BULLETIN ON COURSES OF STUDY

2021-22

B.TECH. & DUAL DEGREE PROGRAMMES

Department of Civil Engineering

IIT Bombay

BULLETIN ON COURSES OF STUDY

2021-22

CONTENTS

CIVIL ENGINEERING DEPARTMENT AT IIT BOMBAY

The Department of Civil Engineering has been a part of IIT Bombay since its inception in 1958. Over the years, the department has grown tremendously, and is now recognized as one of the best and major engineering departments in the country and ranked highly in the World for Civil Engineering. With its multifaceted faculty, it provides high quality teaching and instruction at both UG and PG as well as Ph. D levels. The department has strong focus in the broad research areas of seven specializations, namely, Transportation Systems Engineering (CE-1), Geotechnical Engineering (CE-2), Water Resources Engineering (CE-3), Structural Engineering (CE-4), Ocean Engineering (CE-5), Remote Sensing (CE-6), and Construction Technology and Management (CE-7). Besides, the department is actively involved in basic and applied research and consultancy and provides high quality technical advisory support through various R & D projects and consultancy to various organizations. Civil Engineering Department continues to maintain and cultivate its strong links with the public sector companies, planning agencies, public service providers, consultation firms, construction industry, academic and research institutions both within and outside the country.

The department has attracted significant amount of sponsored research funding from government and private agencies and is delivering excellent output in terms of implementable solutions and large number of research publications in high quality peer reviewed journals having high impact factor. The department disseminates the knowledge gained from its high-quality research through training programs and interacts with world renowned personalities through workshops and conferences. The students and faculty members have won prestigious national and international awards/fellowships/recognitions and continuing to bring laurels to the Institute and nation. As per Quacquarelli Symonds (QS) World University Rankings of 2021, the department is ranked 1st in India and ranked in range of 51-100 in the world ranking for the domain / area of Civil and Structural Engineering.

Contact Address:	The Head, Department of Civil Engineering, Indian Institute of Technology Bombay, Powai, Mumbai - 400076, India.
Phone:	+91-22-2576 7301
E-Mail:	hod[at]civil.iitb.ac.in
Website:	www.civil.iitb.ac.in

B.TECH. AND DUAL DEGREE PROGRAMMES

The Department of Civil Engineering admits about **146** students in undergraduate (B.Tech.) programme. The department also offers dual-degree programmes in the following seven areas of specialization:

1. Transportation Systems Engineering
2. Geotechnical Engineering
3. Water Resources Engineering
4. Structural Engineering
5. Ocean Engineering
6. Remote Sensing
7. Construction Technology and Management

The department has well-equipped laboratories with excellent advanced instrumentation and equipment for research and teaching. State-of-art computational facilities are available in the departmental computational laboratory which is equipped with new servers, workstations and personal computers. All the computers in the department are networked with the institute Local Area Network and are connected to internet through IIT Bombay's proxy servers.

The students of the Department can use the Central Library that has more than 440,000 books and volumes, and subscribes more than 1800 current journals in Science, Engineering, Humanities and Social Sciences. Library cataloguing is fully computerized. The Department also has a library where all B. Tech., M. Tech. and Ph.D. Theses completed at the Department are available for reference. The Department has 49 faculty members and about 29 other technical and non-technical staff. The department disseminates knowledge to working professionals regularly by organizing national and international conferences and workshops. Continuing Education Programme courses are also conducted by the Department on a regular basis. The faculty publishes extensively from the research and consultancy work carried out in the Department. More than 200 research papers are published every year by the faculty in all areas of Civil Engineering in the national and international journals and conferences.

The rules and regulations pertaining to B.Tech. and Dual Degree Programme at IIT Bombay can be found at: https://www.iitb.ac.in/newacadhome/ugrulebook.pdf

COURSEWORK REQUIREMENTS FOR B.TECH. STUDENTS

The B.Tech. Programme involves four full years of coursework that should be completed by the student to earn required credits to graduate. The minimum credit requirement for the student to graduate from Civil Engineering is 275 credits. The students can also pursue honors stream which require an additional 24 credits to be earned by the student. Students can also complete a B.Tech. degree with minor if they pursue an additional 30 credits with another department.

COURSEWORK REQUIREMENTS FOR DUAL DEGREE STUDENTS

The B.Tech. Programme involves five full years of coursework that should be completed by the student to earn required credits to graduate. The minimum credit requirement for the student to graduate from Civil Engineering is 395 credits**.**

B.TECH. IN CIVIL ENGINEERING

Course Structure - First Year

FIRST SEMESTER

Course Code	Course Name	Credit Structure			Credits	Remarks
		L	T	P		
MA 105	Calculus	3	1	0	8	
PH 107	Quantum Physics and application	2	1	0	6	
CH 105	Organic/Inorganic Chemistry	2	0	0	4	
CH 107	Physical Chemistry	2	0	0	4	
CS 101 OR BB101	Computer Programming & Utilization / Biology	2	0	2	6	
ME 113	Workshop Practice	0	0	4	4	
PH 117 OR CH 117	Physics Lab / Chemistry Lab	0	0	3	3	
Total Credits					**35**	

SECOND SEMESTER

Course Code	Course Name	Credit Structure			Credits	Remarks
		L	T	P		
MA 106	Linear Algebra	2	0	0	4	
MA 108	Differential Equations-I	2	0	0	4	
PH 108	Basics of Electricity and Magnetism	2	1	0	6	
CS 101 or BB 101	Computer Programming & Utilization / Biology	2	0	2	6	
ME 119	Engineering Graphics &Drawing	0	1	3	5	
PH 117 or CH 117	Physics Lab / Chemistry Lab	0	0	3	3	
CE 102	Engineering Mechanics	3	0	0	6	
Total Credits					**34**	

Course Structure - Second Year

First Semester

Course Code	Course Name	Credit Structure			Credits	Remarks
		L	T	P		
CE 221	Solid Mechanics	3	1	0	8	Core Course
CE 223	Fluid Mechanics	2	1	0	6	Core Course
CE 231	Solid Mechanics Lab	0	0	3	3	Core Course
CE233	Fluid Mechanics Lab	0	0	3	3	Core Course
EE 101	Introduction to Electrical and Electronics Circuits	3	1	0	8	
MA 207	Differential Equations-II	2	0	0	4	
HS 101	Economics	3	0	0	6	
Total Credits					**38**	

Second Semester

Course Code	Course Name	Credit Structure			Credits	Remarks
		L	T	P		
CE 204	Engineering Surveying	2	1	0	6	Core Course
CE 228	Applied Hydraulic Engineering	2	1	0	6	Core Course
CE 216	Engineering Surveying Practical	0	0	3	3	Core Course
CE 230	Hydraulic Engineering Lab	0	0	3	3	Core Course
CE 222	Structural Mechanics I	3	0	0	6	Core Course
CE 232	Building Materials and Construction	3	0	0	6	Core Course
ES 200	Environmental Studies: Science and Engineering				3	
HS 200	Environmental Studies				3	
Total Credits					**36**	

