Course Structure & Curriculum

[As Per New Education Policy]

For

B.Tech. Programme

In

Civil Engineering

[Effective from 2022-2023]

Department of Civil Engineering

Motilal Nehru National Institute of Technology Allahabad Prayagraj -211004 (India)

Course Structure for B. Tech. Programme in Civil Engineering

I Year (1st Semester)

S. No.	Category	Course Title	Hours per Week			Credits
			L	T	P	
1	CEF	Physics/Chemistry	2	1	2	4
2	CEF	Mathematics-I	3	1	0	4
3	HSS	Professional Communication	2	0	2	3
4	CEE/CES	Building Engineering-I	2	0	2	3
5	CEE	Plumbing & Sanitation Systems	2	0	2	3
6	PCE	Engineering Graphics and 3D Modelling	1	0	2	2
7	PCE	Environment and Climate Change	2	0	0	2
8	EAA	Professional Ethics & Social Values	-	-	4	2
		Total	**14**	**2**	**14**	**23**

I Year (2nd Semester)

S. No.	Category	Course Title	Hours per Week			Credits
			L	T	P	
1	CEF	Chemistry/Physics	2	1	2	4
2	CEF	Mathematics-II	3	1	0	4
3	PCE	Introduction to AI and Machine Learning	2	0	2	3
4	CES	1. Sustainable Urban Habitat 2. Introduction to Transportation Systems 3. Infrastructure Engineering	2	1	0	3
5	CEE/CES	Building Engineering-II	2	1	0	3
6	PCE	Workshop & Manufacturing Processes	1	0	2	2
7	EAA	1. Yoga & Ayush 2. NCC/NSS 3. Foreign Lang/Ancient/Indian Lang. 4. Health & Nutrition 5. Nutrition & Balanced Diet 6. Self Defence	-	-	4	2
		Total	**12**	**4**	**10**	**21**

II Year (3rd Semester)

S. No.	Category	Course Title	Hours per Week			Credits
			L	T	P	
1	HSS	Management Concepts and Applications	3	0	0	3
2	EAA	Extra Academic Activity-B	0	0	4	2
3	CEE	Solid Mechanics	3	1	2	5
4	CEE	Concrete Technology & Construction Management	3	0	2	4
5	CEE	Fluid Mechanics & Hydraulic Machines	3	1	2	5
6	CEE	Engineering Geology	2	0	2	3
7	CEE	Surveying	3	1	2	5
Total			**17**	**3**	**14**	**27**

II Year (4th Semester) *

S. No.	Category	Course Title	Hours per Week			Credits
			L	T	P	
1	HSS	Business Economics	3	0	0	3
2	CEE	Water Supply Engineering	3	1	0	4
3	CEE	Structural Analysis-I	3	1	0	4
4	CEE	Highway & Traffic Engineering	3	1	0	4
5	CEE	Geotechnical Engineering-I	3	0	2	4
6	CEE/CES	Geoinformatics	3	1	0	4
7	EAA	Extra Academic Activity (EAA)-B	Listed Below#			2
		Minors Course*				
Total			**18**	**4**	**2**	**25**

** Minor courses for students of other department students will be offered in 4th, 5th & 6th semester*

#India's Knowledge System (2L), Sanskrit Language for Engineers (2L), National Cadet Corps (NCC) (1L+ 2P), Foreign Language (German) (2L), Foreign Language (French) (2L), Foreign Language (Spanish) (2L), Social and Community Services (4P)

III Year (5th Semester) *#

S. No.	Category	Course Title	Hours per Week			Credits
			L	T	P	
1	CEE	Pavement Engineering & Management	3	0	2	4
2	CEE	Geotechnical Engineering-II	3	1	2	5
3	CEE	Waste Water Engineering	3	1	2	5
4	CEE	Concrete Structures-I	3	1	0	4
5	CEE	Irrigation Engineering	3	1	0	4
6	CEE	Structural Analysis-II	3	1	2	5
		Minors Course*				
		Total	**18**	**5**	**8**	**27**

** Minor courses for students of other department students will be offered in 4th, 5th & 6th semester*

III Year (6th Semester) *#

S. No.	Category	Course Title	Hours per Week			Credits
			L	T	P	
1	CEE	Steel Structures	3	1	2	5
2	CEE	Concrete Structures-II	3	0	2	4
3	CEE	Design of Hydraulic Structures	3	1	0	4
4	CEE	Software Applications in Civil Engineering	0	0	4	2
5	CEE	Engineering Hydrology	2	1	0	3
6	CEE/CES	Professional Elective-I	3	0	0	3
7	HSS	Soft Skills and Personality Development	2	0	1	3
		Minors Course*				
		Honours Course#				
		Research Course#				
		Total	**16**	**3**	**9**	**24**

** Minor courses for students of other department students will be offered in 4th, 5th & 6th semester*

 # Honours & Research Courses will be offered in 6th & 7th semester in addition to the courses listed in 6th & 7th sem

IV Year (7th Semester)

S. No.	Category	Course Title	Hours per Week			Credits
			L	T	P	
1	CEE	Railway & Airport Engineering	3	1	0	4
2	CEE	Earthquake Resistant Design	2	1	0	3
3	CEE/CES	Professional Elective-II	3	0	0	3
		Honours Course#				
		Research Course#				
		Total	**8**	**2**	**0**	**10**

 # Honours & Research Courses will be offered in 6th & 7th semester in addition to the regular courses.

IV Year (8th Semester) [Only B.Tech/Honours/Research/Minors]

S. No.	Course Type	Course Title	Credits
1	IG/GP	Job Orientation/GP/Research@	14
		Total	**14**

@ The students opting for Research in addition to the Regular B.Tech Programme will have to do a Research Project in the Institute in 8th semester.

Acronyms

Acronym	Course Category Nomenclature
PCE	Professional competence enhancing course(s)
CEF	Core Engineering Foundation Course(s)
CES	Core Engineering Supporting Course (s)
CEE	Core Engineering Essentials Course(s)
EAA	Extra Academic Activity-related courses
HSS	Humanities and Social Sciences
IG	Internship
GP	Group Project

POOLS OF COURSES FOR HONOURS (OFFERED IN 6th & 7th SEMESTERS)

*** Credit Requirement: 20 credits**
*** For completing the credit requirement, student can opt only for maximum two courses from any pool.**

S. No.	Course Title	Hours per Week			Credits
		L	T	P	
Structural Engineering					
1	Structural Dynamics	3	1	0	4
2	Advanced Concrete Design	3	1	0	4
3	Finite Element Method	3	1	0	4
4	Seismic Design of Structures	3	1	0	4
Transportation Engineering					
1	Traffic Flow Theory	3	1	0	4
2	Intelligent Transportation Systems	3	1	0	4
3	Software Applications in Transportation Engineering	3	0	2	4
Environmental Engineering					
1	Environmental Chemistry & Microbiology	3	1	0	4
2	Principles of Biological Wastewater Treatment	3	1	0	4
3	Physicochemical Processes for Water & Waste Water Treatment	3	1	0	4
Geotechnical Engineering					
1	Geotechnical Earthquake Engineering	3	1	0	4
2	Rock Engineering	3	0	2	4
3	Ground Improvement	3	1	0	4
Water Resources and Geoinformatics					
1	Artificial Intelligence for Remotely Sensed Image Processing and GIS	3	1	0	4
2	Advanced Geological and Geophysical Investigations	3	1	0	4
3	Water Resources and Climate Change	3	1	0	4
4	Hydropower Engineering	3	1	0	4
Construction Engineering					
1	Advanced Construction Management	3	1	0	4
2	Energy Efficient Construction	3	1	0	4
3	3D Modelling and 3D Printing for Civil Engineering	3	1	0	4

Note: The courses in pools will be offered based on the availability of the faculty

POOLS OF COURSES FOR RESEARCH (OFFERED IN 6TH & 7TH SEMESTER)

*** Credit Requirement: 20 credits**
*** Student can opt all courses from one specialization only**

POOL I-STRUCTURAL ENGINEERING					
S. No.	**Course Title**	**Hours per Week**			**Credits**
		L	T	P	
1	Structural Dynamics	3	1	0	4
2	Advanced Concrete Design	3	1	0	4
3	Elective-I	3	1	0	4
4	Elective-II	3	1	0	4
5	Elective-III	3	1	0	4

Electives

S. No.	Elective-I	S. No.	Elective-II	S. No.	Elective-III
1	Advanced Concrete Technology	1	Durability Assessment and Structural Strengthening of Reinforced Concrete	1	Structural Health Monitoring
2	Theory of Elasticity and Plasticity	2	Finite Element Method	2	Soft Computing Methods in Engineering Problem Solving
3	Seismic Design of Structures	3	High Rise Structures	3	Optimization Methods in Civil Engineering

POOL II-TRANSPORTATION ENGINEERING					
S. No.	**Course Title**	**Hours per Week**			**Credits**
		L	T	P	
1	Transportation System Planning	3	1	0	4
2	Intelligent Transportation Systems	3	1	0	4
3	Elective-I	3	1	0	4
4	Elective-II	3	1	0	4
5	Elective-III	3	1	0	4

Electives

S. No.	Elective-I	S. No.	Elective-II	S. No.	Elective-III
1	Software Applications in Transportation Engineering	1	Traffic Flow Theory	1	Artificial Intelligence for Remotely Sensed Image Processing and GIS
2	Principles of Transportation Systems	2	Highway Geometric Design	2	Soft Computing Methods in Engineering Problem Solving
3	Logistics Transportation Systems	3	Intersection Design	3	Optimization Methods in Civil Engineering

POOL III-GEOTECHNICAL ENGINEERING					
S. No.	Course Title	Hours per Week			Credits
		L	T	P	
1	Geotechnical Earthquake Engineering	3	1	0	4
2	Rock Engineering	3	0	2	4
3	Elective-I	3	1	0	4
4	Elective-II	3	1	0	4
5	Elective-III	3	1	0	4

Electives

S. No.	Elective-I	S. No.	Elective-II	S. No.	Elective-III
1	Ground Improvement	1	Earth and Earth Retaining Structures	1	Advanced Foundation Engineering
2	Finite Element in Geotechnical Engineering	2	Geo-technology for climate change and sustainable development	2	Theory of Elasticity and Plasticity
3	Clay Mineralogy and Expansive soil	3	Stability analysis of soil and rock slopes	3	Soft Computing Methods in Engineering Problem Solving

IV-ENVIRONMENTAL ENGINEERING					
S. No.	Course Title	Hours per Week			Credits
		L	T	P	
1	Physicochemical Processes for Water & Waste Water Treatment	3	1	0	4
2	Environmental Chemistry & Microbiology	3	1	0	4
3	Elective-I	3	1	0	4
4	Elective-II	3	1	0	4
5	Elective-III	3	1	0	4

Electives

S. No.	Elective-I	S. No.	Elective-II	S. No.	Elective-III
1	Principles of Biological Wastewater Treatment	1	Hazardous Waste Management	1	Soft Computing Methods in Engineering problem Solving
2	Rural Water Supply & Wastewater Disposal	2	Air and Water Quality Modelling	2	Design of Environmental Engineering Structures
3	Advance Wastewater Treatment	3	Groundwater Contamination and Pollution Transport	3	Artificial Intelligence for Remotely Sensed Image Processing and GIS

PROFESSIONAL ELECTIVE-I (III Year 6th Semester)

S. No.	Course Title	Hours per Week			Credits
		L	T	P	
1	Prestressed Concrete	3	0	0	3
2	Precast and Modular Construction	3	0	0	3
3	Geotechnical Processes	3	0	0	3
4	Geotechnical Explorations	3	0	0	3
5	Air & Noise Pollution Control	3	0	0	3
6	Environmental Impact Assessment	3	0	0	3
7	Rural Roads	3	0	0	3
8	Astronomy and Photogrammetry	3	0	0	3
9	Open Channel Hydraulics	3	0	0	3
10	Isotope applications in Water Resource Management	3	0	0	3

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POOL OF COURSES FOR PROFESSIONAL ELECTIVE-II (IV Year 7th Semester)

S. No.	Course Title	Hours per Week			Credits
		L	T	P	
1	Bridge Engineering	3	0	0	3
2	Construction Equipment's & Techniques	3	0	0	3
3	Repair and Retrofitting of Structures	3	0	0	3
4	Environmental Geotechnology	3	0	0	3
5	Geosynthetics	3	0	0	3
6	Industrial Wastewater Treatment & Reuse	3	0	0	3
7	Solid & Biomedical Waste Management	3	0	0	3
8	Transport Asset Management	3	0	0	3
9	Geological Studies for Rock Cut Slope Stability Analysis	3	0	0	3
10	Water Resources Systems Management	3	0	0	3

MINOR OPTIONS FOR OTHER DEPARTMENT STUDENTS (Offered in 4th, 5th & 6th)

*** Credit Requirement: Minimum 16 credits**

OPTION 1- Minors in "AI and IoT based Infrastructure Management"

S. No.	Course Title	Hours per Week			Credits	Prerequisite	Remarks
		L	T	P			
1	Internet of Things and Sensors	3	1	0	4	Nil	Compulsory
2	Geoinformatics	3	1	0	4	Nil	Compulsory
3	BIM and Infrastructure Management	3	1	0	4	Nil	Compulsory
4	Infrastructure Engineering	2	1	0	3	Nil	Compulsory
5	Elective				3	Nil	To be selected from elective pool

Electives

S. No.	Course Title	Hours per Week			Credits	Prerequisite	Remarks
		L	T	P			
1	Building Engineering-I	2	0	2	3	Nil	Elective
2	Transport Asset Management	3	0	0	3	Nil	Elective

OPTION 2- Minors in "Smart Cities"

S. No.	Course Title	Hours per Week			Credits	Prerequisite	
		L	T	P			
1	Sustainable Environmental Planning and Management for Urban Settlements	3	1	0	4	Nil	Compulsory
2	Energy Efficient Construction	3	1	0	4	Nil	Compulsory
3	Geoinformatics	3	1	0	4	Nil	Compulsory
4	Sustainable Urban Habitat	2	1	0	3	Nil	Compulsory
5	Elective				3	Nil	To be selected from elective pool

Electives

S. No.	Course Title	Hours per Week			Credits	Prerequisite	Remarks
		L	T	P			
1	Infrastructure Engineering	2	1	0	3	Nil	Elective
2	Introduction to Transportation Systems	2	1	0	3	Nil	Elective

CIVIL ENGINEERING DEPARTMENT
B.Tech Syllabi (As per NEP-2020)

B.Tech I Year (1st Semester)

CEN11101 BUILDING ENGINEERING-I CREDIT: 04(2-0-2)

Course Outcomes	
CO1.	To understand the fundamentals of Surveying and distance measurement and apply in field.
CO2.	To understand bearings, angles and methods of measurement; and apply in the knowledge in field Surveying.
CO3.	To acquire knowledge of levelling in Surveying; and apply in different operations in Civil Engineering projects.
CO4.	Apply the knowledge of building types, building planning and evaluation of building using Green Rating.
CO5.	Understand damp proofing and anti-termite treatment and various components of building likes-different types of staircases, doors and windows, floors.

Course Content

Unit	Content	Number of Lectures
1	Plane and Geodetic Surveying; Principles of Surveying, Classification of Surveys; Plan, Map and Scale; Distance measurement; Chainage and offsets; Tape corrections; EDM.	**04**
2	Designation of Bearings and inter-conversion; Included Angles from Bearings; Prismatic & Surveyors Compass; Vernier Theodolite- Parts and Temporary Adjustments; Measurement of Angles- Repetition and Reiteration method.	**04**
3	Direct Levelling- Basic Terms and Definitions, Fly levelling, Reduction of Field Notes by Height of Instrument and Rise & Fall methods; Dumpy and Tilting Levels; Balancing of Sights; Curvature and Refraction Correction; Reciprocal Levelling.	**04**
4	Types of buildings; Concept of functional planning and efficiency of buildings; Recommendations of NBC 2016 for building planning; Introduction to Green Rating of buildings.	**05**
5	Components of building and area considerations; Damp proofing and anti-termite treatment; Planning, design and construction of vertical circulation means; Different types of floors and roofs; Roof treatments for thermal insulation and water proofing; Different types of doors, windows & ventilators.	**07**

Practical's		
1	To study topographical maps and prepare conventional symbols chart	
2	To measure bearings of a closed traverse by prismatic compass and to adjust the traverse.	
3	To find out reduced levels of given points using dumpy level.	
4	To perform fly levelling with a tilting level.	
5	Planning of buildings with given site conditions.	
6	Details of different types of staircases and section through foundation and super structure	
7	Details of commonly used doors and windows	
8	Computation of thermal load and associated design of building for thermal comforts and lighting.	
9	Evaluation of a buildings for Green Rating.	

