation Engineering	Geotechnical Engineering
5	R5CE3102T	Satellite Image Processing	Geo Informatics
6	R5CE3103T	Environmental Legislation and Management	Environmental Engineering
7	R5CE3104T	Intelligent Transportation Systems for smart cities	Transportation Engineering
8	R5CE3105T	Watershed Conservation and Management	Hydrology & Water Resources Engineering
9	R5CE3106T	River Engineering	Hydraulics

Course Codes for Program Electives (PEC)

Sr. No.	Course Code	Program Elective II (Sem VI)	Name of the Program Elective track
1	R5SE3104T	Introduction to Non-Linear Analysis of structures.	Structural Engineering I
2	R5SE3105T	Repair, Retrofitting, and strengthening of structure	Structural Engineering II
3	R5CE3107T	Construction Equipment and Resource Management	Construction Engineering and Management
4	R5SE3106T	Earth Pressure and Retaining Structures	Geotechnical Engineering
5	R5CE3108T	Remote Sensing	Geo Informatics
6	R5CE3109T	Environmental Impact Assessment and Audit	Environmental Engineering
7	R5CE3110T	Pavement Management System	Transportation Engineering
8	R5CE3111T	Dam and Hydropower Engineering	Hydrology & Water Resources Engineering
9	R5CE3112T	Stormwater Management	Hydraulics

Course Codes for Multi-Disciplinary Minors (MDM)

Sr. No.	Course Code	Name of the MDM Course in Sem V	Name of the MDM
1	R5CE3201T	Product Design and Manufacturing	Innovation and Entrepreneurship
2	R5CE3202T	Project Accounting and Cost Management	Contract Law, Arbitration, and Valuation
3	R5CE3203T	Environmental Economics	Sustainable Environment

Course Codes for Multi-Disciplinary Minors (MDM)

Sr. No.	Course Code	Name of the MDM Course in Sem VI	Name of the MDM
1	R5CE3204T	Six Sigma	Innovation and Entrepreneurship
2	R5CE3205T	Construction Safety, Quality, and Risk Management	Contract Law, Arbitration, and Valuation
3	R5CE3206T	Air and Noise pollution control engineering	Sustainable Environment

Course Codes for Open Elective (OE)

Sr. No.	Course Code	Name of the MDM Course in Sem VI
1	R5CE3301T	Geographical Information System
2	R5CE3302T	Sustainable Development

Semester V

Semester - V		Program Core Course (PCC)						
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
1	R5CE3001T	Quantity Survey and Estimation	2-1-0 = 3	3	20	30	50	3
	Course Outcome: After completion of course students will be able to 1. Estimate quantities of different items of civil engineering works. 2. Prepare specifications for different items of civil works. 3. Analyze rates for various items of works. 4. Prepare tender documents for civil works. 5. Perform valuation of different civil engineering structures.							

Module	**Course Contents**
1	**Introduction** Estimate, purpose, types, comparison, units of measurements, rules for deductions as per IS 1200
2	**Approximate Estimates** Various types, their relative importance. Factors to be considered, purpose, different methods. Estimation by various methods
3	**Detailed Estimates** Methods of preparation of estimates for projects such as Building R.C.C and load bearing, Roads, miscellaneous works like Manhole, water storage tank, septic tanks etc. Bar bending schedules, Mass haul Diagrams, Earthwork Calculations, work charged establishment, schedule of rates, provisional sum, Bill of quantities, centage charges, contingencies, administrative approval, technical sanction, Market survey of basic materials, thumb rules for computation of different materials for buildings. Percentage break up of costs.
4	**Specifications** Types, requirements, and importance, drafting of specifications, detailed specifications for the buildings, roads, minor bridges, and industrial structures.
5	**Rate analysis** Purpose, importance and necessity of the same, factors affecting task work, daily output from different equipment, rate analysis of common building items
6	**Contract and Tender** Preparation of tender documents, importance of inviting tenders, tender notice,

	contract types, relative merits, prequalification. general and special conditions, termination of contracts, extra work and items, penalty and liquidated charges, Settlement of disputes, R.A. Bill & Final Bill, Payment of advance, insurance, claims, price variation. Methods of registration of contracts, Online process, Documents required, E tendering Procedures, Various types of contracts and tender Accepting procedure B1 Percentage Rate B2 Item rate C Lump sum Basis EPC Engineering Procurement and construction AMC Annual Maintenance Contract Hydrid Annuity Module Swiss Challenge Method
7	**Valuation** Different terms used, the role of a valuer, purpose and necessity of the same. Capitalised Value, Years purchase, sinking fund, depreciation, types of values, Purpose of valuation, Different methods of valuation for (i) open plots, (ii) open plots with existing residential & commercial structures, (iii) lease hold properties. Use of valuation tables and formulae. Arbitration Cases, Taxation in Construction Industry
8	**Project Implementation** Agency involved in Implementation, methods of implementation like BOT, BOOT, BOO, BOLT, EPC etc
9	Estimates and Costing of Bridges, Roads, DPR Preparation, Socio Economic Impact, ENV, Clearances, Statutory bonds,
	Recommended Reading 1 M Chakraborti, Estimating, Costing, Specification & Valuation in Civil Engineering, Chakraborti (2006), (ISBN: 818530436X) 2 Dutta B. N., Estimating and Costing In Civil Engineering, UBS Publishers' Distributors Pvt. L td; 28th Revised Edition edition (2016), (ISBN: 8174767703). 3 Patil B.S., Building & Engineering Contracts, Mrs. S. B. Patil; 2011 edition (2011), (ISBN:8190979701). 4 Joy P. K., Handbook of Construction Management, Macmillan Publishers India (2000), (ISBN: 0333926935)

Semester - V		Program Core Course (PCC)						
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
2	R5CE3001L	Quantity Survey and Estimation Laboratory	0-0-2 = 2	1	ISCE:60		40	3
	Course Outcome: After completion of course students will be able to 1. Formulate specifications for different items of civil engineering works 2. Prepare Estimate of civil engineering structures. 3. Analyze the rates							

	Course Contents
	1. To prepare estimate of a residential building 2. To compute the quantities of reinforcement from bar bending schedules 3. To prepare the estimate of a septic tank 4. To prepare the estimate of road work 5. To draft the specifications for various civil engineering works 6. To analyze the rates for various items of works
	Text Books: 1 M Chakraborti, Estimating, Costing, Specification & Valuation in Civil Engineering, Chakraborti (2006), (ISBN: 818530436X) 2 Dutta B. N., Estimating and Costing In Civil Engineering, UBS Publishers Distributors Pvt. Ltd; 28th Revised Edition (2016), (ISBN: 8174767703). 3 Joy P. K., Handbook of Construction Management, Macmillan Publishers India (2000), (ISBN: 0333926935)

Semester - V		PCC						
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
3	R5SE3001T	**Design of Reinforced and Pre-stressed concrete structure**	3-0-0=3	3	20	30	50	3

Course Outcomes

After completion of this course, students will be able to,

1. Implement concept of working stress method for analysis and design of RCC structural elements.
2. Implement concept of limit state method for analysis and design of RCC structural elements.
3. Apply principles of pre-stressed concrete for design of PC.

Module	Course Contents
1	**Working stress method and ultimate load method of design:** Reinforced Concrete Fundamentals (working Stress Method): Concept of reinforced concrete, stress strain characteristics of concrete and steel reinforcement, elastic theory, singly reinforced, balanced section, under reinforced section and over reinforced section.
2	**Limit state method of design:** Concepts of probability and reliability, characteristic loads, characteristic strength, partial safety factors for loads and materials, introduction to limit states of collapse in flexure, direct compression, shear and limit states of serviceability in deflection and cracking, design of singly and doubly reinforced rectangular and T sections for flexure. Design of members in shear and bond. Design of columns for Axial Load, Uni-axial bending moment and Bi-axial bending moment as per IS Code method. Design of one-way and two-way slabs. Design of beam subjected to bending and torsion. Design of Isolated square and rectangular footings subjected to axial load and moments, Design of combined foundations. Design of Doglegged, Open well type staircases. Design of Flat slab and Post tensioned slab
3	**Pre-stressed concrete:** Basic principles of pre-stressed concrete: materials used and their properties, methods and systems of pre-stressing. Losses in pre-stress, analysis of various types of sections subjected to pre-stress and external loads.Prestressed and post

	tensioned members
	Recommended Reading 1. P. Dayaratnam, Design of Reinforced Concrete Structures, Oxford & IBH. (ISBN-9789386479785/9386479788). 2. T.Y. Lin, Design of Prestressed Concrete Structures, John Wiley and Sons Inc., 2010. (ISBN-9788126528035/978-8126528035). 3. P.D. Arthur and V. Ramkrishnan, Ultimate Strength Design for Structural Concrete, Wheeler &Co. Pvt Ltd. (ISBN- 0273403230, 978-0273403234). 4. B.P. Hughes, Limit State Theory for Reinforced Concrete Design, Pitman. (ISBN-0273010239, 978-0273010234). 5. IS456 (2000), Plain and Reinforced Concrete. 6. IS 875 (1987), Part I- Design Loads (Other than earthquake) for Buildings and Structures (Dead Loads). 7. IS 875 (1987), Part II- Design Loads (Other than earthquake) for Buildings and Structures(Imposed Loads). 8. IS 875 (2015), Part III- Design Loads (Other than earthquake) for Buildings and Structures (Wind Loads). 9. IS 875 (1987), Part IV- Design Loads (Other than earthquake) for Buildings and Structures (Snow Loads). **Textbooks** 1 Jain and Jaikrishna, Plain and Reinforced Concrete, Vol. I, Nemchand Brothers.(ISBN-8185240086/978-8185240084). 2 V. L. Shah and Karve, Limit State Design - Reinforced Concrete Structures Publications. (ISBN- 9788190371711/8190371711). 3 N. Krishna Raju, Pre-stressed Concrete, Tata McGraw Hill. (ISBN-9789387886209/9387886204).

Semester - V		VSEC						
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
4	R5SE3001L	Design of RCC Laboratory	0-0-2=2	1	ISCE: 60		40	3

Course Outcomes

After completion of this course, students will be able to,

1. Analyze and design beam, column, slab, foundation, staircases and cantilever and counterfort retaining walls.
2. Draw detailed structural drawings for slab, beam, column, foundation, staircases and cantilever and counterfort retaining walls.

Module	Course Contents
	1. Design and drawing of singly reinforced, doubly reinforced rectangular and T-section simply supported and continuous beam. 2. Design and drawing of one way, two way simply supported and continuous slab system. 3. Design and drawing of Dog-legged and open wall type staircases. 4. Design and drawing of columns and foundation. 5. Design and drawing of Retaining wall. (Cantilever and counterfort)
	Recommended Reading 1. P. Dayaratnam, Design of Reinforced Concrete Structures, Oxford & IBH. (ISBN-9789386479785/9386479788). 2. T.Y. Lin, Design of Prestressed Concrete Structures, John Wiley and Sons Inc., 2010. (ISBN-9788126528035/8126528036). 3. P.D.Arthur and V.Ramkrishnan, Ultimate Strength Design for Structural Concrete, Wheeler&Co. Pvt Ltd. (ISBN- 0273403230/978-0273403234). 4. B.P. Hughes, Limit State Theory for Reinforced Concrete Design, Pitman. (ISBN-0273010239/978-0273010234). **Textbooks**

	1. Jain and Jaikrishna, Plain and Reinforced Concrete, Vol. I, Nemchand Brothers.(ISBN-8185240086/978-8185240084). 2. V.L. Shah and Karve, Limit State Design - Reinforced Concrete Structures Publications. (ISBN- 9788190371711/ 8190371711). 3.K. Raju, Pre-stressed Concrete, Tata McGraw Hill.(ISBN-9789387886209/9387886204).

Semester -V		Program Core Course (PCC)						
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
5	R5CE3002T	Transportation Engineering	3-0-0=3	3	20	30	50	3
	Course Outcome: After completion of course students will be able to 1. Describe the terminology of infrastructure services like railway, docks, harbor and airport facilities. 2. Describe and sketch railway, docks and harbor and airport components. 3. Analyze the factors influencing the site selection for railway, docks, harbor, and airport facilities. 4. Design the components of railway, docks and harbor and airport. 5. Propose appropriate method of construction & maintenance required for railway, docks and harbour and airport facilities.							

Module	Course Contents
1	**Introduction** Role of transportation in society, Objectives of transportation system, Transportation Planning different types of modes, planning & co-ordination of different modes for Indian conditions, modern transportation system.
2	**Railway Engineering** Merits of rail transportation, railway gauges and gauge problems Cross section of permanent way and track components: Sleepers-functions and types,sleeper density, ballast functions and different ballast materials, ballast less track. Rails: Coning of wheels and tilting of rails, rail cross sections, wear and creep of rails rail fastenings. Geometric design: Gradients, transition curves, widening of gauges on curves, cant and cant deficiency.
	Point and crossing: Design of turnouts and description of track junctions. Yards: details of different types of railway yards and their functions. Construction and maintenance of railway track, methods of construction, material requirements, special measures for high speed track, monorail, metrorail, high speed train

3	**Airport Engineering** Aircraft characteristics and factors influencing on airport planning. Airport planning: topographical and geographical features, air traffic characteristics, and development of new airports, factors affecting airport site selection. Airport obstruction: Zoning laws, classification of obstruction, imaginary surfaces, approach zones, turning zones. Airport layout: runway orientation, wind rose diagrams, and basic runway length. Correction of runway length, airport classification, runway configuration, taxiway design, geometric standards, exit taxiways, holding aprons, location of terminal buildings, aircraft hangers and parking. Airport marking and lighting: marking and lighting of runways, taxiways and approach areas
4	**Water Transportation** Harbours: Selection of site, entrance and channel requirement, ship characteristics and their influence on ports management and operations, harbour maintenance. Harbour layout: harbour works, break waters, jetties, wharves, piers, berthing facilities, types and construction, dolphins. Navigational aids: buoys and lighthouses etc. Port facilities: docks, transit sheds and warehouses, general layout, containers and container yard, layout and handling equipment.
	Text Books: 1 Saxena S.C. and Arora S. P., A Textbook of Railway Engineering, DhanpatRai Publications, New Delhi, 2010. (ISBN-9788189928834) 2 Khanna and Arora, Airport planning & design, Nemchand Bros, Roorkee (ISBN-9788185240688) 3 M. M. Agarwal, Indian Railway Track, Prabha& Co., Sachdeva Press, Mayapuri, New Delhi, 2018. (ASIN: B074XSTCHS) **Recommended Reading:** 1 Robert, Horonjeff &Mcklerey William, J Sproule, Seth B. Young, Planning & design of Airport, McGrraw Hill, New Delhi,2010. (ISBN: 9780071446419) 2 A. D. Quinn, Design and Construction of Ports and Marine Structures, McGrraw Hill, Inc, USA,1961. (ISBN: 0070510644)

Semester - V		Program Core Course (PCC)						
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
6	R5CE3002L	Transportation Engineering Laboratory	0-0-2=2	1	ISCE: 60		40	3
	Course Outcome: **1.** Perform quality control Tests needed for pavement construction and maintenance. **2.** Prepare mix design for pavements. **3.** Plan and conduct traffic studies for estimating traffic flow characteristics. **4.** Conduct physical evaluation of pavements using modern tools and equipment.							

Sl. No.	**Course Content: (List of Experiments)**
1	**Bituminous / Asphalt Pavement Design:** Marshall stability, Mix design for pavements: Water Bound Macadam, Bituminous Macadam, and Asphalt concrete, Mastic asphalt pavements
2	**Traffic Studies:** Spot Speed Study, Traffic volume studies, Delay studies
3	**Physical Evaluation of Pavements:** Physical verification and Roughness Measurement: Merlin, Bump Integrator Test, Roughometer tests
4	**Structural Evaluation of Pavements:** Benkelman Beam Test, Bump Integrator Test, Deflectometer tests, Skid Resistance Test,
5	**Non destructive Tests:** Evaluation of bitumen content of core samples.
5	**Evaluation of soil subgrade for flexible pavements** C.B.R test (soaked and unsoaked Lab, Field), Tests on Soils: Density of soil, moisture content, Plasticity index of soil.
	Text Books 1. Rao D.V. B, Rao G. V, and Pahari, K. Highway Material Testing and Quality Control, Dreamtech Press, 2019 (ISBN: 9389447321) 2. Ministry of Road Transport and Highways, by Indian Road Congress, 5th Revision 2013, reprint July 2016, (ISBN: 9788193293201). 3. Asphalt Institute Manual Series No.2 (MS-2) Mix design methods for Asphalt concrete and other hot mix types Lexington Ky, 7th edition.

Semester - V		Program Core Course (PCC)						
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
7	R5CE3003L	Engineering Geology Laboratory	0-0-2 = 2	1	ISCE:60		40	3
	Course Outcome: After completion of course students will be able to 1. Apply the basics of engineering geology at site. 2. Identify the different types and forms of rock and mineral from core samples 3. Identify the topographical features in geological map. 4. Use knowledge of geology in solving civil engineering problems.							

	Course Contents
	1. Branches of geology useful to civil engineering, scope of geological studies in various civil engineering projects. 2. Study of Topographical features from Geological maps. Identification of symbols in maps 3. Physical Geology Study Weathering, Erosion, Denudation.Superficial deposits and its geotechnical importance: Waterfall and Gorges, River meandering, Alluvium, deposits, 4. Study of physical properties of minerals. 5. Study of different group of minerals. 6. Study of Crystal and Crystal system.

