B.TECH. CIVIL ENGINEERING

Year	THIRD SEMESTER						FOURTH SEMESTER					
	Sub. Code	Subject Name	L	T	P	C	Sub. Code	Subject Name	L	T	P	C
II	MAT 2125	Engineering Mathematics – III	2	1	0	3	MAT 2225	Engineering Mathematics – IV	2	1	0	3
	CIE 2121	Fluid Mechanics	3	1	0	4	CIE 2221	Geotechnical Engineering	3	0	0	3
	CIE 2122	Surveying	2	1	0	3	CIE 2222	Transportation Engineering	4	0	0	4
	CIE 2123	Building Materials	3	0	0	3	CIE 2223	Basic Reinforced Concrete Design	2	1	0	3
	CIE 2124	Mechanics of Structures	3	1	0	4	CIE 2224	Wastewater Management	3	0	0	3
	CIE 2125	Water Supply Engineering	3	0	0	3	CIE 2225	Water Resource Engineering	2	1	0	3
	CIE 2141	Fluid Mechanics Lab	0	0	3	1	CIE 2241	Surveying Practice	0	0	3	1
	CIE 2142	Material Testing Lab	0	0	3	1	CIE 2242	Environmental Engineering Lab	0	0	3	1
			16	**4**	**6**	**22**			**16**	**3**	**6**	**21**
	Total Contact Hours(L+T+P)		**26**				**Total Contact Hours(L+T+P)**		**26**			
	FIFTH SEMESTER						**SIXTH SEMESTER**					
III	HUM 3022	Essentials of Management	3	0	0	3	HUM 3021	Engineering Economics and Financial Management	2	1	0	3
	CIE 3121	Basic Structural Steel Design	2	1	0	3	CIE ****	Flexible Core-II (A2/B2/C2)	3	1	0	4
	CIE 3122	Applied Soil Engineering	2	1	0	3	CIE ****	Flexible Core-III (A3/B3/C3)	3	0	0	3
	CIE 3123	Estimation, Costing and Project Management	3	1	0	4	CIE ****	Program Elective –1/ Minor Specialization	3	0	0	3
	CIE ****	Flexible Core-I (A1/B1/C1)	3	0	0	3	CIE ****	Program Elective –2/ Minor Specialization	3	0	0	3
	IPE 4302	Open Elective-1 Creativity, Problem Solving and Innovation	3	0	0	3	*** ****	Open Elective-2	3	0	0	3
	CIE 3141	Soil Mechanics Lab	0	0	3	1	CIE 3241	Building Design and Modelling	0	0	3	1
	CIE 3142	Computer Aided Structural Analysis & Design Lab	0	0	3	1	CIE 3242	Structural Detailing and Drawing	0	0	3	1
			16	**3**	**6**	**21**			**17**	**2**	**6**	**21**
	Total Contact Hours(L+T+P)		**25**				**Total Contact Hours(L+T+P)**		**25**			
	SEVENTH SEMESTER						**EIGHTH SEMESTER**					
IV	CIE ****	Program Elective – III / (Minor Specialization)	3	0	0	3	CIE 4291	Industrial Training				1
	CIE ****	Program Elective – IV / (Minor Specialization)	3	0	0	3	CIE 4292	Project Work				12
	CIE ****	Program Elective –V	3	0	0	3	CIE 4293	Project Work (B. Tech Honours) **				20
	CIE ****	Program Elective – VI	3	0	0	3	CIE ****	B Tech Honours (Theory 1)** (V Semester)				4
	CIE ****	Program Elective – VII	3	0	0	3	CIE ****	B Tech Honours (Theory 2)** (VI Semester)				4
	*** ****	Open Elective-3	3	0	0	3	CIE ****	B Tech Honours (Theory 3)** (VII Semester)				4
	CIE 4191	Mini Project (Minor specialization)*				8						
			18	**0**	**0**	**18/26**						**13/33**
	Total Contact Hours(L+T+P)		**18**									

* Applicable to students who opted for minor specialization

**Applicable to eligible students who opted for and successfully completed the B Tech – Honours requirements

Flexible Core-A

Structural Design

CIE 3124: Design of Pre-Stressed Concrete Structures (A1)
CIE 3221: Advanced Mechanics of Structures (A2)
CIE 3223: Design of Reinforced Concrete Structures (A3)

Flexible Core-B

Sustainable Construction

CIE 3125: Precast Technology (B1)
CIE 3222: Contemporary Construction Practices and Sustainability (B2)
CIE 3224: Engineering Practice & Ethics (B3)

Minor Specialization

I. Building Construction and Management

CIE 4401: Advances in Concrete Technology
CIE 4402: Building Codes and Functional Services
CIE 4403: Construction Materials and Quality Management
CIE 4404: Contract Management

II. Environmental Engineering

CIE 4405: Air Pollution and Control
CIE 4406: Industrial Wastewater Treatment
CIE 4407: Solid Waste Management
CIE 4408: Integrated Management of Watershed Ecology

III. Structural Engineering

CIE 4409: Structural Dynamics
CIE 4410: Design of Steel Structures
CIE 4411: Finite Element Method of Analysis
CIE 4412: Design of Foundation and Earth Retaining Structures

IV. Transportation Engineering

CIE 4413: Urban Mass Transport System
CIE 4414: Urban Transport Planning
CIE 4415: Pavement Material and Design
CIE 4416: Traffic Systems and Engineering

Other Electives

CIE 4441: Bridge Engineering
CIE 4442: Coastal Engineering
CIE 4443: Disaster Management & Mitigation
CIE 4444: Elements of Earthquake Engineering
CIE 4445: Engineering Geology
CIE 4446: Environmental Impact Assessment and Auditing
CIE 4447: Fecal Sludge and Septage Management
CIE 4448: Geo-environmental Engineering
CIE 4449: Ground Improvement Techniques
CIE 4450: Hydraulics and Hydraulic Machines
CIE 4451: Non-Destructive Testing of Concrete Structures
CIE 4452: Remote Sensing and GIS
CIE 4453: Soil Reinforcement and Geosynthetics
CIE 4454: Valuation of Real Properties
CIE 4455: Water Resources Planning and Management

Open Electives

CIE 4311 Air and Noise Pollution
CIE 4312 Contract Management for Engineers
CIE 4313 Environmental Management
CIE 4314 Geology for Engineers
CIE 4315 Introduction to Remote Sensing and GIS
CIE 4316 Strength of Materials

L&T EduTech Courses

Sl. No.	Course Category	Course Name
1	**Flexible Core C** Multi-Modal Transportation Infrastructure	Highway Planning, Design & Construction
2		Airports & Seaports Engineering
3		Metro Rail Transportation Systems & Construction
4	Minor Specialisation in Advanced Practices in Construction (OR)	Formwork Engineering Practices
5		Deep Excavations, Foundations & Tunnels
6		Building Information Modelling in Construction
7		Sustainability Practices in Design of Building
8	Minor Specialisation in Integrated Building System Design	Pre-Engineered Buildings
9		Mechanized Construction Techniques
10		Integrated Approach to Building Services
11		Concrete Building Systems Design
12	Other Electives	Bridge Engineering Design & Practices
13		Geospatial Techniques in Practice
14		Project Management from Professionals

III Semester

CIE 2121 FLUID MECHANICS (3 1 0 4)

Graduates of the program will be able to

CO1: Explain fluid properties under static and dynamic state

CO2: Apply the principles of fluid statics to determine fluid pressure

CO3: Apply the principles of fluid dynamics to determine fluid flow parameters

CO4: Apply the principles of fluid mechanics to determine pipe flow parameters

CO5: Apply the principles of fluid mechanics to determine open channel flow parameters

Introduction: Scope and importance, distinction between fluid, solid and gas. **(2 hrs)**

Fluid Properties: Specific weight, mass density, specific volume, specific gravity, dynamic viscosity, kinematic viscosity. Definition and derivation of Newton's law of viscosity. Surface tension and capillarity. Compressibility and vapour pressure. Real fluid, ideal fluid, Newtonian and non - Newtonian fluid. Compressible and incompressible fluid. **(6 hrs)**

Pressure and its Measurement: Pascal's law. Variation of fluid pressure in static fluids. Atmospheric pressure, absolute pressure, gauge pressure, vacuum pressure- definition and measurement. **(4 hrs)**

Hydrostatics Forces on Plane Surfaces: Total pressure and center of pressure. Forces on inclined plane surfaces and curved surfaces. Pressure distribution diagram and application. **(4 hrs)**

Kinematics of Fluid Motion: methods of describing fluid motion-Lagrangian Eulerian approach. Classification of flow, continuity equation in different cartesian co-ordinates. **(4 hrs)**

Dynamics of Fluid Motion: Euler's equation of motion and Bernoulli's equation – limitations, modifications, application of Bernoulli's theorem- Venturimeter, orificemeter and pitot tube. **(5 hrs)**

Flow through Pipes: Laminar flow through pipes – Reynold's number, numericals. Turbulent flow through pipes – losses in pipe lines, derivation of Darcy Weisbech equation. Pipes in series and parallel, concept of equivalent pipe, hydraulic gradient line and energy gradient line, pipe siphon, water hammer. **(9 hrs)**

Flow Measurement: Flow through orifices, mouthpieces. Flow through notches and weirs. Flow under variable head – time of emptying with no flow, time of emptying / filling with inflow. **(5 hrs)**

Flow in Open Channels: Introduction, types of open channel flow. Geometric elements of open channel flow, Chezy's and Manning's formula. Hydraulically efficient channel cross section- rectangular and triangular. Specific energy, specific energy curve, critical depth and alternate depth. Specific force, specific force curve and conjugate depths. Critical flow in rectangular channel, Froude's number, hydraulic jump, sequent depth, energy loss. **(9 hrs)**

References:

1. Streeter V.L. and Wiley E.B, *Fluid Mechanics*, McGraw Hill book Co., New York, 1998
2. Modi P.N. and Seth S.M. *Hydraulics and Fluid Mechanics*, Standard Book House, New Delhi, 2005
3. Bansal R. K, *Fluid Mechanics and Hydraulic Machines*, Laxmi Publishers, New Delhi, 2010
4. Jain A.K., *Fluid Mechanics*, Khanna Publishers, New Delhi, 2002
5. Introduction to Fluid Mechanics and Fluid Machines " by S K Som, Gautam Biswas and S Chakraborty, 2017, McGraw Hill, New Delhi

CIE 2122 SURVEYING (2 1 0 3)

Graduates of the program will be able to

- ***CO1: Identify surveying methods for linear and angular measurements***
- ***CO2: Explain levelling methods in topographical surveying for various civil engineering projects***
- ***CO3: Explain principles and methods of underground and hydrographic surveying***
- ***CO4: Identify advanced techniques and insruments in surveying***
- ***CO5: Apply the principles of remote sensing in surveying***

Introduction: Principles of surveying, methods – Plane and geodetic.

Distance: Distance measurement conventions and methods- use of tape and EDM. **(2 hrs)**
Directions: Meridians, azimuths and bearings, declination computations**,** local attraction. **(2 hrs)**
Levelling: Concept and terminology, differential levelling instruments, field methods, block levelling, contouring. Angle measurement, Vernier transits; theodolites, tachometric surveying. **(16 hrs)**
Traverse: Using compass, theodolite, plane table, methods of adjustments, areas by coordinates. **(2 hrs)**
Construction surveys: Introduction, building citing, foundation layout, pipeline, bridges highways and culverts **(1 hrs)**

Under Ground Surveys: Introduction - application of under-ground surveys - auxiliary theodolite - aligning the theodolite. (**1 hrs)**

Hydrographic Survey: Shore line survey - methods of sounding -locating - reduction of soundings and plotting. Three-point problem. **(2 hrs)**

Modern Surveying Techniques: Electronic Distance Measurement (EDM), electronic theodolite (total station), Photogrammetry, introduction to remote sensing, global positioning systems (GPS), and Geographic Information Systems (GIS), drone surveying. **(10 hrs)**

References:

1. Punmia B.C, Surveying, Vol. I and II, Lakshmi Publishers, New Delhi, 2015.
2. Duggal S.K, Surveying, Vol. I and II, Tata Mcgraw Hill – Publishing Co. Ltd, New Delhi, 2017
3. Arora K.R , Surveying, Vol.(I, II, III), Standard Book house, New Delhi, 2015.
4. Kanetkar T.P and Kulkarni S.V, Surveying and levelling parts 1 and 2, Pune Vidyarthi Griha Prakashan, 2008.
5. Thomas Norman, Surveying, Edward Arnold Publishers (ELBS), Budapest 2009

CIE 2123 BUILDING MATERIALS (3 0 0 3)

Graduates of the program will be able to

- ***CO1: Identify filler materials and their properties for use in concrete***
- ***CO2: Identify binder materials and their properties for use in concrete***
- ***CO3: Develop concrete mixtures to obtain the physical and mechanical properties for a given application***
- ***CO4: Identify building blocks and their properties for masonry works***
- ***CO5: Select suitable materials for finishing works for a typical building***

Materials for Concrete I (The fillers): types of aggregates, functional requirements and standard specification for quality control, alternative aggregates like plastic wastes, E-waste, C &D waste, rubber tire, fly ash aggregates, slag aggregates, pond ash, marble dust, quarry dust, M sand, P sand **(7 hrs)**

Materials for Concrete II (the binders): describe types of cement, chemical composition and physical properties and standard specification for quality control, alternative binders such as fly-ash, GGBS, silica fume, metakaolin, rice husk ash, incinerated biomedical waste, incinerated municipal solid waste **(8 hrs)**

Concrete: Mix proportioning guidelines as per IS 10262:2019 for standard concrete and concrete with SCMs, introduction to various codes – ACI and EN, properties of concrete: fresh properties – factors affecting the workability of concrete - the role of aggregates and SCMs in workability, hardened properties – strength – compression, flexural and split tension, modulus of elasticity and Poisson's ratio **(8 hrs)**

Building materials for masonry: types of masonry, functional requirements, standard specification for quality control, conventional masonry – laterite, clay brick, alternative masonry – FAL-G, fly ash bricks, AAC Blocks, soil stabilized mud blocks **(7 hrs)**
Building materials for flooring, roofing, doors, windows, and paints: functional requirements and standard specification for quality control – CATALOG: Types, composition, and properties, applications, advantages and limitations, codal recommendations **(6 hrs)**

References:

1. Singh, Gurcharan, Building Construction and Materials, Raj sons Publications Pvt. Ltd., 2019.
2. Shetty, M. S and A. K. Jain. Concrete Technology (Theory and Practice), 8e. S. Chand Publishing, 2019.
3. Chudley, Roy, and Roger Greeno, building construction handbook, Routledge, 2016.
4. Mehta, P. Kumar, and Paulo JM Monteiro, concrete microstructure, properties, and materials, 2017.
5. Neville, A. M., and J. J. Brooks, Concrete Technology, third Indian reprint, (2003).
6. Relevant Handbooks: National Building Code, IS 10262:2019, IS 456:2000
7. Relevant Indian standards

CIE 2124 MECHANICS OF STRUCTURES (3 1 0 4)

Graduates of the program will be able to

- ***CO1: Analyze the plane trusses and beams for forces.***
- ***CO2: Analyze stresses in beams, shafts subjected to torsion, and resultant stresses on inclined planes.***
- ***CO3: Apply buckling theories to determine the critical load for long columns***
- ***CO4: Apply Macaulay's, Moment - Area and Conjugate beam methods to determine deformation in determinate beams***
- ***CO5: Apply energy methods to determine deformation in determinate structures***

Analysis of determinate Trusses: Plane trusses- method of joints and method of sections. **(4 hrs)**

Bending moment and shear force diagrams for determinate beams. **(6 hrs)**

Bending and shear stresses: Determination of bending and shear stresses in statically determinate beams of various cross sections **(7 hrs)**

Torsion in circular shaft: Simple torsion theory, solid and hollow circular shafts, power transmitted by shafts **(5 hrs)**

Stability of columns: Slenderness ratio, failure by buckling, Euler's formula, concept of equivalent length for different support conditions, limitation of Euler's formula, Rankine-Girdon formula. **(4 hrs)**

Stresses on inclined planes: Stresses on any plane, principal stresses and principal planes. **(5 hrs)**

Strain Energy: Strain energy due to axial force, shearing force, bending moment and twisting moment. Law of conservation of energy, virtual work on rigid and elastic bodies, Betti's theorem, Maxwell's law of reciprocal deflections, Castigliano's theorems. **(2 hrs)**

Deflections: Determination of deflection in statically determinate beams using Macaulay's method, Moment -area method and Conjugate beam method. **(8 hrs)**
Deflection: Determination of deflection in beams, simple frames and trusses by strain energy method-Unit load method and Castigliano's method. **(7 hrs)**

References:

1. Timoshenko, Strength of Materials, Vol. I & Vol. II , CBS Publishers and distributers, New Delhi, 2002.
2. James M Gere and Stephen P Timoshenko, Mechanics of Materials , CBS Publishers and
3. Distributers, New Delhi, 2004.
4. Basavarajaiah and Mahadevappa , Strength of Materials, CBS Publishers, 2001.
5. Reddy C.S., Basic structural analysis, Tata McGraw Hill, New Delhi, 2004.
6. Ramamrutham and Narayanan, Strength of Materials, Dhanpat Rai Publishers, 1989.

CIE 2125 WATER SUPPLY ENGINEERING (3 0 0 3)

Graduates of the program will be able to

CO1: Apply empirical techniques to estimate water demand.
CO2: Explain the characteristics of water to assess water quality
CO3: Identify the unit operations and processes for water treatment
CO4: Apply the guidelines for designing water treatment units.
CO5: Identify water distribution systems for water supply

Introduction: Need for protected water supply, essentials of water supply, project documents preparation. **(2 hrs)**

Quantity of water: Population forecasting - different methods, rate of demand, factors affecting and its variation. **(5 hrs)**

Sources of water: different sources of water, intakes/ water borne diseases and their control, conveyance of water (pump capacity, economical diameter). **(3 hrs)**
Quality of water - Physical, chemical and biological characteristics, analysis of water, drinking water standards. (**4 hrs)**
Treatment of water - Aeration of water - types of aerators, theory of sedimentation, sedimentation with coagulation, coagulants, feeding devices, mixing devices, flocculation - design considerations. **(8 hrs)**
Filtration - types of filters - design considerations.
Disinfection – theory, methods of disinfections, chlorination.
Other treatment methods - softening of water, removal of iron and manganese, defluoridation, desalination. **(8 hrs)**
Distribution of water - distribution methods, systems of supply, service reservoirs and their capacity, layouts of distribution. **(4 hrs)**
Pipe appurtenances: service connection, location of water supply pipes in buildings. Wastage of water - leakage detection and prevention, corrosion and its prevention. **(2 hrs)**

References:

1. Manual on water supply and treatment CPHEEO, Ministry of Urban development, New Delhi, 1991.
2. Garg S.K., Environmental Engineering-I, Khanna Publishers, New Delhi, 1999,.
3. Birdie G.S., Water Supply and Sanitary Engineering, Dhanpath Rai and Sons, New Delhi, 1987.
4. B.C. Punmia, Water Supply and Sanitary Engineering, Dhanpath Rai and Sons, New Delhi, 1995
5. P. N Modi, Water Supply Engineering, Standard book house, New Delhi, 2018

CIE 2141 FLUID MECHANICS LAB (0 0 3 1)

Graduates of the program will be able to

CO1: Demonstrate the use of measurement devices to determine the pipe flow parameters

CO2: Demonstrate the use of open channel flow measurement devices to determine the coefficient of discharge

CO3: Demonstrate the use of measurement devices in tanks to determine the coefficient of discharge

Calibration of Triangular Notch	**(3 hrs)**
Calibration of Rectangular Notch	
Calibration of Cippoletti Notch	**(3 hrs)**
Calibration of Venturimeter	
Calibration of Orifices	**(3 hrs)**
Calibration of Mouth pieces	
Calibration of Orifice meter	**(3 hrs)**
Calibration of Broad crested weir	
Calibration of Curved weir	**(3 hrs)**
Calibration of Ogee weir	
Calibration of Plug Sluice	**(3 hrs)**
Determination of friction factor of pipes	**(3 hrs)**
Experiment on Venturi flume	
Experiment on standing wave flume	**(3 hrs)**
Demonstration of Parshall flume	**(3 hrs)**
Repetition class	**(3 hrs)**
Test	**(6 hrs)**

References:

1. Modi P.N. and Seth S.M., Hydraulics and Fluid Mechanics, Standard Book House, New Delhi, 2005
2. Jain A.K., Fluid Mechanics, Khanna Publishers, New Delhi, 2002
3. Streeter V.L and Wiley E.B, Fluid Mechanics, McGraw Hill Co., New York, 1998
4. Bansal R. K ,Fluid Mechanics and Hydraulic Machines, Laxmi Publishers, New Delhi, 2010

CIE 2142 MATERIAL TESTING LAB (0 0 3 1)

Graduates of the program will be able to

CO1: Demonstrate methods to determine the mechanical properties of a given metal

CO2: Demonstrate methods to determine physical and mechanical properties of bitumen

CO3: Demonstrate methods to determine the physical and mechanical properties of binder and filler materials in concrete

CO4: Demonstrate methods to determine the physical and mechanical properties of concrete.