References: -

- *Surveying (Vol-I): B.C. Punmia & A.K. Jain, Laxmi Publications, New Delhi.*
- *Surveying (Vol-I): S.K. Duggal, Tata McGraw-Hill Pub. Co. Ltd., New Delhi.*
- *Plane Surveying & Higher Surveying: A.M. Chandra, New Age Int. Ltd., New Delhi.*
- *Surveying: , A. Bannister, S. Raymond, R. Baker, Pearson Education, New Delhi.*
- *A Text Book of Building Construction: S.K. Sharma, S. Chand & Company Ltd.*
- *A Text Book of Building Construction: B.C. Punmia, Laxmi Publications, Delhi.*
- *A Text Book of Building Construction: S.P. Arora, S. P Bindra, Dhanpat Rai & Sons, Delhi.*
- *Manual of tropical housing and building: O.H. Koenisberger, Orient Longman Ltd., Madras.*
- *TERI Guide to Sustainable Building Design, TERI, New Delhi*

CEN11102 PLUMBING & SANITATION SYSTEMS Credit: 04 (2-0-2)

Course Outcomes	
CO1.	Identify & select the plumbing tools/plumbing materials and fittings.
CO2.	Select appropriate pipes and carry out pipe fitting after carrying out operations like cutting, bending, threading, joining, aligning and other necessary operations
CO3.	Understand the simple water supply system, trace leakage and repair water supply system

CO4.	Prepare the plan, prepare and inspect domestic drainage system
CO5.	Select and install appropriate sanitary appliances

Course Content		
Unit	**Content**	**Number of Lectures**
1	Sources of water; wells, tube wells, method of construction, types of pumps, with valves and fittings Collection of surface water and its conveyance through pipes, pipe appurtenances, pipe laying, Rainwater harvesting	**04**
2	Water distribution systems; Distribution reservoirs; Storage of water in buildings; Types of tanks; Laying water supply pipe lines, corrosion in pipes and their control measures. Housing Plumbing- Systems and other accessories, Appurtenances in distribution system, Fire hydrants, Concepts of rural water supply and sanitation.	**05**
3	Principles of sanitation, Study of Indian standards and plumbing by-laws (NBC). Introduction to various sanitary pipes, joints, fittings and fixtures, their function, placement and constructional details	**05**
4	Study of internal & external drainage system of various buildings including small residences, apartments, public buildings etc.– one pipe and two pipe system, Single stack system, testing of house drains, Gradients used in laying drains and sewers, Self-cleaning and Sanitary fillings.	**05**
5	Plumbing equipment's and operations, Repairing of various types of fittings and fixtures, Study, construction and maintenance of privies, Traps, Septic tanks, Soak pits, and public sewage line. Study of Disposal systems for domestic effluent from fitting to sewer line. Study of low-cost sanitary systems (sulabh complexes) and CBRI criteria.	**05**
Practical		
1	To demonstrate and provide hand-on training on various types of water pipes such as PVC pipes, G.I. pipes copper pipes etc. used in building	
2	To demonstrate and provide hand-on training on Plumbing Drainage System in Buildings such as Soil Pipes and Waste pipes, vent pipe, rainwater pipe and ant siphonage pipes etc	

3	To demonstrate and provide hand-on training on Plumbing Sanitary Fittings used in Buildings	
4	To demonstrate and provide hand-on training on Different Types of Pipe Joints	
5	To demonstrate and provide hand-on training on Different Types of connection	
6	To demonstrate and provide hand-on training on different types of valves and fitting in pipes.	
7	To demonstrate and provide hand-on training on different types of Tools Used in Common Plumbing Works:	
8	To demonstrate and provide hand-on training on different Types of Pipes.	
9	To demonstrate and provide hand-on training on different Types of connections for Sanitary Plumbing and drainage	

References: -

- *Environmental Engineering Vol. I: Water Supply Engineering, S.K. Garg, Khanna Publishers, Delhi, 1998.*
- *Environmental Engineering Vol. II: Sewage Disposal & Air Pollution Engineering, S.K. Garg, Khnna Publishers, Delhi, 1998.*
- *Elements of Public Health Engineering, K.N. Duggal, S. Chand & Co, New Delhi, 2000.*
- *Water Supply & Sanitary Engineering, S.C. Rangawala, Charotar Publishing House, Anand, India, 2000.*
- *Water Supply and Sanitary Installations, A C Panchdhari, New Age International, New Delhi, 1993.*
- *CPHEEO Manual on Water Supply and Treatment*
- *CPHEEO Manual on Sewerage and Sewage Treatment.*

CEN11600 ENGINEERING GRAPHICS AND 3D MODELLING
Credit: 03 (1-0-2)

Course Outcomes	
CO1.	Understand standard symbols, convention, rules and methods for preparing engineering drawings; and apply the concepts of drawing orthographic projections, isometric projections and perspective views.
CO2.	Apply orthographic projection for points, lines and simple solid objects; sections and associated sectional details of solid objects.

CO3.	Understand and apply the knowledge in the development of surfaces and isometric views of simple solid objects.
CO4.	Understand drawings related to simple mechanical components.
CO5.	Develop 3D-models for a simple building and to use it for engineering applications.

Course Content

Unit	Content	Number of Lectures
1	Standard methods; Convention, rules and methods for preparing engineering drawings; Types of projection methods; Orthographic projection of points.	**02**
2	Orthographic projection of lines and simple solids	**02**
3	Sections of solids through Orthographic projection; Development of Surfaces; Isometric Projections; Drawing of simple mechanical assemblies.	**03**
4	Integration with building design process; Evolution and development of 3D-Modelling; Object-based parametric modeling.	**03**
5	Mass and concept modeling; Detailed modeling; Creating, importing and modifying families of objects and elements; Architecture, MEP and structural applications; Creating plans, sections, details, schedules, cover page; Conflicts/Interference checking.	**02**

References: -

- *N.D. Bhatt, Engineering Drawing [2000] , Charotar Publishing House , Ananad*
- *N.D. Bhatt, Mechanical Engineering Drawing [2000], Charotar Publishing House, Ananad*
- *Eastman, C., Teicholz, P., Sacks, R., & Liston, C. (2011). BIM handbook: A guide to building information modeling for owners, managers, designers, engineers and contractors. John Wiley & Sons.*
- *Krygiel, E., & Nies, B. (2008). Green BIM: successful sustainable design with building information modeling. John Wiley & Sons.*
- *Issa, R. R., & Olbina, S. (Eds.). (2015, May). Building Information Modeling: Applications and Practices. American Society of Civil Engineers.*
- *Eynon, J. (2016). Construction Manager's BIM Handbook. John Wiley & Sons.*
- *Duell, R., Hathorn, T, and Hathorn, T.R. (2015), Autodesk Revit Architecture 2016 Essentials, Wiley and Sons, Inc*
- *http://www.autodesk.com/education/free-software*
- *IS: 962 -1989 : Architectural and Building Drawing*

B.Tech I Year (2nd Semester)

CEN12400 SUSTAINABLE URBAN HABITAT Credit: 03 (2-1-0)

Course Outcomes	
CO1.	To describe the state of urbanization and identify associate environmental effects
CO2.	To explain the approach of sustainability in the design of urban habitat as per the requirements of sustainable development goals
CO3.	To bring out the characterization of future cities for sustainable development
CO4.	To compute the sustainability indicators for urban habitat along with green rating system.
CO5.	To describe Sustainability considerations in planning of Smart City, greenfield smart city project intelligent buildings, alternative building enclosures such as LHP, Urban heat Island mitigation strategies.

Course Content

Unit	Content	Number of Lectures
1	Classes of urban vulnerability; Urban inequality and implications for the environment; State of the environment in cities; Effects of environmental changes; Drivers of environmental change; Local and global environment effects of cities; Impacts on human health and well-being in cities; Urban land management, environmentally sustainable and just transformations.	**05**
2	Terminology, Sustainable Buildings–Siting, Form, Design Site Design and Development, External Development and Landscape, Envelope Optimization, Sustainable Materials , Classification of materials based on energy intensity, Traditional efficient materials, water and Waste water management , Building Services Optimization, Construction Practices, Environmental Descriptors in Urban environment.	**05**
3	Dimensions of integrated action for urban transformation, Net-zero circular cities, Resilient & sustainable cities, Inclusive and just cities, urban metabolism, Outline of a circular economy	**05**
4	Carbon Foot Prints and Ecological Foot Prints, Green Rating systems, Efficiency of vernacular architecture and traditional building systems, road map for rural habitat	**05**
5	Greenfield smart city project intelligent buildings, alternative building enclosures LHP, Urban heat Island mitigation strategies.	**04**

References: -

- *Campbell, S. (1996). Green cities, growing cities, just cities? Urban planning and the contradictions of sustainable development. Journal of the American Planning Association, 62(3), pp. 296-312.*
- *National Building Code of India 2016, Volume 2 BIS, New Delhi*

- *https://unhabitat. or "Ecological Footprint." The Sustainable Scale Project, Santa-Barbara Family Foundation, www.sustainablescale.org/conceptualframework/understandingscale/measuringscale/ecologicalfootprint.aspx.*
- *Kevin Lynch- Imageability of City*
- *Ralph Thomlinson -Urban structure, social and Spatial character of cities*
- *Bernard Feildan- Conservation of Historic Buildings*
- *The Environment (protection) Act 1986*
- *The Energy Conservation (Amendment) Act 2001, and Amendments*
- *Energy conservation building code 2007*
- *National building code – India*
- *smartcities.gov.in*

CEN12401 INTRODUCTION TO TRANSPORTATION SYSTEMS
Credit: 03 (2-1-0)

Course Outcomes	
CO1.	Understand the importance, type and structure of transportation systems
CO2.	Understand the characteristics, components and elements of road transportation.
CO3.	Understand the characteristics and elements of rail transportation.
CO4.	Understand the characteristics, components and structure of air transportation
CO5.	Understand the elements and attributes of the water transportation.

Course Content

Unit	Content	Number of Lectures
1	Introduction, Significance and Benefits of Transportation, Modes of Transports and Characteristics of Transportation Systems, Dimensions of Transportation Systems.	**04**
2	Historical Background**,** Road Transport Characteristics, Benefits, Classification of Roads, Pavement Types and Characteristics, Basic of Traffic Controls.	**05**
3	Introduction, Rail Transportation in India, Advantages of Railways, Permanent Way, Components of a Railway Track, Stations and Yards.	**05**
4	Characteristics and Functions of Air Transport, Airports, Airport Planning, Selection of Site, Classification of Aerodromes, Components of an Aircraft, Components of an Airport, Taxiways and Apron.	**05**
5	Characteristics and Functions of Water Transport, Coastal Structures, Dolphins, Transit Sheds, Seaports, Port Structures,	**05**

	Docks, Buoy, Navigational Aids.	

References: -

- *Kadiyali, L. R.. Transportation engineering. Khanna Publishing.*
- *Khanna, S.K.Justo, C.E.G.,and A.Veeraragavan, Highway Engineering, Nemchand Brothers.*
- *Chandra,S. and Agrawal,M.M., Railway engineering. Oxford University Press,Inc.*
- *Khanna, S.K.,Arora, M.G..,& Jain,S.S. Airport Planning and Design. Nemchand Brothers.*
- *Srinivasan, R., & Bhavsar, R. C.. Harbour, Dock and Tunnel Engineering. Charotar Publishing House*
- *Teodorovic, D., & Janic, M. Transportation Engineering: Theory, Practice and Modeling. Butterworth-Heinemann.*

CEN12402 INFRASTRUCTURE ENGINEERING Credit: 03 (2-1-0)

Course Outcomes	
CO1.	Understand the importance of planning in Infrastructure development
CO2.	Evaluate the construction methods for Civil Engineering Infrastructures.
CO3.	Identify suitable materials for construction of the Civil Engineering Structures.
CO4.	Describe the importance, type and characteristics of the transportation infrastructure.
CO5.	Understand and evaluate the environmental, economic, social and sustainability constraints of infrastructure projects.

Course Content

Unit	Content	Number of Lectures
1	Role of Engineers for Infrastructure Development; Life Cycle of Infrastructure; Real-World Examples of Infrastructures; Planning Considerations.	**04**
2	Cement Concrete, Reinforced Cement Concrete, Steel Sections, Timber, Bitumen; Brick Masonry, Stone Masonry, RCC Structural Members, Roofing, Flooring, Damp-Proofing, Water-Proofing Plastering, Painting and White Color Washing Road Construction	**05**
3	Classification of Buildings; Components of Buildings; Building by Laws; Orientation of Buildings; Ventilation; Acoustic	**05**

	Requirements; Selection of Site; Substructure; Site Inspection; Loads on Buildings; Load Transferring System.	
4	Role of Transportation, Modes of Transportation, Characteristics of Transport Modes; Pavements Types; Road Networks in India, Road Development Plans; Air Transport in India, Air Transport Characteristics; Rail Transport Infrastructure-Basic Elements; Water Transportation, Inland Navigation; Emerging Transportation Technologies and Systems.	**05**
5	Design of smart infrastructure with adaptive capabilities; Design of smart city considering infrastructures of energy, mobility, health and sustainability and their growing interdependencies; Measures of Sustainability; Role of Civil Engineers; Sustainable Design; Green Buildings; Building Rating System; Sustainable Land Development; Water Reuse.	**05**

References: -

- *Penn, M. R., & Parker, P. J.. Introduction to Infrastructure: An Introduction to Civil and Environmental Engineering, Wiley Global Education.*
- *Punmia, B. C., Jain, A. K., & Jain, A. K. Building Construction. Laxmi Publications.*
- *Kumar, Sushil, Building Construction.*
- *Teodorovic, D., & Janic, M.. Transportation Engineering: Theory, Practice and Modelling. Butterworth-Heinemann.*
- *Chakroborty, P., & Das, A. Principles of Transportation Engineering. PHI Learning Pvt. Ltd..*
- *National Building Code-2016.*

CEN12101 BUILDING ENGINEERING-II Credit: 03 (2-1-0)

Course Outcomes	
CO1.	Understand the properties and uses of common building materials.
CO2.	Describe the properties and uses of various types of other building materials.
CO3.	Present the quantity surveying, modes of measurement and utility of various types of estimates.
CO4.	Explain the use of current schedule of rates and quantitative resource allocation for the rate analysis.
CO5.	Describe utility, purpose and concepts involved in the building valuation.

Course Content

Unit	Content	Number of Lectures
1	Bricks, Stones, Cement, Lime, Gypsum products, Ferrous and non-ferrous metals, Natural and artificial Pozzolonas, Paints and distempers	**06**
2	Timber and plywood, Seasoning and preservation, Asphalt, Bitumen and Tar, Glass, Plastics.	**06**
3	Importance of estimation; Different types of estimates; General and detailed specifications; Methods of estimation- items of work for estimates, units and measurement of items.	**04**
4	Detailed estimates of a two roomed single storey residential building; Analysis of rates; Material and other cost considerations; Resource planning through analysis of rates; Market rates and P.W.D. schedule rates; Nonscheduled items and cost indices for building material and labour.	**04**
5	Standard terminology; Factors affecting the values of property; Methods of valuation, years purchase, capitalized value and depreciation; Standard rent, free hold and lease hold propriety; Mortgage and easement	**04**

References: -

- *Building Materials: S.K. Duggal, New Age International Publishers, New Delhi*
- *"Civil Engineering Materials "Technical Teachers" Training Institute Chandigarh, Tata McGraw Hill Publishing Company Ltd., New Delhi.*
- *Advances in Building Materials and Construction: Rai Mohan and Jai Singh M.P, CBRI Roorkee.*
- *Estimating Costing and Valuation in Civil Engg., Principle and Applications: Chakraborty M., (Authors Publication, Kolkata)*
- *Estimating Costing and Valuation in Civil Engg., Principle and Applications: Frederick E. Gould. Pearson Education*
- *Estimating & Costing in Civil Engineering: B.N. Dutta, UBS Publishers & Distributors Pvt. Ltd. New Delhi.*
- *CPWD Works Manual 2012.*

B.Tech II Year (3rd Semester)

AMN13102 SOLID MECHANICS CREDIT: 05 (3-1-2)

Course Outcomes	
CO1.	Recall and describe the fundamental principles of engineering mechanics, stress-strain relationships, beam deflections, column behaviour, and failure theories.
CO2.	Understanding the concepts of force systems, stress and strain analysis, beam deflection methods, and column stability theories.
CO3.	Apply knowledge of mechanics to solve problems related to equilibrium, stress-strain, beam deflections, and column stability.
CO4.	Analyse complex engineering problems involving stresses in beams, torsion of shafts, and deflections of beams to determine the most effective solutions.
CO5.	Evaluate the behavior of materials and structures under various loading conditions and assess the suitability of different failure theories.
CO6.	Design experiments and models to test theories and predict the behavior of materials and structures under different conditions.

Course Content		
Unit	**Content**	**Number of Lectures**
1	Idealization in Mechanics, Free Body Diagrams and Equilibrium of Force Systems, Application to Structures: Analysis of Plane Trusses. Geometric Properties of Sections: C.G. and Centroid, Area Moments of Inertia, Transformation of Moments of Inertia and Principal Axes	**08**
2	Uniaxial Stress and Strain: Stress, Strain, Hooke's Law, Stress-Strain Curves, Elastic Constants, Strain Energy, Statically Indeterminate Problems, Thermal Effect, Impact Loading. Biaxial Stress and Strain: Stress at a Point, Stress Transformation and Principal Stresses, Analysis of Strain, Strain-Displacement Relations, Constitutive Equations, Strain Transformation and Principal Strains, Strain Measurement.	**08**
3	Beams: Loading vs. Shear Force vs. Bending Moment Relations, S.F.D and B.M.D, Pure Bending, Normal and Shear Stresses, Combined Bending and Axial Stresses, Composite Beams Shafts: Torsion of circular Shaft, Power Transmitted by a Shaft, Compound Shaft, Stain Energy in Torsion, Combined Bending and Twisting; Strain Energy in Bending and Torsion	**08**
4	Equations of Elastic Curve, Methods of Double Integration for Determining Deflections, Macaulay's Method, Moment-Area Method, Castigliano's Theorem	**06**
5	Euler 's Theory for long columns, Rankine-Gordon Formula, Eccentrically Loaded Columns, Theories of Failure	**06**
Practical's		
1	Verification of conditions of equilibrium for concurrent (polygon law) and parallel forces and moment systems	
2	To determine the coefficient of friction in case of rollers and sliding boxes over inclined planes	
3	To determine the mass moment of inertia of a fly-wheel	
4	Experimental verification of forces in a roof truss model	
5	To determine the mechanical properties of mild steel specimen on a universal testing machine (UTM).	
6	To perform the torsion test on a given specimen	
7	To determine the value of modulus of elasticity by measurement of slope and deflection of a beam using beam bending apparatus	
8	To determine the impact strength of the material using Charpy test and Izod test.	