	7. Identification of minerals a. Silica group: Quartz, Amethyst, Opal b. Feldspar group: Orthoclase, Plagioclase c. Cryptocrystalline group: Jasper d. Carbonate group: Calcite e. Element group: Graphite f. Pyroxene group: Talc g. Mica group: Muscovite h. Amphibole group: Asbestos, Olivine, Hornblende, Magnetite, Hematite, Corundum, Kyanite, Garnet, Galena, Gypsum 8. Identification of rocks(Igneous Petrology) a. Acidic Igneous rock: Granite and its varieties, Syenite, Rhyolite, Pumice, Obsidian, Scoria, Pegmatite, Volcanic Tuff. b. Basic rock: Gabbro, Dolerite, Basalt and its varieties, Trachyte. 9. Identification of rocks (Sedimentary Petrology): Conglomerate, Breccia, Sandstone and its varieties, Laterite, Limestone and its varieties, Shales and its varieties. 10. Identification of rocks (Metamorphic Petrology) : Marble, slate, Gneiss and its varieties, Schist and its varieties, Quartzite, Phyllite. 11. Study of core samples, Core logging, RQD. 12. Engineering problem based on field data collected during site investigation. 13. Ground water: Sources and zone, water table, factors controlling bearing capacity of rocks, Different types of rock as source of ground water.
	Text Book: 1 Parbin Singh, Engineering and General Geology , Publisher: S. K. Kataria & Sons , Edition 2013,(ISBN - 9350142678) **Recommended Reading:** 1 Kesavalu, Text Book of Engineering Geology, Publisher: MacMillan 2nd edition, 2009. 2 Geology for Geotechnical Engineers, J.C.Harvey, Cambridge University Press, 1st edition, 1982

Semester - V		PCC						
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
1	R5SE3002T	Geotechnical Engineering	3-0-0=3	3	20	30	50	3
	Course Outcome: After completion of course students will be able to 1. Evaluate earth pressures and apply them to check the external stability of retaining structures. 2. Analyse and design using stress distribution of shallow foundations by shear and settlement criteria under different loading and soil conditions. 3. Evaluate the load-carrying capacity and settlement of deep foundation by shear and settlement criteria for different soil conditions under axial load. 4. Apply principles of Three-Dimensional Consolidation and soil reinforcement for soft soil improvement. 5. Interpret and use results of soil investigation for design of Geotechnical systems.							

Module	**Course Contents**
1	**Lateral earth pressure theories** Earth pressure theories, earth pressure at rest (elastic equilibrium). Rankine's Earth Pressure (limiting or plastic equilibrium): active and passive earth pressure for horizontal and inclined backfill including non-homogenous deposit, Coloumb's Wedge Theory: mathematical approach, condition for failure plane, graphical methods, passive pressure by friction circle method.
2	**Earth retaining structures** Stability analysis of cantilever retaining wall or sheet piles in sand and clay.
3	**Stress Distribution in Soil** Boussinesq's Formula for point load, line load, circular and rectangular area, and embankment loading. New Marks Influence chart.
4	**Bearing capacity of shallow foundation** Definitions of ultimate bearing capacity, gross, net and safe pressures, allowable bearing pressure, types of shallow foundations modes of failures. Bearing capacity theories: Terzaghi's approach, Vesic's approach and IS 6403 (1981) method. Bearing capacity based on Standard Penetration Test. Settlement estimation, plate load test (IS1888) and SPT for estimation of settlements. Bearing capacity of foundation on compact and weathered rock.

5	**Axially loaded pile foundations** Introduction, necessity and classification of pile foundation, classification of piles. Pile capacity and settlement based on static analysis, single and group piles in sand and clay, critical depth method, dynamic methods and their limitations, in-situ penetration tests and pile load test as per IS 2911 specifications, negative skin friction.
6	**Ground improvement techniques** Ground improvement techniques: Stone columns and sand/band drains. Basic principle of for Reinforced Earth wall or Soil nailing.
7	**Planning of subsurface investigation** Planning of investigation programs and Geophysical methods. Soil reports.
	Recommended Reading 1. K. Terzaghi and R. B. Peck, Gholamreza Mesri, Soil Mechanics in Engineering Practice, Wiley and Sons, 1996. (ISBN-8126523816/978-8126523818). 2. H. Winterkorn and F.Y. Fang, Foundation Engineering Handbook, CBS Publishers & Distributors, New Delhi, 1990. (ISBN 9788123905457). 3. J. E. Bowles, Foundation Analysis and Design, McGraw-Hill Book Co, 2001. (ISBN-0071188444/ 978-0071188449). 4. P. Shamsher and H. Sharma, Pile Foundations in Engineering Practice, Wiley and Sons, 1990. (ISBN-0471616532/978-0471616535). 5. P. Purushothama Raj, Ground Improvement Techniques (HB), Laxmi Publication Pvt Ltd., New Delhi, 2005. (ISBN-9788170080985/978-8170080985). 6. M. R. Hausmann, Engineering Principles of Ground Modification, McGraw-Hill Inc., US, 1990. (ISBN-0070272794/978-0070272798). 7. R.D. Holtz and W.D. Kovacs, An introduction to geotechnical engineering, Prentice Hall, 1981. (ISBN-9332507619/978-9332507616). 8. IS 1892 (1979), Subsurface Investigation for Foundation. 9. IS 6403 (1981), Determination of Bearing Capacity of Shallow Foundation. 8. IS 8009 Part I (1978), Calculation of Settlement of Foundation and Shallow Foundation Subjected to Symmetrical Static Vertical Loads. 9. IS 12070 Code Practice and Construction of Shallow Foundations on Rocks. **Textbooks** 1. G. Ranjan and A.S.R. Rao, Basic and Applied Soil Mechanics, New Age International Pvt. Ltd., 2005. (ISBN: 9788122440393/8122440398.

	2. V.N.S. Murthy, Advanced Foundation Engineering, CBS Publishers and Distributors, New Delhi, 2016. (ISBN- 9788123915067). 3. B. M. Das, Principles of Foundation Engineering, PWS Publishing Company, 2012. (ISBN-978-8131518786).

PROGRAM ELECTIVE COURSES

Semester - V		PEC	Structural Engineering I					
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
1	R5SE3101T	Advanced Structural Analysis	3-1-0=4	4	20	30	50	3

Course Outcomes

After completion of this course, students will be able to,

1. Analyze beams, frames and trusses by using matric flexibility method.
2. Analyze beams, frames and trusses by using matric stiffness method.
3. Apply modified moment distributed method for symmetric/anti-symmetric structures.
4. Apply structural mechanics principles to symmetric/unsymmetrical-open-thin-walled cross sections and curved beams in elevation and plan.
5. Determine the shape factor and plastic modulus of steel structures using the concept of plastic analysis.

Module	Course Contents
1	**Revision of Flexibility Method in Matrix Form** Definition of Flexibility coefficient, Selection of primary determinate structure, Structure flexibility matrix, compatibility equations. Evaluation of Redundant forces, computation of internal forces and joint displacements. Applications to continuous beams, pin jointed trusses and rigid jointed plane frames.
2	**Introduction to Stiffness Method in Matrix Form** Definition of Stiffness coefficient, member stiffness matrix for prismatic truss and beam elements, properties of the member stiffness matrix, coordinate transformation matrix, stiffness matrix in local and global coordinate axes system. Global stiffness matrix, Boundary conditions, calculation of equivalent joint loads. Solution of Equilibrium equations for displacements. Evaluation of Internal forces in members. Symmetric and anti-symmetric conditions of loading. Application of matrix stiffness method to beams, pin jointed trusses, and rigid jointed plane frames.
3	**Modified Moment Distribution Method**

	Symmetric and anti-symmetric conditions of loading, modification of stiffness and carryover factors for symmetric and anti-symmetric loads. Application of modified moment distribution method for beams and rigid jointed plane frames.
4	**Symmetrical and Unsymmetrical Section** Unsymmetrical bending, flexural stresses due to bending in two planes, shear center, bending of unsymmetrical section. Bending of beams with large initial curvature loaded in their plane of curvature. Analysis of hooks, chain links etc. Beams curved in plan loaded perpendicular to their plane, fixed and continuous curved beams.
5	**Introduction to Plastic Analysis of Steel Structures** Concept of plastic Hinge. Calculation of plastic moment carrying capacity and shape factor for a given structural steel cross section.
	Recommended Reading 1. P.Dayaratnam, Design of Reinforced Concrete Structures, Oxford & IBH. (ISBN-9789386479785/9386479788). 2. T.Y. Lin, Design of Prestressed Concrete Structures, John Wiley and Sons Inc., 2010. (ISBN-9788126528035/8126528036). 3. P.D.Arthur and V.Ramkrishnan, Ultimate Strength Design for Structural Concrete, Wheeler&Co. Pvt Ltd. (ISBN- 0273403230/978-0273403234). 4. B.P. Hughes, Limit State Theory for Reinforced Concrete Design, Pitman. (ISBN-0273010239/978-0273010234). **Textbooks** 1. Jain and Jaikrishna, Plain and Reinforced Concrete, Vol. I, Nemchand Brothers.(ISBN-8185240086/978-8185240084). 2. V.L. Shah and Karve, Limit State Design - Reinforced Concrete Structures Publications. (ISBN- 9788190371711/ 8190371711). 3.K. Raju, Pre-stressed Concrete, Tata McGraw Hill.(ISBN-9789387886209/9387886204).

Semester – V		PEC	Structural Engineering II					
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
1	R5SE3102T	Bridge Engineering	3-1-0=4	4	20	30	50	3

Course Outcomes

After completion of this course, students will be able to,

1. Evaluate the design loads and use them for safe and serviceable design of bridges.
2. Conceive and design different types of reinforced concrete bridges.
3. Conceive and design steel and pre stressed concrete bridges along with their substructu and foundation.
4. Conceive and design of continuous and composite bridges.

Module	Course Contents
1	**Introduction and Investigation for Bridges** Components of bridge - classification - need for investigation, data collection, design discharge, linear waterway, economical span scour depth, traffic projection, choice of bridge type
2	**Loads on Bridges** Indian Road Congress (IRC) bridge codes, dimensions, dead and live loads, impact effect, wind and seismic forces, Loads due to road unevenness, longitudinal and centrifugal forces, hydraulic forces, earth pressure, temperature effect and secondary stresses.
3	**Slab and T - Beam Bridges** Design of slab bridges, skew slab culverts, box culverts. T - pigeaud curves - courbon'stheory - Hendry Jaegar method design of T - beam bridges. Introduction to composite girders
4	**Long Span Bridges** Hollow girder bridges, balanced cantilever bridges, continuous girder bridges, rigid frame bridges, arch bridges, bow string gird prestressed concrete bridges, composite prestressed concrete super structures, erection of precast girders, continuous construction, recent trends.

5	**Design of bearings** Introduction to different types of bearing. Design of bearings for slab, girder, skew bridges
6	**Design of Substructure** Design of piers, pier cap, abutments. trestles, joints- expansion joints.
	Recommended Reading 1. Taylor F. W., Thomson S. E. and Smulski E., Reinforced Concrete Bridges, JohnWiley & Sons, New York, 1955. 2. Raina V. K., Concrete Bridge Practice, Tata McGraw Hill Publishi Co., New Delhi –1991. 3. Conference Proceedings, Advances and Innovations in Bridge Engineering, IIT, Madras and Indian Institute of Bridge Engineering, Tamilnadu, Allied Publisher,New Delhi, 1999. 4. Johnson V. D., Essentials of Bridge Engineering, Oxford and IBH Publishing Co.Pvt. Ltd., New Delhi, 2006. 5. Krishna Raju N., Design of Bridges, Fourth edition, Oxford & IBM Publishing Co., Bombay, 2009. 6. Relevant IRC Codes. Complete details

Semester - V		PEC	Geotechnical Engineering					
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
1	R5SE3103T	Advanced Foundation Engineering	3-1-0=4	4	20	30	50	3

Course Outcomes

After completion of this course, students will be able to,

1. Evaluate compressibility and shear strength of soil.
2. Evaluate the safe allowable bearing capacity of and settlement shallow foundation.
3. Determine load carrying capacityand settlement of single and group piles under downward a lateral load.
4. Illustrate the methods of ground improvement technique for improvement of weak soils.

Module	Course Contents
1	**Consolidation and Shear Strength** One dimensional consolidation, Terzaghi's theory, differential equation, and solution (Optional), Different loading; constant, linear and sinusoidal variation pore pressure variation, pore pressure parameters, shear strength of sand, critical void ratio, dilatancy.
2	**Bearing Capacity of Soils** Shallow foundations, Terzaghi theory: detailed derivation, Various bearing capacity methods to determine net ultimate bearing capacity, factors affecting ultimate. **Bearing capacity**: shape, GWL, eccentricity and compressibility of clay (including critical rigidity Index criteria), settlement analysis for clay and sand, elastic settlement use of Steinbrenner and Fox Theory, Schmertmman's method, primary consolidation. Bearing capacity of foundation on compact and weathered rock. Raft foundation.
3	**Pile Foundation** Pile load test, laterally loaded pile, Separation of end bearing and shaft friction, settlement of single pile and group piles in sand and clay, Based on uniaxial compressive rock, safe load on weathered rock. Laterally loaded pile- subgrade reaction approach, lateral deflection of single pile – free head, partially fixed head, and fixed head pile, p-y curves. Introduction to pile raft. NDT of pile, PDA etc.

4	**Ground Improvement** Sand drains and stone columns. Reinforced Earth Wall: Materials and general considerations, Design and Stability or Soil Nailing -Application, components, materials used for nailing.
	Recommended Reading 1. Terzaghi K. and Peck R. B., Soil Mechanics in Engineering Practice, Wiley and Sons,1996. 2. Holtz, R.D. & Kovacs, W.D., "An introduction to geotechnical engineering", Prentice Hall, 1981. 3. Taylor D.W., Fundamentals of soil mechanics, Asia publications Bombay, 1967. 4. Das B. M., Shallow Foundation- Bearing Capacity & Settlement" Taylor & Francis, 2009 5. Das B. M., Principles of Foundation engineering, PWS Publishing Company, 2012. 6. Winterkorn H. and Fang F. Y., Foundation Engineering Handbook, CBS Publishers & Distributors, New Delhi, 1990. 7. Bowles J. E., Foundation Analysis and Design, McGraw-Hill Book Co, 2001. 8. Shamsher P. and Sharma H., Pile Foundations in Engineering Practice, Wiley and Sons,1990. 9. Purushothama R., Ground Improvement Techniques (HB), Laxmi Publication Pvt Ltd. New Delhi, 2005. 10. Ranjan, Gopal & Rao, A.S.R., "Basic and applied soil mechanics", New Age International Pvt. Ltd., 2004 11. Das B. M. Advanced Soil Mechanics, 4th Ed. C.R.C. Press, 2013. 12. Murthy V.N.S., Advanced Foundation Engineering, CBD Publishers and Distributors, New Delhi, 2010. 13. Hausmann M. R., Engineering Principles of Ground Modification McGraw-Hill Inc, US, 1990.

Semester - V		PEC	Construction Engineering and Management					
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
9*	R5CE3101T	Advanced Construction Techniques	3-1-0=4	4	20	30	50	3
	Course Outcome: After completion of course students will be able to 1. Describe different construction techniques used at site. 2. Justify use of various construction equipment's with reference to cost and site conditions. 3. Analyze and suggest ground improvement techniques.							

Module	Course Contents
1	**Pile construction** Types of piles & construction, pile driving equipments-Single Acting, Double Acting,Pile driving Hammer, Differential Acting hammer, Hydraulic and diesel Hammer, Vibratory Hammer
2	**Dewatering** Well point system, deep well, selection of pumps, types of pumps- Reciprocating, Centrifugal and Diaphragm, selection of pump
3	**Tunnelling** Geotechnical investigations, selection of alignment, methods of tunnelling in soft soils and in hard rock, sequence of operations for drilling and blasting method, mechanical moles,boomers, tunnel boring machines, mucking, ventilation of tunnels, dust control, types of tunnel supports, sequence of lining operation, lining with pneumatic placers and by pumpcrete method. Pipe Jaking, Selection of Tunnel Alignment, Tunneling using road headers, Cut and fill techniques, Jackdown techniques, Box type tunnelling Techniques
4	**Bridge construction** Geotechnical investigation, Site selection, launching of bridges by incremental launching, using false work, balanced cantilever construction method, Coffer dams types and applications Afflux and Scour depth Launching Girder, Bridge Decks, Offshore platforms, Special Forms for shells, Techniques for Heavy Decks
5	**Ground improvement techniques**

	Deep Dynamic Compaction, Drainage / Surcharge, Electro-osmosis, Compaction, Grouting, Blasting, Surface compaction, selection for field compaction procedures, compaction quality control, stone column, sand drain, diaphragm wall, soil reinforcement, thermal methods, improving rock stability and quality.
6	**Prefabricated Construction:** Planning for pre-casting, Prestressed Slab, 3D modular construction of Buildings,3D Printing in Construction, selection of equipment for fabrication, transport and erection, quality measures, safety measure during erection IoT based monitoring of Construction activity
7	**Introduction Prestresseing equipment** Post Tensioning - Le-mcall, Magnell Blaton, Gifford Udall, Freyssinet, Pretensioning- Hoyer System or Long Line method, Shorer System
	Textbooks 1. Construction planning, equipments, and methods-Tata McGraw- hill edition, sixth edition 2. B. C. Punmia, Building construction Laxmi publications [P] lt. tenth edition (ISBN 9788131804285) 3. R. Srinivasan Harbour dock and tunneling- Charotar publishing house private limited (ISBN 9385039199) **Recommended Reading** 1. Dr. V. K. Raina, Concrete Bridge Practice, Tata McGraw Hill Publications, 2nd edition (ISBN - 818404805X) 2. Dr. P. Purushothama Raj, Ground Improvement Techniques, Bangalore University Press, 7th edition (ISBN - 9788131805947) 3. N. V. Nayak, Foundation Design Manual, Dhanpatrai Prakashan, 3rd edition (ISBN -9383182903) 4. Mahesh Varma, Metropolitan Book Co. Construction Equipment and its Planning and Applications (P) Ltd., New Delhi, India. 5. Construction Machinery and Equipment in India, (A compilation of articles Published in Civil Engineering and Construction Review), Publish by Civil Engineering and Construction Review New Delhi,1991

Semester - V		PEC	Geoinformatics					
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
	R5CE3102T	Satellite Image Processing	3-1-0=4	4	20	30	50	3
	Course Outcome: After completion of course students will be able to 1. Analyze the various types of infrastructure systems and their role in acquiring Satellite data 2. Evaluate Challenges and strategies for analyzing Satellite Images 3. Apply Modern Tools to interpret the Satellite Image data.							