CO5: Demonstrate methods to determine the mechanical properties of bricks and tiles

Tests to determine the mechanical properties of mild steel and cast iron **(3 hrs)**
Tension test, Torsion test, and shear test (single and double shear), compression test on cast iron
Tests to determine the hardness of various metals, and impact test on mild steel **(3 hrs)**
Rockwell hardness test, Brinell's hardness test, Impact tests: a) Izod and b) Charpy **(3 hrs)**
Tests to determine the physical and mechanical properties of bitumen **(3 hrs)**
Tests on bitumen: Specific gravity, viscosity, softening point, flash and fire point, ductility, and penetration Value. **(3 hrs)**
Tests to determine physical properties of conventional and alternative aggregates **(3 hrs)**
Sieve analysis, specific gravity, bulking, determination of silt and Clay content, comparison of various properties for conventional and alternative aggregates.
Tests to determine physical, properties of cement (OPC and Blended) **(3 hrs)**
Blaine's air permeability to determine surface area, standard consistency, Initial and final setting time, compressive strength of cement mortar for OPC and blended cement.
Tests to determine mechanical properties of hardened concrete **(3 hrs)**
Test related to fresh concrete properties:
Marsh cone test for selection of optimum dosage of plasticizer, slump cone test for different w/b ratio for ordinary (normal concrete), slump flow test for Self-compacting concrete, L-Box, U-Box, J-Ring, V-Funnel, segregation resistance test
Test related to hardened concrete properties:
Compression, flexural and split tension test, modulus of elasticity
Test on masonry and flooring tiles:
Water absorption, compressive strength, soundness test
Flooring tiles: water absorption, compressive strength, abrasive resistance, transverse strength
Demonstration **(3 hrs)**
Fatigue test on mild steel, bend and re-bend test, Poisson's ratio, water penetration resistance test

References:

1. Suryanarayana A.V.K., Testing of Metallic Materials, BS Publications, Hyderabad, 2020
2. Khanna, S. K., and C. E. G. Justo. Highway engineering. Nem Chand and Bros, 1991.
3. Technical Teachers' Training Institute, Laboratory Manual of Strength of Materials, Oxford University Press, 1983.
4. Shetty, M. S., and A. K. Jain. Concrete Technology (Theory and Practice), 8e. S. Chand Publishing, 2019.
5. Neville, A. M., and J. J. Brooks, Concrete Technology, Third Indian reprint, 2003.
6. Relevant Indian Standard codes

IV Semester

CIE 2221 GEOTECHNICAL ENGINEERING (3 0 0 3)

Graduates of the program will be able to

CO1: Classify the soil based on its properties

CO2: Interpret the flow of water through soil to address the seepage problems

CO3: Compute the in-situ stresses and stresses due to external load at any point within the soil

CO4: Evaluate compressibility of soil to assess its stability

CO5: Evaluate the shear strength of soil for geotechnical applications

Introduction: Introduction to geotechnical engineering, soil structure-single grained, flocculated and dispersed structure, clay minerals.

Index properties of soil : Soil as a three phase system, physical properties of soil - specific gravity, void ratio, porosity, degree of saturation, bulk unit weight, dry unit weight, saturated unit weight, density index, moisture content, inter - relationships between them, Atterberg's limits, sieve analysis, hydrometer analysis, IS classification of soils. **(9 hrs)**

Total, effective and neutral stresses: Principles of effective, neutral and total stresses.

Stress distribution in soil: Boussinesq's theory for stresses in soils. Use of Boussinesq's equations for determination of stress distribution (no derivation) - for point load, uniformly loaded circular and rectangular areas. **(6 hrs)**

Flow Through Soil: Darcy's law, factors affecting permeability, laboratory determination of permeability of soils, permeability of stratified deposits.

Seepage through soils: quick sand condition, Laplace equation (no derivation), flow nets-properties and applications, construction of flow nets for sheet pile and weir. **(6 hrs)**

Compaction of soil: Optimum moisture content, maximum dry unit weight and zero air voids line, factors affecting compaction, IS light and heavy compaction tests, compaction control in the field.

Consolidation of soil: Concept, spring analogy, definition of - compression index, coefficient of compressibility, coefficient of volume change. Normally, over and under consolidated soils. Casagrande's method for determination of pre-consolidation pressure, its significance, Terzaghi's one dimensional consolidation theory (no derivation). Consolidation tests. **(9 hrs)**

Shear strength of soil: Concept of shear strength of soils, Mohr-Coulomb theory and failure criteria, Laboratory determination of shear strength parameters - Direct shear, Triaxial, Unconfined compression and Vane shear tests, drained, undrained and consolidated undrained tests and their applications. **(6 hrs)**

References:

1. Bowels J.E, Foundation Analysis and Design, (4e), McGraw-Hills Book Company, 1998.
2. Punmia B.C., Jain AK and Jain AK , Soil Mechanics and Foundations, (17e), Laxmi Publications Pvt. Ltd., 2017.
3. Arora K.R, Soil Mechanics and Foundation Engineering, (7e), Standard, Publishers and Distributors, 2011.
4. Murthy V.N.S, A Text Book of Soil Mechanics and Foundation Engineering, CBS Publishers and
5. Distributors, New Delhi, 2008.
6. Gopal Ranjan and Rao A.S.R, Basic and Applied Soil Mechanics, New Age International Pvt. Ltd, Publishers, 2016.

CIE 2222 TRANSPORTATION ENGINEERING (4 0 0 4)

Graduates of the program will be able to

- ***CO1: Illustrate the components of the highway, railway and runway.***
- ***CO2: Utilize vehicular characteristics for geometric design of highway, permanent way and runway.***
- ***CO3: Identify the engineering properties of materials for the design of paving mixes***
- ***CO4: Utilize material and load characteristics to design the structural layers of pavement***
- ***CO5: Apply the fundamentals of traffic flow characteristics to design road intersections***

Transportation Infrastructure: Geometric design of highways – cross-sectional elements, sight distances, horizontal and vertical alignments. (**10 hrs)**

Tractive resistance and Geometric design of railway Track – Speed and Cant. (**10 hrs)**

Concept of airport runway length, calculations, and corrections; taxiway and exit taxiway design. (**6 hrs)**

Highway Pavements: Highway materials – desirable properties and tests; Desirable properties of bituminous paving mixes; Design factors for flexible and rigid pavements; Design of flexible and rigid pavement using IRC codes. (**12 hrs)**

Traffic Engineering: Traffic studies on flow and speed, peak hour factor, accident study, statistical analysis of traffic data; Microscopic and macroscopic parameters of traffic flow, fundamental relationships; Traffic signs; Signal design by Webster's method; Types of intersections; Highway capacity. (**10 hrs)**

References:

1. Khanna S.K and Justo C.E.G, Highway Engineering, (10e), Nemchand and Brothers, Roorkee, 2015.
2. Kadiyali L.R, Traffic Engineering and Transportation Planning (5e), Khanna Publisher, New Delhi, 2000.
3. Yoder E.J, Principles of Pavement Design, John Wiley and Sons, Inc., New York, 1975.
4. Yang H Huang, Pavement Analysis and Design, Prentice Hall, 2003.
5. Saxena S. C and Arora S. P, A Text Book of Railway Engineering, (8e), Dhanpat Rai Publications, Ltd., New Delhi, 2017.
6. Khanna S. K, Arora M. G and Jain S. S, Airport Planning and Design, (6e), Nemchand and Brothers, Roorkee, 1999.
7. Horenjeff, R and McKelvey, F, Planning and Design of Airports, (4e), Mc Graw Hill Company, New York, 1994.
8. Ashford, N and Wright, P.H, Airport Engineering, (3e), John Wiley and Sons, New York, 1992.

CIE 2223 BASIC REINFORCED CONCRETE DESIGN (3 1 0 3)

Graduates of the program will be able to

- ***CO1: Summarize design philosophy and principles of limit state design of reinforced concrete structures.***
- ***CO2: Apply the limit state method to design reinforced concrete beams***
- ***CO3: Apply the limit state method to design reinforced concrete slabs***
- ***CO4: Apply the limit state method to design reinforced concrete columns***
- ***CO5: Apply the limit state method to design reinforced concrete isolated footing***

Introduction to RCC structures, design philosophy. **(1 hr)**

Limit state method: principle of limit state method of design, characteristic loads, characteristic strength and partial safety factors. Stress strain characteristics for concrete and steel. **(2 hrs)**

Introduction to stress block parameters for collapse, limit state of serviceability. **(1 hr)**

Design of rectangular beams (singly and doubly reinforced), flanged beams, design for shear and torsion. **(10 hrs)**

Design of one way and two way slabs for various boundary conditions **(8 hrs)**

Limit state of collapse in compression, Design of axially loaded short and slender R.C. columns, uniaxial and bi-axial bending using SP16 hand book. **(8 hrs)**

Design of isolated footings. **(6 hrs)**

Reference:

1. Karve S.R and Shah V.L, Limit State Theory and Design of Reinforced Concrete, Structures Publications, Pune, 1996.
2. Varghese P.C, Limit State Design of Reinforced Concrete, Prentice Hall of India, New Delhi, 1999.
3. Shah H.J, Reinforced concrete, Vol. I, Charotar Publishing house, Anand, 2005.

Code books:

1. IS: 456 – 2000, Code of practice for plain and reinforced concrete, Bureau of Indian Standards, New Delhi.
2. SP-16 – 1984, Design aids for reinforced concrete IS 456. Bureau of Indian Standards, New Delhi

CIE 2224 WASTE WATER MANAGEMENT (3 0 0 3)

Graduates of the program will be able to

CO1: Identify the components of sewerage systems for design of sewers.

CO2: Explain the characteristics of wastewater to assess its quality

CO3: Apply basic principles for design of unit operations in sewage treatment

CO4: Apply basic principles for design of unit processes in sewage treatment

CO5: Identify various methods for sewage disposal and industrial effluent treatment

Introduction: Aim and object of sewage disposal, systems of sewage disposal. **(2 hrs)**

Quantity of sanitary sewage and storm sewage: flow variations, quantity of sewage and storm water, design of sewers. **(4 hrs)**

Construction of sewerage system: Sewer appurtenances, laying of sewers, testing of sewers, pumping of sewage, house drainage systems, systems of plumbing, typical layout plan showing house drainage system. **(6 hrs)**

Characteristics of sewage: Physical, chemical and biological characteristics of sewage, aerobic and anaerobic process. **(3 hrs)**

Treatment of sewage: Unit operations- flow diagrams for sewage treatment, screens, grit chamber, skimming tank, primary and secondary sedimentation. **(6 hrs)**

Unit process - Suspended and attached growth systems, trickling filters - theory, parts, operation and design. Rotating biological contactors. Activated sludge process - meaning, flow diagram, modifications, bulking of sludge, sludge volume index. Chlorination of sewage, sludge treatment. **(7 hrs)**

Disposal of sewage–IS standards for sewage disposal, Methods of disposal: dilution - self-purification of streams, oxygen sag curve. Land disposal – suitability, sewage farming and sewage sickness. Low cost sewage treatment. **(5 hrs**)

Industrial Effluent Treatment: Introduction, general characteristics of industrial wastes, IS standards for industrial effluent disposal on land, water and sewers. Population equivalent, concept CETP and zero effluent system. **(3 hrs)**

Reference:

1. Garg S. K, Environmental Engineering- II, Volume – II, Khanna Publishers, New Delhi, 2014.
2. Birdie G.S, Water Supply and Sanitary Engineering, Dhanpat Rai and Sons, New Delhi, 1987.
3. Metcalf and Eddy Inc, Wastewater Engineering - Treatment and Reuse, (2003), 4th Edition, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 2003
4. Karia G.L, and Christian R.A, Wastewater Treatment Concepts and Design Approach, Prentice Hall of India Pvt. Ltd., New Delhi, 2001
5. IS Standards 2490 - 1974 , 3360 – 1974, 3307 – 1974, Indian Standard Institution, Manak Bhavan, New Delhi.
6. Manual on sewage and sewage treatment CPHEO, Ministry of Urban development, New Delhi.
7. Standard Methods – APHEA, American Public Health Association, 1015 fifteenth street, NW Washington DC.

CIE 2225 WATER RESOURCE ENGINEERING (2 1 0 3)

Graduates of the program will be able to

CO1: ***Illustrate the techniques and use of instruments to analyse precipitation and water loss data***

CO2: ***Apply concepts of hydrology to determine runoff and flood flow parameters***

CO3: ***Construct hydrographs for runoff and flood flow analysis***

CO4: ***Explain water storage structures with emphasis on design of gravity dam***

CO5: ***Illustrate water conveyance structures for irrigation with emphasis on impervious floor design***

Introduction: Scope of the subject, world water resources, need for planned utilization of water resources, hydrologic cycle, hydrological data and hydrological equation **(3 hrs)**

Precipitation and water losses: Types of precipitation, rainfall intensity, duration and measurement, estimation of mean rainfall on the basin ─ need, water losses – infiltration, infiltration indices, illustrations, evaporation, transpiration, estimation of evapotranspiration, run-off process, estimation, stream gauging, flow duration curves, flow-mass curves. **(9 hrs)**

Flood studies: Importance, estimation of flood magnitude, flood routing, flood control measures, river training works. Hydrographs-types and uses. **(9 hrs)**

Dams: Introduction, classification and types, gravity dams, arch dams, buttress dams, earth dams, spillways and energy dissipaters, design of gravity dams – forces acting on the dam, design requirements, single step method for design of low gravity dams, illustrations. **(9 hrs)**

Diversion head works: components; weirs on permeable foundations, design of impervious floor by Bligh's creep theory, canal masonry works, falls, regulators, cross drainage works (descriptions only, no designs). **(6 hrs)**

References:

1. Viessman and Knapp, Introduction to hydrology, Harper and Row Publishers, Singapore, 1989
2. H.M.Raghunath, Hydrology, Wiley Eastern publications, New Delhi, 1985.
3. Modi.P.N, Irrigation, water resource and water power, Standard book house publications, New Delhi, 1988.
4. R. K. Sharma, T. K. Sharma, Irrigation Engineering, S Chand and Co., New Delhi, 2002.
5. Santhosh Kumar Garg, Irrigation Engineering and Hydraulic Structures, Khanna Publishers, New Delhi, 1998.

CIE 2241 SURVEYING PRACTICE LAB (0 0 3 1)

Graduates of the program will be able to

CO1: Demonstrate levelling methods for surveying
CO2: Demonstrate the use of theodolite in surveying
CO3: Demonstrate the use of total station in surveying
CO4: Demonstrate the application of GIS tools in surveying

1. **Levelling**:
   a. Differential levelling (H I and rise and fall methods) **(3 hr)**
   b. Reciprocal levelling and block levelling (contouring by grid method) **(3 hr)**
2. **Theodolite**:
   a. Repetition and reiteration method
   b. Determination of R.L of an object when its base is inaccessible by single plane and double plane methods. **(3 hr)**
3. **Construction Surveying:**
   a. Setting out center line for buildings and bridges. **(3 hr)**
4. **Tacheometric surveying:**
   a. Determination of tacheometric constants, the gradient of a line joining two points at different elevations. **(3 hr)**
5. **Curve Surveying (using theodolite):**
   a. Setting out a compound curve and reverse curve **(3 hr)**
6. **Surveying using Total Station:**
   a. Study of the operation of instrument **(3 hr)**
   b. Determination of distance and difference in height between two inaccessible points **(3 hr)**
   c. Traversing using total station **(3 hr)**
   d. Preparation of contour plan **(3 hr)**
7. **Working with open-source GIS software**
   a. Introduction to open source GIS software **(3 hr)**
   b. Working with maps (**3 hrs)**

References:

1. Punmia B.C, Surveying, Vol. I and II, Lakshmi Publishers, New Delhi, 2015.
2. Duggal S.K, Surveying, Vol. I and II, Tata McGraw Hill Publishing Co. Ltd, New Delhi, 2017
3. Arora K.R , Surveying, Vol.I, II and III, Standard Book House, New Delhi, 2015.
4. Kanetkar T.P and Kulkarni S.V, Surveying and levelling, parts 1 and 2, Pune Vidyarthi Griha Prakashan, 2008.
5. Thomas Norman, Surveying, Edward Arnold Publishers (ELBS), Budapest, 2009

CIE 2242 ENVIRONMENTAL ENGINEERING LAB (0 0 3 1)

Graduates of the program will be able to

- ***CO1: Demonstrate the methods to determine the physical and chemical characteristics of drinking water as per standard code of practice***
- ***CO2: Demonstrate the methods to determine physical and chemical characteristics of wastewater and interpret the results for safe disposal***
- ***CO3: Demonstrate the methods to determine bacteriological characteristics of water as per standard code of practice***

Determination of solids: total solids, suspended solids, dissolved solids, volatile solids, fixed solids, settlable solids. **(3 hrs)**
Turbidity, Conductivity determination and Jar test. **(3 hrs)**
Determination of alkalinity, acidity and pH. **(3 hrs)**
Determination of calcium, magnesium and total hardness. **(3 hrs)**
Determination of chlorides and percentage available chlorine in bleaching powder. **(3 hrs)**
Determination of dissolved oxygen **(3 hrs)**
Determination of residual chlorine and chlorine demand. **(3 hrs)**
Determination of Iron and Fluorides.
Determination of C. O. D. **(3 hrs)**
Total count test and MPN determination
Determination of Ammonical Nitrogen and Nitrates. **(3 hrs)**
Demonstration of high volume sample and sound lever meter.
Demonstration of determination of oil, grease and sulphates. **(3 hrs)**

References:

1. Standard Methods for the Examination of Water and Waste Water – ALPHA – AWWA – WPCF
2. Sawyer and Mc Carty, Chemistry for Environmental Engineering, McGraw Hill, New York, 1994.
3. IS – 3025 – 1964 – Methods of Sampling and Test (physical and chemical) for water Used in Industry, IIT New Delhi.
4. Drinking water standards, IS – 10500-2012.

V Semester

CIE 3121 BASIC STRUCTURAL STEEL DESIGN (2 1 0 3)

Graduates of the program will be able to

CO1: Apply limit state method to design bolted and welded connections in steel structures.
CO2: Apply limit state method to design tension members in steel structures.
CO3: Apply limit state method to design compression members in steel structures
CO4: Apply limit state method to design column splice and column bases.
CO5: Apply limit state method to design steel beams.

Introduction: Different type of steel structures, properties of structural steel. Type of standard steel section- Indian standard sections, the difference in design of steel and RCC structures. Limit state method of design. **(2 hrs)**

Bolted connection: Introduction, type of bolts, advantages and disadvantages of bolted connection over riveted and welded connections. Behavior of bolted joints, failure mode of bolted joints, strength of bearing bolt in tension, shear and bearing. Efficiency of joint. Eccentric bolted connection, in-plane bolt group and out of plane bolt group **(9 hrs)**

Welded connections: Advantages and disadvantages, types of welded joints- fillet welded joints, butt welded joints, slot and plug welded joints, type of butt welded joints, fillet weld size and throat thickness. Strength of weld and welded joints. Eccentric connections in-plane weld group and out of plane weld group. **(6 hrs)**

Tension Members: Introduction, design strength of tension member, design problems, tension splices. **(4 hrs)**
Compression members: Introduction, type of standard and built up section used, buckling class of sections, design compressive strength of steel members **(5 hrs)**

Design of column splices: Introduction and types of column splices, design of simple column base. **(3 hrs)**

Flexure member: Introduction, laterally supported and laterally unsupported beams. Plastic moment capacity of section. Classification of cross sections based and calculation of flexural strength of laterally supported beams with low shear and combined shear, web buckling and crippling strength, effective length of beams, warping and torsional restrains. **(7 hrs)**

References:

1. Duggal S.K., Limit State Design of Steel Structures, Tata McGraw Hill education private Limited – New Delhi 2008.
2. Subramanian N., Design of Steel Structures, oxford university New Delhi 2008.
3. IS 800-2007, General construction of steel in code of practice, Bureau of Indian Standards, New Delhi.
4. SP-6 (Part I) 1964, Structural Steel Sections. Bureau of Indian Standards, New Delhi

CIE 3122 APPLIED SOIL ENGINEERING (3 0 0 3)

Graduates of the program will be able to

CO1: Identify suitable soil exploration method for geotechnical investigation

CO2: Apply earth pressure theories to analyse forces on retaining structures

CO3: Analyse infinite and finite slopes for its stability and design

CO4: Determine bearing capacity of shallow foundation to design footings

CO5: apply static method and field techniques to analyze pile foundation

Soil Exploration: Objectives, methods of boring, types of samples and samplers, requirements of good sampler, significant depth, depth and spacing of bore holes, penetration tests, ground water investigations, geo-physical exploration, exploration log, planning of exploration programme. **(5 hrs)**

Earth pressure: Earth pressure at rest, active and passive conditions, Rankine's theory for active and passive condition **(9 hrs)**

Stability of slopes: Finite and infinite slopes, types of failure of finite slopes. Factor of safety, stability of finite slopes by Swedish circle method and friction circle method, factor of safety using Taylor's stability chart. **(8 hrs)**

Bearing capacity of shallow footings: Classification of footings, types of shallow footings, definitions, modes of shear failure, Terzaghi's theory (no derivation), factors affecting bearing capacity, IS code method, estimation of bearing capacity from plate load and penetration tests. **(8 hrs)**

Pile foundations: Classification of pile foundation, load carrying capacity of a single pile by static formula, group action and negative skin friction, settlement of pile foundations, under reamed piles and bored compaction piles. **(6 hrs)**

References:

1. Bowels J.E, Foundation Analysis and Design, (4e), McGraw Hills Book Company, 1998.
2. Punmia B.C, Jain AK and Jain AK, Soil Mechanics and Foundations, (17e), Laxmi Publications Pvt. Ltd., 2017
3. Arora K.R, Soil Mechanics and Foundation Engineering, (7e), Standard, Publishers and Distributors 2011.
4. Murthy V.N.S, A Text Book of Soil Mechanics and Foundation Engineering, CBS Publishers and Distributors, New Delhi, 2008.
5. Gopal Ranjan and Rao A.S.R, Basic and Applied Soil Mechanics, New Age International Pvt. Limited, 2016.
6. B.M Das, Principles of Geotechnical engineering, (7e), Cengage Learning, 2010.

