

### Curriculum for B. Tech. (Civil Engineering) of School of Infrastructure

Subject Name	Code	L-T-P	Credit	Contact Hour
<b>SEMESTER - I</b>				
Mathematics - I	MA1L001	3-1-0	4	4
Physics / Chemistry	PH1L001 / CY1L001	3-1-0	4	4
Mechanics / English for Communications or Learning English	ME1L001 / HS1L001 or HS1L002	3-1-0/3-0-2 or 3-1-0	4	4/5 or 4
Electrical Technology / Introduction to Programing and Data Structures	EE1L001 / CS1L001	3-1-0	4	4
Introduction to Manufacturing Processes / Engineering Drawing and Graphics	ME1P001 / CE1P001	0-0-3/1-0-3	2/3	3/4
Physics Laboratory / Chemistry Laboratory	PH1P001 / CY1P001	0-0-3	2	3
Electrical Technology Laboratory / Introduction to Programing and Data Structures Laboratory	EE1P001 / CS1P001	0-0-3	2	3
EAA - 1	ID1T001	0-0-3	1	3
		<b>Total</b>	<b>22/ 23 +1</b>	<b>25/ 27 or 26+3</b>
<b>SEMESTER - II</b>				
Mathematics - II	MA1L002	3-1-0	4	4
Chemistry / Physics	CY1L001 / PH1L001	3-1-0	4	4
English for Communication or Learning English / Mechanics	HS1L001 or HS1L002 / ME1L001	3-0-2 or 3-1-0/3-1-0	4	5 or 4/4
Introduction to Programing and Data Structures / Electrical Technology	CS1L001 / EE1L001	3-1-0	4	4
Chemistry Laboratory / Physics Laboratory	CY1P001 / PH1P001	0-0-3	2	3
Introduction to Programing and Data Structures Laboratory / Electrical Technology Laboratory	CS1P001 / EE1P001	0-0-3	2	3
Engineering Drawing and Graphics / Introduction to Manufacturing Processes	CE1P001 / ME1P001	1-0-3/0-0-3	3/2	4/3
EAA - 2	ID1T002	0-0-3	1	3
		<b>Total</b>	<b>23/22+1</b>	<b>27or 26/ 25 +3</b>
<b>SEMESTER - III</b>				
Introduction to Material Science and Engineering	ID2L001	2-0-0	2	2
Introduction to Bioscience and Technology	ID2L002	2-0-0	2	2
Basic Electronics		3-1-0	4	4
Mathematics - 3 (Probability, Statistics & Stochastic Processes)	MA2L003	3-1-0	4	4
Solid Mechanics	CE2L001	3-1-0	4	4
Surveying	CE2L002	3-0-0	3	3
Basic Electronics Laboratory		0-0-3	2	3
Surveying Practice	CE2P002	0-0-3	2	3
Project Seminar	CE2S001	0-0-0	2	0
		<b>Total</b>	<b>25</b>	<b>25</b>
<b>SEMESTER - IV</b>				
Lateral 1			3/4	3/4
Breadth-1			3/4	3/4
Environmental Science, Technology and Management	ID3L003	2-0-0	2	2
Introduction to Civil Engineering and Construction Materials	CE2L003	3-0-0	3	3
Structural Analysis	CE2L004	3-1-0	4	4
Hydraulics	CE2L005	3-1-0	4	4
Transportation Engineering	CE2L006	3-0-0	3	3
Transportation Engineering Laboratory	CE2P001	0-0-3	2	3

Subject Name	Code	L-T-P	Credit	Contact Hour
		<b>Total</b>	<b>24/26</b>	<b>25/27</b>
<b>SEMESTER - V</b>				
Lateral 2			3/4	3/4
Breadth-2			3	3
Design of Reinforced Concrete Structures	CE3L001	3-1-0	4	4
Soil Mechanics	CE3L002	3-1-0	4	4
Water Resources Engineering	CE3L003	3-0-0	3	3
Structural Engineering Laboratory	CE3P001	0-0-3	2	3
Soil Mechanics Laboratory	CE3P002	0-0-3	2	3
Water Resources Engineering Laboratory	CE3P003	0-0-3	2	3
		<b>Total</b>	<b>23/24</b>	<b>26/27</b>
<b>SEMESTER - VI</b>				
Lateral 3			3	3
Breadth - 3			3	3
Design of Steel Structures	CE3L004	3-0-0	3	3
Foundation Engineering	CE3L005	3-0-0	3	3
Water and Wastewater Engineering	CE3L006	3-1-0	4	4
Civil Engineering Drawing and Estimation	CE3P004	0-0-3	2	3
Structural Design and Detailing	CE3P005	0-0-6	4	6
Water and Wastewater Engineering Laboratory	CE3P006	0-0-3	2	3
		<b>Total</b>	<b>24</b>	<b>28</b>
INDUSTRIAL SUMMER TRAINING AFTER 6 <sup>th</sup> SEMESTER				
<b>SEMESTER - VII</b>				
Breadth - 4			3/4	3/4
Dynamics of Structures	CE6L301	3-1-0	4	4
Advanced Structural Analysis	CE6L302	3-1-0	4	4
Elective-1	CE4LXXX	3-0-0	3	3
CAD Laboratory	CE4P001	0-0-3	2	3
Industrial Training Defence	CE4T001	0-0-0	2	0
Project - Part 1 (CE)	CE4D001	0-0-0	4	0
		<b>Total</b>	<b>22/23</b>	<b>17/18</b>
<b>SEMESTER - VIII</b>				
Advanced Solid Mechanics	CE6L303	3-1-0	4	4
Elective - 2	CE4LXXX/ CE6LXXX	3-0-0	3	3
Elective - 3	CE4LXXX/ CE6LXXX	3-0-0	3	3
Elective - 4	CE4LXXX/ CE6LXXX	3-1-0	4	4
Design of Special Structures	CE6P303	0-0-6	4	6
Project - Part 2 (CE)	CE4D002	0-0-0	6	0
		<b>Total</b>	<b>24</b>	<b>20</b>
<b>SEMESTER - IX</b>				
Elective-5	CE6LXXX	3-0-0	3	3
Advanced Structural Laboratory	CE6P301	0-0-3	2	3
Thesis : Part-I (CE)	CE6D001	0-0-0	12	0
		<b>Total</b>	<b>17</b>	<b>6</b>
<b>SEMESTER - X</b>				
Seminar	CE6S002	0-0-0	2	0
Computational Laboratory	CE6P302	0-0-3	2	3
Thesis : Part-I (CE)	CE6D001	0-0-0	12	0
		<b>Total</b>	<b>16</b>	<b>3</b>
	<b>Grand Total</b>	<b>Total</b>	<b>220/225</b>	

### List of Subjects as Elective (1)

Sl. No.	Subject Code	Subject Name	L-T-P	Credit
1	CE4L003	Advanced Transportation Engineering	3-0-0	3
2	CE4L004	Rock Mechanics and Tunnelling	3-0-0	3
3	CE4L005	Maintenance and Rehabilitation of Concrete Structures	3-0-0	3
4	CE4L006	Computational Hydraulics	3-0-0	3
5	CE4L008	Hydraulic and Hydrologic Analysis and Design	3-0-0	3
6	CE4L022	Bridge Engineering	3-0-0	3
7	CE4L023	Prestressed Concrete	3-0-0	3
8	CE4L042	Advanced Foundation Engineering	3-0-0	3
9	CE4L043	Numerical Methods in Geotechnical Engineering	3-0-0	3
10	CE4L044	Soil Engineering	3-0-0	3
11	CE4L045	Earth Retaining Structures	3-0-0	3
12	CE4L053	Open Channel Hydraulics	3-0-0	3
13	CE4L054	Water Resources Systems	3-0-0	3
14	CE4L055	Design of Hydraulic Structures	3-0-0	3
15	CE4L062	Pavement Design	3-0-0	3

NB: Any other subjects of same or higher level floated by any other specialisations of SIF or any other Schools can also be taken as an elective, as suggested by faculty advisor/PG Coordinator

### List of Subjects as Elective (1 to 5)

Sl. No.	Subject Code	Name	L-T-P	Credit
1	CE6L304	Advanced Concrete Technology	3-0-0	3
2	CE6L305	Theory of Plates & Shells	3-1-0	4
3	CE6L306	Seismic Design of Structures	3-1-0	4
4	CE6L307	Bridge Engineering	3-0-0	3
5	CE6L308	Infrastructure Maintenance and Rehabilitation	3-0-0	3
6	CE6L309	Modern Construction Materials	3-0-0	3
7	CE6L310	Advanced construction Techniques	3-0-0	3
8	CE6L311	Construction Project Management	3-0-0	3
9	CE6L312	Advanced Design of RC Structures	3-1-0	4
10	MA6L002	Advanced Techniques in Operation Research	3-1-0	4
11	MA7L020	Nonlinear Functional Analysis	3-1-0	4
12	CE6L008	Hydraulics of Sediment Transport	3-0-0	3
13	CE6L017	Advanced Transportation Systems Analysis	3-0-0	3
14	CE6L018	Analysis and Design of Pavements	3-0-0	3
15	CE6L019	Pavement Evaluation, Maintenance and Rehabilitation	3-0-0	3
16	CE6L020	Dynamics of Soil and Foundations	3-0-0	3
17	CE6L021	Soil-Structure Interaction	3-0-0	3
18	CE6L022	Ground Improvement	3-0-0	3
19	CE6L023	Computational Geomechanics	3-0-0	3
20	CE6L024	Geotechnical Earthquake Engineering	3-0-0	3
21	CE6L025	Geotechnical Risk and Reliability	3-0-0	3
22	CE6L026	Advanced Soil Mechanics	3-0-0	3
23	CE6L027	Free Surface Flows	3-0-0	3
24	CE6L028	Applied Elasticity	3-0-0	3
25	CE6L029	Structural Health Monitoring	3-0-0	3

NB: Any other subjects of same level floated by any other specialisations of SIF or any other Schools can also be taken as an elective, as suggested by faculty advisor/PG Coordinators

<b>Subject Code: CE1P001</b>	<b>Name: Engineering Drawing &amp; Graphics</b>	<b>L-T-P: 1-0-3</b>	<b>Credit: 3</b>
<p><b>Prerequisite: None</b></p> <p>Introduction to IS code of drawing; Conics and Engineering Curves - ellipse, parabola, hyperbola, cycloid, trochoid, involute; Projection of lines - traces, true length; Projection of planes and solids; solid objects - cube, prism, pyramid, cylinder, cone and sphere; Projection on Auxiliary planes; Isometric projection, isometric scale; Section of solids - true shape of section; Introduction to CAD tools - basics; Introduction of Development and Intersection of surfaces.</p> <p><b>Books:</b></p> <ul style="list-style-type: none"> <li>• Bhatt, N.D., Elementary Engineering Drawing, Charotar Publishing House</li> <li>• Gill, P.S., Engineering Drawing &amp; Engg. Graphics, S. K. Kataria &amp; Sons</li> <li>• Lakshminarayan, L.V. &amp; Vaish. R.S., Engineering Graphics, Jain Brothers</li> </ul>			
<b>Subject Code: CE2L001</b>	<b>Name: Solid Mechanics</b>	<b>L-T-P: 3-1-0</b>	<b>Credit: 4</b>
<p><b>Prerequisite: None</b></p> <p>Stress analysis: forces and moments, theory of stress, principal stresses and stress invariants, compatibility equations, equilibrium equations; Strain analysis: deformation and velocity gradients, Lagrangian and Eulerian description and finite strain, small deformation theory, principal strains and strain invariants, compatibility conditions; Bending of Symmetric and non-symmetric sections; Thick cylinders and pressure vessels; Introduction of theory of elasticity Simple problems (semi-inverse method); Theories of failure; Stress concentration; Fatigue; Creep and relaxation.</p> <p><b>Books:</b></p> <ul style="list-style-type: none"> <li>• Kazioni, S.M.A., Solid Mechanics, Tata McGraw Hill,</li> <li>• Popoo, E.P., Introduction to Mechanics of Solids, Prentice Hill of India</li> <li>• Crandall, S.H., Dahl, N.C., Lardner, T.J. and Sivakumar, M.S., An Introduction to Mechanics of Solids, Tata McGraw Hill</li> <li>• Jindal, U. C., Strength of Materials, Pearson</li> <li>• Timoshenko, Strength of Materials, CBS</li> </ul>			
<b>Subject Code: CE2L002</b>	<b>Name: Surveying</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
<p><b>Prerequisite: None</b></p> <p>Introduction: Elements of surveying and mapping, types of surveys, Measurement of Distance, Direction and Elevation. Chain Surveying, Compass Surveying, Plane Table Surveying, Levelling and Contouring, Theodolite Surveying, Layout of curves, Tacheometry, Triangulation, Computation of Area and Volume, Total Station, Global Positioning System, Introduction to Remote Sensing and Geographical Information System.</p> <p><b>Books:</b></p> <ul style="list-style-type: none"> <li>• Punmia, B.C., Surveying Vol. I, II and III, Laxmi Publication Pvt. Ltd.</li> <li>• Arora, K. R., Surveying Vol. I, II and III, Standard Book House.</li> <li>• Gopi, S., Sathikumar, R. and Madu, N., Advanced Surveying: Total Station, GIS and Remote Sensing, Pearson Education India.</li> </ul>			
<b>Subject Code: CE2P002</b>	<b>Name: Surveying Practice</b>	<b>L-T-P: 0-0-3</b>	<b>Credit: 2</b>
<p><b>Prerequisite: None</b></p> <p>Introduction, Types of Surveys, Chaining, Taping, Corrections, Angle and Direction Measurements, Prismatic compass, Measurement of bearing, Computations of angles from bearings, Theodolite Surveying, Temporary Adjustments, Traversing, Principle of Levelling,</p>			

Simple and Differential Levelling, Adjustments, Plane table Surveying, Different Methods, Two and Three Point Problems, Minor Surveying Instruments, Setting out Simple Works. Practicals: Chaining, Offsets, Field book entry, Triangulation AND Traversing, Compass Surveying AND Traversing, Plane Table Surveying , Two Point and Three Point Problems, Levelling, Level book entry, Preparation of contour Map, Study of Theodolites and Angle Measurements, Theodolite Traversing, Techeometric Traversing, Use of Distomat / Theomat, Interpretation of Aerial Photographs AND Satellite Imagery. Surveying through Total Station equipment.

**Subject Code: CE2L003**

**Name: Introduction to Civil Engineering and Construction Materials**

**L-T-P: 3-0-0**

**Credit: 3**

**Prerequisite: None**

Introduction to Civil Engineering; Major Divisions; Civil Engineering Infrastructures; Ethics in Civil Engineering; Properties of construction material and their evaluation; test methods and specifications; Cement - chemical composition, properties such as setting, strength, fineness, hydration; Aggregates - sources, properties, chemical reactivity; Concrete - constituents, proportioning, properties in fresh and hardened state, characteristic strength, quality control, transportation and placing, testing, porosity; Admixtures - chemical, mineral; Steel - properties, types of steel, steel in civil engineering; Bricks - manufacture, properties and classification; masonry bonds; Wood - Structure, defects & preservation; Paints, New materials - Fibre reinforced plastics (FRPs), epoxy-coated bars, Geo-synthetics etc., Construction methodologies and equipment.