Course Structure - Third Year

First Semester

Course Code	Course Name	Credit Structure			Credits	Remarks
		L	T	P		
CE 323	Geotechnical Engineering I	2	1	0	6	Core Course
CE 325	Structural Design – I	2	0	2	6	Core Course
CE 310	Transportation Engineering I	2	1	0	6	Core Course
CE 317	Structural Mechanics II	3	0	0	6	Core Course
CE 329	Geotechnical Engineering Lab I	0	0	3	3	Core Course
CE 328	Transportation Engineering Lab	0	0	3	3	Core Course
HS XXX	Humanities Elective - I	3	0	0	6	Humanities Elective
Total Credits					**36**	

Humanities Electives

Course Code	Course Name	Credits
HS 301	Philosophy	6
HS 303	Psychology	6
HS 305	Reading Literature	6
HS 307	Sociology	6

Second Semester

Course Code	Course Name	Credit Structure			Credits	Remarks
		L	T	P		
CE 330	Geotechnical Engineering II	2	1	0	6	Core Course
CE 332	Structural Design II	2	0	2	6	Core Course
CE 334	Transportation Engineering II	2	1	0	6	Core Course
CE 336	Geotechnical Engineering Lab II	0	0	3	3	Core Course
CE 338	Estimation and Materials Testing Laboratory	0	0	3	3	Core Course
GS 318	Applied Geology for Civil Engineers	2	0	2	6	Core Course
	Institute Elective I				6	
Total Credits					**36**	

Course Structure (B. Tech.) - Fourth Year

First Semester

Course Code	Course Name	Credit Structure			Credits	Remarks
		L	T	P		
CE 401	Water Resources Engineering	3	0	0	6	Core Course
CE 463	Probability and Statistics for Civil Engineers	3	0	0	6	Core Course
CE 407	Foundation Engineering	3	0	0	6	Core Course
CE 4XX	Departmental Elective I				6	Departmental Elective including BTP
CE 4XX	Departmental Elective II				6	Departmental Elective including BTP
	Institute Elective II				6	Institute Elective
Total Credits					**36**	

Second Semester

Course Code	Course Name	Credit Structure			Credits	Remarks
		L	T	P		
CE 4XX	Department Elective III				6	Departmental Electives including BTP
CE 4XX	Department Elective IV				6	
CE 4XX	Department Elective V				6	
CE 4XX	Department Elective VI				6	
Total Credits					**24**	

List of Departmental Electives

Course Code	Course Title	Credits
CE 324	Engineering Law	6
CE 346	Industry Internship	6
CE 402	Introduction to Geotechnical Earthquake Engineering	6
CE 403	Design of Structures III	6
CE 410	Introduction to Offshore Engineering	6
CE 418	Introduction to Finite Elements Methods	6
CE 419	Physical Modelling in Geotechnics	6
CE 422	Hydraulic Structures	6
CE 424	Groundwater Hydrology	6
CE 429	Urban Hydrology and Drainage Systems	6
CE 433	Water Supply and Waste Water Engineering	6
CE 442	Machine Foundations	6
CE 434	Traffic Analysis and Design	6
CE 444	Advanced Geotechnical Analysis	6
CE 448	Pre-stressed Concrete Design	6
CE 462	Elements of Structural Dynamics	6
CE 465	Numerical Methods in Civil Engineering	6
CE 469	Advanced Solid Mechanics	6
CE 478	Plastic Analysis and Design	6
CE 480	Computer Aided Design in Civil Engineering	6
CE 482	Construction Management	6
CE 484	Concrete Technology	6
CE 488	Environmental Geotechnics	6
CE 490	Elements of Remote Sensing.	6
CE 492	Reinforced Earth	6
CE 494	BTP-I	6
CE 495	BTP-II	6
CE 496	Irrigation Engineering and Technology	6
CE 620	Advanced Finite Element Methods	6
CE 676	Water Resources System	6
CE 695	R & D Project (Supervised Learning Project)	6
CE 346	Credit Based Industry/University Internship	6
CE 766	Watershed Management	6

** The following courses are no-departmental courses which can be tagged as department electives and equivalent departmental courses. Please check the corresponding department website for course content for these courses.

Note: This list was approved in the 121st DUGC meeting in March, 2017.

	Relevant Non-Departmental Courses			Equivalent Department Course		
S.No.	**Course Code**	**Name of the course**	**Credits**	**Course Code**	**Name of the course**	**Credits**
1	ES 203	Water and Wastewater Engineering	6	-	-	-
2	ES 624	Hazardous Waste Management	6	-	-	-
3	GNR 401	Remote Sensing and Image Processing	6	CE 712	Digital Image Processing of Remotely Sensed Data	6
4	GNR 402	Introduction to Geographic Information Systems	6	CE 630	GIS in Civil Engineering	6
5	GNR 626	Climate and Natural Resources	6	CE 608	Eco-Hydro Climatology	6
6	GNR 613	Atmospheric Remote Sensing	6	-	-	-
7	GP 403	Earthquake and Engineering Technology	6	-	-	-
8	US 602	Fundamentals of Urban Science and Engineering	6	-	-	-
9	US 603	Research Methods in Urban Science	6	-	-	-
10	US 604	Management Techniques for Urban Systems	6	-	-	-
11	US 605	Introduction to Building: Functional Design and Science	6	-	-	-

Dual Degree (B.Tech. + M.Tech.) In Civil Engineering

CE-1: Transportation Systems Engineering

Course Structure - Fourth Year

First Semester

Course Code	Course Name	Credit Structure			Credits	Remarks- Core/ Departmental Elective/ Institute Elective
		L	T	P		
CE 401	Water Resources Engineering	3	0	0	6	Core Course
CE 463	Probability and Statistics for Civil Engineers	3	0	0	6	Core Course
CE 603*	Numerical Methods	3	0	0	6	Core Course
CE 407	Foundation Engineering	3	0	0	6	Core Course
CE xxx**	Departmental Elective I (PG Elective I)				6	Departmental Electives
CE 740	Traffic Engineering				6	PG Core
CE 751	Urban Transportation Systems Planning				6	PG Core
Total Credits					**42**	

*CE 465 can be manually registered as core course in place of CE 603 if the student is interested.