CODE BOOKS:

1. **IS 6403 : 1981** (Reaffirmed 2002) CODE OF PRACTICE FOR DETERMINATION OF BEARING CAPACITY OF SHALLOW FOUNDATIONS
2. **IS : 2911 - 1980** (Reaffirmed 2000) CODE OF PRACTICE FOR DESIGN AND CONSTRUCTION OF PILE FOUNDATIONS
3. **IS :2131 - 1981** (Reaffirmed 1997) METHOD FOR STANDARD PENETRATION TEST FOR SOILS

CIE 3123 ESTIMATION COSTING AND PROJECT MANAGEMENT
(3 1 0 4)

Graduates of the program will be able to

- ***CO1: Choose appropriate specifications for various item of work to prepare a bill of quantities***
- ***CO2: Compute the quantities and analyze the rates of various item of works for buildings to prepare project estimate***
- ***CO3: Apply principles of construction management to prepare work breakdown structure, define roles of the stakeholders and organise the project resources***
- ***CO4: Apply principles of network analysis to develop a robust construction schedule***
- ***CO5: Apply the construction management tools to perform project planning and control***

Estimation and Costing
Purpose and **methods** of building estimation. **(2 hrs)**

Listing the items of work for a given building plan: formwork, steel, concrete, mechanical, electrical and plumbing (MEP) elements, flooring and roofing elements, plastering, and pointing, painting, and waterproofing. **(3 hrs)**

Rate Analysis: Conduct rate analysis for the listed items of work. **(5 hrs)**

Principles of computing methods for quantity: Center line and long-short wall methods for buildings, estimating earthwork using trapezoidal method, prismoidal method, volume of earth work from contour plan, spot levels, mass diagram for roads. **(4 hrs)**

Project management:
Preparing the final estimate of a building and road work / BOQ **(7 hrs)**

Introduction to Construction Planning: Classification of construction works, construction project life cycle, construction team, organization structure, work breakdown structure, objectives of planning, steps involved in planning. **(2 hrs)**

Construction Project management: Definition, scheduling using Gantt charts– Preparation, scheduling a project using Gantt chart **(3 hrs)**

Networks Analysis- Arrow network (ADM) and node network (PDM), precedence diagram method, critical path method. **(6 hrs)**

Time-Cost Tradeoff: Direct cost, indirect cost, total project cost, network crashing. **(5 hrs)**

Use of Gantt chart to arrive cumulative cost curve and resource allocation. **(6 hrs)**

Project updating: Data required for updating, updating flow chart.
Project control- EVA. **(5 hrs)**

Reference:

1. M. Chakraborti., Estimating, Costing, Specification and Valuation in Civil Engineering, (16e), 2003.
2. B.N. Dutta, Estimating and Costing in Civil Engineering, (16e), UBS Publishers' Distributors Ltd, 2000.
3. CPWD, Manual for Standard Specification and Rate Analysis
4. IS 1200: Part 1 to 16: Method of measurement of building and civil engineering work

CIE 3124 DESIGN OF PRE-STRESSED CONCRETE STRUCTURES
(2 1 0 3)

Graduates of the program will be able to

- ***CO1: Summarize fundamental principles and codal provisions to design prestressed concrete members***
- ***CO2: Apply working stress method to determine the stresses in prestressed concrete members***
- ***CO3: Apply limit state method to determine moment of resistance and check for serviceability of flexural members.***
- ***CO4: Determine transmission stresses in prestressed members to design end block and anchorage zone.***
- ***CO5: Analyze composite sections for stresses.***

Introduction, Prestressing systems and Material properties: Basic concepts, pre tensioning and post tensioning systems and end anchorages, advantages and applications of prestressed concrete, need for high strength concrete and high tensile steel. Stress strain characteristics and properties. Load balancing concept, stress concept, center of thrust. **(5 hrs)**

Losses in prestress: Various losses in pretensioned and post tensioned systems. **(4 hrs)**

Analysis of prestressed concrete members: Stresses in concrete due to pre-stress and loads, permissible stresses, limiting zone of pre-stressing force and eccentricity, cable profile, design of simply supported beams. **(10 hrs)**

Limit state of collapse in flexure and shear: I.S. Code recommendations, ultimate flexural and shear resistance of sections, design of shear reinforcement. **(5 hrs)**

Limit state of serviceability: Prediction of short term and long term deflections of uncracked section as per I.S. code provisions. **(4 hrs)**

Transmission of pre-stress in pre tensioned and post tensioned members: Transmission length, bond stress. Anchorage stresses in post tensioned members, bearing stress, I.S. code provisions for the design of end block reinforcements. **(4 hrs)**

Analysis of Composite Sections: Analysis of stresses in composite section for propped and un-propped conditions, computation of shear connectors. **(4 hrs)**

References:

1. Krishna Raju N, Pre-stressed Concrete, (5e) ,Tata McGraw Hill, , New Delhi, 2012.
2. Dayaratnam P, Pre-stressed Concrete Structures, (7e), Oxford and IBH Publications, New Delhi , 2017.
3. Mallick S. K. and Gupta A. P., Pre-stressed Concrete, (3e), Oxford and IBH, New Delhi, 1997.
4. Lin T.Y. and Ned. Burns H, Design of Pre-stressed Concrete Structures, John Wiley and Sons, New York, 2017.

Code books:

1. IS:1343-2012, Code of Practice for Prestressed concrete, Bureau of Indian Standards, New Delhi.

CIE 3125 PRECAST TECHNOLOGY (3 0 0 3)

Graduates of the program will be able to

CO1: Summarize the fundamentals of prefabrication techniques in construction

CO2: Identify suitable components and pre-stressing systems used for precast applications

CO3: Apply the concepts of precast technology for sub-structure and super-structures

CO4: Summarise the process of transportation and erection of prefabricated components

CO5: Develop appropriate context-specific design using precast elements

Introduction to Prefabrication: Types of prefabrication, necessity, advantages and disadvantages, modular coordination- grid systems, layout, code provisions, structural concepts **(5 hrs)**

Precast Concrete: Different precast components, application of code provisions and structural concepts, Classification and comparison of different types of pre-stressing systems **(7 hrs)**

Substructure and support system: Classification of different types of precast foundation systems based on application, Explanation of structural concepts and uses of precast components (columns, beam and slab) in accordance with the necessary code provisions, various joinery details and use of respective construction techniques, process of transportation and erection of prefabrication components on the construction site **(9 hrs)**

Roof and Wall systems: Types of walling and roofing materials, joinery details, transportation and erection, use of structural and construction details required for prefabrication wall construction, installation and erecting process of wall and roofing systems **(8 hrs)**

Precast Components: Various precast components- stairs, toilets, doors, windows, furniture units. Composites: Analysis of context and appropriate design solutions **(7 hrs)**

Reference:

1. Elliott, Kim S. Precast concrete structures. Crc Press, 2019.
2. Lin, Tung Yen, and Ned Hamilton Burns, Design of prestressed concrete structures, 1981.
3. Raju, N. Krishna. Prestressed concrete, Tata McGraw-Hill Education, 2006.
4. Bruggeling, A. S. G and G. F. Huyghe, Prefabrication with concrete, CRC Press, 1991.
5. Glover, Charles William, Structural Precast Concrete. [with illustrations.], CR Books, 1964.
6. Richardson, John George, Precast concrete production, 1973.
7. Bachmann, Hubert, and Alfred Steinle, Precast concrete structures, Berlin: Ernst and Sohn, 2011.
8. IS 10297-1982

CIE 3141 SOIL MECHANIC LAB (0 0 3 1)

Graduates of the program will be able to

CO1: Demonstrate methods to determine index properties of a given soil sample

CO2: Demonstrate methods to determine compaction characteristics of a given soil sample

CO3: Demonstrate methods to determine hydraulic conductivity of a given soil sample

CO4: Demonstrate methods to determine shear strength parameters of a given soil sample

1. Determination of moisture content by oven drying method, using pycnometer and Torsion moisture meter. **(3 hrs)**
2. Determination of specific gravity using density bottle and pycnometer. **(3 hrs)**

3. Determination of Atterberg's limits. **(3 hrs)**
4. Determination of in-situ unit weight by core cutter method and sand replacement method. **(3 hrs)**
5. Grain size analysis. **(1 hr)**
6. Determination of coefficient of permeability by constant head and variable head permeability tests. **(3 hrs)**
7. Determination of maximum dry unit weight and optimum moisture content by standard compaction test, use of proctor needle **(3 hrs)**
8. Determination of shear strength parameters:
   (a) Unconfined compressive strength test
   (b) Direct shear test
   (c) Triaxial compression test
   (d) Vane shear test **(3 hrs)**
9. Determination of California bearing ratio **(3 hrs)**
10. Demonstration of-
    Consolidation test
    Static cone penetration test
    Plate load test **(3 hrs)**

Reference:

1. Relevant IS codes
2. Bowles J.E, Engineering properties of soil and their measurement, (2e), McGraw – Hill Book Company, New York, 1986.
3. Lambe T.W, Soil testing for Engineers, John Wiley and Sons, INC.
4. Cheng Liu and Jack B. Evett, Soil properties, Testing, Measurement and Evaluation, Prentice-Hall, Inc. Englewood Cliffs, New Jersey, 1987

CIE 3142 COMPUTER APPLICATION LAB (0 0 3 1)

Graduates of the program will be able to

CO1: Apply software tools to study the response of continuous beams.

CO2: Apply software tools to study the response of trusses.

CO3: Apply software tools to study the response of plane frames.

CO4: Apply software tools to study the response of space frames.

CO5: Apply software tools to design structural frames.

Introduction to STAAD Pro. software package- modeling and analysis of continuous beams **(6 hrs)**

Analysis of plane trusses, plane frames, and space frames using STAAD Pro. **(15 hrs)**

Design of frames using STAAD Pro. **(6 hrs)**

Introduction to ETABS – modeling and analysis of 3D space frames. **(9 hrs)**

Reference:

1. Sharma T.S, STAAD Pro. V8i for beginners – with Indian examples (1e), Notion Press, 2014
2. Rajendran D, Analysis and Design of a Multistorey Building using STAAD.Pro and E-TABS (with Manual Calculation) (1e), Designtech Publishers, 2016
3. Bentley, STAAD Pro. – Technical Reference Manual, Retrieved from https://communities.bentley.com/cfs-file/__key/telligent-evolution-components-attachments/13-275895-00-00-00-24-18-/Technical_5F00_Reference_5F00_V8i.pdf 2012
4. Computers and Structures, Inc., CSI Analysis Reference Manual, Retrieved from http://docs.csiamerica.com/manuals/etabs/Analysis

VI Semester

CIE 3221 ADVANCED MECHANICS OF STRUCTURES (3 1 0 4)

Graduates of the program will be able to

CO1: Analyze the arches to determine the forces

CO2: Apply force methods to analyze indeterminate beams

CO3: Apply displacement methods to analyze indeterminate beams and frames

CO4: Apply plastic theory to analyze beams and frames

CO5: Construct influence line diagrams to analyze indeterminate beams

Introduction: Forms of structures, 1D, 2D and 3 dimensional structural systems, degrees of freedom, conditions of equilibrium, degree of freedom (kinematic indeterminacy), determinate and indeterminate structures- static indeterminacy, linear and nonlinear structures, law of conservation of energy. **(2 hrs)**

Analysis of arches: Three hinged arches- analysis of three hinged parabolic arches- Determination of horizontal reaction, normal thrust, radial shear and bending moment. Two hinged arches- Determination of horizontal reaction, normal thrust, radial shear and bending moment. Lateral yielding, rib shortening and effect of temperature change. **(8 hrs)**

Analysis of propped cantilever, fixed and continuous beams by strain energy and consistent deformation methods. **(8 hrs)**

Analysis of beams and frames using slope deflection, and moment distribution methods. Analysis of continuous beams by three moment theorem. **(13 hrs)**

Plastic Analysis: Ductility behavior in the plastic range, concept of plastic hinge, plastic moments, shape factor for different shapes of cross - section, redistribution of moment, collapse mechanism. Upper and lower bound theorems. Determination of collapse loads using statical and kinematic methods for beams and frames structures. **(8 hrs)**

Rolling loads and Influence lines: Introduction to influence line diagram, application of Muller Breslau's Principle. **(6 hrs)**

Introduction to stiffness matrix method **(3 hrs)**

Reference:

1. Reddy C.S, Basic structural Analysis, Tata McGraw Hill, New Delhi, 2010.
2. Ramamrutham S,Theory of Structures, Dhanpat Rai Publishing Company, New Delhi, 2014.
3. Rao Prakash D.S, Structural Analysis, Universities Press, India, 1997.
4. Hibbeler RC, Structural analysis, Pearson Education, United States, 2015.
5. Daniel L Schodak, Structures, Pearson Education, United States, 2015

CIE 3222 CONTEMPORARY CONSTUCTION PRACTICES AND SUSTAINABILITY (4 0 0 4)

Graduates of the program will be able to

CO1: Identify various techniques of contemporary construction practices

CO2: Examine the feasibility of various equipment in construction projects

CO3: Apply the principles of sustainability for assessing life cycle energy of a building

CO4: Apply life cycle assessment tool to determine the environmental credentials of a building

CO5: Apply the principles of green building rating systems for sustainability

Contemporary construction practices: Production, transportation and erection of precast concrete structures, tunnel form construction techniques, stay in place formwork system. monolithic concrete construction using MIVAN technique. **(10 hrs)**

Composite masonry, cavity walls, infill walls, prefabricated panels, Shoring and Scaffolding. **(3 hrs)**

3D printing technology in construction. **(2 hrs)**

Management of construction equipment: Classification of construction equipment, factors affecting equipment selection, economic life and maintenance of equipment, ownership, and operating costs. **(4 hrs)**

Earthmoving, hoisting and hauling equipment, aggregate crushers, tunneling, and paving equipment. **(3 hrs)**

Concept of sustainability: Definition, principles (5R), operational reuses of construction materials, sustainability goals for construction industry. **(4 hrs)**

Life cycle energy use in buildings, embodied energy, on-site construction energy, operational energy and demolition energy, methods to reduce life cycle energy use, introduction to net-zero energy buildings. **(5 hrs)**

Life cycle analysis of material sustainability: Introduction to LCA, construction materials LCA, life cycle phases, LCA methodology, LCA in construction, carbon footprint, parameters that influence emissions in building construction, methods to calculate emissions and carbon calculators. **(10 hrs)**

Introduction to green building rating systems: Introduction and need for green building, benefits of rating systems, introduction to LEED, GRIHA and IGBC. **(7 hrs)**

References:

1. Arora, S.P and Bindra, S.P, A Text Book of Building Construction, Dhanpat Rai Publications, New Delhi, 2005.
2. Varghese P.C, Building Constructions, Prentice Hall, 2007.
3. Sharma and Kaul, Building Construction, S. Chand and Company, New Delhi, 1998
4. Peurifoy R.L, Schexnayder, J.C, and Shapira, A, Construction Planning, Equipment and Methods, Tata McGraw Hill, New Delhi, 2010.
5. Sharma S.C. Construction Equipment and Management, Khanna Publishers, New Delhi, 2013.
6. Adler A, Armstrong, J, Azerbegi R, Guy G.B, Fuller S.K, Kalin M, Karolides A, Lelek M. Lippiatt B, Macaluso J, Spencer E, Waier P, Walker A, Green Building: Project Planning and Cost Estimating, Second Edition, RS Means, Reed Construction Data, Inc, 2006.
7. Hendrickson C.T, Lave L.B and H.S, Matthews H.S, Environmental Life Cycle Assessment of Goods and Services: An Input-Output Approach, Resources for the Future Press, 2006.
8. Liv Haselbach, The Engineering Guide to LEED-New Directions (Green Source): Sustainable construction, McGraw-Hill Professional, 2008.
9. Martin Melaver and Phyllis Mueller, The green building bottom line: The real cost of sustainable building, McGraw-Hill Professional, 2008.
10. Indian Green Building Council, Green building rating system: New construction and major renovations (LEED-India NC) reference guide version 1.0, Confederation of Indian Industry, CII-Sohrabaji Godrej Green Business Centre, Hyderabad, 2007.
11. The Energy and Resources Institute Press, Green Rating for Integrated Habitat Assessment (GRIHA), Ministry of New and Renewable Energy and The Energy and Resources Institute

CIE 3223 DESIGN OF REINFORCED CONCRETE STRUCTURE

(3 0 0 3)

Graduates of the program will be able to

CO1: Apply the limit state method to design reinforced concrete staircase

CO2: Apply the limit state method to design reinforced concrete flat slab

CO3: Apply the limit state method to design reinforced concrete retaining walls

CO4: Apply the limit state method to design reinforced concrete foundations

CO5: Apply working stress method to design reinforced concrete water tank

Design of staircases: General features, types of staircase, loads on staircases, effective span as per IS code provisions, distribution of loading on stairs, design of staircases spanning along traverse and longitudinal direction. Design of waist slabs. **(6 hrs)**

Foundations: Introduction, types of foundations, pressure distribution under footings, design of combined footing - slab, slab and beam types, raft foundation. **(7 hrs)**

Retaining walls: Introduction, types of retaining walls and their suitability for adoption, design of cantilever and counterfort retaining walls. **(9 hrs)**

Design of water tank: Design of circular and rectangular water tanks resting on ground (rigid base only). Design of rectangular underground water tanks. **(8 hrs)**

Design of flat slabs by direct design method. **(6 hrs)**

Reference:

1. Unnikrishna Pillai, Devadas Menon, Reinforced Concrete Design, (3e), Tata McGraw Hill Publishing Company Limited, New Delhi, 2009.
2. Shah H. J, Reinforced Concrete, Vol. II, (6e), Charotar Publishing House Pvt. Ltd, Anand, Gujarat, 2012.
3. Varghese P. C, Design of Reinforced Concrete Foundations, PHI Learning Private Limited, New Delhi, 2010.
4. Varghese P. C, Advanced Reinforced Concrete Design, PHI Learning Private Limited, New Delhi, 2011.

Code books:

1. IS:456 – 2000, Code of practice for plain and Reinforced concrete, Bureau of Indian Standards, New Delhi.
2. SP-16 – 1984, Design Aids for Reinforced concrete IS 456, Bureau of Indian Standards, New Delhi.