**Books:**

- Taylor, G.D., Materials of Construction, Prentice Hall
- Mehta P.K. and Montiero, P.M.J., Concrete - Material, Microstructure and Properties, Tata Mcgraw Hill
- Gambhir, M.L., Concrete Technology, Tata Mcgraw Hill
- Neville, A.M. and Brooks, J.J., Concrete Technology, ELBS/Longman
- Neville, A.M., Properties of Concrete, 4th Edition, ELBS/Longman
- Dayaratnam, P. Brick and Reinforced Brick Structures, Oxford and IBH
- Ghose, D.N., Construction Materials, Tata Mcgraw Hill
- Relevant IS codes for testing and specifications

**Subject Code: CE2L004**

**Name: Structural Analysis**

**L-T-P: 3-1-0**

**Credit: 4**

**Prerequisite: None**

Stability and Determinacy of Structures; Analysis of Statically Determinate Structures; Review of shear force and bending moment diagrams in beams and frames; Plane trusses: Deflection of trusses; Deflection of beams and frames; Influence line diagrams and moving loads; Analysis of Statically Indeterminate Structures; Force and stiffness methods of analysis; Plane trusses by using method of consistent deformations, Beams and frames: Plane trusses by using direct stiffness method; Curved beams, arches and rings;

**Books:**

- Wang, C.K., Intermediate Structural Analysis, McGraw Hill
- Vazirani, V.N. and Ratwani, M.M., Analysis of Structures Vol-1, Vol-2, Khanna Publishers
- Ramamrutham, S. and Narayan, R., Theory of Structures, Dhanpat Rai

<b>Subject Code: CE2L005</b>	<b>Name: Hydraulics</b>	<b>L-T-P: 3-1-0</b>	<b>Credit: 4</b>
<p><b><u>Prerequisite: None</u></b></p> <p>Basic properties of water; Determination of hydrostatic forces; Kinematics of flow; Potential flow; Continuity, Energy and Momentum principles; Open channel flow; Uniform and gradually varied flows; Dimensional analysis; Hydraulic similitude and Modelling; Flow in pipes and Pipe networks; Hydraulics machines; Pumps and Turbines.</p> <p><b>Books:</b></p> <ul style="list-style-type: none"> <li>• Subramanya, K., Fluid Mechanics and Hydraulic Machines, Tata McGraw Hill</li> <li>• Kundu, P.K., Cohen, I.M. and Dowling, D.R., Fluid Mechanics, Academic Press, Elsevier</li> <li>• White, F.M., Fluid Mechanics, Tata McGraw Hill</li> <li>• Streeter, V.L., Fluid Mechanics, Tata McGraw Hill</li> </ul>			
<b>Subject Code: CE2L006</b>	<b>Name: Transportation Engineering</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
<p><b><u>Prerequisite: None</u></b></p> <p>Different Modes of Transportation; Highway Development in India; Highway Alignment, Survey and Detailed Project Report; Geometric Design of Highways: cross-sectional elements, horizontal and vertical alignments; Elements of Traffic Engineering; Pavement Materials: subgrade soil, aggregates, bituminous binders; Pavement Design: design of flexible and rigid pavements, Elements of Highway Construction: embankment, subgrade, subbase and base courses, bituminous surface courses, concrete pavements, soil stabilization; Drainage; Evaluation and Maintenance of highways.</p> <p><b>Books:</b></p> <ul style="list-style-type: none"> <li>• Khanna, S. K. and Justo, C.E.G., Highway Engineering, Nem Chand &amp; Bros</li> <li>• Kadiyali, L.R., Traffic Engineering and Transport Planning, Khanna Publishers</li> <li>• Chakraborty, P. and Das, A., Principles of Transportation Engineering, Prentice Hall of India</li> </ul>			
<b>Subject Code: CE2P001</b>	<b>Name: Transportation Engineering Laboratory</b>	<b>L-T-P: 0-0-3</b>	<b>Credit: 2</b>
<p><b><u>Prerequisite: None</u></b></p> <p>Tests on Bitumen: Penetration Test, Viscosity Test, Ductility Test, Softening Point Test; Tests on Aggregates: Crushing test, Abrasion Test, Impact Test, Shape Test; CBR test on Soil, Dynamic Cone penetrometer Test, Roughness measurement of road surface, Traffic Studies: Classified Traffic Volume Count, Speed Studies etc.</p> <p><b>Books:</b></p> <ul style="list-style-type: none"> <li>• Khanna, S. K. and Justo, C.E.G., Highway Material Testing, Nem Chand &amp; Bros.</li> <li>• Khanna, S.K, Justo, A and Veeraragavan, A, Highway Materials and Pavement Testing, Nem Chand &amp; Bros.</li> <li>• Kadiyali, L. R., Traffic Engineering and Transportation Planning, Khanna Publishers</li> </ul>			
<b>Subject Code: CE3L001</b>	<b>Name: Design of Reinforced Concrete Structures</b>	<b>L-T-P: 3-1-0</b>	<b>Credit: 4</b>
<p><b><u>Prerequisite: None</u></b></p> <p>Introduction to the design of Concrete structures: Structural Systems, Materials, Loadings and Structural Analysis, Working Stress Design, Ultimate Load Design, Limit State Design; Working Stress Design: Beams for Bending Moment and Shear Force; Limit State Design: Beams for Bending Moment, Shear Force, Bond and Torsion. Axially and eccentrically loaded Columns. Beam-Columns for combined compression and flexure. One and two-way Slabs, Structural Components: Isolated and Combined Footings; Lintels, Stair Cases, Retaining Walls.</p>			

**Books:**

- Gambhir, M.L., Design of Reinforced Concrete Structures, PHI Learning
- Varghese, P.C., Limit State Design of Reinforced Concrete, PHI Learning
- Pillai, S.U. and Menon, D., Reinforced Concrete Design, Tata McGraw Hill
- Punmia, B.C., Jain A.K. and Jain A.K., Reinforced Concrete Structures Vol-I and II, Laxmi Publications
- Park, R. and Pauley, T., Reinforced Concrete Structures, Willey International

<b>Subject Code: CE3L002</b>	<b>Name: Soil Mechanics</b>	<b>L-T-P: 3-1-0</b>	<b>Credit: 4</b>
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**Prerequisite: None**

Introduction, formation of soils, index properties and classification of soils, soil compaction, proctor and modified compaction, field control of compaction, effective stress, stress point and stress path, soil-water-system - surface tension and capillarity, Darcy's law, permeability of soils, methods of determining coefficient of permeability, seepage analysis, flow nets, piping, quick sand condition, compressibility and consolidation of soils, normally and over consolidated soil, time rate of consolidation, determination of coefficient of consolidation, shear strength of soils, direct shear and triaxial tests, Mohr-Coulomb strength criterion, CU, CD and UU tests, pore pressures, Skempton's pore pressure coefficients.

**Books:**

- Murthy, V.N.S., Geotechnical Engineering: Principles and Practices of Soil Mechanics and Foundation Engineering by Marcel Dekkar, Inc., USA
- Das, B.M., Principles of Geotechnical Engineering, PWS Publishing Company, Boston, USA.
- Terzaghi, K., Ralph B.P. and Mesri, G., Soil Mechanics in Engineering Practice, John Wiely and Sons, Inc.
- Muniram, B., Soil Mechanics and Foundations, John Wiely and Sons, Inc.
- Lambe, T.W., Whitman, R.V., Soil Mechanics, John Wiely and Sons, Inc. Canada.
- Parry, R.H.G., Mohr Circles, Stress Paths and Geotechnics, E & FN SPON publishers.

<b>Subject Code: CE3L003</b>	<b>Name: Water Resources Engineering</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
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**Prerequisite: None**

Concepts of hydrologic cycle; Measurement and analysis of precipitation and runoff; Hydrograph analysis; Irrigation requirement of crops; Design of canals; Design and drawing of weirs and barrages; cross drainage works; Classification; analysis; design and drawing of Gravity and Earth dams; Design and drawing of spillways and energy dissipators.

**Books:**

- Subramanya, K., Engineering Hydrology, Tata McGraw-Hill
- Garg, S.K., Irrigation Engineering and Hydraulic Structures, Khanna Publishers
- Chow, V.T., Maidment, D.R. and Mays, L.W., Applied Hydrology, Tata McGraw-Hill

<b>Subject Code: CE3P001</b>	<b>Name: Structural Engineering Laboratory</b>	<b>L-T-P: 0-0-3</b>	<b>Credit: 2</b>
<p><b>Prerequisite: None</b></p> <p>Casting and load-deformation test of reinforced concrete and post tensioned beams; Cement test: Standard consistency, setting times, compressive strength, fineness and soundness; Aggregate Tests: Sieve analysis, Bulking of sand, Aggregate crushing value, Absorption, Unit weights; Tension test of MS, HYSD, HT bars: Yield/Proof stress, Ultimate Strength, Young's modulus, percentage elongation; Compressive strength of bricks and Pre-conditioning; Load deformation testing of steel beam; Concrete mix design and slump test; Demonstration of flow table, compacting factor and V.B. tests; Compressive strength of cubes by Non-Destructive Testing; Dynamics of SDOF, MDOF systems; Indirect tensile strength of cylinders.</p>			
<b>Subject Code: CE3P002</b>	<b>Name: Soil Mechanics Laboratory</b>	<b>L-T-P: 0-0-3</b>	<b>Credit: 2</b>
<p><b>Prerequisite: None</b></p> <p>Specific gravity test, sieve analysis, hydrometer analysis, Atterberg's limits tests, Proctor compaction test, relative density of sand, in-situ density test, permeability tests, direct shear test, unconfined compression test, vane shear test, triaxial tests, consolidation test.</p> <p><b>Books:</b></p> <ul style="list-style-type: none"> <li>• Lambe, T.W., Soil Testing for Engineers John Wiley &amp; Sons Inc.</li> <li>• Murthy, V.N.S., Geotechnical Engineering: Principles and Practices of Soil Mechanics and Foundation Engineering, Marcel Dekkar, Inc., USA.</li> <li>• Robert W.D., Soil Testing Manual: Procedures, Classification Data, and Sampling Practices, McGraw-Hill Professional.</li> </ul>			
<b>Subject Code: CE3P003</b>	<b>Name: Water Resources Engineering Laboratory</b>	<b>L-T-P: 0-0-3</b>	<b>Credit: 2</b>
<p><b>Prerequisite: CE2L005: Hydraulics</b></p> <p>Experiments on flow measurements in open channels and pipes; verification of momentum and energy equations; hydraulic jump; measurement of hydrostatic and hydrodynamic forces; flow in open channels; specific energy</p>			
<b>Subject Code: CE3L004</b>	<b>Name: Design of Steel Structures</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
<p><b>Prerequisite: None</b></p> <p>Introduction to Steel Structure Design: Structural Systems, Design Loads and Load Combinations, Rolled Sections and Built-up sections; Working Stress Design; Plastic Design; Limit State Design Methods; Design of structural fasteners: rivets, bolts and welds. Simple and Eccentric Connections; Design of tension members; Design of compression members; Design of Built-up column using lacing and battening; Design of flexure members; Design of Beam-Column; Design of Column Bases; Design of Plate Girder and Gantry Girder.</p> <p><b>Books:</b></p> <ul style="list-style-type: none"> <li>• Subramanian, N., Design of Steel Structures, Oxford University Press</li> <li>• Duggal, S.K., Limit State Design of Steel Structures, McGraw Hill</li> <li>• Ram, K S, Design of Steel Structures, Pearson Education</li> </ul>			

<b>Subject Code: CE3L005</b>	<b>Name: Foundation Engineering</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
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**Prerequisite: None**

Introduction, examples of foundation problems, site characterization, soil exploration, site investigation methods, in-situ tests, Bearing capacity: general, local and punching shear failure, effect of size, shape, depth and water table, Settlement of foundations: elastic, consolidation and total settlement, Types of foundation: shallow and deep foundations, isolated, combined, mat etc., contact pressure distribution, basics of design of shallow foundation, deep foundation type, load transfer mechanism in piles, pile capacity, laterally loaded pile, test pile and pile load test, efficiency of pile group, settlement of pile, earth pressure theories: Rankine's theory, Coulomb's theory, Stability analysis of earth retaining structures - gravity, cantilever, counterfort, Slope stability: finite slopes and infinite slopes, Bishop's simplified method, method of slices.

**Books:**

- Bowles, E., Foundation Analysis and Design by Joseph, McGraw Hill Higher, USA.
- Das, B. M., Principles of Foundation Engineering, Cengage Learning.
- Das, B. M., Principles of Geotechnical Engineering, Cengage Learning.
- Budhu, M., Soil mechanics and foundations, Wiley Publishers, New Delhi.
- Murthy, V. N. S., Principles of Soil Mechanics and Foundation Engg, UBSPD.
- Khan, I.H., A text book of Geotechnical Engg, Prentice Hall India.
- Gopal Ranjan & Rao, A. S. R. Basic and Applied Soil Mechanics, Wiley Eastern Ltd.

Bowles, Joseph E. Foundation analysis and design, McGraw-Hill Publishers

<b>Subject Code: CE3L006</b>	<b>Name: Water and Wastewater Engineering</b>	<b>L-T-P: 3-1-0</b>	<b>Credit: 4</b>
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**Prerequisite: None**

General requirement for water supply, population forecasting and water demand, sources, intake, pumping and transportation of water; Physical, chemical and biological characteristics of water and their significance, Water quality criteria, Water borne diseases, Natural purification of water sources. Engineered systems for water treatment: aeration, sedimentation, softening, coagulation, filtration, adsorption, ion exchange, and disinfection. Generation and collection of wastewater, quantities of sanitary wastes and storm water. Design of sewerage system Primary, secondary and tertiary treatment of wastewater; Wastewater disposal standards. Basics of microbiology. Biological wastewater treatment systems: Aerobic processes - activated sludge process and its modifications, trickling filter, RBC, Anaerobic Processes- conventional anaerobic digester, High rate and hybrid anaerobic reactors. Sludge digestion and handling. Disposal of effluent and sludge Design problems on water and wastewater treatment units and sludge digestion.

**Books:**

- Peavy, H. S., Rowe, D. R. and Tchobanoglous, G., Environmental Engineering, McGraw-Hill International Ed.
- McGhee, T. J, Water Supply and Sewerage, McGraw-Hill Inc.
- Davis, M. L and Cornwell, D. A, Introduction to Environmental Engineering, McGraw-Hill, Inc.
- Metcalf & Eddy, Wastewater Engineering- Treatment and Reuse (Revised by G. Tchobanoglous, F. L. Burton and H. D. Stensel), Tata McGraw Hill.
- Sawyer, C. N, McCarty, P. L and Parkin, G. F., Chemistry for Environmental Engineers, McGraw- Hill.
- APHA, Standard Methods Examination of Water and Wastewater, American Public Health

Association, Washington DC.

- Manual for Sewer and Sewerage, Central Public Health & Environmental Engineering Organisation, Ministry of Housing and Urban Development, Govt. of India.
- Manual for water supply and treatment, Central Public Health & Environmental Engineering Organisation, Ministry of Housing and Urban Development, Govt. of India.

**Subject Code: CE3P004**

**Name: Civil Engineering  
Drawing and Estimation**

**L-T-P: 0-0-3**

**Credit: 2**

**Prerequisite: None**

Building drawing: Components of buildings - Plan, elevation and section of buildings; Hands on Practice using AutoCAD or Solid Works, Estimation: Central line method, short wall - long wall method, units of measurement, Rate analysis, Cost estimation for buildings and other structures.

**Books:**

- Malik, R.S. and Meo, G.S. Civil Engineering Drawing, Computech Publications Limited
- Dutta, B.N., Estimating and Costing in Civil Engineering: Theory and Practice including Specification and Valuation, Sangam Books
- Chakraborti, M., Estimating, Costing, Specification, Valuation in Civil Engineering, Chakraborti

**Subject Code: CE3P005**

**Name: Structural Design and  
Detailing**

**L-T-P: 0-0-6**

**Credit: 4**

**Prerequisite: CE3L001: Design of Reinforced Concrete Structures**

Detailed Design of Multistoried RC Building and Detailing of RC Slabs, Beams, columns and footings; Design of Industrial Steel Building with Truss Roof and Detailing of Trusses, Gusseted Joints, Eccentric Connections Riveted/Welded, Beam End Connections, Built-up Column; Design and detailing of Special Structures: Pile foundation, Water tank and Retaining wall.

**Subject Code: CE3P006**

**Name: Water and Wastewater  
Engineering Laboratory**

**L-T-P: 0-0-3**

**Credit: 2**

**Prerequisite:None**

Physical characteristics of water - Turbidity, Taste, Odor, Colour, Electrical conductivity; Analysis of solids content of water - Dissolved, settleable, suspended, total, volatile, inorganic;; Alkalinity and acidity; Hardness - Total, calcium and magnesium; Analysis of ions - Fluoride, copper, arsenic; Optimum coagulant dose; Break point chlorination; Settling column analysis for sedimentation tank design; BOD and BOD rate constant determination; COD; DO and re-aeration constant determination; Bacteriological quality measurement: MPN, plate count

<b>Subject Code: CE4P001</b>	<b>Name: CAD Laboratory</b>	<b>L-T-P: 0-0-3</b>	<b>Credit: 2</b>
<b>Prerequisite: None</b> Exposure to commercial software tools for analysis, design and research in civil engineering.			
<b>Subject Code: CE4L001</b>	<b>Name: Construction Management</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
<b>Prerequisite: None</b> Construction Management Overview; Construction Industry; Construction Projects Management; Scheduling Techniques for Construction Projects; Construction Estimating; Construction Cost Control; Construction Contracts Administration; Construction Practice			
<b>Books:</b>			
<ul style="list-style-type: none"> <li>• Jha, Neeraj Kumar, Construction Project Management, Pearson Education India</li> <li>• Williams, Trefor, Construction Management, Pearson Education India</li> <li>• Chitkara, Krishnan, Construction Project Management Techniques And Practice, Tata McGraw Hill</li> <li>• Purifoy R.L., Construction Planning, equipments and Methods, Mc Graw Hill, Tokyo, Japan.</li> </ul>			
<b>Subject Code: CE4L002</b>	<b>Name: Air Pollution and Solid Waste Management</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
<b>Prerequisite: None</b> Air pollution: Pollutants, their sources, harmful effects on environment, metrology and atmospheric diffusion of pollutants, dispersion modeling, air sampling and pollutant measurement methods, ambient air quality and emission standards, control, removal of gaseous pollutants, particulate emission control, control of automobile pollution. Solid waste management: Engineering principles; Sources, Composition and Properties of Municipal Solid Waste, Onsite handling, storage and processing, Collection, Transfer and transport, Recovery of resources, Conversion products and energy, Disposal of solid waste including sanitary landfill. Introduction to biomedical and hazardous waste management.			
<b>Books:</b>			
<ul style="list-style-type: none"> <li>• Peavy, H. S., Rowe, D. R. and Tchobanoglous, G., Environmental Engineering, McGraw-Hill International Ed.</li> <li>• Rao, M N, Air Pollution, Tata McGraw Hill, New Delhi.</li> <li>• Garg, S. K., Sewage Disposal and Air Pollution Engineering, Khanna Publication.</li> <li>• Nevers, N. D. Air Pollution Control Engineering, Mc. Graw Hill International Ed.</li> <li>• Tchobanoglous, G., Theisen, H., and Vigil, S.A., Integrated Solid Waste Management: Principles and Management Issues, McGraw Hill Book Company.</li> <li>• LaGrega, M.D., Buckingham, P.L., and Evans, J.C., Hazardous Waste Management, McGraw-Hill International Editions.</li> <li>• Martin, E.J. and Johnson, J.H., Hazardous Waste Management Engineering, van Nostrand-Reinhold.</li> <li>• Wentz, C.A., Hazardous Waste Management, McGraw Hill.</li> <li>• Wark K, Warner, C F and Davis, W. Air Pollution Its Origin and Control, Harper and Row</li> <li>• Griffin, R D, Principles of Air Quality Management, CRC Press.</li> </ul>			
<b>Subject Code: CE4L003</b>	<b>Name: Advanced Transportation Engineering</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
<b>Prerequisite: None</b> Airports: introduction; characteristics of aircrafts related to airport design; obstruction clearance criteria; design of airside facilities: runway orientation, length, capacity, configuration and number, taxiway layout, design of fillets, high-speed exit taxiway, apron gate and circulation areas, hanger; design of landside facilities: terminal building functional areas and facilities, centralized and de-centralized concepts, vertical distribution; airport planning and site selection;			

pavement design; visual aids; demand estimation of air travel, drainage. Railways:- Introduction, classification of routes; railway gauge, coning of wheels and canting of rails, train resistance and hauling power; track components: rails, sleepers, fastenings, ballast and formation; track stresses; turnouts and crossings, signals and control systems, welded rails. Elements of water and pipeline transportation. Economic Analysis of Transportation Projects

