Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

Syllabus for B. Tech in Civil Engineering

(Applicable from the academic session 2018-2019)

Semester V [Third year]

CE(PC)501	Design of RC Structures	2L + 1T	3 Credits
Course Outcome	After going through this course, the students will be able to: **1.** Understand material properties and design methodologies for reinforced concrete structures. **2.** Assess different type of loads and prepare layout for reinforced concrete structures. **3.** Identify and apply the applicable industrial design codes relevant to the design of reinforced concrete members. **4.** Analyse and design various structural elements of reinforced concrete building like beam, slab, column, footing, and staircase. **5.** Assessment of serviceability criteria for reinforced concrete beam and slab. **6.** Prepare structural drawings and detailing and produce design calculations and drawing in appropriate professional format.		
Prerequisite	Introduction to Solid Mechanics (CE(ES)402), Concrete Technology (CE(PC)404).		
Module 1:	**Introduction:** Principles of design of reinforced concrete members - Working stress and Limit State method of design		1L
Module 2:	**Working stress method of design:** Basic concepts and IS code provisions (IS: 456 2000)for design against bending moment and shear forces - Balanced, under reinforced and overreinforced beam/ slab sections; design of singly and doubly reinforced sections		2L+2T
Module 3:	**Limit state method of design**: Basic concepts and IS code provisions (IS: 456 2000) for design against bending moment and shear forces; concepts of bond stress and development length; Use of 'design aids for reinforced concrete' (SP:16).		5L+2T
Module 4:	**Beam Design by LSM:** Analysis, design and detailing of singly reinforced rectangular, 'T', 'L' and doubly reinforced beam sections by limit state method.		3L+2T
Module 5:	**Slab Design by LSM :** Design and detailing of one-way and two-way slab panels as per IS code provisions		2L+1T
Module 6:	**Continuous slab and beam design by LSM:** Design and detailing of continuous beams and slabs as per IS code provisions		2L+1T
Module 7:	**Design of Staircases by LSM**: Types; Design and detailing of reinforced concrete doglegged staircase		3L+1T
Module 8	**Design of Columns by LSM**: Design and detailing of reinforced concrete short columns of rectangular and circular crosssections under axial load. Design of short columns subjected to axial load with moments (uniaxial and biaxial bending) – using SP 16.		4L+1T
Module 9	**Design of Foundation by LSM:** Design and detailing of reinforced concrete isolated square and rectangular isolated and combined footing for columns as per IS code provisions by limit state method Design and detailing of Pile foundation as per IS code provisions.		6L+2T
IS Codes	**1** IS: 456 - 2000		
	2 IS 875 – I (1987), II (1987), -III (2015), -IV(1987), V (1987)		
	3 SP: 16 Design Aid to IS 456		

Reference	**Sl.**	**Book Name**	**Author**	**Publishing House**
	1	Reinforced Concrete Design	Pillai and Menon	TMH
	2	Reinforced Concrete Design	Krishna Raju & Pranesh	New Age
	3	R.C.C. Design	B.C. Punmia	Laxmi Publication
	4	Reinforced concrete structures	N. Subramanian	OXFORD University Press
	5	Limit State Design of Reinforced Concrete	P. C. Varghese	PHI
	6	Reinforced concrete	S.N. Sinha	TMH

CE(PC)502	Engineering Hydrology	3L + 0T	3 Credits
Course Outcome	On completion of the course, the students will be able to: **1.** study the source, occurrence, movement and distribution of water which is a prime resource for development of a nation. **2.** learn about the functioning of reservoirs and estimation of storage capacities. **3.** learn about flood hazards, estimation of design floods for various structures and methods of estimating effects of passage of floods through rivers and reservoirs. **4.** know the basic principles of measurement of flow in rivers.		
Prerequisite	Introduction to Civil Engineering CE(HS)302, CE(ES)401_Fluid Mechanics, Chemistry BS-CH101, Physics BS-PH101.		
Module 1	Hydrology: Hydrologic Cycle, Global Water Budget, India's Water Budget.		1L