CIE 3224 ENGINEERING PRACTICE & ETHICS (3 0 0 3)

Graduates of the program will be able to

CO1: Identify the relevant stakeholders and their responsibilities in the construction sector

CO2: Apply code of ethics using theories about ethical issues in engineering profession

CO3: Evaluate sustainability of the built environment in societal and environmental contexts

CO4: Apply ethics and professional responsibility in public safety, contractual obligation and dispute resolution

CO5: Identify laws and regulations published by government bodies for professional practice

Professional Practice: Roles of various stakeholders: Government regulatory bodies & Standardization Bodies; professional bodies; Clients/ owners; Developers; Contractors; Manufacturers/ Vendors/ Service agencies **(4 hrs)**

Professional Ethics: Kohlberg's theory – Gilligan's theory – Consensus and Controversy – Models of Professional Roles & Professionalism – theories about right action Definition of Ethics, Professional Ethics, Business Ethics, Corporate Ethics, Engineering Ethics, Personal Ethics; Code of Ethics as defined in ASCE, Institution of Engineers (India); Profession, Professionalism, Professional Responsibility, Professional Ethics; Conflict of Interest, Gift Vs Bribery, Environmental breaches, Negligence, Deficiencies in state-of-the-art; Vigil Mechanism, Whistleblowing, protected disclosures **(8 hrs)**

Sustainable Considerations: Sustainability, UN sustainable development goals, sustainable practices and techniques in construction, Environmental Impact Assessment, Corporate sustainability assessment: Frameworks, Standards, Ratings and indices, Environmental Impact Assessment, Occupational safety, Green buildings, Green credentials – LEED, GRIHA, Construction & Demolition waste management, relevant case studies **(12 hrs)**

Laws and Regulations: General principles of contracting; Contract Formation & Law; Privacy of contract; Various types of contract and their features; Valid & Voidable Contracts; Prime and sub contracts; Joint Ventures & Consortium; Contract documentation; Contract Notices; Wrong practices in contracting (Bid shopping, Bid fixing, Cartels); Reverse auction; Case Studies; Build-Own-Operate & variations; Public- Private Partnerships; International Commercial Terms; Industrial Disputes Act, 1947; Collective bargaining; Industrial Employment (Standing Orders) Act, 1946; Workmen's Compensation Act, 1923; Building & Other Construction Workers (regulation of employment and conditions of service) Act (1996) and Rules (1998); RERA Act 2017, NBC 2017; Distinction between conciliation, negotiation, mediation and arbitration, confidentiality, resort to judicial proceedings, costs; Dispute Resolution Boards; Lok Adalats ; Safety and risk – assessment of safety and risk – Riysis – Risk benefit analysis and reducing risk – Govt. Regulator's approach to risks **(12 hrs)**

References:

1. Kibert, Charles J. Sustainable construction: green building design and delivery. John Wiley & Sons, 2016.
2. Fox, Warwick, ed. Ethics and the built environment. Routledge, 2012.
3. Montoya, Michael. Green building fundamentals. Prentice Hall, 2010.
4. Leffers, M. Regina. Sustainable Construction and Design. Pearson Education, 2010.
5. American Society of Civil Engineers (2011) ASCE Code of Ethics – Principles Study and Application
6. Ostwald, Michael J. "Warwick Fox A Theory of General Ethics: Human Relationships, Nature, and the Built Environment." Nexus Network Journal. Birkhäuser Basel, 2008. 195-198.
7. B.S. Patil, Legal Aspects of Building and Engineering Contracts

CIE 3241 BUILDING DESIGN AND MODELLING LAB (0 0 3 1)

Graduates of the program will be able to

- ***CO1: Visualize the layout, orientation, and elevation of the building to develop a 2D drawing***
- ***CO2: Develop a working drawing of various building components***
- ***CO3: Visualise and design functional space for various buildings as per requirements of client***
- ***CO4: Understand and apply the statutory requirements in planning the building***
- ***CO5: Develop building drawings and models using Auto CAD and BIM software***

Foundations: **(1 hr)**

Study and draw the plan, elevation and sectional views giving all details for masonry foundation, RCC isolated footing, combined footing

Self-Study: Raft footing

Doors and Windows: **(2 hrs)**

Study the scale models and hand sketching of the following

(i) Flush door and PVC doors

(ii) Aluminium Doors/ windows

(iii) UPVC windows and structural Glazing

Self-Study: Collapsible door and rolling shutter

Design, Drawing and Modelling of Buildings: **(9 hrs)**

Functional design of building, positioning of various components of buildings, orientation of buildings, building standards, bye laws (As per NBC), set back distances and calculation of carpet area, plinth area and floor area ratio.

Introduction to Planning the building as per requirements of client within the allotted site. Application of bubble diagram, functional aspects and aesthetic, scientific aspects of Vaastu Principle in planning. **(1 hr)**

(i) Drawing plan, section, elevation of 2 BHK house **(1 hr)**
[on drawing sheet]

(ii) Drafting bank building/Primary health Centre/ Cafeteria using Auto CADD **(2 hrs)**
[1: Introduction class for various commands; 2: Practice/ Application]

Self-Study: 2BHK House Plan

(iii) Modelling 2 BHK house in open building designer (OBD) **(3 hrs)**

[1: Introduction class for various commands; 2: Practice/ Application 3: Practice / Application]

(iv) Learning MEP component drafting in OBD **(2 hrs)**

[1: Introduction class for various commands of MEP design components]

Self-study: Planning a River side Resort / Commercial Mall / Warehouse

Reference:

1. Shah M.G, Kale C.M and Patki S.Y, Building Drawing with an Integrated Approach to Built Environment, Tata McGraw Hill Publishers Limited, 2007.
2. Chuck Eastman, Paul Teicholz, Rafael Sacks, Kathleen Liston, BIM Handbook: A Guide to building information modeling for Owners, Managers, Designers, Engineers, and Contractors, John Wiley and Sons. Inc, 2011.
3. Sikka V.B, A Course in Civil Engineering Drawing, 4th Edition, S.K.Kataria and Sons, 2015
4. National Building Code of India, Bureau of Indian Standards, 2016.

CIE 3242 STRUCTURAL DETAILING AND DRAWING LAB (0 0 3 1)

Graduates of the program will be able to

CO1: Illustrate the structural detailing of RC beams, slabs and staircase

CO2: Illustrate the structural detailing of footings

CO3: Illustrate the structural detailing of retaining walls

CO4: Illustrate the structural detailing of steel connections

CO5: Illustrate the structural detailing of water tanks

Detailing of singly and doubly reinforced rectangular beams	**(3 hrs)**
Detailing of one way slabs, detailing of two-way slabs, detailing of continuous beams.	**(6 hrs)**
Detailing of dog legged staircase.	**(3 hrs)**
Detailing of circular tank and rectangular tank.	**(6 hrs)**
Detailing of isolated footing and combined footing	**(6 hrs)**
Design and detailing of cantilever retaining wall	**(3 hrs)**
Beam to beam and beam to column connections in steel buildings.	**(6 hrs)**
Detailing of flat slabs	**(3 hrs)**

Reference:

1. Subramanian N, Design of Reinforced Concrete Structures (1e), Oxford University Press, 2013.
2. Shah H.J, Reinforced Concrete – Vol. 1(Elementary Reinforced Concrete) (11e), Charotar Publishing House Pvt. Ltd., 2016
3. Chandra R, Gehlot V, Elements of Limit State Design of Concrete Structures, Scientific Publishers, 2004
4. Gambhir M. L, Fundamentals of Structural Steel Design (1e), Tata McGraw Hill Publishing Co. Ltd, 2013

Code books:

1. IS: 456 – 2000, Code of practice for plain and Reinforced concrete, Bureau of Indian Standards, New Delhi.
2. SP-16 – 1984, Design Aids for Reinforced concrete IS 456. Bureau of Indian Standards, New Delhi
3. IS 800-2007, General construction of steel in code of practice, Bureau of Indian Standards, New Delhi.
4. SP-6 (Part I) 1964, Structural Steel Sections. Bureau of Indian Standards, New Delhi

MINOR SPECIALIZATION

I. BUILDING CONSTRUCTION AND MANAGEMENT

CIE 4401 ADVANCES IN CONCRETE TECHNOLOGY (3 0 0 3)

Graduates of the program will be able to

CO1: ***Identify various phases and their influence on designing a concrete mixture for given application***
CO2: ***Examine the suitability of various admixtures to design a concrete mixture of a given specification***
CO3: ***Develop mix proportions for standard and special concretes***
CO4: ***Compare suitability of special concretes for various structural applications***
CO5: ***Assess durability indicators through performance-based design approaches***

Understanding structure of concrete: Macrostructure – two-phase (aggregate and matrix phase) and Microstructure – three-phase (aggregate and filler, matrix and interfacial transition zone) understanding influence of each phase of concrete on properties of concrete. (**2 hrs)**
Understanding the role of various phases of concrete: on the mechanism of strength development and deformation characteristics of early and later age concrete. Shrinkage- plastic, drying, chemical, thermal, autogenous, and carbonation, creep – behavior, advantages, and disadvantages **(5 hrs)**

Admixtures: Mineral and Chemical admixtures: Set-controlling, air-entraining, water reducing admixtures (with different generations), viscosity modifying admixtures, waterproofing admixtures **(2 hrs)**

Mineral admixtures: Pozzolanic and cementitious admixtures: fly ash class C and F, silica fume, rice husk ash, bagasse ash, metakaolin, ground granulated blast furnace slag **(5 hrs)**
Advancements in designing sustainable concrete: Concept of sustainability, definition, and scope, sustainable materials – design principles, durability, guidelines and case examples **(4 hrs)**
Design principles of concretes for general Applications: High strength concrete and self-compacting concrete - IS 10262:2019, ACI and EFNARC guidelines **(5 hrs)**
Design principles of special concretes with suitability and applications: Reactive powder concrete, geopolymer concrete, polymer impregnated concrete, fiber reinforced concrete, high-density concrete, lightweight aggregate concrete, roller compacted concrete or Zero slump concrete, bio-cement concrete, ready-mix concrete, and tremie concreting, ferro-cement, NAC **(9 hrs)**
Performance-based design approach for sustainable construction: Prescriptive and performance based approach for concrete – EN and South African standards for understanding performance based approach, durability of concrete and durability indicators. **(4 hrs)**

References:

1. Mehta, P. Kumar and Paulo JM Monteiro, Concrete microstructure, properties, and materials, 2017.
2. Neville, Adam M, Properties of Concrete, 4th, London Pearson Education Limited 443.846, 2011
3. Page, Chris L and Mary M, Page, eds. Durability of concrete and cement composites, Elsevier, 2007.
4. Thomas, Michael, Supplementary cementing materials in concrete, CRC Press, 2013.

CIE 4402 BUILDING CODES AND FUNCTIONAL SERVICES (3 0 0 3)

Graduates of the program will be able to

- ***CO1: Apply the knowledge of building requirements and land use practices for infrastructure development***
- ***CO2: Apply standard code of practice to enhance structural safety requirements in construction practice***
- ***CO3: Make use of standard code of practice for general and engineering services in buildings***
- ***CO4: Apply standard code of practice for maintenance planning of a building***
- ***CO5: Examine the environmental factors for energy management in a building***

Introduction to National Building Code: Salient features of National Building Code, scope and terminologies related to building construction, permit forms and inspection, general building requirements- land use classification, classification of buildings, area and height limitations, requirements of various parts of building. **(5 hrs)**

Fire and Safety: fire prevention, life safety, fire protection. **(2hrs)**

Design and Construction: Construction practices and safety requirements in wind load design, earthquake resistant of masonry wall. Design of masonry wall – special considerations in earthquake zone, guidelines for improving earthquake resistance. **(5 hrs)**

General Building Services- Lighting and ventilation: C ventilation - design consideration, methods, air requirements, air conditioning acoustics, sound insulation and heat insulation in buildings. **(4 hrs)**

Engineering services in a building as a system: Lifts, escalators, cold and hot water systems, wastewater systems and electrical systems. **(2 hrs)**

Building Maintenance: Scheduled and contingency maintenance planning, maintenance standards, economic maintenance decisions. **(8 hrs)**

Environmental factors: Thermal performance of buildings, comfort factors and measurements, climatic design, solar control and shading devices, louver design, ventilation, introduction to lighting, units of light, colour lamps, luminaries, daylight design of general lighting schemes, energy management and lighting, acoustical design of auditoria and noise control in buildings. **(10 hrs)**

References:

1. National Building Code of India, 2005
2. SP 64 (2001), SP 7 (2005), Bureau of Indian Standards
3. Kut Euring David, Illustrated enyclopedia of building services , E and F N Spon, London, 1993.
4. Building Services Research Information Association, Building services material handbook, E and FN Span, London, 1987.
5. Chadderton David V, Building services engineering, E and FN Span, London, 1991.
6. Shear Mel A , Handbook of building maintenance management, Reston Publishing, Reston, 1983.
7. Miller Elmo J, Blood Jerome W, Modern maintenance management, Taraporevala, Bombay, 1971.
8. Newbrough E T, Effective maintenance management, MGH New York, 1967.
9. Cowan Henry J, Solar energy applications in the design of buildings, Applied Science Publishers, London, 1980.
10. Durrant D W, Interior lighting design, Lighting Industry Federation, London, 1977.
11. Watson Lee, Lighting design handbook, Mc Graw Hill, New York, 1990

CIE 4403 CONSTRUCTION MATERIALS AND QUALITY MANAGEMENT (3 0 0 3)

Graduates of the program will be able to

- ***CO1: Compare various material management principles for optimising construction management practices***
- ***CO2: Apply selective control and codification techniques for inventory management.***
- ***CO3: Apply forecasting techniques and suitable strategy for effective material purchase and inventory management***
- ***CO4: Illustrate total quality management philosophies and their applications in construction.***
- ***CO5: Apply various quality control tools to identify/solve quality related issues in construction***

Introduction to the concept of Integrated Material Management: meaning, functions, and advantages, classical approach v/s integrated approach. **(3 hrs)**

Selective Inventory Control: meaning and need for selective inventory control, inventory related costs, selective control methods - FSN, HML, VED, SOS and GOLF methods, worked examples on ABC and XYZ analysis. **(4 hrs)**

Codification and Standardisation: need for material standardisation with examples, methods of variety reduction - Renard's numbers, 1-2-5 series, M-series with examples, meaning and need for grouping and coding, objectives and classification, alphabetical, alpha-numerical, numerical, Kodak and Brisch systems of coding. **(5 hrs)**

Material planning budgeting and procuring: Background to material plan, steps to prepare material plan-work breakdown structure (WBS) and bill of quantities (BOQ), exercise to prepare material plan. **(4 hrs)**

Purchase Management: Introduction, 5-R's, planning, organising and directing functions of purchase management, need for purchase system, computational techniques for price forecasting under fluctuating prices- thumb rule and time series- average method, moving average method, weighted moving average method, exponential smoothing, regression analysis, purchase strategy- conservative strategy, hind sight approach, purchasing capital equipment, source selection. **(9 hrs)**

Foundations of Total Quality Management: understanding quality, TQM philosophy: concept of Ishikawa, Taguchi, Shingo philosophies. Models and frame work. TQM Tools: An overview of flowcharts, check sheets, histogram, cause and effect diagrams, Pareto diagram, Scatter diagram and Control charts. **(5 hrs)**

ISO 9000 quality systems. ISO 14001 quality systems. **(2 hrs)**

Application of quality tools in construction management. **(2 hrs)**

Case problems on IMM concepts. **(2 hrs)**

References:

1. GopalKrishnanan P, Sundaresan M, Material Management Integrated Approach, Prentice Hall India, New Delhi, (1992)
2. Datta A.K, Material Management and Inventory Control: Principles and Practice, Jaico Publishing House, Bombay, 1988.
3. Woodside Gayle, Aurrichio Patrick ISO 14001, Auditing manual Mc-Graw Hill, New Delhi, 2000.
4. Bhat Sridhara K, Total Quality Management, Himalaya Publication House, Mumbai, 2007.
5. Oakland John S TQM, Text with cases, Butterworth- Heinemann, Oxford, 2006.

CIE 4404 CONTRACT MANAGEMENT (3 0 0 3)

Graduates of the program will be able to

CO1: Classify engineering contracts and their applicability in construction projects

CO2: Illustrate tendering process for inviting bids.

CO3: Identify relevant clauses for the contract's administration, performance, and breaches.

CO4: Decide a suitable method for resolving disputes in construction projects.

CO5: Compare International and domestic bidding process and international arbitration.

Introduction to contracts: Definitions, essentials for a legally valid contract, salient features of a contract, discharging of a contract, documents for an engineering contract, types of contracts: Classification based on − tendering process, economic consideration, tasks involved, main and subcontracts, features, merits, demerits, applicability of the various types of contracts. **(4 hrs)**

Tendering process: Definitions, list of documents, EMD, SD, preparation of enquiry documents, Invitation for tenders and sale of documents, preparation of tender documents and its submission, receipt of tender documents and its opening, evaluation of tender and award of contract – letter of award, letter of Intent, issues in tendering process: pre - registration, pre – qualification, nominated tendering, rejection of tenders, repeat orders, revocation of tenders, unbalanced bidding, cartel or collusion in tendering. **(7 hrs)**

Administration/Performance of contract: responsibilities (duties and liabilities) of principal and contractor, monitoring and quality control/assurance, settlement of claims − advances, bills, extension for time, extras and variations, cost escalations. Security deposit, retention money, performance bond, liquidated damages, penalties, statutory requirements, social obligations/responsibilities, labour welfare, reports, records, files. **(7 hrs)**

Breach of contract: Definition and classification, common breaches by – Principal, Contractor, damage assessment, claims for damages, quantum meruit, force majeure, or frustration. **(5 hrs)**

Dispute resolution: General, methods for dispute resolution − negotiations, mediation, conciliation, dispute resolution boards, arbitration, litigation/adjudication by courts.
Conciliation: Appointment of Conciliator, role of Conciliator, special features of conciliation
Dispute Resolution Boards (DRB) − Constitution of DRB, functioning of DRB, procedure for hearings, status of award. **Arbitration** – Arbitration agreement, terms of reference, litigation. **(7 hrs)**

International contracts / contracts with international funding: International competitive bidding, domestic preference, FIDIC documents, conditions, currency of bid and payment, escalation in foreign currency, financing of projects, applicable law and settlement of disputes, International arbitration. **(2 hrs)**

Tendering Process- Demonstration of standard contract documents, actual contract documents, case studies on various malpractices **(2 hrs)**

Case studies on dispute resolution **(1 hr)**

Exercise on preparing a dummy contract document as per Indian Contract Act 1872. **(1 hr)**

References:

1. Prakash V. A, Contracts Management in Civil Engineering Projects, NICMAR, 1997.
2. Patil B. S, Civil Engineering Contracts and Estimates, University Press, 2009.
3. John G. Betty, Engineering Contracts, McGraw Hills, 1993.
4. Albett Robert W, Engineering Contracts and Specifications, John Willey and Sons, New York, 1961.
5. Vaid K.N, Global perspective on International Construction Contracting Technology and Project Management, NICMAR, Mumbai, 1998.

II. ENVIRONMENTAL ENGINEERING

CIE 4405 AIR POLLUTION AND CONTROL (3 0 0 3)

Graduates of the program will be able to

CO1: Categorise various air pollutants to assess the air quality

CO2: Identify various meteorological factors and plume behavior to design stack height

CO3: Summarize the effects of air pollutants on local and global atmosphere

CO4: Apply air sampling techniques to analyse various air pollutants and identify control methods

CO5: Analyse air quality index to assess air quality based on relevant standards

Definition, classification and properties of air pollutants, behaviour of air pollutants, chemical reactions in atmosphere smog. Air pollution act **(6 hrs)**

Meteorology variables, primary and secondary lapse rate, inversions, stability conditions, general characteristics of stack plumes, design problems, stack height estimation. **(6 hrs)**

Effects of air pollution: human health, animals, plants and materials. Global effects of air pollution - acid rain, greenhouse effect, ozone layer depletion. Air quality and emission standards, gaussian plume model, box model and line model, air pollution index. **(11 hrs)**

Industrial plant location and planning. **(2 hrs)**

Sampling, analysis and control: measurement of gaseous and particulate pollutants, stack sampling, control methods, different types. **(4 hrs)**

Air pollution control technology

Particulate control technologies: gravity settler, cyclone separator, fabric filter, electrostatic precipitator, venturi-scrubber

Gaseous emission control technologies: selective catalytic reduction, scrubbers **(7 hrs)**

References:

1. Rao H.V.N and Rao M.N, Air pollution, Tata Mc Graw Hill, New Delhi, 1989.
2. Rao C.S, Environmental Pollution control, Wiley Eastern Ltd. New Delhi, 1995.
3. Wark Kenneth and Wamer C.F, Air Pollution, its Origin and Control, Harper and Row, 1998.
4. Sincero. A. P and Sincero G.A, Environmental Engineering, Prentice Hall, 2015.
5. Air Pollution - Sampling and Analysis – APHA, 1998.

CIE 4406 INDUSTRIAL WASTE WATER TREATMENT (3 0 0 3)

Graduates of the program will be able to

CO1: Summarize source, impact, and disposal standards of industrial wastewater

CO2: Explain the characteristics and evaluation technique for industrial wastewater

CO3: Illustrate the methods of industrial waste reduction to control waste generation

CO4: Make use of quality requirements for management of treatment plant

CO5: Identify wastewater treatment processes applicable for major industries.