Module	Course Contents
1	**Introduction to Satellite Data:** Satellite Image and Its Representation, Different Techniques of Image Acquisition, Importance of Digital Image Processing, Image Characteristics and Different Resolutions in Remote Sensing, EM Spectrum, Solar Section, and Thermal Emission Remote Sensing.
2	**Image Transform:** Color, Representations and Transforms, Image Histograms and Statistics, Geometric Transformations/Georeferencing Techniques, and Image Enhancement Techniques.
3	**Multispectral transforms:** Scatter Plot, Principal Component Analysis, and Decorrelation Stretch, Spatial Filtering Techniques, Frequency Domain - Fourier Transformation, Basic Image Compression Techniques and Different Image -Le Formats, Image Classification Techniques.
4	**Image Registration:** Registration- Preprocessing, Feature Selection-Points, Lines, Regions and Templates Feature Correspondence, Point Pattern Matching, Line Matching, Region Matching, Template Matching. Transformation Functions-Similarity Transformation and Affine Transformation. Resampling, Nearest Neighbour, and Cubic Splines.
5	**Image Interpretation:** Principles of Image Interpretation, SAR Interferometry (Insar) Technique, Image Merging and Mosaicking Techniques, Applications of Image Analysis, Limitations

	and Future of Digital Image Processing Technique.
	Textbooks **1.** John C.Russ, "The Image Processing Handbook", CRC Press, 2007. **2.** Sanjit K. Mitra, "Digital Signal Processing", A Computer Based Approach, Tata McGraw Hill, 2001. **3.** Ardeshir Goshtasby, "2D and 3D Image registration for Medical, Remote Sensing and Industrial Applications", John Wiley and Sons, 2005. **Recommended Reading** **1.** Digital Signal Processing, Principles, algorithms and applications - J. Proakis, D. G. Manolakis, D. Sharma, Pearson Education. **2.** P.M. Mather, Digital Image Processing of Remotely sensed Images, Wiley,2004. **3.** P.M. Mather, Digital Image Processing of Remotely sensed Images, Wiley,2004. **4.** David L. Verbyla, Satellite Remote Sensing of Natural Resources, CRC Press,1995. **5.** R. C. Gonzalez, J. W. woods, Digital Image Processing, Prentice-Hall,2002.

Semester - V		PEC	Environmental Engineering					
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
	R5CE3103T	Environmental Legislation and Management	3-1-0=4	4	20	30	50	3
	Course Outcome: After completion of course students will be able to 1. To elucidate the application of Environmental Management 2. To demonstrate concepts of sustainability for environmental management 3. To analyse the need of environmental legislation. 4. To illustrate the application of National Environmental Protection Acts							

Module	**Course Contents**
1	**Introduction:** Definition of Environmental Management, Principles of Environmental Management, Nature, Scope and Components of Environmental Management, Policies and Legal Aspect of Environ mental Management
2	**EIA process:** Overview of Environmental Impact Assessment (EIA), Need and Importance, Steps involved, Methods of EIA, Public Participation and Communication, Preparation and Review of Environ mental Impact Assessment Report, Life Cycle Assessment as Environmental Management Tool, Environmental Audit, Components of Audit, Preparation of Audit Reports.
3	**Environmental Policy Analysis:** Environmental Policy Analysis, Macro level and Micro level, Methods of Policy Analysis, steps involved, Environmental Management Plan (EMP), Components of EMP, Preparation of EMP, Case Study
4	**Organizational Framework for Environmental Management in India:** Organization for Environmental Management, Organizational Design, Institutionalization of Environmental management in India, Ministry of Environment and Forest, Central Pollution Control Boards, State Pollution Control Boards, Local Bodies, their scopes, Organizational and Functional issues, Related Issues in

	Environmental Management.
5	**Environmental Legislation and Regulatory Framework**: Environmental Legislation -their need, historical background, national and international acts; Genesis of environmental acts – general procedure followed in changing a bill into an act; implementation of an act using judiciary, executive and legislative powers and their limitations. Environmental protection agency, air act, water act, water and sewerage Board's Factory act, Municipal acts, acts dealing with hazardous and infections wastes. Preventive and reactive strategies for environmental pollution control, sustainable development.
6	ISO: 14000 – its need, procedure to be followed to obtain ISO: 14000 certification, implications of ISO.
	Recommended books: 1. Pollution législation – A.K. Mhaskar, M/s. Media Enviro, Pune 2. Environmental Audit – An overview, A. K. Mhaskar – M/s. Media Enviro, Pune. 3. Matter Hazardous Laws Explained. A. K. Mhaskar M/s. Media Enviro, Pune 4. Environmental impact assessment Larry W Canter McGraw Hill International Edition, New York 1996. 5. Environmental Impact Assessment, Lauren David P., Willy Interscience, New Jersey editions. 6. Primes on 'Environmental Management ', Prof. P. Khanna, Multitech publications Co. New Delhi 2001. 7. Assessment and analysis of Environmental management, Shukla S. S., Shrivastva P. R. 1992, commonwealth publishers New Delhi 2003

Semester - V		PEC	Transportation Engineering					
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
	R5CE3104T	Intelligent Transportation System for smart cities	3-1-0=4	4	20	30	50	3
	Course Outcome: After completion of course students will be able to 1. Identify various components of Intelligent transportation systems (ITS) and supporting technologies 2. Comprehend the role of ITS and its applications for improving the performance of the transportation system 3. Apply ITS related strategies for varying roadway and traffic conditions using design and control parameters.							

Module	Course Contents
1	**Introduction To ITS:** Definition Objectives, Historical Background, Benefits of ITS – Introduction to Automatic Vehicle Location (AVL), Automatic Vehicle Identification (AVI), Geographic Information Systems (GIS), Traffic Control and Monitoring Aspects, Components Of ITS.
2	**Advanced Traveler Information Systems (ATTS):** Trip Planner and Its Impact, Traffic Density Measurement, Variable Message Signs, Parking Guidance, Weather Information and Variable Speed Limits, Impacts of ATTS
3	**Advance Vehicle Monitoring Systems** Security CCTV Systems, Wireless Sensor Network And RFID, Blue-Tooth and Wi-Fi Sensors, Inductive Loop Detectors and Image Processing Techniques, Impacts of AVMS.
4	**Commercial Vehicle Operations (CVO):** Emergency Vehicle Notification Systems, Automatic Road Enforcement, Variable Speed Limits, Collision Avoidance Systems, Dynamic Traffic Light Sequence, Cooperative Systems on Road, Automatic Number Plate Recognition by Image Processing, Impacts Of CVO.
5	**ITS applications and programmes in the world** Advanced Traffic Management Systems (ATMS) Advanced Vehicle Control Systems

	(AVCS), Advanced Public Transportation Systems (APTS), Advanced Rural Transportation Systems (ARTS), Automated Highway Systems, and Framework for Evaluating ITS Related Strategies. Overview of ITS Implementations in Developed Countries, ITS in Developing Countries, Potential Applications of Offline and Online Real Time Measurement of Traffic Flow Characteristics.
	Textbooks **1.** Chowdhary M A and A Sadek. Fundamentals of Intelligent Transportation systems planning. Artech House Inc., US, 2003. **2.** M.A. Chowdhury and A. Sadek, Fundamentals of Intelligent Transportation Systems Planning, Artech House, 2010 **Recommended Reading** **1.** AUSTROADS, The Implication of Intelligent Transport Systems for Road Safety, Austroads Incorporated, 1999. **2.** Bob Williams, Intelligent Transport Systems Standards, Artech House Publishers, 2008. **3.** Sumit Ghosh and Tony Lee, Intelligent Transportation Systems, CRC Press, ISBN: 0849300673. **4.** Chris Drane and C. R. Drane, Positioning Systems in Intelligent Transportation Systems, Artech House Publishers, ISBN: 0890065365. **5.** Judy Mc Queen and Bob Mc Queen, Intelligent Transportation System and Architecture, Artech House Publishers, ISBN: 089006525X **6.** Asad J. Khattak, Intelligent Transportation Systems: Planning, Operations, and Evaluation, CRC Press

Semester - V		PEC	Hydrology & Water Resources Engineering					
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
	R5CE3105T	Watershed Conservation and Management	3-1-0=4	4	20	30	50	3
	Course Outcome: After completion of the course students will be able to 1. Use an integrated watershed management approach. 2. Analyze the socio-economic aspects of the watershed. 3. Apply techniques to analyze and solve watershed problems.							

Module	Course Contents
1	**Introduction to Basic Concepts:** Concept of watershed, introduction to watershed management, different stakeholders and their relative importance, watershed management policies and decision making.
2	**Sustainable Watershed Approach & Watershed Management Practices:** Sustainable Integrated Watershed Management, Natural Resources Management, Agricultural Practices, Integrated Farming, Soil Erosion, and Conservation. Watershed Management Practices in Arid and Semiarid Regions, Case Studies, Short Term, and Long-Term Strategic Planning.
3	**Integrated Watershed Management and its Social Aspects:** Introduction to Integrated Approach, Integrated Water Resources Management, Conjunctive Use of Water Resources, Rainwater Harvesting, Roof Catchment System. Community Participation, Private Sector Participation, Institutional Issues, Socio-Economy, Integrated Development, Water Legislation and Implementations, Case Studies
4	**Use of modern techniques in watershed management:** Applications of Geographical Information System and Remote Sensing in Watershed Management, Role of Decision Support System in Watershed Management.

5	**Management of Water Quality:** Water Quality and Pollution, Types and Sources of Pollution, Water Quality Modeling, and Environmental Guidelines for Water Quality.
6	**Stormwater and Flood Management:** Stormwater Management, Design of Drainage System, Flood Routing Through Channels and Reservoir, Flood Control and Reservoir Operation, Case Studies on Flood Damage.
7	**Water Conservation, Recycling, and Drought Management:** Rainwater Harvesting, Perspective on Recycle and Reuse, Wastewater Reclamation. Drought Assessment and Classification, Drought Analysis Techniques, and Drought Mitigation Planning.
	Textbooks **1.** J. V. S. Murty, Watershed Management, New Age International Publishers, New Delhi, 2nd edition, 2017. (ISBN: 9788122435184/8122435181) **2.** J.V.S. Murty, Watershed Management in India, Wiley Eastern Limited, New Delhi, 1994. (ISBN: 8122405665/9788122405668) **3.** A. P. Purandare and A. K. Jaiswal, Watershed Development in India, National Institute of Rural Development, Hyderabad, 1995. (ISBN: 978-8185542348/8185542341) **4.** R. Singh, Watershed Planning and Management, Yash Publishing House, Bikaner, 3rd edition,2003. (ISBN: 9788186882122 / 818688212x) **Recommended Reading** **1.** Allam, Gamal Ibrahim Y., Decision Support System for Integrated Watershed Management, Colorado State University, 1994. **2.** American Society. of Civil Engineers, Watershed Management, American Society of Civil Engineers, New York, 1975. **3.** Black Peter E., Watershed Hydrology, Prentice Hall, London, 1991. **4.** A. M. Michael, Irrigation Theory and Practice, Vikas Publishing House, 2nd edition, 1992. (ISBN: 9788125918677)

Semester - V		PEC	Hydraulics					
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
	R5CE3106T	River Engineering	3-1-0 = 4	4	20	30	50	3
	Course Outcome: After completion of course students will be able to 1. Analyze the various types of river systems and its fundamentals. 2. Evaluate various techniques of hydrological and Hydraulic flow modeling. 3. Understand flood measurements,control systems and methods.							

Module	Course Contents
1	**Introduction to River Engineering:** Introduction: Primary function of a river, River uses and measures, Water and Sediment Load of Rivers, Rivers in India, Himalaya and Peninsular. River Morphology, Plan form Variations, and River Channel Pattern, River Dynamics: Degradation and Aggradation of River Bed, and River Gauging
2	**River Equilibrium:** Stability of Channel, Regime Relations, River Bend Equilibrium, Hydraulic Geometry of Downstream, Bars and Meandering, Characteristics of Braided and Meandering Rivers, Confluences and Branches, River Database, Sediment Transport in Rivers, Bed Load and Suspended Load Transport for Uniform and Non-Uniform Bed Material, Total Load Equations, Sediment Sampling
3	**Water Resources Management:** Erosion Control and Watershed Development are Their Benefit Towards the Conservation of National Water Wealth. Rainwater Harnessing and Recharge of Groundwater: Role of Society and People's Participation for Sustainable Water Resource Development. Mitigation Strategies for Flood Damage: Structural and Non-Structural Measures.
4	**Surface Flow Modeling Techniques:** Hydrological and Hydraulics Flow Model, Reservoir Routing, Channel Routing, The General Operation of Flood Forecasting, Forecasting Methods Adopted in India, Forecasting by Unit Hydrograph Method, and Numerical Modeling.
5	**Flood Measurements:**

	Flood Forecasting: Need, Problems, Limitations, River Forecasting Procedure, Flood Forecasting Methods, Flood Routing: Channel Routing, Muskingum Method, Crest Segment Routing, Reservoir Routing, Modified Pul's Method.
6	**Flood Control:** History, Structural and Non-Structural Measures for Flood Control, Gully Control Structures: Temporary Check Dams, Permanent Structures for Gully Control, Design of Chute Spillway, Design of Drop Inlets, Control and Training of Rivers, Objectives, Classification, Methods of River Training, Marginal Embankments, Guide Banks, Earthen Embankments: Introduction, Types, Methods of Construction, Grouting.
	Textbooks 1. P. P. H. Jansen, Principals of River Engineering, VSSD Publications, 1994 2. R. J. Garde, River Morphology, New Age International Publishers, 2006 **Recommended Reading** 1. Engineering Hydrology- K. Subramanya. Third Edition, The Tata McGraw-Hill companies, New Delhi. 2. Water Resource Engineering by Ralph A Wurbs and Wesley P James, PHI Learning Private Ltd, New Delhi, 2009 3. R. J. Garde and K. G. Ranga Raju, Mechanics of Sediment Transportation and Alluvial Stream Problems, New Age International Publishers, 2000

Multidisciplinary Minor - Innovation and Entrepreneurship

Semester - V		Multidisciplinary Minor	Innovation and Entrepreneurship					
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
10*	R5CE3201T	Product Design and Manufacturing	3-0-0=3	3	20	30	50	3
	Course Outcome: After completion of course students will be able to 1. Understanding fundamentals of design and manufacturing, and computer aided tools 2. Apply visual and value engineering principles 3. Analyse material selection and manufacturing & maintenance processes 4. Develop and apply costing strategies							

Module	Course Contents
1	**Introduction to Product Design** Product -consumption cycle, product realization process, product -design and manufacturing, features, product characteristics, cost and duration of product development, Rapid prototyping process
2	**Visual Design** Elements of visual design, aesthetic design, design principles-proportion/ratio, contrast, variety etc, product message, translating customer needs-voice of customer, quality function deployment (QFD)- tools used, product design specifications-components
3	**Value Engineering** Defining value engineering, cost-reduction versus value engineering, reasons for poor value, Value engineering methodology/ job plan phases-information, function, creativity, evaluation, development and implementation phase, Function analysis system technique (FAST), Case study
4	**Material Selection**

	Importance of material selection, Factors affecting the material selection process, Material selection procedures, design recommendations, materials recommended-ferrous/non ferrous, copper/brass, engineering materials etc
5	**Manufacturing Process & Manufacturing Design** Selection of manufacturing processes, primary manufacturing processes, secondary manufacturing processes, tertiary manufacturing processes, and design for manufacturing. Design review, DFM & DFA principle, manufacturing guidelines, Computer aided design, Design for Assembly
6	**Product Costing** Cost and Price Structure, Information resources, Estimating direct and indirect costs, Design and manufacturing costs, ways to model manufacturing cost process flow model, parametric cost model
7	**Design for Maintenance** Importance, Factors affecting ease of maintenance, elements and concepts of maintenance, corrective and preventive maintenance, Maintenance of a degrading system
	Textbook 1. Eppinger, S. and Ulrich, K., 2015. Product design and development. McGraw-Hill Higher Education 2. Magrab, E.B., Gupta, S.K., McCluskey, F.P. and Sandborn, P., 2009. Integrated product and process design and development: the product realization process. CRC Press. 3. Boothroyd, G., 1994. Product design for manufacture and assembly. Computer-Aided Design, 26(7), pp505-520. 4. Pahl, G., Beitz, W., Feldhusen, J., & Grote, K.H. – *Engineering Design: A Systematic Approach* (Springer)

Multidisciplinary Minor - Contract Law, Arbitration, and Valuation

Semester - V		Multidisciplinary Minor	Contract Law, Arbitration, and Valuation					
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
	R5CE3202T	Project Accounting and Cost Management	3-0-0=3	3	20	30	50	3
	Course Outcome: After completion of course students will be able to 1. Understand fundamental concepts and principles of project accounting 2. Prepare comprehensive project budgets aligned with organizational goals. 3. Analyze project financial data to aid in decision-making.							