Module 2	Catchment: Definition & Descriptions, Various Types of Catchment, Factors Characterizing a Catchment, Delineation of Catchment Boundary.	2L
Module 3:	Measurement of Precipitation: Precipitation, Description and Functioning of Various Types of Rain gauges, Rain gauge Network- Codal Provisions, Optimum Number of Raingauge Stations.	2L
Module 4:	Processing of Rainfall Data: Normal Rainfall, Estimation of Missing Rainfall Data, Test for Consistency of Record; Mass Curve of Rainfall, Hyetograph, Point Rainfall; Mean Precipitation over an Area– Arithmetic Mean, Thiessen Polygon and Isohyetal Method.	4L
Module 5:	Losses from Precipitation: Evaporation – Evaporation Process, Factors affecting Evaporation, Measurement of Evaporation– Description and Functioning of Pan Evaporimeter, Pan Coefficient, Evapotranspiration: AET, PET, Measurement of ET, Estimation of ET–Blaney Criddle Formulae; Infiltration– Process, Factors Affecting Infiltration, Infiltration Rate and Infiltration Capacity, Measurement of Infiltration, Infiltration Equations, Infiltration Indices.	6L
Module 6	Streamflow Measurement: Importance, Direct and Indirect Methods, Measurement of Stage– Various Gauges and Recorders, Measurement of Velocity–Current Meters, their Functioning and Calibration; Velocity Distribution, Floats; Streamflow Computation– Area-Velocity Method, Moving Boat Method, Dilution Technique, Electromagnetic Method, Ultrasonic Method; Indirect Methods– Flow Measuring Structures, Slope Area Method; Stage-Discharge Relation, Permanent Control, Stage for Zero Discharge, Shifting Control– Backwater Effect, Unsteady Flow Effect, Extension of the Rating Curve.	12L
Module 7	Runoff: Description of the Process, Components of Runoff, Factors Affecting Runoff, Characteristics of Streams, Rainfall Runoff Relationships. Hydrographs: Types, Base Flow Separation, Effective Rainfall.	2L
Module 8	Unit Hydrograph– Definition, Assumptions, Applications– Derivation of Unit Hydrograph, Distribution Graph, Unit Hydrograph of Different Durations– Method of Superposition and S-Curve.	4L
Module 9	Floods: Concept of flood as a natural hazard; Estimation of flood discharge in a river – rational method, empirical formulae, unit hydrograph method; flood frequency studies – return period.	2L
Module 10	Flood Routing: Concept of flood routing in channels and through a reservoir, basic routing equations; reservoir routing – Modified Pul's method; channel routing – Muskingum method.	5L

Reference	**Sl.**	**Book Name**	**Author**	**Publishing House**
	1	Engineering Hydrology (4th Ed.	K. Subramanya	McGraw Hill Education (India) Private Limited, New Delhi, 2013.
	2	Engineering Hydrology	R. Srivastava and A. Jain	McGraw Hill Education (India) Private Limited, New Delhi, 2017.
	3	Applied Hydrology	V. T. Chow, D. Maidment, L. Mays	Tata McGraw Hill Edition, New Delhi, 2010.
	4	Hydrology	M. M. Das, M. Das Saikia	PHI Learning Private Limited, New Delhi, 2009.

CE(PC)503	**Structural Analysis – I**	2L + 1T	3 Credits
Course Outcome	After going through this course, the students will be able to: **1.** Distinguish between stable and unstable and statically determinate and indeterminate structures. **2.** Apply equations of equilibrium to structures and compute the reactions. **3.** Calculate the internal forces in cable and arch type structures. **4.** Evaluate and draw the influence lines for reactions, shears and bending moments in beams due to moving loads. **5.** Use approximate methods for analysis of statically indeterminate structures. **6.** Calculate the deflections of truss structures and beams.		
Prerequisite	Introduction to Solid Mechanics (CE(ES)402)		
Module 1	**Basics of Structural Analysis**: Concept of static and kinematic indeterminacy, Determination of degree of indeterminacy for different types of structures. Theorem of minimum potential energy, law of conservation energy, principle of virtual work, the first and second theorems of Castigilano, Betti's law, Clark Maxwell's theorem of reciprocal deflection		3L+1T
Module 2	**Analysis of Determinate Structures:** Portal Frames, Three hinged arches, Cables		3L+2T