Industries and Environment:

Industrial scenario in India, Industrial activity and environment - Uses of water by industry - sources and types of industrial wastewater - Industrial wastewater and environmental impacts - Regulatory requirements for treatment of industrial wastewater - Industrial waste survey - Industrial wastewater generation rates, characterization and variables - Population equivalent - Toxicity of industrial effluents and Bioassay tests. **(9 hrs)**

Treatment of Industrial Waste Water:

Volume reduction, strength reduction, equalization, neutralization and proportioning. Oil separation - flotation - precipitation - heavy metal removal - refractory organics separation by adsorption - aerobic and anaerobic biological treatment – sequencing batch reactors - high rate reactors - Ion exchange - membrane technologies - nutrient removal. **(9 hrs)**

Management of Treatment Plants:

Individual and common effluent treatment plants - joint treatment of industrial wastewater - zero effluent discharge systems - quality requirements for wastewater reuse - Industrial reuse - disposal on water and land - residuals of industrial wastewater treatment - quantification and characteristics of sludge - thickening, digestion, conditioning, dewatering and disposal of sludge - management of RO rejects. **(9 hrs)**

Practical Application in Industries:

Industrial manufacturing process description, wastewater characteristics, source reduction options and waste treatment flow sheet for textiles - tanneries - pulp and paper - sugar and distilleries - thermal power plants. **(9 hrs)**

References:

1. Eckenfelder, W.W, Industrial Water Pollution Control, Mc-Graw Hill, 2000.
2. Frank Woodard, Industrial waste treatment Handbook, Butterworth Heinemann, New Delhi, 2001.
3. Paul L. Bishop, Pollution Prevention: Fundamentals and Practice, Mc-Graw Hill International, Boston, 2000.
4. Nelson, L Nemerrow, Industrial wastewater Pollution, Addison-Wesley Publishing Company, 2000.
5. Mahajan S.P, Pollution Control in Process Industries, Tata McGraw Hill Publishing Company, 1998

CIE 4407 SOLID WASTE MANAGEMENT (3 0 0 3)

Graduates of the program will be able to

- ***CO1: Identify the source, composition and properties of solid waste for its characterization***
- ***CO2: Apply the appropriate methods of collection, storage and transfer of solid waste for effective management***
- ***CO3: Outline the significance of material recovery facility and transfer stations in solid waste management***
- ***CO4: Identify unit operations for the separation, processing, and recycling of solid waste***
- ***CO5: Identify the components of landfill for its operation and monitoring***

Introduction: Solid waste - definition, sources of wastes, classification, characterization, composition and properties of solid wastes. **(4 hrs)**

Waste generation collection and transportation: Solid waste generation, methods to estimate waste quantities, waste handling, separation, storage and processing at source, material recovery facility, collection rate, collection system, equipments used, manpower requirement, collection routes optimization, transfer station. **(12 hrs)**

Processing and recycling: Unit operations for separation and processing, size reduction, separation, density separation, biological processing, Incineration process and other methods of processing – combustion, pyrolysis, gasification, energy recovery system. **(8 hrs)**

Disposal: Methods, landfills- types, design of landfills, operation of landfills, leachates, closure of landfill, monitoring of landfill. **(8 hrs)**

Siting of wastes management facilities: Siting guidelines, planning and developing a site for solid waste management. **(4 hrs)**

References:

1. Tchobanoglous, G, Theisen, H and Vigil, S. A. Integrated solid waste management, McGraw-Hill international edition, Civil Engineering Series, 1993.
2. Bhide and Sundaresan, Solid Waste Management in Developing Countries – Indian National Scientific Documentation Centre, New Delhi, 2000.
3. Ramachandra T.V, Management of Municipal Solid Waste, Commonwealth of Learning, Canada and Indian Institute of Science, Bangalore, 2006.

CIE 4408 INTEGRATED WATER SHED MANAGEMENT (3 0 0 3)

Graduates of the program will be able to

CO1: ***Identify characteristics and the factors affecting watershed management***

CO2: ***Summarize the concepts of land capability for sustainable development of watershed***

CO3: ***Outline soil-water-plant relationship for effective water management***

CO4: ***Choose suitable methods of water and soil consersvation for integrated watershed ecology***

CO5: ***Select preventive measures for waterlogging problems for effective watershed management***

Introduction: Definition of watershed, watershed characteristics, Causes and consequences of watershed deterioration. Watershed management – definition and objectives, management plan, People's participation – mobilization, organization. **(4 hrs)**

Land Capability Classification: Introduction, purpose, characteristics, classification – classes, sub-class, units, mapping, characteristics of classes, capability ratings, land capability improvements, recommendations for land-use practices, sustainability. **(8 hrs)**

Agronomic Aspects: Soil-water-plant relationship, soil groups, classification of soil water, water holding capability, extraction by plants, depth and frequency of irrigation, maintaining soil fertility – essential nutrients, non-essential elements, salinity, alkalinity, reclamation; crop rotation. **(8 hrs)**

Water Conservation: Introduction, conservation methods for cropland, small storage structures planning and design– earthen bunds, weirs, farm pond, nala-bunding, losses and conservation techniques. **(6 hrs)**

Soil Erosion and Control: Soil erosion, erosion problems, need for soil conservation, conservation methods – agriculture and non-agriculture lands, watershed approach, vegetative cover – grassland management, agro-forestry. **(6 hrs)**

Waterlogging and Land drainage: Waterlogging –introduction, causes and effects, preventive measures, canal lining, land drainage – surface drainage, open drainage, sub-surface drainage, tile drainage, design and maintenance of drains. **(4 hrs)**

References:

1. E. M. Tideman, Watershed Management: Guidelines for Indian Conditions, Omega Scientific Publishers, 2007.
2. Ghanashyamdas Das, Hydrology and Soil Conservation Practices, Prentice Hall, India, 2008.
3. Dr. Rajvir Singh, Watershed Planning and Management, Yash Publishing House, 2000.
4. Pau A. Debarry, Watersheds – Processes, Assessment and Management, John Wiley and Sons, 2004.
5. P. Singh and Donald K. Frevert, Watershed Models, Taylor & Francis, 2010.

III. STRUCTURAL ENGINEERING

CIE 4409 STRUCTURAL DYNAMICS (3 0 0 3)

Graduates of the program will be able to

- ***CO1: Make use of various principles to formulate equation of motion***
- ***CO2: Solve equation of motion to determine the free vibration response of single degree of freedom system***
- ***CO3: Solve equation of motion to determine the dynamic response of single degree of freedom system subjected to harmonic loading***
- ***CO4: Solve equation of motion to determine the dynamic response of single degree of freedom system subjected to impulsive loading***
- ***CO5: Solve equations of motion to determine the free vibration response of multi degree freedom system***

Introduction: Objectives, dynamic loading, types of dynamic problems. Formulation of equations of motion: D'Alembert's principle, principle of virtual work, variational approach. **(6 hrs)**

Single Degree of Freedom Systems: Components of the system, un-damped and damped free vibrations, logarithmic decrement. Forced vibrations due to harmonic excitation – steady state and transient response, transmissibility, vibration isolation, evaluation of damping – half power band width method. Forced vibrations due to general dynamic loading – Duhamel's integral, response of SDOF system to impulsive loading, numerical methods – direct integration (constant and linear acceleration) of Duhamel's integral, trapezoidal rule and Simpson's rule. **(21 hrs)**

Multi-Degree of Freedom Systems: Equations of motion, un-damped and damped free vibration, Eigenvalues and Eigen vectors, orthogonality conditions. **(9 hrs)**

References:

1. Rao, S.D, Mechanical Vibrations, 3rd ed, Addison Wesely, NewYork, 1995.
2. Chopra A.K, Dynamics of structures – Theory and application to Earthquake Engineering, Prentice - Hall of India Pvt. Ltd. New Delhi, 2001
3. Seto, Mechanical vibrations, Schuam's Outline Series, McGraw Hill, Book Co, NewYork, 1964.
4. Paz. M, Structural Dynamics, 2nd ed, C.B.S. Publishers and Distributors, New Delhi, 2004
5. Mukhopadhay, Vibrations of structures and structural systems, Oxford and IBH, New Delhi, 2000.
6. Biggs J.M, Introduction to structural dynamics ,McGraw Hill publications, 1964.
7. Clough and Penzien, Dynamics of structures, McGraw Hill publications, 1993.
8. Humar, J.C, Dynamics of structures, Prentice hall, N.J, 2002.

CIE 4410 DESIGN OF STEEL STRUCTURES (3 0 0 3)

Graduates of the program will be able to

- ***CO1: Apply the limit state method to design a plate girder.***
- ***CO2: Apply the limit state method to design a gantry girder.***
- ***CO3: Apply the limit state method to design steel columns.***
- ***CO4: Apply the limit state method to design moment resisting connections.***
- ***CO5: Apply the limit state method to design composite beams and light gauge steel structures.***

Introduction, elements of plate girders with stiffeners, general considerations proportioning of web, proportioning of flanges, flexural strength, shear strength of web, shear buckling design methods. Plate girder end panel design, plate girder bearing stiffener, load carrying stiffener and intermediate web stiffeners design, welded connections design**.** **(12hrs)**

Introduction to Gantry girder, loads, design procedure, Gantry girder section check for fatigue strength. **(7 hrs)**

Design of compression member subjected to combined axial and uniaxial bending, combined axial and biaxial bending for column sections. Design of flexural members for unsymmetrical bending**.** **(8 hrs)**

Introduction to light gauge steel members, post buckling strength of the light gauge members, effective width calculations for unstiffened, stiffened and multi stiffened elements. Axially loaded compression members of light gauge steel members, laterally supported beams in light gauge steel members. **(7 hrs)**

Introduction to prefabricated steel structures and their applications**.** **(2hrs)**

References:

1. Duggal S.K, Limit State Design of Steel Structures, Tata McGraw Hill education private Limited, New Delhi, 2008.
2. Subramanian N, Design of Steel Structures, oxford university New Delhi, 2008.

Code books:

1. IS 800-2007, General construction of steel in code of practice, Bureau of Indian Standards, New Delhi.
2. SP-6 (Part I) Structural Steel Sections, Bureau of Indian Standards, New Delhi, 1964
3. IS 801-1975, Code of practice for use of cold framed light gauge steel, Bureau of Indian Standards, New Delhi.

CIE 4411 FINITE ELEMENT METHOD OF ANALYSIS (3 0 0 3)

Graduates of the program will be able to

CO1: Summarize fundamental principles of finite element method for analyzing various structures
CO2: Apply finite element method to determine member forces in axially loaded members
CO3: Apply finite element method to determine member forces in pin jointed structures
CO4: Apply finite element method to determine member forces in rigid jointed structures
CO5: Apply finite element method to solve plane stress and plane strain problems

Brief general description of the method, theory of elasticity - constitutive relationships – plane stress and plane strain**.** **(2hrs)**

Concept of an element, types of elements, displacement models - displacement models by generalized coordinates, shape functions for different types of elements. **(4hrs)**

Variational method of formulation- minimization of potential energy approach, formulation of element stiffness and consistent load vector for different types of elements **(4 hrs**)

Application of finite element method to analyze pin jointed and rigid jointed structures **(17hrs)**

Application of finite element method to analyse plane stress and plane strain problems using three noded triangular element and isoparametric four-noded element**.** **(9hrs)**

References:

1. Zinkiewiecz O.C, The Finite Element Method, (3e), Tata McGraw Hill Book Co, New Delhi, 1979.
2. Desai C.S and Abel J.E, Introduction to the Finite Element Method, (1e), CBS publications, New Delhi, 1987.
3. Krishnamoorthy C.S, Finite Element Analysis, (2e), Tata McGraw Hill Publishing Company Ltd, New Delhi, 1987.
4. Bathe K.J, Finite Element Procedures in Engineering Analysis, (2e), Prentice Hall Engle Wood, Cliffs, New Jersey, 1997.

CIE 4412 DESIGN OF FOUNDATION AND EARTH RETAINING STRUCTURES (3 0 0 3)

Graduates of the program will be able to

CO1: Determine the bearing capacity of soil for foundations.

CO2: Illustrate the design of foundations for various soil types.

CO3: Determine the response of piles to lateral loads.

CO4: Analyze the stability of retaining walls.

CO5: Determine the design parameters for machine foundations.

Bearing capacity: Brinch Hansen's, Meyerhoff's, Skempton's and Vesic's bearing capacity equations, plate load test and penetration tests. **(7 hrs)**

Piles subjected to lateral loads: Ultimate lateral resistance of piles in cohesionless and cohesive soils -Brom's theory **(5 hrs)**

Retaining walls: Principle and design of cantilever sheet pile wall and anchored sheet pile wall, stability analysis of cantilever retaining wall, counterfort retaining wall, cofferdams and braced excavation. **(14 hrs)**

Foundations in expansive soils: Problems of foundations on expansive soils, remedial measures, load carrying capacity of under-reamed pile foundations. **(4 hrs)**

Machine Foundations: Introduction, types of machine foundations, degree of freedom, general criteria - mass -spring - dash pot model, block foundation subjected to vertical, horizontal and rocking vibrations, elastic half space approach, soil spring constants and vibration isolation. **(6 hrs)**

References:

1. Bowles J.E, Foundation Analysis and Design, McGraw Hill, New York, 1997
2. Winterkorn H.F and Fange H.Y., Foundation Engineering Hand book, Van Nostand Reinhold Company, New York, 1991
3. Teng W.C, Foundation Design, Prentice Hall of India, New Delhi, 1981.
4. Swami Saran., Analysis and Design of Substructures, (2e), Oxford and IBH Publishers, 2015
5. Srinivasalu P and Vaidyanathan C.V, Hand Book of Machine Foundations, Tata McGraw Hill, 1987.

IV. TRANSPORTATION ENGINEERING

CIE 4413 URBAN MASS TRANSPORT SYSTEM (3 0 0 3)

Graduates of the program will be able to

CO1: Examine the demand characteristics to suggest a suitable transit system

CO2: Illustrate the operating elements to compare the modes of public transport system

CO3: Evaluate transit routes and networks to optimize transit systems

CO4: Develop transit schedule to optimize transit system operations

CO5: Develop layout for bus stops and terminals for an effective transit usage

Introduction: Recent trends in transit, mass transportation characteristics, demand characteristics- spatial, temporal and behavioral characteristic **(3 hrs)**

Public Transport: Definitions, modes of public transport and comparison, public transport travel characteristics, trip chaining, technology of bus, rail, rapid transit systems, basic operating elements. **(8 hrs)**

Transit Network Planning: Planning objectives, principles, considerations, transit lines types, geometry and characteristics, transit routes and their characteristics, timed transfer networks, prediction of transit usage, evaluation of network, accessibility considerations. **(8hrs)**
Transit Scheduling: Components of scheduling process, determination of service requirements, scheduling procedure, marginal ridership, crew scheduling. **(8 hrs)**

Terminals and Depot: Design of bus stops, design of terminals – principles of good layout, types of layout, truck terminal, depot location, twin depot concept, crew facilities and amenities. **(6 hrs)**
Transit Fares: Objectives in transit fare determination, fare collection, fare structures, special higher and lower fares, fare level. (**3 hrs)**

References:

1. Kristhi and Lal, Transporation Engineering, (3e), PHI, Delhi, 2008.
2. Dickey, J.W, et. al., Metropolitan Transportation Planning, TMH edition, 2002.
3. Vuchic V.R, Urban Public Transportation System and Technology, Prentice Hall, 2007
4. Agarwal M.K, Urban Transportation in India, INAE, Allied Publishers Ltd, 1996.
5. Grey G.E. and Hoel, LA, Public Transportation Prentice Hall, Englewood Cliffs, N.J, 1979

CIE 4414 URBAN TRANSPORT PLANNING (3 0 0 3)

Graduates of the program will be able to

- ***CO1: Conduct surveys to provide the data required for transportation planning***
- ***CO2: Apply regression models for trip generation in transport planning***
- ***CO3: Apply synthetic and non-synthetic models for trip distribution in transport planning***
- ***CO4: Apply mathematical models to evaluate mode choice and network assignment in transport planning***
- ***CO5: Apply mathematical models to evaluate land-use characterstics in transport planning***

Transportation Planning Process and Surveys: Scope of the subject, system approach to transport planning, definition of study area, zoning and Types of Surveys. (**6 hrs)**
Trip Generation: Introduction, trip purpose, factors governing trip generation and attraction, analysis of trip generation and attraction – regression and category analysis. (**6 hrs)**
Trip Distribution: Introduction, O-D Matrix, growth factor methods – uniform factor, average, fratar and furness methods, synthetic methods – gravity model, tanner model, intervening opportunities model and competing opportunities models. (**6 hrs)**
Traffic Assignment: Purpose of traffic assignment, principles, assignment technique – all or nothing assignment, multiple route assignment, capacity restraint assignment, diversion curves. (**6 hrs)**
Modal Split: Introduction, factors affecting modal split, modal split in the planning process, probit and logit analysis. (**6 hrs)**

Land-use Transport Models: Introduction, selection of land-use transport model, lowry derivative models, Garin-Lowry model. (**6 hrs)**

References:

1. Kadiyali L.R, Traffic Engineering and Transportation Planning, (6e), Khanna Publisher, New Delhi., 2000
2. Jotin Khisty C and Kent Lal B, Transporation Engineering-An Introduction, (3e), New Delhi 2016.
3. Papacostas C S, Fundamentals of Traffic Engineering, Prentice Hall., 2002
4. M.J.Bruton, Introduction to Transportation Planning – Hutchinson, London Ltd., 1975
5. B.G.Hutchinson, Introduction to Urban System Planning, Mc Gra Hill, 1974

CIE 4415 PAVEMENT MATERIAL AND DESIGN (3 0 0 3)

Graduates of the program will be able to

CO1: Identify the parameters for pavement design.

CO2: Assess the engineering properties of materials for pavement design

CO3: Apply mechanistic empirical methods to design flexible pavement.

CO4: Apply mechanistic methods to design rigid pavement.

CO5: Examine the serviceability of pavement to suggest suitable rehabilitation measures.

Introduction: Types of pavements, design wheel load – maximum wheel load, equivalent single wheel load, soil classification, strength determination of soil, strength properties of mineral aggregates. **(5 hrs)**

Design of Flexible Pavement: Stress in flexible pavements, design factors, design methods – IRC and AASHTO. **(6 hrs)**

Bituminous Materials: Introduction, properties of bitumen, test on bitumen and bituminous materials, binders, engineering properties of bituminous materials and mix design. **(4 hrs)**

Design of Rigid Pavement: Westergaard's design factors, critical load position and stress computation, temperature stresses, warping stresses, Bradburry equation for stress calculation, frictional stress, combination of stress, design of slab thickness, position and types of joints, design of joints – design of tie bars and spacing of dowel bars. **(8 hrs)**

Design of cement concrete mixes:- Factor considered, BIS method of cement concrete mix design, IRC method, Dry Lean Cement concrete, Concrete mix design for rural roads. Roller compacted concrete**.** **(3 hrs)**

Soil Stabilisation: Introduction, mechanical stabilisation, combining material to obtain required gradation, soil-lime stabilisation, lime-cement-Soil stabilization, soil-cement stabilization, soil bitumen stabilization. **(3 hrs)**

Design of Runway Pavement: Requirements, types of pavements, design of flexible pavement, design of rigid pavement. **(3 hrs)**

Pavement Failure and Evaluation: - Types of failure in flexible and rigid pavements, causes of failure and precautionary measures, structural evaluation of flexible pavement- Benkelman beam deflection method, falling weight deflectometer, GPR method, structural evaluation of rigid pavement- functional evaluation by visual inspection and unevenness measurements. **(4 hrs)**

References:

1. Khanna S.K and Justo C.E.G, Highway Engineering, (10e), Nemchand and Bros., Roorkee, 2015.
2. Kadiyali L.R and Lal N.B, Prinicples and Practices of Highway Engineering, (4e), Khanna Publisher, New Delhi, 2003.
3. E.J. Yoder, Principles of Pavement Design, (2e), John Wiley and Sons, Inc., New York, 1975.
4. Yang H. Huang, Pavement Analysis and Design, Prentice Hall, 2003.
5. IRC 37 2018 – Guidelines for the design of flexible pavements.
6. IRC 58 2015 – Rigid pavement design.

CIE 4416 TRAFFIC SYSTEM AND ENGINEERING (3 0 0 3)

Graduates of the program will be able to

CO1: Conduct surveys to provide the data required for traffic planning

CO2: Apply principles of traffic flow theories to evaluate road traffic performance

CO3: Examine the traffic facilities to regulate traffic flow

CO4: Apply the fundamentals of traffic flow to design traffic control systems

CO5: Examine the safety of transport facilities and suggest preventive measures.

Traffic Engineering Studies: Objectives and scope of traffic engineering, speed study, speed and delay study, traffic volume study, origin-destination study, capacity study, relation between speed, travel time and traffic volume, passenger car unit and level of service, traffic congestion study. **(6hrs)**

Traffic Flow Analysis: Lighthill and Whitham's theory, assumption, law of conservation of vehicles, approach to signalised intersections, shock wave, bottleneck and Greenberg's extension of law of continuity. **(6 hrs)**

Design of Traffic Facilities: Vehicular movements at intersections and conflict points, design of Channelizing islands, T, Y and AT-grade crossings including provision for safe crossing of pedestrians and cyclists, grade separated intersection, rotary, design of parking facilities, design of cycling tracks, bus stop location and bus bay design. **(8 hrs)**

Road Accidents Analysis: Causes, collection of accident data, mathematical equations in accident analysis, prevention. **(6hrs)**

Design of Traffic Control System: Traffic signs, markings and signals, principles of signal design, signal system, design and coordination, regulation of speed at different zones (areas) and intersections. **(6hrs)**

Design of Road Lighting System: Laws of illumination, distribution of light, glare problems, light at intersections, rotaries, bridges and in tunnels. **(4hrs)**

References:

1. Papacostas C S, Fundamentals of Traffic Engineering, Prentice Hall, 1990.
2. Jotin Khisty C and Lall, Transportation Engineering, (3e), Prentice Hall, 2000.
3. Khanna S.K and Justo C.E.G, Highway Engineering, (10e), Nemchand and Bros., Roorkee, 2015.
4. Kadiyali L.R, Traffic Engineering and Transportation Planning, (5e), Khanna Publisher, New Delhi, 2000.