Module	Course Contents
1	**Introduction to Project Accounting and Cost Management** Definition and importance, The Project Accountant, Project Pricing Methodologies: Cost Plus Pricing, Fixed Fee Pricing, Contractual Modifiers.
2	**Project Billing and Revenue** Progress Billings, Project Revenue Recognition, Percentage of Completion Method, Completed Contract Method, Contract Modifications, Measurement of Progress Completion
3	**Construction financing and control** Cost associated with constructed facilities, Techniques for cost estimation, effect of scale on construction cost, Measurement of Progress Completion, cost control in construction.
4	**Project Cost Management** Progress Monitoring, Cost Variance Reporting, Change Order Management, Allowance Management, Contingency Management, The Sunk Cost Consideration.
5	**Decision Making Tools** Marginal Costing, Techniques of Marginal Costing, Application of Marginal Costing in Decision Making, Differential Cost Analysis, Transfer Pricing, Methods of Transfer Pricing.
6	**Budgeting and Budgetary Control** Budgetary Control and Preparation of Functional and Master Budgeting, Fixed, Variable, Semi-variable Budgets, Financial statements for projects, Zero Based Budgeting (ZBB).
7	**Tools for Financial Analysis and Planning** Financial Ratio Analysis, Fund Flow Analysis, Cash Flow Analysis
8	**Project Measurements** Learning Curve, Cost Variance, Net Present Value, Breakeven Analysis, Return on Assets.

	Recommended Reading **1.** Prasanna Chandra, Projects: Planning, Analysis, Selection, Financing, Implementation, and Review, Tenth edition. **2.** K.Nagarajan, Project Management, New Age International Publishers. **3.** Panneerselvam R., Engineering Economics, PHI. **Textbooks** **1.** M N Arora, A Textbook Of Cost And Management Accounting , Vikas Publishing House, 2017

Multidisciplinary Minor – Sustainable Environment

Semester - V		Multidisciplinary Minor	Sustainable Environment					
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
	R5CE3203T	Environmental Economics	3-0-0=3	3	20	30	50	3
	Course Outcome: After completion of course students will be able to 1. Understand the Economic Principles Underlying Environmental Issues. 2. Evaluate Economic Practices for Sustainable Development. 3. Evaluate Environmental Policies and Regulations Based on Economics.							

Module	Course Contents
1	**Introduction to Environmental Economics:** Meaning, Definition, and Relevance of Environmental Economics; Basic Concepts and Tools from Microeconomics and Welfare Economics; Comparison with Other Sub-disciplines like Ecological, Economics, and Natural Resource Economics; Major Problems and Key Concerns of Environmental Economics. Commons and Collective Actions Problem: Seminal Theories; Mancur Olson's Theory of Collective Action; Collective Action and Prisoner's Dilemma Game.
2	**Environment and Economic Growth:** Poverty, Environment and Economic Growth Linkages-Environmental Kuznets Curve, Environmental Sustainability; Environmental Performance Index; Benefit-cost Analysis.
3	**Consumer Demand for Environmental Goods:** Consumer Demand for Environmental Goods and Welfare Effects of Price Change; Values, Environmental Values, and Non-market Valuations: Revealed Preference Methods, Stated Preference Methods. Market-efficiency, Optimality, Consumers and Producers Surplus.
4	**Public Market and Environment:** Optimal Provision of Public Goods and Bads; Externality and Market Failure;

	Pigouvian Fee, Property Rights and Coase Theorem.
5	**Environmental Acts and Regulations:** Environmental Regulations and Basic Regulatory Instruments-Market-based Instruments/ Approaches; Environmental Regulation and Basic Regulatory Instruments-Market Trading Systems.
	Textbooks **1.** Hanley, Nick, Jason F Shogren& Ben White, (2008). Environmental Economics, Macmillan. **2.** Folmer, Henk, Hlandis Gabel and Hans Opschoor (1997). Principles of Environmental and Resource Economics, Edward Elgar Pub. **Recommended Reading** **1.** Brady, John (2006). Environmental Management in organizations, Earthscan Pub. **2.** Bromely, Daniel E The Handbook of Environmental Economics **3.** Connor, Robin and Stephen, Dovers (2004). Edward Institutional Change for Sustainable Development, Edward Elgar Publishing. **4.** Waheed Uddin, Ronald Hudson, and Ralph Haas, Public Infrastructure Asset Management, McGraw-Hill Professional **5.** Hart, Staurt L (1997). Strategies for Sustainable World, Harvard Business Review.

Semester - V		VSEC						
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
11	R5CE3004L	Disaster Planning and Management	0-0-2=2	1	ISCE:60		40	3
	Course Outcome: After completion of course students will develop competencies in 1. Apply disaster management concepts to effectively plan, mitigate, and respond to various types of disasters. 2. Analyze the interrelationship between development and disasters to assess risks and implement sustainable disaster management strategies. 3. Classify different categories of disasters and evaluate their causes, impacts, and management approaches. 4. Demonstrate awareness of social responsibilities in disaster preparedness, response, recovery, and resilience-building.							

Module	**Course Contents**
1	**Introduction:** Concepts and definitions: disaster, hazard, vulnerability, risks - severity, frequency and details, capacity, impact, prevention, mitigation.
2	**Disasters:** Disasters classification: Natural disasters (floods, drought, cyclones, volcanoes, earthquakes, tsunami, landslides, coastal erosion, soil erosion, forest fires, etc.). Manmade disasters (industrial pollution, artificial flooding in urban areas, nuclear radiation, chemical spills, transportation accidents, terrorist strikes, etc.). Hazard and vulnerability profile of India, mountain and coastal areas, ecological fragility.
3	**Disaster Impacts** Road development scenarios in India; State of rural infrastructure and its implications on growth; Characteristics of rural India; Strategies for improving infrastructure in rural areas; Government initiatives for rural infrastructure development; Role of private sector participation in rural infrastructure projects.

4	**Disaster Risk Reduction (DRR):** Disaster management cycle – its phases: prevention, mitigation, preparedness, relief, and recovery. Structural and non-structural measures. Risk analysis, vulnerability, and capacity assessment. Early warning systems. Post-disaster environmental response (water, sanitation, food safety, waste management, disease control, security, communications). Roles and responsibilities of government, community, local institutions, NGOs, and other stakeholders. Policies and legislation for disaster risk reduction. DRR programmes in India and the activities of the National Disaster Management Authority (NDMA).
5	**Disasters, Environment, and Development** Factors affecting vulnerability such as: Impact of developmental projects and environmental modifications (including dams, land-use changes, urbanization, etc.). Sustainable and environmentally friendly recovery. Reconstruction and development methods.
6	**Accessibility in Disaster Contexts and Emergency Services** Accessibility in the context of Disaster Preparedness, Response, Mitigation, and Reconstruction for differently abled individuals.
	Text/Reference Books: 1. S.C. Sharma, *Disaster Management*, Khanna Publishing House, 2022. 2. National Disaster Management Authority (NDMA) 3. National Disaster Management in India, Ministry of Home Affairs. 4. Pradeep Sahni, 2004, *Disaster Risk Reduction in South Asia*, Prentice Hall. 5. Singh B.K., 2008, *Handbook of Disaster Management: Techniques & Guidelines*, Rajat Publication. 6. Ghosh G.K., 2006, *Disaster Management*, APH Publishing Corporation. 7. Disaster Medical Systems Guidelines. Emergency Medical Services Authority, State of California, EMSA no.214, June 2003. 8. Inter-Agency Standing Committee (IASC) (Feb. 2007). *IASC Guidelines on Mental Health and Psychosocial Support in Emergency Settings.* Geneva: IASC.

Semester VI

Semester - VI		PCC						
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
1	R5SE3003T	**Design of Steel Structures**	3-0-0=3	3	20	30	50	3

Course Outcomes

After completion of this course, students will be able to,

1. Apply the limit state design philosophy for analysis and design of structural steel components.
2. Apply the limit state design philosophy for analysis and design of structural steel connections.
3. Analyze and design structural steel roofing and flooring systems.

Module	Course Contents
1	**Bolted and welded connections** Introduction to riveted connection, design of bolted and welded connections, axially and eccentrically loaded joints, simple connection of bracket plates to columns, beam to beam and beam to column connections, design of framed, unstiffened and stiffened seat connections.
2	**Roofing system** Imposed loads on flat and sloping roofs and floors, wind loads on sloping roofs and vertical cladding including effect of degree permeability and wind drag, analysis of pin-jointed trusses under various loading cases, computation of design forces in members, design and detailing of connections and supports.
3	**Flooring system** Concept of floor system with secondary beams, main beams and columns, design of simply supported beams using rolled steel sections.
4	**Columns and Bases** Design of columns under axial loads using single or multiple rolled steel sections, design of lacing, battens, columns subjected to axial load and bending, design of slab and Gusseted base.
	Recommended Reading 1. S.S. Bhavikatti, Design of Steel Structures, I.K. International Publishing House Limited, 2017. (ISBN: 9789385909559/938590955X). 2. V.L. Shah and V. Gore, Limit State Design of Steel Structures IS:800-2007,

	Structures Publication, 2012. (ISBN: 8190371754). 3. IS 800 (2007), General Construction in Steel- Code of Practice, Ced 7: Structural Engineering and Structural Section, Published by Bureau of Indian Standard Manak Bhavan, New Delhi. 4. IS 875- Part 1 (1987): Dead Loads, Indian Standard Code of Practice for Design Loads(Other than Earthquake) for Buildings and Structures, Published by Bureau of Indian Standard Manak Bhavan, New Delhi. 5. IS 875- Part 2 (1987): Imposed Loads, Indian Standard Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures, Published by Bureau of Indian Standard Manak Bhavan, New Delhi. 6. IS 875- Part 3 (2017): Wind Loads, Indian Standard Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures, Published by Bureau of Indian Standard Manak Bhavan, New Delhi. 7. IS 875- Part 4 (1987): Snow Loads, Indian Standard Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures, Published by Bureau of Indian Standard Manak Bhavan, New Delhi. 8. IS 875- Part 5 (1987): Special Loads and Combinations, Indian Standard Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures, Published by Bureau of Indian Standard Manak Bhavan, New Delhi. **Textbooks** 1. S.K. Duggal, Limit State Design of Steel Structures, Tata McGraw Hill Education

Semester - VI		PCC						
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
2	R5SE3003L	**Design of Steel Structures Laboratory**	0-0-2=2	1	ISCE:60		40	3

Course Outcomes

After completion of this course, students will be able to,

1. Identify and compute the design loads on various structural steel systems.
2. Apply principles and relevant codal provisions for the analysis and design of vari structural steel systems.
3. Use commercial software for analysis and design of steel structures.
4. Prepare detailed steel structural drawings.

Module	Course Contents
	A. Design of roof truss system. B. Design of columns and columns bases. C. Design of structural steel flooring system. D. Design of bolted and welded connections
	Recommended Reading 2. S.S. Bhavikatti, Design of Steel Structures, I.K. International Publishing House Limited, 2017. (ISBN: 9789385909559/938590955X). 3. V.L. Shah and V. Gore, Limit State Design of Steel Structures IS:800-2007, Structures Publication, 2012. (ISBN: 8190371754). 4. IS 800 (2007), General Construction in Steel- Code of Practice, Ced 7: Structural Engineering and Structural Section, Published by Bureau of Indian Standard Manak Bhavan, New Delhi. 5. IS 875- Part 1 (1987): Dead Loads, Indian Standard Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures, Published by Bureau of Indian Standard Manak Bhavan, New Delhi. 6. IS 875- Part 2 (1987): Imposed Loads, Indian Standard Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures, Published by Bureau of Indian Standard Manak Bhavan, New Delhi.

	7. IS 875- Part 3 (2017): Wind Loads, Indian Standard Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures, Published by Bureau of Indian Standard Manak Bhavan, New Delhi. 8. IS 875- Part 4 (1987): Snow Loads, Indian Standard Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures, Published by Bureau of Indian Standard Manak Bhavan, New Delhi. 9. IS 875- Part 5 (1987): Special Loads and Combinations, Indian Standard Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures, Published by Bureau of Indian Standard Manak Bhavan, New Delhi. **Textbooks** 1. S.K. Duggal, Limit State Design of Steel Structures, Tata McGraw Hill Education Private Limited, 2017. (ISBN: 9789351343493/9351343499). 2. N. Subramanian, Design of Steel Structures, Oxford University Press, 2011. (ISBN: 9780198068815/0198068816).

Semester – VI		Program Core Course (PCC)						
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
3	R5CE3005T	Pavement Engineering	3-0-0 = 3	3	20	30	50	3
	Course Outcome: After completion of this course, students will be able to, 1. Use knowledge on Traffic study, highway planning, geometric design of pavements. 2. Acquire the basic knowledge of Construction techniques of Flexible and Concrete pavements. 3. Plan various highway cross sectional element. 4. Carry out structural design flexible and rigid pavements. 5. Design pavement material mix for flexible and rigid pavements.							

Module	Course Contents
1	**Introduction to Highway Engineering:** Traffic engineering definitions: functions, organization and importance, necessity of understanding the behavior of road user and vehicle characteristics, human factors governing the road user behavior- power performance and other vehicular characteristics.
2	**Traffic Engineering & Control:** Traffic studies and surveys: Speed studies: presentation of data, journey time and delay study, uses and various methods, relative merits and demerits. Vehicular volume counts: types, various available methods, relative merits and demerits, planning of traffic counts, vehicle occupancy surveys. Origin: destination surveys, need and uses, various available methods, checks for accuracy, presentation of data, Parking surveys: needs and types Highway Capacity, PCU, Level of Service, Factors affecting Highway capacity and level of Service
3	**Geometric Design of Highways** Terrain classification, design speed, vehicular characteristics, highway cross-section elements Sight distance: introduction to sight distance, reaction time, analysis of safe sight distance, analysis of overtaking sight distance, Intermediate sight distance. Design of horizontal alignment: horizontal curves, design of super elevation and its provision, radius at horizontal curves, widening of pavements at horizontal curves, analysis of transition curves. Design of vertical alignment: different types of gradients, grade compensation on curves, analysis of vertical curves, summit curves, valley curves. Intersection: at grade and grade separated intersections, speed change lanes, Canalization, Design of rotary intersection and mini roundabout, Determination of optimal signal time by Webster method

4	**Design of Pavements:** Types of pavements, comparison of different types of pavements, functions of pavement components, pavement design factors, design wheel load, equivalent single wheel load, repetition of loads, equivalent wheel load factors, strength characteristics of pavement materials, climatic variation design of flexible highway pavement as per IRC approach Stresses in rigid highway pavements, critical load positions, stresses due to loads, stresses due to temperature change, combined loading and temperature stresses, Joints in rigid pavements: transverse joints, longitudinal joints, fillers and sealers
5	**Highway Construction** Equipment used for construction, embankment design and construction, construction of different Types of roads: water bound macadam, different types of bituminous pavements, cement concrete pavements, Modern Techniques for construction of Roads (Bituminous and concrete roads)
6	**Highway Maintenance & Rehabilitation** Pavement failures: flexible pavement failures, rigid pavement failures, maintenance of different types of pavements: assessment and need for maintenance, pavement management system, evaluation of pavements: structural evaluation of pavements, functional evaluation of pavements, strengthening of existing pavements: object of strengthening, types of overlays, design of different types of overlays
	Text Books: 1 L. R. Kadiyali, N. B. Lal, Principles and Practice of Highway Engineering, Khanna Publications, 2005 (ISBN- 9788174091659) 2 Partha Chakroborty, Principles of Transportation Engineering, PHI Learning, 1st edition 2011, (ISBN-9788120320840) 3 Fred L. Mannering, Scott S. Washburn, Walter P. Kilareski, John Wiley, Principles of Highway Engineering and Traffic Analysis, 4th Edition, (ISBN-9781118120149)

	Recommended Reading: 1 Morlok, E. R., An Introduction to Transportation Engineering and Planning, McGraw Hill Kagakusha International Student Edition, (ISBN: 0070431329) 2 Hay, W. W., Introduction to Transportation Engineering. John Wiley and Sons, New York, (1988), 2nd edition, (ISBN: 0471364339) 3 Papacostas, C. S., Fundamentals of Transportation Engineering, Prentice Hall of India, New Delhi, (1987), (ISBN: 0133448703) 4 IRC 37 –Design of Flexible Pavement 2012, 5 IRC-58- Design of Rigid Pavement 2002 6 IRC-SP62 Design of Low volume roads-2014

Semester - VI		Humanities and Social Science Management (HSSM)						
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
4	R5CE3006T	Construction Management	3-0-0=3	3	20	30	50	3
	Course Outcome: After completion of this course, students will be able to, 1. Explain the significance of infrastructure in economic development and analyze the factors influencing infrastructure demand and supply. 2. Develop infrastructure planning strategies by applying forecasting techniques and prioritizing development areas at urban, regional, and national levels. 3. Evaluate infrastructure management practices, including maintenance planning, risk management, and public-private partnerships in various sectors. 4. Apply infrastructure assessment methods to monitor and control projects concerning time, cost, and quality through progress reporting and case studies.							