**Book:**

- Horonjeff, Robert, Planning and Design of Airports, McGraw Hill
- Chandra, Satish and Agarwal, M.M., Railway Engineering, Oxford University Press India
- Garber, NJ and Hoel, LA, Principles of Traffic and Highway Engineering, Cengage Learning

<b>Subject Code: CE4L004</b>	<b>Name: Rock Mechanics and Tunnelling</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
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**Prerequisite: None**

Introduction - objective, scope and problems of Rock Mechanics. Classification by origin, Lithological, Engineering. Rock exploration - rock coring, geophysical methods. Laboratory testing of rocks - all types of compressive strength, tensile strength and flexural strength tests. Strength and failure of rocks, Griffith's theory, Coulombs theory, rheological methods. In-situ tests on rock mass. Deformation characteristics of rocks, instrumentation and measurement of deformation of rocks. Permeability characteristics - interstitial water on rocks, unsteady flow of water through jointed rock mass. Mechanical, thermal and electrical properties of rock mass. Correlation between laboratory and field properties. Analysis of stresses. Thick wall cylinder, formulae, Kreish equation, Green span method. Openings in rock mass and stresses around openings. Pressure tunnels, development of plastic zone. Rock support needed to avoid plastic deformation. Lined and unlined tunnels. Underground excavation and subsidence. Rock mechanics applications. Bearing capacity of homogeneous as well as discontinuous rocks. Support pressure and slip of the joint. Delineation of types of rock failure. Unsupported span of underground openings, pillars. Rock slopes. Rock bolting. Plastic mechanics. Tunnels, shapes, usages, Methods of Construction, Problems associated with tunnels, tunnelling in various subsoil conditions and rocks.

**Books:**

- Goodman, R. E., Introduction to Rock Mechanics, John Wiley and Sons.
- Hudson, J.A. and Harrison, J.P. Engineering rock Mechanics: an introduction to the principles, Pergamon publishers.
- Chapman, David, Metje, Nicole and Stärk, Alfred, Introduction to Tunnel Construction. Spon Publishers, Taylor and Francis Group.
- Brady, B. H. G. and Brown, E. T. Rock Mechanics: for underground mining, Kluwer Academic Publishers.

<b>Subject Code: CE4L005</b>	<b>Name: Maintenance and Rehabilitation of Concrete Structures</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
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**Prerequisite: None**

Maintenance and Repair strategies - Maintenance, repair and rehabilitation, Facets of Maintenance, importance of Maintenance various aspects of Inspection, Assessment procedure for evaluating a damaged structure, causes of deterioration; Serviceability and Durability of Concrete - Quality assurance for concrete construction concrete properties- strength, permeability, thermal properties and cracking. - Effects due to climate, temperature, chemicals, corrosion - design and construction errors - Effects of cover thickness and cracking; Materials and Techniques for Repair - Special concretes and mortar, concrete chemicals, special elements for accelerated strength gain, Expansive cement, polymer concrete, sulphur infiltrated concrete, Ferrocement and polymers coating for rebars loadings from concrete, mortar and dry pack, vacuum concrete, Guniting and Shotcrete, Epoxy injection, Mortar repair for cracks shoring and

underpinning. Methods of corrosion protection, corrosion inhibitors, corrosion resistant steels and cathodic protection.; Repairs to Structures - Repair of structures distressed due to earthquake - Strengthening using FRP Strengthening and stabilization techniques for repair.

**Books:**

- Denison Campbell, Allen and Harold Roper, Concrete Structures, Materials, Maintenance and Repair, Longman Scientific and Technical UK.
- Allen R.T and Edwards S.C, Repair of Concrete Structures, Blakie and Sons, UK.
- Raikar, R.N., Learning from failures - Deficiencies in Design, Construction and Service - R&D Centre (SDCPL), Raikar Bhavan, Bombay.
- Santhakumar A.R., Concrete Technology, Oxford University Press, Printed in India by Radha Press, New Delhi.
- Emmons, Peter H., Concrete Repair and Maintenance Illustrated Galgotia Publications pvt. Ltd.

<b>Subject Code: CE4L006</b>	<b>Name: Computational Hydraulics</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
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**Prerequisite: None**

General numerical methods; Introduction to FEM, FDM and BEM; Perturbation method; Methods of characteristics; Hydroinformatics; Applications to water resources engineering

**Books:**

- Michael B. Abbott, Anthony W. Minns, Computational Hydraulics.
- Cornelis B. Vreugdenhil, Computational Hydraulics.
- Ioana Popescu, Computational Hydraulics.

<b>Subject Code: CE4L007</b>	<b>Name: Water Resources Management</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
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**Prerequisite: None**

Water resources economics; Water resources conservation techniques; Optimization in water resources engineering; Irrigation management; Reservoir management; Sustainable water resources development; Environmental impact assessment of water resources projects.

**Books:**

- Feldman, Dave Water Resources Management.
- Nageswara Rao, K., Water Resources Management.
- Lenton, Roberto L., Muller, Mike, Integrated Water Resources Management in Practice.

<b>Subject Code: CE4L008</b>	<b>Name: Hydraulic and Hydrologic Analysis and Design</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
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**Prerequisite: None**

Synthetic design storms & Estimation of peak discharge, Urban storm drainage design, Culvert design, Detention storage design, Flood frequency analysis; Design of water distribution network, Analysis and design of mobile and rigid boundary channels, Tractive force concepts in channel design, Design of canal headworks, distribution works, and cross-drainage works, Design of gravity dams, spillways, and energy dissipators.

**Books:**

- Ben C. Yen, Yeou-Koung Tung, Reliability and Uncertainty Analyses in Hydraulic Design: A Report, American Society of Civil Engineers
- Bruce E. Larock, Roland W. Jeppson, Gary Z. Watters, Hydraulics of Pipeline Systems, CRC Press
- Ghosh, Karunamoy, Analysis and Design Practice of Hydraulic Concrete Structures, PHI Learning Pvt. Ltd
- Chow, Ven Te, Maidment, David R. and Mays, Larry W., Applied Hydrology, Tata McGraw-Hill Education

<b>Subject Code: CE4L009</b>	<b>Name: Hydropower Engineering</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
<p><b>Prerequisite: None</b></p> <p>Power generation through storage (dams) and diversion (barrages); run-of the river schemes with and without pondage; integrated powerhouse with barrage / on diversion channel; pumped storage schemes; tidal power plants; hydroelectric plant layouts for open flow diversion schemes and pressure diversion system or their combinations; underground projects with pressure diversion systems; position of power house (surface, underground or semi-underground); hydropower conveyance structures intakes, conveyance structures and outflow structures; intakes to canals and tunnels (with corresponding de-silting arrangements); intakes for in-stream powerhouses; reservoir type intakes, trash rack and its design; intakes for embankment dams; water conducting systems open channels, fore-bays, tunnels, surge tanks, penstocks, valves and anchor blocks; layout and sections of tunnels; tunnel design basics; construction methods for tunnels; penstock components (bends, reducer, branches, manifolds); turbine foundations and overhead traveling crane frame; underground powerhouse cavern; types of turbines and their selection.</p> <p><b>Books:</b></p> <ul style="list-style-type: none"> <li>• Subramanya, K., Flow in open channels, Tata McGraw-Hill Education</li> <li>• Garg, S. K., Irrigation Engineering and Hydraulic Structures, Khanna Publishers</li> <li>• Subramanya, K., Fluid Mechanics and Hydraulic Machines, Tata McGraw-Hill Education</li> <li>• Daugherty, Robert Long, Hydraulic Turbines, McGraw-Hill</li> </ul>			
<b>Subject Code: CE4L021</b>	<b>Name: Structural Dynamics</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
<p><b>Prerequisite: None</b></p> <p>Single-degree-freedom systems: undamped and damped free vibration; Response to harmonic and periodic excitations; Response to non-periodic excitations; Numerical evaluation of dynamic response; Generalized single-degree-freedom systems. Elements of analytical dynamics: The principle of virtual work; Principle of D Alembert; Hamiltons principle; Lagrange's equation. Multi-degree-freedom systems: Equation of motion; undamped free vibration; Interpretation of modal orthogonality; Decomposition of response in terms of modal co-ordinates; Modal analysis; Response to external excitations; Rayleigh's quotient and its properties; Systems with proportional damping; Systems with arbitrary viscous damping. Distributed parameter systems: axial and bending vibration of beams; orthogonality of modes; Response to external excitations; Rayleigh s quotient; Approximate methods. Earthquake response of linear systems: Earthquake excitations; Equations of motion; Response spectrum concept; Response spectrum characteristics; Design response spectrum; Modal analysis; Displacement response; Element forces; Modal response contribution; Response history analysis; Response spectrum analysis.</p> <p><b>Books:</b></p> <ul style="list-style-type: none"> <li>• Paz, M, Structural Dynamics, CBS Publisher</li> <li>• Clough, R.W. and Penzin, J., Dynamics of Structures, Printice-Hall &amp; Tata McGraw Hill</li> <li>• Chopra, A K, Dynamics of Structures, Pearson Education</li> </ul>			
<b>Subject Code: CE4L022</b>	<b>Name: Bridge Engineering</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
<p><b>Prerequisite: None</b></p> <p>Types of Bridges and loading standards. Hydraulic Design of Bridges, Foundation for piers and abutments, Open Foundation, Pile Foundation, Well Foundation, Bridge Substructure: Piers and Abutments. Bridge Superstructure: Design aspects, RC slab deck, Tee Beam and Slab deck. Composite Bridges. Pre-stressed concrete bridges, Steel trussed bridges; Bridge Construction, Inspection and Maintenance.</p> <p><b>Books:</b></p>			

- Ponnuswamy, S, Bridge Engineering, McGraw Hill
- Jagadeesh and Jayaram, Design of Bridge Structure, PHI Learning
- Victor, D. J., Essentials of Bridge Engineering, Oxford and IBH Publishing

<b>Subject Code: CE4L023</b>	<b>Name: Pre-stressed Concrete</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
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**Prerequisite: None**

Concept on Mechanics; Materials; Properties of sections; Stress analysis - three methods; Prestressing and Post stressing; Beam design - no tension and ultimate; Poles and slab panels; Loss assessment; Composite beams; Design for shear. Large span structures; Structural forms and design principles; Special materials, open web and built-up structures.

**Books:**

- Lin and Burns, Design Of Prestressed Concrete Structures, Wiley India
- Dayaratnam, P Prestressed Concrete Structures, Oxford and IBH
- Raju, K., Prestressed Concrete Bridges, CBS

<b>Subject Code: CE4L024</b>	<b>Name: Earthquake Engineering</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
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**Prerequisite: None**

Characteristics of earthquakes; Seismic Hazards, Earthquake response of structures; Mechanisms of earthquake generation and propagation, Magnitude and Intensity of an earthquake. Response of SDOF and MDOF systems to Earthquake Loading. Geotechnical Failures Due to Earthquakes, Faulting, Liquefaction; Wave Propagation. Concept of Earthquake Resistant Design, Code provisions.

**Books:**

- Duggal, S K, Earthquake Resistant Design of Structures, Oxford University Press
- Chopra, A K, Dynamics of Structures, Pearson
- Paulay and Priestley, Seismic Design of Reinforced Concrete and Masonry Buildings, Wiley International Publication
- Bolt, B A, Earthquakes, WH Freeman & Company, New York
- Kramer, S L, Geotechnical Earthquake Engineering, Pearson
- Dutta, S C and Mukhopadhyay, P S, Improving Earthquake and Cyclone Resistance of Structures, TERI Delhi

<b>Subject Code: CE4L031</b>	<b>Name: Environmental Engineering</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
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**Prerequisite: None**

Components of water supply systems, Water use and demand estimation, Design period, population data and flow rates for water supply systems, Factors affecting water consumption and variation in demand, Intakes, Transportation of water, Pumping of water, Design of water distribution systems, methods of analysis for optimal distribution network design, Types of reservoirs and design parameters and methods, Water supply plumbing systems in buildings, Rural Water supply.

Design principles of wastewater collection systems, quantities of sanitary wastes and storm water, Estimation of dry weather flows, separate, combined and semi-combined sewers, Sewer pipe hydraulics, construction, maintenance and appurtenances for sewers, Pumping stations, sewage collection from buildings.

Estimation, Handling, Storage, Collection, Transfer, Transport and Disposal of Solid waste

**Books:**

- Peavy, H. S., Rowe, D. R. and Tchobanoglous, G., Environmental Engineering, McGraw-Hill International.
- Garg, S. K., Water Supply Engineering, Khanna Publication.
- Garg, S. K., Sewage Disposal and Air Pollution Engineering, Khanna Publication.
- McGhee, T. J., Water Supply and Sewerage, McGraw Hill International.

- Central Public Health and Environmental Engineering Organization, Manual on Water Supply and Treatment, Ministry of Urban Development, New Delhi.
- Central Public Health and Environmental Engineering Organization, Manual on Sewerage and Sewage Treatment, Ministry of Urban Development, New Delhi.
- Quasim, S. R., Motley, E. M. and Zhu, G., Water Works Engineering- Planning, Design and Operation, Prentice Hall.
- Bhave, P. R. and Gupta, R., Analysis of Water Distribution Networks, Narosa publishing house, New Delhi.
- Bhave, P. R., Optimal Design Of Water Distribution Networks, Narosa publishing house, New Delhi., 2003

<b>Subject Code: CE4L032</b>	<b>Name: Environmental Impact Assessment</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
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**Prerequisite: None**

Evolution of EIA; EIA at project; Regional and policy levels; Strategic EIA; EIA process; Screening and scoping criteria; Rapid and comprehensive EIA. Legislative and environmental clearance procedures in India and other countries, Siting criteria; CRZ; Public participation; Resettlement and rehabilitation. Practical applications of EIA; EIA methodologies; Baseline data collection; Prediction and assessment of impacts on physical, biological and socio-economic environment; Environmental management plan; Post project monitoring, EIA report and EIS; Review process. Case studies on project, regional and sectoral EIA. Specialised areas like environmental health impact assessment; Environmental risk analysis; Economic valuation methods; Cost-benefit analysis; Expert system and GIS applications; Uncertainties. EMP.

**Books:**

- Canter, L., Environmental Impact Assessment, McGraw Hill.
- Kiely, G., Environmental Engineering, Tata McGraw Hill.
- Rau, G. J. and Wooten, C. D., Environmental Impact Analysis Handbook, McGraw Hill.
- Munn, R. E., Environmental Impact Assessment, John Wiley & Sons.
- Dhameja, S. K., Environmental Engineering and Management, S. K. Kataria & Sons.

<b>Subject Code: CE4L033</b>	<b>Name: Sustainable Water and Sanitation Systems</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
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**Prerequisite: None**

Concept of sustainability in water and waste management, Water Conservation, Rainwater Harvesting: Roof water harvesting, technology, quality, health issues, Groundwater recharge, techniques, case studies, Water tariff, sustainable water management. Decentralised wastewater treatment systems, Reliability and cost effectiveness of wastewater systems, Tertiary treatment, process selection, granular- medium filtration, micro screening, removal of toxic compounds and refractory organics, removal of dissolved inorganic substances, Natural Wastewater Treatment Systems, Natural and constructed wetlands, different types, Mechanisms, performance, design, case studies. Land treatment systems. Wastewater reuse and reclamation. Rural water supply and sanitation, Low-cost sanitation, Dry sanitation methods, Pit latrines, VIP latrines, Aquaprivy, septic tank, Organic solid waste management techniques, Composting/vermicomposting, biogas technology, plasma technology,

**Books:**

- Ahluwalia, P. and Nema, A. K., Water and Wastewater Systems: Source, Treatment, Conveyance and Disposal, S. K. Kataria & Sons.
- Arceivala, S. J. and Asolekar, S. R., Wastewater Treatment for Pollution Control and Reuse, Tata McGraw Hill.
- Cites, R. W., Middlebrooks, E. J., and Reed, S. C., Natural Wastewater Treatment Systems, CRC Taylor and Francis.

- Cairncross, S. and Feachem, R., Environmental Health Engineering in the Tropics, John Wiley & Sons.
- Metcalf & Eddy, Wastewater Engineering- Treatment and Reuse (Revised by Tchobanoglous, G., Burton, F. L. and Stensel, H. D.), Tata McGraw Hill.