OTHER ELECTIVES

CIE 4450 HYDRAULICS AND HYDRAULIC MACHINES (3 0 0 3)

Graduates of the program will be able to

CO1: Determine open channel flow parameters using energy and momentum principles

CO2: Illustrate the flow profiles to analyse uniform and non-uniform open channel flow

CO3: Make use of empirical approaches to design stable alluvial open channel

CO4: Apply impulse momentum principle to determine impact forces of jet on vanes

CO5: Analyse the design parameters of turbines and pumps to assess the performance

Fundamentals of Open Channel Flow: Classification of open channel flow, properties of open channels, velocity and pressure distribution, energy and momentum principles, uniform flow and critical flow - concepts, formulae and computations. **(6 hrs)**

Gradually Varied Flow: Basic assumptions, dynamic equation of GVF, characteristics and classification of flow profiles, Integration, step methods. **(5 hrs)**

Rapidly Varied flow: Characteristics of flow, flow over spillways, hydraulic jump- types, basic characteristics of the jump, surface profiles, location of jump, use of hydraulic jump as energy dissipater. **(5 hrs)**

Design of Stable Channels: Introduction, variables and conditions for design, empirical approach. **(4 hrs)**

Impulse Momentum Principle and its Applications: Momentum equation, impact of free jets - forces exerted by a jet on stationery, moving and series of flat plates - forces exerted by a jet on stationary, moving and series of curved vanes, Work done and efficiencies **(4 hrs)**

Hydraulic turbines: General layout of hydro power plants - classification of turbines - Impulse turbine and reaction turbines, description, typical dimensions and general principles of working of Pelton, Francis and Kaplan turbines. Work done and efficiencies of impulse and reaction turbines. (inlet and outlet velocity diagrams and solution to simple problems only) Governing of turbines, specific speed and unit quantities of different types of turbines, selection of turbines and functions of a draft tube. **(8 hrs)**

Hydraulic Pumps: Classification, description and general principle of operation of centrifugal pumps – work done and efficiencies, multistage pumps, pumps in series and pumps in parallel, specific speed of a pump. Reciprocating pumps, functions of air vessels. **(4 hrs)**

Reference:

1. VenTe Chow, Open Channel Flow, McGraw Hill Company Ltd, New York, 1985
2. Subramanya K, Flow in Open Channels, Tata McGraw Hill Publishing Company, New Delhi, 2005
3. Modi P.N. and Seth S.M, Hydraulics and Fluid Mechanics, Standard Book House, New Delhi, 2005
4. Bansal R. K. Fluid Mechanics and Hydraulic Machines, Laxmi Publishers, New Delhi, 2010

CIE 4446 ENVIRONMENTAL IMPACT ASSESSMENT AND AUDITING (3 0 0 3)

Graduates of the program will be able to

- ***CO1: Summarize need, procedure and conceptual approach for Environmental Impact Assessment***
- ***CO2: Illustrate the methodologies of impact identification and assessment parameters for developmental projects***
- ***CO3: Explain the procedure for prediction and assessment of impacts on various environmental attributes***
- ***CO4: Apply the procedure of EIA to assess the feasibility for various developmental projects***
- ***CO5: Explain the significance and process of Environmental monitoring and Auditing for environmental management***

Environmental Impact Assessment: Introduction, benefits and limitations, procedure of EIA in India. Conceptual approach in EIA **(4 hrs)**

Impact identification: Ad hoc, checklists, matrices, networks and overlay. **(6 hrs)**
Description of affected environment, indices and indicators for describing affected environment. **(3 hrs)**
Prediction and assessment of impacts on air, surface water, soil, noise, biological, cultural and socio-economic environment. **(12 hrs)**
Public participation in environmental decision making.
Preparation of written documentation. **(3 hrs)**
Environmental monitoring and its importance. **(2 hrs)**
EIA case study on a developmental project / activity **(3 hrs)**
Environmental audit: meaning, benefits, procedure and case studies **(3 hrs)**

References:

1. Barbara Caroll,. Environmental Impact Assessment Handbook: A Practical Guide for Planners, Developers and Communities. Thomas Telford, London, 2002.
2. Canter, L.W, Environmental Impact Assessment, (2e), McGraw-Hill, 1996.
3. Christopher Wood, Environmental Impact Assessment: A Comparative Review. Prentice Hall, New Jersey, 2003.
4. Riki Therivel, Peter Morris,. Methods of Environmental Impact Assessment, Spon Press, London, 2001.

CIE 4455 WATER RESOURCE PLANNING AND MANAGEMENT

(3 0 0 3)

Graduates of the program will be able to

CO1: Explain the importance of water resource planning for multipurpose projects

CO2: Make use of hydrological data and water balance models for water resources management

CO3: Explain the concepts of reservoir planning and operation for optimal design

CO4: Illustrate canal management systems and river training works

CO5: Identify the benefits of water resource projects considering economic, social and legal aspects.

Introduction: General, purposes served by water resources projects, classification, capability and requirement of multipurpose projects, steps involved in planning, common pitfalls. **(4 hrs)**

Water Resource Projects: Irrigation, water power, industrial and municipal supply, flood control, navigation, data collection – importance, storage, retrieval, extrapolation of data to ungauged catchments, simulated data, water balance models, conjunctive-use management. **(8 hrs)**

Reservoir Planning and Operation: Investigation, selection of site, reservoir capacity, choice of dams, economic height of dams, yield determination, demand patterns, optimal reservoir operation, rule curves, operating tables, reservoir induced seismicity. **(6 hrs)**

Water Conveyance System: Canal management – objectives and criteria, need and Inadequacies, methods for improving management, planning canal systems, canal regulation, delivery to farms, river Training –objectives, classification, methods, structures. **(6 hrs)**

Economics of Water Resource Projects: Benefits – primary, secondary, tangible intangible, cost-benefit analysis, apportionment of total cost, economic appraisal, economic and financial efficiency, project selection, water pricing, assessment of charges. **(8 hrs)**

Socio-Legal and Environmental Aspects: Riparian rights, human settlements, rehabilitation, environmental aspects, sustainable development. **(4 hrs)**

References:

1. Loucks, D.P and Eelco van Beek, Water resources systems planning and management: An introduction to methods, models and applications, UNESCO, 2005
2. Vedula, S and Mujumdar, P.P, Water resources systems: Modeling techniques and analysis, Tata McGraw Hill, New Delhi, 2005.
3. Mays, L.W. and Tung, Y.K, Hydro systems engineering and management, McGraw Hill, USA, 1992.
4. Simonovic, S.P Managing water resources: Methods and tools for a systems approach, UNESCO publishing, France, 2009.
5. Jain, S.K. and Singh V. P, Water Resources Systems Planning and Management, Elsevier, 2003.

CIE 4441 BRIDGE ENGNEERING (3 0 0 3)

Graduates of the program will be able to

CO1: Summarize the feasibility of site for bridge construction

CO2: Apply relevant standards to design pipe culverts

CO3: Apply relevant standards to design RCC bridges

CO4: Apply relevant standards to check the stability of bridge substructures

CO5: Apply relevant standards to design prestressed concrete bridge

Introduction: Definitions, components of a bridge, classification and importance. **(2 hrs)**

Investigation for Bridge: Site selection, data drawing, design discharge linear water way, economical span, location of piers and abutments, vertical clearance above HFL, scour depth, traffic projection, investigation report, choice of bridge type. **(7 hrs)**

Standard Specification for Road Bridge: IRC bridge code, determination of dead loads and live load, wind loads, longitudinal forces, centrifugal forces, horizontal forces due to water current, buoyancy effect, earth pressure, temperature effect, deformation stresses, erection stresses, seismic forces. **(2 hrs)**

Culverts: Pipe culverts. (**3 hrs)**

Substructure: Different types of bridge bearings, piers and masonry abutments, different types of foundation and their choices, wing walls. **(12 hrs)**

Concrete Bridges: T-beam reinforced concrete bridges and prestressed concrete bridges, RCC slab bridge. **(10 hrs)**

References:

1. T. R. Jagadeesh and M.A Jayaram, Design of Bridge Structures, Prentice Hall of India Pvt. Ltd, New Delhi, 2009
2. D.J.Victor, Essentials of bridge engineering, Oxford & IBH Publishing Co. Pvt. Ltd, 2019
3. Ponnusamy S, Bridge Engineering, Tata McGraw Hill Publishing Co, New Delhi , 2008
4. Whitney, C.S, Bridges, Greenwich House,1983
5. Singh, V.P Wells and Caissons, Nemchand and Sons,1979
6. N.K.Raju, Design of bridges, Oxford and IBH Publishing Co. Pvt. Ltd, 2019
7. Indian Road Congress Codes No.5, 6,18,21,24, Jamnagar House, Shah Jahan Road, New Delhi.

CIE 4442 COASTAL ENGINEERING (3 0 0 3)

Graduates of the program will be able to

CO1: Apply linear wave theory to determine wave parameters acting on structures at coast

CO2: Illustrate different coastal processes and their effect on waves

CO3: Identify suitable coastal protection work to mitigate coastal erosion

CO4: Categorize components of port and assess their impact on coastal ecosystem

CO5: Analyse wave forces by conducting preliminary analysis to design rubble mound breakwaters

Introduction to coastal engineering, importance, origin of coasts, wind, waves, tides and ocean currents, wave theories, wave energy and power, wave forces: Morison Regime. (**10 hrs)**

Coastal process: wave shoaling, wave refraction, wave diffraction, wave reflection, wave breaking, types of breakers, wave run-up, beach profile, beach process **(3 hrs)**

Coastal erosion: Erosion process, causes for erosion, littoral drift **(2 hrs)**
Coastal protection work: Seawalls and bulkheads, design of seawall and groins, jetties, off-shore breakwaters, artificial beach nourishment, new technologies of shore protection **(6 hrs)**

Environmental impact assessment: concept of coastal zone management, coastal eco-systems, coastal pollution and its implications. **(3 hrs)**

Port Planning: Introduction to harbours, general planning, classification of harbours, requirements, planning requirement for navigation channel, berth occupancy, graving and floating dry docks, planning requirement for slipways. **(4 hrs)**

Berthing structures: Types, loads on berthing structures, preliminary analysis and design. **(2 hrs)**

Breakwaters: introduction and types, rubble mound breakwaters, preliminary analysis and design. **(6 hrs)**

Reference:

1. Dominic Reeve, Coastal Engineering, (3e), CRSC press, 2018
2. S. Narasimhan, S. Kathiroli, Nagendra Kumar B, Harbour and coastal Engineering, Volume I & II, National Institute of Ocean Technology, NIOT, Chennai, Ocean and Coastal Engineering Publications, 2002.
3. William kamphuis J, Introduction to coastal engineering and management, (2e), world scientific publishing company, 2009.
4. Robert M Sorensen, Basic coastal engineering, (3e), Springer publication, 2005.
5. Coastal Engineering Manual (CEM), U.S.Army Corps of Engineer, Vicksburg, Miss, 2012.
6. Brunn P, Port Engineering Gulf, publishing Company, 1981.
7. Mani, J. S, Coastal Hydrodynamics, PHI Learning Pvt. Ltd, 2011.

CIE 4444 ELEMENTS OF EARTHQUAKE ENGINEERING (3 0 0 3)

Graduates of the program will be able to

- ***CO1: Summarize fundamental concepts of earthquake engineering and seismic effects on structures***
- ***CO2: Apply equivalent static load method to determine the storey shear forces***
- ***CO3: Apply standard code of practice for ductile detailing of structural members***
- ***CO4: Identify retrofitting and rehabilitation techniques to enhance the strength of structures***
- ***CO5: Interpret various damage mitigation strategies through relevant case studies***

Introduction: Plate tectonics, elastic rebound theory of earthquake, seismic zoning map of India, seismic waves, seismograms, earthquake magnitude and intensity, liquefaction of soils, seismic effects on various structures, response spectrum **(7 hrs)**
Equivalent static load method (IS 1893): seismic coefficients- evaluation, estimation of fundamental time period, base shear and its distribution. **(7 hrs)**

Ductile detailing of RC frames as per IS 13920 (1993): Ductile detailing of beams, ductile detailing of columns and frame members with axial load and moment **(7 hrs)**

Retrofitting and rehabilitation of structures, various techniques to control seismic response. **(8 hrs)**

Case studies related to seismic damages and damage mitigation strategies. **(7 hrs)**

Reference:

1. Pankaj Agarwal and Manish Shrikhande, Earthquake Resistant Design of Structures, Prentice-Hall of India Private Limited, New Delhi, 2006
2. Murty, C.V.R, Earthquake Tips- Learning Earthquake Design and Construction, National Information Centre of Earthquake Engineering, IIT Kanpur, 2005
3. Varghese. P. C, Advanced reinforced concrete design, Prentice-Hall of India Private Limited, New Delhi, 2005
5. IS:1893 (part 1)- 2002, Criteria for earthquake resistant design of structures, Bureau of Indian Standards, New Delhi
6. IS: 13920 – 1993, Ductile detailing of reinforced concrete structures subjected to seismic forces-code of practice, Bureau of Indian Standards, New Delhi

CIE 4447 FECAL SLUDGE AND SEPTAGE MANAGEMENT (3 0 0 3)

Graduates of the program will be able to

CO1: Identify types of sanitation system and its selection for septage management

CO2: Explain the methods for quantification of fecal sludge for its collection and transport

CO3: Identify the technologies for treatment and end use of fecal sludge

CO4: Illustrate the stages for planning of fecal sludge management

CO5: Explain the institutional framework and regulatory mechanism for fecal sludge management

Introduction: Sanitation system and technology, classification and types of sanitation systems, selection of sanitation systems, global and national statues of sanitation, fecal sludge and septage management (FSSM), need for septage management (**6 hrs)**

Characterization of fecal sludge: Quantification of faecal sludge, shit flow diagram, operational factors that impact the variability of FS characteristics (**3 hrs)**

Collection and transport of fecal sludge: Manual collection - cartridge containment devices, direct lift, manually operated mechanical collection- sludge gulper, diaphragm pumps, nibbler, fully mechanised collection- motorised diaphragm pumps, trash pump, motorised pit screw auger, gobbler, vehicle-mounted vacuum equipment, vacutug (**4 hrs)**

Treatment of fecal sludge: Treatment objectives, Kinetics of sludge utilization, Michaelis Menten Equation, Fractional saturation of enzymes. Imhoff tank, Settling-thickening tanks, Unplanted drying beds, Planted drying beds, Mechanical dewatering, Waste stabilization pond, Co-composting and Anaerobic digestion, LaDePa and black soldier fly, case studies (**13 hrs)**

End use technology options: Fecal sludge as a soil conditioner, use of liquid streams, fecal sludge treatment plant, operation and maintenance plans, steps for planning septage management, monitoring septage programs, integrated fecal sludge management systems, case studies **(6 hrs)**

Institutional Frameworks: Regulatory mechanism and finance, national policy for fecal sludge and septage management, 2017, regulation, act and programme, case studies **(4 hrs)**

Reference:

1. Strande, L, Ronteltap, M and Brdjanovic, D, Faecal Sludge Management: Systems Approach for Implementation and Operation, IWA Publising, London, 2014.
2. MoUD, National Policy on Fecal Sludge and Septage Management (FSSM), Ministry of Urban Development, New Delhi, 2017
3. MoUD, Primary report on Fecal Sludge and Septage Management (FSSM), Ministry of Urban Development, New Delhi, 2014.
4. Rohilla S K, Luthra B, Bhatnagar A, Matto M and Bhonde U, Septage Management: A Practitioner's Guide, Centre for Science and Environment, New Delhi, 2017.

CIE 4451 NON-DESTRUCTIVE TESTING OF CONCRETE STRUCTURES (3 0 0 3)

Graduates of the program will be able to

CO1: Apply visual inspection technique to identify surface defects in concrete structures.

CO2: Assess the condition of concrete structure using principles of elastic rebound

CO3: Assess the condition of concrete structure using principles of accoustic methods

CO4: Assess the reinforcement corrosion in concrete structures by electrical potential/resistivity methods

CO5: Apply electromagnetic methods to inspect subsurface defects in concrete structures

Introduction: - Importance and need of non-destructive testing, basic methods for NDT of concrete structures, qualification and certification, testing of concrete, comparison of NDT methods, Quality control. (**2hr)**

Visual Inspection Technique: Introduction, tools and equipment for visual inspection, general procedure of visual inspection, applications of visual inspection, sketches of typical defects found by visual inspection. (**3hrs)**

Schmidt Rebound Hammer Test: Fundamental principle, equipment for Schmidt/rebound hammer test, general procedure for Schmidt rebound hammer test, applications of Schmidt rebound hammer test, range and limitations of Schmidt rebound hammer test. **(3hrs)**

Ultrasonic Testing: - Pulse velocity test, Ultrasound pulse echo, Impact-echo/resonance frequency/stress wave test, relative amplitude method, velocity versus rebound number curves. **(5 hrs)**

Acoustic Emission Testing: Fundamental principle, equipment and sensor, Kaiser effect and facility ratio. **(5 hrs)**

Carbonation Depth Measurement Test: Fundamental principle, equipment for carbonation depth measurement test, general procedure for carbonation depth measurement test, range and limitations of carbonation depth measurement test. **(3hrs)**

Half-Cell Electrical Potential Method: Fundamental principle, equipment for half-cell electrical potential method, general procedure for half-cell electrical potential method, applications of half-cell electrical potential testing method, range and limitations of half-cell electrical potential inspection method. (**3hrs)**

Resistivity Measurement: - Fundamental principles, equipment, general procedure, applications. **(3hrs)**

Electromagnetic Methods of Testing Concrete: Fundamental principles, equipment for electromagnetic inspection, general procedure for electromagnetic testing, applications of electromagnetic testing method, range and limitations of electromagnetic testing method, work or site calibration. **(3hrs)**

Radiographic Testing: Fundamental principles, equipment for radiographic testing method, general procedure for radiographic testing method, applications of radiographic testing method. **(3 hrs)**

Ground Penetrating Radar: Fundamental principle, equipment for the GPR technique, application of GPR techniques, accuracy and interpretation of GPR, advantages and limitations of GPR techniques, safety advice, examples of inspection of structures. **(3hrs)**

References:

1. J.H.Bungey, The Testing of Concrete in Structures, 4th edition, Surry University Press, 2006.
2. Guidebook on Non-Destructive Testing Of Concrete Structures, Training Course Series No. 17, International Atomic Energy Agency, Vienna, 2002.
3. Christiane Maierhofer, Hans-Wolf Reinhardt and Gerd Dobmann, Non-Destructive Evaluation of Reinforced Concrete Structures, Vol. 1 & 2, 1st edition, Woodhead Publishing Limited, 2010.
4. V.M. Malhotra and N.J. Carino, Handbook On Nondestructive Testing of Concrete, 2nd, CRC Press, 2003.

CIE 4452 REMOTE SENSING AND GIS (3 0 0 3)

Graduates of the program will be able to

CO1: Explain concepts of electromagnetic spectrum and components of remote sensing

CO2: Apply image interpretation methods in base map preparation

CO3: Explain the concept of Geographic Information System to process satellite images

CO4: Apply vector models to develop thematic maps and interpret results

CO5: Apply remote sensing and Geographic Information System tools to prepare thematic maps

Electromagnetic Radiation: Electromagnetic Radiation. Sun as a source of energy. Electromagnetic spectrum. Stages in remote sensing. Interaction of electromagnetic radiation with atmosphere and earth surface features. Concept of Scattering, Absorption, Reflectance, Emission, Spectral Reflectance Curve, False Color composite, Scanners, Sensors, Limitations and advantages of remote sensing. **(3 hrs)**

Orbits and Resolution: Orbits- Sun synchronous, Geostationary, Near polar, Platforms, Swath, Concept of Spatial, spectral, radiometric and temporal resolution. **(4 hrs)**

Image interpretation- Visual and Digital: Visual interpretation, Elements, Visual Interpretation keys, Comparison between visual & digital interpretation, Basics of Digital Interpretation of images, operations in digital interpretation, application of Toposheet in base map preparation**.** **(9 hrs)**

Concept of GIS: Fundamentals and Objectives of GIS, Components of GIS, contributing disciplines and technologies. **(6 hrs)**

Representation of Real world in GIS: Raster, Vector, Definitions of Triangular irregular network (TIN) and Digital Elevation Model (DEM). **(8 hrs)**

Indian satellite program: Indian satellite program, Launch vehicles, application areas. **(3 hrs)**

Exercise on Civil engineering applications: Exercise on Remote sensing and GIS Applications in Civil Engineering. **(3 hrs)**

References:

1. Lillesand T. M., and Kiefer, R.W. *Remote Sensing and Image interpretation*, (6e), of John Wiley& Sons 2000
2. John R. Jensen, *Introductory Digital Image Processing: A Remote Sensing Perspective*, (2e),1995
3. Sabins, F. F. Jr, "*Remote Sensing Principles and Image interpretation*", W. H. Freeman & Co.1978
4. Allan Brimicombe, "GIS Environmental Modeling and Engineering", Taylor & Francis, 2003

CIE 4454 VALUATION OF REAL PROPERTIES (3 0 0 3)

Graduates of the program will be able to

CO1: Identify various values and outgoings for valuation of real properties.
CO2: Choose suitable method of depreciation to arrive at value of a real property.
CO3: Apply suitable methods to arrive at value of land and buildings.