Module	Course Contents
1	**Management** Definition, functions of management, advances and societal influences in construction management
2	**Construction projects:** Relationships with Project, Program and Portfolio Management, Project lifecycle, Phases of a project, agencies involved, Indian standards on construction and project management, lean construction techniques
3	**Construction project planning** Stages of project planning: pre-tender planning, pre-construction planning, detailed construction planning, role of client and contractor, level of detail. Process of development of plans and schedules, work break-down structure, activity lists, assessment of work content, estimating durations, sequence of activities, activity utility data

4	**Techniques of planning** Bar charts, Networks: basic terminology, types of precedence relationships: finish to start, Start to start, finish to finish, start to finish, preparation of CPM networks: activity on link and activity on node representation, analysis of single relationship (finish to start) networks, computation of float values, critical and semi-critical paths, calendaring networks.
	Resource Scheduling Bar chart, line of balance technique, resource constraints and conflicts, resource aggregation, allocation, smoothening and leveling
	PERT Assumptions underlying PERT analysis, determining three time estimates, analysis, slack computations, calculation of probability of completion
	Construction costs Classification of costs, time cost trade-off in construction projects, compression and decompression
	Monitoring & control Project communications, record keeping, periodic progress reports, periodical progress meetings, earned value management, scope creep and change management, updating of plans: purpose, frequency and methods of updating common causes of time and cost overruns and corrective measures. PMI / PMBOK for efficient management of projects. Quality control: concept of quality, quality of constructed structure, supervision, use of manuals and checklists for quality control, role of inspection, basics of statistical quality control. Delay analysis: Techniques- As planned, As Built, Impacted As Planned, As Planned But For, Collapsed As Built, Window analysis, Time Impact analysis
	Project Closure Closeout documentation, Project punch list, Lessons Learned, as builddrawing, operation and maintenance manual.
	Text Books: 1 K. K. Chitkara, Construction Project Management- Planning, Scheduling and Controlling, Tata McGraw Hill Education, 2nd edition, 2010. (ISBN: 9780070680753/ 0070680752) 2 K. N. Jha, Construction Project Management- Theory and Practice, Pearson Education India, 2nd edition, 2015. (ISBN: 978-9332542013/9332542015)

	Reference Books: 1 J. M. Antilland R. W. Woodhead, Critical Path Methods in Construction Practice, Wiley- Interscience, 4th edition, 1990. (ISBN:9780471620570/0471620572) 2 D.S. Barrie & B. C. Paulson, Professional Construction Management: Including CM, Design- Construct and General Contracting, McGraw Hill Inc, 3rd edition, 1991. (ISBN: 9780070038899) 3 Indian and other relevant Standards

Semester - VI		Humanities and Social Science Management (HSSM)						
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
5	R5CE3006L	Construction Management Laboratory	0-0-2 = 2	1	ISCE:60		40	3
	Course Outcome: 1. Develop plan for construction of civil engineering facility 2. Use project management software for generation of plans, schedules and reports.							

	Course Contents
	1 Preparation of a project plan for one of the following projects using working drawings - Residential bungalow - Single storied building for commercial purpose - Single span bridge. 2 Use of project management software, capability, input requirements, possible outputs. use of software like MS Project and Primavera for real time applications.
	Text Books: 1. K. K. Chitkara, Construction Project Management- Planning, Scheduling and Controlling, Tata McGraw Hill Education, 2nd edition, 2010. (ISBN: 9780070680753/ 0070680752) 2. K. N. Jha, Construction Project Management- Theory and Practice, Pearson Education India, 2nd edition, 2015. (ISBN: 978-9332542013/9332542015)

	Reference Books: 1. J. M. Antill and R. W. Woodhead, Critical Path Methods in Construction Practice, Wiley- Interscience, 4th edition, 1990 (ISBN:9780471620570/0471620572) 2. P. K. Joy, Handbook of Construction Management, Macmillan Publishers India, 2nd edition, 2000. (ISBN:9780333926932/0333926935) 3. M. L. Sidney, Project Management in Construction, McGraw-Hill Education, 7th edition, 2017. (ISBN: 9781259859700/1259859703)

Semester - VI		Humanities and Social Science Management (HSSM)						
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
6	R5CE3007T	Infrastructure Development Planning	2-0-0 = 2	2	ISCE: 60		40	3
	Course Outcome: After completion of this course, students will be able to, 1. Explain the significance of infrastructure in economic development and analyze the factors influencing infrastructure demand and supply. 2. Develop infrastructure planning strategies by applying forecasting techniques and prioritizing development areas at urban, regional, and national levels. 3. Evaluate infrastructure management practices, including maintenance planning, risk management, and public-private partnerships in various sectors. 4. Apply infrastructure assessment methods to monitor and control projects concerning time, cost, and quality through progress reporting and case studies.							

Module	Course Contents
1	**Introduction to Infrastructure** Definition of basic terminologies, role of infrastructure in economic development, types of infrastructure, measurement of infrastructure capacity, bases for quantification of demand and supply of various types of infrastructure, Indian scenario in respect of adequacy and quality. Field-based exercises on identifying infrastructure deficiencies and assessing adequacy in a selected locality.
2	**Infrastructure Planning** Goals and objectives of infrastructure planning, identification and quantification of the causal factors influencing the demand for infrastructure, review and application of techniques to estimate supply and demand for infrastructure, use of econometric, social, and land-use indicators and models to forecast demand and level of service of infrastructure and its impact on land use, critical review of the relevant forecasting techniques, infrastructure planning to identify and prioritize preferred areas for development, integration of strategic planning for infrastructure at urban, regional, and national levels, case studies in infrastructure planning. Preparing an infrastructure demand analysis report for a selected urban or rural area.
3	**Infrastructure Management** Concepts of infrastructure management, common aspects of urban and rural infrastructure management systems, pavement and bridge management systems, integrated infrastructure management, case studies related to infrastructure management. Practical work involving condition assessment of roads, bridges, and other infrastructure components, along with preparation of progress reports for maintenance and repair recommendations.

4	**Risk and Value Management** Value, value engineering, value analysis, value management, Habits, Roadblocks & attitudes and their relation to value engineering. Sources of risk, risk classification, risk effects, common tools and techniques of identification. Risk measurement, qualitative and quantitative techniques. Risk management plan, risk retention, risk reduction, risk transfer, risk avoidance, attitudes towards risk.
5	**Sectoral Overview of Infrastructure** Infrastructure sectoral overview including highways, railways, waterways, airports, urban and rural infrastructure, roads, housing, water supply, and sanitation, case study examples. Exercises on preparing feasibility and impact assessment reports for small-scale infrastructure projects in selected sectors.
6	**Safety and Health Management:** Occupational Health Hazards, Promoting Safety, Safety and Health training, Stress and Safety. Safety Psychology, Safety information system, Ergonomics - Introduction, Definition, Objectives, Advantages. Ergonomics Hazards - Musculoskeletal Disorders and Cumulative Trauma Disorders. iii. Importance of Industrial safety.
7	**Safety at workplace:** Safe use of machines and tools: Safety in the use of: Grinding, CNC‟s computer numeric control, Shearing, Bending, Milling, Boring, Shaping Safe use of hand tools.
	Text Books: 1. V. Proag, Infrastructure Planning and Management: An Integrated Approach, Springer, 2020 (ISBN: 9783030485585) 2. S. Goodman and M. Hastak, Infrastructure Planning Handbook: Planning, Engineering, and Economics, McGraw Hill, 2006 (ISBN: 9780071474948/0071474943) 3. D. Coffelt and C. Hendrickson, Fundamentals of Infrastructure Management, CRC Press, 2014 (ISBN: 9781466552159) 4. A. S. Goodman and M. Hastak, Infrastructure Planning, Engineering, and Economics, McGraw Hill, 2nd Edition, 2015 (ISBN: 9780071850131)

PROGRAM ELECTIVE COURSES

Semester - VI		PEC	Structural Engineering I					
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
1	R5SE3104T	Introduction to Non-Linear Analysis of structures.	3-1-0=4	4	20	30	50	3

Course Outcomes

After completion of this course, students will be able to,

1. Apply principles of nonlinear behavior in structural stability analysis.
2. Perform stability analysis for simple and complex structures.
3. Perform plastic analysis of simple and complex steel and concrete structures.
4. Design simple and complex steel and concrete structures using plastic design methods

Module	Course Contents
1	**Introduction to elastic stability** Geometric non-linearity: basic concept. Analysis of beam column with conditions, use of trigonometric series. various end
2	**Introduction to torsional buckling** Pure torsion of thin walled beams of open cross section warping and warping rigidity, Torsional buckling of columns, combined buckling by torsion and flexure. Lateral torsional buckling of beams, Indian codal provisions regarding buckling of steel members (columns and beams).
3	**Introduction to plastic analysis** Concepts of plastic analysis of structures, Stress strain relations of steel and concrete. Concept of Redistribution of Moments, Plastic modulus, Shape factor, Plastic hinge, rotation capacity for steel and concrete plastic hinges, Fully plastic moment, moment curvature relations for rigid, semi rigid and ductile joints, Effect of Axial Force and Shear Force on the fully plastic moment of a cross section, Various types of failure mechanisms, Statical and Mechanism method for calculation of collapse loads, Lower and upper bound theorems.
4	**Determination of collapse loads for steel structures** Determination of Collapse loads for single and multiple span beams, carrying

	various types of loads, single/multi bay multi storied rigid jointed portal frames and single bay gable frames. Incremental Load Method for pin jointed and rigid jointed frames
5	**Determination of collapse loads for concrete slabs** Yield Line Analysis of Slabs.
	Recommended Reading 1 J.N. Reddy, Nonlinear Finite Element Analysis, Oxford University Press, 2008. (ISBN- 019852529X/978-0198525295) 2 S. Chandrasekaran, L. Nunziante , G. Serino and F. Carannante, Seismic Design Aids for Nonlinear Analysis of Reinforced Concrete Structures, Taylor and Francis, 2010. (ISBN- 1439809143/978-1439809143).
	Text Books: 1. M.Sathyamoorthy, Nonlinear Analysis of Structures, CRC Press, Boca Raton, Florida, 1997. (ISBN: 9781138105881/1138105880). 2. D.G. Fertis, Nonlinear Mechanics, CRC Press, Boca Raton, Florida, 1998. (ISBN: 0849390028/978-0849390029)

Semester – VI		PEC	Geotechnical Engineering					
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
1	R5SE3106T	**Earth Pressure and Retaining Structures**	3-1-0=4	4	20	30	50	3

Course Outcomes

After completion of this course, students will be able to,

1. Discuss classical theories of earth pressure.
2. Evaluate stability of rigid and flexible retaining structures.
3. Evaluate behaviour of underground structure and open cuts.
4. Evaluate stability of Reinforced Soil Walls and shoring system.

Module	Course Contents
1	**Earth Pressure** Types, Rankine's theory, backfill features - soil type, surface inclination, loads on surface, soil layers, water level, Coulomb's theory, effects due to wall friction and wall inclination, graphical methods, earthquake effects.
2	**Rigid Retaining Structures** Types, empirical methods, stability analysis.
3	**Flexible Retaining Structures** Types, material, cantilever sheet piles, anchored bulkheads - free earth method, fixed earth method, moment reduction factors, anchorage.
4	**Braced Excavation** Types, construction methods, pressure distribution in sands and clays, stability, bottom heave, seepage, ground deformation
5	**Reinforced Soil Walls** Elements, construction methods, external stability, internal stability.
6	**Shoring system** Tangent and secant pile and supporting anchors. Corner sturts and shoring piles supporting strut.
	Recommended Reading 1. K. Terzaghi and R. B. Peck, Gholamreza Mesri, Soil Mechanics in Engineering Practice, Wiley and Sons, 1996. (ISBN-8126523816/978-8126523818). 2. H. Winterkorn and F.Y. Fang, Foundation Engineering Handbook, CBS Publishers & Distributors, New Delhi, 1990. (ISBN 9788123905457). 3. J. E. Bowles, Foundation Analysis and Design, McGraw-Hill Book Co, 2001. (ISBN-0071188444/ 978-0071188449). 4. T.S. Ingold, Reinforced Earth, Thomas Telford Ltd (ISBN-978-0727700896 5. IRC SP 102 Design and Construction of Reinforced Soil Walls

	Textbooks 1. G. Ranjan and A.S.R. Rao, Basic and Applied Soil Mechanics, New Age International Pvt. Ltd., 2005. (ISBN: 9788122440393/8122440398. 2. V.N.S. Murthy, Advanced Foundation Engineering, CBS Publishers and Distributors, New Delhi, 2016. (ISBN- 9788123915067). 3. P. Shamsher and H. Sharma, Pile Foundations in Engineering Practice, Wiley and Sons, 1990. (ISBN-0471616532/978-0471616535).

Semester – VI		PEC	Structural Engineering II					
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
1	R5SE3105T	Repair, Retrofitting and Strengthening of Structures	3-1-0=4	4	20	30	50	3

Course Outcomes

After completion of this course, students will be able to,

5. Conduct POE and identify various types of distresses in buildings.
6. Identify the effects due to climate, temperature, chemicals, wear and erosion on structures.
7. Justify appropriate materials and techniques for repairs and rehabilitation

Module	**Course Contents**
1	**Introduction to Repair, Rehabilitation and Retrofitting** Post occupancy evaluation of buildings, deformation and common defects in buildings. Routine maintenance, Preventive measures, Remedial maintenance
2	**Structural health and condition assessment** Structural & Non-structural cracks, crack type, important characteristics & possible reasons, Embedded metal corrosion. Disintegration mechanisms, moisture effect, exposure to aggressive chemicals, thermal effects, load effects, faulty workmanship.Models for deterioration.
3	**Methods of Repair, Rehabilitation, and retrofitting** Repairs to corrosion infected members, damaged water proofing, junction of beam, column, wall, jacketing, fibre wrapping technique Different types of shoring, under pinning, Properties, Cement, aggregate, wire mesh, admixtures, bonding agents, corrosion protection, repair mortar, protective coating, and polymer modified mortar.
4	**Material Selection and Characterization** using XRD, SEM-EDS, TGA/DTA, etc of advanced supplementary cementitious material. Studies on advanced structural composite material.
5	**Repair, Rehabilitation and Retrofitting of masonry, RCC and steel structures.** Historical structures, Pipelines (water/ sewage/ air/ gas): Purpose and methods of evaluation, evaluation of physical condition, methods of rehabilitation. Roads: Evaluation and performance surveys, distress evaluation, methods of resurfacing, overlays, restoring and rehabilitation. Bridges: Inspection and reporting methods, rehabilitation measures. Ports and harbours: Maintenance of ports, port buildings, and services.
6	**Retrofitting of structures for dynamic loads**- performance based evaluation/design approach.
7	**Anchorages and management of Repair, Rehabilitation and retrofitting of Structures.**
	Reference Books: **1** P. K. Guha, Maintenance and Repairs of Buildings, New Central Book

	Agency (P) Ltd., Kolkata, 2nd edition, 2015. (ISBN: 9788173810732) **2** M. S. Shetty, Concrete Technology (Theory and Practice), S. Chand & Co Ltd., 2008. (ISBN: 9788121900034) **3** P. C. Varghese, Maintenance, Repair & Rehabilitation & Minor Works of Buildings, PHI Learning Private Limited, Delhi,2004. (ISBN: 9788120349452) **4** J. Bhattacharjee, Concrete Structures- Repair, Rehabilitation and Retrofitting, CBS Publishers & Distributors Pvt Ltd, New Delhi, 2017. (ISBN: 9789385915901) **5** Published books in the relevant areas to be supplemented by latest journal articles and papers, seminar and conference proceedings, in-house publications, monographs.
	Text Books: 1 K. Saxena, Repairs, Rehabilitation & Restoration of structures, Anuvi Chemicals Ltd. 2 J. J. Shah, Point of View – Repair, Rehabilitation and Waterproofing of Structures-Some View,Published in April 1998 issue of The Indian Concrete Journal, Mumbai.

Semester – VI		PEC	Construction Engineering and Management					
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
7	R5CE3107T	Construction Equipment and Resource Management	3-1-0=4	4	20	30	50	3
	Course Outcome: After completion of course students will be able to 1. Classify construction equipment and evaluate selection criteria, productivity, maintenance, and economic aspects. 2. Able to prepare inventory analysis and make material purchase decisions. 3. Analyze and monitor equipment's and material requirements 4. Apply materials management principles for estimation, procurement, inventory control, and waste minimization in construction.							