<b>Subject Code: CE4L034</b>	<b>Name: Environmental System Management</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
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**Prerequisite: None**

Human - environment relationship, normative criteria, descriptive and prescriptive models, limits of growth; Environmental and natural resources economics, pollution control policy, growth in a finite environment; Environmental protection laws; Numerical/mathematical modelling of environmental systems, subsystems, and pollutant transport processes; Planning and management of environmental systems: optimization techniques, stochastic modelling, statistical inferences; Large scale systems; Optimal monitoring network design, identification of sources; Risk reliability and uncertainty in environmental systems; Topics in groundwater and surface water quality management.

**Books:**

- Schnoor, J. L., Environmental Modelling, Wiley-interscience.
- Boubel, R. W., Fox, D. L., Turner, D. B. and Stern, A. C., Fundamentals of Air Pollution, Academic Press, New York.
- Thomann, R. V., and Muller, J. A., Principles of Surface Water Quality Modelling and Control, Harper International Edition.
- Tchobanoglous, G., Schroeder, E. D., Water Quality, Addison - Wesley Publishing Company, Reading, Massachusetts.
- Welford, R., Corporate Environmental Management, Earthscan Publications Limited, London.
- Rosencranz, A., Divan, S. and Noble, M. L., Environmental Law and Policy in India : Cases, Materials and Statutes, Tripathi Pvt. Ltd, Bombay.
- Asolekar, S. R. and Gopichandran, R., Preventive Environmental Management - An Indian Perspective Foundation Books Pvt. Ltd., New Delhi (The Indian Association of Cambridge University Press, UK).

<b>Subject Code: CE4L035</b>	<b>Name: Industrial Pollution Prevention</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
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**Prerequisite: None**

Nature and characteristics of industrial wastes; Prevention versus control of industrial pollution; Linkage between technology and pollution prevention; Tools for clean processes, reuse, recycle, recovery, source reduction, raw material substitution, toxic use reduction and process modifications; Unit operations in separation technology; Separation technologies as tools for waste minimization. Process optimization for cleaner industrial processes; Flow sheet analysis; Energy and resource (material and water) audits for efficient usage and conservation; Waste audits, emission inventories and waste management hierarchy for process industries; Thermodynamic constraints to waste minimization; Holistic and critical technology assessment; Environmental performance indicators; Concept of industrial ecology and symbiosis of eco-parks. Case studies on industrial applications of cleaner technologies in chemical, metallurgical, pulp and paper, textile, electroplating, leather, dairy, cement and other industries.

**Books:**

- Bishop, P. E., Pollution Prevention : Fundamentals And Practice, McGraw Hill.
- Freeman, H. M., Industrial Pollution Prevention Handbook, McGraw Hill, 1995.
- Allen, D. T., and Rosselot, K. S., Pollution Prevention for Chemical Processes, John Wiley.
- Allen, D. T., Bakshani, N., and Rosselot, K. S., Pollution Prevention: Homework and Design Problems for Engineering Curricula, American Institute for Pollution Prevention.

- Johansson, A., Clean Technology, Lewis Publishers.
- Theodore, L. and McGuinn, Y. C., Pollution Prevention, Van Nostrand Reinhold, New York.
- Asolekar, S. R. and Gopichandran, R., Preventive Environmental Management - An Indian Perspective Foundation Books Pvt. Ltd., New Delhi (The Indian Association of Cambridge University Press, UK).

<b>Subject Code: CE4L041</b>	<b>Name: Soil Dynamics</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
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**Prerequisite: None**

Introduction, Fundamental of vibrations, dynamic properties of geomaterials, transient vibrations, analysis of free and forced vibrations using spring dashpot model, single degree of freedom system, multidegrees of freedom system, application of single and multidegree of freedom systems, wave propagation in elastic media, laboratory and field evaluation of soil properties, analysis of earthquake loadings, liquefaction analysis.

**Books:**

- Saran, S., Soil Dynamics and Machine Foundations, Galgotia Publications.
- Das, B. M. and Ramana, G. V., Principles of Soil Dynamics, CL-Engineering.
- Richart, F. E., Woods, R. D., and Hall, J. R., Vibrations of Soils and Foundations, Prentice Hall.
- Kramer, S. L., Geotechnical Earthquake Engineering, Prentice Hall.

<b>Subject Code: CE4L042</b>	<b>Name: Advanced Foundation Engineering</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
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**Prerequisite: None**

Bearing capacity of shallow foundations: Prandtl, Terzaghi and Meyerhof s method of analysis, safe and allowable bearing pressures, selection of type and depth of foundations, combined footings, mat foundations including floating raft, settlement calculations, Skempton - Bjerrum modification, and Martin s method, bearing capacity of layered soils, bearing capacity of footings on slopes, Deep foundations: mechanics of load transfer in piles, load carrying capacity, pile load test, lateral loaded piles, design of pile groups including settlement calculations, design of block foundation, well foundations, coffer dams, pier foundations, earth pressure computations on retaining walls and their design, earthquake response of foundations.

**Books:**

- Das, B. M., Principles of Foundation Engineering, Cengage Learning.
- Budhu, M., Soil Mechanics and Foundations, Wiley Publishers, New Delhi.
- Coduto, D. P., Foundation Design: Principles and Practices, Prentice Hill Publishers.
- Holts, R. D. and Kovacs, W. D., An Introduction to Geotechnical Engineering, Prentice Hall.
- Das, B. M., Shallow Foundations: Bearing Capacity and Settlement, CRC Press.
- Tomilson, M. J., Foundation Design and Construction, Pearson Publishers.

<b>Subject Code: CE4L043</b>	<b>Name: Numerical Methods in Geotechnical Engineering</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
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**Prerequisite: None**

Introduction to numerical modeling in Geotechnical Engineering, constitutive modeling, review of basic concepts, solution of nonlinear systems of equations, finite difference method, finite element method, constitutive modeling of soil response, large deformation - large strain analysis, applications: flow and consolidation, groundwater and seepage, slopes and cuts, embankments, shallow and deep foundations, retaining walls, tunnels and caverns and rock Mechanics

**Books:**

- Desai, C. S. and Christian, J. T., Numerical Methods in Geotechnical Engineering, McGraw-Hill Publishers.
- Potts, D. M. and Zdravkovic, L., Finite Element Analysis in Geotechnical Engineering: Theory and Application, Thomas Telford Publishing.

- Benz, T. and Nordal, S., Numerical Methods in Geotechnical Engineering: NUMGE 2010, CRC Press.
- Christian, J. T., Numerical Methods in Geotechnical Engineering, McGraw-Hill Publishers.

<b>Subject Code: CE4L044</b>	<b>Name: Soil Engineering</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
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**Prerequisite: None**

Shear strength of cohesionless and cohesive soils, physico-chemical aspects, experimental determination of shear strength, failure theories, Yield criteria, influence on failure conditions of inter-mediate principal stress, history, drainage, rate of stress applications etc.; Plastic equilibrium in soils, Mohr diagram, active and passive states, theories of earth pressure on retaining walls, effect of wall friction on the shape of sliding surface, theories of arching, bearing capacity, concepts of general and local shear failure, critical height of vertical banks, various methods of computation of slope stability, earth pressure on timbering of cuts and on free and anchored bulkheads.

**Books:**

- Lambe, T. W. and Whitman, R. V., Soil Mechanics in SI Version, Wiley, New Delhi.
- Scott, R. F., Principles of Soil Mechanics, Addison Wesley, World Student Edition.
- Leonards, G. A., Foundation Engineering, McGraw-Hill.
- Bowles, J. E., Foundations Analysis and Design, McGraw-Hill.
- Peck, R. B., Hanson, W. E., and Thornburn, T. H., Foundation Engineering, John Wiley and Sons.

<b>Subject Code: CE4L045</b>	<b>Name: Earth Retaining Structures</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
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**Prerequisite: None**

Earth Pressure: Fundamental relationships between the lateral pressures and the strain with a back fill. Rankine's and Coulomb's theories, Active, passive and earth pressure at-rest; Backfill with broken surface, wall with broken back, concentrated surcharge above the back fill, earth pressure due to uniform surcharge, earth pressure of stratified backfills, saturated and partially saturated backfill. Passive earth pressure in engineering practice. Assumption and conditions, point of application of passive earth pressures; Bulkheads: Definition and assumptions, conditions of end supports and distribution of active earth pressure and bulkheads, bulkheads with free and fixed earth supports, equivalent beam method, Improvements suggested by Rowe, Tschebotarioff's method, Anchorage of bulkheads and resistance of anchor walls, spacing between bulkheads and anchor walls, resistance of anchor plates, Consideration of effects of ground water, seepage, surcharge loading together with possibility of shallow and deep sliding failures on retaining structure; Sheet Pile wall: Free earth system, fixed earth system, Dead man; Tunnel and Conduit: Stress distribution around tunnels, Types of conduits, Load on projecting conduits; Arching and Open Cuts: Arching in soils, Braced excavations, Earth pressure against bracings in cuts, Heave of the bottom of cut in soft clays; Reinforced earth retaining structures- Design of earth embankments and slopes; Recent advances in Earth retaining structures.

**Books:**

- Das, B. M., Principles of Foundation Engineering, Thomson, Indian Edition.
- Clayton, C. R. I., Milititsky, J. and Woods, R. I., Earth Pressure and Earth-retaining Structures, Chapman and Hall Publishers.
- Bowel, J., Foundation Engineering, Analysis and Design, McGraw Hill.
- Raj, P., Geotechnical Engineering, Tata McGraw Hill.
- Craig, R. F., Soil Mechanics, Chapman and Hall (ELBS).

<b>Subject Code: CE4L051</b>	<b>Name: Remote Sensing and GIS</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
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**Prerequisite: None**

Physics of remote sensing: Electromagnetic spectrum, atmospheric effects, energy interaction

with earth surface features. Platforms and remote sensing sensors: Photographic camera, scanners, earth resources satellites, active and passive microwave sensors. Digital image processing: Image rectification, image enhancement, image classification and accuracy. Image interpretation. Geographical Information System (GIS): Map data representation, geographic database concepts and analysis. Application of remote sensing and GIS in land and water resources system and evaluation.

**Books:**

- Bhatta, B., Remote Sensing and GIS, Oxford University Press.
- Mesev, V., Integration of GIS and Remote Sensing, John Wiley & Sons Ltd.
- Nayak, S., and Zlatanova, S., Remote Sensing and GIS Technologies for Monitoring and Prediction of Disasters, Springer.

<b>Subject Code: CE4L052</b>	<b>Name: River Engineering</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
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**Prerequisite: None**

River basins; erosion from river catchments and its transportation by rivers; classification of streams, delta, alluvial fans, point bars, etc.; hydraulic geometry and plan form of alluvial rivers; features of gravel bed rivers; bed level changes in streams sedimentation on the upstream and degradation on the downstream of dams and barrages; morphology of some Indian rivers; river flow measurement techniques; stream gauging and analysis of rating curves (hydrometry); dynamics of tidal rivers and estuarine flows; mathematical models for sediment transport and pollutant transport in rivers; introduction to software packages for river flow, sediment and pollutant transport; riverbank erosion mechanisms; direct bank erosion protection methods (use of fascine mattresses; geosynthetics; other [hard] options); indirect bank erosion protection methods (flow deflection using spurs, groynes, etc. and their possible ill effects); foundations for bridges across rivers; river training works (guide bunds) for bridges and barrages.

**Books:**

- Julien, P. Y., River Mechanics, Cambridge University Press.
- Garg, S. K., Irrigation Engineering and Hydraulic Structures, Khanna Publishers.
- U. S. Army Corps of Engineers, River Hydraulics.

<b>Subject Code: CE4L053</b>	<b>Name: Open Channel Hydraulics</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
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**Prerequisite: None**

Basic concepts; Energy and Momentum equations and their applications; Critical flow, channel control ad transitions; Uniform flow and flow resistance; Sheet flow; Concepts of boundary layer and surface roughness; Theoretical uniform flow equations; Instability of uniform flow; Gradually varied flow, flow profile classification and computation methods; Flow profiles in natural channels; Spatially varied flow; Hydraulic jump; Unsteady flow, continuity equation, dynamic equation, wave propagation; Method of characteristics; Rapidly varied unsteady flow, surges; Dam break problems.

**Books:**

- Subramanya, K., Flow in Open Channels, Tata McGraw-Hill.
- Chanson, H., Hydraulics of Open Channel Flow, Elsevier.
- Chow, V. T., Open Channel Hydraulics, McGraw Hill.
- French, R., Open Channel Hydraulics, McGraw-Hill.
- Sturm, T.W., Open Channel Hydraulics, Tata McGraw-Hill.

<b>Subject Code: CE4L054</b>	<b>Name: Water Resources Systems</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
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**Prerequisite: None**

Introduction to systems concept in water resources engineering: its role in planning and management; data acquisition and processing; descriptive and prescriptive models; economics of water resources systems; social, economical, technical and environmental issues; decision making under uncertainty and/or risk; evaluation of project alternatives; application to surface and subsurface water resources systems planning and management.

**Books:**

- Vedula, S. and Mujumdar, P. P., Water Resources Systems, McGraw-Hill.
- Jain, S. K., and Singh, V. P., Water Resources Systems Planning and Management, Elsevier.
- Purcell, P., Design of Water Resources Systems, Thomas Telford Publishing.

<b>Subject Code: CE4L055</b>	<b>Name: Design of Hydraulic Structures</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
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**Prerequisite: None**

Concrete dams, force and stress analysis for components like piers, bridges and trash rack and their reinforcement detailing; stress analysis around galleries, adits and shafts and reinforcement provisions; integrated stability analysis of concrete dams considering foundation rock; construction methods for concrete dams. Embankment dams, seepage analysis (finding the phreatic line) for different types of embankment dams; seepage control measures for embankment dams; construction methods for embankment dams. Spillways and energy dissipators design of ogee spillways; calculations for chute spillway profiles; flow characteristics of shaft and syphon spillways; types of energy dissipators, their selection and dimensioning; flow characteristics of radial gates; introduction to relevant BIS codes and guidelines. Barrages - design of barrage structure and canal head regulator; construction methods for barrages. Irrigation structures, Canals, cross drainage works, falls and energy dissipators.

**Books:**

- Garg, S. K., Irrigation Engineering and Hydraulic Structures, Khanna Publishers.
- Ghosh, K., Analysis and Design Practice of Hydraulic Concrete Structures, PHI Learning Private Limited.
- Novak, P., Moffat, A. I. B., Nalluri, C., and Narayanan, R. Hydraulic Structures, Taylor & Fransis.

<b>Subject Code: CE4L061</b>	<b>Name: Transportation Planning</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
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**Prerequisite: None**

Transportation planning Process, Demand-supply interaction of a transportation system, four-step-travel demand modeling- such as trip generation, trip distribution, modal split and traffic assignment, discussion of case study on travel demand model, land-use transport model, household travel survey, public transportation, traffic forecasting techniques on highway, Demand analysis for air transportation

**Book:**

- Kadiyali, L. R., Traffic Engineering and Transport Planning, Khanna Publishers.
- Ortuzar, J. D. and Williumsen, L. G., Modeling Transport, John Wiley & Sons Ltd.

<b>Subject Code: CE4L062</b>	<b>Name: Pavement Design</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
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**Prerequisite: None**

Types of Pavement, Pavement Composition, Philosophy of design of flexible and rigid pavements, analysis of pavements using different analytical methods, selection of pavement design input parameters, traffic loading and volume, material characterization, drainage, failure criteria, reliability, design of flexible and rigid pavements using different methods, pavement evaluation and overlay design.

**Books:**

- Huang, Y. H., Pavement Analysis and Design, Pearson Education.
- Yoder, E. J. and Witczak, M. W., Principles of Pavement Design, John Wiley & Sons Ltd.
- Mallick, R. B. and El-Korchi, T., Pavement Engineering: Principles and Practice, CRC Press.

**Subject Code: CE4L063****Name: Traffic Engineering****L-T-P: 3-0-0****Credit: 3****Prerequisite: None**

Driver behaviour, visual angle modelling, traffic information and control systems, traffic studies-volume, speed and delay studies, elements of traffic flow theory, Greenshields' model and Greenberg's model, PCU concept, characteristics of uninterrupted traffic, gap acceptance-Raff's method, queuing theory, shock wave, capacity and LOS of Uninterrupted facilities, characteristics of interrupted traffic, IRC method of roundabout design, traffic characteristics at unsignalised intersections, queue discharge characteristics at signalised intersections, Trial Cycle method and Webster's method of signal design, dilemma zone, actuated signal control, signal coordination.

**Books:**

- Mannering, F. L., Kilareski, W. P. and Washburn, S. S., Principles of Highway Engineering and Traffic Analysis, Wiley India Edition.
- Drew, D. R., Traffic Flow Theory and Control, McGraw-Hill.
- May, A. D. Traffic Flow Fundamentals, Prentice Hall.
- Slinn, M., Guest, P. and Mathews, P., Traffic Engineering Design, Elsevier.
- Roess, R. P., Prassas, E. S., McShane, W. R. Traffic Engineering, Pearson.
- Kadiyali, L. R., Traffic Engineering and Transport Planning, Khanna Publishers.
- Pignaturo, L. J., Traffic Engineering-Theory and Practice, Prentice-Hall, Englewood Cliffs, New Jersey.
- Khanna, S. K. and Justo, C. E. G., Highway Engineering, Nem Chand & Bros, Roorkee.
- Khisty, C. J. and Lal, B. K., Transportation Engineering, Prentice Hall India.
- Papacostas, C. S. and Prevedouros, P. D., Transportation Engineering & Planning, Prentice-Hall.