CO4: Assess the value of leasehold and freehold properties.
CO5: Interpret the concepts of easement rights for valuation of real properties.

Introduction: Purpose of valuation, different forms of values, scrap value, salvage value, market value, factors affecting the value. **(2 hrs)**

Outgoings: Municipal and Govt. taxes, insurance, loss of rent, collection charges, sinking fund, annual repairs and maintenance. **(1 hr)**

Depreciation: Methods of calculation of depreciation, worked out examples. **(5 hrs)**

Rent: Definition, forms of rents, cost of structure. **(2 hrs)**

Cost of structure, BIS rules for measuring plinth area and cubical contents **(2 hrs)**

Methods of valuation: open land valuation, factors affecting intrinsic values of land, comparative method, abstractive method, belting method. **(5 hrs)**

Valuation of land with buildings: Rental method, land and building method, valuation on profit basis, direct comparison of capital value, residual or development method. **(8 hrs)**

Valuation of agricultural/farmlands. **(1 hrs)**

Additional Topics: Rights and liabilities of lessor and lessee, leasehold properties, freehold properties, year's purchase, capitalized value, obsolescence, amortization. **(6 hrs)**

Easements: Self-imposed, legally created, dominant and servient heritage, effect of easements on valuation. **(4 hrs)**

References:

1. Banerjee D.N, Principles and Practice of Valuation, Eastern law house, 1998.
2. Roshan H, Namavathi, Professional Practice, Lakhani Book Depot, 2001.
3. Mitra A.K, Theory and Practice of Valuation, Eastern law house, 1986.
4. Rao Gopinath C H, Valuation Practices of Immovable Properties, Edition 12, C H Gopinath Rao, Chennai, 2002.
5. Tedkay, Asserssment and Renovation of Concrete Structures, Longman Scientific and Technical, Harlow, England, 1992.
6. Jagadisa R, Structural Failures- Case Histories, Gcford andIBH Publishing Co. Ltd, New Delhi, 1995.
7. Raikar R.N, Diagnosis and Treatment of Structures in Distress, R & D Centre Structural Designers and Consultants Pvt. Ltd., Vashi, New Bombay, 1994.

CIE 4449 GROUND IMPROVEMENT TECHNIQUES (3 0 0 3)

Graduates of the program will be able to

- ***CO1: Apply suitable mechanical modification technique based on site condition to improve soil strength***
- ***CO2: Apply suitable hydraulic modification technique based on site condition to improve soil strength***
- ***CO3: Apply suitable physical, chemical and thermal modification techniques for soil stabilization***
- ***CO4: Identify suitable grouting techniques for a given application***
- ***CO5: Identify suitable modification by inclusion and confinement using different materials for ground improvement***

Introduction: Introduction to ground improvement, necessity of ground improvement, classification of ground modification techniques. **(2 hrs)**

Mechanical modification: Methods of compaction-shallow and deep compaction, properties of compacted soil, compaction control tests, vibratory methods **(6 hrs)**

Hydraulic modification: Objectives and techniques, traditional dewatering methods, well points, preloading, vertical drains-sand drains and prefabricated drains, vacuum consolidation, electro-kinetic dewatering. **(8 hrs)**

Physical and chemical modification: Modification by admixtures- granular admixtures, cement, lime, flyash and industrial wastes, construction techniques and applications. Stabilization of soil with stone columns and lime columns, modification at depth by grouting techniques, grouting plant, applications of grouting. **(9 hrs)**

Thermal modification: Thermal properties of soils, heat treatment of soils, ground freezing, strength and behavior of frozen ground **(2 hrs)**

Modification by inclusions: Evolution of soil reinforcement, principles and advantages of reinforced earth, behavior of reinforced earth, design methods, material specifications, soil nailing – applications, construction procedure, design and specification. Geo-synthetics - types, Civil Engineering applications of geo synthetics. **(7 hrs)**

Application of ground improvement techniques **(2 hrs)**

References:

1. M.R. Hausmann, Engineering Principles of Ground Modifications, (3e), McGraw Hill Publishing Co, 2002.
2. Moseley M.P, Ground Improvement, (2e), Blackie Academic and Professional, Boca Taton, Florida, USA, 2007.
3. Robert M. Koerner, Designing with Geosynthetics, (2e), Prentice Hall New Jersey, USA, 2000
4. Purushotham Raj, Ground Improvement Techniques, Laxmi Publications, New Delhi, 2016.
5. Das B.M, Principles of Foundation Engineering, CENGAGE Learning, 2010

CIE 4453 SOIL REINFORCEMENT AND GEOSYNTHETICS (3 0 0 3)

Graduates of the program will be able to

- ***CO1: Identify the materials and properties of geosynthetics for suitable ground improvement application***
- ***CO2: Solve problems related to earth retention, slope stability, and foundation using geosynthetics.***
- ***CO3: Solve the problems related to subgrade material in paved and unpaved roads using geosynthetics***
- ***CO4: Select suitable geosynthetics based on filtration and drainage requirements for a given application***
- ***CO5: Identify suitable geosynthetics to prevent landfill related issues.***

Different types of geosynthetics: Types of geosynthetics-geotextiles, geogrids, geonets, geocells, geo-composites, their manufacturing methods and uses. **(2hrs)**

Properties and tests on geosynthetics: Properties – physical, chemical, mechanical, hydraulic, endurance, degradation considerations, testing and evaluation of properties. **(3 hrs)**

Reinforced soil: Definition, historical background of reinforced soil, applications and potential of soil reinforcement, design mechanism and concept of reinforced soil, factors affecting the performance and behaviour of reinforced soil. **(2 hrs)**

Design of reinforced soil retaining walls: Mechanics of reinforced earth retaining wall, components of reinforced soil walls, design principles- internal and external stability, typical design problems. **(7 hrs)**

Design of reinforced earth foundations: Modes of failure of foundation, determination of force induced in reinforcement ties – location of failure surface, tension failure and pull out resistance, length of tie and its curtailment, bearing capacity improvement in soft soils, and typical design problems. **(5 hrs)**

Reinforced soil slopes: Causes for slope failure, construction of steep slopes with reinforcement layers on competent soils, different slope stability analysis methods like planar wedge method, circular slip methods, numerical problems, erosion control on slopes using geosynthetics. **(4 hrs)**

Soil nailing techniques: Concept, advantages and limitations of soil nailing techniques, comparison of soil nailing with reinforced soil, methods of soil nailing- construction sequence and components of system, design aspects. **(4 hrs)**

Pavement application: Geosynthetics for separation and reinforcement in flexible pavements, design by Giroud-Noiray approach, reflection cracking and control using geosynthetics. **(4 hrs)**

Drainage and filtration applications of geosynthetics: Different filtration requirements, filtration in different types of soils and criteria for selection of geotextiles, estimation of flow of water in retaining walls, and pavements, selection of geosynthetics. **(3 hrs)**

Construction of landfills using geosynthetics: Different components of landfills, collection techniques for leachate, application of different geosynthetics like geonets, geotextiles for drainage in landfills, use of geomembranes and geosynthetic clay liner (GCL) as barriers, issues in usage of geosynthetics. **(2 hrs)**

Reference:

1. Koerner. R.M, Designing with Geosynthetics, (5e), Prince Hall Publication, USA, 2005.
2. Sivakumar Babu G. L., An introduction to Soil Reinforcement and Geosynthetic, Universities Press, Hyderabad, 2009
3. Swami Saran, Reinforced Soil and its Engineering Applications, I. K. International Pvt. Ltd, New Delhi, 2006.
4. G.V. Rao, P.K Banerjee, J.T. Shahu,G.V. Ramana., Geosynthetics - New Horizons, Asian Books Private Ltd, New Delhi, 2004.
5. Jones CJEP, Earth reinforcement and Soil structures, Thomas Telford Publishing, London, 1996.

CIE 4448 GEO-ENVIRONMENTAL ENGINEERING (3 0 0 3)

Graduates of the program will be able to

CO1: Describe geo-environmental problems and relevant regulations.

CO2: Apply the concept and modelling of subsurface flow and contaminant transport.

CO3: Understand the In situ waste containment system for the landfills.

CO4: Design the liner system for engineered landfills.

CO5: Identify the soil and groundwater remediation technologies and waste recycle.

Introduction: Emergence of geo-environmental engineering and types of geo-environmental problems, relevant regulations, impact of regulations on geo-environmental Practice. **(2 hrs)**

Composition and Properties of Soils and Wastes: Composition of Soils, properties of soils (geotechnical and chemical), sources and classification of wastes, properties of Wastes. **(2 hrs)**

Subsurface Flow and Contaminant Transport: Introduction, hydrologic cycle and groundwater, aquifer, aquiclude, and aquitard, hydraulic head and aquifer properties, groundwater flow in aquifers, one dimensional steady flow, flow towards a pumping well, pumping and slug testing, two and three dimensional groundwater flow, flow modeling**,** contaminant types and geochemical processes, biodegradation**,** transport processes, transport and fate modeling. **(3 hrs)**

Subsurface Contamination: Sources, contaminants, regulations, and remedial approach, contaminated site characterization. **(2 hrs)**

In-situ waste Containment: Vertical barriers, bottom barriers, surface caps or covers, groundwater pumping systems, subsurface drains. **(2 hrs)**

Waste Containment Liner Systems: Introduction, low permeability soil liners, geomembrane liners, geosynthetic clay liners, geotextiles, geonets, geogrids, and geocomposites, interface shear strengths. **(3 hrs)**

Leachate Collection and Removal Systems: Criteria and components, Leachate quantity estimation, collection pipes, drainage materials, Leachate recirculation and treatment. **(3 hrs)**
Waste Containment System Liner Design: Leakage through liners and performance data, contaminant transport analysis, material stresses, geomembrane puncture resistance, waste and liner slope stability. **(4 hrs)**

Final Cover Systems: Regulatory requirements, cover systems and materials, Infiltration analysis, erosion assessment, drainage layer capacity, gas collection and management cover geomembrane analysis, waste and cover slope stability, waste settlement. **(3 hrs)**

Contaminated Site Investigation and Risk Assessment: Site investigation- geologic data, hydrogeologic data, chemical data, data analysis risk assessment. **(3 hrs)**

Soil and Groundwater Remediation Technologies: Soil remediation technologies- soil vapor extraction, soil washing, stabilization/solidification, electrokinetic remediation, soil remediation technologies- thermal desorption, vitrification, bioremediation, phytoremediation groundwater remediation technologies- pump-and-treat; In-situ flushing, permeable reactive barriers groundwater remediation technologies- In-situ air sparging, monitored natural attenuation, bioremediation. **(4 hrs)**

Beneficial use of Waste Materials- Recycling: Introduction, types and evaluation of waste materials, fly ash, blast furnace slag, foundry sand, papermill sludge, Municipal sludge, Incinerator ash (sewage sludge ash), glass, plastics, scrap tires, demolition debris and recycled concrete, wood wastes. **(3 hrs)**

Case studies: **(2 hrs)**

References:

1. Sharma, H.D and Reddy, K.R, Geoenvironmental Engineering: Site Remediation, Waste Containment, and Emerging Waste Management Technologies, John Wiley and Sons, Inc., 2004.
2. Sharma, H.D and Lewis, S.P, Waste Containment Systems, Waste Stabilization, and Landfills: Design and Evaluation, John Wiley and Sons, Inc, 1994.
3. Qian, X, Koerner, R.M, and Gray, D.H, Geotechnical Aspects of Landfill Design and Construction, Prentice Hall, 2002.
4. Daniel, David E, Geotechnical Practice for Waste Disposal, Chapman and Hall, 1993.

CIE 4445 ENGINEERING GEOLOGY (3 0 0 3)

Graduates of the program will be able to

CO1: Apply the knowledge of geological sciences to protect the earth's environment

CO2: Design solutions for the mitigation and prevention of natural disasters

CO3: Apply the knowledge of structural geology to analyze their impact on infrastructure

CO4: Appraise the groundwater, geomorphology and rock types for resource management

CO5: Apply remote sensing and GIS tools for civil engineering applications

Introduction: Different branches of geology, scope and importance of Engineering Geology in the field of Civil Engineering **(1 hr)**

Physical Geology: Origin of earth, interior structure of earth, differentiation between crust, mantle and core based on its physical and chemical properties, stratigraphic timescale **(2 hrs)**

Plate Tectonics and Seismology: Continental drift theories, different types of seismic waves, characteristics of strong ground motion and its effects **(2 hrs)**

Earthquake and Tsunami: Causative factors, recording instruments, Indian earthquakes, seismic zonation map of India **(2 hrs)**

Mineralogy: Introduction to mineralogy, rock-forming and ore minerals, their physical properties **(2 hrs)**

Petrology: Introduction to rock cycle, classification of rocks – igneous, sedimentary and metamorphic, textures and structures of these rocks, rocks as building materials **(4 hrs)**

Weathering and soil formation: Different agents of weathering- physical, biological and chemical, soil profile, classification of soils, soil erosion and prevention, conservation of soils **(2 hrs)**

Landforms and processes associated with river, wind, and groundwater: Origin and development of river systems, erosional and depositional features, aeolian landforms, aquifers, saline water intrusion, groundwater potential zones, groundwater prospecting **(5 hrs)**

Structural Geology: Dip and strike, outcrop, instruments used in structural geology, folds, faults, joints, unconformities – their types, origin and recognition in the field and importance in Civil Engineering projects **(5 hrs)**

Engineering Geology: Introduction, dams, reservoirs, tunnels, bridges, and highways – geological consideration in site selection **(4 hrs)**

Landslides: Causes and prevention, case studies with relevance to India **(1 hr)**

Remote Sensing and GIS: Introduction and applications in civil engineering **(2 hrs)**

Geophysical methods for sub-surface investigation: Gravity and magnetic methods **(1 hr)**

Climate Change: Introduction, causes and solutions to control climate change **(1 hr)**

Visit to the field: Field visit to observe various river erosional features and weathering, geological structures: folds, faults and joints in the rock formations **(2 hrs)**

References:

1. Parbin Singh, Engineering Geology, S.K. Kataria and Sons, New Delhi, 2002.
2. Mukherjee P.K, A text book of Geology, World Press, Kolkata, 2003.
3. Venkata Reddy D, Engineering Geology for Civil Engineering, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, 1995.
4. Internet resources.

CIE 4443 DISASTER MANAGEMENT & MITIGATION (3 0 0 3)

Graduates of the program will be able to

CO1: ***Identify types of disasters and institutional framework to assess the scale of disaster***

CO2: ***Apply the knowledge of technical planning and policy-making for vulnerability assessment of disaster***

CO3: ***Develop a critical capacity to evaluate the principles and practices of disaster recovery and management***

CO4: ***Identify the impact of climate change to monitor and mitigate its effect on the built environment***

CO5: ***Identify data, methods, and tools to enhance disaster monitoring and mitigation***

Understanding Disaster Management **(6 hrs)**

Introduction to natural resources, their distribution and challenges, natural disasters and their classification. Definition and scales of disasters, National Disaster Management Act and Policy, Institutional Framework and Mechanism, History and Status of Disaster Management in India, Terminology and Concepts in Disaster Risk Management

Introduction to Hazard **(8 hrs)**

Definition of hazard, Hazard estimation, Effect of hazard on structures; Vulnerability: Definition of vulnerability, Methodologies of vulnerability assessment, Evaluation, Building Types, Micro & Macro methods, Intensity Scales, Damage probability matrix, Vulnerability functions; Risk: Definition and components of risk, Fundamentals of risk analysis, Element at risk and their attributes, Seismic risk evaluation The assessment for different disaster types, the extreme event analysis

Recovery and reconstruction: **(11 hrs)**

Introduction, medium term and long term recovery aspects, community participation in defining objectives and their priorities. Rehabilitation: Physical and social infrastructure: Relocation and reconstruction of housing, public buildings, bridges, dams, archives and monuments, services such as water supply, electricity, waste management, communication, capacity building for self help construction, Numerical condition surveys for foundation, structural and functional deterioration, design criteria, materials and techniques. Predictive performance models, Repair and retrofitting: Earthquake damages of buildings, their

retrofitting, restoration, Superficial repair, structural repair, structural strengthening of habitable spaces, public buildings, roads, bridges, dams, culverts etc.

Climate Change: Its Impact and mitigation (11 hrs)

Sea- level increase in response to climate change and its impact on the coastal regions. Flood Control and Management: Detailed study of flood control methods - Flood plain zoning - Flood disaster monitoring and mitigation procedure

Drought Assessment: Drought definitions - NCA classification -Direct and indirect losses, Hydrology of arid and semi-arid zones, Drought indices, Drought severity assessment in meteorological, hydrological and agricultural aspects. Drought Monitoring and Management: Drought monitoring - Supply and demand oriented

measures - Drought Prone Areas Programme (DPAP) - Drought management.

Remote Sensing Applications: Principles of Remote Sensing - Satellites and sensors – Data products - Applications to flood and drought studies – Flood mapping - NDVI concepts

References:

1. Chen, A.Y; Pena-Mora, F. and Ouyang, Y. (2010). A collaborative GIS framework to support equipment distribution for civil engineering disaster response operations. Automation in Construction
2. Ghosh, G. K. (2006). Disaster Management. Delhi: A.P.H. Publishing Corporation
3. UNDP (2016) Disaster Risk Management Training Manual, 2016
4. Reiter, L (2001)., "Earthquake Hazard Analysis, Issues and Insights", Columbia University Press.
5. G. Bankoff, G. Frerks, D. Hilhorst (eds.) (2003). Mapping Vulnerability: Disasters Development and People. ISBN ISBN 1-85383-964-7.

OPEN ELECTIVES

CIE 4311 AIR AND NOISE POLLUTION (3 0 0 3)

Graduates of the program will be able to

- ***CO1: Categorise various air pollutants to assess the air quality***
- ***CO2: Identify various meteorological factors and plume behavior to design stack height***
- ***CO3: Summarize the effects of air pollutants on local and global atmosphere***
- ***CO4: Apply air sampling techniques to analyse various air pollutants and identify control methods***
- ***CO5: Summarize the effects of noise pollution to recommend suitable control measures***

Air Pollution: Definition, significance in general, air pollutants, sources, classification, emission, behavior of air pollutants, chemical reactions in atmosphere – smog **(5 hrs)**

Meteorology variables, primary and secondary lapse rate, Inversions, stability conditions, general characteristics of stack plumes, estimation of plume rise and stack height **(9 hrs)**

Effects of air pollution: on human health, animals, vegetation, materials and atmosphere, reactions of pollutants in the atmosphere and their effects **(5 hrs)**

Industrial plant location and planning. **(2 hrs)**

Sampling, analysis and control: Measurement of gaseous and particulate pollutants, stack sampling, smoke and smoke measurement, particulate emission control and other removal methods - absorption, adsorption and precipitation. Control methods - different types **(5 hrs)**
Global effects of air pollution: Acid rain, greenhouse effect, ozone layer depletion. Air quality and emission standards, air pollution act, air pollution index. **(3 hrs)**

Noise Pollution : Definitions – significance in general - sources, effects and control measures. **(2 hrs)**
Noise Impact Analysis: Sound pressure level, sound power, sound intensity, sound propagation, excess attenuation, wave divergence, noise scale and noise rating. **(4 hrs)**
Air and noise legislations. **(1 hrs)**

References:

1. Rao H.V.N. and Rao M.N, *Air pollution*, Tata Mc Graw Hill, New Delhi 1989.
2. Rao C.S., *Environmental Pollution contro*, Wiley Eastern Ltd. Delhi.1995.
3. Wark Kenneth and Wamer C.F, *Air Pollution its Origin and Control. Harper and Row*, Publ.
4. Sincero. A. P.and Sincero G.A. *Environmental Engineering*. Prentice Hall.
5. *Air Pollution* - Sampling and Analysis - APHA.