Module	Course Contents
1	**Introduction to Construction Equipment:** Classification of construction equipment, factors influencing equipment selection, productivity and operational efficiency, maintenance strategies, safety considerations in equipment usage, economic aspects including cost analysis, investment, operational expenses, and depreciation.
2	**Construction Machinery for Earthmoving, Material Handling, and Roadworks** Earthmoving and excavation equipment: Excavators, bulldozers, loaders, scrapers, and trenchers; working principles, applications, and performance parameters; operational cost analysis and efficiency considerations. Material handling and transportation equipment: Cranes, hoists, conveyors, and forklifts; hauling equipment such as dumpers, tippers, and trailers; selection criteria for different construction applications; safety measures in material handling and transportation. Concrete and road construction equipment: Concrete mixers, batching plants, and concrete pumps; asphalt pavers, compactors, and rollers; advancements in paving and compacting technologies for improved construction efficiency and durability.
3	**Automation and Advanced Technologies in Construction** Construction automation and robotics: Introduction to automation in construction; robotic applications such as 3D printing and robotic arms; AI applications in predictive maintenance and project scheduling; IoT-based smart construction

	technologies for real-time monitoring and resource optimization. Advanced technologies and digital transformation: Building Information Modeling (BIM) and digital twin technology; drone applications in surveying and site monitoring; case studies on automation in mega projects, showcasing real-world implementation and challenges.
4	**Equipment Management** Mechanization on construction projects, selection of major and minor equipment, production estimating, sizing and matching of equipment Sources of construction equipment: purchase, rent and lease, old and new equipment. Economics of equipment, useful / economic life of equipment, equipment operation and service, maintenance, depreciation, obsolescence and replacement. Equipment management systems, organizations, record keeping, training to operators
5	**Materials Management** Importance, estimation of materials, Classification and codification, ABC analysis Purchase function: legal aspects of purchase, inventory control, concept of EOQ Stores management, minimizing wastage, Material management systems, Organizations, record keeping
	Textbooks 1. Peurifoy, R. L., Schexnayder, C., Shapira, A., & Schmitt, R. "Construction Planning, Equipment, and Methods." McGraw-Hill Education. 2. Mahesh Varma, "Construction Equipment and Its Planning and Application," Metropolitan Book Company. 3. R. L. Peurifoy, "Construction Equipment Management for Engineers, Estimators, and Owners," McGraw Hill. 4. S. W. Nunnally, "Construction Methods and Management," Pearson. **Recommended Reading** 1. R. Chudley & R. Greeno, "Advanced Construction Technology," Pearson Education. 2. Varma Mahesh, Construction Equipment, its Planning & Application, Metropolitan & Co 3. Gopalkrishnan, Materials Management 4. Nunnally, Managing construction equipment, Prentice Hall

Semester - VI		PEC	Geoinformatics					
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
8	R5CE3108T	Remote Sensing	3-1-0=4	4	20	30	50	3
	Course Outcome: After completion of course students will be able to 1. Understand the fundamental concepts of remote sensing technology 2. Apply image processing techniques for data interpretation and understand the output 3. Integrate remote sensing data and its applications in real-world scenarios							

Module	Course Contents
1	**Introduction to Remote Sensing:** Concepts and foundations of remote sensing- electromagnetic spectrum, spectral signatures, remote sensing systems. Elements of photographic systems - Basic principles of photogrammetry – relief displacement. Solar Reflection and Thermal Emission Remote Sensing, Interaction of EM Radiation with Atmosphere Including Atmospheric Scattering, Absorption and Emission.
2	**Remote Sensing Platforms and Sensors:** Satellite System Parameters, Sensor Parameters, The Indian Remote Sensing Program. Visual Image Interpretation - Digital Image Processing.
3	**Image Analysis Using Remote Sensing:** Interaction Mechanisms of EM Radiation with Ground, Spectral Response Curves, Principles of Image Interpretation, Multi-Spectral Scanners and Imaging Devices, Salient Characteristics of LANDSAT, IRS, Cartosat, Resourcesat etc. Sensors, Image Characteristics, and Different Resolutions in Remote Sensing.
4	**Image classification techniques:** InSAR Technique and its Applications, Hyperspectral Remote Sensing, Integrated applications of RS and GIS in Groundwater Studies, Limitations of Remote Sensing Technique.
5	**Applications of Remote Sensing Technology:** Image Interpretation of Different Geological Landforms, Rock Types, and Structures, Remote Sensing Integration with GIS and GPS, Georeferencing Technique, Basic Image Enhancement Techniques, Spatial-Filtering Techniques

	Recommended Reading **1.** Thomas. M. Lillesand and Ralph. W. Kiefer, Remote Sensing and Image Interpretation, John Wiley and Sons, Inc. **2.** Imaging Radar for Resource Survey: Remote Sensing Applications, 3, W Travelt, Chapman & Hall. **3.** Remote Sensing: The quantitative approach, P.H. Swain and S.M. Davis, McGraw Hill. **4.** Floyd, F. Sabins, Jr: Remote Sensing Principles and Interpretation, Freeman and Co., San Francisco, 1978 **5.** https://archive.nptel.ac.in/courses/121/107/121107009/- Remote sensing basics. **Textbooks** **1.** Thomas. M. Lillesand and Ralph. W. Kiefer, Remote Sensing and Image Interpretation, John Wiley and Sons, Inc. **2.** Burrough P.A., Principles of GIS for Land Resources Assessment, Oxford Publication, 1980.

Semester - VI		PEC	Environmental Engineering					
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
9	R5CE3109T	Environmental Impact Assessment and Audit	3-1-0=4	4	20	30	50	3
	Course Outcome: After completion of course students will be able to 1. Describe EIA process and relate various government notifications. 2. Formulate the methodology for prediction and assessment of various impacts on environment 3. Apply various methods of environmental audit.							

Module	Course Contents
1	**Fundamental Approach To EIA:** History of EIA: Evolution Environmental Laws in World &India, Development of EIA in India, Environmental Clearance Procedure in India. Categorization of projects, Basic Concept of EIA: Introduction, Objective of EIA, Significances Systematic Approach for Using EIA: Introduction, Identification of Study Area, Classification of Environmental Parameters, Preparation of EIA Report, Screening, Scoping Public consultation and appraisal Baseline Studies in EIA, Environmental Monitoring & Management Planning, Draft and Final EIA, Impact Analysis, Final EIA Report. Government of India Ministry of Environment and Forest Notification regarding Environmental clearance. List of projects requiring Environmental clearance, Application form, Composition of Expert Committee, Ecological sensitive places, Statutory Clearance required for projects along with EIA such as Forest/ Wildlife/ CRZ Clearance.
2	**EIA Methodologies:** Introduction, Criteria for The Selection of EIA Methodology, EIA Methods: Ad hoc Methods, Checklists Methods, Matrices Methods, Networks Methods, and Overlays Methods, Environmental Index Using Factor Analysis, Cost/Benefit Analysis, Predictive or Simulation Methods. Predictive Models for Impact Assessment.
3	**Environmental Impact Statement (EIS):** Introduction, Basic Concepts behind EIS, Various Stages in EIS Production, Typical EIS Outline. Rapid EIA: Introduction, Procedure, Advantages and Limitation. Terms of References (TOR) for the Projects such as Coal sector,

	Hydropower, river valley, High way Project, Building construction and town ship development projects etc.
4	**Prediction and Assessment of Environmental Impacts:** Impacts on soil and ground water environment: introduction, soils and ground water, methodology for the prediction and assessment of impacts on soil and groundwater. Impacts on Surface Water Environment: Introduction, Project Which Create Impact Concerns for the Surface-Water Environment, Systematic Methods for Evaluation of Impacts. Impacts on Biological Environment: Introduction, General Methodology for the Assessment of Impacts on Biological Environment, Systematic Approach for Evaluating Biological Impacts. Impacts on the air environment: Introduction, a generalized approach for assessment of air pollution impact. Impacts of noise on the environment: Introduction, Basic Information of Noise, Noise Measurement, Effects of Noise on People, Systematic Methodology for Assessing Environmental Impacts of Noise. Impacts on the Socio-Economic Environment: Introduction, Social Assessment, Conceptual Frame Work for Socio Economic Assessment.
5	**Environmental Audit:** Aims & Objective, Types of audits, General audit methodology, Waste Audits and Pollution Prevention Assessments, Liability Audits and Site Assessment, Case Studies
6	**Case studies on EIA for Industries and Infrastructure projects**
	Recommended books: 1. Environmental Impact Assessment, second edition, Larry W. Canter, McGraw-Hill International editions. 2. Environmental Impact Assessment, Lauren David P., Willy Interscience, New Jersey. 3. Environmental Impacts of Industrial & Mining activities, Lalit N. Patraik, Ashish Public house. 4. Anjaneyulu Y., Manickam Valli, “Environmental Impact Assessment Methodologies”, CRC Press 2011 5. Impact of Mining on Environment, Trivedi R. K., Sinha M. P., Ashish Publication House. 6. Radioactive releases in the environment: Impact and Assessment, cooper, John R., Randle, Keith and other, 2003, John Wiley’s sons. 7. Environment, construction and sustainable development vol. 1, The Environmental Impact of Car penter T. G., 2001, John Wiley & sons

Semester – VI		PEC	Transportation Engineering					
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
10	R5CE3110T	Pavement Management System	3-1-0=4	4	20	30	50	3
	Course Outcome: After completion of course students will be able to 1. Acquire the knowledge of pavement management systems at network level and project level. 2. Perform the functional and structural evaluation of pavement. 3. Design strategies of pavement and economic evaluation.							

Module	Course Contents
1	**Pavement Management System (PMS):** Components of PMS and their Activities, Major Steps in Implementing PMS, Inputs, Design, Construction and Maintenance, Rehabilitation and Feedback Systems. Pavement Structural Design and Economic Analysis. Emerging Technology in Pavement Management Systems. Life Cycle Cost Analysis of Pavements
2	**Pavement distresses:** Distresses in flexible/rigid pavements: Causes and Remedies. Visual Surface Distress Survey Procedures and Techniques. Serviceability Indicators for Roads. Functional Evaluation of Pavements: Serviceability Concepts, Visual Rating, Pavement Serviceability Index, Skid Resistance, Roughness, and Safety Aspects. Inventory System.
3	**Maintenance Operations/Alternatives** Classification of maintenance operations, Routine, Periodic, and Special. Common types of maintenance: Potholes, Cracked Surfaces, Ruts and Undulations Resurfacing, Interface Treatments, White Topping: Types of White Toppings, Precast Concrete Panel Roads, Rehabilitation of Pavements Bituminous Thin Surface Courses: Seal Coat, Surface Dressing, Premixed Carpet, Mixed Seal Surface, Micro Asphalt Concrete (MAC). Bituminous Surface Courses: Semi-Dense Bituminous Concrete, Bituminous Concrete, and Bitumen Mastic. Use of Plastic Waste in Pavement Construction Road Maintenance in High Rainfall Areas. Choice of Materials. Modified

	Bitumen & Geo-Fabrics. Maintenance Alternatives Including Recycling. Cement Stabilization for Road Pavement
	Recommended Reading **1.** IRC 58-2015, Guidelines for the design of rigid pavements for highways **2.** Specifications for rural road, MORD 2004 **3.** Rural roads manual, Indian Road Congress September 2016 edition. **4.** Guidelines for the design of flexible pavements, Indian Road Congress, Fourth Revision-2018 **5.** IRC 81-1997, Guidelines for strengthening of flexible road pavements using Benkelman deflection technique. **6.** D. Croney and P. Croney, The Design and Performance of Road Pavements, McGraw Hill Professional, 3rd edition, 1997. (ISBN: 978-0070144514/0070144516) **7.** E. J. Yoder and M. W. Witczak, Principles of Pavement Design, Wiley International, 2nd Edition, 1991. (ISBN: 978-0471977803) **Textbooks** **1.** L. R. Kadiyali and N. B. Lal, Principles and Practice of Highway Engineering, Khanna Publishers, Edition 2017. (ISBN: 978-8174091659/8174091653) **2.** S. K. Khanna and C. E. G. Justo, Highway Engineering, Nem Chand & Sons, Revised 10th Edition, 2017. (ISBN: 9788185240930)

Semester - VI		PEC	Hydrology and Water Resource Engineering					
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
11	R5CE3111T	Dam and Hydropower Engineering	3-1-0=4	4	20	30	50	3
	Course Outcome: After completion of course students will be able to 1. Understand different types of dams, their elements and site selection for construction of dams. 2. Analyze the construction technique of gravity dams and its failure causes. 3. Understand different hydropower plants its constructions and machinery.							

Module	**Course Contents**
1	**Introduction to Dam Engineering:** Introductory Perspectives, Embankment Types and Characteristics- Concrete Dams and Characteristics- Spillways and Ancillary Works – Site Assessment and Selection of Type of Dam. Nature and Classification of Soil- Engineering Characteristics of Soil, Principles of Design, Material and Construction, Internal Seepage, Stability and Stresses, Settlement and Deformation in Rock Fill Embankments.
2	**Concrete Dam Engineering:** Loading: Concepts and Criteria, Gravity Dam Analysis Design Features and Stability Elementary Profile of Gravity Dam, Concrete for Dams, Roller Compacted Concrete Gravity Dams. Dam Outlet Works Spillways – Ogee Spillway, Cavitations on Spillway, Design Feature, Design Principles and Design of Spillways, Chute Spillways, Energy Dissipation, Stilling Basins, Plunge Pools.
3	**Drop Structures for Reservoirs:** Sarda fall, Glacis fall, Design principles- Cross regulator, head regulator and functions.
4	**Basic of Hydro Power:** Introduction to Non-Conventional Energy, Types of Energy – Solar Energy, Wind Energy, Biomass Energy, Ocean & Geothermal Energy and Hydrogen Energy etc. Hydropower Energy, Need for Hydropower Energy and Its Power Estimation. Law of Conservation of Energy, Route of Energy Conversion.

	Types of Hydropower Plants and Schemes, Hydrology: Runoff Studies, Flood Estimation Studies, Assessment of Hydropower Potential of a Basin, Storage and Pondage, Load Studies, Elements of Hydropower Plants and Their Hydraulic Design: Dams, Intakes, Conveyance System, Types of Powerhouses.
5	**Elements of Hydropower Plants:** Description of Main Parts of Hydropower Station: Block Diagram of Small Hydro Power Station. Dam, Details of The Desilting Tank. Storage and Balancing Reservoir. Pen Stock, Pipeline and Tunnelling. Surge Tank, Valve House, Turbines. Synchronous Generator. Protection and Control Equipment. Governors (Mechanical, Electromechanical). Synchronous Generator and Its Construction.
	Recommended Reading **1.** Modi, P.N., Introduction to Water Resources And Waterpower Engineering, Standard Publication, Delhi **2.** Garg, S.K., Irrigation Engineering and Hydraulic Structures Khanna Publishers **Textbooks** **1.** Asawa, G, L Irrigation and Water Resources Engineering, New Age Int. Ltd. **2.** Arora, K.R., Irrigation, Water Power and Water Resources Engineering, Standard Publishers Distributors, Delhi

Semester - VI		PEC	Hydraulics					
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
12	R5CE3112T	Stormwater Management	3-1-0=4	4	20	30	50	3
	Course Outcome: After completion of course students will be able to 1. Perform rainfall and runoff computations for urban catchments. 2. Compute overland flow and channel flows. 3. Design stormwater drainage systems for urban settings.							