**Subject Code: CE2L011****Name: Building materials and Construction****L-T-P: 3-0-0****Credit: 3****Prerequisite: None**

Introduction to Civil Engineering; Major Divisions; Civil Engineering Infrastructures; Ethics in Civil Engineering; Properties of construction material and their evaluation; test methods and specifications; Cement - chemical composition, properties such as setting, strength, fineness, hydration; Aggregates - sources, properties, chemical reactivity; Concrete - constituents, proportioning, properties in fresh and hardened state, characteristic strength, quality control, transportation and placing, testing, porosity; Admixtures - chemical, mineral; Steel - properties, types of steel, steel in civil engineering; Bricks - manufacture, properties and classification; masonry bonds; Wood - Structure, defects & preservation; Paints, New materials - Fibre reinforced plastics (FRPs), epoxy-coated bars, Geo-synthetics etc., Construction methodologies and equipment.

**Books:**

- Taylor, G.D., Materials of Construction, Prentice Hall
- Mehta P.K. and Montiero, P.M.J., Concrete - Material, Microstructure and Properties, Tata McGraw Hill
- Gambhir, M.L., Concrete Technology, Tata McGraw Hill
- Neville, A.M. and Brooks, J.J., Concrete Technology, ELBS/Longman

- Neville, A.M., Properties of Concrete, 4th Edition, ELBS/Longman
- Dayaratnam, P. Brick and Reinforced Brick Structures, Oxford and IBH
- Ghose, D.N., Construction Materials, Tata Mcgraw Hill
- Relevant IS codes for testing and specifications

**Subject Code: CE2L012**

**Name: Infrastructure Planning and Management**

**L-T-P: 3-0-0**

**Credit: 3**

**Prerequisite: None**

An Overview of Basic Concepts Related to Infrastructure in India (Power sector, Water Supply and Sanitation Sector, Road, Rail, Air, and Port Transportation Sectors, Telecommunications Sector, Urban & Rural Infrastructure, SEZ, Infrastructure players, Infrastructure Project Finance); Private Involvement in Infrastructure (Infrastructure Privatization, Types of PPs, BOT, Private players in PPPs & BOT; Case studies); Challenges to Successful Infrastructure Planning and Implementation (Risks in Infrastructure, Political risks, : Socio-Environmental Risks, Cultural risks, Legal and Contractual Issues); Strategies for Successful Infrastructure Project Implementation (Risk management, Risk mitigation, Sustainable Development of Infrastructure, Infrastructure management systems, maintenance of infrastructure facilities, quality control in design and construction, life-cycle analysis), Planning and Evaluation of infrastructure project (say transportation projects) Decision Making (Engineering economics, Economic evaluation based on economic criteria, multiple criteria, ranking of project alternatives)

**Books:**

- Hudson, W. and Ralph, H., Infrastructure Management: Integrating Design, Construction, Maintenance, Rehabilitation and Renovation, Tata Mc Graw Hills.
- Garber, N.J. and Hoel, L.A., Principles of Traffic and Highway Engineering, Cengage Learning.
- Fricker, J.D., and Whitford, R.K., Fundamentals of Transportation Engineering: A Multimodal Systems Approach, Pearson Prentice Hall
- The India Infrastructure Report, Ministry of Finance, Govt of India.

**Subject Code: CE3L021**

**Name: Traffic Engineering and Management**

**L-T-P: 3-0-0**

**Credit: 3**

**Prerequisite: None**

Introduction to traffic engineering; Fundamental parameters and relations of traffic flow; Traffic stream models; Traffic speed and volume measurement procedures: Capacity and Level of service LOS; Ramp metering; Principles of traffic control; Uncontrolled intersection; Channelization; Traffic rotary; Grade separated intersection; Basic principle and elements of Traffic signal design, Coordinated traffic signal; Specialised Traffic Studies: Parking Studies; Accident Studies; Fuel consumption and emission studies; Congestion studies; Toll operation: Pedestrian studies; Intelligent transportation system; Traffic Control, Traffic Management

**Books:**

- Mannering, F.L., Kilareski, W.P. and Washburn, S.S., Principles of Highway Engineering and Traffic Analysis, John Wiley & Sons.
- Drew, D.R., Traffic Flow Theory and Control, McGraw-Hill Book Company.
- May, A.D., Traffic Flow Fundamentals, Prentice Hall.
- Slinn, M., Guest, P. and Mathews, P., Traffic Engineering design, Elsevier.
- Roess, R.P., Prassas, E.S., McShane W.R., Traffic Engineering, Prentice Hall
- Kadiyali, L.R., Traffic Engineering and Transport Planning, Khanna Publishers.
- Pignaturo, L.J., Traffic Engineering-Theory and Practice, Prentice-Hall

<ul style="list-style-type: none"> <li>• Khanna, S. K. and Justo, C.E.G., Highway Material Testing, Nem Chand &amp; Bros.</li> <li>• Khisty, C.J. and Lal, B.K., Transportation Engg., Prentice Hall India.</li> <li>• Papacostas C.S. and Prevedouros, P.D., Transportation Engineering &amp; Planning, Prentice Hall</li> </ul>			
<b>Subject Code: CE3L022</b>	<b>Name: Construction Planning and Management</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
<p><b>Prerequisite: None</b></p> <p>Construction and fabrication methods; Pre-fabrication techniques; choice of equipment safety features and Regulations; Agreements and Contracts; Use of IS codes and Building Laws; Value Analysis; Feasibility studies; Economics of project evaluation; Finance, material and man power development; Network analysis; Levelling of Resources; Site organisation; layout; work study; Decision making processes; CPM and L.P. Project monitoring; Maintenance management; Case studies.</p> <p><b>Books:</b></p> <ul style="list-style-type: none"> <li>• Jha, N.K., Construction Project Management, Pearson Education India</li> <li>• Williams, T., Construction Management, Pearson Education India</li> <li>• Chitkara, K., Construction Project Management techniques and practice, Tata McGraw Hill</li> <li>• Purifoy, Construction Planning, equipments and Methods, Tata McGraw Hill</li> </ul>			
<b>Subject Code: CE3L031</b>	<b>Name: Environmental Pollution Management</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
<p><b>Prerequisite: None</b></p> <p>Man and environment, Their inter relationships. Types of environmental pollutants, their sources and effects. Water Pollution and Control, Indoor pollution, Air pollution, sources, effects and controls technologies. Noise pollution and control, Industrial wastes and their treatment. Solid wastes, generation, collection, processing and disposal. Environmental impact assessment and auditing. Introduction to Environmental standards, laws and policies. Global issues on environment, Waste minimization, Building environment services.</p> <p><b>Books:</b></p> <ul style="list-style-type: none"> <li>• Kiely, G., Environmental Engineering, Tata McGraw Hill.</li> <li>• Garg, S. K., Sewage Disposal and Air Pollution Engineering, Khanna Publication.</li> <li>• Cunningham, W.P. and Cunningham, M.A. 2002, Principles of Environmental Science, Tata McGraw-Hill Publishing.</li> <li>• Nathanson, J.A., (2002), Basic Environmental Technology, Prentice Hall of India, New Delhi.</li> <li>• Peavy, H. S., Rowe, D. R. and Tchobanoglous, G., Environmental Engineering, McGraw-Hill International Ed.</li> <li>• Masters, G.M., Ela, W.P., Introduction to Environmental Engineering and Science, Pearson Education.</li> <li>• Asolekar, S. R. and Gopichandran, R. Preventive Environmental Management - An Indian Perspective Foundation Books Pvt. Ltd., New Delhi (the Indian association of Cambridge University Press, UK).</li> </ul>			
<b>Subject Code: CE3L032</b>	<b>Name: Geo-environmental Management</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
<p><b>Prerequisite: None</b></p> <p>Introduction, Perspectives, Forms of waste and their engineering properties; Geosynthetics and Applications; Waste disposal sites, Landfills; Ash ponds &amp; dykes; Subsurface Contamination; Three "RS", Geotechnical Reuse of Waste materials; International Standards; Mechanics of erosion and erosion control; Landslides and their control.</p>			

**Books:**

- Sharma, H.D., and Reddy, K.R., "Geoenvironmental Engineering: Site Remediation, Waste Containment, and Emerging Waste Management Technologies" John Wiley & Sons, Inc.
- Lakshmi N. Reddi, Hilary I. Inyang, Geoenvironmental Engineering: Principles and Applications, Marcel Dekker Inc, Publishers.
- Yong, R. N., Young, Raymond N., Geoenvironmental Engineering: Contaminated Soils, Pollutant Fate, and Mitigation, Lewis Publication.

<b>Subject Code:</b> CE6P301	<b>Name: Advanced Structural Laboratory</b>	<b>L-T-P: 0-0-3</b>	<b>Credit: 2</b>
<b>Prerequisite: None</b> Vibration analysis of SDOF system, Modal study, Natural Period determination using free and forced vibration, Stress-strain behaviour of MS steel and high strength steel bars. 1g shake table test.			
<b>Subject Code:</b> MA6L001	<b>Name: Mathematical Methods</b>	<b>L-T-P: 3-1-0</b>	<b>Credit: 4</b>
<b>Prerequisite: None</b> Probability and Statistics : Random variables (rv) and their properties, some standard discrete and continuous rv, Expectation, Variance, moments, moment generating functions, functions of a rv, their distribution and moments, joint, marginal and conditional distribution and independence of rvs, Hypothesis testing. Numerical solutions of systems of linear equations: Gauss elimination, LU decomposition, Gauss-Jacobi and Gauss-Seidel methods. Numerical methods of ODE and PDE: Runge-Kutta and finite difference methods for ODE, Finite difference methods for solving 2-D Laplace's equation, Poisson's equation, 1-D heat equation : Bender Schmidt, Crank Nicholson method and Du Fort Frankel methods, 1-D wave equation using Explicit method. Consistency and stability analysis. <b>Books:</b> 1. Grawel, B.S. <i>Numerical Methods</i> , Khanna Publishers 2. Jain, M.K., Iyengar, S.R.K. and Jain, R.K. <i>Numerical Methods-problem and solutions</i> , Wiley Eastern Limited 3. Ross, S. <i>Introduction to Probability Models</i> , Wiley India 4. Gun, A.M., Gupta, M.K. and Gupta, B.S., <i>Fundamentals of Statistics</i> 5. Hayter, A.J., <i>Probability and Statistics</i> , Duxbury 6. Scarborough, J.B., <i>Numerical mathematical analysis</i> , Oxford & IBH Publishing Co.Pvt. 7. Hamming, R.W., <i>Numerical Methods for Scientist and Engineers</i> , McGraw Hill 8. Mathews, J.H. and Fink, K.D., <i>Numerical Methods using MATLAB</i> , Pearson Education.			

<b>Subject Code:</b> CE6L312	<b>Name: Advanced Design of RC Structure</b>	<b>L-T-P: 3-1-0</b>	<b>Credit: 4</b>
<p><b>Prerequisite: None</b>  Design of overhead, underground, ground supported water tanks, dams; Design of industrial structures; Design of bunkers and silos, Airy's theory, Janssen's theory; Design of special RC elements: Design of slender columns, RC walls, ordinary and shear walls, Corbels, Deep beams, RCC chimney; Introduction to shell and folded plate roofs, their forms and structural behaviour. Design of simple cylindrical shell roof by beam theory, Yield line analysis of slabs by virtual work, Yield line analysis by equilibrium methods.</p> <p><b>Books:</b></p> <ol style="list-style-type: none"> <li>1. Varghese , P.C., <i>Advanced Reinforced Concrete Design</i>, PHI Learning</li> <li>2. Naeim, F., <i>Handbook on Seismic Analysis and Design of Structures</i>, Kluwer Academic Publisher</li> <li>3. IS 4326, <i>Earthquake Resistant Design and Construction of Buildings - Code of Practice</i>, Bureau of Indian Standard; New Delhi</li> <li>4. Jain, S.K. and Jaiswal, O.R., <i>Guidelines for Seismic Design of Liquid Storage Tanks</i>, NICEE, IIT Kanpur</li> <li>5. Fintel, M., <i>Handbook of Concrete Engineering</i>, CBS Publishers Delhi</li> </ol>			
<b>Subject Code:</b> CE6P302	<b>Name: Computational Laboratory</b>	<b>L-T-P: 0-0-3</b>	<b>Credit: 2</b>
<p><b>Prerequisite: None</b>  Finite element modelling of structures, Seismic analysis of structures, Pushover analysis, seismic ground response analysis.</p>			

<b>COMPULSORY SUBJECTS</b>			
<b>Subject Code:</b> CE6L301	<b>Subject Name:</b> Dynamics of Structures	<b>L-T-P:</b> 3-1-0	<b>Credit:</b> 4
<p><b>Prerequisite: None</b></p> <p>Single-degree-freedom systems: undamped and damped free vibration; Response to harmonic and periodic excitations; Response to non-periodic excitations; Numerical evaluation of dynamic response; Generalized single-degree-freedom systems. Elements of analytical dynamics: The principle of virtual work; Principle of D Alembert; Hamiltons principle; Lagrange's equation. Multi-degree-freedom systems: Equation of motion; undamped free vibration; Interpretation of modal orthogonality; Decomposition of response in terms of modal co-ordinates; Modal analysis; Response to external excitations; Rayleigh s quotient and its properties; Systems with proportional damping; Systems with arbitrary viscous damping. Distributed parameter systems: axial and bending vibration of beams; orthogonality of modes; Response to external excitations; Rayleigh s quotient; Approximate methods. Earthquake response of linear systems: Earthquake excitations; Equations of motion; Response spectrum concept; Response spectrum characteristics; Design response spectrum; Modal analysis; Displacement response; Element forces; Modal response contribution; Response history analysis; Response spectrum analysis. Introduction to Random Vibration; Stationary and non-stationery random processes; Ergodic random processes. Narrow band and wide band random processes; Properties of Autocorrelation and Power spectral density functions; Response to arbitrary excitation by Fourier transform method.</p> <p><b>Books::</b></p> <ul style="list-style-type: none"> <li>• Chopra, A.K., Dynamics of Structures: Theory and Applications to Earthquake Engineering, Prentice Hall/Pearson Education</li> <li>• Clough, R.W. and Penzien, J., Dynamics of structures, McGraw Hill, Inc., New York</li> <li>• Craig, R.R., Structural Dynamics: An Introduction to Computer Methods, Wiley New York</li> <li>• Meriovitch, L., Elements of vibration analysis, McGraw-Hill</li> <li>• Rao, S.S., Mechanical Vibrations, Pearson</li> <li>• Thomson, W.T., Theory of Vibration with Application, CRC Press</li> <li>• Newland, D.E., An Introduction to Random Vibrations, Spectral and Wavelet Analysis, Courier Dover Publications</li> <li>• Y K Lin and C Q Cai, 2004, Probabilistic structural dynamics: Advanced theory and applications, McGraw-Hill, New York.</li> <li>• N C Nigam, 1983, Introduction to random vibrations, MIT press, Cambridge.</li> <li>•</li> </ul>			
<b>Subject Code:</b> CE6L302	<b>Subject Name: Advanced Structural Analysis</b>	<b>L-T-P:</b> 3-1-0	<b>Credit:</b> 4
<p><b>Prerequisite: None</b></p> <p>Basics of structural analysis: static &amp; dynamic loading, linear &amp; nonlinear structural behaviour, geometric &amp; material nonlinearity, hysteretic behaviour; Classical linear analysis of frames and trusses: displacement method, slope deflection equations &amp; matrix displacement method, effect of foundation settlement and temperature; Geometric nonlinear analysis of frames and trusses: displacement method, nonlinear slope-deflection equations &amp; nonlinear behaviour, linearized iterative matrix displacement method, geometric stiffness matrix, tangent stiffness matrix, P- Δ effect, buckling of frames, tension structures; Material nonlinear analysis of frames: basics of plasticity, distributed plasticity &amp; lumped plasticity, incremental nonlinear analysis.</p> <p><b>Books::</b></p> <ul style="list-style-type: none"> <li>• Thandavamoorthy, T.S., Structural Analysis, Oxford University Press</li> <li>• Weaver, W. and Gere, J.M., Matrix Analysis of Framed Structures, CBS Publisher</li> <li>• Wang, C.K., Intermediate Structural Analysis, McGraw Hill</li> </ul>			

- Kanchi, M.B., Matrix Methods of Structural Analysis, Wiley Eastern Limited
- Hibbeler, R.C., Structural Analysis, Pearson
- William McGuire, Richard H. Gallagher and Ronald D. Ziemian, "Matrix Structural Analysis" John Wiley and Sons, Inc.

**Subject Code:**  
CE6L303

**Subject Name: Advanced Solid Mechanics**

**L-T-P: 3-1-0**

**Credit:4**

**Prerequisite: None**

Introduction to elasticity theory; Stress analysis: forces and moments, theory of stress, principal stresses and stress invariants, compatibility equations, equilibrium equations; Strain: deformation and velocity gradients, Lagrangian and Eulerian description and finite strain, small deformation theory, principal strains and strain invariants, compatibility conditions; Fundamental physical principles: conservation of mass, linear momentum, angular momentum, and energy, second law of thermodynamics; Constitutive theory: St. Venant's principal, linear elasticity and generalized Hook's law, Stokesian and Newtonian fluids, Navier-Stokes equations, Bernoulli equation, linear viscoelasticity, yield criteria; Applications: Airy stress function, two-dimensional elastostatics problems, torsion.