Module 3	**Deflection of Determinate Structures**: Energy methods. Unit Load method for beams, Deflection of trusses and Simple Portal Frames.	3L+2T
Module 4	**Influence Line Diagram:** Statically determinate beams and trusses under series of concentrated and uniformly distributed rolling loads, criteria for maximum and absolute maximum moments and shear.	6L+3T
Module 5	**Analysis of Statically Indeterminate Beams**: Theorem of three moments, Energy methods, Force method (Method of consistent deformation) [For analysis of propped cantilever, fixed beams and continuous beams (maximum two degree of indeterminacy) for simple loading case], Analysis of two hinged arch.	8L+4T
Module 6	**Influence Line Diagram for Indeterminate Structures:** Muller – Breslau principle.	3L+2T

Reference	**Sl.**	**Book Name**	**Author**	**Publishing House**
	1	Structural Analysis	R. Agor	Khanna Publishing House
	2	Structural Analysis (Vol I & Vol II)	S S Bhavikatti	Vikas Publishing House Pvt. Ltd
	3	Structural Analysis	Ramammurtham	
	4	Strength of Materials and Theory of Structures (Vol I & Vol II)	Punmia, Jain, Jain	Laxmi Publication
	5	Structural Analysis	R.C. Hibbeler	Prentice Hall
	6	Theory of Structures	Timoshenko and Young	McGrawHill
	7	Structural Analysis	Pandit and Gupta	TMH

CE(PC)504	**Soil Mechanics – II**	2L + 1T	3 Credits
Course Outcome	After going through this course, the students will be able to: **1.** Assess the compaction and consolidation characteristics of soil for solving geotechnical problems. **2.** Calculate earth pressure on rigid retaining walls on the basis of classical earth pressure theories. **3.** Analyze and design rigid retaining walls (cantilever types) from geotechnical engineering consideration. **4.** Evaluate the bearing capacity of shallow foundation by applying established theory. **5.** Estimate settlement in soils by different methods. **6.** Compute safety of dams and embankments on the basis of various methods of slope stability analysis.		
Prerequisite	Soil Mechanics – I (CE(PC)401)		
Module 1	**Consolidation of Soil** Terzaghi's theory of one dimensional consolidation, Compressibility characteristics of soils, Compression index, Coefficient of compressibility and volume change, Coefficient of consolidation, Degree and rate of consolidation, Time factor, Settlement computation, Consolidometer and laboratory one dimensional consolidation test as per latest IS Code, Determination of consolidation parameters.		5L+3T
Module 2	**Compaction of Soil** Principles of compaction, Standard and modified proctor compaction test, Field compaction methods, Field compaction control, Factors affecting compaction, Effect of compaction on soil properties.		3L+1T
Module 3	**Earth Pressure Theories** Plastic equilibrium of soil, Earth pressure at rest, Active and passive earth pressures, Rankine's and Coulomb's earth pressure theories, Different types of backfill, Wedge method of analysis. Analytical and graphical methods for determination of earth pressure against various earth retaining structures. **Stability of retaining walls:** Cantilever retaining wall.		7L+3T
Module 4	**Bearing capacity of shallow foundations** Bearing capacity, Definition, Factors affecting bearing capacity, Modes of failures, Methods of determining bearing capacity of soils. Terzaghi's bearing capacity theory, Effect of depth of embedment, Eccentricity of load, Foundation shape on bearing capacity, Effect of 11 water table and eccentric loads. Isolated footings with combined action of loads and moments, Bearing capacity as per IS: 6403.		7L+4T
Module 5	**Settlement** Allowable bearing pressure and settlement analysis (as per IS: 8009), Immediate and consolidation settlements, Rigidity and depth factor corrections, Settlement values as per IS: 1904 recommendations.		2L+1T
Module 6	**Stability of slopes** Types of failure, Analysis of finite and infinite slopes, Swedish and friction circle method, Ordinary method of slices, Factor of safety, Taylor's stability number,		3L+2T