9	To determine the maximum shear stress (parallel to grains) of timber	
10	To study the behavior of different types of struts and calculation of Euler's buckling load in each case	

References

- Beer F.P. and Johnston E.R., Mechanics of engineers-volume 1-Statics, Volume II – Dynamics,McGrawHill,New York.
- Merriam J.L and Kraige L.G. Engineering Mechanics,Volume I-Statics,Volume-II-Dynamics, John Wiley & Sons New York
- Shames L.H. Engineering Mechanics,PrenticeHall,New Delhi
- R.C. Hibbler, Engineering Mechanics, Vol I and II,Pearson Press,2002
- Elements of strength of materials, S.P. Timoshenko and D.H. Young, East- West Press Pvt.Ltd.Publication
- Mechanics of Materials,Pytel and Kiusalaas,Cengage Learning Publication.
- Mechanics of Materials,Gere and Timoshenko,CBS Publications.
- Mechanics of Materials, E.P. Popov, Prentics Hall Publications.
- Hibbeler, R.C., Mechanics of materials. 10th Edition Pearson Educación.
- Strength of Materials,G.H. Ryder, Macmillan India Limited.
- Strength of Materials- Pytel and Singer, HarperCollins College Division Publications.
- Strength Of Materials, Crandals,Dahal and Lardener, Tata McGraw Hill Publications.
- Mechanics Of Materials – Riley, Struges and Morris,John Wiley & Sons

CEN13101: CONCRETE TECHNOLOGY AND CONSTRUCTION MANAGEMENT Credit: 04 (3-0-2)

Course Outcomes	
CO1.	Remembering composition and properties of concrete materials, the process of concrete mix design, the factors affecting concrete durability, the basics of construction engineering systems, and the principles of engineering economics.
CO2.	Understanding significance of testing cements as per BIS specifications, the importance of workability and curing in concrete, the mechanisms of concrete deterioration, the role of network diagrams in construction projects, and the concept of time value of money.
CO3.	Apply knowledge of concrete materials to create appropriate mix designs, use methods to measure and ensure workability, implement strategies to enhance concrete durability, utilize network techniques for project management.
CO4.	Analyse the effects of various admixtures on concrete properties, assess the microstructure of hardened concrete, evaluate the transport mechanisms in concrete mass.
CO5.	Evaluate the suitability of different types of cements and aggregates for specific construction needs, assess the strength and durability of concrete structures.
CO6.	Design experiments to test the properties of concrete materials, develop new concrete mixtures with desired properties

Course Content		
Unit	**Content**	**Number of Lectures**
1	Composition; Physical & chemical properties of cement; Testing of cements as per BIS specifications; Types of cements, admixtures, and aggregates; Effects of plasticizers and superplasticizers	**06**
2	Concrete mix design, Workability and its measurements; Compaction & curing of concrete; Strength of concrete; Factors affecting strength of concrete; Micro structure of hardened concrete; NDT & Conventional testing of concrete; Light weight concrete; High strength concrete; Roller compacted concrete; Self compacted concrete; High performance concrete.	**12**
3	Mechanism of deterioration of concrete; Different modes of transport mechanism in concrete mass; Carbonation; Chloride attack; Corrosion of reinforcement in concrete; Carbon economics; Life cycle costing and energy considerations	**06**
4	Introduction to construction projects–magnitude and critical considerations; Bar charts, milestone charts, and network diagrams; Resource quantification; CPM, PERT, PDM and GERT; Critical path evaluation; Cost planning and resource allocation through network techniques; Project monitoring and controls; Line of balance technique.	**06**
5	Time value of money; Present economy studies; Equivalence concept; Economic comparison; Depreciation and break even cost analysis; Contract and contract management; Tenders and tender preparation; settlements of disputes, arbitration and commissioning of project; Decision making under risk–decision tree concept.	**06**
Practical's		
1	To determine the specific gravity of cement using Lechatelier flask and the fineness by sieve analysis.	
2	To determine the normal consistency and setting times.	
3	To assess the soundness of cement using Lechatelier apparatus.	
4	To determine the compressive strength of cement.	
5	To determine the specific gravity, bulk density and water absorption of aggregates.	
6	To study the phenomenon of bulking of sand	
7	To draw the grading curves for fine and coarse aggregates and hence to determine their fineness moduli.	
8	To determine the crushing value, impact value and ten percent fine value for coarse aggregates.	
9	To measure the workability of concrete using slump cone, and compaction factor apparatus	
10	To design a concrete mix of given specifications and to evaluate associated trial mixes.	

References: -

- *M. Neville, Properties of Concrete, Pearson education.*
- *P. K. Mehta & Paulo J. M. Monterio, Concrete: Microstructure, Properties, and Materials, Tata Mc Graw Hill.*
- *M. S. Shetty, Concrete Technology, theory and Practice, S. Chand*
- *M. L. Gambhir, Concrete Technology, Theory and Practice, Mc Graw Hill.*
- *J. Kroop and H. K. Hilsdorf, Performance Criteria for Concrete Durability, E & F N Spon, London.*
- *Panneerselvam, R., Engineering Economics, Prentice- Hall of India Private Limited New Delhi.*
- *Seetharaman, S., Construction Engineering and Management, Umesh Publications New Delhi.*
- *Project Planning and Control with PERT and CPM Book by B.C. Punmia and K. K. Khandelwal*

AMN13103 FLUID MECHANICS & HYDRAULICS CREDIT: 05 (3-1-2)

Course Outcomes	
CO1.	Identify and obtain the values of fluid properties and relationship between them and understand the principles of continuity, momentum, and energy as applied to fluid motions.
CO2.	Recognize these principles written in form of mathematical equations.
CO3.	Apply fluid dynamic fundamentals to understand and design various open channel flows.
CO4.	Describe the function of flow metering devices and apply Bernoulli equation to determine the performance of flow-metering and measuring devices.
CO5.	Describe the function and efficiency of pumps and turbines

Course Content		
Unit	**Content**	**Number of Lectures**
1	Fluid and continuum, Physical properties of fluids, Types of fluid flows, , manometers, pressure transducers, pressure on plane and curved surfaces, centre of pressure. Kinematics of Fluid flow: steadiness, uniformity, rotational and irrotational flows, streamline, streakline, pathline, continuity equation, stream function and velocity potential, flow net.	**04**
2	Euler's Equation of motion along a streamline and its integration, Bernoulli's equation and its applications, momentum equation and its application to pipe bends. Dimensional Analysis. Equation of motion for laminar flow through pipes, transition from laminar to turbulent flow, types of turbulent flow, velocity distribution in turbulent flow over smooth and rough surfaces, resistance to flow, minor losses, pipe in series and parallel, power transmission through a pipe, water hammer (rigid theory). Introduction of boundary layer,	**13**

	displacement and momentum thickness, boundary layer over a flat plate.	
3	Classification, types and regimes, Channel geometry. Velocity and momentum distribution, Specific energy and Critical flow, Specific force. Qualification of Uniform flow, Velocity measurement, Chezy's and Manning's Equation. Determination of Roughness Coefficient, Normal Depth and Velocity. Most Economical Section, Non-erodible Channels. Flow in channel with equivalent roughness, Horton's method of Equivalent, roughness estimation, Semi-filled flow in close conduits.	**05**
4	Dynamic equations of gradually varied flow, Draw-down and Back water curves, Channel slopes, Classification of surface profile, Graphical integration, Direct and standard step method, Numerical methods, Flow through channel transitions, Dynamic equation of spatially varied flow, Spatially varied flow profile, Computation of spatially varied flow. Hydraulic jump, Types and analysis of hydraulic jump, Basic characteristic of jump, Length, Profile jump, Jump on sloping floor, Location of jump, Jump as energy dissipation, Control of jump, Surges in open channel. Sudden transition, Sub-critical flow through sudden transition, Flow through culverts, Flow through bridge piers, High flow through bridge pier and obstruction, Channel junction.	**08**
5	Hydraulic Turbines: Introduction to Hydroelectric power station and its components, Classification of turbines, Heads and efficiencies, Pelton wheel, Francis and Kaplan turbines, specific speed and unit quantities, Characteristic curves. Pumps: Centrifugal Pumps, specific speed, priming, Characteristic curves, Reciprocating pumps, Comparison between Centrifugal and Reciprocating pumps. Cavitation in pumps and turbines.	**06**
Practical's		
	To verify the momentum equation using the experimental set-up on diffusion of submerged air jet.	
	To study the transition from laminar to turbulent flow and to determine the lower critical Reynolds number.	
	To study the boundary layer velocity profile over a flat plate and to determine the boundary layer thickness.	
	To calibrate an orifice meter, venturimeter, and bend meter and study the variation of the co-efficient of discharge with the Reynolds number.	
	To study performance of a Centrifugal pump / Reciprocating pump	
	To study the impact of jets on a flat plate.	
	To study performance of a Turbines (Pelton / Francis / Kalpan).	
	Discharge of an open channel using rectangular / V-notches.	
	To study the characteristics of hydraulic jump in an open channel.	
References		

- *Som, S.K. and Biswas G, Introduction of Fluid Mechanics & Fluid Machines, TMH, New Delhi.*
- *Fox, R.W., McDonald, A.T., Introduction to Fluid Mechanics, 7th edition, Wiley India.*
- *Ojha, C.S.P., Berndtsson, R., Chandramouli, P.N., Fluid Mechanics and Machinery, Oxford University Press, New Delhi.*
- *Ranga Raju, K.G., Open Channel Hydraulics, , Tata McGraw Hill, 2nd Ed.*
- *Garde, R.J., Fluid Mechanics through Problems, New Age International Pvt. Ltd, New Delhi.*
- *Majumdar, B., Fluid Mechanics with Laboratory Manual, PHI Learning, New Delhi.*

CEN13102 ENGINEERING GEOLOGY Credit: 03 (2-0-2)

Course Outcomes	
CO1.	To understand the concept of mineral and rock formations and their detail characteristics including Physical and Optical properties.
CO2.	To acquire and attain the knowledge of rock deformations and their applications in Civil Engineering.
CO3.	To acquire the geological and geophysical knowledge pertaining to the causes of Earthquake and its mapping.
CO4.	To understand the concept and acquire knowledge of Landslides and design the Rain Water Harvesting System for Urban areas.
CO5.	Apply the Geological and Geophysical knowledge for selection of feasible sites for construction of Civil Engineering Projects.

Course Content

Unit	Content	Number of Lectures
1	Minerals: Physical and Engineering properties of rock. Origin, structure, texture and classification of igneous, sedimentary and metamorphic rocks and their suitability and their impacts in Civil Engineering projects.	**06**
2	Rock deformation**:** Folds, Faults, joints unconformity and t applications in Civil Engineering.	**05**
3	Earthquake, its causes, classification and seismic zones of India.	**02**
4	Landslides, its causes, classification and preventive measures with a case study. Concept, techniques and design of Rainwater harvesting with case study.	**05**
5	Modern approach under geological investigations for site selection of Dams and reservoirs, tunnels, bridges and Highways.	**06**

Practical's		
1	Study of physical and engineering properties of Quartz, Felspar, Calcite and Mica Minerals.	**4hrs**
2	Study of physical and engineering properties of Granite, Basalt, Sandstone, Marble, Quartzite, Limestone, Granite Gneiss, Mica Schist and their applications in Civil Engineering structures/Projects.	**8hrs**
3	Petrography of selected minerals and rocks through thin sections under Trinocular Polarizing Optical microscope with reference to alkali silica reaction and textures.	**4hrs**
4	Study of different geological models and their relevance to the different engineering structures	**6hrs**
5	Preparation of cross (X) sections of different geological maps including calculation of dip and its direction.	**2hrs**

References

- Krynine and Judd : Principal of Engg. Geology and Geotechnics, Mc Graw Hill Book Company Inc. New York.
- J.M. Treteth : Geology of Engineers, Princeton, Von. Nostrand.
- Prabin Singh :Engg. and General Geology, Katson Publishing House.
- Blyth F.G.M. : A Geology for Engineers, Arnold, London.
- D.S. Arora : Geology for Engineers, Mohindra Capital Publishers, Chandigarh.
- Leggot, R.F. : Geology and Engineering, McGraw Hill, New York.
- P.K. Mukerjee : A text Book of Geology, Calcutta Word Publishers.
- S.K.Duggal, H.K.Pandey, NR Rawal, Mc-Gra Hill Publisher

CEN13103 SURVEYING CREDIT: 05 (3-1-2)

Course Outcomes	
CO1.	To understand the fundamentals of Surveying and distance measurement; and apply the theoretical knowledge in the field.
CO2.	To understand bearings, angles and methods of measurement; and apply in the knowledge in field Surveying.
CO3.	To acquire knowledge of levelling in Surveying; and apply in different operations in Civil Engineering projects.

Course Content

Unit	Content	Number of Lectures
1	Introduction to the course; Traversing- Fundamentals & methods, traverse computations- latitude & Departure, Traverse Adjustment, Gales Traverse Table, Omitted Measurements; Total Station; Trilateration- Principle and methods.	**07**
2	Review of levelling concepts; Trigonometrical Levelling- observations in single vertical plane; Contours- Characteristics, methods and uses; Tacheometry: Basic terms & principles, Distance elevation formula, Stadia method.	**08**

3	Triangulation- Principle and classification, Triangulation field work, intervisibility of stations, satellite station; Plane Table Survey- Principles, accessories, methods- radiation, intersection & traversing, Resection by three-point problem, Lehmann's rules	**06**
4	Curve Surveying- Elements of simple circular curves, Setting out simple circular curves by linear & instrumental methods; Compound curves- Elements and setting out; Reverse curves; Transition curves- Need and characteristics, Ideal transition curve and intrinsic equation, Transition curves and equations, Combined transition curve and circular curves- shift, elements and setting out; Vertical curves- Types, Methods of setting out	**09**
5	Errors, Accuracy and precision, Characteristics of random errors, Weighting of observations, Propagation of errors, Principle of least squares, Most probable value, Determination of mpv, Method of normal equations, Method of differences, Observation equations accompanied by condition equation, Adjustment of simple triangulation figures.	**06**
Practical's		
1	To perform fly levelling using automatic level.	
2	To measure horizontal angle between four objects by method of reiteration using a Vernier theodolite.	
3	To determine tacheometric constants of a Vernier theodolite.	
4	To set out a simple circular curve by Rankine's method of tangential angles	
5	To study working of total station and practice for taking observations	
6	To prepare topographic map of small area using total station (Day-01).	
7	To prepare topographic map of small area using total station (Day-02).	
8	To carry out control surveying [using total station] and plot the coordinates of control points at a given scale on Plane Table and their field checking.	
9	To solve three point problem in Plane Table surveying and plotting of details in an area.	
10	To plot details of an area using radiation method.	
11	To plot the details of an area using intersection method.	
12	Colouring of map prepared by Plane Table surveying and submission.	

References: -

- Surveying (Vol- I & II): B.C. Punmia& A.K. Jain, Laxmi Publications, New Delhi.
- Surveying (Vol- I &, II): S.K. Duggal, Tata McGraw-Hill, New Delhi.
- Surveying (Vol- I & II): K.R. Arora, Standard Book House, New Delhi.
- Plane Surveying & Higher Surveying: A.M. Chandra, New Age Int. (P) Ltd., New Delhi.
- Surveying: Bannister, A., Raymond S., Baker, R., Pearson Education, New Delhi.

II Year (4th Semester)

CEN14101 WATER SUPPLY ENGINEERING CREDIT: 04 (3-1-0)

Course Outcomes	
CO1.	Remembering the key concepts of water demand and sources, water quality parameters, pumping and conveyance of water, and conventional and miscellaneous treatment of water.
CO2.	Understanding the importance of population forecasting in water demand, the necessity of water quality examination, the principles of hydraulics in water conveyance, and the objectives of various water treatment processes.
CO3.	Apply the methods for estimating water quantity, assessing water quality, designing pump systems, and implementing water treatment operations and processes.
CO4.	Analyze the capacity requirements for impounding reservoirs, the impact of chemical interactions on water quality, the efficiency of different types of pumps, and the effectiveness of sedimentation, coagulation, and flocculation processes.
CO5.	Evaluate the suitability of surface and subsurface sources for water supply, the adequacy of water quality standards, the design of pumping and conveyance systems, and the performance of water treatment systems.
CO6.	Design rainwater harvesting systems, develop strategies for improving water quality, create plans for efficient water conveyance, and innovate water treatment flow sheets and unit processes.

Course Content		
Unit	**Content**	**Number of Lectures**
1	Introduction, population forecasting, variations in water demand, estimation of quantity of water. Sources of Water: determination of capacity of impounding reservoirs: Suitability of surface and subsurface sources; Rain water harvesting intake structures.	**06**
2	Necessity of water quality examination, examination of various water quality parameters including chemical interactions, water quality standards for various beneficial uses	**06**
3	Pipes for conveyance of water, hydraulics of pressure and gravity conduits, capacity and sizes including economical size of rising main, pipe laying, types of pumps, selection of pumps, characteristics curve, design of pumps.	**05**
4	Layouts and components of water distribution system, Method of water supply and storage, principle of analysis of distribution network-Hardy Cross method, Equivalent pipe method. Application of software for network analysis.	**06**
5	Objective of water treatment, Water treatment Unit Operation and Unit Processes, Chemistry and microbiology of different water treatment systems, Water treatment flow sheets. Sedimentation: Theory of sedimentation, Efficiency of ideal and real settling tank, settling and removal efficiency of discrete and	**13**

	flocculant particles. Design of primary sedimentation tanks & tube settlers etc. Coagulation: Theory & mechanism of coagulation, Coagulant and their reaction, Determination of optimum dose of coagulant and design of rapid mixer. Flocculation: Theory of flocculation, Hydraulics and mechanical flocculator and their design. Design of secondary sedimentation tank. Filteration: Theory of filtration, Hydraulic of filtration and backwashing slow sand and rapid sand filters, brief introduction to dual & multimedia filters, deep filteration Disinfection: Theory and mechanism of disinfection, various disinfectants and their application, chlorination and practice of chlorination & dose estimate. Water Softening: Membrane filtration, Miscellaneous treatment, removal of priority pollutant.	

References

- *McGhee: Water supply and sewerage, Tata McgrawHill, publication.*
- *Peavy, Rowe and Techbanoglous: Environmental Engineering, Tata McgrawHill, publication.*
- *MetCalf& Eddy: Wastewater Engineering: Treatmment and Reuse, Tata McgrawHill, publication.*
- *Sawyer and McCarty: Chemistry for Environmental Engineering, Tata McgrawHill, publication.*
- *Garg S. K.: Environmental Enggineering (I&II),Khanna publication, New Delhi.*
- *B.C. Punamia& Jain A.: Environmental Enggineering (I&II), Laxmi publication, New Delhi.*
- *Weber, W.J., "Physico-chemical Processess", Wiley Interscience 1983*
- *S. Vigneswaran and C. Visvanathan, "Water Treatment Processes: Simple Options", CRC Press. 1995*
- *R.L.Droste, "Theory and Practice of Water and Wastewater Treatment", John Wiley. 1997*
- *S.R. Qasim, Edward and Motley and Zhu, H., "Water Works Engineering – Planning, Design and Operation", Prentice Hall, India. 2002*
- *Nicholas G. Pizzi, "Water Treatment Operator Handbook", American Water Works Association. 2005*

AMN14101 STRUCTURAL ANALYSIS- I CREDIT: 04 (3-1-0)

Course Outcomes	
CO1.	Remembering the fundamental concepts of structural analysis, rolling loads, influence line diagrams, arches, cables, suspension bridges, and unsymmetrical bending.
CO2.	Explain the significance of static and kinematic indeterminacy, the principles behind influence lines, and the behaviour of arches and cables under various loading conditions.
CO3.	Apply the methods of energy analysis to determine deflections in trusses and frames, construct influence line diagrams for beams and trusses, and analyze arches and suspension bridges for stability.
CO4.	Analyze the effects of rolling loads on structures, determine the most critical loading conditions using influence lines, and evaluate the stresses and deflections in unsymmetrical bending.

CO5.	Evaluate the stability and efficiency of different structural systems, including arches, cables, and suspension bridges, and evaluate the impact of unsymmetrical loads on structural elements.
CO6.	Design experiments to test the behaviour of structures under various loads, develop new methods for analyzing complex structures, and innovate solutions for challenges in structural engineering.