**Books::**

- Srinath, L.S., Advanced Mechanics of Solids, Tata McGraw Hill
- Timoshenko, S., Strength of Materials, CBS
- Bruhns, O.T., Advanced Mechanics of Solids, Springer
- Timoshenko, S., and Goodier, J.N., Theory of Elasticity, Tata McGraw Hill
- Chakrabarty, J. Theory of Plasticity , Butterworth-Heinemann

<b>LABORATORY/SESSIONAL SUBJECTS</b>			
<b>Subject Code: CE4P001</b>	<b>Subject Name: CAD Laboratory</b>	<b>L-T-P: 0-0-3</b>	<b>Credit: 2</b>
<b>Prerequisite: None</b> Exposure to commercial software tools for analysis, design and research in civil engineering.			
<b>Subject Code: CE6P303</b>	<b>Subject Name: Design of Special Structures</b>	<b>L-T-P: 0-0-6</b>	<b>Credit: 4</b>
<b>Prerequisite: Design of RC Structures</b> Design of overhead, underground, ground supported water tanks, dams; Design of industrial structures; Design of bunkers and silos; Design of special RC elements: Design of slender columns, RC walls, ordinary and shear walls, Corbels, Deep beams, RCC chimney; Design of simple cylindrical shell roof by beam theory.  <b>Books::</b> <ul style="list-style-type: none"> <li>• Fintel, M., Handbook of Concrete Engineering, CBS Publishers Delhi</li> <li>• Naeim, F., Handbook on Seismic Analysis and Design of Structures, Kluwer Academic Publisher</li> <li>• IS 4326, Earthquake Resistant Design and Construction of Buildings - Code of Practice, Bureau of Indian Standard; New Delhi</li> <li>• Jain, S.K. and Jaiswal, O.R., Guidelines for Seismic Design of Liquid Storage Tanks, NICEE, IIT Kanpur</li> </ul>			
<b>Subject Code: CE6P301</b>	<b>Subject Name: Advanced Structural Laboratory</b>	<b>L-T-P: 0-0-3</b>	<b>Credit: 2</b>
<b>Prerequisite: None</b> Vibration analysis of SDOF system, Modal study, Natural Period determination using free and forced vibration, Stress-strain behaviour of MS steel and high strength steel bars. 1g shake table test.			
<b>Subject Code: CE6P302</b>	<b>Subject Name: Computational Laboratory</b>	<b>L-T-P: 0-0-3</b>	<b>Credit: 2</b>
<b>Prerequisite: None</b> Finite element modelling of structures, Seismic analysis of structures, Pushover analysis, seismic ground response analysis.			

## ELECTIVE SUBJECTS

<b>Subject Code: CE4L003</b>	<b>Subject Name: Advanced Transportation Engineering</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
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**Prerequisite: None**

Airports: introduction; characteristics of aircrafts related to airport design; obstruction clearance criteria; design of airside facilities: runway orientation, length, capacity, configuration and number, taxiway layout, design of fillets, high-speed exit taxiway, apron gate and circulation areas, hanger; design of landside facilities: terminal building functional areas and facilities, centralized and de-centralized concepts, vertical distribution; airport planning and site selection; pavement design; visual aids; demand estimation of air travel, drainage. Railways:- Introduction, classification of routes; railway gauge, coning of wheels and canting of rails, train resistance and hauling power; track components: rails, sleepers, fastenings, ballast and formation; track stresses; turnouts and crossings, signals and control systems, welded rails. Elements of water and pipeline transportation. Economic Analysis of Transportation Projects

**Book:**

- Horonjeff, Robert, Planning and Design of Airports, McGraw Hill
- Chandra, Satish and Agarwal, M.M., Railway Engineering, Oxford University Press India
- Garber, NJ and Hoel, LA, Principles of Traffic and Highway Engineering, Cengage Learning

<b>Subject Code: CE4L004</b>	<b>Subject Name: Rock Mechanics and Tunnelling</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
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**Prerequisite: None**

Introduction - objective, scope and problems of Rock Mechanics. Classification by origin, Lithological, Engineering. Rock exploration - rock coring, geophysical methods. Laboratory testing of rocks - all types of compressive strength, tensile strength and flexural strength tests. Strength and failure of rocks, Griffith's theory, Coulombs theory, rheological methods. In-situ tests on rock mass. Deformation characteristics of rocks, instrumentation and measurement of deformation of rocks. Permeability characteristics - interstitial water on rocks, unsteady flow of water through jointed rock mass. Mechanical, thermal and electrical properties of rock mass. Correlation between laboratory and field properties. Analysis of stresses. Thick wall cylinder, formulae, Kreish equation, Green span method. Openings in rock mass and stresses around openings. Pressure tunnels, development of plastic zone. Rock support needed to avoid plastic deformation. Lined and unlined tunnels. Underground excavation and subsidence. Rock mechanics applications. Bearing capacity of homogeneous as well as discontinuous rocks. Support pressure and slip of the joint. Delineation of types of rock failure. Unsupported span of underground openings, pillars. Rock slopes. Rock bolting. Plastic mechanics. Tunnels, shapes, usages, Methods of Construction, Problems associated with tunnels, tunnelling in various subsoil conditions and rocks.

**Books::**

- Goodman, R. E., Introduction to Rock Mechanics, John Wiley and Sons.
- Hudson, J.A. and Harrison, J.P. Engineering rock Mechanics: an introduction to the principles, Pergamon publishers.
- Chapman, David, Metje, Nicole and Stärk, Alfred, Introduction to Tunnel Construction. Spon Publishers, Taylor and Francis Group.
- Brady, B. H. G. and Brown, E. T. Rock Mechanics: for underground mining, Kluwer Academic Publishers.

<b>Subject Code: CE4L005</b>	<b>Subject Name: Maintenance and Rehabilitation of Concrete Structures</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
<p><b><u>Prerequisite: None</u></b>  Maintenance and Repair strategies - Maintenance, repair and rehabilitation, Facets of Maintenance, importance of Maintenance various aspects of Inspection, Assessment procedure for evaluating a damaged structure, causes of deterioration; Serviceability and Durability of Concrete - Quality assurance for concrete construction concrete properties- strength, permeability, thermal properties and cracking. - Effects due to climate, temperature, chemicals, corrosion - design and construction errors - Effects of cover thickness and cracking; Materials and Techniques for Repair - Special concretes and mortar, concrete chemicals, special elements for accelerated strength gain, Expansive cement, polymer concrete, sulphur infiltrated concrete, Ferrocement and polymers coating for rebars loadings from concrete, mortar and dry pack, vacuum concrete, Guniting and Shotcrete, Epoxy injection, Mortar repair for cracks shoring and underpinning. Methods of corrosion protection, corrosion inhibitors, corrosion resistant steels and cathodic protection.; Repairs to Structures - Repair of structures distressed due to earthquake - Strengthening using FRP Strengthening and stabilization techniques for repair.</p> <p><b><u>Books::</u></b></p> <ul style="list-style-type: none"> <li>• Denison Campbell, Allen and Harold Roper, Concrete Structures, Materials, Maintenance and Repair, Longman Scientific and Technical UK.</li> <li>• Allen R.T and Edwards S.C, Repair of Concrete Structures, Blakie and Sons, UK.</li> <li>• Raikar, R.N., Learning from failures - Deficiencies in Design, Construction and Service - R&amp;D Centre (SDCPL), Raikar Bhavan, Bombay.</li> <li>• Santhakumar A.R., Concrete Technology, Oxford University Press, Printed in India by Radha Press, New Delhi.</li> <li>• Emmons, Peter H., Concrete Repair and Maintenance Illustrated Galgotia Publications pvt. Ltd.</li> </ul>			
<b>Subject Code: CE4L006</b>	<b>Subject Name: Computational Hydraulics</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
<p><b><u>Prerequisite: None</u></b>  General numerical methods; Introduction to FEM, FDM and BEM; Perturbation method; Methods of characteristics; Hydroinformatics; Applications to water resources engineering</p> <p><b><u>Books::</u></b></p> <ul style="list-style-type: none"> <li>• Michael B. Abbott, Anthony W. Minns, Computational Hydraulics.</li> <li>• Cornelis B. Vreugdenhil, Computational Hydraulics.</li> <li>• Ioana Popescu, Computational Hydraulics.</li> </ul>			
<b>Subject Code: CE4L008</b>	<b>Subject Name: Hydraulic and Hydrologic Analysis and Design</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
<p><b><u>Prerequisite: None</u></b>  Synthetic design storms &amp; Estimation of peak discharge, Urban storm drainage design, Culvert design, Detention storage design, Flood frequency analysis; Design of water distribution network, Analysis and design of mobile and rigid boundary channels, Tractive force concepts in channel design, Design of canal headworks, distribution works, and cross-drainage works, Design of gravity dams, spillways, and energy dissipators.</p> <p><b><u>Books::</u></b></p> <ul style="list-style-type: none"> <li>• Ben C. Yen, Yeou-Koung Tung, Reliability and Uncertainty Analyses in Hydraulic Design: A Report, American Society of Civil Engineers</li> <li>• Bruce E. Larock, Roland W. Jeppson, Gary Z. Watters, Hydraulics of Pipeline Systems, CRC Press</li> <li>• Ghosh, Karunamoy, Analysis and Design Practice of Hydraulic Concrete Structures, PHI Learning Pvt. Ltd</li> <li>• Chow, Ven Te, Maidment, David R. and Mays, Larry W., Applied Hydrology, Tata McGraw-Hill Education</li> </ul>			

<b>Subject Code: CE4L023</b>	<b>Subject Name: Pre-stressed Concrete</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
<p><b><u>Prerequisite: None</u></b>  Concept on Mechanics; Materials; Properties of sections; Stress analysis - three methods; Prestressing and Post stressing; Beam design - no tension and ultimate; Poles and slab panels; Loss assessment; Composite beams; Design for shear. Large span structures; Structural forms and design principles; Special materials, open web and built-up structures.</p> <p><b><u>Books::</u></b></p> <ul style="list-style-type: none"> <li>• Lin and Burns, Design Of Prestressed Concrete Structures, Wiley India</li> <li>• Dayaratnam, P Prestressed Concrete Structures, Oxford and IBH</li> <li>• Raju, K., Prestressed Concrete Bridges, CBS</li> </ul>			
<b>Subject Code: CE4L042</b>	<b>Subject Name: Advanced Foundation Engineering</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
<p><b><u>Prerequisite: None</u></b>  Bearing capacity of shallow foundations: Prandtl, Terzaghi and Meyerhof s method of analysis, safe and allowable bearing pressures, selection of type and depth of foundations, combined footings, mat foundations including floating raft, settlement calculations, Skempton - Bjerrum modification, and Martin s method, bearing capacity of layered soils, bearing capacity of footings on slopes, Deep foundations: mechanics of load transfer in piles, load carrying capacity, pile load test, lateral loaded piles, design of pile groups including settlement calculations, design of block foundation, well foundations, coffer dams, pier foundations, earth pressure computations on retaining walls and their design, earthquake response of foundations.</p> <p><b><u>Books::</u></b></p> <ul style="list-style-type: none"> <li>• Das, B. M., Principles of Foundation Engineering, Cengage Learning.</li> <li>• Budhu, M., Soil Mechanics and Foundations, Wiley Publishers, New Delhi.</li> <li>• Coduto, D. P., Foundation Design: Principles and Practices, Prentice Hill Publishers.</li> <li>• Holts, R. D. and Kovacs, W. D., An Introduction to Geotechnical Engineering, Prentice Hall.</li> <li>• Das, B. M., Shallow Foundations: Bearing Capacity and Settlement, CRC Press.</li> <li>• Tomilson, M. J., Foundation Design and Construction, Pearson Publishers.</li> </ul>			
<b>Subject Code: CE4L043</b>	<b>Subject Name: Numerical Methods in Geotechnical Engineering</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
<p><b><u>Prerequisite: None</u></b>  Introduction to numerical modeling in Geotechnical Engineering, constitutive modeling, review of basic concepts, solution of nonlinear systems of equations, finite difference method, finite element method, constitutive modeling of soil response, large deformation - large strain analysis, applications: flow and consolidation, groundwater and seepage, slopes and cuts, embankments, shallow and deep foundations, retaining walls, tunnels and caverns and rock Mechanics</p> <p><b><u>Books::</u></b></p> <ul style="list-style-type: none"> <li>• Desai, C. S. and Christian, J. T., Numerical Methods in Geotechnical Engineering, McGraw-Hill Publishers.</li> <li>• Potts, D. M. and Zdravkovic, L., Finite Element Analysis in Geotechnical Engineering: Theory and Application, Thomas Telford Publishing.</li> <li>• Benz, T. and Nordal, S., Numerical Methods in Geotechnical Engineering: NUMGE 2010, CRC Press.</li> <li>• Christian, J. T., Numerical Methods in Geotechnical Engineering, McGraw-Hill Publishers.</li> </ul>			

<b>Subject Code: CE4L044</b>	<b>Subject Name: Soil Engineering</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
<p><b><u>Prerequisite: None</u></b>  Shear strength of cohesionless and cohesive soils, physico-chemical aspects, experimental determination of shear strength, failure theories, Yield criteria, influence on failure conditions of inter-mediate principal stress, history, drainage, rate of stress applications etc.; Plastic equilibrium in soils, Mohr diagram, active and passive states, theories of earth pressure on retaining walls, effect of wall friction on the shape of sliding surface, theories of arching, bearing capacity, concepts of general and local shear failure, critical height of vertical banks, various methods of computation of slope stability, earth pressure on timbering of cuts and on free and anchored bulkheads.</p> <p><b><u>Books::</u></b></p> <ul style="list-style-type: none"> <li>• Lambe, T. W. and Whitman, R. V., Soil Mechanics in SI Version, Wiley, New Delhi.</li> <li>• Scott, R. F., Principles of Soil Mechanics, Addison Wesley, World Student Edition.</li> <li>• Leonards, G. A., Foundation Engineering, McGraw-Hill.</li> <li>• Bowles, J. E., Foundations Analysis and Design, McGraw-Hill.</li> <li>• Peck, R. B., Hanson, W. E., and Thornburn, T. H., Foundation Engineering, John Wiley and Sons.</li> </ul>			
<b>Subject Code: CE4L045</b>	<b>Subject Name: Earth Retaining Structures</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
<p><b><u>Prerequisite: None</u></b>  Earth Pressure: Fundamental relationships between the lateral pressures and the strain with a back fill. Rankine's and Coulomb's theories, Active, passive and earth pressure at-rest; Backfill with broken surface, wall with broken back, concentrated surcharge above the back fill, earth pressure due to uniform surcharge, earth pressure of stratified backfills, saturated and partially saturated backfill. Passive earth pressure in engineering practice. Assumption and conditions, point of application of passive earth pressures; Bulkheads: Definition and assumptions, conditions of end supports and distribution of active earth pressure and bulkheads, bulkheads with free and fixed earth supports, equivalent beam method, Improvements suggested by Rowe, Tschebotarioff's method, Anchorage of bulkheads and resistance of anchor walls, spacing between bulkheads and anchor walls, resistance of anchor plates, Consideration of effects of ground water, seepage, surcharge loading together with possibility of shallow and deep sliding failures on retaining structure; Sheet Pile wall: Free earth system, fixed earth system, Dead man; Tunnel and Conduit: Stress distribution around tunnels, Types of conduits, Load on projecting conduits; Arching and Open Cuts: Arching in soils, Braced excavations, Earth pressure against bracings in cuts, Heave of the bottom of cut in soft clays; Reinforced earth retaining structures- Design of earth embankments and slopes; Recent advances in Earth retaining structures.</p> <p><b><u>Books::</u></b></p> <ul style="list-style-type: none"> <li>• Das, B. M., Principles of Foundation Engineering, Thomson, Indian Edition.</li> <li>• Clayton, C. R. I., Milititsky, J. and Woods, R. I., Earth Pressure and Earth-retaining Structures, Chapman and Hall Publishers.</li> <li>• Bowel, J., Foundation Engineering, Analysis and Design, McGraw Hill.</li> <li>• Raj, P., Geotechnical Engineering, Tata McGraw Hill.</li> <li>• Craig, R. F., Soil Mechanics, Chapman and Hall (ELBS).</li> </ul>			
<b>Subject Code: CE4L053</b>	<b>Subject Name: Open Channel Hydraulics</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
<p><b><u>Prerequisite: None</u></b>  Basic concepts; Energy and Momentum equations and their applications; Critical flow, channel control ad transitions; Uniform flow and flow resistance; Sheet flow; Concepts of boundary layer and surface roughness; Theoretical uniform flow equations; Instability of uniform flow; Gradually varied flow, flow profile classification and computation methods; Flow profiles in</p>			

natural channels; Spatially varied flow; Hydraulic jump; Unsteady flow, continuity equation, dynamic equation, wave propagation; Method of characteristics; Rapidly varied unsteady flow, surges; Dam break problems.

**Books::**

- Subramanya, K., Flow in Open Channels, Tata McGraw-Hill.
- Chanson, H., Hydraulics of Open Channel Flow, Elsevier.
- Chow, V. T., Open Channel Hydraulics, McGraw Hill.
- French, R., Open Channel Hydraulics, McGraw-Hill.
- Sturm, T.W., Open Channel Hydraulics, Tata McGraw-Hill.