	Bishop's simplified method of stability analysis.			
Reference	**Sl.**	**Book Name**	**Author**	**Publishing House**
	1	Textbook of Soil Mechanics and Foundation Engineering (Geotechnical Engineering Series)	V.N.S. Murthy	CBS Publishers
	2	Soil Mechanics and Foundations	Punmia, B.C. and Jain A. K	Laxmi Publications (P) Ltd
	3	Basic and Applied Soil Mechanics	Gopal Ranjan & A.S.R. Rao	New Age International Pvt.Ltd, Publishers
	4	Principles of Geotechnical Engineering	B.M. Das	Thomson Brooks / Cole

CE(PC)505	**Environmental Engineering – II**	2L + 1T	3 Credits
Course Outcome	After going through this course, the students will be able to: 1. Define the basic concepts and terminologies of waste water engineering and hazardous waste management 2. Describe different home plumbing systems for water supply and wastewater disposal 3. Apply the methods of quantifying sanitary sewage and storm sewage 4. Solve different mathematical problems regarding different components of sewerage system 5. Compare between different wastewater samples based on their physical, chemical and biological characteristics 6. Design different unit processes and operations involved in wastewater treatment		
Prerequisite	Class-XII level knowledge of Physics, Chemistry, Mathematics, Biology and Environmental Science; Undergraduate level knowledge of Engineering Mechanics, Fluid Mechanics and Hydraulics; Environmental Engineering – I (CE(PC)402)		
Module 1	**Sewage and Drainage** Definition of Common Terms: Sewage or Sanitary Sewage, Drainage or Storm Sewage, Sullage, Black Water, Grey Water Sewerage Systems: Separate system, Combined System, Partially Separate System; applicability, advantages and disadvantages		1L+1T
Module 2	**Sewage and Drainage Quantity** Quantity estimation for sanitary sewage; Quantity estimation for storm sewage		3L+1T
Module 3	**Conveyance of Sewage** Sewers: Shapes; Design parameters; Operation and maintenance of sewers; Sewer appurtenances Hydraulic Design of Sewers: Partial flow diagrams and Nomograms		4L+2T
Module 4	**Wastewater Characteristics** Physical, chemical and biological characteristics of municipal and domestic sewage; Effluent discharge standards		4L+2T
Module 5	**Wastewater Treatment** Primary, secondary and tertiary treatment of wastewater; aerobic an anaerobic treatment options Primary and Secondary Treatment of Domestic Wastewater: Typical Flow Chart of STP; Screen and Bar Racks; Grit Chamber; Primary and Secondary Sedimentation Tank; Activated Sludge Process; Trickling Filter		8L+4T
Module 6	**Sludge Handling and Disposal** Sludge Thickening; Sludge Digestion; Sludge Drying Bed		3L+1T
Module 7	**Building Plumbing** Introduction to various types of home plumbing systems for water supply and waste water disposal; high rise building plumbing; Pressure reducing valves; Break pressure tanks; Storage tanks; Building drainage for high rise buildings; various kinds of fixtures and fittings used		3L+1T
Module 8	**Hazardous waste** Types and nature of hazardous waste as per the HW Schedules of regulating authorities		3L+1T

Reference	**Sl.**	**Book Name**	**Author**	**Publishing House**
	1	Environmental Engineering	S.C. Sharma	Khanna Publishing House
	2	Environmental Engineering. Volume-1 and Volume-2	Garg, S.K.	Khanna Publishers
	3	Environmental Engineering	Peavy, H.S, Rowe, D.R, Tchobanoglous, G	Tata McGraw Hill Indian Edition
	4	Elements of Environmental Pollution Control	O.P. Gupta	Khanna Publishing House
	5`	Elements of Solid & Hazardous	O.P. Gupta	Khanna Publishing House

		Waste Management		
	6	Introduction to Environmental Engineering and Science	Masters, G.M., Ela, W.P.	Prentice Hall / Pearson
	7	Manual on Sewerage and Sewage Treatment	CPHEEO	Govt. of India
	8	Manual on Municipal Solid Waste Management.	CPHEEO	Govt. of India
	9	Hazardous and other waste (Management and Transboundary Movement) Rules, 2016	MoEF	Govt. of India