**CE xxx must be from List of CE-1 PG Electives.

Second Semester

Course Code	Course Name	Credit Structure			Credits	Remarks- Core/ Departmental Elective/ Institute Elective
		L	T	P		
CE 699	Transportation Systems Studio				4	PG Core
CE 694	Credit Seminar				4	
CE xxx	Elective II				6	
CE xxx	Elective III				6	Departmental Electives
CE xxx	Elective IV				6	
CE xxx	Elective V				6	
CE xxx	Specialization Elective I				6	
Total Credits					**38**	

Course Structure – Fifth Year

First Semester

Course Code	Course Name	Credit Structure			Credits	Remarks- Core/ Departmental Elective/ Institute Elective
		L	T	P		
CE 681	Advance Pavement Engineering Lab				2	PG Core
CE 742	Pavement Systems Engineering				6	PG Core
CX xxx	Specialization Elective II				6	
CE 593	Dual Degree Project Stage I				36	
Total Credits					**50**	

Second Semester

Course Code	Course Name	Credit Structure			Credits	Remarks- Core/ Departmental Elective/ Institute Elective
		L	T	P		
CE xxx	Specialization Elective III				6	PG Elective
CE xxx	Specialization Elective IV				6	PG Elective
CE 594	Dual Degree Project Stage II				36	
Total Credits					**48**	

List of Transportation Systems Engineering PG Electives

Course Code	Course Title
CE-605	Applied Statistics
CE-630	GIS in Civil Engineering
CE-744	Analysis of Transportation Systems
CE-780	Behavioural Travel Modelling
CE-771	Optimization in Civil Engineering
CE-772	Pavement Materials
CE-774	Traffic Management and Design
CE-776	Transportation project evaluation and decision making
CE-775	Airport planning and design
CE-773	Geometric Design and Analysis of High-Speed Roadways
CE-657	Computing in Civil Engineering

Dual Degree (B.Tech. + M.Tech.) In Civil Engineering

CE-2: Geotechnical Engineering

Course Structure– Fourth Year

First Semester

Course Code	Course Name	Credit Structure			Credits	Remarks- Core/ Departmental Elective/ Institute Elective
		L	T	P		
CE 401	Water Resources Engineering	3	0	0	6	Core Course
CE 463	Probability and Statistics for Civil Engineers	3	0	0	6	Core Course
CE 603*	Numerical Methods	3	0	0	6	Core Course
CE 407	Foundation Engineering	3	0	0	6	Core Course
CE 4xx	Departmental Elective I				6	Departmental UG Electives
CE xxx	Specialization Elective I				6	PG Elective
CE 643	Experimental Geotechnics				4	PG Laboratory course
Total Credits					**40**	

*CE 465 can be manually registered as core course in place of CE 603 if the student is interested.

Second Semester

Course Code	Course Name	Credit Structure			Credits	Remarks- Core/ Departmental Elective/ Institute Elective
		L	T	P		
CE xxx	Specialization Election II				6	PG Elective
CE xxx	Specialization Elective III				6	PG Elective
CE 694	Credit seminar				4	Seminar
CE 4xx	Departmental UG Elective II				6	Departmental UG Electives
CE 4xx	Departmental UG Elective III				6	
CE 4xx	Departmental UG Elective IV				6	
CE 4xx	Departmental UG Elective V				6	
Total Credits					**40**	

Course Structure– Fifth Year

First Semester

Course Code	Course Name	Credit Structure			Credits	Remarks- Core/ Departmental Elective/ Institute Elective
		L	T	P		
CE xxx	PG Elective II				6	PG Elective
CE xxx	PG Elective III				6	PG Elective
CE xxx	PG Elective IV				6	PG Elective
CE 593	Dual Degree Project Stage I				36	
Total Credits					**54**	

Second Semester

Course Code	Course Name	Credit Structure			Credits	Remarks- Core/ Departmental Elective/ Institute Elective
		L	T	P		
CE xxx	PG Elective V				6	PG Elective
CE xxx	PG Elective VI				6	PG Elective
CE 594	Dual Degree Project Stage II				36	
Total Credits					**48**	

List of Geotechnical Engineering PG Electives

Course Code	Course Title
CE 632	Ground Improvement
CE 633	Soil Structure Interaction
CE 637	Rock Mechanics
CE 781	Advanced Foundation Engineering
CE 641	Environmental Geomechanics
CE 645	Geotechnical Centrifuge Modelling
CE 647	Soil Dynamics and Machine Foundations
CE 648	Finite Element Methods in Geotechnical Engineering
CE 652	Foundations of Offshore Structures
CE 656	Plasticity Theory and Applications in Geomechanics
CE 683	Marine Geotechnical Engineering
CE 684	Advanced Geotechnical Earthquake Engineering
CE 688	Risk Assessment & Management in Geotechnical Engineering
CE-677	Design and Testing of Pile Foundations
CE 702	Geotechnical Constitutive Models
CE 746	Reinforced Earth and Geotextiles

Dual Degree (B.Tech. + M.Tech.) In Civil Engineering

CE-3: Water Resources Engineering

Course Structure – Fourth Year

First Semester

Course Code	Course Name	Credit Structure			Credits	Remarks- Core/ Departmental Elective/ Institute Elective
		L	T	P		
CE 401	Water Resources Engineering	3	0	0	6	Core Course
CE 463	Probability and Statistics for Civil Engineers	3	0	0	6	Core Course
CE 603*	Numerical Methods	3	0	0	6	Core Course
CE 407	Foundation Engineering	3	0	0	6	Core Course
CE 4xx	Departmental UG Elective I				6	Departmental UG Electives
CE 675	Advanced Experimental Fluid Mechanics				4	Core Course
CE 731 OR CE-626	Mechanics of Fluid Flow OR Groundwater Systems and Management				6	Core Course
Total Credits					**40**	

*CE 465 can be manually registered as core course in place of CE 603 if the student is interested.

Second Semester

Course Code	Course Name	Credit Structure			Credits	Remarks- Core/ Departmental Elective/ Institute Elective
		L	T	P		
CE 654	Advanced Hydrological Analysis and Design				6	PG Core
CE 676	Water Resources System				6	PG Core
CE 694	Credit Seminar				4	Seminar
CE 4xx	Departmental UG Elective II				6	Departmental UG Electives
CE 4xx	Departmental UG Elective III				6	
CE 4xx	Departmental UG Elective IV				6	
CE 4xx	Departmental UG Elective V				6	
Total Credits					**40**	

Course Structure– Fifth Year

First Semester

Course Code	Course Name	Credit Structure			Credits	Remarks- Core/ Departmental Elective/ Institute Elective
		L	T	P		
CE 731 OR CE-626	Mechanics of Fluid Flow OR Groundwater Systems and Management				6	PG Core
CE xxx	Specialization Elective I				6	PG Core
CE xxx	Specialization Elective II				6	PG Elective II
CE 593	Dual Degree Project Stage I				36	
Total Credits					**54**	

Second Semester

Course Code	Course Name	Credit Structure			Credits	Remarks- Core/ Departmental Elective/ Institute Elective
		L	T	P		
CE xxx	Specialization Elective III				6	PG Elective II
CE xxx	Specialization Elective IV				6	PG Elective II
CE 594	Dual Degree Project Stage II				36	
Total Credits					**48**	

List of Water Resources Engineering PG Electives

Course Code	Course Title
CE-605	Applied Statistics
CE-607	Numerical Techniques in Hydraulic Engineering
CE-608	Eco-hydro climatology
CE 658	Hydrogeomorphology
CE-667	Hydraulic Structures
CE-672	River Mechanics and Control Structures
CE-682	Finite Element Application To Flow Problems
CE-736	Environmental Impact Analysis of Water Resources Systems
CE-738	Irrigation and Conveyance Network
CE-764	Hydro informatics
CE-765	Environmental Fluid Mechanics
CE-766	Watershed Management
CE-767	Hydrological Hazard Mitigation Management
CE-768	Urban Water and Environmental Management
CE-603	Numerical Methods
CE-630	GIS in Civil Engineering
CE-657	Computing in Civil Engineering
CE-680	Mechanics of Water Waves
CE-701	Remote Sensing Technology
CE-710	Remote Sensing and GIS for Water Resources Management
CE-712	Digital Image Processing of Remotely Sensed Data
CE-769	Coastal and Ocean Environment