**Subject Code: CE4L054**

**Subject Name: Water Resources Systems**

**L-T-P: 3-0-0**

**Credit: 3**

**Prerequisite: None**

Introduction to systems concept in water resources engineering; its role in planning and management; data acquisition and processing; descriptive and prescriptive models; economics of water resources systems; social, economical, technical and environmental issues; decision making under uncertainty and/or risk; evaluation of project alternatives; application to surface and subsurface water resources systems planning and management.

**Books::**

- Vedula, S. and Mujumdar, P. P., Water Resources Systems, McGraw-Hill.
- Jain, S. K., and Singh, V. P., Water Resources Systems Planning and Management, Elsevier.
- Purcell, P., Design of Water Resources Systems, Thomas Telford Publishing.

**Subject Code: CE4L055**

**Subject Name: Design of Hydraulic Structures**

**L-T-P: 3-0-0**

**Credit: 3**

**Prerequisite: None**

Concrete dams, force and stress analysis for components like piers, bridges and trash rack and their reinforcement detailing; stress analysis around galleries, adits and shafts and reinforcement provisions; integrated stability analysis of concrete dams considering foundation rock; construction methods for concrete dams. Embankment dams, seepage analysis (finding the phreatic line) for different types of embankment dams; seepage control measures for embankment dams; construction methods for embankment dams. Spillways and energy dissipators design of ogee spillways; calculations for chute spillway profiles; flow characteristics of shaft and syphon spillways; types of energy dissipators, their selection and dimensioning; flow characteristics of radial gates; introduction to relevant BIS codes and guidelines. Barrages - design of barrage structure and canal head regulator; construction methods for barrages. Irrigation structures, Canals, cross drainage works, falls and energy dissipators.

**Books::**

- Garg, S. K., Irrigation Engineering and Hydraulic Structures, Khanna Publishers.
- Ghosh, K., Analysis and Design Practice of Hydraulic Concrete Structures, PHI Learning Private Limited.
- Novak, P., Moffat, A. I. B., Nalluri, C., and Narayanan, R. Hydraulic Structures, Taylor & Francis.

**Subject Code: CE4L062**

**Subject Name: Pavement Design**

**L-T-P: 3-0-0**

**Credit: 3**

**Prerequisite: None**

Types of Pavement, Pavement Composition, Philosophy of design of flexible and rigid pavements, analysis of pavements using different analytical methods, selection of pavement design input parameters, traffic loading and volume, material characterization, drainage, failure criteria, reliability, design of flexible and rigid pavements using different methods, pavement evaluation and overlay design.

<b>Books::</b>			
<ul style="list-style-type: none"> <li>• Huang, Y. H., Pavement Analysis and Design, Pearson Education.</li> <li>• Yoder, E. J. and Witczak, M. W., Principles of Pavement Design, John Wiley &amp; Sons Ltd.</li> <li>• Mallick, R. B. and El-Korchi, T., Pavement Engineering: Principles and Practice, CRC Press.</li> </ul>			
<b>Subject Code:</b> CE6L304	<b>Subject Name: Advanced Concrete Technology</b>	<b>L-T-P: 3-0-0</b>	<b>Credit:3</b>
<b>Prerequisite: None</b>			
<p>Fundamental of concrete - constituents, proportioning, mixing, transportation, placing and curing., Properties of fresh and hardened concrete., Quality control in concrete construction, Concrete mix design, Durability of concrete - alkali aggregate reaction, reinforcement corrosion, freezing and thawing, etc., Special concretes - high strength, low heat of hydration, high early strength, self-compacting, etc., Construction methods - shot-crete, roller compacted concrete, etc., Reinforcing materials - epoxy coated bars, fibre-reinforced plastics, Introduction to 'maintenance' of concrete structures - use of non-destructive testing, evaluation criteria.</p>			
<b>Books::</b>			
<ul style="list-style-type: none"> <li>• Gambhir, M,L., Concrete Technology, Tata Mcgraw Hill</li> <li>• Neville, A.M. and Brooks, J.J., Concrete Technology, Neville, ELBS/Longman</li> <li>• Neville, A.M., Properties of Concrete, ELBS/Longman</li> <li>• Ghose, D.N., Construction Materials, Tata Mcgraw Hill</li> <li>• Mehta, P.K. and Montiero, P.M.J., Concrete Material, Microstructure and Properties, Tata Mcgraw Hill</li> </ul>			
<b>Subject Code:</b> CE6L305	<b>Subject Name: Theory of Plates &amp; Shells</b>	<b>L-T-P: 3-1-0</b>	<b>Credit: 4</b>
<b>Prerequisite: None</b>			
<p>Pure bending of plates; Symmetric bending of circular plates; Small deflection of laterally loaded plates; Rectangular plates with various edge conditions; Continuous rectangular plates; Plates of various shapes; Shells as space enclosure, geometry, classification, principal and Gauss curvature; General theory of thin elastic shells; Shallow and high rise shells; Circular long and short cylindrical shells, beam-arch approximation for long shells; Shells of double curvature, surfaces of revolution and translation; Circular, elliptic and hyperbolic paraboloids, conoids and funicular shells - membrane and approximate bending theories; Closed form and numerical methods of analysis of synclastic and anticlastic shells.</p>			
<b>Books::</b>			
<ul style="list-style-type: none"> <li>• Timoshenko, S.L., Theory of Plates and Shells, McGraw Hill</li> <li>• Reddy, J.N., Theory and Analysis of Elastic Plates and Shells, Taylor &amp; Francis</li> <li>• Ugral, A.C., Stresses in plates and shells, WCB/McGraw Hill</li> <li>• Ventsel, E. and Krauthammer, T., Thin Plates and Shells: Theory: Analysis, and Applications, CRC Press</li> </ul>			
<b>Subject Code:</b> CE6L306	<b>Subject Name: Seismic Design of Structures</b>	<b>L-T-P: 3-1-0</b>	<b>Credit: 4</b>
<b>Prerequisite: None</b>			
<p>Characteristics of earthquakes; Earthquake response of structures; Concept of earthquake resistant design; Response of SDOF and MDOF systems to random excitations. Code provisions of design of buildings; Design for Liquefaction; Non-engineered construction; Special topics: bridges, dams, strengthening of existing buildings.</p>			

<p><b>Books::</b></p> <ul style="list-style-type: none"> <li>• Duggal, S.K., Earthquake Resistant Design of Structures, Oxford University Press</li> <li>• Chopra, A.K., Dynamics of Structures: Theory and Applications to Earthquake Engineering, Prentice Hall/Pearson Education</li> <li>• Paulay, T. and Priestley, M.J.N., Seismic Design of Reinforced Concrete and Masonry Buildings, Wiley International Publication</li> <li>• Bolt, B.A., Earthquakes, W.H. Freeman</li> <li>• Kramer, S.L., Geotechnical Earthquake Engineering, Pearson</li> </ul>			
<p><b>Subject Code:</b> CE6L307</p>	<p><b>Subject Name: Bridge Engineering</b></p>	<p><b>L-T-P: 3-0-0</b></p>	<p><b>Credit: 3</b></p>
<p><b>Pre-requisite(s): None</b></p> <p>Introduction, historical review, engineering and aesthetic requirements in bridge design, introduction to bridge codes of practice, economic evaluation of bridge projects, site investigation and planning, hydraulic calculations for bridges, bridge foundations-open, pile, well and caisson, Piers, abutments and approach structures, superstructures-analysis and design of right, skew and curved slabs, Girder bridges-Types, load distribution, design, orthotropic plate analysis of bridge decks, introduction to long span bridges- cantilever, arch, cable stayed and suspension bridges.</p> <p><b>Books::</b></p> <ul style="list-style-type: none"> <li>• Victor, D.J., Essentials of bridge engineering, Oxford &amp; IBH Publishing</li> <li>• Ponnuswamy, S., Bridge Engineering, Tata Mcgraw Hill</li> <li>• Jagadeesh, T.R. and Jayaram, M.A., Design of Bridge Structures, Phi Learning</li> <li>• Bindra, S.P., Principles and Practice of Bridge Engineering, Dhanpat Rai Publications</li> </ul>			
<p><b>Subject Code:</b> CE6L308</p>	<p><b>Subject Name: Infrastructure Maintenance and Rehabilitation</b></p>	<p><b>L-T-P: 3-0-0</b></p>	<p><b>Credit: 3</b></p>
<p><b>Pre-requisite(s): None</b></p> <p>Quality assurance for concrete construction as built concrete properties strength, permeability, thermal properties and cracking. Influence on serviceability and durability:-Effects due to climate, temperature, chemicals, wear and erosion, Design and construction errors, corrosion mechanism, Effects of cover thickness and cracking, methods of corrosion protection, corrosion inhibitors, corrosion resistant steels, coatings, cathodic protection; Maintenance and repair strategies:- Definitions: Maintenance, repair and rehabilitation, Facets of Maintenance importance of Maintenance, Preventive measures on various aspects Inspection, Assessment procedure for evaluating a damaged structure, causes of deterioration , testing techniques; Materials:-Materials for Repair - Special Mortar and Concretes, Concrete Chemicals, Special Cements and High Grade Concrete, Expansive Cement, Polymer Concrete, Sulphur Infiltrated Concrete, Ferro Cement, Fiber Reinforced Concrete, and Admixtures of latest origin. Techniques for Repair-Surface Repair - Material Selection - Surface Preparation - Rust Eliminators and Polymers Coating For Rebar During Repair - Repair Of Cracks In Concrete and Masonry-Methods of Repair - Epoxy Injection, Mortar Repair For Cracks - Guniting and Shotcreting - Waterproofing Of Concrete Roofs; Strengthening Measures - Flexural Strengthening, Beam Shear Capacity Strengthening, Column Strengthening, Shoring, Under Pinning and Jacketing. Demolition of Buildings - Introduction, Planning, Precautions and protective measures in demolition work, Sequence of operations, demolition of structural elements.</p> <p><b>Books::</b></p> <ul style="list-style-type: none"> <li>• Campbell-Allen, D. and Roper, H., Concrete Structures, Materials, Maintenance and Repair, Longman Scientific and Technical, UK</li> </ul>			

- Allen, R.T and Edwards, S.C, Repair of Concrete Structures, Blakie and Sons, UK
- Santhakumar A.R., Concrete Technology, Oxford University Press
- Dayaratnam, P. and Rao, R., Maintenance and Durability of Concrete Structures, University Press, India
- CPWD, Handbook on Repairs and Rehabilitation of RCC Buildings.

**Subject Code:**  
CE6L309

**Subject Name: Modern Construction Materials**

**L-T-P: 3-0-0**

**Credit: 3**

**Prerequisite: None**

Basics (Introduction to the course, Science, Engineering and Technology of Materials); Microstructure (Atomic Bonding, Structure of solids, Movement of atoms, Development of microstructure); Material behaviour (Surface properties, Response to stress, Failure theories, Fracture mechanics, Rheology, Thermal properties); Structural Materials (Review of Construction Materials and Criteria for Selection, Wood and Wood Products, Polymers, Fibre Reinforced Polymers, Metals, Bituminous Materials, Concrete, Glass); : Non-structural materials, accessories and finishes (Review of Non-structural Materials and Criteria for Selection, Waterproofing materials, Polymer Floor Finishes, Paints, Tiles, Acoustic Treatment, Dry walls, Anchors); Environmental Concerns, Social Perception of Construction Materials.

**Books::**

- Varghese, P.C., Building Materials, Prentice-Hall India
- Callister, W.D., Materials Science and Engineering: An introduction, John Wiley
- Raghavan, V., Materials Science and Engineering, Prentice Hall
- Higgins, R.A., Properties of Engineering Materials, Industrial Press
- Construction materials: Their nature and behaviour, Eds. J.M. Illston and P.L.J. Domone, Spon Press
- Young, J.F., Mindess, S., Gray, R.J. and Bentur, A., The Science and Technology of Civil Engineering Materials, Prentice Hall
- Neville, A.M., Properties of concrete, Pearson

**Subject Code:**  
CE6L310

**Subject Name: Advanced construction Techniques**

**L-T-P: 3-0-0**

**Credit: 3**

**Prerequisite: None**

Sub Structure Construction -Box jacking, Pipe Jacking, Under Water Construction of diaphragm walls and Basement, Tunnelling Techniques, Piling Techniques, Driving Well and Caisson Sinking, Cofferdam, Cable Anchoring and Grouting, Driving Diaphragm Walls, Sheet Piles-Laying Operations For Built Up Offshore System-Shoring For Deep Cutting-Large Reservoir Construction with membranes and Earth system-well points-Dewatering and stand by Plant equipment for underground open excavation ; Super Structure Construction- Vacuum dewatering of concrete flooring-Concrete paving technology, Techniques of construction for continuous concreting operation in Tall buildings of various shapes and Varying sections, Launching Techniques-Suspended formwork-erection techniques of tall structures, Large span structures-Launching techniques for heavy decks- in-situ pre-stressing in high rise structures, aerial transporting ,handling, erecting light weight components on tall structures-erection of lattice towers and rigging of transmission line structures; Construction Sequences- in cooling towers, Silos Chimney, Sky scrapers, bow string bridges, cable stayed bridges; Launching and pushing of box decks, support structure for heavy Equipment and conveyor and machinery in heavy industries, erection of articulated structures, braced domes and space decks; Repair Construction: Mud Jacking Grout through Slab Foundation, Micro Piling for Strengthening Floor and Shallow Profile, Pipeline Laying, Protecting Sheet Piles, Sub Grade Water Proofing, Underpinning Advanced Techniques and Sequence in Demolition and Dismantling.

**Books::**

- Brown, R., Practical foundation engineering hand book, McGraw Hill Publications
- Powers, J.P., Corwin, A.B., Schmall, P.C. and Kaeck, W.E., Construction Dewatering: New Methods and Applications, John Wiley and Sons
- Irvine, J., Advanced Construction Techniques, California Rocketry
- National Building Code of India, Part-IV and VII - 2006
- Mohan, R. and Jaisingh. M.P., Advances in Building Materials and Construction, CBRI Roorkee
- Hand Book on concrete Mixes based on Indian standards, SP-23 (S&T)

<b>Subject Code:</b> CE6L311	<b>Subject Name: Construction Project Management</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
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**Prerequisite: None**  
Principles of Project Management, Project Planning, Introduction to scheduling -work/project break down structures, Bar-charts; Principles of application of CPM and PERT; Precedence Method; Updating; Time - cost trade-offs, Resource constrained scheduling; Resource leveling Project control; Performance Measurement, Earned value; Multiple Construction Projects; Other network techniques; Project Management Software Packages.

**Books::**

- Jha, N.K., Construction Project Management, Pearson Education India
- Williams, T., Construction Management, Pearson Education India
- Chitkara, K., Construction Project Management Techniques And Practice, Tata McGraw Hill
- Purifoy, R., Schexnayder, C.J., Shapira, A. and Schmitt, R., Construction Planning, equipment and Methods, McGraw Hill, Tokyo, Japan

<b>Subject Code:</b> CE6L312	<b>Subject Name: Advanced Design of RC Structure</b>	<b>L-T-P: 3-1-0</b>	<b>Credit: 4</b>
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**Prerequisite: None**  
Design of overhead, underground, ground supported water tanks, dams; Design of industrial structures; Design of bunkers and silos, Airy's theory, Janssen's theory; Design of special RC elements: Design of slender columns, RC walls, ordinary and shear walls, Corbels, Deep beams, RCC chimney; Introduction to shell and folded plate roofs, their forms and structural behaviour. Design of simple cylindrical shell roof by beam theory, Yield line analysis of slabs by virtual work, Yield line analysis by equilibrium methods.

**Books::**

- Varghese , P.C., Advanced Reinforced Concrete Design, PHI Learning
- Naeim, F., Handbook on Seismic Analysis and Design of Structures, Kluwer Academic Publisher
- IS 4326, Earthquake Resistant Design and Construction of Buildings - Code of Practice, Bureau of Indian Standard; New Delhi
- Jain, S.K. and Jaiswal, O.R., Guidelines for Seismic Design of Liquid Storage Tanks, NICEE, IIT Kanpur
- Fintel, M., Handbook of Concrete Engineering, CBS Publishers Delhi

<b>Subject Code:</b> MA6L002	<b>Subject Name: Advanced Techniques in Operation Research</b>	<b>L-T-P: 3-1-0</b>	<b>Credit: 4</b>
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**Prerequisite: None**  
One variable unconstrained optimization, multivariable unconstrained optimisation, Karush-Kuhn-Tucker (KKT) conditions for constrained optimization, quadratic programming, separable programming, convex and non convex programming, steepest and Quasi-Newton method. Dynamic Programming: Characteristics of dynamic problems, deterministic dynamic programming and probabilistic dynamic programming, Network analysis, Shortest path problems, minimum spanning tree problem, maximum flow problem, minimum cost flow

problem, network simplex, interior point methods, stochastic programming, Nonlinear goal programming applications, Geometric Programming. Multi-objective Optimization Problems: Linear and non linear programming problems, Weighting and Epsilon method, P-norm methods, Gradient Projection Method, STEM method, Convex Optimization.