CE(PC)506	**Transportation Engineering**	2L + 1T	3 Credits
Course Outcome	After going through this course, the students will be able to: **1.** Understand the knowledge of planning, design and the fundamental properties of highway materials in highway engineering. **2.** Apply the knowledge of geometric design and draw appropriate conclusion. **3.** Interpret the concept of different methods in design, construction of the pavement. **4.** Interpret traffic parameters by applying the knowledge in traffic planning and intersection design.		
Prerequisite	Class-XII level knowledge of Physics, Mathematics; Undergraduate level knowledge of Engineering Mechanics, Strength of Materials, Soil Mechanics		
Module 1	**Introduction to Highway Engineering** Scope of Highway Engineering; Jayakar Committee Report: Recommendations – CRF, IRC, CRRI; Scope of Motor Vehicle Act; Recommendations of Nagpur Road conference; Road Classification as per third 20 years road development plan (1981-2001); Basic types of Road Patterns and its scope of application		2L+1T
Module 2	**Highway alignment** Factors controlling Highway Alignment; Engineering Surveys for Highway Alignment.		1L+1T
Module 3	**Geometric Design** Cross-sectional elements of highway; Design Parameters (as per IRC) – Vehicle dimensions, Carriageway width, Design speed, Frictional coefficients (Lateral and Longitudinal) etc; Design Principles of Horizontal Alignment: Camber, Sight Distance (PIEV theory, SSD, OSD, ISD); Horizontal Curves – [Radius, Super elevation, Extra widening, Set back distance, Transition curve]; Design Principles of Vertical Alignment: Gradients; Grade Compensation; Vertical Curves – Summit Curve, Valley curve.		8L+4T
Module 4	**Traffic Engineering** Traffic studies: Fundamental parameters of Traffic Flow (speed, flow, density, capacity) and their basic relations; Basics of Spot Speed Studies- Speed and Delay study- O & D study; Intersections and Channelization: At Grade and Grade Separated intersections; Conflict points; Salient features of Rotary; Traffic Signs; Signal Design – Basic concepts of IRC design method, 2 phase signal design by Webster method.		7L+3T
Module 5	**Pavement Design** Pavement materials: Bitumen, Aggregate, Subgrade soil; Types of Pavement: Flexible and Rigid pavements and their typical cross-sections; Design parameters: Wheel Load, ESWL, Tyre Pressure, CBR, Resilient Modulus & Poisson's Ratio of various layers, Subgrade Modulus etc. Design of Flexible Pavement using IRC 37:2018 Design of Rigid Pavement: Wheel Stresses, Frictional Stresses and Warping Stresses; Expansion, Contraction and Construction Joints; Design of Rigid Pavement thickness, Dowel Bar and Tie Bar. Distresses in Pavements		8L+5T
Module 6	**Sustainability** Scope of adoption of sustainable construction techniques by using recyclable hazardous materials- fly ash, plastics, recyclable construction materials.		1L+1T

Reference	**Sl.**	**Book Name**	**Author**	**Publishing House**
	1	Transportation Engineering	Kadiyali L.R	Khanna Book Publishing Co. (P) Ltd.
	2	Traffic Engineering and Transport Planning	Kadiyali L.R	Khanna Publishers
	3	Highway Engineering	Khanna, S.K. and C.E.G. Justo	Nem Chand and Bros
	4	Transportation Engineering – An	Jotin Khisty C. and B.	Prentice Hall of India Pvt.

		Introduction	Kent Lall	Ltd
	5	Principles of Transportation and Highway Engineering	Rao G.V.	Tata McGraw-Hill Publishing Company Ltd
	6	Specifications for Road and Bridge Works, Fourth Edition	Indian Roads Congress	Ministry of Road Transport and Highways