Course Content

Unit	Content	Number of Lectures
1	Introduction and Classification of Structures, Static and Kinematic Indeterminacy of Structures; Analysis of Compound and Complex Trusses; Analysis of Plane Frames; Energy methods, Maxwell's Reciprocal & Betti's Theorem, Unit Load method, Deflection of trusses and plane frames.	**07**
2	Introduction; Influence Line Diagrams for Beams & Trusses, Absolute Maximum Bending Moments; Muller- Breslau principle and its applications.	**07**
3	Introduction; Linear Arch; Eddy's Theorem; Three-Hinged & Two-Hinged Arches; Spandrel Braced Arch; Influence Lines for Arches; Analysis of Cables; Suspension bridges with three and two hinged stiffening girders.	**06**
4	Introduction; Location of Neutral axis; Computation of Stresses and deflections	**05**
5	Bending of curved beams in plane of bending; stresses in bars with small and large initial curvatures; Beams Curved in plan.	**05**

References

- Structural Analysis, Hibbeler, Pearson Publications.
- Structural Analysis, Aslam Kassimali, Cengage Learning Publications.
- Structural Analysis in Theory and Practice, Alan Williams, Elsevier Publications.
- Elementary Structural Analysis, C. H. Norris, J. B. Wilbur and S. Utku, Tata Mcgraw Hill Publications.
- Structural Analysis, L.S. Negi and R. S. Jangid, Tata Mcgraw Hill Publications.

CEN14102 HIGHWAY & TRAFFIC ENGINEERING
CREDIT: 04 (3-1-0)

Course Outcomes

CO1.	Remembering the key elements of highway planning, geometric design, traffic characteristics, traffic studies, and traffic control.
CO2.	Understand the importance of highway development institutions, the factors affecting geometric design, and the characteristics of road users and vehicles.
CO3.	Apply engineering surveys for highway planning, design horizontal and vertical alignments, and conduct traffic studies.
CO4.	Analyse the classification of roads, sight distances, traffic flow diagrams, and the effectiveness of traffic control measures.

CO5.	Evaluate the vision documents for rural and urban roads, the level of service of highways, and the design of intersections.
CO6.	Design traffic control systems, develop strategies for improving highway capacity, and innovate solutions for road safety challenges.

Course Content		
Unit	**Content**	**Number of Lectures**
1	Introduction to Highway Development; Institutions for Highway Development at National level; Highway Planning and Alignment; Engineering surveys for highway planning. Vision Documents for Rural and Urban Roads (2021, 2025, NUTP). Classification of Roads, Network patterns.	**05**
2	Highway Cross Sectional Elements. Factors affecting geometric design. Sight Distances. Design of Horizontal and Vertical Alignments. Geometric Design considerations in hilly areas.	**08**
3	Road user, vehicle and highway characteristics. Traffic Stream Characteristics- Macroscopic, Microscopic. Distance-Time diagram. Traffic Flow Diagrams, Highway Capacity, Level of Service.	**07**
4	Traffic Studies- Volume studies, Speed studies, Origin & Destination studies, Parking & Accident studies; Design of rotary and signalized intersections. Signal Coordination.	**08**
5	Traffic Signs & markings, Islands, Signals; Intersections: At grade and grade separated intersections, rotary intersection; Traffic Regulation measures, Road Safety.	**08**

References

- *Highway Engineering by S.K. Khanna and C.E.J. Justo, Nem Chand Publication.*
- *Principles of Transportation Engineering, by Animesh Das and P. Chakraborty, PHI Learning; 2nd edition*
- *Traffic Engineering and Transport Planning by L.R. Kadiyali, Khanna Publishers.*
- *Indian Roads Congress [IRC] Codes –IRC:3, 38, SP-48, 69, 73, 86, SP-23, SP-44, SP-88*

CEN14103 GEOTECHNICAL ENGINEERING – I CREDIT: 04 (3-0-2)

Prerequisites: Strength of Materials

Course Outcomes	
CO1.	Apply Principles of Phase diagram for Soil Properties, Perform Basic weight-volume calculations, characterize and classify soils.
CO2.	Apply appropriate laboratory tests to determine the permeability of soil and its application in the field
CO3.	Compute and analyse the compaction and consolidation settlements.

CO4.	Identify shear strength parameters for field conditions.
CO5.	Apply suitable methods for analyse slope stability and suitable measures to improve it.

Course Content		
Unit	**Content**	**Number of Lectures**
1	Soil mechanics and its importance, Particle size analysis, Phase relationship, Index properties, Soil mineralogy and structure, Identification and Classification of soils, Soil Classification systems.	**10**
2	Types of soil water, effective stress principle, Permeability and seepage of soils, Coefficient of permeability and its determination in laboratory and field, Quick sand and Liquefaction phenomenon, Seepage analysis, Flow nets and its construction, Seepage through earthen embankments.	**07**
3	Theory of compaction, Standard and Modified Proctor test, Effect of compaction on properties of soils, Field compaction of soils, Compaction control in fields. Compressibility of soils, Types of consolidation, Terzaghi's theory of consolidation, Consolidation test, Determination of coefficient of consolidation, Pre-consolidation pressure and its determination, Time rate of consolidation, Computation of settlement, Sand drains.	**10**
4	Mechanism of shear resistance, Mohr-Coulomb theory, Shear strength and effective stress principle, Shear tests under different drainage conditions, Pore pressure parameters, Shear characteristics of cohesion less and cohesive soils, Modified failure envelop, Stress path.	**05**
5	Types of slope failure, Stability of infinite and finite slopes, Taylor's stability number, Stability analysis – Culmann's method, Swedish Circle method, Friction circle method, Bishop's method, Stability charts.	**04**
Practicals		
1	Visual identification and specific gravity	
2	Grain Size Analysis: Sieve Analysis & Hydrometer Analysis	
3	Atterberg's Limits	
4	Relative Density Test	
5	Proctor Compaction Test	
6	In site Density-Core Cutter & Sand Replacement Method.	
7	Permeability Test: Constant Head & Variable Head	
8	Direct Shear Test	
9	Shear Strength Test: Unconfined Compression Test & Triaxial test	
10	Consolidation test	
References		

- Lambe & Whitman: Soil Mechanics, Wiley-India.
- Gopal Ranjan and A.S.R. Rao: Basic and Applied Soil Mechanics, New Age International
- B. M. Das: Principles of Geotechnical Engineering, CL-Engineering.
- D.F. Mc Garthy: Essentials of soil mechanics and foundation. New Age International
- Alam Singh: Modern Geotechnical Engineering., CBS publisher
- K.R. Arora: Soil Mechanics and Foundation Engineering, Standard Publishers Distributors
- Purushotama Raj: Geotechnical Engineering, New Age International Limited
- SP 36-1: Compendium of Indian Standards on Soil Engineering: Part-1 Laboratory Testing of Soils for civil Engineering Purposes.

CEN14104 GEOINFORMATICS CREDIT: 04 (3-1-0)

Course Outcomes	
CO1.	To understand, acquire and apply the knowledge of optical remote sensing for solving real life problems.
CO2.	To acquire the knowledge of digital tools and techniques of processing of remote sensing satellite imageries, and apply in various studies.
CO3.	To understand and disseminate knowledge of geospatial information storage, management and processing; and apply in real life problems solution.
CO4.	To attain knowledge of satellite-based positioning and navigation system, and apply in managing real world projects.
CO5.	To acquire knowledge and hand on training on Open-Source Software (OSS) in the field of image processing and GIS; and apply in solving societal problems.

Course Content

Unit	Content	Number of Lectures
1	Introduction to Geoinformatics, Physics of remote sensing, remote sensing system, Spectral reflectance curves, resolution and multi-concept, Sensors and orbital characteristics, Visual interpretation-FCC, Remote Sensing satellites and data products.	**08**
2	Satellite Image- Characteristics and formats, Image statistics, Land use and land cover classification system, Image rectification, Unsupervised and Supervised classification.	**07**
3	Geographic data- Basic concepts, GIS and its components, Data acquisition, Raster and Vector models, topology, creation of integrated geographic database, Data organization, Query formation, Buffering, Spatial Overlay, Data output.	**08**
4	Introduction, Satellite navigation System, Datums and Map projections, GPS- Basics and segments, GPS signal, Static, Kinematic and Differential GPS, NavIC fundamentals.	**06**
5	Applications of remote sensing, image processing, GIS and GPS in Civil Engineering and related fields; OSS, Open data and Open	**07**

	standards, Hands on practice on OSS in the field of GIS; Hands on practice on OSS in the field of image processing.	

References

- Remote Sensing & Image Interpretation: T.M. Lillesand & R.W. Kiefer; Wiley Students Edition, India.
- Principles of Geographical Information Systems: Peter A. Burrough & Rachael A. McDonnell; Oxford University Press.
- Principles and Theory of Geoinformatics: P.K. Garg; Khanna Book Publishing, Delhi.
- GIS and Remote Sensing: A.M. Chandra & S.K. Ghosh; Narosa Publications, Delhi.
- Computer Processing of Remotely Sensed Images: P.M. Mather; John Wiley & Sons.
- Remote Sensing and GIS: M. Anji Reddy; BS Publications, Hyderabad.
- Essentials of GPS: N.K. Agarwal; Spatial Networks Publishers, Hyderabad.

III YEAR (5th SEMESTER)

CEN15101 PAVEMENT ENGINEERING & MANAGEMENT
CREDIT: 04 (3-0-2)

Course Outcomes	
CO1.	Evaluate the mechanical and physical properties of pavement materials
CO2.	Design the flexible pavements as per relevant design specifications
CO3.	Design the rigid pavements as per relevant design specifications
CO4.	Understand and evaluate the construction methods of flexible and rigid pavement as per standard specification.
CO5.	Evaluate the necessity of required maintenance and suggest suitable treatment
CO6.	Evaluate new technologies related the highway materials and construction.

Course Content

Unit	Content	Number of Lectures
1	Pavement Types and their classification – Flexible, and Rigid pavements, Highway and low volume roads and their pavement types; Pavement components, Highway Construction materials and their Characterisation – soil, aggregate, bitumen, cement and unconventional materials, Material Characterizations/ specifications as per relevant codes, Cementitious materials: Cement treated base; cement treated sub-base; stabilised soil, characterization, Bituminous mixes: Types of mixes; Marshall mix design; Mix specifications, Emerging Sustainable Materials for pavement construction.	**07**
2	Stresses in flexible pavements: layered system concepts, stress solution for one, two, and three-layered systems, fundamental design concepts; Factors effecting pavement design and variables considered in pavement design: axle types, standard and legal axle loads, ESWL, EWLF, vehicle damage factor, ADT, AADT, growth factor, lane distribution factor, directional distribution factor, tire pressure, contact pressure, design life; Mechanistic Methods of flexible pavement design, Drainage considerations, design of flexible pavements of low volume roads, design of flexible pavement using IRC method and AASHTO method	**07**
3	Stresses in rigid pavements: Westergaard's theory and assumptions, stresses due to curling, stresses and deflections due to loading, frictional stresses, design of joints; design of rigid pavement using IRC method, Design of Rigid Pavement Thickness as per IRC Provisions, Design of Dowel bars, Design of Tie bars, Design factors for Runway pavements, Design methods for Airfield pavements.	**06**
4	Types of bituminous constructions, Construction equipment, Construction procedure for embankments, subgrades, subbase,	**10**

	drainage layer, filter /separation layers and base courses-WBM, WMM, stabilized layers, Interface treatments, Constructions practices for Binder & Wearing Courses for roads as per IRC and MORT&H specifications, IRC Specifications for Dry lean concrete, Pavement quality concrete, construction procedure and requirements for rigid pavements as per IRC and MORTH specifications, Construction methods for joints in rigid pavements as per IRC Provisions, Quality Control in Construction	
5	Introduction, Pre-requirements, organizational setup, specification and code of practices, Distresses/Defects in flexible and rigid pavements, Structural and functional evaluation, Pavement Evaluation Methods, Types of Maintenance Activities, Overlay Design as per IRC Provisions.	**06**
Practicals		
1	Tests on Aggregate: (a) Impact Test. (b) Abrasion Test. (c) Shape Test.	
2	Tests on Bituminous materials: (a) Penetration Test. (b) Viscosity Test. (c) Ductility Test. (d) Stripping Value Test. (e) Softening point Test. (f) Flash and Fire point Test.	
3	Marshall Mix Design	
4	Traffic studies: (a) Traffic Volume study. (b) Traffic speed studies.	

References : -

- Chakroborty, P., & Das, A. Principles of transportation engineering. PHI Learning Pvt. Ltd.
- Huang, Y. H. Pavement analysis and design, Upper Saddle River, NJ: Pearson Prentice Hall.
- Islam, M. R., &Tarefder, R. A. Pavement Design. Pavement Design: Materials, Analysis, and Highways. McGraw-Hill Education.
- Kadiyali L. R. and Lal, N. B., Principles & Practice of Highway Engineering, Khanna Publishers,
- Kandhal, P. S. Bituminous road construction in India. PHI Learning Pvt. Ltd..
- Khanna, S. K., Justo, C. E. G., & Veeraraghavan, A. , Highway Engineering, Nem Chand & Bros Publishers.
- Sharma, S. K. Principles, practice and design of Highway Engineering. S. Chand Publishing.

Codes:-

1. IRC 82-2015, Code of practice for maintenance of bituminous surfaces of highways
2. IRC: SP:83-2015, Maintenance & Rehabilitation of Cement Concrete Pavements
3. IRC: 37-2018, Guidelines for the design of flexible pavement
4. IRC: 58-2015, Guidelines for the design of plain jointed rigid pavement for highways
5. IRC:15 -2017, Standard specification and code of practice for construction of concrete roads
6. IRC:120, Recycling of Bituminous Pavements
7. IRC SP-100, Use of Cold Mix Technology in Construction and Maintenance of Roads Using Bitumen Emulsion
8. IRC:82, Code of Practice for Maintenance of Bituminous Surfaces of Highways

9. MoRTH (Ministry of Road Transport and Highways). (2013). Specifications for road and bridge works. In Indian roads congress. New Delhi, India: MoRTH.
10. IRC:81, Guidelines. for Strengthening of Flexible Road Pavements using Benkelman beam deflection
11. Other relevant IRC & IS Codes

CEN15102 GEOTECHNICAL ENGINEERING – II
CREDIT: 05 (3-1-2)

Course Outcomes	
CO1.	Determination of stresses in soils
CO2.	Determination of earth pressures on Retaining structure
CO3.	Assessment of Bearing capacity by various methods for design of shallow foundation and settlement estimation
CO4.	Load Carrying capacity of well foundation &Pile foundation under different loading condition
CO5.	To understand the design criteria of machine foundation

Course Content

Unit	Content	Number of Lectures
1	Causes of stress in soil, Geostatic stress, Boussinesq's equation, Stress distribution diagrams, Vertical stress in soils under different types of loading, Newmark's influence chart, Westergard's equation.	**06**
2	Types of lateral earth pressure, Rankine's and Coulomb's earth pressure theory, Graphical methods of determination of lateral earth pressures, Types of retaining walls, Design Principles, Stability conditions, Sheet pile walls.	**06**
3	Methods of determining bearing capacity, Analytical methods of determining bearing capacity –Rankine's method, Terzaghi's theory, Meyerhof's method, Brinch–Hansen's method, Skempton's analysis, Vesic's analysis, IS code method, Settlement of foundation, Differential settlement, Settlement analysis, Bearing capacity based on tolerable settlement, Field tests, Types & design of shallow foundations.	**09**
4	Type of pile foundation, Types, Pile driving, Pile capacity by static and dynamic analysis, Pile load tests, Negative skin friction, Group action of piles, Settlement of pile groups, Under reamed piles – analysis and design. Types of wells, Component of wells, Depth and bearing capacity of well foundation, Forces acting on well foundation, Construction and sinking of well foundation, Measures to prevent and rectify tilts and shifts.	**09**
5	Types, Design criteria, Equation of motion, Natural frequency, Design of Reciprocating, Impact and Rotary type of machine foundation as per codal provisions.	**06**

Practicals		
1	Methods of Soil Exploration & Planning of Site investigations	
2	Free swell Index & Differential free swell Index	
3	Swelling pressure test	
4	Static cone penetration test	
5	Dynamic cone penetration test	
6	Standard penetration test	
7	Plate load test.	
8	Vane shear test	
9	Pile load test	
10	Geophysical Investigations	

References:-

- J.E. Bowels: Foundation Analysis and Design, McGraw-Hill.
- W. C. Teng: Foundation Design, Prentice-Hall.
- B. M. Das: Principles of Foundation Engineering, PWS Publishing.
- K.R. Arora: Soil Mechanics and Foundation Engineering, Standard Publishers Distributors.
- P. C. Varghese: Foundation Engineering, PHI Learning Private Limited.
- V. N. S. Murthy: Advance Foundation Engineering, CBS Publisher.
- Nainan P. Kurian: Design of Foundation Systems, Narosa Publishing House.
- SP 36-1: Compendium of Indian Standards on Soil Engineering: Part-1 Laboratory Testing of Soils for civil Engineering Purposes.

CEN15103 WASTE WATER ENGINEERING

CREDIT: 05 (3-1-2)

Course Outcomes	
CO1.	Remembering the principles of wastewater collection and conveyance, the objectives of wastewater treatment, and the design considerations for primary, aerobic, and anaerobic treatment units.
CO2.	Explain the significance of BOD, COD, and other water quality parameters, the kinetics of biological treatment systems, and the microbiology of wastewater treatment processes.
CO3.	Explain the significance of BOD, COD, and other water quality parameters, the kinetics of biological treatment systems, and the microbiology of wastewater treatment processes.
CO4.	Analyse the design and operation of screens, grit chambers, equalization tanks, primary settling tanks, and various aerobic and anaerobic treatment systems.
CO5.	Evaluate the effectiveness of different wastewater treatment methods, the efficiency of treatment units, and the suitability of treatment processes for specific wastewater characteristics.
CO6.	Design innovative wastewater treatment systems, develop strategies for optimizing treatment processes, and create plans for sustainable wastewater management.

Course Content		
Unit	**Content**	**Number of Lectures**
1	Wastewater collection: System of sanitation, estimation of wastewater flows and variations in wastewater flows. Estimation of storm water with numerical example. Flow in sewer: flow in fully and partially full sewer and design of sewer; Types of sewers, materials and construction of sewer, joints and sewer appurtenances, layout and construction of sewer lines, small bore sewer system.	**06**
2	Objectives of wastewater treatment: characteristics, analysis of BOD, COD, solids and volatile solids & their significance, BOD kinetics, types of reactors and reactor analysis. Wastewater treatment, flow sheets for wastewater treatment. Kinetics of biological treatment system: biokinetics constants and their determination in both in batch and continuous systems	**06**
3	Principles and design-Screens, grit chamber, equalization tank, primary settling tank	**07**
4	Principles and design of aerobic treatment system: Suspended growth system- conventional activated sludge process and its modifications, oxidation ditch, Aerated lagoon, Waste stabilization pond. Principles and design of attached growth system-Trickling filter, bio-tower and rotating biological contactors. Microbiology of aerobic wastewater treatment systems.	**08**
5	Principles and design of anaerobic wastewater treatment system including anaerobic filters, UASB reactor, Hybrid reactor etc. Sludge processing: saperation , sludge thickener, volume reduction, conditioning , aerobic and anaerobic sludge digestion. Nutrient removal, Nitrification and Denitrification process, Self purification of streams. Microbiology of aerobic wastewater treatment systems.	**09**
Practicals		
1	Determination of pH, electrical conductivity & turbidity of the given water sample.	
2	Determination of acidity & alkalinity of given sample	
3	Determination of solids (TS, TSS, TDS, VSS and Inorganic solids) in a given wastewater sample.	
4	Determination of optimum coagulant dose required for treating the given water sample	
5	Determination of chloride content & hardness in given water sample.	
6	Determination of residual chlorine in the given water sample & the chlorine demand.	
7	Determination of amount of iron present in the given sample.	
8	Determination of amount of dissolved oxygen (DO) present in the sample	

9	Determination of amount of nitrate in the given water sample using PDA method.	
10	Determination of amount of fluoride present in the given water sample.	
11	Determination of chemical oxygen demand (COD) of given sample	
12	Determination of biochemical oxygen demand (BOD) of given sample.	