Dual Degree (B.Tech. + M.Tech.) In Civil Engineering

CE-4: Structural Engineering

Course Structure – Fourth Year

First Semester

Course Code	Course Name	Credit Structure			Credits	Remarks- Core/ Departmental Elective/ Institute Elective
		L	T	P		
CE 401	Water Resources Engineering	3	0	0	6	Core Course
CE 463	Probability and Statistics for Civil Engineers	3	0	0	6	Core Course
CE 603*	Numerical Methods	3	0	0	6	Core Course
CE 407	Foundation Engineering	3	0	0	6	Core Course
CE 4xx	Departmental UG Elective I**				6	Departmental UG Elective
CE 623	Advanced Solid Mechanics				6	PG Core
CE 627	Structural Design				4	PG Core
Total Credits					**40**	

*CE 465 can be manually registered as core course in place of CE 603 if the student is interested.

**CE 403 Advanced Design of Structures or Equivalent

Second Semester

Course Code	Course Name	Credit Structure			Credits	Remarks- Core/ Departmental Elective/ Institute Elective
		L	T	P		
CE 694	Credit Seminar				4	Seminar
CE xxx	Specialization Elective I				6	PG Core
CE xxx	Specialization Elective II				6	PG Core
CE 4xx	Departmental UG Elective II*				6	Departmental UG Electives
CE 4xx	Departmental UG Elective III				6	
CE 4xx	Departmental UG Elective IV				6	
CE 4xx	Departmental UG Elective V				6	
Total Credits					**40**	

* One of the Electives should be CE 448 Pre-stressed Concrete Design

Course Structure– Fifth Year

First Semester

Course Code	Course Name	Credit Structure			Credits	Remarks Core/ Departmental Elective/ Institute Elective
		L	T	P		
CE xxx	PG Elective III				6	PG Elective
CE xxx	PG Elective IV				6	PG Elective
CE 616	Structural Dynamics				6	PG Core
CE 593	Dual Degree Project Stage I				36	Core Course
Total Credits					**54**	

Second Semester

Course Code	Course Name	Credit Structure			Credits	Remarks Core/ Departmental Elective/ Institute Elective
		L	T	P		
CE xxx	PG Elective V				6	PG Elective
CE xxx	PG Elective VI				6	PG Elective
CE 594	Dual Degree Project Stage II				36	
Total Credits					**48**	

List of Structural Engineering PG Electives

Course Code	Course Name
CE 615	Structural Optimization
CE 617	Plate and Shells
CE 619	Structural Stability
CE 621	Plastic Analysis
CE 639	Green Building Design

Or other approved PG Courses in Structures, other Groups, and other Departments as recommended by Faculty Advisor/Thesis Supervisor.

Dual Degree (B.Tech. + M.Tech.) In Civil Engineering

CE-5: Ocean Engineering

Course Structure – Fourth Year

First Semester

Course Code	Course Name	Credit Structure			Credits	Remarks Core/ Departmental Elective/ Institute Elective
		L	T	P		
CE 401	Water Resources Engineering	3	0	0	6	Core Course
CE 463	Probability and Statistics for Civil Engineers	3	0	0	6	Core Course
CE 603*	Numerical Methods	3	0	0	6	Core Course
CE 407	Foundation Engineering	3	0	0	6	Core Course
CE 4xx	Departmental UG Elective I				6	Departmental UG Electives
CE 680	Mechanics of Water Waves				6	PG Core
CE 769	Coastal and Ocean Environment				6	PG Core
Total Credits					**42**	

*CE 465can be manually registered as core course in place of CE 603 if the student is interested.

Second semester

Course Code	Course Name	Credit Structure			Credits	Remarks Core/ Departmental Elective/ Institute Elective
		L	T	P		
CE 707	Coastal, Port and Harbor Engineering				6	PG Core
CE 708	Offshore Engineering				6	PG Core
CE 4xx	Departmental UG Elective II				6	Departmental UG Electives
CE 4xx	Departmental UG Elective III				6	
CE 4xx	Departmental UG Elective IV				6	
CE 4xx	Departmental UG Elective V				6	
CE 694	Credit Seminar				4	Seminar
Total Credits					**40**	

Course structure – Fifth year

FIRST SEMESTER

Course Code	Course Name	Credit Structure			Credits	Remarks Core/ Departmental Elective/ Institute Elective
		L	T	P		
CE 706	Ocean Engineering Laboratory				4	PG Laboratory course
CE xxx	PG Elective I				6	PG Elective
CE xxx	PG Elective II				6	PG Elective
CE 593	Dual Degree Project Stage I				36	
Total Credits					**52**	

SECOND SEMESTER

Course Code	Course Name	Credit Structure			Credits	Remarks Core/ Departmental Elective/ Institute Elective
		L	T	P		
CE xxx	PG Elective III				6	PG Elective
CE xxx	PG Elective IV				6	PG Elective
CE 594	Dual Degree Project Stage II				36	
Total Credits					**48**	

List of Ocean Engineering PG Electives

Course Code	Course Name	Semester Offered
CE 607	Numerical Techniques in Hydraulic Engineering	II
CE 608	Eco-hydro-climatology	I
CE 701	Remote Sensing Technology	I
CE 710	Remote Sensing and Geographical Information Systems in Water Resources Management	II
CE 731	Mechanics of Fluid Flow	I
CE-687	Offshore Construction	I
CE-770	Ocean Renewable Energy	II

Dual Degree (B.Tech. + M.Tech.) In Civil Engineering

CE-6: Remote Sensing

Course Structure – Fourth Year

First Semester

Course Code	Course Name	Credit Structure			Credits	Remarks Core/ Departmental Elective/ Institute Elective
		L	T	P		
CE 401	Water Resources Engineering	3	0	0	6	Core Course
CE 463	Probability and Statistics for Civil Engineers	3	0	0	6	Core Course
CE 603*	Numerical Methods	3	0	0	6	Core Course
CE 407	Foundation Engineering	3	0	0	6	Core Course
CE xxx	Departmental UG Elective I(preferably CE 712)	2	1	0	6	Departmental UG Electives
CE 701	Remote Sensing Technology	3	0	0	6	PG Core
CE 703	Remote Sensing lab	3	0	0	4	PG Laboratory Course
Total Credits					**40**	

*CE 465 can be manually registered as core course in place of CE 603 if the student is interested.