CE(PC)591	**RC Design Sessional**	2P	1 Credits
Course Outcome	After going through this course, the students will be able to: **1.** Understand material properties and design methodologies for reinforced concrete structures. **2.** Assess different type of loads and prepare layout for reinforced concrete structures. **3.** Identify and apply the applicable industrial design codes relevant to the design of reinforced concrete members. **4.** Analyse and design various structural elements of reinforced concrete building like beam, slab, column, footing, and staircase. **5.** Assessment of serviceability criteria for reinforced concrete beam and slab. **6.** Prepare structural drawings and detailing and produce design calculations and drawing in appropriate professional format.		
Prerequisite	Design of RC Structures (CE(PC)501)		
	Design of a small RCC framed building using Limit State method of design including preparation of necessary working drawing and report in accordance with CE(PC)501		

CE(PC)594	**Soil Mechanics Laboratory**	2P	1 Credits
Course Outcome	After going through this course, the students will be able to: 1. Identify different types of soil by visual inspection. 2. Determine natural moisture content and specific gravity of various types of soil. 3. Estimate in-situ density by core cutter method and sand replacement method. 4. Analyze grain size distribution and Atterberg limits for soil. 5. Perform laboratory tests to determine permeability and compaction characteristics of soil. 6. Determine shear strength parameters of soil by unconfined compression test and vane shear test. 7. Determine shear strength parameters of soil by direct shear test. 8. Perform triaxial test to determine shear strength parameters of soil. 9. Determine California Bearing Ratio (CBR) of soil. 10. Prepare technical laboratory report		
Prerequisite	Soil Mechanics – I (CE(PC)401) and Soil Mechanics – II (CE(PC)504)		
Experiment 1	Field identification of different types of soil as per Indian Standards [collection of field samples and identifications without laboratory testing].		
Experiment 2	Determination of natural moisture content.		
Experiment 3	Determination of specific gravity of cohesionless and cohesive soils.		
Experiment 4	Determination of in-situ density by core cutter method and sand replacement method.		
Experiment 5	Determination of grain size distribution by sieve and hydrometer analysis.		
Experiment 6	Determination of Atterberg limits (liquid limit, plastic limit and shrinkage limit).		
Experiment 7	Determination of co-efficient of permeability by constant and variable head permeability tests.		
Experiment 8	Determination of compaction characteristics of soil by standard proctor compaction test.		
Experiment 9	Determination of unconfined compressive strength of soil by unconfined compression test.		
Experiment 10	Determination of shear strength parameters of soil by direct shear test.		
Experiment 11	Determination of undrained shear strength of soil by vane shear test.		
Experiment 12	Determination of shear strength parameters of soil by unconsolidated undrained triaxial test.		
Experiment 13	Determination of California Bearing Ratio (CBR) of soil.		
Experiment 14	Determination of relative density of soil.		
Experiment 15	Standard Penetration Test.		
Reference	**1.** Soil Mechanics Laboratory Manual by Braja Mohan Das (Oxford university press). **2.** SP: 36 (Part - I and Part - II)		

CE(PC)595	**Environmental Engineering Laboratory**	2P	1 Credits
Course Outcome	On completion of the course the students will be able to: **1.** Experiment various physical characteristics for a given sample of water and wastewater **2.** Determine various chemical characteristics for a given sample of water and wastewater **3.** Examine the bacteriological characteristics for a given sample of water and wastewater **4.** Examine the suitability of a few treatment options for a given sample of water and wastewater		