References: -

- Masters: Introduction to Environmental Engineering and Science, Prentice Hall Publication.
- McGhee: Water supply and sewerage, Tata McgrawHill, publication.
- Peavy, Rowe and Techbanoglous: Environmental Engineering, Tata McgrawHill, publication.
- Garg S. K.: Environmental Enggineering (I&II), Khanna publication, New Delhi.
- MetCalf& Eddy: Wastewater Engineering: Treatmment and Reuse, Tata McgrawHill, publication.
- Mannual on Water Supply and Treatment, CPHEEO, Govt. of India.
- Mannual on Sewerage and Sewage Disposal, CPHEEO, Govt. of India.
- Standard Methods for the Examination of Water & Wastewater, APHA, AWWA, U.S.A.
- Sawyer and McCarty: Chemistry for Environmental Engineering
- Kotaiah: Environmental Engineering Laboratory Mannual, Charotar Publishing House.

CEN15104 CONCRETE STRUCTURES-I CREDIT: 04 (3-1-0)

Course Outcomes	
CO1.	Understanding basic principles of working stress and limit state design of RCC structures
CO2.	Understanding and application of IS 456 -2000 in design of RCC structures
CO3.	Design of beams, slabs and staircase using basic design principles
CO4.	Design of columns, and footings using basic design principles
CO5.	Understanding how to place and detail steel in RCC structures

Course Content

Unit	Content	Number of Lectures
1	Introduction to Reinforced Cement Concrete, Introduction to different design philosophy, Assumption, Distribution of Stresses on the cross section in bending, transformed area, Analysis and Design of a rectangular singly and doubly reinforced section, T and L sections for flexure, shear and bond.	**10**
2	Behaviour of RC beam in shear, shear strength of beam with and without shear reinforcement, Minimum and Maximum shear	**07**

	reinforcement, Design of beam in shear using Limit state methods. Nature of bond between steel and concrete. Development of bond stress in reinforcement, Concept of development length and anchorage, Design of RC section in bond and calculation of development length using Limit state methods. Failure of beam under torsion, interaction between shear and torsion and between moment and torsion, Concept of equivalent shear and moments. Analysis and design of beam curved in plan.	
3	Design of one-way and two-way solid slabs, and design of staircase.	**05**
4	Classification of Compression members, Effective length, Slenderness ratio and slenderness limit, Axially loaded short column's design - Limit State methods, Increase in permissible load in helically reinforced columns. Eccentrically loaded columns, Minimum eccentricity, Pu & Mu interaction diagrams, Design of Columns using IS-456 Design Aids with Uniaxial and Biaxial bending.	**07**
5	Structural behaviour of footings, design of footing for a wall and a single column, combined rectangular and trapezoidal footings, Design of strap footing.	**07**

References

- Fundamentals of Reinforced Concrete Structures , M L Gambhir , PHI
- Reinforced Concrete Design , A K Jain , Nem Chand
- Reinforced Concrete Design , P Dayratnam , Oxford IBH
- Reinforced Concrete , Pillai & Menon , TMH 2
- Reinforced Concrete Design , S N Sinha , TMH

CEN15105 IRRIGATION ENGINEERING CREDIT: 04 (3-1-0)

Course Outcomes	
CO1.	Understand Concepts of irrigation and different hydraulic structures.
CO2.	Estimate the quantity of water required by crops
CO3.	Plan and design irrigation projects
CO4.	Design channels and other irrigation structures required for irrigation, drainage, soil conservation, flood control and other water-management projects.
CO5.	Describe canal regulation wok, Cross drainage work, perceive the effects of water logging and adapt the preventive measures.

Course Content

Unit	Content	Number of Lectures
1	Definition, Scope of subject, Advantage, Lift and flow irrigation, Development of irrigation in India, crops season, Important crops,	**10**

	Functions of water in plant growth, Soil moisture, consumptive use of water, Irrigation frequency, irrigation methods.	
2	Classes of irrigation canal, Parts of a canal system, Preliminary survey, Detailed survey, Commanded areas, Channel alignment, Curves, Assessment of water requirement, Channel losses, Kennedy's Theory, Lacey's Theory, Longitudinal section, Schedule of area statistics and channel dimension cross- section of irrigation channel.	**06**
3	Definition, Effect, Causes and Anti-water logging measure, concrete lining, shotcrete lining, Asphaltic lining, Brick tile lining of earth material, Sections of lined channel. Drainage of Water logged land, Types of Drains, Open Drains, Closed Drains, Spacing of closed Drains.	**05**
4	Definition, requirement and classes of outlets, Non-modular outlet, Semi-module, Rigid module, Selection of outlet. Regulation, Measurement of discharge, Assessment of canal Revenue, Efficient Management of irrigation water.	**05**
5	Hydrologic statistics-probabilistic treatment of hydrologic data, frequency and probability functions, statistical parameters, probability distribution of hydrologic variables; Frequency analysis- extreme value distributions, flood frequency analysis, risk and reliability; Hydrologic design-design scale and level, safety factors and safety margins; uncertainty analysis.	**10**

References: -

- Singh, Dr. Bharat - Fundamentals of Irrigation Engineering, Nem Chand and Bros.
- Varshney, Dr. R.S., Gupta & Gupta - Theory and Design of Irrigation Structures Vol. I & II., Nem Chand and Bros.
- Punamia, Dr. B.C. and Pandey B.B. Lal, Irrigation and Water Power Engineering, Laxmi Publications(Pvt)Ltd.
- Bedient and Huber- Hydrology and Flodplain Analysis, Prentice Hall.
- Ojha,C.S.P. , Bhunya, P. and Berndtsson, R.- Engineering Hydrology, Oxford University Press Canada.
- Todd and Mays- Groundwater Hydrology, John Wiley and Sons, Inc.
- K. Subramanya - Engineering Hydrology, Tata McGraw Hill Education Pvt.Ltd.
- Modi, P.N. – Irrigation Water Resources and Water Power Engineering, Standard Book House
- Asawa, G.L. – Irrigation and Water Resources Engineering, New Age International.
- Walker, W.R. and Skogerboe, G.V. 1986. Surface irrigation theory and practice. Prentice-Hall, Inc.

AMN15101 STRUCTURAL ANALYSIS-II CREDIT: 05 (3-1-2)

Course Outcomes	
CO1.	Understanding basic principles of analysis of indeterminate structures by energy methods
CO2.	Understanding basic principles of analysis of indeterminate structures by stiffness methods
CO3.	Determination of internal and external forces and displacements using matrix stiffness approach

CO4.	Understanding computer-oriented stiffness method
CO5.	Understanding and analysing structures using plastic analysis approach

Course Content		
Unit	**Content**	**Number of Lectures**
1	Introduction, Force and Displacement Methods of Analysis of Indeterminate Structures, Method of Consistent Deformation for beams and plane frames. Method of Minimum Strain Energy for indeterminate beams, Trusses and plane frames.	**08**
2	Introduction, Moment distribution and Slope Deflection methods for continuous beams and plane frames	**07**
3	Introduction, Flexibility Method- Application to Beams, Trusses, Frames and Grid Structures; Stiffness Method- Application to Beams, Trusses, Frames and Grid Structures (including plane and space structures.	**10**
4	Introduction, Application to Beams, Frames and Trusses	**07**
5	Introduction, Analysis of Plastic Structures.	**04**
Practical's		
1	Analysis of Redundant Joint	
2	Flexural Stiffness of Beam	
3	Verification of Maxwell's Reciprocal Theorem	
4	Analysis of Curved Members	
5	Verification of Carry Over Factor	
6	Three Hinged Arch	
7	Two Hinged Arch	
8	Elastically Coupled Beam	
9	Unsymmetrical Bending	

References

- Structural Analysis, Hibbeler, Pearson Publications.
- Structural Analysis, Aslam Kassimali, Cengage Learning Publications.
- Structural Analysis in Theory and Practice, Alan Williams, Elsevier Publications.
- Elementary Structural Analysis, C. H. Norris, J. B. Wilbur and S. Utku., Tata Mcgraw Hill Publications.
- Structural Analysis, L.S. Negi and R. S. Jangid, Tata Mcgraw Hill Publications.
- Intermediate Structural Analysis, C. K. Wang, Tata Mcgraw Hill Publications.
- Matrix Analysis of Framed Structures, W. Weaver (Jr.) and J. M. Gere, CBS Publications.

III Year (6th Semester)

CEN16101 STEEL STRUCTURES CREDIT: 05 (3-1-2)

Course Outcomes	
CO1.	Remember and identify key concepts of structural steel design, including stress-strain relationships, rolled steel sections, and various types of structural connections.
CO2.	Understand and explain the principles of plastic analysis and design, working stress, and limit state methods, as well as the behavior of tension and compression members under various loading conditions.
CO3.	Apply knowledge to design effective structural elements, including bolted and welded connections, tension members, compression members, flexural members, and plate girders, considering factors such as load transfer, failure modes, and lateral stability
CO4.	Analyze and evaluate the structural behavior of beams and the design of plate girders, including the proportioning of web and flanges, and the use of stiffeners and flange curtailment.
CO5.	Create comprehensive structural designs that integrate the learned concepts and adhere to current engineering standards and practices, demonstrating a high level of proficiency in critical thinking and problem-solving skills as outlined in Bloom's Taxonomy.

Course Content		
Unit	**Content**	**Number of Lectures**
1	General Considerations: Structural Steel, Stress-Strain Curve for Mild Steel, Rolled Steel Sections, Introduction to Plastic Analysis and Design, Working stress and Limit State Method of Steel Design	**06**
2	Types of connections & joints, Bolted and Welded Connections, Load Transfer Mechanism, Failure Modes, Prying Action, Slip-Critical Connections, Moment Resistant Connections, Eccentric Connections, Beams-Column Connections, Bracket Connections, Framed Connections, Seat Connections.	**06**
3	Types of Tension Members, Net and effective Sectional Areas, Types of Failure, Design Strength and design of Tension Member, Lug Angles, Splices, Gusset Plate. Effective Length and Slenderness Ratio of compression members, Classification of Cross Sections, Column Formula, Design of Axially Loaded Compression Members, Built-Up Columns (Latticed Columns), Encased Column, Column Splices, Design of Column Bases and Caps	**06**
4	Structural behaviour of Beams, Types of Sections for flexural design Lateral Stability of Beams, Lateral Torsional Buckling, Plastic design of beams, Design of Laterally Supported Unsupported Beams Rolled Beams, Built-Up Beams, Lintels, Purlins, Bearing Plates, Design of Beam-columns	**12**

	Elements of Plate Girder, General considerations, Proportioning of web, Proportioning of flanges, Design methods, End panel design, Design of Stiffeners, Curtailment of Flanges	
5	(a) Gantry Girders: Introduction, Loads, Fatigue Effects, Design of gantry Girders. (b) Industrial Buildings: Introduction, Planning, Structural Framing, Types, Roof and Side Coverings, Elements of an Industrial Building, Design Steps of Industrial Building	**06**
Practical's		
1	General Detailing Lay-out, details of Steel Sections and Symbolic representation of connections	
2	Detailing of simple and moment resistant Bolted and Welded Connections	
3	Detailing of trusses and Trussed Roofs: Using Angle sections, Tee sections, Channel sections, I-sections, and Tubular sections	
4	Detailing of beam and column connection using bolts and welds.	
5	Detailing of beams , built-up columns and beam & column splicing	
6	Detailing of column and footing connection using bolts and welds.	
7	Detailing of Plate girder.	
8	Detailing of Gantry girder.	

References: -

- Design of Steel Structures by N. Subramanian, Oxford University Press
- Design of Steel Structures by K.S.SaiRam,Pearson India Education Pvt. Ltd.
- Design of Steel Structures by S. K. Duggal, Tata Mcgraw Hill.
- Steel Structures by Robert Englekirk. Hohn Wiley & sons inc.
- Structural Steel Design by Lambert Tall, Ronald Press Comp. New York
- BIS Codes of Practice
- IS 800-2007 : Code of Practice for General Construction in Steel
- Hand Book for Structural Engineers : SP:6(1)-1964 [Reaffirmed in 2003]
- IS 808 : 1989 [Reaffirmed in 2003]
- Code of Practice for Design Loads (other than earthquake) for buildings and structures : IS 875 Part I to V : 1987 [Reaffirmed in 2003]

CEN16102 CONCRETE STRUCTURES-II CREDIT: 04 (3-0-2)

Course Outcomes	
CO1.	Understanding basic principles of design of various structures
CO2.	Evaluate , BM , Shear and torsion etc in the structural elements
CO3.	Design of roofing elements , water tanks and retaining walls
CO4.	Understanding basics of Prestressed Concrete

CO5.	Design of Prestressed concrete beams as per provisions of IS 1343-2012

Course Content		
Unit	**Content**	**Number of Lectures**
1	Design of flat slabs with and without drops. Circular slabs with various edge and loading conditions, and their usages.	**05**
2	Water tanks: Design criteria, material specifications and Permissible stresses for water retaining structures, Design of circular water tanks with fixed & flexible bases, situated on onground/underground	**05**
3	Design of square /rectangular tanks situated on ground/underground, using approximate method and IS- code method.	**05**
4	Structural behaviour of retaining wall, stability of retaining wall against over-turning sliding and pressure developed under the base, Design of T-shaped retaining wall, Concept of counterfort retaining wall.	**06**
5	Advantages of prestressing, methods of prestressing, Losses in prestress, analysis of simple prestressed rectangular and T-sections. Intoduction to design of elements, load balancing concept, profile of cable. Design of rectangular, T, I beam under flexure and shear using IS 1343	**15**
Practicals	**CONCRETE STRUCTURES-II (LAB.)**	
1	Simple Beam/Lintel	
2	T-Beam floor	
3	Rectangular Slabs	
4	Brick wall and Isolated footing	
5	Combined Rectangular and Trapezoidal Footing	
6	Water tank	
7	T. shape Retaining wall	
8	Details of Flat slab & Circular Slabs	
9	Details of Stair Case	

References :-

- Reinforced Concrete Design, Limit State Method ,Jain A.K. , NemChand
- Reinforced Concrete Structures , M L Gambhir , PHI
- Reinforced Concrete Design , Pillai & Menon , TMH
- Design of Reinforced Concrete Structures ,Dayaratnam , P. , Oxford IBH
- Prestressed Concrete , Krishna Raju , N , CBS
- IS 456-2000: Code of practice for plain & reinforced concrete.
- SP-16: Design Aids of Reinforced Concrete to IS: 456-1978. 8. IS 3370-1968 & IS 3370-2009: Code of practice for water retaining structures
- IS 1343 -2012 – Code of Practice for Prestressed Concrete

CEN16103 DESIGN OF HYDRAULIC STRUCTURES
CREDIT: 04 (3-1-0)

Course Outcomes	
CO1.	Remember and identify the fundamental principles of irrigation hydraulic structure design, including BLIGH's and Khosla's theories, and the functions and layouts of canal headworks.
CO2.	Understand and explain the design considerations for weirs on permeable foundations, the classification and design of falls, and the objectives and methods of river training.
CO3.	Apply knowledge to design and analyse various hydraulic structures such as aqueducts, syphon aqueducts, and gravity dams, considering factors like safety, stability, and energy dissipation.
CO4.	Analyse and evaluate the selection of dam sites, estimation of storage capacity, reservoir planning principles, and the characteristics of different types of dams.
CO5.	Create comprehensive plans for hydraulic structures and hydro-electric power systems, integrating the learned concepts to ensure efficient, safe, and sustainable water resource management, demonstrating a high level of proficiency.

Course Content		
Unit	**Content**	**Number of Lectures**
1	Principle of design irrigation hydraulic structures and Headworks-BLIGH'S Theory, Khosla's theory for determination of pressure and exit gradient, Hydraulic jump. Canal Head Works-Functions, Location, Layout of Head work, Weir, Canal head regulator, Design of Weirs on permeable foundation, silt control at head work.	**10**
2	Canal Regulation Works and Cross Drainage Works-Falls, Classification of falls, Design of falls, Distributory head regulator and cross-regulator, Escape, Bed bars. Necessity and types, Aquaduct, Syphon Aquaduct, Super passage, Canal syphon, Level crossing, Design of cross drainage work	**06**
3	River Training Planning of Dams & Reservoirs- Objective, scope & classification of river & river training, stages, Methods of River Training, bank protection. Selection of Dam sites, Investigation, Estimation of storage capacity, Principle of Reservoir planning. Flood Routing, Reservior loss, Reservoir sedimentation.	**06**
4	Types of Dams and Their Characteristics- Gravity Dams, Forces acting, method of analysis, Modes of failure and factors of safety, Elementary Profile of a gravity dam, Stability analysis, galleries. Earth dam, Foundation, Materials, Criteria for safe design, typical sections, compaction of Rock fill dam. Spilways, Spilway capacity, Types of spilway, Energy dissipation below spillway, Gates.	**10**
5	Water Power-Hydro-Electric Power: Assessment of potential, Classification of power plants, Types of turbine, Power house.	**04**

References:-

- *Singh, Dr. Bharat - Fundamentals of Irrigation Engineering, Nem Chand and Bros.*
- *Varshney, Dr. R.S., Gupta & Gupta - Theory and Design of Irrigation Structures Vol. I & II., Nem Chand and Bros.*
- *Punamia, Dr. B.C. and Pandey B.B. Lal, Irrigation and Water Power Engineering, Laxmi Publications(Pvt)Ltd.*
- *Modi, P.N. – Irrigation Water Resources and Water Power Engineering, Standard Book House*
- *Bedient and Huber- Hydrlogy and Flodplain Analysis, Prentice Hall.*
- *Asawa, G.L. – Irrigation and Water Resources Engineering, New Age International.*
- *Walker, W.R. and Skogerboe, G.V. 1986. Surface irrigation theory and practice. Prentice-Hall, Inc.*

CEN16300 SOFTWARE APPLICATION IN CIVIL ENGINEERING CREDIT: 02 (0-0-4)

Course Outcomes	
CO1.	Understand the elements of structural modelling, specification of loads and boundary condition,
CO2.	Perform analysis and interpretation of results for design of buildings
CO3.	Design geometric elements of roads using software

Practical	**Content**	**Number of Lectures**
1	Develop the algorithms and computer programme to compute SFD and BMD of the beams (Cantilever, Simply Supported and Fixed) and slabs subjected to different kind of loading conditions.	
2	Write computer programmes to design the different components of the RCC building structure using Limit State Method.	
3	Analyse and design the multi-storey buildings as per relevant IS Codes using design software.	
4	Prepare the calculations of concrete mixes design using spreadsheet.	
5	Develop the algorithms and computer programme for designing the isolated, combined footing, raft footing and strip footing.	
6	Carry out geometric design of roads using Road Design Software	
7	Develop the computer programmes to design the flexible and rigid pavements using relevant IS Codes.	
8	Develop the spatial database of a given area of interest using satellite data products and GIS Software.	