Second semester

Course Code	Course Name	Credit Structure			Credits	Remarks Core/ Departmental Elective/ Institute Elective
		L	T	P		
CE xxx	PG Elective-I				6	PG Elective
CE xxx	PG Elective-II				6	PG Elective
CE 4xx	Departmental UG Elective II				6	Departmental UG Electives
CE 4xx	Departmental UG Elective III				6	
CE 4xx	Departmental UG Elective IV				6	
CE 4xx	Departmental UG Elective V				6	
CE 694	Credit Seminar				4	Seminar
Total Credits					**40**	

Course structure – Fifth year

First Semester

Course Code	Course Name	Credit Structure			Credits	Remarks Core/ Departmental Elective/ Institute Elective
		L	T	P		
CE 630	GIS in Civil Engineering				6	PG Elective
CE xxx	PG Elective III				6	PG Elective
CE 593	Dual Degree Project Stage I				36	
Total Credits					**48**	

Second semester

Course Code	Course Name	Credit Structure			Credits	Remarks Core/ Departmental Elective/ Institute Elective
		L	T	P		
CE xxx	PG Elective IV				6	PG Elective
CE xxx	PG Elective V				6	PG Elective
CE 594	Dual Degree Project Stage II				36	
Total Credits					**48**	

List of Remote Sensing PG Electives

Course code	Course Name	Credits	Semester Offered
CE 608	Eco-Hydro Climatology	3-0-0	I
CE 657	Computing in Civil Engineering	2-0-2	I
CE 705	Photogrammetric Engineering	3-0-0	I
CE 712	Digital Image Processing of Remotely Sensed Data	2-1-0	I
CE 771	Optimization in Civil Engineering	3-0-0	I
US 601	Urban Geomatics and Analytics	3-0-0	I
GS 535	Statistical Methods in Geosciences	3-0-0	I
CE 659	Advanced Surveying	2-0-2	II
CE 695	R&D Project		II
CE 710	Remote sensing and GIS for Water Resources Management	3-0-0	II
CE 716	Advanced Digital Image Processing of Remotely Sensed Data	2-1-0	II
GNR 636	Remote Sensing of Vegetation	2-1-0	II
GNR 647	Microwave Remote Sensing	2-1-0	II
GNR 651	Digital Photogrammetric and Cartography	2-1-0	II
GNR 652	Machine Learning in Remote Sensing-I	3-0-0	II

Dual Degree (B.Tech. + M.Tech.) In Civil Engineering

CE-7: Construction Technology and Management (CTaM)

Course Structure – Fourth Year

First Semester

Course Code	Course Name	Credit Structure			Credits	Remarks
		L	T	P		
CE 401	Water Resources Engineering	3	0	0	6	Core Course
CE 463	Probability and Statistics for Civil Engineers	3	0	0	6	Core Course
CE 603*	Numerical Methods	3	0	0	6	Core Course
CE 407	Foundation Engineering	3	0	0	6	Core Course
CE 717	Construction Planning and Control	3	1	0	8	PG Core
CE 4xx	Departmental UG Elective I	3	0	0	6	Departmental UG Elective
CE 718	Construction Materials Laboratory	0	0	4	4	PG Lab
Total Credits					**42**	

*CE 465 can be manually registered as core course in place of CE 603 if the student is interested.

Second semester

Course Code	Course Name	Credit Structure			Credits	Remarks
		L	T	P		
CE 4xx	Departmental UG Elective II	3	0	0	6	Departmental UG Electives
CE 4xx	Departmental UG Elective III	3	0	0	6	
CE 4xx	Departmental UG Elective IV	3	0	0	6	
CE 4xx	Departmental UG Elective V	3	0	0	6	
CE 719	Construction Contracts	3	0	0	6	PG Core
CE xxx	PG Elective I	3	0	0	6	PG Elective
CE 722	Construction Management Studio	0	0	4	4	PG Lab
CE 694	Credit seminar				4	Seminar
Total Credits					**44**	

Course Structure – Fifth Year

First Semester

Course Code	Course Name	Credit Structure			Credits	Remarks
		L	T	P		
CE 713	Advanced Concrete Technology	3	0	0	6	PG core
CE xxx	PG Elective II	3	0	0	6	PG Elective
CE 593	Dual Degree Project Stage I				36	Project - Stage I
Total Credits					**48**	

Second Semester

Course Code	Course Name	Credit Structure			Credits	Remarks
		L	T	P		
CE xxx	PG Elective III	3	0	0	6	PG Elective
CE xxx	PG Elective IV	3	0	0	6	PG Elective
CE 594	Dual Degree Project Stage II				36	Project – Stage II
Total Credits					**48**	

List of Construction Technology and Management PG Electives

Course Code	Course Title
CE-723	Construction equipments and personnel management
CE-725	Construction economics and finance
CE-727	Construction materials
CE-729	Quality and safety in construction
CE-741	Formwork for concrete structures
CE-743	Condition Assessment and rehabilitation of structures
CE-771	Optimization in civil engineering
CE-720	Non Destructive Testing of Materials
US-602	Fundamentals of urban science and engineering
US-603	Research methods for urban science
US-604	Management techniques for urban systems
CE-639	Green building design
CE-707	Coastal, Port and Harbour Engineering
CE-687	Offshore Construction
CE-605	Applied statistics
CE-776	Transportation Project Evaluation and Decision Making
CE-603	Numerical Methods
CE-657	Computing in Civil Engineering

Course Details

CE-102 Engineering Mechanics

Equivalent Force Systems: Basic concepts of force-couple systems. Planar force systems: parallel force systems; simplest equivalent for general force system- "wrench". Distributed force systems. Equations of Statics and its Applications: Simple frictionless rigid body assemblies; two force members: machines: trusses: cables: rigid body assemblies including friction. Virtual Work and Potential Energy Principles: Application of these principles as replacement of equations of statics for real life problems. Vibrations: Equations of motion for single degree-of-freedom systems and rigid body assemblies: free vibration (simple harmonic oscillator): concepts of damping and critical damping: damped free vibration: equations of motion for harmonic excitation: transient and steady-state vibrations: illustration of MDOF systems concepts with two degree-of-freedom systems.

References:

1. I.H. Shames, "Introduction to Solid Mechanics, Second Edition, Prentice Hall of India, New Delhi, 1989.
2. F.P. Beer and Jhonston, "Mechanics for Engineers", McGraw Hill, New Delhi, 1987.

CE-204 ENGINEERING SURVEYING

Introduction to Plane & Geodetic Surveying, Fundamental Principles, Traversing, Leveling, Instrumentation: Total Stations; Digital Levels; Data Processing, Theory of Errors and Adjustment Computations, Introduction to Space Geodetic Techniques: GNSS

References:

1. B.C. Punmia, A.K. Jain and A.K. Jain, Surveying, Vol. 1 and II, 5th or later editions, Laxmi Publications, New Delhi, 2015.
2. Satheesh Gopi, R. Sathikumar, and N. Madhu. Advanced Surveying: Total Station, GIS and Remote Sensing 1st Edition, 2007, Pearson India
3. Charles D. Ghilani, Elementary Surveying: An Introduction to Geomatics (15th Edition) Pearson Publishers. 2017
4. R.E. Davis, F.S. Foote and J.W. Kelly, Surveying: Theory and Practice, 7th Ed., McGraw Hill, New York, 1980.
5. D.Clark, Plane and Geodetic Surveying, Vol. I and II, Constable and Company, London, 1980.