**Books:**

- Rao, S.S., Engineering Optimization Theory and Practices, John Wiley and Sons
- Ehrgott, M., Multi-criteria Optimization, Springer
- Miettien, K.M., Non-linear multi-objective optimization, Kluwers International Series
- Deb, K., Multi-Objective Optimization using Evolutionary Algorithms, John Wiley & Sons

<b>Subject Code:</b> MA7L020	<b>Subject Name:</b> Nonlinear Functional Analysis	<b>L-T-P:</b> 3-1-0	<b>Credit:</b> 4
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**Prerequisite: Mathematics - II (MA1L002)**

Fixed point theory, Banach contraction mapping theorem, contractive type mappings, generalization of Banach contraction mapping theorem, fixed point theorem of other types. Nonlinear operators, monotone, strictly monotone and strongly monotone operators, their properties and applications. Variational inequalities and complementarity problem. Approximation theory, theory of best approximation and farthest points. Calculus of Banach Space, Frechet and Gateaux differentiability, strict convexity and uniform convexity of norms, semi inner product space.

**Books:**

- Zeidler E. Nonlinear Functional Analysis and its applications, Springer
- Ambrosetti A., Arcoya D., Birkhauser. An Introduction to Nonlinear Functional Analysis and Ellepctic Problems,
- Debnath L. and Mikusinski P., Hilbert Spaces with Applications, Academic Press
- Kinderleherer D., Stampacchia G. An Introduction to Variational Inequalities and their Applications, Academic Press
- Tinsley Oden J., Demkowicz L. Applied Functional Analysis, CRC Press

<b>Subject Code:</b> CE6L008	<b>Subject Name:</b> Hydraulics of Sediment Transport	<b>L-T-P:</b> 3-0-0	<b>Credit:</b> 3
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**Prerequisite: None**

Sediment properties; Initiation of motion; Bed Load; Bed Forms; Effective bed roughness; Armouring; Suspended Load; Total Load; Transport of Sediment due to unsteady flow; Meandering of rivers; Braided river; Local scour at different structures; Sediment sampling; Mathematical models of sediment transport.

**Books:**

- Yang, Sediment Transport: Theory and Practice
- Graf, Hydraulics of Sediment Transport
- Fredsoe and Diegaard, Mechanics of Coastal Sediment Transport
- Garde, History of Fluvial Hydraulics

<b>Subject Code:</b> CE6L017	<b>Subject Name:</b> Advanced Transportation Systems Analysis	<b>L-T-P:</b> 3-0-0	<b>Credit:</b> 3
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**Prerequisite: None**

Behavioural aspect of transportation planning: Basics of travel behaviour analysis, stated and revealed preference data, binary logit, multinomial logit, nested logit model, maximum likelihood technique, travel behaviour survey, case study analysis/discussion on travel behaviour analysis- destination choice, mode choice, route choice etc. demand-supply interaction in an urban transport system, urban transportation network analysis, shortest path analysis, formulation of traffic assignment problem, solving traffic assignment problems, equilibrium traffic assignment with link interactions, traffic assignment under travel behaviour,

<p>Basics of dynamic traffic assignment</p> <p>Book</p> <ul style="list-style-type: none"> <li>• Marvin L. Manheim, Fundamentals Of Transportation Systems Analysis, Volume 1</li> <li>• Swait, Louviere and Hensher, Stated Preference Methods</li> <li>• Moshe Ben Akiva, Discrete Choice Analysis: Theory and Analysis to Travel Demand</li> <li>• YosefSheffi, Urban Transportation Networks</li> <li>• Transportation Systems Engineering: Theory and Methods by Ennio Cascetta</li> </ul>			
<b>Subject Code:</b> CE6L018	<b>Subject Name: Analysis and Design of Pavements</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
<p><b>Prerequisite: None</b></p> <p>Types of Pavements, Pavement Composition, Philosophy of design of flexible and rigid pavements, analysis of pavements using different analytical methods, selection of pavement design input parameters, traffic loading and volume, material characterization, drainage, failure criteria, reliability, design of flexible and rigid pavements using different methods, comparison of different pavement design approaches, design of overlays and drainage system.</p> <p><b>Books:</b></p> <ul style="list-style-type: none"> <li>• Y. H. Huang, Pavement Analysis and Design</li> <li>• E.J. Yoder and M. W. Witzak, Principles of Pavement Design</li> <li>• Rajib B. Mallick, Tahar El-Korchi, Pavement Engineering: Principles and Practice</li> </ul> <p>*The examination for this course may be considered for open book system.</p>			
<b>Subject Code:</b> CE6L019	<b>Subject Name: Pavement Evaluation, Maintenance and Rehabilitation</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
<p><b>Prerequisite: None</b></p> <p>Types of pavements, Distresses in flexible and rigid pavements , Techniques for functional and structural evaluation of pavements, pavement rehabilitation techniques, overlay design procedures, recycling of flexible and rigid pavements, Maintenance of paved and unpaved roads, Pavement management systems</p> <p><b>Books:</b></p> <ul style="list-style-type: none"> <li>• Y. H. Huang, Pavement Analysis and Design</li> <li>• Rajib B. Mallick, Tahar El-Korchi, Pavement Engineering: Principles and Practice</li> <li>• Derek Pearson, Deterioration and Maintenance of Pavements</li> <li>• Ralph Haas, W. Ronald Hudson, John P. Zaniewski, Modern pavement management</li> </ul>			
<b>Subject Code:</b> CE6L020	<b>Subject Name: Dynamics of Soil and Foundations</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
<p><b>Prerequisite: None</b></p> <p>Introduction, vibration theories, analysis of free and forced vibrations using spring dashpot model, single degree of freedom system, multi-degrees of freedom system, application of single and multi-degree of freedom systems, wave propagation in elastic media, laboratory and field evaluation of dynamic soil properties, seismic bearing capacity of shallow foundations, pile foundation under dynamic load, seismic earth pressures, seismic slope stability.</p> <p><b>Books:</b></p> <ul style="list-style-type: none"> <li>• Swami Saran, Soil Dynamics and Machine Foundations, Galgotia Publications.</li> <li>• Braja M. Das and G. V. Ramana, Principles of Soil Dynamics, Publisher: CL-Engineering.</li> <li>• Richart, F.E., Woods, R.D., and Hall, J.R., Vibrations of soils and foundations, Prentice Hall, 1970.</li> <li>• Steven L. Kramer, Geotechnical Earthquake Engineering, 1996, Prentice Hall.</li> </ul>			
<b>Subject Code:</b> CE6L021	<b>Subject Name: Soil-Structure Interaction</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
<p><b>Prerequisite: None</b></p> <p>Introduction to soil foundation interaction problems, soil behaviour, foundation behaviour,</p>			

interface behaviour, concept of subgrade modulus, effects/parameters influencing subgrade modulus soil foundation interaction analysis, Winkler, elastic continuum, two parameter elastic model, Elastic Plastic behaviour, time dependent behaviour, elastic analysis of single pile, theoretical solutions for settlement and load distributions, analysis of pile group, interaction analysis, Load deflection prediction for laterally loaded piles, other applications.

**Books:**

- Selvadurai, A.P.S., "Elastic analysis of soil foundation interaction. Elsevier Science Ltd.
- Plasticity and Geomechanics by R. O. Davis, A. P. S. Selvadurai, Cambridge University Press
- R.O. Davis and A.P.S. Selvadurai, Elasticity and Geomechanics, Cambridge University Press, New York.
- Poulos, H.G. and Davis E.H. Pile Foundation Analysis and Design.
- Soil structure interaction: numerical analysis and modelling / edited by John W. Bull. London, New York : E & FN Spon, 1994.

**Subject Code:**  
CE6L022

**Subject Name: Ground Improvement**

**L-T-P: 3-0-0**

**Credit: 3**

**Prerequisite: None**

Introduction, ground improvements schemes for cohesive soil sites (preloading, staged construction, accelerated consolidation with prefabricated drains, granular columns, lime columns, electro-osmosis, compaction piles, deep mixing, and vibro-replacement), ground improvement schemes for cohesionless soil sites (deep dynamic compaction, vibro-compaction, blast densification, grouting, and jet grouting), mechanically stabilized earthwork, soil nailing, ground anchors, light weight fill, and monitoring and quality control in ground improvement projects.

**Books:**

- P. Puroshothama Raju, Ground Improvement Techniques, Laxmi Publications, New Delhi.
- M.P. Moseley and K. Kirsch, Ground Improvement, Spon Press, Taylor and Francis Group.
- B. M. Das, Principles of Foundation Engineering, Cengage Learning.
- Buddhima Indraratna and Jian J Chu, Ground Improvement: Case Histories, Elsevier.
- Chris A. Raison, Ground and Soil Improvement, Thomas telford, UK.
- Robert M. Koerner., Designing with Geosynthetics, Pearson Prentice Hall.

**Subject Code:**  
CE6L023

**Subject Name: Computational Geomechanics**

**L-T-P: 3-0-0**

**Credit: 3**

**Prerequisite: None**

Numerical modeling, constitutive modeling of soils and rock, continuum and discrete element modeling. Concept of stress and strain, principle stresses and strains. Octahedral stresses and strains, finite element discretization of a continuum, geomechanics problems of plane strain and axisymmetric problem. Failure criteria for soils, associated and non-associated flow rule. Finite elements for non-linear material problems in soil mechanics computational procedures. Finite difference approach. Simulation of soil-structure interaction problems, application in consolidation, bearing capacity and slope stability problems using numerical approaches.

**Books:**

- Chandrakant S. Desai and J.T. Christian Numerical Methods in Geotechnical Engineering, McGraw-Hill Publishers.
- Plasticity and Geomechanics by R. O. Davis, A. P. S. Selvadurai, Cambridge University Press
- Finite Element Analysis in Geotechnical Engineering: Theory and Application Author: David M. Potts and Lidija Zdravkovic (January 1, 2001)
- John T. Christian, Numerical Methods in Geotechnical Engineering, McGraw-Hill Publishers
- Computational Geomechanics with Special Reference to Earthquake Engineering by O. C. Zienkiewicz, A. H. C. Chan, M. Pastor, and B. A. Schrefler (Hardcover - May 11, 1999), Publisher: Wiley

<b>Subject Code:</b> CE6L024	<b>Subject Name: Geotechnical Earthquake Engineering</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
<p><b>Prerequisite: None</b></p> <p>Introduction, engineering seismology, plate tectonics, earthquake magnitude, ground motion characteristics, effect of local soil conditions on ground motion, dynamic behaviour of soils, analysis of seismic site response. Liquefaction analysis of soil, laboratory and in-situ testing for seismic loading, analysis and design of slopes, embankments, foundations and earth retaining structures for seismic loading, computer-aided analysis.</p> <p><b>Books:</b></p> <ul style="list-style-type: none"> <li>• Kramer, S.L., Geotechnical Earthquake Engineering, Pearson Education.</li> <li>• Day, R.W., Geotechnical Earthquake Engineering Handbook, McGraw Hill.</li> </ul>			
<b>Subject Code:</b> CE6L025	<b>Subject Name: Geotechnical Risk and Reliability</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
<p><b>Prerequisite: None</b></p> <p>Introduction to probabilistic geotechnical engineering, variability measures, random variables, probability mass and density functions, moments of distribution, modelling of uncertainty, engineering judgment, spatial variability of soil, autocovariance functions, functions of random fields, levels of reliability, loads and resistances, reliability methods, first order second moment (FOSM) method, Hasofer-Lind approach, Response Surface Method, Monte Carlo simulations.</p> <p><b>Books:</b></p> <ul style="list-style-type: none"> <li>• Achintya Haldar and Sankaran Mahadevan, Probability, Reliability, and Statistical Methods in Engineering Design, John Wiley and Sons</li> <li>• Gregory Baecher and John Christian, Reliability and Statistics in Geotechnical Engineering, John Wiley and Sons, Inc.</li> <li>• Alfredo Hua-Sing Ang and Wilson H. Tang, Probability Concepts in Engineering Planning and Design: Basic Principles (Vol. I), John Wiley and Sons, Inc.</li> <li>• Alfredo Hua-Sing Ang and Wilson H. Tang, Probability Concepts in Engineering Planning and Design: Decision, Risk, and Reliability (Vol. II), John Wiley and Sons, Inc.</li> <li>• Alfredo Hua-sing Ang, Wilson H. Tang, Probability Concepts In Engineering: Emphasis On Applications In Civil &amp; Environmental Engineering, Publisher: Wiley</li> <li>• Robert E. Melchers, Structural Reliability Analysis and Prediction, John Wiley and Sons.</li> <li>• Andrzej S Nowak and Kevin R. Collins, Reliability of Structures</li> <li>• Erik Vanmarcke, Random Fields: Analysis and Synthesis, The MIT Press, Cambridge, Massachusetts.</li> </ul>			
<b>Subject Code:</b> CE6L026	<b>Subject Name: Advanced Soil Mechanics</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
<p><b>Prerequisite: None</b></p> <p>Introduction: Origin of soil and its types, mineralogy and structure of clay minerals, Consolidation: Steady State flow, 2D and 3D seepage, transient flow; Compressibility and rate of consolidation, one, two, and three dimensional consolidation theories; Sand drains; Mohr's circles; Critical state soil mechanics: Critical State Line, Hvorslev Surface, Yield Surfaces: Modified Cam-clay and Original Cam-clay; Elastic and plastic analysis of soil: Constitutive relationships of soil; failure theories. Limit analysis-Upper bound theorems, lower bound theorems, limit equilibrium methods; Soil Stabilization: Classification of stabilizing agents and stabilization processes. Strength improvement characteristic of soft and sensitive clays, Marine clay and waste material.</p> <p><b>Books:</b></p> <ul style="list-style-type: none"> <li>• B M Das, Advanced Soil Mechanics, Taylor and Francis</li> <li>• R F Scott, Principles of Soil Mechanics, Addison &amp; Wesley.</li> <li>• R.O. Davis and A.P.S. Selvadurai, Elasticity and Geomechanics, Cambridge University Press, New York.</li> <li>• Mitchell, James K, Fundamentals of Soil Behaviour, John Wiley and Sons.</li> <li>• D.M. Wood, Soil Behaviour and Critical State Soil Mechanics, University of Glasgow.</li> <li>• Schofield, A. N.; Wroth, C. P., Critical State Soil Mechanics, McGraw-Hill</li> </ul>			

<b>Subject Code:</b> CE6L027	<b>Subject Name: Free Surface Flows</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
<p><b><u>Prerequisite: None</u></b>  Energy and momentum of flow; critical flow; channel control and transitions; discharge measurement methods; uniform flow and flow resistance; composite roughness and compound channels; gradually varied flow; classifications and computations of free surface profiles; spatially varied flow; supercritical flows and oblique flows; rapidly varied flow; hydraulic jump; continuity and dynamic equations of unsteady flow; wave propagation and surge; method of characteristics; dam-break problem; flow in channel bends; buoyant and submerged jets.</p> <p><b><u>Books:</u></b></p> <ul style="list-style-type: none"> <li>• K. Subramanya, Flow in open channels</li> <li>• Hubert Chanson, Hydraulics of Open Channel Flow</li> <li>• V. T. Chow, Open Channel Hydraulics</li> <li>• Richard French, Open Channel Hydraulics</li> <li>• Sturm, Open Channel Hydraulics</li> </ul>			
<b>Subject Code:</b> ME6L052	<b>Subject Name: Applied Elasticity</b>	<b>L-T-P: 3-1-0</b>	<b>Credit: 4</b>
<p><b><u>Prerequisite: None</u></b>  Concepts of states of stress and strain. Analysis of three dimensional stresses and strains, equations of equilibrium, generalized Hookes law, Plane elastic problems in cartesian and polar coordinates, axisymmetric problems, torsion, solutions of problems using elasticity theory, anisotropic elasticity, thermoelasticity, contact problems, energy and variational principles and elastic stability.</p> <p><b><u>Books:</u></b></p> <ol style="list-style-type: none"> <li>1. Y. C. Fung, "Foundations of Solid Mechanics", Prentice - Hall Publishers.</li> <li>2. T.G. Sitharam and L.GovindaRaju, "Applied Elasticity", Interline Publishers, Bangalore.</li> <li>3. S.P.Timoshenko and J.N. Goodier, "Theory of Elasticity", McGraw-Hill Book Company.</li> <li>4. C.T. Wang, "Applied Elasticity", McGraw-Hill Book Company</li> <li>5. Elasticity in engineering mechanics- Arthur Peter Boresi, Ken Pin Chong (Wiley)</li> </ol>			
<b>Subject Code:</b> CE6L029	<b>Subject Name: Structural Health Monitoring</b>	<b>L-T-P: 3-0-0</b>	<b>Credit: 3</b>
<p><b><u>Prerequisite: None</u></b>  Introduction to structural health monitoring and overview of different techniques. Vibration based damage detection techniques. Sensors for structural health monitoring. Non-destructive techniques (NDT). Noncontact measurement. Numerical modelling, analysis of structures and inverse analysis. Linear and Non-Linear systems. Application of structural health monitoring.</p> <p><b><u>Books:</u></b></p> <ol style="list-style-type: none"> <li>1. Karvari an Ansari, "Structural health monitoring of civil infrastructure", Elsevier.</li> <li>2. Adams Douglas E., "Health Monitoring of Structural Materials and Components: Methods with Application" John Wiley and Sons Inc.</li> <li>3. Ferrar and Worden "Structural Health Monitoring: A Machine Learning Perspective" John Wiley and Sons Inc.</li> <li>4. Daniel Balageas, Claus-Peter Fritzen, Alfredo Güemes "Structural Health Monitoring" John Wiley and Sons Inc.</li> <li>5. Ostachowicz, Wieslaw, Güemes, Alfredo, "New Trends in Structural Health Monitoring" Springer</li> </ol>			