	5. Compare the determined quality parameters with standards to decide on the suitability of use for the tested water and disposal of tested wastewater
Prerequisite	Class-XII level knowledge of Physics, Chemistry, Mathematics, Biology and Environmental Science; Undergraduate level knowledge of Environmental Engineering, Biology for Engineers, Chemistry Laboratory, Physics Laboratory
Experiment 1	Determination of turbidity for a given sample of water
Experiment 2	Determination of electrical conductivity for a given sample of water
Experiment 3	Determination of Total Solids, Suspended Solids, Dissolved Solids and Volatile Solids in a given sample of water
Experiment 4	Determination of pH for a given sample of water
Experiment 5	Determination of carbonate, bi-carbonate and hydroxide alkalinity for a given sample of water
Experiment 6	Determination of acidity for a given sample of water
Experiment 7	Determination of hardness for a given sample of water
Experiment 8	Determination of concentration of Iron in a given sample of water
Experiment 9	Determination of concentration of Chlorides in a given sample of water
Experiment 10	Determination of the Optimum Alum Dose for a given sample of water through Jar Test
Experiment 11	Determination of the Chlorine Demand and Break-Point Chlorination for a given sample of water
Experiment 12	Determination of amount of Dissolved Oxygen (DO) in a given sample of water
Experiment 13	Determination of the Biochemical Oxygen Demand (BOD) for a given sample of wastewater
Experiment 14	Determination of the Chemical Oxygen Demand (COD) for a given sample of wastewater
Experiment 15	Determination of Colliform Bacteria: presumptive test, Confirmative test and Determination of MPN
Reference	**1.** Garg, S.K. *Environmental Engineering*. Volume-1 and Volume-2. Khanna Publishers **2.** Peavy, H.S, Rowe, D.R, Tchobanoglous, G. *Environmental Engineering*. McGraw Hill International Edition / Tata McGraw Hill Indian Edition **3.** Sawyer, C.N., McCarty, P.L., Parkin, G.F. *Chemistry for Environmental Engineering and Science*. McGraw Hill International Edition / Tata McGraw Hill Indian Edition **4.** IS: 3025 (Different Parts), "METIHODS OF SAMPLING AND TEST (PIIYSICAL AND CHEMICAL) FOR WATER AND WASTE WATER". **5.** APHA Standard Methods for the Examination of Water and Wastewater. **6.** IS: 10500 – 2012, "DRINKING WATER SPECIFICATION (SECOND REVISION)".

CE(PC)596	**Transportation Engineering Laboratory**	2P	1 Credits
Prerequisite	Transportation Engineering (CE(PC)506)		
Introduction	Introduction on pavement construction materials		
Experiment 1	Shape test of aggregate		
Experiment 2	Crushing Strength Test of aggregate		
Experiment 3	Impact test of aggregate		
Experiment 4	Los Angeles Abrasion test of aggregate		
Experiment 5	Specific Gravity and Water Absorption test of aggregate		
Experiment 6	Specific Gravity test		
Experiment 7	Penetration test		
Experiment 8	Static or Kinematic viscosity		
Experiment 9	Softening point test		
Experiment 10	Flash and Fire Point test		
Experiment 11	Ductility test		
Experiment 12	CBR value of sub-grade (Soaked and unsoaked)		
Experiment 13	Marshall Stability test		
Demonstration	Demonstration on Stripping value and Loss on heating tests of bitumen, Benkelman Beam and Bump Integrator test.		

CE(PC)597	**Computer Applications in Civil Engineering**	2P	1 Credits
Course Outcome	On successful completion of this course, student should be able to: **1.** Use the computer as a problem-solving tool. **2.** Identify and formulate Civil Engineering problems solvable by computers. **3.** Perform linear algebra and matrix operations and their application to solve Civil Engineering problems **4.** Solve sets of linear equations and determine roots and nonlinear equations		

	5. Construct, interpret and solve simple optimization problems **6.** Develop programs for Civil Engineering analysis and design problems. **7.** Use various software used in industries for analysis and design.
Prerequisite	ES-CS291 Programming for Problem Solving, CE(ES)392 Computer-aided Civil Engineering Drawing.
Module 1	**Introduction:** Concept of problem-solving using computer, use of programming language and software for problem solving; Identification of various design and analysis problems in different fields of Civil Engineering to be solved using computers; Procedure, formulae and data related to the analysis and design of such problems.
Module 2	**Use of spreadsheets:** Learning spreadsheets like MS Excel, matrix analysis, use of Goal Seek and Solver, Optimization Tools; Plotting. Applications to problems involving tabular data, CE estimation, surveying, and design problems.
Module 3	**Programming Languages:** Learning at least one language: Fortran 2003/2008/2018, C++11/C++14, Python 3, VBA 7.0; Computing platforms like Matlab/Scilab/MathCAD; Solving analysis and design problems in areas like surveying, hydraulics, structural analysis, RCC design, soil mechanics and foundation, transportation, water resources, etc.
Module 4	**Use of Software:** Familiarity with widely used Civil Engineering software like STAAD Pro, HEC-RAS, HEC-HMS, SWMM, Mx Roads, etc.; Solving at least two such analysis/design problems.