CE-216 Engineering Surveying Practical

Angular & Distance Observations with Digital Theodolites and Total Stations, Triangulation & Traversing, Leveling, Surveying & Mapping using Global Navigation Satellite System (GNSS).

References: NA

CE-221 Solid Mechanics - I

Rigid and deformable solids; Method of sections for evaluating internal forces in bodies - review of free body diagrams; Concept of stress - normal and shear stresses; State of stress; Concept of strain - normal and shear strains; State of strain; Hooke's law; Constitutive relations; Axially loaded members, force and deflections; Indeterminate systems and compatibility conditions; Simple indeterminate systems and lack of fit problems; Generalized Hooke's law; Stress in cylindrical and spherical shells; Torsion of circular shafts - determinate and simple indeterminate systems. Elastic theory of bending of beams; Shear force and bending moment diagrams; Bending and shearing stresses in beams of symmetrical cross-section; Concept of shear flow and shear center; Principle of superposition and its limitations. Transformation of plane stress and strain; Principal stresses and strains; Mohr's circle. Bending deflection of beams by direct integration method; Application of direct integration method to simple indeterminate systems; Elastic buckling of compression members.

References:

1. E.P. Popov, Engineering Mechanics of Solids, 2nd Ed., Prentice Hill, New Delhi, 1999.
2. F.P. Beer, E.R. Johnston and J.T. DeWolf, Mechanics of Materials, 3rd Ed., Tata McGraw Hill, New Delhi, 2004.
3. I.H. Shames and J.M. Pitarresi, Introduction to the Solid Mechanics, 3rd Ed., Prentice Hill, New Delhi, 1989.
4. J.M. Gere, Mechanics of Materials, 5th Ed., Brooks/Cole, Chennai, 2001.
5. S.H. Crandall, N.C. Dhal and T.J. Lardner, Mechanics of Solids: An Introduction, McGraw Hill, Tokyo, 1994.
6. S.M.A. Kazimi, Solid Mechanics, Tata McGraw-Hill, New Delhi, 1981.

CE-222 STRUCTURAL MECHANICS - I

Analysis of Statically Determinate Structures - Determination of forces in trusses, frames, arches, and cables; Drawing bending moment, shear force and axial force diagrams; Computation of displacements using principle of virtual work; Moment-area method, Conjugate-beam method; Energy Principles; Maxwell's and Betti's laws; Analysis of Statically Indeterminate Structures - Concept of static indeterminacy; Concept of compatibility conditions; Method of consistent deformations for statically indeterminate trusses, beams, frames, arches; Matrix formulation of force method; Influence Lines - Concept of influence lines using equilibrium methods, and by using Muller Breslau principle for both statically determinate and indeterminate structures.

References:

1. H.H. West, Fundamentals of Structural Analysis, Wiley, New York, 1993.
2. C.H. Norris, J.B. Wilbur and S. Utku, Elementary Structural Analysis, 3rd Ed., McGraw Hill International, Tokyo, 1976.
3. C.S. Reddy, Basic Structural Analysis, 2nd Ed. Tata McGraw Hill, New Delhi, 1996.
4. L.S. Negi and R.S. Jangid, Structural Analysis, Tata McGraw Hill, New Delhi, 1997.

CE-223 Fluid Mechanics - I

Fundamental Concepts of Fluid Flow: Fundamental definitions, Flow characteristics, Classification of fluids, Fluid properties, Foundations of flow analysis. Fluid Statics: Fluid pressure, Forces on solid surfaces, Buoyant forces. Kinematics of Fluid Flow: Equations for acceleration, Continuity equation, Irrotational and rotational flow, Potential and stream functions. Dynamics of Fluid Flow: Finite control volume analysis, Euler and Bernoulli's theorems, Impulse momentum theory, Applications of energy and momentum equations. Laminar and Turbulent Flows: Types of flow, Reynolds experiment, Laminar flow between parallel plates, Laminar flow in pipes, Turbulent flow in pipes. Navier-Stokes Equations and Applications: Introduction to Navier-Stokes equations, Exact solutions for simple cases of flow, Plane Poiseuille flow, Couette flow, Stokes flow and porous media flow. Boundary Layer Theory and Applications: Concepts of boundary layer, Flow separation, Circulation, Drag and lift on immersed bodies.

References:

1. V.L. Streeter and E.B. Wylie, Fluid Mechanics, McGraw Hill, 1998.
2. Granger, R.A., Fluid Mechanics, CBS College Publishing, New York, 1985.
3. J.F. Douglas, J.M. Gasiorek, and J.A. Swaffield, Fluid Mechanics, Addison-Wesley, Harlow 1999.
4. I.H. Shames, Mechanics of Fluids, McGraw Hill, New York, 1992.
5. R.L. Daugherthy, J.B. Franzini and E.J. Finnemore, Fluid Mechanics with Engineering Applications, McGraw Hill, New York, 1985.
6. A.K. Jain, Fluid Mechanics, Khanna Publishers, New Delhi, 1998.
7. L.P.N. Modi and S.M. Seth, Hydraulics and Fluid Mechanics, Standard Book House, New Delhi, 2002.

CE-228 APPLIED HYDRAULIC ENGINEERING

Dimensional Analysis, Model similitude, Model scales, Physical modeling, Computational hydraulics, Theory and applications. Momentum and energy equations, Correction factors, Specific energy, Specific force,Criticalflows; Uniform and non-uniform flows – properties, design of channels, Gradually varied flows– Theory and analysis, typical method of computation. Rapidly varied flows – flow over a spillway, hydraulic jump, control and stabilization, Unsteady flows – basic equations, uniformly progressive flow, flood waves, flood routing. Revisiting Major and minor losses; components of water distribution system; Multiple reservoir problem; Pipe network: Hardy-cross method; Unsteady flow in pipes: water hammer, Surge tank; Water distribution systems and analysis; Intakes, pumping and transportation of water; Appurtenances of water transport and distribution systems. Essentials of water supply; Water Demand and Quantity Estimation: Design period, population forecast; Domestic water standards; Sources of water and their yield; Water quality: definitions and characteristics, suspended solids, turbidity, alkalinity, hardness, fluoride, metals, Nutrients, BOD and COD; Processes of water treatment: Aeration, sedimentation and flocculation; Settling, coagulation, Softening, Filtration: slow and rapid sand filters; chlorination and other disinfecting methods

References:

1. Vent te Chow (2009), “Open Channel Hydraulics”, McGraw-hill, New Delhi.
2. K.G. Rangaraju (1993), Flow in Open Channels, Tata McGraw Hill Publication Co. Ltd., New Delhi.
3. K. Subramanya (1992), Flow in Open Channels, Tata McGraw Hill Publication Co. Ltd.,New Delhi.
4. R.H. French (1986), Open Channel Hydraulics, McGraw Hill Book Co., New York.
5. Peavy, Rowe and Tchobanoglous, (2003), Environmental Engineering, McGraw-hill, New York. S.K.
6. Garg, (2005) “Environmental Engineering 1: Water Supply Engineering”, Khanna Publisher, New Delhi.
7. R. Srivastava (2010), “Flow through open channels”, Oxford University Press (2008)
8. Jain A K, “Fluid Mechanics”, Khanna Publisher, New Delhi.
9. M.J. Hammer, (1986), Water and Waste Water Technology, John Wiley and Sons, New York.
10. CPHEEO: Manual on Water Supply and Treatment, Ministry of Urban Development, 1991.
11. CPHEEO: Manual on Sewerage and Sewage Treatment, Ministry of Works and Housing, New Delhi, 1980.