Module	Course Contents
1	**Rainfall and Runoff Computations:** Introduction, Urbanization, Stormwater Runoff Quantity and Quality Issues, Rainfall Design for Urban Catchments, Hydrologic and Probabilistic Description of Rainfall, Design Rainfall, Methods for Construction of Design Storm, Hyetographs, Rainfall Excess Calculations, Computation of Abstractions, Combined Loss Models Calculation of Runoff Rates- Basic Concepts, Elements of Urban Runoff Hydrographs, Time of Concentration, Definition and Calculation by Various Methods, Unit Hydrograph Method – NRCS Method (TR-55)
2	**Channel flow and Overland flow:** Open-Channel Flow- Definitions, States of Open Channel Flows, Open Channel Flow Equations, Steady, Gradually Varied Flow, Normal Flow, Open Channel Rating Curve, Overland Flow, Kinematic Wave Model, Overland Flow On Impervious And Pervious Surfaces, Channel Flow Routing, Simplified And Numerical Models
3	**Storm Water Drainage:** Design of Stormwater Drainage Structures –Drainage Design for Street Pavements, Storm sewer systems: Culverts, Surface Drainage Channels
4	**Storm Water Management:** Urban Flooding and Associated Issues – Detention Basins, Stage-Storage Relationship, Stage-Discharge Relationship, Detention Basin Design Infiltration Practices, Infiltration Basins, Trenches, Dry Wells, Porous Pavements Urban Stormwater Pollution Modeling Stormwater Quality - Annual Pollutant Load Estimates Strom Water Quality Control, Concepts of Bmps, Extended Detention Basins, Retention

	Basins, Water Quality Trenches, Sand Filters, Stormwater Wetlands, Vegetative Bmps Low Impact Development, Advantages, Urban Stormwater Computer Models-HEC-HMS – EPA-SWMM.
	Textbooks **1.** H. Pazwash, Urban Storm Water Management, CRC Press, Second edition, 2016 **2.** V. T. Chow, D. Maidment, and L. W. Mays, Applied Hydrology, McGraw Hill Co. First edition, 2017. **Recommended Reading** **1.** O. Akan, A and R. J. Houghtalen, Urban Hydrology, Hydraulics, and Stormwater Quality: Engineering Applications and Computer Modeling, John Wiley and Sons, First edition, 2013 **2.** D. Butler, C. Digman, C. Makropoulos and J. W. Davies, Urban Drainage, CRC Press, Fourth edition, 2018 **3.** National Engineering Handbook, Part 630, Natural Resources Conservation Service, United States Department of Agriculture **4.** HEC-HMS Technical Reference Manual, US Army Corps of Engineers, CPD-74B **5.** Storm Water Management Model Applications Manual, USEPA - EPA/600/R-09/077

Multidisciplinary Minor - Innovation and Entrepreneurship

Semester - VI		Multidisciplinary Minor	Innovation and Entrepreneurship					
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
8*	R5CE3204T	Six Sigma	3-0-0=3	3	20	30	50	3
	Course Outcome: After completion of course students will be able to 1. Understand the Fundamentals of Six Sigma and Quality Management 2. Apply DMAIC Methodology for Process Improvement 3. Apply Statistical Tools for Data-Driven Decision Making 4. Explore Effective Process Control and Quality Assurance 5. Analyse Challenges in Six Sigma Implementation							

Module	Course Contents
1	**Introduction to Six Sigma** Quality concepts and definition, History of continuous improvement, Six sigma principles, Historical context and evolution, Key concepts: DMAIC (Define, Measure, Analyze, Improve, Control, Focus area, Six sigma applications
2	**Quality Management Principles** Fundamentals of Total Quality Management (TQM), TQM vs Six Sigma, Cost of quality, Quality function deployment, Management and planning tools
3	**Define and Measure** Six Sigma Project Identification, Selection and Definition, Project Charter and Monitoring, Process characteristics and analysis, Process Mapping: SIPOC, Data Collection and Summarization, Measurement systems, Fundamentals of statistics, Process capability analysis
4	**Analyze and Improve** Hypothesis testing,Correlation and Regression Analysis, One-Way ANOVA,Two - Way ANOVA, Multivariate analysis, Failure mode effect analysis (FEMA),

	Fractional factorial design,Taguchi method
5	**Control** Seven QC tools, statistical process control, Operating characteristics curve for variable controls and attribute control, Design of acceptance sampling for attributes, Design of acceptance sampling for variables
6	**Six Sigma Implementation Challenges** Design for Six Sigma (DFSS)-DMADV, DMADOV, DFX, Team management, Case studies
	Text and References 1.Roderick A. Munro and Govindarajan Ramu and Daniel J. Zrymiak. The certified six sigma Green Belt Handbook, 2015 (2nd edition), ASQ Quality Press and Infotech Standards India Pvt. Ltd. 2.T. M. Kubiak and Donald W. Benbow.The Certified Six Sigma Black Belt Handbook, 2009 (2nd edition), Pearson Publication 3.Forrest W. Breyfogle III. Implementing Six Sigma: Smarter Solutions Using Statistical Methods, 2003 (2^{nd} edition), Wiley publications. 4.Evans, J R and W M Lindsay.An Introduction to Six Sigma and Process Improvement,2014, CENGAGE Learning. 5.Howard S. Gitlow and David M. Levine, Six Sigma for Green Belts and Champions, 2004, Pearson Education, Inc. 6.Mitra, Amitava. Fundamentals of Quality Control and Improvement, 2013 (3^{rd} edition), Wiley India Pvt Ltd.

Multidisciplinary Minor - Contract Law, Arbitration, and Valuation

Semester - VI		Multidisciplinary Minor	Contract Law, Arbitration, and Valuation					
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
	R5CE3205T	Construction Safety, Quality, and Risk Management	3-0-0=3	3	20	30	50	3
	Course Outcome: After completion of course students will be able to 1. Identify common construction site hazards and appropriate mitigation strategies. 2. Develop and implement site-specific safety plans and protocols. 3. Utilize quality assurance (QA) and quality control (QC) techniques to maintain construction standards.							

Module	Course Contents
1	**Introduction to Construction Safety** Importance of safety in construction, Common hazards and risks, Regulatory frameworks and safety standards. Basic terminology in safety, types of injuries, safety pyramid. Accident patterns, theories of accident-causation.
2	**Safety Management Systems** Components of a safety management system, Implementing safety protocols, Monitoring and continuous improvement. Types of PPE and their uses, Proper usage and maintenance of PPE, Employer and employee responsibilities.
3	**Planning for safety** Safety budget, safety culture, Introduction to OSHA regulations, Role of stakeholders in safety, Site safety programs - Job hazard analysis, accident investigation & accident indices-violation, penalty.
4	**Construction Quality Management** Definition and importance of quality in construction, Quality control vs. quality assurance, Tools and techniques for quality management.
5	**Standards and Compliance** Industry standards for quality, Compliance with legal and regulatory requirements, Quality certifications and audits.

6	**Risk Management Process** Identifying risks, Analyzing and evaluating risks, Implementing risk controls. Introduction to risk management, Types of risks in construction (e.g., financial, legal, strategic), Risk assessment and mitigation strategies.
7	**Best Practices for Construction Safety and Quality** SoPs (Safe Operating Procedures) – Construction equipment, materials handling-disposal & hand tools. Awareness and training programs, Effective communication and documentation, Use of proper equipment and technology
	Recommended Reading **1.** Hinze, J.W. (1997) Construction Safety, Prentice Hall **2.** MacCollum, D.V. (1995) Construction SafetyPlanning, John Wiley & Sons **3.** Total Quality Management: Dale H. Besterfield , Hemant Urdhwareshe , Mary Besterfield-Sacre , Carol. **Textbooks** **1.** MacCollum, D.V. (2007) Construction Safety Engineering Principles, McGraw Hill Publishers **2.** Bhattacharjee, S.K. (2011) Safety Management in Construction, Khanna Publishers

Multidisciplinary Minor – Sustainable Environment

Semester - VI		Multidisciplinary Minor	Sustainable Environment					
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
	R5CE3206T	Air and Noise pollution control engineering	3-0-0=3	3	20	30	50	3
		Course Outcome: After completion of course students will be able to 1. Analyze air and noise pollution related environmental issues. 2. Formulate economic and technically feasible solutions to air and noise pollution problems. 3. Analyze and develop competency in use of various air modeling software and noise mapping software.						

Module	Course Contents
1	**Fundamentals of Air Pollution and Noise Pollution** Composition of dry ambient air, properties of air, Definition of air pollution, Classification of air pollutants, Units for classification of air pollutants, History of air pollution- global and national, Scope of problem-general, urban, rural, and specific. Noise: Basic concept, measurement, various control methods.
2	**Sources of Air Pollution and Its Effects** Sources of air pollution: Natural and man-made, Major pollutants from different sources in Greater Mumbai area and other Indian cities, Emission factors. 3. Effect of air and noise pollution on human health, plants, animals, properties, and visibility, CoH, CoHb
3	**Meteorology and Air Pollution Dispersion** Meteorological aspects of air pollution, large-scale wind circulation including geostrophic wind and gradient wind, influence of cyclones, anticyclones, planetary boundary layers, lapse rate, and stability conditions, wind velocity profile and maximum mixing depth, topographic effects and their role in pollutant dispersion, types of plume patterns and their significance in air quality assessment
4	**Air Quality Monitoring and Standards** Methods and instruments for stack and ambient air monitoring, sampling and analysis techniques for gaseous and particulate pollutants, principles of isokinetic sampling and continuous monitoring, particle size analysis and mass analysis, Government of India's air pollution acts and laws, Indian emission and air quality

	standards, noise standards, amendments in air pollution laws, IS standards for ambient air quality and industrial emissions.
5	**Air Pollution Control Devices – Principles and Design** Design and operation of air pollution control devices, hoods and ducts including hood specifications and design considerations, duct design and ventilation by dilution, settling chambers for dust removal in laminar and turbulent flow, economic sizing and efficiency considerations, inertial devices such as cyclones for particulate collection, factors affecting efficiency, pressure drop and power requirements, economic sizing of cyclones.
6	**Advanced Control Technologies and Filtration Systems** Electrostatic precipitators (ESP) including collection efficiency, electric field principles, particle charging mechanisms, effects of temperature and dust resistivity on collection efficiency, pressure drop, power requirement, sizing, and costing, particulate scrubbers including interception, impaction, collection efficiencies, design criteria for cyclone and Venturi scrubbers, filtration systems such as bag filters and baghouses, fabric filtration theory, collection efficiency, pressure drop, design considerations, sizing, and costing of filtration units**.**
	Recommended Reading: 1. "Air pollution" by Henry C Perkins - McGraw Hill Publications 2. "Air Pollution" by Wark and Warner 3. "Air pollution control Guidebook for Management" Edited by A.T. Rossano 4. Environ-Science Service Dirn. ERA Inc.USA 5. Government of India's publication of laws related to air pollution. Maharashtra Pollution control Board's (MPCB) publication of standards IS relevant to air pollution monitoring definitions, standards etc. 6. “Environmental Engineers” Handbook vol. II ‘Air pollution’ by B.G. Liptak(ed.) Chilton book co. USA 7. Industrial Air Pollution Handbook by A Parker Tata McGraw Hill Publications Handbooks 8. "Environmental Engineers" Handbook Vol. II 'Air Pollution' by B. G. Liptak (ed.) Chilton Book Co.USA 9. Air Pollution Handbook by P.L. Magill and Others. McGraw Hill Publ. New York. 10. Industrial Air Pollution Handbook by A. Parker Tata McGraw Hill Publication Journals

OPEN ELECTIVE

Semester - VI		Open Elective (OE)					
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
9*	R5CE3301T	Geographical Information System	3-1-0=4	4	20	30	50	3
	Course Outcome: After completion of course students will be able to 1. Acquire a basic understanding of GIS modeling concepts, components, requirements and applications 2. Create spatial and non-spatial models for presentation, analysis and decision-making 3. Use of GIS software modules 4. Design and execute a workflow using GIS techniques appropriate to an applied field.						

Module	Course Contents
1	**Basic Concepts of GIS:** Information Systems, Spatial and Non-Spatial Information, Geographical Concepts and Terminology, Advantages of GIS, Basic Components of GIS, Commercially Available GIS Hardware and Software, Organization of Data in GIS.
2	**GIS Data:** Field Data, Statistical Data, Maps, Aerial Photographs, Satellite Data, Points, Line and Area Features, Vector and Raster Data, Advantages and Disadvantages, Data Entry Through Keyboard, Digitizers and Scanners, Digital Data, Preprocessing of Data-Rectification and Registration, Interpolation Techniques, Use of Different Plugins.
3	**Data Management:** DBMS, Various Data Models, Run-Length Encoding, Quadtrees, Data Analysis-Data Layers, Analysis of Spatial and Non-Spatial Data, Data Overlay and Modeling, Data Processing: Raster Based and Vector Based, Data Presentation – Hardcopy Devices, Softcopy Devices
4	**Remote Sensing and GIS integration** Principles of Electromagnetic Remote Sensing, Imaging Characteristics of

	Remote Sensing Systems, Extraction of Metric and Descriptive Information From Remotely Sensed Images, Integration of Remote Sensing and GIS
5	**Application of GIS** Map Revision, Land Use Land Cover (LULC), Agriculture, Forestry, Archaeology, Municipal Geology, Water Resources, Dam Site Selection, Canal Site Selection, Catchment Area Detection, Rivers and its Tributaries Location Finding, Environmental Impact Assessment, Oceanography, Soil Erosion, Land Suitability Analysis, Change Detection
	Textbooks **1.** Lo C P, Yeung A K W, Concepts and Techniques of Geographic Information Systems, 2nd edition, Prentice Hall India (August 20, 2006), (ISBN: 013149502X). **2.** Kang-tsung Chang, Introduction to Geographic Information Systems, Tata McGraw Hill, 2007- 7th edition, (ISBN: 9780078095139) **Recommended Reading** **1.** K. Anji Rao, Remote sensing and Geographical Information System, BS Publications,3rd edition, 2008, (ISBN: 9788178001357)

Semester - VI		Open Elective (OE)						
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
	R5CE3302T	Sustainable Development	3-1-0=4	4	20	30	50	3
	Course Outcome: After completion of course students will be able to 1. Describe sustainable development its processes and relate the impact of various levels of development 2. Formulate the methodology for assessment of sustainability of project using various indicators. 3. Apply environmental legislation to various development processes and projects							

Module	**Course Contents**
1	**Development:** Goals and Means of Development, MDG's and SDG's Sustainable Development, Comparing Levels of Development, GDP, GNP, Global Development Level.
2	**Industrialization and Post-industrialization Era:** Major Structural Shifts, Knowledge Revolution, Implications for Development Sustainability
3	**Environmental Episodes and Pollution:** Ozone Depletion, Global Warming, Greenhouse Effect, Bhopal Gas Tragedy, etc. Pollutions: Major Sources, Permissible Standards, and Controls of Urban Air Pollution, Water Pollution, Solid and Hazardous Waste Disposals
4	**Climate Change and Environmental Legislation:** The Risk of Global Climate Change, Legislative Provisions and Measures Towards Sustainability
5	**Indicators of Development Sustainability:** Composition of National Wealth, Accumulation of National Wealth as an Indicator of Sustainable Development, Development Goals and Strategies, Gross Happiness Index, Millennium Development Goals, Role of National Development Policies, Life Cycle Assessment, Carbon Footprint
	Textbooks **1.** Tatyana P. Soubbotina, Beyond Economic Growth: An Introduction to Sustainable Development, World Bank Institute Learning Resources Series, 2nd edition, 2004. (ISBN: 0-8213-5933-99)

	2. P. P. Roger, F. J. Jalal and J. A. Boyd, An Introduction to Sustainable Development, Earthscan Publications, 2nd edition, 2008. (ISBN: 9781844075201/1844075206) **Recommended Reading** **1.** T. Strange and A. Bayley, Sustainable Development: Linking Economy, Society, Environment, 2008. (ISBN: 9789264047785) **2.** H. G. Brauch, Sustainable Development and Sustainability Transition Studies, Series: Springer Briefs in Environment, Security, Development and Peace, Series Ed. **3.** G. Marletto, S. Franceschini, C. Ortolani and C. Sillig, Mapping Sustainability Transitions: Networks of Innovators, Techno-economic Competences and Political Discourses, Springer Briefs in Business, 2016. (ISBN: 9783319422725/9783319422749)

EXIT COURSES

Semester – VI		Program Exit Course						
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
1	R5CE3901I	Internship		6	ISCE: 60		40	3
	Course Outcome: 1. Relate engineering knowledge and civil engineering works 2. Use Standard practices in civil engineering projects 3. Write technical report 4. Work as an individual and team							

Module	Course Content:
1	Student will undergo internship for summer vacation for minimum of 40 days in any of the Civil engineering firms to have an exposure to practical aspects of structural engineering, geotechnical engineering, environmental engineering, transportation engineering, water resources engineering, construction engineering and management etc. Student will submit a report and give presentation based on internship. The internship report shall cover the following: Introduction, Brief History of the Organization, Summary of the Project Assignment, Technical and practical information gained during the summer training period, Planning, Designing, check lists, Quality practices, safety measures, record keeping etc. (This must constitute the major part of the report), Conclusion and Recommendations, Photo gallery, References, Appendices.

Semester - VI		Program Exit Course						
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
2	R5CE3902P	Project/ Mini-Project	0-0-12 = 12	6	ISCE: 60		40	3
	Course Outcome: 1. Review available knowledge with reference to specific problem 2. Formulate the problem and collect relevant data. 3. Define systematic approach to arrive at solution							

Module	Course Content:
1	Every student has to work on a project under the guidance of a Guide allotted by the department. In case of a group project, role of every individual should be clearly defined. The project may be related to theoretical analysis, fabrication of a model and experimental work, etc. Through the project, students have to exhibit both the analytical and practical skills. The evaluation shall be done at the end of the project period. Students are expected to define the problem and its scope, complete literature survey and finalize methodology for data collection. They are also expected to give critical comments, necessity of work, scheme of experiments etc.

Semester - VI		Exit Course						
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
3	R5CE3903T	Health and Safety Management	3-0-0=3	3	20	30	50	3
	Course Outcome: After completion of course students will be able to 1. An ability to identify and analyze Environment, Health and safety issues. 2. Be able to identify the key principles, causes and consequences of Health and safety issues 3. Ability to use the signs, future projections, impacts of workplace hazards;							

Module	Course Contents
1	**Safety and Health Management:** Occupational Health Hazards, Promoting Safety, Safety and Health training, Stress and Safety. Safety Psychology, Safety information system, Ergonomics - Introduction, Definition, Objectives, Advantages. Ergonomics Hazards - Musculoskeletal Disorders and Cumulative Trauma Disorders. iii. Importance of Industrial safety.
2	**Radiation and Industrial Hazards:** Types and effects of radiation on human body, Measurement and detection of radiation intensity. Effects of radiation on human body, Measurement – disposal of radioactive waste, Control of radiation, Indian Standards. ii. Different air pollutants in industries, Effect of different gases and particulate matter, acid fumes, smoke, fog on human health, Industrial Hygiene & Health Unit
3	**Electrical Hazards and Hazards in Construction Industry:** Safe limits of amperages, voltages, distance from lines, etc., Joints and connections, Overload and Short circuit protection, Earthing standards and earth fault protection, Protection against voltage fluctuations, Effects of shock on human body Hazards
4	**Fire and other Hazards:** General causes and classification of fire, Detection of fire, extinguishing methods, firefighting installations with and without water. Machine guards and its types, automation. High pressure hazards, safety, emptying, inspecting, repairing, hydraulic and non-destructive testing, hazards and control in mines.
5	**Safety at workplace:** Safe use of machines and tools: Safety in the use of: Grinding, CNC‟s

	computer numeric control, Shearing, Bending, Milling, Boring, Shaping Safe use of hand tools:
6	**Plant design and Housekeeping:** Plant layout, design and safe distance, Ventilation and heat stress, Significance of ventilation, Natural ventilation, Mechanical ventilation Air conditioning , National Building code part VIII and Building service,
7	**Industrial Lighting:** Purpose of lighting, Uses of good illumination, recommended optimum standards of illumination, Design of lighting installation, Standards for lighting and color. Testing and Mainte- nance of ventilation systems. Vibration and Noise: Vibration- effects, Measurement & control, Ac- tivities related to vibrations, its impact on human health, Sources. Industrial Noise- sources & its con- trol, effects of noise on man, Measurement and evaluation of noise, Silencers, Practical aspects of control of noise. Audiometry, hearing conservation programmes.
8	**Accident prevention techniques:** Principles of accidents prevention: Definition: Incident, accident, injury, dangerous occurrences, unsafe acts, unsafe conditions, hazards, error, oversight, mistakes, etc. Accident Prevention: Theories of accident occurrences, Principles of accident prevention, Accident and Financial implications, Hazard identification and analysis.
	Reference Books: 1. The Factories Act with amendments 1987, Govt. of India Publications DGFASLI, Mumbai 2. Grimaldi and Simonds, Safety Management, AITBS Publishers, New Delhi (2001) 3. Industrial Safety –National Safety Council of India ISHET.