9	Develop a computer program to design the sedimentation tank for water treatment.	
10	Develop a computer program to calculate the runoff for a given catchment area.	

References

1. *Krishnamoorthy, C. S., Rajeev, S., & Rajaraman, A. (2005). Computer aided design: software and analytical tools. Alpha Science International Limited.*
2. *Davenport, C., & Voiculescu, I. (2015). Mastering AutoCAD Civil 3D 2016: Autodesk Official Press. John Wiley & Sons.*
3. *Omura, George. Mastering AutoCAD. SYBEX Inc.*
4. *Raphael, B., & Smith, I. F. (2013). Engineering informatics: Fundamentals of computer-aided engineering. John Wiley & Sons.*
5. *Sharma, T.S., Staad Pro V8i for Beginners: With Indian Examples, Notion Press; 1st edition (1 January 2014)*

CEN16104 ENGINEERING HYDROLOGY CREDIT: 03 (2-1-0)

Course Outcomes

CO1.	Remember and identify the fundamental concepts of the hydrologic cycle, forms of precipitation, and the processes of evaporation, infiltration, and evapotranspiration.
CO2.	Understand and explain the methodologies for measuring and estimating hydrologic elements, and the significance of rainfall-runoff correlations and streamflow measurements.
CO3.	Apply knowledge to analyze hydrographs, perform flood frequency studies, and forecast floods using various hydrologic methods and models.
CO4.	Analyze and evaluate the factors affecting hydrographs, the reliability and safety factors in flood risk assessment, and the effectiveness of flood control measures.
CO5.	Create comprehensive plans for flood routing, integrating the learned concepts to ensure efficient and sustainable water resource management

Course Content

Unit	Content	Number of Lectures
1	General Consideration-Introduction, Definition, Hydrologic cycle.	**4**
2	Precipitation and Abstractions-Precipitation, Infiltration and Evapotranspiration, Forms of precipitation, measurement, depth-area-duration and intensity-duration frequency relations,	**6**

	Evaporation - process, measurement, and estimation, Infiltration process, measurement, and estimation, Evapotranspiration measurement and estimation, Runoff, Rainfall Runoff correlations, Flow duration curve, Mass curve, Stream Flow measurements.	
3	Hydrograph- Factors affecting flow hydrograph, Unit hydrograph, its analysis, and S-curve hydrograph, Synthetic and instantaneous unit hydrographs.	**4**
4	Floods-Statistical analysis, Flood frequency studies, Flood forecasting, Rational method, Time Area curves, Risk, reliability, and safety factor, Flood control measures.	**6**
5	Flood Routing-Introduction to basic routing equations, Design flood, Channel and flood routing, Hydrologic Routing, Hydraulic routing.	**4**

References
1. Engineering Hydrology by Dr. K. Subramanya Tata Mcgraw Hill Education Limited 2. Engineering Hydrology by Dr. C. S. P. Ojha

CEXXXXX PROFESSIONAL ELECTIVE-I CREDIT: 03 (3-0-0)

- Prestressed Concrete
- Precast and Modular Construction
- Geotechnical Processes
- Geotechnical Explorations
- Air & Noise Pollution Control
- Environmental Impact Assessment
- Rural Roads
- Astronomy and Photogrammetry
- Open Channel Hydraulics
- Isotope applications in Water Resource Management

CEN16250 PRE-STRESSED CONCRETE CREDIT: 04 (3-1-0)

Course Outcomes	
CO1.	Determination of deflection and flexural strength of Prestressed concrete members.
CO2.	Determination of shear and torsional strength of Prestressed concrete members.
CO3.	Design of Anchorage Zone of Prestressed concrete members and Limit State of Prestressed concrete members.
CO4.	Design of Prestressed concrete sections.
CO5.	Design of Poles and Sleepers.

Course Content

Unit	Content	Number of Lectures
1	**Deflection and Flexure** Importance of control deflection, Short term deflections of uncracked members, Prediction of long time deflections, deflections of cracked members, Types of flexural failure, Different methods of estimating flexural strength, Shear resistance of Prestressed concrete members	**08**
2	**Shear and Torsional Resistance of Prestressed Concrete Members** Shear and Principal stresses, Ultimate shear resistance of Prestressed Concrete Members, Design of Shear Reinforcements, Prestrred Concrete Members in Torsion, Design of Reinforcements for Torsion, Shear and Bending	**06**
3	**Transfer of Prestress in Pretensioned Members and Anchorage Zone Stresses and Limit State design Criterion** Transmission of Prestressing Force by Bond, Bond Stresses, Transverse Tensile stresses, End Zone Reinforcement, Stress distribution in end block of post-tensioned members, Investigations on Anchorage zone stresses and anchorage zone reinforcement, Limit state design criteria for prestressed concrete members, principles of dimensioning prestressed concrete members	**08**
4	**Design of prestressed concrete sections** Design of prestressed concrete sections for flexure, axial tension, compression & bending, shear & torsion, bond and bearing, Design of pre-tensioned, post-tensioned and partially prestressed members.	**08**

5	**Introduction of Continuous Prestressed Concrete Beams and design of Pole and Sleeper** Introduction of Continuous Prestressed Concrete Beams, Design of Poles and Sleepers.	**06**

References

1. *Theory of Prestressed Concrete, Michael Chi & frank A. Biberstein, Prentic Hall International, London*
2. *Prestressed Concrete Theory and Practice,P.B.Morice&E.H.Cooley, Sir Isaac Pitman &Sons, Ltd. London.*
3. *Modern Prestressed Concrete,James R. Libby, Van Nostrand Reinhold Company New York.*
4. *Prestressed Concrete, N.Rajgopalan, Narosa Publishing House, New Delhi.*

Prestressed Concrete, N. Krishna Raju,Tata McGraw Hill,Publishing Company Limited

CEN16251 PRECAST AND MODULAR CONSTRUCTION
CREDIT: 04 (3-1-0)

Course Outcomes	
CO1.	Identify the Design Principles, Special Characteristics and Rules associated with Precast Concrete Design and Construction.
CO2.	Introduction of prefabricated components and their applications.
CO3.	Describe the load system, load path and design principles of precast structures.
CO4.	Analyse and Design the joints and connection for Precast Structural elements.
CO5.	Analyse and Design the Precast Structural elements for abnormal loads.

Course Content

Unit	Content	Number of Lectures
1	**Introduction** Detailed description of Precast Concrete Construction. Difference between Precast and Other forms of Concrete construction. Advantages of this form of construction. Need for Prefabrication: Principles of prefabrication, Comparison with cast-in-situ construction, types of prefabrication, automation in manufacturing of precast elements, Modular Coordination, Standardization, Transportation, Erection Materials in Precast Structures – Mix design, Steel reinforcement, Structural steel, welding, inserts and bolts,	**05**

2	**Prefabricated Components** Behaviour and types of structural components – Large panel systems – roof and floor slabs – Walls panels - Beams - Columns - Shear walls	**02**
3	**Design Principles** Structural Concepts of Precast Concrete Systems: Loads, Load path, Limit states, Precast Concrete building systems, Pre-cast frame analysis, Overview of the Structural Ties, Design philosophy- Design of cross section based on efficiency of material used – Problems in design because of joint flexibility – Allowance for joint deformation - Demountable precast concrete systems.	**04**
4	**Joints and Connections in Structural Members** Types Of Joints – Based On Action Of Forces - Compression Joints - Shear Joints - Tension Joints - Based On Function - Construction, Contraction, Expansion. Design Of Expansion Joints - Dimensions And Detailing - Types Of Sealants - Types Of Structural Connections - Beam To Column - Column To Column - Beam To Beam - Column To Foundation.	**04**
5	**Design for Abnormal Loads** Progressive collapse – Codal provisions – Equivalent design loads for considering abnormal effects such as earthquakes, cyclones, etc.,- Importance of avoidance of progressive collapse.	**04**

References

1. Bruggeling A.S. G and Huyghe G.F. "Prefabrication with Concrete", A.A. Balkema Publishers,USA,1991.
2. Lewitt,M. " Precast Concrete- Materials, Manufacture, Properties And Usage", Applied Science Publishers , London And New Jersey, 1982.
3. Bachmann, H. and Steinle, A. "Precast Concrete Structures", Ernst & Sohn, Berlin, 2011.
4. Precast Concrete Structures by KIM S. ELLIOT, Second Edition, CRC Press, Taylor & Francis Group.
5. The Structural Precast Concrete Handbook 2 nd Edition, ISBN : 981-04-3609-2, Building and Construction Authority, May 2001..

CEN16252 GEOTECHNICAL PROCESSES CREDIT: 04 (3-1-0)

Course Outcomes	
CO1.	Know about the various stabilisation techniques.
CO2.	Know how to control compaction characteristics in the field.
CO3.	Understanding various techniques to improve the ground.
CO4.	Understanding about the application of grouting technique.
CO5.	Understanding how to reinforce earth with the application geosynthetics.

Course Content		
Unit	**Content**	**Number of Lectures**
1	Soil Stabilization-Soil Stabilization Techniques; Mechanical, Lime, Cement, Bituminous, Chemical, Thermal, Electrical stabilization.	**7**
2	Compaction-Field and Laboratory compaction, Properties of soil on wet and dry of OMC, Compaction control, Precompaction, Compaction piles.	**6**
3	Dewatering-Dewatering Methods; Intercepter Ditches, Single and multi-stage well points, Vacuum Well points, Electro-osmosis, Vertical drains.	**9**
4	Grouting-Grouting materials; Suspension, Solutions and Resins, Grouting technology.	**6**
5	Geosynthetics-Types of Geosynthetics, Geotextile testing, Application of Geosynthetic material, Bearing Capacity improvement. Reinforced Earth- Mechanism of reinforced earth, Soil reinforcement, Design of reinforced earth wall.	**8**

References: -

- Haussman: Engineering Principles of Ground Modification, McGraw-Hill
- Leonards: Foundation Engineering, McGraw-Hill
- Witerkorn& Fang: Foundation Engineering, Springer
- F.G. Bell: Foundation on Difficult Ground, Newnes-Butterworth
- Shroff: Grouting Technology in Tunnelling and Dam Construction, A A Balkema Publishers
- Ingles and Metcallf: Soil Stabilization, Wiley.

CEN16253 GEOTECHNICAL EXPLORATIONS CREDIT: 04 (3-1-0)

Course Outcomes	
CO1.	Know the process of the soil exploration and geophysical exploration
CO2.	To Understand the Drilling methods applicable in the Field
CO3.	Collection, Preservation and Transportation of Soil Samples
CO4.	Conducting tests in the field and Results Interpretation
CO5.	Assessment of Bearing Capacity and Applications of Field Test Data for Design of Structures

Course Content		
Unit	**Content**	**Number of Lectures**
1	Soil Exploration: Importance, Terminology, Planning of Ground Investigations, Geophysical methods.	**5**
2	Borings: drilling, Probing and Trail pits, Location, spacing and depth, Methods of Boring including Drilling, Stabilization of Boreholes, Planning of exploration.	**8**
3	Sampling and Sample Disturbance: Methods of sampling - Types of Samples and Samplers Cleaning of Bore holes, Preservation, Labeling and Shipment of Samples, Design Considerations of Open Drive Samplers. Bore log, Preparation of Soil Report.	**7**
4	Field tests: Standard Penetration Test, Cone Penetration Test, Field Vane Shear Test, Bore Hole Shear Test, Dilatometer Test, Pressure Meter test, Field Permeability Test.	**8**
5	Bearing Capacity Assessment from Field Data for Design of Structures, Plate load test, Monotonic and Cyclic Pile load test.	**8**

References

1. Site Investigation by C.R.I.Clayton, M.C. Matthews and N.E,Simons, University of Surrey, UK.
2. Geotechnical Investigation methods: A filed Guide for Geotechnical Engineers – Roy. E. Hunt, CRC Press.
3. Hvorslev, M. J., Sub- Surface Exploration and Sampling of Soils for Civil Engineering Purposes, US Waterways Experiment Station, Vicksburg, 1949.
4. Soil Mechanics in Engineering Practice by Terzagi and Peck
5. Foundation Analysis and Design by J.E. Bowles McGraw Hill Publishing Co.,
6. Foundation Design and Construction by MJ Tomlinson – Longman Scientific
7. Relevant IS Codes

CEN16254 AIR & NOISE POLLUTION CONTROL CREDIT: 04 (3-1-0)

Course Outcomes	
CO1.	Remember and identify the major air pollutants, their sources, effects, and the criteria for air quality standards.
CO2.	Understand and explain the photochemistry of the atmosphere, the meteorological factors affecting air pollution, and the principles of pollutant dispersion.
CO3.	Apply knowledge to analyze and calculate the dispersion of pollutants using Gaussian and other models, and to design control mechanisms for particulate and gaseous pollutants.
CO4.	Analyze and evaluate the efficiency of various air pollution control equipment and techniques, including those for automobile emissions.
CO5.	Create comprehensive strategies for air quality management, integrating the learned concepts to ensure compliance with air pollution laws and standards

Course Content

Unit	**Content**	**Number of Lectures**
1	Introduction: Major Air pollutants-their sources and effects in quality criteria and ambient air quality standard. Photo- Chemistry of atmosphere: Photo-Chemical reactions, Monatomic oxygen and ozone formation, role of oxides of Nitrogen, Hydrocarbons, and oxidants in photochemical smog; Oxidation of SO2 in polluted atmospheres.	**6**
2	Meteorology: Introduction, Solar radiation, Wind circulation lapse rate, Stability conditions, wind velocity profile, Maximum mixing depth, wind-roses, Atmospheric turbulence, general characteristics of stack plumes, heat island effect, global circulation of pollutants. Dispersion of pollutants-Gaussian and other models, calculation of effective stack height**.**	**7**
3	Control of Particulates and gaseous pollutants: Particulate distribution, collection efficiency, Settling and Deposition. Particulate collection mechanisms, control equipment. Vapor and gaseous pollutants: Adsorption and absorption processes, Kinetic reactions, Carbon Monoxide emission control, Incineration or after-burning processes, control of oxides of Sulphur and oxides of Nitrogen, General control methods, flue gas control**.**	**10**
4	Automobile Pollution: Automobile emissions and their control techniques. Automobile emission standards. Legislation and	**5**

	regulatory trends: Air pollution laws, standards and implementation and compliance.	
5	Noise Pollution and Control: Effects of Noise, Basic principles of noise control; Industrial and construction noise and control. Aircraft and airport noise and control, Highway and rail traffic noise and control. Control of noise in the home, control of noise from recreational activities, methods of controlling noise. Noise Indices. Noise control legislation.	**8**

References

1. Peavy, Rowe and Tchobanoglous: Environmental Engineering.

2. Martin Crawford: Air Pollution Control Theory.

3. Wark and Warner: Air Pollution: Its Origin and Control

4. Rao and Rao: Air Pollution Control Engineering.

5. Environmental Pollution Control Engineering- CS Rao, Wiley Eastern Ltd., New Delhi, 1996.

6. C.S. Rao, Air pollution and control

7. Environmental Noise Pollution - PE Cunniff, McGraw Hill, New York, 1987

8. Nevers: Air Pollution Control Engineering.

9. Mycock, McKenna and Theodore: Handbook of Air Pollution Control Engineering and Technology.Suess and Craxford: W.H.O. Manual on Urban Air Quality Management

10. Environmental Noise Pollution – PE Cunniff, McGraw Hill, New York, 1987

11. Report of the Committee appointed by Hon. Justice Smt. Sujata Manohar on Noise

Pollution, (Distributed by Bombay Environmental Action Group, 4, Kurla Industrial Estate,

Ghatkopar, Mumbai 400 086), 1986.

CEN16255 ENVIRONMENTAL IMPACT ASSESSMENT
CREDIT: 04 (3-1-0)

Course Outcomes	
CO1.	Remember and identify the key components of the environment, the concept of ecological imbalances, and the principles of sustainable development.
CO2.	Understand and explain the Environmental Impact Analysis (EIA) procedure, the notification process by the Ministry of Environment, Forest and Climate Change (MoEF), and the elements of environmental analysis.
CO3.	Apply various impact assessment methodologies, including matrices, overlays, network analysis, GIS, and cost-benefit analysis, to predict and assess impacts on the physical, biological, and socio-economic environment.
CO4.	Analyze the approaches for air and water quality impact analysis and evaluate the methods for assessing the impact of air pollution.
CO5.	Create comprehensive environmental impact statements and audits, and develop strategies for mitigating negative impacts on noise, human health.

Course Content		
Unit	**Content**	**Number of Lectures**
1	**Introduction** Environment and its components, Concept of Ecological imbalances, carrying capacity and sustainable development.	**5**
2	**EIA Procedure** Introduction to Environmental impact Analysis, EIA procedure, A step-by-step procedures for developing EIA. Notification of EIA by MoEF, Environmental impact Statement. Elements of Environmental Analysis.	**6**
3	**Methodologies** Impact Assessment Methodologies, -Matrices, overlays, network analysis. Battle system, Geographic Information System (GIS), Cost-Benefit Analysis, etc. Prediction and assessment of impacts on physical, biological and socio-economic environment.	**8**
4	**Air and Water Quality Impact Analysis** Brief Introduction of Air Quality Impact analysis. General	**8**

	Approach for Assessment of Air Pollution Impact, Introduction of Water Quality Impact Analysis.	
5	**Noise and Human Health Quality Impact Analysis** Introduction of Noise quality impact analysis and energy impact analysis. Introduction of Socio Economic and Human Health Impact Analysis. Environmental Laws: Brief introduction about Environment legislation and Environmental Audit. Case studies of EIA of developmental projects.	**9**

References

- Environmental Impact Assessment by C.W. Canter, Tata McGraw-Hill publication 2. Environmental Impact Assessment Methodologies by Y. Anjaneyulu & V. Manickam, BS Publication
- Environmental Impact Assessment Theory and Practice by Peter Wathern, Routedge-Taylor & Francis Group.
- Environmental Impact Assessment-A guide to Best Professional Practice by Charles H. Eccleston, CRS Press
- Manual on Environmental Impact Assessment, Ministry of Environment & Forest (MoEF), Govt. of India.
- World Bank, 'Environmental Assessment Source Book', Environment Dept., Washington D.C., 1991.
- Rau, G.J. and Wooten, C.D., Environmental Impact Analysis Handbook, McGraw Hill, New York, 1980.
- Canter, L., Environmental Impact Assessment, McGraw Hill, New York, 1996.