CE-230 Hydraulic Design Lab

Seepage analysis - Heleshaw model; Infiltration experiment - Infiltrometer; Groundwater Flow model; Permeability studies; Hydraulic jump experiments; Channel expansion and contraction studies; Small surges and wave experiments; Flow measurements in open channels – Flow over a weir, sharp and broad crested weirs, spillway; Boundary layer flows – wind tunnel; Hydrology – rainfall simulator, overland and channel flow experiments; Flow in pipes – Pipe network; Sedimentation and scour studies – settling tank, sedimentation flume, scour at structures

References:

1. W.R. Lamox, Laboratory work in hydraulics, Granada Publishers, London, 1979.
2. S. Narasimhan, Fluid Mechanics Laboratory – A Manual for Experiments, Curriculum Development Programme, IIT Bombay, 1982.
3. V.T. Chow, Open Channel Hydraulics, McGraw Hill, London, 1975.
4. V.L. Streeter and E.B. Wylie, Fluid Mechanics, McGraw Hill, London, 1998.

CE-231 Solid Mechanics Lab - I

Tension test on mild steel and cast iron rods, impact test on metal, compression and shear test on Neoprene pad specimens, buckling of slender steel columns, torsion test on round mild steel and cast iron rods, indentation hardness test on metals. Measurement of strain by electrical resistance strain gauge (cantilever beam), evaluation of Poisson??s ratio on mild steel flat, deflection of simply supported, location of shear centre in a channel section, unsymmetrical bending. Compression test on plane concrete cube and cylinder, ultrasonic test on concrete cube.

References:

1. H.E. Davis, G.E. Troxell and C.R. Litecky, Inspection and Testing of Engineering Materials, 3rd Ed., McGraw Hill, New York, 1964.
2. E.P. Popov, Introduction to Mechanics of Solids, Prentice Hill, New Delhi, 1973.
3. American Society for Testing and Materials (ASTM), Annual Book of ASTM Standards, 2005.

CE-232 Building Materials and Construction

Building Materials: Introduction, Structure and properties of materials - Stone, brick (Clay and Fly ash), Hollow blocks, Tiles, Steel, Cement concrete, Glass. (IS codes/ ASTM codes for assessing the Engineering property of materials and relevant test procedures will be discussed)

Building Construction: Building systems, Foundations, Masonry, Walls, Floors, Lintels and arches, Roofs, Formwork and scaffolding, Plastering and Pointing, Weather proofing, Construction Equipments

References:

1. M. S. Mamlouk and J. P. Zaniewski, "Materials for Civil and Construction Engineers," 3rd Ed., Prentice Hall, USA, 2010.
2. W. D. Callister, Jr., "Materials Science and Engineering – An Introduction," 3rd Ed., John Wiley and Sons, USA, 1994.
3. P. C. Varghese, "Building Materials", PHI Learning Pvt. Ltd., India, 2005.
4. K. S. Jagadish, Alternative building materials technology, New Age International, India, 2007.
5. B. C. Punmia, Building Construction, 5th Ed., Laxmi Publications, India, 1993.
6. W. B. McKay, "Building Construction – Volumes 1 - 4," 5th Edition, Orient Longman, UK, 1993.
7. R. Chudley, "Construction Technology – Volumes 1 - 2," 2nd Edition, Longman, UK, 1987.
8. P. C. Varghese, "Building Construction", PHI Learning Pvt. Ltd., India, 2007.
9. P. Spence and E. Kultermann, "Construction Materials, Methods and Techniques: Building for a Sustainable Future", 3rd Ed., Cengage Learning, USA, 2010.

CE-233 Fluid Mechanics Lab - I

Study experiments: Ideal fluid motion past a two-dimensional circular cylinder by means of electrical analogues, Boundary layer growth analysis in a wind tunnel, Minor transition losses in pipes, friction factors in pipe, Flow measurements by orifices, venturimeter and notches, Bernoulli apparatus, Reynolds apparatus. Flow net studies around circular cylinder, Verification of Darcy's law.

References:

1. W.R. Lamox, Laboratory work in hydraulics, Granada Publishers, London, 1979.
2. S. Narasimhan, Fluid Mechanics Laboratory: A Manual for Experiments, Curriculum Development Programme, IIT Bombay, 1982.

CE-310 TRANSPORTATION ENGINEERING I

Introduction to transportation systems engineering; Transportation system characteristics; Planning of highway, railway and airport systems; Highway/railway route selection; Airport site selection; Geometric design of highway, railway and airfield elements; Pavement/track materials and testing; Material characterization for design; Design of highway and airfield pavements; Structural design of the railway track; Highway construction, maintenance and rehabilitation.

References:

1. C.S. Papacostas and P.D. Prevedouros, Transportation Engineering and Planning, 3rd Ed., Prentice Hall, New Jersey, 2001.
2. J.H. Banks, Introduction to Transportation Engineering, McGraw-Hill, New York, 2002.
3. P.H. Wright and K. Dixon, Highway Engineering, Th. Ed., Wiley, New York, 2003.
4. S.K. Khanna and C.E.G. Justo, Highway Engineering, Khanna Publishers, Roorkee, 2001.
5. L.R. Kadiyali, Principles and Practice of Highway Engineering, Khanna Technical Publications, Delhi, 2000.
6. Y.H. Huang, Pavement Analysis and Design, Prentice Hall, New Jersey, 2003.
7. R. Horonjeff and F.X. Mckelvey, Planning andDesign of Airports, McGraw Hill, New York, 1994.
8. S.C. Sexena and S.P. Arora, A Text Book of Railway Engineering, Dhanpat Rai & Sons, New Delhi, 1998.
9. W.W. Hay, Railroad Engineering, Wiley, New York, 1988.

CE-317 STRUCTURAL MECHANICS II

Analysis of Statically Indeterminate Structures - Concept of kinematic indeterminacy; Degrees of freedom; Development of slope-deflection equations; Concept of relative stiffness; Moment distribution method and application to beams and simple frames; Matrix formulation of displacement methods - Stiffness matrix approach with reference to computer application; Generation of 1-dimensional frame element stiffness matrix, flexural, axial & shear deformations,. Torsional effects; Concept of local effects, generation of load vector, Effects of finite joints;. Application to plane frames, space frames, grid structures; Matrix formulation of force and displacement methods - Solution of simultaneous equations; Stiffness matrix approach with reference to computer application; Generation of 1-dimensional frame element stiffness matrix, flexibility and displacement approaches; Torsional effects; Concept of local effects, generation of load vector, Effects of finite joints; Application to plane frames, space frames, grid structures, Introduction to Finite Elements Method for 2-D plane problems..