CIE 4312 CONTRACT MANAGEMENT FOR ENGINEERS (3 0 0 3)

Graduates of the program will be able to

- ***CO1: Classify engineering contracts and their applicability in manufacturing and service projects***
- ***CO2: Illustrate methods and various issues in tendering for inviting bids***
- ***CO3: Identify relevant clauses for the administration, performance and breaches as per Indian Contract Act 1872***
- ***CO4: Compare various methods to resolve disputes between parties in manufacturing and service projects***
- ***CO5: Compare International and domestic bidding process and arbitration***

Introduction to contracts: Definitions, Essentials for a legally valid contract, Salient features of a contract, Discharging of a contract, Documents for an Engineering Contract; Types of contracts: Classification Based on − Tendering Process, Economic Consideration, Tasks Involved; Main and Sub Contracts, Features, Merits, Demerits, Applicability of the various types of contracts. **(4 hrs)**

Tendering process: Definitions, List of Documents, EMD, SD, Preparation of Enquiry Documents, Invitation for Tenders and sale of Documents, Preparation of Tender Documents and its submission, Receipt of Tender Documents and its opening, Evaluation of Tender and Award of contract – Letter of Award, Letter of Intent, Issues in tendering process: Pre - Registration, Pre – Qualification, Nominated Tendering, Rejection of Tenders, Repeat Orders, Revocation of Tenders, Unbalanced Bidding, Cartel or Collusion in Tendering. **(9 hrs)**

Administration/Performance of contract: Responsibilities (Duties and Liabilities) of Principal and Contractor, Monitoring and Quality control/assurance, Settlement of claims − Advances, Bills, Extension for time, Extras & Variations, Cost Escalations. Security Deposit, Retention Money, Performance Bond, Liquidated Damages, Penalties, Statutory Requirements, Social Obligations/Responsibilities, Labour Welfare, Reports, Records, Files. **(8 hrs)**

Breach of contract: Definition and Classification, Common Breaches by – Principal, Contractor, Damage Assessment, Claims for Damages, Quantum Meruit, Force Majeure or Frustration. **(5 hrs)**

Dispute resolution: General, Methods for dispute resolution − Negotiations, Mediation, Conciliation, Dispute Resolution Boards, Arbitration, Litigation/Adjudication by courts.
Conciliation − Appointment of Conciliator, Role of Conciliator, Special Features of Conciliation
Dispute Resolution Boards (DRB) − Constitution Of DRB, Functioning of DRB, Procedure for Hearings, Status of Award. Arbitration – Arbitration Agreement, Terms of Reference. Litigation. **(8 hrs)**
International contracts / contracts with international funding: International Competitive Bidding, Domestic Preference, FIDIC Documents, Conditions, Currency of Bid and Payment, Escalation in Foreign Currency, Financing of projects, Applicable Law and Settlement of Disputes, International Arbitration. **(2 hrs)**

References:

1. Prakash V. A., *Contracts Management in Civil Engineering Projects*, NICMAR 1997
2. Patil B. S., *Civil Engineering Contracts and Estimates*, University Press 2009.
3. John G. Betty, *Engineering Contracts*, McGraw Hills 1993
4. Vasavada B. J. *Engineering Contracts and Arbitration*, (Self Publication by Jyoti B.` Vasavada) 1997.
5. Albett Robert W., *Engineering Contracts and Specifications*, John Willey and Sons, New York., 1961

CIE 4313 ENVIRONMENTAL MANAGEMENT (3 0 0 3)

Graduates of the program will be able to

- ***CO1: Identify the need and policies of environmental management system for sustainable development***
- ***CO2: Apply EIA and strategic assessment as a tool for environmental management***
- ***CO3: Explain the environmental auditing and life cycle assessment process***
- ***CO4: Summarize standard guidelines and requirement for environmental management system***
- ***CO5: Explain environmental economics and environmental design for sustainable practices***

The context of environmental management, overview of the state of the global environment, the earth's natural systems, sustainability and sustainable development–case study, introduction to the evaluation tools, environmental management system (EMS), organizational barriers, management responsibility, elements and extent of application, EMS structure. **(4 hrs)**

Environmental ethics, laws, International environmental legislation, Indian scenario, International policy, sectorial allocation. **(3 hrs)**

Environmental Impact Assessment- Purpose, objective, scope, steps, usage, EIS, SEA, difference between EIA and SEA, case study **(6 hrs)**

Life cycle assessment components of LCA, measuring environmental impact (lifecycle stages of product, boundaries, functional unit, issues at each life-cycle stage, benefits of LCA), strategic framework for LCA and LCA-a tool for sustainability-Case study **(5 hrs)**

ISO 14000-background, the ISO 14000 series, business and standards, voluntary, elements of EMS-environmental policy, planning, implementation and operation checking and correction action and management review–case study **(5 hrs)**

Auditing scope and objectives, standards for auditing, registration, implementing the audit, procedures, benefits, environmental auditing as a management tool-case study **(5 hrs)**

Newer concepts of corporate environmental management product design for the environment (ISO 14062), product stewardship, principles of clean production, packaging, sustainable procurement, the social responsibility function of corporations, eco-labelling, ecological and carbon footprints (ISO 14064-65)–case study **(6 hrs)**

Environmental economics and environmental design-application **(2 hrs)**

References:

1. RamachandraT.V, Environmental Management, IISC Bangalore, 2012
2. Lohani B.N, Environmental Quality Management, South Asian Publishers, New Delhi, 1984
3. MOEF, Government of India, Carrying Capacity Based Developmental Planning Studies for the National Capital Region, 1995-96.
4. Chanlett, Environmental Protection, McGraw Hill Publication, New York, 1973
5. Environmental Laws-MOEF, Government of India

CIE 4314 GEOLOGY FOR ENGINEERS (3 0 0 3)

Graduates of the program will be able to

CO1: Apply the knowledge of geological sciences to protect the earth's environment

CO2: Design solutions for the mitigation and prevention of natural disasters

CO3: Apply the knowledge of structural geology to analyze their impact on infrastructure

CO4: Appraise the groundwater, geomorphology and rock types for resource management

CO5: Apply remote sensing and GIS tools for engineering applications

Introduction: Different branches of Geology, scope and importance of Engineering Geology in the field of Civil Engineering. **(1 hr)**

Physical Geology: Origin of Earth, Interior structure of Earth, Differentiation between crust, mantle and core based on its physical and chemical properties, Stratigraphic timescale **(2 hrs)**

Plate Tectonics and Seismology: Continental drift theories, different types of seismic waves, characteristics of strong ground motion and its effects **(2 hrs)**

Earthquake and Tsunami: Causative factors, recording instruments, Indian earthquakes, seismic zonation map of India **(2 hrs)**

Mineralogy: Introduction to mineralogy, rock-forming and ore minerals, their physical properties **(2 hrs)**

Petrology: Introduction to rock cycle, classification of rocks – igneous, sedimentary and metamorphic. Textures and structures of these rocks, rocks as building materials **(4 hrs)**

Weathering and soil formation: different agents of weathering: Physical, biological and chemical; soil profile, classification of soils, soil erosion and prevention, conservation of soils **(2 hrs)**

Landforms and processes associated with river, wind, and groundwater: Origin and development of river systems, erosional and depositional features, aeolian landforms, aquifers, saline water intrusion, groundwater potential zones, groundwater prospecting **(5 hrs)**

Structural Geology: Dip and Strike, outcrop, instruments used in structural geology, folds, faults, joints, unconformities – their types, origin and recognition in the field and importance in civil engineering projects **(5 hrs)**

Engineering Geology: Introduction, Dams, reservoirs, tunnels, bridges, and highways – geological consideration in site selection **(4 hrs)**

Landslides: Causes and prevention; Case studies with relevance to India **(1 hr)**

Remote Sensing and GIS: Introduction and applications in civil engineering **(2 hrs)**

Geophysical methods for sub-surface investigation: Gravity and magnetic methods **(1hr)**

Climate Change: Introduction, causes and solutions to control climate change **(1hr)**

Visit to the field: Field visit to observe various river erosional features and weathering, geological structures: folds, faults and joints in the rock formations **(2 hrs)**

References:

1. Parbin Singh, *Engineering Geology*, S.K. Kataria and Sons, New Delhi. (2002).
2. Mukherjee P.K., *A text book of Geology*, World Press, Kolkata (2003).
3. Venkata Reddy D., *Engineering Geology for Civil Engineering*, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, (1995).
4. Internet resources.

CIE 4315 INTRODUCTION TO REMOTE SENSING AND GIS (3 0 0 3)

Graduates of the program will be able to

- ***CO1: Explain concepts of the electromagnetic spectrum and components of remote sensing***
- ***CO2: Apply image interpretation methods in base map preparation***
- ***CO3: Explain the concept of Geographic Information System to process satellite images***
- ***CO4: Apply vector models to develop thematic maps and interpret results***
- ***CO5: Apply remote sensing and Geographic Information System tools to prepare thematic maps***

Introduction, Basic concepts and physics of remote sensing, description of various satellite orbits **(3 hrs)**

Image composition, different types of resolutions, image correction, and noise removal **(10 hrs)**

Image enhancement, visual interpretation, image classification techniques and various kinds remote sensing data products and their purchase. **(9 hrs)**

Fundamentals of GIS, objectives, components of GIS, contributing disciplines and technologies, Raster, Vector, exercise on remote sensing and GIS application, definitions of Triangular Irregular Network (TIN) and Digital Elevation Model (DEM) **(7 hrs)**

In-class exercises in GIS- basic functionalities of software, map making, data manipulation and display **(5 hrs)**

Indian satellite program, launch vehicles, exercise on RS and GIS applications **(2 hrs)**

References:

1. Remote Sensing and Image Interpretation, Lille sand, Kiefer and Chipman, 2015.
2. John R. Jensen, Introductory Digital Image Processing: A Remote Sensing Perspective, (2e), 1995
3. Sabins F. F. Jr, Remote Sensing Principles and Image interpretation, W. H. Freeman and Co., 1978
4. Allan Brimicombe, GIS Environmental Modeling and Engineering, Taylor and Francis, 2003

CIE 4316 STRENGTH OF MATERIALS (3 0 0 3)

Graduates of the program will be able to

CO1: Illustrate bending moment and shear force diagram for beams subjected to various loads
CO2: Apply elastic theory to determine bending and shear stresses in beams and stress due to torsion in shafts
CO3: Apply Macaulay's method to determine deflection in statically determinate beams
CO4: Analyze the state of compound stresses using analytical and graphical methods
CO5: Apply buckling theories to determine the critical load for long columns

Introduction- Basic of Mechanics of solids.

Shear Force and Bending Moment in Beams: Introduction to types of beam, supports and loadings. Definition of bending moment and shear force, sign conventions, relationship between load intensity, bending moment and shear force. Shear force and bending moment diagrams for statically determinate beams subjected to point load, uniformly distributed load, uniformly varying load, couple and their combinations, related numerical problems. **(7 hrs)**

Bending and Shear Stresses in Beams: Introduction, pure bending theory, assumptions, derivation of bending equation, modulus of rupture, section modulus, flexural rigidity. Expression for transverse shear stress in beams. Bending and shear stress distribution diagrams for circular, rectangular, 'I', and 'T' sections, related numerical problems. **(7 hrs)**

Slope and Deflection of beam: Introduction, derivation of Euler-Bernoulli differential equation, Macaulay's method for determining slope and defection. Slope and deflection of simply supported, cantilever and overhanging beam with different load combinations, application problems. **(5 hrs)**

Torsion in Circular Shaft: Introduction, pure torsion, assumptions, derivation of torsion equation for circular shafts, torsional rigidity and polar modulus, power transmitted by a shaft, application numerical. **(6 hrs)**

Compound Stresses: Introduction, state of stress at a point. General two dimensional stress system, principal stresses and principal planes. Mohr's circle of stresses, numerical problems **(6 hrs)**

Columns and Struts: Introduction, short and long columns. Euler's theory- assumptions, derivation for Euler's buckling load for different end conditions, limitations of Euler's theory. Rankine-Gordon's formula for columns, related numerical problems **(5hrs)**

References:

1. Basavarajaiah B.S and Mahadevappa P, Strength of Materials, University Press (India) Pvt. Ltd., 2010.
2. Ferdinand P. Beer, E. Russell Johnston and Jr.John T. D., Mechanics of Materials, (3e), Tata McGraw-Hill, 2012
3. Andrew Pytel, Singer F. L, Strength of Materials Harper and Collins 1987.
4. Young D. H, Timoshenko S.P, Elements of Strength of Materials, East West Press Pvt. Ltd., 2014.
6. Bansal R.K, A Textbook of Strength of Materials, Laxmi Publications, 2014.
7. Rattan S.S, Strength of Materials, McGraw Hill Education (India) Pvt. Ltd., 2013.

***

Course Details
L&T EduTech

S. No.	Course Category	Course Name	Credits	Semester	Selection Mode
1	Flexible Core C Multi-Modal Transportation Infrastructure	Highway Planning, Design & Construction	3	V	Mandatory Course
2		Airports & Seaports Engineering	3	VI	Mandatory Course
3		Metro Rail Transportation Systems & Construction	3	VI	Mandatory Course
4	Minor Specialisation in Advanced Practices in Construction (OR)	Formwork Engineering Practices	3	VI	Learners will be given an option to select one Minor Specialization among the two. Thesemester wise courses delivered shall be based on opted Specialisation.
5		Deep Excavations, Foundations & Tunnels	3	VI	
6		Building Information Modelling in Construction	3	VII	
7		Sustainability Practices in Design of Building	3	VII	
8	Minor Specialisation in Integrated Building System Design	Pre-Engineered Buildings	3	VI	
9		Mechanized Construction Techniques	3	VI	
10		Integrated Approach to Building Services	3	VII	
11		Concrete Building Systems Design	3	VII	
12	Other Electives	Bridge Engineering Design & Practices	3	VII	Mandatory Course
13		Geospatial Techniques in Practice	3	VII	Mandatory Course
14		Project Management from Professionals	3	VII	Mandatory Course

Flexible Core C.

Multi-Modal Transportation Infrastructure

1. Highway Planning, Design & Construction : **V Semester**
2. Airports & Seaports Engineering: VI Semester : **VI Semester**
3. Metro Rail Transportation Systems & Construction : **VI Semester**

Minor Specialization

Advanced Practices in Construction

1. Formwork Engineering Practices : **VI Semester**
2. Deep Excavations, Foundations & Tunnels : **VI Semester**
3. Building Information Modelling in Construction : **VII Semester**
4. Sustainability Practices in Design of Building : **VII Semester**

Integrated Building System Design

1. Pre-Engineered Buildings : **VI Semester**
2. Mechanized Construction Techniques : **VI Semester**
3. Integrated Approach to Building Services : **VII Semester**
4. Concrete Building Systems Design : **VII Semester**

Other Electives

1. Bridge Engineering Design & Practices : **VII Semester**
2. Project Management for Professionals : **VII Semester**
3. Geospatial Techniques in Practice : **VII Semester**

Flexible Core C.

Multi-Modal Transportation Infrastructure

1. **Highway Planning, Design & Construction**

   Introduction and Subgrade Materials I Pavement Materials I Principles and Design of Pavements I Plants and Machinery, Planning for Pavement Construction I Construction Practices of Flexible and Rigid Pavement

   Reference Books:
   1. Relevant IRC and IS Codes of Practices, MoRTH Specification
   2. Course content on LMS of L&T EduTech

2. **Airports & Seaports Engineering**

   Commercial Airport Master Planning (ICAO) | Airside and Landside Infrastructure Planning, Terminal Buildings | Runway and Taxiway Design | Navigational Aids | Flexible and Rigid Airfield Pavement Construction | Overview of Marine Structures | Port Operation and Components | Dredging, Shore Protection, and Reclamation Work | Design Considerations and Functional Requirements of Marine Structures | Breakwater and Berthing Structures.

   Reference Books:

   E-resources: L&T EduTech LMS

3. **Metro Rail Transportation Systems & Construction**

   Transit oriented development | Planning of Metros | MEP systems in Metros | Contracts and Quality | Elevated stations and viaducts | Underground stations and tunnels | Earth retaining systems | Analysis and design of stations (STAAD.Pro) and diaphragm walls | Future trends in transportation.

   Reference Books:
   1. Indian Standard code- IS 456
   2. E-learning content on L&T EduTech Platform

Advanced Practices in Construction

1. **Formwork Engineering Practices**

   Types of formwork | Codes & standards | Formwork planning & monitoring | Analysis, design of formwork systems | Detailed drawing of formwork systems | Bill of quantities | Formwork failures & remedies

   Reference Books:
   1. IS14687:1999 Guidelines for falsework for concrete structures
   2. ACI 347-04 Guide to Formwork for Concrete
   3. Concrete pressure on formwork (R108D) - CIRIA
   4. DIN 18218 Pressure of fresh concrete on vertical formwork
   5. IS 456: Plain and Reinforced Concrete - Code of Practice

6. IS: 800-2007 General Construction in Steel - Code of Practice
7. IS: 399–1963 Classification of Commercial Timbers and their Zonal Distribution
8. IS: 883-1994 Design of Structural Timber in Building - Code of Practice
9. IS: 4990–1993 Plywood for concrete shuttering work
10. IS: 2750-1964 Steel Scaffoldings
11. IS 1161: 2014 Covers Steel Tubes for Structural Purposes
12. Course content on LMS of L&T EduTech

2. Deep Excavations, Foundations & Tunnels

Construction, design & case studies of bored cast in-situ pile, driven cast in-situ pile, precast driven piles, precast concrete piles in pre-bored holes & under reamed piles | Methods of load testing | Overview of spun piles, helical piles, micro piles, CFA piles, steel piles | Quality Checks for Pile Foundation | Software analysis using PLAXIS 2D | Challenges faced during execution.

Reference Books:

1. Indian Standard code- IS 456, Guidance on embedded retaining wall design CIRIA- C760
2. David Chapman, Nicole Metje, Alfred Stark " Introduction to Tunnel Construction "2017 , CRC Press
3. M. Ramachandran ,"Metro Rail Projects in India- A Study in Project Planning "2011, Oxford University Press
4. E-learning content on L&T EduTech Platform

3. Building Information Modelling in Construction

Evolution of BIM | Introduction to BIM | Design authoring using Revit | Visualisation | Interference/clash check using Revit | Documentation & Common Data Environment (CDE) | Level of Development | Field BIM | Introduction to 5D & Asset Information Model (AIM)

Reference Books:

1. ISO 19650 Building Information Modelling (BIM)
2. L&T EduTech LMS

4. Sustainability Practices in Design of Buildings

Climatology, Heat gain through building elements | Comfort in building (Thermal, visual and Acoustics) | Energy management system | Building Life Cycle Assessment | Stages ingreen project management | Green building rating system | Web tools - Solar rooftop calculator and ECONIWAS

Reference Books:

Course content on LMS of L&T EduTech

Integrated Building System Design

1. **Pre-Engineered Buildings**

   Introduction to PEB, Materials used in PEB and its specifications I Components and Loads on a PEB I Connections in PEB and Codes of Practice I Design of a PEB warehouse and Industrial PEB structure I Base connection, Drawings in a PEB, Stakeholders of a PEB & Fabrication, Erection and Execution aspects I

   Reference Books:

   1. IS 800:2007, IS 1893, IS 875 (Part 1-5), SP6, NBC (Part 1 & 2) : 2016
   2. Course content on LMS of L&T EduTech

2. **Mechanized Construction Techniques**

   Formwork Basics | Various Types of Formwork -Vertical Applications, Horizontal Applications | Planning, Monitoring and Design Concepts in Formwork | Quantity take off and Cost Estimation| Modular and Special formwork| Construction Equipment and its management | Heavy lifts, Hydraulic systems and design | Application of Hydraulics | Lift Plan and Alternative Methodologies

   Reference Books:

   1. Jha, K.N., Formwork for Concrete Structures, First Edition, McGraw Hill. 2012
   2. Construction Planning, Equipment and Methods" by Robert Peurifoy and Clifford J Schexnayder
   3. E-learning content on L&T EduTech Platform

3. **Integrated Approach to Building Services**

   Building Power Distribution & Schemes | Power Distribution Transformer | Diesel Generator Set | High Voltage & Medium Voltage Panels | Distribution Boards (DB) | Lighting Fixtures & Control System | Lighting Types & Calculations |Substation Building | Air Conditioning Introduction & Psychrometry | Pressurization Systems | Chilled Water System & Air Handling Units| Fire Protection System Basics | Pump and Sump Capacity Calculation | Life Safety Importance | Smoke Control & Fire Zoning | Plumbing Engineering | Water Demand for Occupancies | Water Treatment Units| Storm Drainage System | Extra Low voltage for infrastructure and its principles

   Reference Books:

   Course content on LMS of L&T EduTech

4. **Concrete Building Systems Design**

   IS Codes & NBC | Design Basis Report | Structural Modelling & coordination | Calculations for gravity and Lateral loads | Structural scheme setting | Analysis in software - ETABS & SAFE | RCC Design including Flat slab & Shear wall | Detailing | Bill of quantities.

Reference Books:

1. IS 456, IS 1893, IS 875 (Part 1-5), SP 16, SP 34, IS 13920
2. National Building Code Vol 1&2 : 2016
3. L&T EduTech LMS

Other Electives

1. **Bridge Engineering Design & Practices**

Design Loads on Bridges according to IRC code | Grillage and Transverse Analysis using STAAD.Pro | Single Cell Box Culvert | Beam & Slab type Super-structure | Bearings | Pier Cap and pier | Pile & Well Foundation | Composite Plate Girder Bridge | Construction stage monitoring | Periodic inspection methods | Erection methods -Segmental, Balanced Cantilever and Cable -Stayed Bridges

Reference Books:

1. Relevant Indian Road Congress (IRC) codes and Ministry of Road Transport & Highway (MORT) Specifications
2. Course content on LMS of L&T EduTech

2. **Project Management for Professionals**

Project management fundamentals & methodology |Emerging trends |Scope management |Scheduling|Costing & estimation |Quality management |Project risk management |Communication & negotiation |Resource management |MS Project

Reference Books:

1. Project management institute, Guide to the Project Management Body of Knowledge (PMBOK® Guide), seventh edition/2022.
2. Course content on LMS of L&T EduTech

3. **Geospatial Techniques in Practice**

Geospatial technology Survey & mapping |Sensors & scanners | Platforms |Satellite positioning |Stockpile quantity estimation |Subsurface investigation & bathymetry survey |Spatial analysis & GIS database |Decision support systems |Future trends

Reference Books:

L&T EduTech, LMS