CEN16256 RURAL ROADS CREDIT: 04 (3-1-0)

Course Outcomes

CO1.	Describe the rural road planning process.
CO2.	Design the geometric components of rural road code provisions
CO3.	Design the pavement for rural areas as per code provisions
CO4.	Select the materials and corresponding construction technology for rural roads
CO5.	Explain the type and requirements of drainage systems for rural roads
CO6.	Explain the types and techniques of maintenance for rural roads

Course Content		
Unit	**Content**	**Number of Lectures**
1	Rural Road Planning-Introduction -Concept, Objective and Significance of rural roads for Developing Countries, Rural Road Planning and Investment -State of Art, Existing practices for Rural Road Planning, PMGSY Models, Accessibility Based Models vertical, horizon and transit.	**8**
2	Geometric Design Planning-Geometrics of low-cost rural roads - traffic and design speed, Horizontal alignment, Vertical alignment and Cross-section elements	**5**
3	Pavement Design-Pavement design: CBR method of Rural Road Design as adopted in PMGSY programme, IRC method of pavement design for rural roads.	**7**
4	Materials and Construction Techniques-Materials for low-cost roads -Stabilized techniques, various construction techniques for sub-base, base and surface courses; soil tests for construction of rural roads.	**6**
5	Rural Road Drainage and Cross Drainage Structures-Road Drainage -Various Low-Cost Drainage Alternatives for rural roads. Types of cross drainage structures for rural roads: Hume pipe, slab culverts and cause ways, Preparation of detailed estimates for rural road, Rural Road Low-Cost Maintenance Management Techniques.	**8**

CEN16257 ASTRONOMY AND PHOTOGRAMMETRY
CREDIT: 04 (3-1-0)

Course Outcomes	
CO1	To acquire knowledge of astronomical terms, and apply in understanding astronomical coordinate systemsand astronomical triangle.
CO2	To attain the knowledge of time in astronomy and methods of observations of Sun and stars, and apply them in field astronomy.
CO3	To understand and acquire the knowledge of Photogrammetry, and to apply for precise measurements on aerial photographs in mono and stereo-mode.
CO4	To acquire and disseminate knowledge of Photogrammetric project planning and aerial photo interpretation, and apply in mapping of features.

CO5	To understand mathematical principles in the perspective from Analog to Analytical to Digital Photogrammetry, and apply for generation of digital maps.

Course Content		
Unit	**Content**	**Number of Lectures**
1	**Astronomical Triangle and Coordinates Systems** :Introduction to the Course, Terms and definitions in astronomy, Basics of Spherical Trigonometry, Astronomical coordinate systems, Astronomical triangle, Napier's rules, Star at elongation, prime vertical, horizon and transit.	**8**
2	**Time in Astronomy :**Systems of time in Astronomy, Inter-conversion, Equations of time, Methods of determining azimuth, latitude and time, Correction to field observations.	**7**
3	**Introductory Photogrammetry & Stereoscopy:**Introduction, Photogrammetry as mapping technique, Aerial Photographs- Basics, Geometry, Scale and Relief displacement, Stereoscopy- Overlap of photographs, Stereoscopes, Stereoscopic view, Parallax, Parallax measurement, Parallax equation, Parallax bar, Tilted Photographs- Geometry, Scale, Relief and Tilt displacement.	**7**
4	**Photogrammetric Mapping :**Flight planning for aerial photography, Aerial Photo Interpretation- Fundamentals, Image characteristics, Interpretation keys and instruments, Orientation- Concepts, Interior and Exterior, Ground controls, Photo-triangulation, Photomaps and Mosaics, Stereo-plotting instruments and modern trends.	**7**
5	**Digital Methods in Photogrammetry :**Mathematical Photogrammetric principles- Analog vs Analytical vs Digital models, Digital Photogrammetric systems- Potential, capabilities and characteristics, Digital photographs- characteristics, Model formation using digital stereo-pairs, Concept of Collinearity and Coplanarity, Digital orthophotos, Generation of digital map.	**7**

References

1. Elements of Photogrammetry with Application in GIS: Paul R. Wolf and Bon A. Dewitt, McGraw Hill.
2. Introduction to Modern Photogrammetry: Edward M. Mikhail, Janan S. Bethel & Chris McGlone, Wiley & Sons Inc.

3. Photogrammetry: Kraus, K., Berlin: de Gruyter.
4. Photogrammetry: Hallert, B., McGraw Hill.
5. Photogrammetry: Moffitt, Francis H. & Mikhail, Edward M., Harper and Row Publisher.
6. Remote Sensing & Image Interpretation: T.M. Lillesand & R.W. Kiefer, Wiley Students Edition, India.
7. Surveying(Vol-II):B.C.Punmia&A.K. Jain, LaxmiPublications,New Delhi.
8. Surveying(Vol-II):S.K. Duggal, TataMcGraw-Hill,New Delhi.

CEN16258 OPEN CHANNEL HYDRAULICS CREDIT: 04 (3-1-0)

Course Outcomes	
CO1.	Understand and analyze the uniform and non-uniform flow characteristics in open channels
CO2.	Compute the Gradually Varied Flow Profiles
CO3.	Compute and analyse the Hydraulic Jump Profiles
CO4.	Understand the Spatially Varied Flow features
CO5.	Understand the unsteady Flow features.

Course Content

Unit	Content	Number of Lectures
1	General Considerations-Classification, description, types energy and momentum equation for prismatic and non prismatic channels.	**6**
2	Uniform Flow-Uniform flow, critical flow, critical depth, specific energy. Channel transitions, Energy-depth relationships, uniform flow computations, Manning's coefficient, Compound Channels	**8**
3	Gradually and Rapidly Varied Flow- Gradually varied flow, dynamic equation, flow profiles and computation, analytical and graphical methods, transitions of subcritical and supercritical flows. Rapidly Varied Flow-Characteristics of the flow, hydraulic jump in horizontal, and sloping channels, submerged hydraulic jump, Flow in channel of non-linear alignment and non-prismatic channel sections.	**10**
4	Spatially Varied Flow- Basic principles, dynamic equation, analysis of flow profile, methods of numerical integration.	**6**

5	Unsteady Flow and Flow in Mobile Boundary Channel- Introduction to unsteady flow, continuity and momentum equations, Finite difference techniques for open channel problems, bed forms, channel resistance, sediment loads.	**6**

References

1. *Open Channel Hydraulics - Ven Te Chow, mcgraw Hill International Edition*
2. *Flow Through Open Channel - K.G. Ranga Raju., Tata McGraw-Hill*
3. *Open Channel Flow – Henderson, Macmillan.*
4. *Open Channel Hydraulics – Hanif Choudhary, Prentice Hall of India.*
5. *Flow in Open Channels – K. Subramanya, Tata McGraw Hill*
6. *Flow Through Open Channels- Rajesh Srivastava, Oxford University Press.*

CEN16259 ISOTOPE APPLICATIONS IN WATER RESOURCE MANAGEMENT CREDIT: 04 (3-1-0)

Course Outcomes	
CO1.	Understand the basic concepts of Isotope and their applications
CO2.	Explain the concepts of detecting different isotopes
CO3.	Apply the concept of hydrologic application of Isotope
CO4.	Estimate the groundwater recharge and contaminants transport
CO5.	Analyse the interrelation of hydrologic elements and interconnection of water bodies

Course Content

Unit	Content	Number of Lectures
1	Introduction to Isotopes, their classifications, and characteristics. Principle of radioactivity and radio isotopes; Fundamentals of absorption and scattering of alpha and beta particles, gamma rays and neutrons.	**10**
2	Concept of Detecting stable and radioactive isotopes, as well as accompanying equipment. Environmental isotopes and their variations in nature	**6**

3	HydrologicalApplication of Isotope. To assess the surface water and groundwater interaction and assessment of baseflow.	**6**
4	Estimation of Groundwater recharge and contaminant transport	**6**
5	Technique for Dating sediment and groundwater, application of isotopes to study the interrelation of hydrologic elements and interconnection of water bodies	**8**

References

1. Stable Isotope Hydrology, Deuterium and Oxygen- 18 in Water Cycle", IAEA, Vienna, Austria, Technical report series no. 210
2. Clark, I. And Fritz. P, "Environmental Isotopes in Hydrogeology", Lewis Publishers
3. Fritz, P. and Fontes, J. Ch (Editors), "Handbook of Applied Isotope Hydrogeochemistry; The Marine Environment" Vol. 3., Elselvier
4. Mazor, E., "Chemical and Isotopic Groundwater Hydrology",2nd Edition. Marcel Dekker Inc.
5. Faure, G., "Principles of Isotope Geology", 2nd edition, Wiley Publishers.
6. Fritz, P. andFontes, J. Ch (Editors), "Handbook of Applied Isotope Hydrogeochemistry; The Terrestrial Environment", Vol 2. Elselvier

IV Year (7th Semester)

CEN17101 RAILWAY & AIRPORT ENGINEERING
CREDIT: 04 (3-1-0)

Course Outcomes	
CO1.	Understand the structure of Indian Railways, concepts of railway track planning, geometric design of railway
CO2.	Design the various parameters related to geometrics of railway tracks and turnouts
CO3.	Understand the operations and functioning of signalling systems, turnouts, interlocking, control systems and modernization of Indian Railways
CO4.	Understand and apply the concepts of airport planning, design, operations; airport configurations and layout.
CO5.	Design airport runways, taxiways, runway pavement and overlay

Course Content

Unit	Content	Number of Lectures
1	**History of Railways & Components of Permanent Way** Introduction to Indian Railway; Classification of Railway Lines in India; Alignment of Railway Lines; Rail gauges; Coning of wheels; Permanent way- Rails, Rail Fastenings, Sleepers, Ballast.	**06**
2	**Geometric Design of Track** Track stresses; Train Resistance & Tractive Power; Gradients; Grade compensation on curves, Track Geometry- Super elevation, Transition curves, Extra clearance on curves,Widening of gauges on curves; Points and Crossings- Switches, Components and types of crossing, Turnouts, Design of turnouts.	**08**
3	**Signaling and Stations and Yards** Signalling: Classification, signalling systems, systems for controlling train movements, Interlocking. Classification of railway stations and yards; platforms, sidings.	**06**
4	**Modernization of Indian Railways** High Speed Trains, Dedicated Freight Corridors, Rail Transit Systems, Safety & Information System	**05**
5	**Airport Engineering** Air craft characteristics affecting airport design, Airport Planning, Runway Design. Airport Configuration- Runway configurations	**11**

	and operations, Taxiway configurations. Runway pavement design, design of overlay, Airport Layout, Runway lighting and Marking, Airport drainage.	

References
1. *Railway Engineering by Satish Chandra and M. M. Agarwal, Oxford University Press.* 2. *A Text Book of Railway Engineering by S. C. Saxena and S. P. Arora, Dhanpat Rai Publications.* 3. *Airport Planning and Design by S. K Khanna, M.G. Arora and S.S Jain,Nem Chand & Bros. Roorkee.* 4. *R. Horonjeff and F. X. Mckelvey, Planning & Design of Airports, 5th Edition, Mc Graw Hill.*

CEN17102 EARTHQUAKE RESISTANT DESIGN
CREDIT: 03 (2-1-0)

Course Outcomes	
CO1.	Understand the basic concepts of seismology and dynamics of the structure
CO2.	Analyse the Single Degree and Multi Degree of Freedom System for Dynamic Loads
CO3.	Explain the design concepts for structures under dynamic loading
CO4.	Evaluate seismic forces for RCC Frame, masonry and steel structures as per relevant standards
CO5.	Design the RCC Frame, masonry and steel structures for evaluated seismic forces

Course Content

Unit	Content	Number of Lectures
1	Response of Single-Degree-Freedom Systems- Introduction to Seismology. Response of Structure to Earthquake motion, Modeling of structures, Dynamics of single degree of freedom system. Free and forced vibration, Response of the systems to general loadings.	**4**
2	Response of Multi-Degree-Freedom Systems, Dynamics of multi degree of freedom system, Idealization of structures, Modal analysis of structures, Distributed mass system, Dynamics of soils and seismic response. Response spectra method.	**5**
3	Concept of Structural Design-Conceptual design, Analysis of single and multi storey frame, Equivalent lateral force method.	**5**

	Design of Reinforced Concrete Buildings. Time history method, IS codes provisions.	
4	Design of Masonry and Steel Buildings-Design of Masonry buildings, Steel Buildings and non structural element, Material Properties, IS Code provisions for ductile design.	**5**
5	Earthquake analysis and response of inelastic buildings. Approximate analysis procedures, Uncoupled modal response history analysis, Modal pushover analysis, Earthquake dynamic of base isolated buildings.	**5**

References: -

- Introduction to Structural Dynamics - J.M. Biggs, McGraw-Hill Companies.
- Earthquake Resistant of Design of structures, S.K.Duggal, Oxford University Press.
- IS: 1893 – 2002, Criterion for Earthquake Resistant Design.
- Engineering Vibrations - L.S. Jacobsen & R.S. Ayre, McGrawHill Book Co., New York
- Structural Dynamics - Theory & computation - Mario Paz, Springer, 1997.
- Dynamics of Structures Theory and Applicaions to Earthquake Engineering - Anil K. Chopra, Pearson/Prentice Hall.
- Structural dynamics - R. Roy Craig Jr, Wiley, 1981.
- Dynamics of structures - R. W. Clough and J Penjien.McGraw-Hil, Inc. 19

CEXXXXX PROFESSIONAL ELECTIVE-II CREDIT: 03 (3-0-0)

- Bridge Engineering
- Construction Equipments & Techniques
- Repair and Retrofitting of Structures
- Environmental Geotechnology
- Geosynthetics
- Industrial Wastewater Treatment & Reuse
- Solid & Biomedical Waste Management
- Transport Asset Management
- Geological Studies for Rock Cut Slope Stability Analysis
- Water Resources Systems Management

CEN17260 BRIDGE ENGINEERING CREDIT: 04 (3-1-0)

Course Outcomes	
CO1.	Describe and relate the suitability of the different bridge types under different conditions.
CO2.	Examine the different loads/forces and their combinations for the bridge design.
CO3.	Plan bridge components for different conditions.
CO4.	Analyse bridges and their components under different loads.
CO5.	Evaluate the design parameters for different types of bridges.
CO6.	Design some RC/PC super-structures, bearing, sub-structure and foundation.

Course Content

Unit	Content	Number of Lectures
1	**General Introduction- S**ite selection, various types of bridges and their suitability, loads, forces, IRC bridge loading and permissible stresses.	**7**
2	**Culvert Design-** Theory of force calculation in bridge slabs, design of RC & PC culverts.	**7**
3	**RC/PC Bridges Types-** Introduction to analysis and design of other RC/PC bridge types, and cable stayed bridges.	**8**
4	**T-beam Bridges Design-** Theory of load distribution in girders. Detailed design of RC/PC T-beam bridges.	**11**
5	**Bearing, Substructures and Foundations-** Introduction to design of bearing, abutment, pier and foundation.	**5**

References: -

- *Concrete Bridge Practice: Analysis,Design & Economics– V.K. Raina, Shroff Publisher & Distributor Pvt Ltd.*
- *Design of Bridges- N. Krishna Raju , Oxford & IBH Publication Co. Pvt. Ltd.*
- *Essential of Bridge Engineering – D.J. Victor, Oxford & IBH publication Co.*
- *Plain & Reinforced Concrete – O.P. Jain ,Nemchand, Roorkee.*

CEN17261 CONSTRUCTION EQUIPMENTS & TECHNIQUES
CREDIT: (3 3-0-0)

Course Outcomes	
CO1.	Remember and identify the key concepts and terminologies related to mechanized construction, including the types of construction equipment and their specifications.
CO2.	Understand and explain the general considerations for the use of construction equipment, the principles of building construction practices, and the techniques involved in substructure and superstructure construction.
CO3.	Apply knowledge to evaluate the efficiency and performance of construction equipment, and to design safe construction practices and methods.
CO4.	Analyze the economic aspects of equipment ownership and operation, and the impact of various construction techniques on project outcomes.
CO5.	Create comprehensive plans for construction projects, integrating the learned concepts to ensure efficient, safe, and sustainable construction practices.

Course Content		
Unit	**Content**	**Number of Lectures**
1	**Imperatives of Mechanized Construction -**General considerations, specifications, types of drives, classification of equipment, efficiency and performance evaluation criteria of equipment, terminology relating to equipment and machine. Sources of equipment cost of owning and operating of equipment, economic life of equipment, time motion study.	**10**
2	**Construction Equipment-**Excavating, hauling, loading and unloading equipment. Earthmovers, soil compacting equipment, and pile driving equipment. Hoists and cranes. Details and applications of composite equipment viz. power shovel, dragline, clamshell, backhoe, scraper etc. Concrete producing equipment, Ready mixed concrete plants, transit mixers and vibrators. Equipment for dredging, trenching, tunneling, drilling, blasting, dewatering and pumping equipment. Safety in construction.	**6**
3	**Building Construction Practices-**Building construction: Site clearance, earthwork, shallow anddeep building foundations, masonry construction water and damp proofing, flooring, joints. Temporary	**7**

	works viz. form work centering and shuttering. Slip forms, steel trusses.	
4	**Sub Structure Construction** -Techniques of Box jacking – Pipe Jacking -under water construction of diaphragm walls, cofferdams. Piling, well and caisson sheet piles, shoring for deep cutting.	**7**
5	**Super Structure Construction-**Launching girders, bridge decks, offshore platforms, in-situ prestressing in high rise structures, aerial transporting handling, erection of transmission towers. Construction sequences in cooling towers, silos, chimney, sky scrapers, bow string bridges, cable stayed bridges -Support structure for heavy Equipment and conveyors - Erection of articulated structures, braced domes and space decks.	**7**

References
1. Jha J and Sinha S.K., Construction and Foundation Engineering, Khanna Publishers, 1993. *2. Sharma S.C., "Construction Equipment and Management", Khanna Publishers New Delhi.* *3. Deodhar, S.V., "Construction Equipment and Job Planning", Khanna Publishers, New Delhi.* *4. Varma, M., "Construction Equipment and its Planning and Application", Metropolitan Book Company, New Delhi..* *5. Stuart Wood J. R. - Heavy construction equipment and methods, Prentice Hall Englewood Cliffs, New Jersy.* *6. Peuritoy, R. L. - Construction Planning equipment and methods, McGraw Hills International Book* *Company.* *7. Russel, J. F. - Construction equipment, Metropolitan Book Co. Delhi.*

CEN17262 REPAIR AND RETROFITTING OF STRUCTURES CREDIT: (3 3-0-0)

Course Outcomes	
CO1.	Remember and identify the fundamental principles of structural analysis and the various modelling techniques for structures, soil, and foundations.
CO2.	Understand and explain the concepts of dynamic loading, the Demand Capacity Ratio Method, and the principles of Performance Based Engineering.
CO3.	Apply knowledge to analyze structures using Non-linear Pushover and Time-History Analysis, and to design retrofitting solutions for buildings and bridges.
CO4.	Analyze and evaluate the effectiveness of different retrofitting materials and techniques, as well as non-destructive testing methods for assessing structural integrity.