Semester - VI		Exit Course						
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
4	R5CE3904T	Sustainable and Green Construction	3-0-0=3	3	20	30	50	3
	Course Outcome: After completion of course students will be able to 1. Able to understand the various performance certification techniques for sustainable construction of buildings 2. Able to know the national and international standards such as LEED, and MEP for sustainable construction of buildings							

Module	Course Contents
1	**Introduction to Green Buildings** Definition of green buildings and sustainable development, typical features of green buildings, benefits of green buildings towards sustainable development. Green building rating systems – GRIHA, IGBC and LEED, overview of the criteria as per these rating systems. Green and Lean construction.
2	**Site selection and planning** Criteria for site selection, preservation of landscape, soil erosion control, minimizing urban heat island effect, maximize comfort by proper orientation of building facades, daylighting, ventilation, etc
3	**Water conservation and efficiency** Rainwater harvesting methods for roof & non-roof, reducing landscape-water demand by proper irrigation systems, water efficient plumbing systems, water metering, wastewater treatment, recycle and reuse systems.
4	**Energy Efficiency** Environmental impact of building constructions, Concepts of embodied energy, operational energy and life cycle energy. Methods to reduce operational energy, zero ozone depleting potential (ODP) materials, wind and solar energy harvesting, energy metering and monitoring, concept of net zero buildings. Orientation of building according to sun diagram to reduce energy requirements;
4	**Utility of Solar Energy in Buildings** Utility of Solar energy in buildings concepts of Solar Passive Cooling and Heating of Buildings. Low Energy Cooling. Case studies of Solar Passive Cooled and Heated Buildings.

5	**Materials, Resources** Local building materials, natural and renewable materials, materials with recycled content, waste and salvaged materials, waste management,Circular economy
6	**Indoor Environmental Quality** Daylighting, air ventilation, exhaust systems, low VOC paints, materials & adhesives, building acoustics
7	**Climate Change** The Risk of Global Climate Change, Contribution of Buildings towards Global Warming - Carbon Footprint – Global Efforts to reduce carbon Emissions by Green Buildings
	Recommended Reading: 1. HarharaIyer G, Green Building Fundamentals, Notion Press 2. Dr. Adv. HarshulSavla, Green Building: Principles & Practices 3. LEED Reference Guide – Green Building Design and Construction – 2009 edition Available from US Green Building Council 4. IGBC Green Homes Rating System, Version 2.0., Abridged reference guide, 2013, Indian GreenBuilding Council Publishers. 5. GRIHA version 2015, GRIHA rating system, Green Rating for Integrated Habitat Assessment.

Semester - VI		Exit Course						
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
5	R5CE3905T	Water Resource Management	2-0-0=2	2	20	30	50	3
	Course Outcome: After completion of course students will be able to 1. Choose the correct management techniques for water resources 2. Identify and define problems, gather data, generate and prioritize a set of alternative solutions for water conservation 3. Apply the principles of remote sensing and GIS to water resources management							

Module	**Course Contents**
1	**Water Resources System and Watershed Concepts** Water Resources System: Components, Planning, Management, System Concept, Advantages, and Limitations. Watershed: Definition, Elements, and Types, Need for an Integrated Approach in Watershed Management, Influencing Factors: Geology, Soil, Morphological Characteristics, Toposheet Interpretation, Delineation, Codification, and Prioritization of Watersheds, Watershed Hydrology: Hydrological Cycle, Precipitation, Water Losses, Runoff, Rainfall-Runoff Analysis.
2	**Measurement, Data Processing, and Water Resource Assessment** Measurement and Processing of Hydrological Data, Rainfall Data, Streamflow Data, Meteorological Data, Water Quality Data, Groundwater Data, Data Acquisition and Management of Spatial Data, Hydrological Databases and Dissemination of Data, Statistical Analysis of Data: Regression, Correlation, and Data Generation, Network Design: Streamflow Gauging, Weir Design, Gauges, Current Gauging, Salt Dilution, Geophysical Exploration, Test Drilling, and Remote Sensing Applications.
3	**Watershed Management techniques**: Rain water harvesting, On-site and off-site management structures for soil and water conservation. Community Watershed Management
4	**Surface and Subsurface Flow Modeling Techniques** Surface Flow Modeling: Hydrological and Hydraulic Flow Models, Reservoir Routing, Channel Routing, Flood Forecasting: Methods Adopted in India, Unit Hydrograph Method, Numerical Modeling

	Subsurface Flow Modeling: Groundwater Yield, Transmissibility, Darcy's Law, Dupuit's Theory of Unconfined Flow, Steady Flow Towards Fully Penetrating Wells (Confined and Unconfined Aquifers), Numerical Modeling of Groundwater Flow
5	**Water Economics and Optimization Techniques** Economic Characteristics of Water Goods and Services, Non-Market Monetary Valuation Methods, Water Economic Instruments and Policy Options for Water Conservation, Pricing Strategies: Distinction Between Values and Charges, Private Sector Involvement in Water Resources Management, Optimization Techniques: Linear Programming and Dynamic Programming Applications, Constrained and Unconstrained Optimization, Applications in Reservoir Sizing, Operation, Water Allocation, and Capacity Expansion
6	**Water Policy, Legal Framework, and Resource Management** National and International Framework for Water Law, Evolution and Key Features of Water Law in India,Water Policy for Irrigation, Decentralization, and Water User Associations, National-Level Initiatives for Groundwater Regulation and Rainwater Harvesting, Mitigation Strategies for Flood Damage: Structural and Non-Structural Measures,Role of Society and People's Participation in Sustainable Water Resource Development, GIS and Remote Sensing in Watershed Management, Role of Decision Support Systems, Conceptual Models, and Case Studies
	Recommended Reading 1. Engineering Hydrology- K. Subramanya. Third Edition, The Tata McGraw-Hill com-panies, New Delhi. 2. Water Resource Engineering by Ralph A Wurbs and Wesley P James, PHI Learning Private Ltd, New Delhi, 2009 3. Varshney, Gupta & Gupta, Theory and Design of Irrigation Structures, Nem Chand & Bros 4. Punmia B C & Pande B B lal, irrigation Engineering and Waterpower Engineering, Laxmi Publications 5. Elementary Hydrology, V.P. Singh, Prentice Hall of India Pvt. Ltd. , New Delhi-110 001,1994

Semester - VI		Exit Course						
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
6	R5CE3905L	Water Resource Management Laboratory	0-0-2=2	1	ISCE: 60		40	3
	Course Outcome: After completion of course students will be able to 1. Develop spreadsheets and database management systems. 2. Acquire proficiency in using environmental software. 3. Apply software to arrive at optimized solutions in design.							

Module	Course Contents
1	**Introduction to Water Resource Software** Overview of software like EPANET, Loop, Branch, SewerGEMS, ArcGIS/QGIS applications in water supply, sewerage, and GIS systems
2	**Water Distribution Network Analysis Using EPANET** Modeling a simple water distribution system, Analyzing pressure, velocity, and head losses in pipelines, Pump and valve modeling
3	**Design of Water Supply Systems Using Loop & Branch Software** Basics of Loop and Branch software, Demand estimation and pipe sizing Network optimization and pressure balancing, Identifying critical nodes and pipe diameters
4	**Sewerage System Design Using SewerGEMS** Designing sewer networks: pipe sizing, slope selection, and flow analysis
5	**GIS Applications in Water Resource Management** Data collection and mapping of water supply and sewerage networks using ArcGIS/QGIS
	Recommended Reading 1. Engineering Hydrology- K. Subramanya. Third Edition, The Tata McGraw-Hill com-panies, New Delhi. 2. Water Resource Engineering by Ralph A Wurbs and Wesley P James, PHI Learning Private Ltd, New Delhi, 2009 3. Varshney, Gupta & Gupta, Theory and Design of Irrigation Structures, Nem Chand & Bros

Semester – VI		Exit Course (EC)						
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
7	R5CE3906T	Introduction and Application of AI, ML, and IOT for Civil Engineering	3-0-0=3	3	20	30	50	3
	Course Outcome: After completion of course students will be able to 1. Identify the basics of Artificial Intelligence and Machine Learning. 2. Indicate how AI and ML can improve different activities in civil engineering. 3. Apply AI and ML algorithms to solve problems in civil engineering. 4. Develop skills to apply AI and ML algorithms for solving problems in civil engineering.							

Module	Course Contents
1	**Introduction to AI and ML:** Brief review of History of AI and ML, Related fields. Introduction to Artificial Neural Networks: Biological Neurons and Biological Neural Networks, Artificial Neural Networks, Activation Functions, Back-propagation Neural Networks, Training Methods, Basic definition of supervised and unsupervised Learning. Introduction to Machine Learning: Introduction (Different Types of Learning) Hypothesis Space, Inductive Bias, Evaluation and Cross Validation
2	**AI and ML in Construction Management:** Introduction to construction management, Schedule optimization using ML algorithms, Resource allocation and risk management with AI, Predictive analytics for infrastructure maintenance. Case studies: AI-driven construction project management systems
3	**Infrastructure Monitoring and Management:** Introduction to infrastructure monitoring, IoT and sensor data integration with ML, Implementation of AI and ML algorithms using Python. Ethical considerations in AI and ML applications, Regulatory challenges and standards in civil engineering, Future trends and emerging technologies in AI and ML for civil engineering

4	**Structural Analysis and Design Optimization:** Application of AI/ML in Structural Analysis. Design Optimization Techniques using Genetic Algorithms and Neural Networks, Case Studies: Predictive Maintenance and Optimal Design Solutions, Structural health monitoring with AI techniques, Case studies: predictive modelling for structural integrity assessment.
5	**Design Optimization using Machine Learning:** Introduction to design optimization, Genetic algorithms and optimization techniques. Neural network-based optimization. Application of ML in optimal design of civil engineering structures
	Recommended Reading: 1. Mark Fenner, Machine Learning with Python for Everyone, Addison-Wesley Professional, 1st edition, 2019 (ISBN: 9780134845622) 2. U. Dinesh Kumar and Manaranjan Pradhan, Machine Learning using Python, Wiley, 1st edition, 2019 (ISBN: 9788126579907) 3. S. Rajasekaran and G. A. Vijayalakshmi Pai, Neural Networks, Fuzzy Logic, and Genetic Algorithms: Synthesis and Applications, PHI Learning, 1st edition, 2003 (ISBN: 9788120321861) 4. Tom M. Mitchell, Machine Learning, McGraw-Hill Education, 1st edition, 1997 (ISBN: 9780070428072) 5. Ethem Alpaydin, Introduction to Machine Learning, PHI Learning, 3rd edition, 2014 (ISBN: 9788120350786) 6. Andries P. Engelbrecht, Computational Intelligence: An Introduction, Wiley, 2nd edition, 2007 (ISBN: 9780470035610)

Semester – VI		Exit Course (EC)						
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
8	R5CE3907T	Formwork Engineering	3-0-0=3	3	20	30	50	3
	Course Outcome: After completion of course students will be able to 1. Identify appropriate formwork systems, accessories, and materials based on structural requirements and construction conditions. 2. Design efficient formwork solutions for different structures. 3. Analyze the principles and applications of flying formwork systems. 4. Evaluate formwork failures through case studies.							

Module	**Course Contents**
1	**Introduction:** Formwork and False work, Requirement and selection of formwork, Temporary work system, Construction planning and site constraints, Materials and construction of the common formwork and false work systems, Formwork material, Timber, Plywood, Steel, Aluminium, Plastic, Type of support. 7 Formwork Design for Special Structures: Shells, Domes, Folded Plates, Overhead Water Tanks, Natural Draft Cooling Tower, Bridges.
2	**Formwork Design:** Concepts, Design considerations, Live loads and Wind pressure, Concrete pressure on formwork, Concrete density, Height of discharge, Temperature, Rate of Placing, Consistency of concrete, Vibration, Hydrostatic pressure and pressure distribution, Basic simplification, Beam, Slab, Column, Wall forms, Allowable stresses, check for, deflection, bending and lateral stability. Design of Decks and False works: Types of beams, decking and column formwork, Design of decking, False work design, Effects of wind load, Foundation and soil on false work design.
3	**Flying Formwork** Table Form, Tunnel Form, Slip Form, Formwork for Precast Concrete, Formwork Management Issues, Pre- and Post-Award.
4	**Failure and Safety of Formwork:** Formwork Failures: Causes and Case studies in Formwork Failure, Formwork Issues in Multi-Story Building Construction. Construction Sequence and Safety in

	use of Formwork: Sequence of construction, Safety use of formwork and false work.
	Reference Books: 1. Robert L. Peurifoy and Garold D. Oberlender, “Formwork for Concrete Structures”, McGraw- Hill, 2006. 2. Hurd. M.K., “Formwork for Concrete”, Special Publication, 5th Edition American Concrete Institute, Detroit, 2003. 3. Austin. C.K., “Formwork for Concrete”, Cleaver- Hume Press ltd., London 2006. 4. Tudor Dinescu and Constantin Radulescu, “Slip Form Techniques”, Abacus Press Tum Bridge Wells, Kent, 2002. 5. Indian Concrete Institute, “Technical Monograph for Formwork”, 2002. P. Chandra, Projects: Planning, analysis, selection, financing, implementation, and review, Tata McGraw-Hill, New Delhi, 2009. 6. IS 14687: 1999, false work for Concrete Structures Guidelines, BIS.

Semester – VI		Exit Course (EC)						
SN	**Course Code**	**Course Title**	**L-T-P (Hours/Week)**	**Credit**	**TA**	**MST**	**ESE**	**ESE hours**
9	R5CE3908T	Tunnel Engineering	3-0-0=3	3	20	30	50	3
	Course Outcome: After completion of course students will be able to 1. Classify different types of tunnels and tunneling methods based on geological and site conditions. 2. Analyze various tunneling operations and select appropriate machinery for efficient excavation and construction. 3. Evaluate excavation methods and operations for large and deep tunnels, considering safety, stability, and efficiency. 4. Recommend suitable tunneling and excavation techniques to optimize performance, cost, and environmental impact.							

Module	Course Contents
1	**Tunnelling Methods:** Types and purpose of tunnels; factors affecting choice of excavation technique; Methods - soft ground tunneling, hard rock tunneling, shallow tunneling, deep tunneling; Shallow tunnels – cut and cover, cover and cut, pipe jacking, jacked box excavation techniques, methods of muck disposal, supporting, problems encountered and remedial measures.
2	**Tunneling by Drilling and Blasting:** Unit operations in conventional tunneling; Drilling – drilling principles, drilling equipment, drilling tools, drill selection, specific drilling; Blasting - explosives, initiators, blasting mechanics, blast holes nomenclature; types of cuts- fan, wedge and others; blast design, tunnel blast performance - powder factor, parameters influencing, models for prediction; mucking and transportation
3	**Tunneling by Road headers and Impact Hammers:** Cutting principles, method of excavation, selection, performance, limitations and problems. Tunneling by Tunnel Boring Machines: Boring principles, method of excavation, selection, performance, limitations and problems; TBM applications.
4	**Excavation of large and deep tunnels Introduction:** Purpose and use of large and deep tunnels; excavation issues governing large and deep tunnels; excavation methods of large and deep tunnels - unit operations,

	different equipment, types of rocks. pressure and methods to deal, roof and wall supports, case studies from hydel, road and rail tunnels.
5	**Shield Tunneling:** Introduction; advantages of shield tunneling; classification; different types of shields tunneling techniques – open shield, close shield, half shield; conventional shields, special features in shield tunneling; factors affecting selection of a shield; slurry shield, earth pressure balance shield, slime shields, other shield development methods, problems encountered with possible remedies. in infrastructure development; Issues in construction and maintenance of large-scale infrastructure systems.
	Reference Books: 1. Stack, B. (1982). Handbook of Mining and Tunnelling Machinery, Wiley, New York. 2. Chugh, C.P., (1977). Drilling Technology Handbook, Oxford & IBH Publication. 3. Bickel J.O. and. Kuesel T.R, (2018). Tunnel Engineering Handbook, CBS Publishers and Distributors Pvt. Ltd. 4. Brebbia C.A., Kaliampakos D., Prochazka P., (2008). Underground Spaces Design, Engineering and Environmental Aspects, WIT Press