CO5.	Create comprehensive strategies for ensuring seismic safety, enhancing durability, and estimating the life cycle costs of structure.

Course Content		
Unit	**Content**	**Number of Lectures**
1	Review of principles of structural analysis; Modelling of structures – Linear modelling, Non-linear modelling, Modelling of soil and foundations	**05**
2	Introduction to dynamic loading; Demand Capacity Ratio Method; Non-linear Pushover Analysis, Non-linear Time-History Analysis, Introduction to Performance Based Engineering	**09**
3	Principles of structural repair & retrofit, Terminology, Retrofitting Materials, Retrofitting of Buildings and Bridges, Techniques of repair and retrofitting of masonry buildings	**10**
4	Non-destructive testing (NDT) methods, Rapid visual screening and simplified evaluation of buildings, Material Properties; In-situ testing methods for RC and masonry structures	**06**
5	Seismic safety of building equipment and services, Design for durability, Life cycle cost estimation of structures	**06**

References

1. FEMA 356, 2000, Prestandard and Commentary for the Seismic Rehabilitation of Buildings, Federal Emergency Management Agency, Building Seismic Safety Council, Washington, D.C.
2. FEMA 440 / ATC 55, 2005, Improvement of Nonlinear static Seismic analysis Procedures, Federal Emergency Management Agency, Building Seismic Safety Council, Washington, D.C.
3. ATC 40, 1996, Seismic Evaluation and Retrofit of Concrete Buildings, Applied Technology Council, California.
4. FEMA 273, 1997, NEHRP Guidelines for the Seismic Rehabilitation of Buildings, Federal Emergency Management Agency, Building Seismic Safety Council, Washington, D.C.
5. FEMA 310, 1998, Handbook for the Seismic Evaluation of Buildings – A Prestandard, Federal Emergency Management Agency, Building Seismic Safety Council, Washington, D.C.
6. J. H. Bungey, 1989, The Testing of Concrete in Structures, Surrey University Press.
7. Penelis, George G., and Kappos, Andreas J., 1997, Earthquake Resistant Concrete Structures

CEN17263 ENVIRONMENTAL GEOTECHNOLOGY
CREDIT: (3 3-0-0)

Course Outcomes	
CO1.	To understand about the soils contaminated by various pollutants.
CO2.	To know about the treatment of contaminated soil
CO3.	To know Man made changes in geotechnical environment for civil engineering structures
CO4.	Understanding about the control of contamination by various techniques
CO5.	Understand about the control of ground pollution and treatment

Course Content

Unit	Content	Number of Lectures
1	Soil and ground water pollutants - their sources, nature, composition and polluting effects. The physico-chemical aspects of soils contaminated by various pollutants. Effects of environment and wastes on the properties of soils.	**7**
2	Solid and liquid wastes disposal method and management. Land treatment systems.	**8**
3	Man made changes in geotechnical environment - mining, embankments, pumping, reservoir, landfills and reclamation effects and control.	**6**
4	Control of contamination with use of clay barriers, geosynthetics, cut-off walls, leachate collection systems.	**8**
5	Stabilization - different materials and techniques in control of ground pollution and treatment.	**7**

References:-

- Lakshmi N. Reddy, Hilary. I. Inyang – Geo-Environmental Engineering – Principles and Applications – Makcel Dekker Ink, 2000.
- D.E.Daniel, Geotechnical Practice for Waste Disposal, Chaman & Hall, London.
- IS 2720: “Method of Test for Soil (relevant parts)”.

- Introduction to Environmental Geotechnology by Hsai-Yang Fang (Author), Ronald C. Chaney (Author), Pub.: CRC Press.

CEN17264 GEOSYNTHETICS CREDIT: (3 3-0-0)

Course Outcomes	
CO1.	Understand the Basic Applications and Functions of Geosynthetics
CO2.	Analysis, Design and Use of Geotextiles
CO3.	Understand the application of Geogrids and Geonets
CO4.	To know the basic Properties and use of Geomembranes
CO5.	Design of Geocomposites with use of Geomembrane, Fibres and Meshes.

Course Content

Unit	Content	Number of Lectures
1	**Introduction:** An overview on the development and applications various geosynthetics - the geotextiles, geogrids, geonets, geomembranes and geocomposites.	**6**
2	**Designing with geotextiles:**Geotextile properties and test methods – functions - Designing for separation, reinforcement, stabilization, filtration, drainage.	**8**
3	**Designing with geogrids and with geonets:** Geogrid properties and test methods–physical properties, mechanical properties, endurance properties and environmental properties – Designing for grid reinforcement and bearing capacity. Geonet properties and test methods – Physical properties, mechanical properties, hydraulic properties, endurance properties and environmental properties -Designing geonet for drainage	**10**
4	**Designing with geomembranes:** Geomembrane properties and test methods – physical properties, mechanical properties, chemical properties and biological hazard - Applications for geomembranes.	**5**
5	**Designing with Geocomposites :** Geo composites in separation, reinforcement – reinforced geotextile composites – reinforced geomembrane composites – reinforced soil composites using	**7**

	discontinuous fibers and meshes, continuous fibers and three – dimensional cells, geocomposites in drainage and filtration.	

References

1. Sivakumar Babu G.L. "An Introduction to Soil Reinforcement and Geosynthetics" University Press, 2005.
2. Koerner, R.M. – "Designing with geosynthetics", Pearson Education Inc., 2005.
3. Rao, G.V. – "Geosynthetics – an Introduction", Sai MasterGeoenvironmental Services Pvt. Ltd. Hyderabad, 2011.
4. Shukla, "Fundamentals of Geosynthetic Engg. Imperial College Press, London, 2006.
5. P. Purushothama Raj, "Ground Improvement Techniques" Laxmi Publications (P) Limited, 2016.

CEN17265 INDUSTRIAL WASTEWATER TREATMENT & REUSE CREDIT: (3 3-0-0)

Course Outcomes

CO1.	Remember and identify the differences between industrial and municipal wastewater, the uses of water in various industries, and the environmental impacts of industrial wastewater disposal.
CO2.	Understand and explain the reasons for industrial wastewater treatment, the effects of waste on watercourses, and the principles of volume and strength reduction.
CO3.	Apply knowledge to analyze case studies of wastewater characteristics and treatment processes across different industries, and to design treatment flow sheets for specific pollutants.
CO4.	Analyze and evaluate advanced wastewater treatment technologies, including chemical oxidation and membrane technologies, and their applications in industrial wastewater management.
CO5.	Create comprehensive strategies for industrial wastewater recycle, reuse, and reclamation, and develop zero discharge concepts

Course Content

Unit	Content	Number of Lectures
1	**Introduction and volume reduction** Industrial wastewater versus municipal wastewater, Uses of water by industry, Sources and types of industrial wastewater, Industrial wastewater disposal and environmental impacts, Reasons for	**8**

	treatment of industrial wastewater, Effects of waste on watercourses and wastewater treatment plants, Computation of Organic Waste Loads on Streams, Stream Protection Measures, Stream and Groundwater Sampling. Volume and Strength reduction; Neutralizations; Equalization and Proportioning**.**	
2	**Case Studies.** Industrial manufacturing process description, wastewater characteristics and Treatment flow sheet for industries like Textiles, Tanneries, Pulp and Paper, Electroplating, Petroleum Refining, Chemical, Pharmaceuticals, Sugar and Distilleries, Dairy, Iron and Steel, Fertilizer, etc. Treatment techniques for specific pollutants in industrial effluents, e.g oil & grease, phenol, cyanide, chromium, toxic organics.	**8**
3	**Advanced Wastewater Treatment.** Chemical oxidation, Wet Air Oxidation, Ion exchange, Membrane technologies, Wastewater Nutrients removal. Industrial Wastewater Recycle, Reuse and Reclamation in industries.	**7**
4	**Applications.** Joint treatment of raw or partially industrial waste with domestic sewage, Discharge of completely treated wastes to municipal sewer systems, Discharge of partially and completely treated waste to streams**.**	**7**
5	**Zero Discharge Concepts.** Introduction to Industrial Ecology, Industrial Symbiosis, Material flow analysis**.**	**6**

References: -

- 1. Nemerow, N. L. and Agardy, F. J., “Strategies of Industrial and Hazardous Waste Management,” 2nd Edition, Van Nostrand Reinhold Company, USA, 1998.
- 2. Patwardhan, A. D., “Industrial Wastewater Treatment,” PHI Learning Pvt. Ltd., 2008.
- 3. Ranade, V. V. and Bhandari, V. M., “Industrial Wastewater Treatment, Recycling and Reuse,” Butterworth-Heinemann, Elsevier, UK, 2014
- 4. Eckenfelder, W.W., "Industrial Water Pollution Control ", McGraw Hill, 1999.
- 5. Arceivala, S.J., "Wastewater Treatment for Pollution Control ", Tata McGraw Hill, 1998.
- 6. Metcalf & Eddy, Inc. "Wastewater Engineering - Treatment, Disposal, and Reuse", Seventh Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2007.

- 7. Rao, M.N. and Datta, A.K., "Wastewater Treatment- Rational Methods of Design and Industrial Practices" 2nd Ed., Oxford and IBH Publishing Co. Pvt. Limited, New Delhi, 1987.
- 8. Mahajan, S.P., "Pollution Control in Process Industries", 2nd Reprint, Tata McGraw-Hill Publishing Co. Ltd., New Delhi, 1990.
- 9. Asolekar, S.R., Ecocentric Technologies for Recycle and Reuse of Municipal and Industrial Effluents. A monograph published by the QIP-CDP Office of IIT, Bombay, 2005.
- 10. Metcalf & Eddy, Inc, Tchobanoglous G. and Burton, F.L., Wastewater Engineering: Treatment, Disposal and Reuse, 4th Edition, Tata McGraw Hill, New Delhi, 2003.

CEN17266 SOLID & BIOMEDICAL WASTE MANAGEMENT
CREDIT: (3 3-0-0)

Course Outcomes	
CO1.	Remember and identify the principles of municipal solid waste (MSW) management, the scenarios of urban solid waste management, and the categorization of biomedical waste.
CO2.	Understand and explain the physical, chemical, and biological properties of solid waste, the economics of transfer stations, and the legal framework governing solid waste management.
CO3.	Apply knowledge to analyze and calculate storage requirements for solid waste, design transfer stations, and develop recovery processes for resources and energy.
CO4.	Analyze and evaluate the methods of landfilling, the engineering principles of landfill design, and the treatment and disposal processes for biomedical waste.
CO5.	Create comprehensive waste management strategies that integrate the learned concepts to ensure compliance with environmental regulations and promote sustainable waste management practice

Course Content		
Unit	**Content**	**Number of Lectures**
1	Solid Waste. Principles of MSW management. Urban solid waste management scenarios. Waste generation. Physical, chemical and biological properties of MSW. Onsite Storage and Collection. Calculation of storage requirement; container and truck size. Stationary and Hauled container system. Comparison of labor requirement, haul routes, equipment number, size and suitability for manual and mechanical collection systems.	**10**

2	Transfer and transport. Economics and preliminary design of transfer station, truck movement, compaction, recycling. Processing and Recovery techniques; and related equipment. Recovery of resources and energy by mechanical separation, thermal and biological techniques. Preliminary design of composting facility. Process details of Material Recovery Facility. Working principle and design approach of recovery equipment.	**7**
3	Disposal of solid waste. Landfilling methods, Engineering principle of landfill design & its applications. Design of sanitary landfill leachate and off-gas collection system. Landfill liner system: material, cost, failure.	**6**
4	Biomedical waste. Categorization, collection, transport, treatment and disposal.	**8**
5	Municipal Solid Waste Management Rules, 2000 and Bio- Medical Waste (Management & Handling) Act, 1998.	**5**

References:_

1. Tchbanoglous, G., Theisan, H., and Vgils; Integrated solid waste management. McGraw Hill, New York, 1993.

2. Pavoni, J.L., "Handbook of solid waste disposal and management", Van Nostrand-Reinhold Co, USA, 1973.

3. Mantdl, C.L., "Solid waste management", John Wiley N.Y, 1975.

4. Dutta, S., "Environmental treatment technologies for Hazardous and Medical waste", Tata McGraw Hill, New Delhi, 2009.

5. CPHEEO, Manual on solid waste management, Ministry of Urban Development and Poverty Alleviation, Govt. of India, Delhi.

CEN17267 TRANSPORT ASSET MANAGEMENT CREDIT:(3 3-0-0)

Course Outcomes	
CO1.	Explain specific terms and concepts in context of asset management.
CO2.	Identify data requirements and quality assurance parameters relevant to transportation asset management.
CO3.	Identify required performance parameters for monitoring and risk assessment processes related to transportation assets.

CO4.	Identify the life cycle processes for the transportation asset management.
CO5.	Identify benefits, costs and alternative options relevant to evaluate asset management options.
CO6.	Apply the software tools for transportation asset management.

Course Content

Unit	Content	Number of Lectures
1	**Introduction-** Introduction to Asset Management, History & Background, Overview & Principles, Components, Roles, Advantages and Risks, Real word application	**05**
2	**Data and Modelling-** Types,Data Collection Needs, Method and Technology options for data collection, Quality control/quality assurance, Condition indices, Application of Geospatial Tools and Techniques for Asset Data Management	**06**
3	**Performance Monitoring and Risk Assessment-** Definition and Need of Performance Monitoring, Performance Monitoring Parameters, Monitoring process, Performance reporting, Performance reviews, Benchmarking performance, Actions and plans, Risk Assessment and Identification of Critical Assets	**05**
4	**Lifecycle and Financial Planning -**Lifecycle planning process, Required Asset data for Lifecycle Planning, Deterioration models, Costs for Life Cycle Planning, Financial Planning,	**06**
5	**Asset Valuation and Economic Analysis:**Introduction to Asset Valuation, Requirement of Asset Valuation, Valuation Steps, Parameters used in Transport economic analysis, Life Cycle CostAnalysis, Cost and benefit components in Transportation Systems, Economic Evaluation of Transportation	**06**

References

- *AASHTO Transportation Asset Management Guide: A Focus on Implementation. AASHTO.*
  Asset Management Manual: A Guide For Practitioners, PIARC, World Road Association, Available Online, Link: https://road-asset.piarc.org/en
- *Haas, R., & Hudson, W. R. Pavement management systems, McGraw Hill.*
- *Li, Z.. Transportation asset management: Methodology and applications. CRC Press.Uddin, W., Hudson, W. R., & Haas, R. (2013). Public infrastructure asset management. McGraw-Hill Education.*

CEN17268 GEOLOGICAL STUDIES FOR ROCK CUT SLOPE STABILITY ANALYSIS CREDIT: (3 3-0-0)

Course Outcomes	
CO1.	Understanding the basic concept of rock cut slope.
CO2.	Explain the concepts of Geological Mapping and its application.
CO3.	Evaluate the nature of rock cut failure.
CO4.	Explain the concepts of different rock mass rating.
CO5.	Analyse the roc-cut failure and stabilisation techniques.

Course Content

Unit	Content	Number of Lectures
1	Description of rock mass and discontinuities, rock strength and failure criteria.	**4**
2	Geological mapping of rock mass. Hemispherical projections and their application. Slope stability. Factors affecting the Slope Stability.	**8**
3	Kinematic analysis to evaluate the nature of rock cut failure	**6**
4	Concept and estimation of rock mass rating, slope mass rating and continuous slope mass rating of rock mass.	**10**
5	Assessment of rock cut failure viz. plane failure, wedge failure, circular failure and, toppling. Slope stabilisation techniques with certain case studies in different geological terrain.	**8**

References

1. *Rock Slope Engineering, by E.Hoek& J.W. Bray, Revised third edition, The Institution of Mining & Metallurgy, London, 1981*
2. *Engineering Geology, by Bell, F.G. (2007). Burlington : Elsevier.*
3. *Engineering Geology, by S K Duggal, H K Pandey and, N Rawal, McGraw Hill Education.*
4. *Rock Slope Engineering, 4th Edition, by Wyllie, D.C. and Ma, C.W. (2004). Spon Press:New York.*
5. *Goodman P.E., "Introduction to Rock Mechanics", John Wiley and Sons, 1999.*

CEN17269 WATER RESOURCES SYSTEMS MANAGEMENT
CREDIT: (3 3-0-0)

Course Outcomes	
CO1.	Have knowledge about global and National water resources status
CO2.	Have understanding of water power and associated components
CO3.	Have understanding of Broad Principles of Hydraulic structures and canal systems in irrigation
CO4.	To apply optimization methods in Water Resources Planning projects.
CO5.	To understand Water Related Environmental Problems and conservation measures.

Course Content

Unit	Content	Number of Lectures
1	General Considerations-Introduction, Global and National scenario of water availability, Economics of Water Resources Systems: principles of engineering economics; Projected water needs for drinking, agriculture and other uses, National water policy. Water related environmental problems, water pollution, ground water and river pollutions etc., Water conservation measures.	**8**
2	River Basins-River basins of India and Inter Basin transfer of water, Run off and rainfall data of basins, Interstate and Inter National level sharing of water.	**6**
3	Water Power-Water power, its relation with irrigation and other needs, water power potential and estimation, Storage of water - Current storage scenario in India. Sedimentation, evaporation and other related problems like location of storage sites and rehabilation problems, etc.	**6**
4	Irrigation and Hydraulic Structures -Broad Principles of Hydraulic structures and canal systems, Floods and draughts, drainage, water logging, soil salinity and soil conservation problems.	**8**
5	Introduction to Mathematical Optimization-Optimization Techniques; Application of Optimization techniques; Water Resources Planning under uncertainty; Stochastic Planning models; Application of Simulation models.	**8**

References

- *Water Resources systems- Vedula and Mujumdar, Tata McGraw-Hill.*
- *Bedient and Huber- Hydrlogy and Flodplain Analysis, Prentice Hall.*
- *Ojha,C.S.P. , Bhunya, P. and Berndtsson, R.- Engineering Hydrology, Oxford University Press Canada.*
- *Todd and Mays- Groundwater Hydrology, John Wiley and Sons, Inc.*
- *K. Subramanya - Engineering Hydrology, Tata McGraw Hill Education Pvt.Ltd.*
- *Modi, P.N. – Irrigation Water Resources and Water Power Engineering, Standard Book House*
- *Asawa, G.L. – Irrigation and Water Resources Engineering, New Age International.*