References:

1. W. Weaver and J.M. Gere, Matrix Analysis of Framed Structures, 3rd Ed., Von. Nastrand, New York, 1990.
2. H.H. West, Fundamentals of Structural Analysis, Wiley, New York, 1993.
3. C.S. Reddy, Basic Structural Analysis, 2nd Ed. Tata McGraw Hill, New Delhi, 1996.
4. J.S. Przemieniecki, Theory of Matrix Structural Analysis, Dover, New York, 1968.
5. G.S. Pandit and S.P. Gupta, Structural Analysis - A Matrix Approach, Tata McGraw Hill, New Delhi 1994.
6. M.B. Kanchi, Matrix Methods of Structural Analysis, Wiley Eastern, New Delhi, 1993.
7. L.S. Negi and R.S. Jangid, Structural Analysis, Tata McGraw Hill, New Delhi, 1997.
8. S. Utku, C.H. Norris and J.B. Wilbur, Elementary Structural Analysis,3022404th Ed., McGraw Hill College, New York, 1990..

CE-323 GEOTECHNICAL ENGINEERING I

Origin of Soils and Rocks; Rock cycle; Basic relationships; Index properties of aggregates; Soil structure; Soil classification; Soil compaction; laboratory compaction; factors affecting soil compaction; Field compaction; Soil-water statics; Effective stress; Capillarity phenomenon in soils; Flow through soils; Quick sand condition; Permeability and methods for its determination; Flownets; Stresses in soil from surface loads; Boussinesq theory; Newmarks chart, Contact pressures; Consolidation of soils; Settlement of compressible soil layers.

References:

1. Terzaghi, K., Peck, R. B. &Mesri, G., "Soil Mechanics in Engineering Practice", Wiley, 1996.
2. Craig, R.F. "Craig's Soil Mechanics", 7th Ed., Spon Press, 2004.
3. Holtz, R.D. & Kovacs, W.D., "An Introduction to Geotechnical Engineering", Prentice Hall, 1981.
4. Lambe, T.W. & Whitman, R.V., "Soil Mechanics", John Wiley & Sons, 1979.
5. Mitchell, J.K. & Soga, K., "Fundamentals of Soil Behaviour", John Wiley & Sons, 2005.
6. Ranjan, Gopal & Rao, A.S.R., "Basic and Applied Soil Mechanics", New Age Int. Pvt. Ltd., 2004.
7. Bolton, M.D. "A Guide to Soil Mechanics", Universities Press, 2003.
8. Das, B.M. "Principles of Geotechnical Engineering", Thomson Books, 2006.
9. Murthy, V. N. S. "Geotechnical Engineering: Principles and Practices ofSoil Mechanics and Foundation Engineering", CRC Press, 2002.
10. Coduto, D.P. "Geotechnical Engineering: Principles and Practices", Pearson Education, Prentice Hall, 2007.

CE-324ENGINEERING LAW

The Indian legal system from an engineer's perspective. Socratic-method analysis of statutory and case law. Contract, patent, corporation, antitrust, property, and environmental laws. Development of law, courts, and ethics; law on contracts, agency, sales, property, and patterns; specifications; preparation of contract documents. Coverage of following topics: 1. Overview of Indian legal system, 2. Contracts: Definitions and essentials, 3. Conditions: 3rd parties and law, 4. Construction: Performance/Breach/Damages and Contracts, 5. General Conditions: Proposals, advertisements and applications, 6. Financial Considerations: Loans and leans, 7. Specifications: Workmanship, material, drawings, 8. Agencies: Partnerships and corporations, 9. Torts: Limited coverage, 10. Professional liability: Insurance, bonds, property, 11. Litigation: Evidence, expert witness, mediation, ethics.

References:

1. Judgements and case studies.

CE-325 Structural Design I

Introduction to reinforced concrete structures; Properties of plain concrete, steel and reinforced concrete; Structural design philosophies and design codes; Analysis and design of beams and one way slabs for flexure; Design for shear; Bond, anchorage, development length and splicing; Design of bending member for serviceability limit states; Design of two way slab systems; Design of compression members; Design of footings; Design of staircases

References:

1. S. Unnikrishnan Pillai and Devdas Menon (2009), "Reinforced Concrete Design", Third Edition, McGraw Hill Education.
2. P.C. Varghese (2013), "Limit State Design of Reinforced Concrete Structures", Second Edition, PHI Learning Private Limited.
3. James K. Wight and James G. MacGregor (2011), "Reinforced Concrete: Mechanics and Design", Sixth Edition, Prentice Hall.
4. N. Subramanian (2013), "Design of Reinforced Concrete Structures", Second Edition, Oxford University Press.

CE-328TRANSPORTATION ENGINEERING LAB I

Laboratory testing of road aggregates, bituminous binders and mixes for their suitability in road construction with reference to IRC/BIS specifications. Sub grade evaluation - California bearing ratio, resilient modulus, modulus of sub grade reaction; Pavement evaluation studies - measurement of pavement distresses, deflection studies; Traffic studies.

References:

1. S. K. Khanna and C.E.G Justo, Highway Material Testing (Laboratory Manual) Nem Chand & Bros, Roorkee.
2. Relevant IRC/BIS/ASTM Specifications
3. Relevant highway design software manual Relevant IRC/BIS/ASTM codes.
4. R.P. Roess, E.S. Prassas and W.R. McShane, Traffic Engineering, 3rd Ed., Prentice Hall, New Jersey, 2004.
5. Highway Capacity Manual, Transportation Research Board, National Research Council, Washington, D.C., 2000.

CE-329 GEOTECHNICAL ENGINEERING LAB I

Identification and processing of soils, Determination of moisture content of soils, Absorption test for rocks, Particle size distribution using sieve analysis and hydrometer analysis for soils, Specific gravity test, Atterberg limit tests for soils, Standard Proctor compaction test for soils, Field density measurements for soils, Permeability tests for soils, Consolidation of soils,

References:

1. B.M. Das, "Soil Mechanics Laboratory Manual", 6th Ed., London, University Press, 2001.
2. J.E. Bowles, "Physical Properties of Soils", 2nd Ed., McGraw Hill International, Singapore, 1990.
3. K.H. Head and R. J. Epps, "Manual of Soil Laboratory Testing vol II", 3rd Edition, Whittles Publishing, 2011.

CE-330 GEOTECHNICAL ENGINEERING II

Shear strength of soils and rocks; Mohr circle of stress; Mohr-Coulomb failure criterion; Estimation of shear strength parameters for soil and rock; Stress paths; Theories of earth pressure and retaining walls; excavation; bracing system; stability of slopes.

References:

1. Terzaghi, K., Peck, R. B. &Mesri, G., "Soil Mechanics in Engineering Practice", Wiley, 1996.
2. Craig, R.F. "Craig's Soil Mechanics", 7th Ed., Spon Press, 2004.
3. Holtz, R.D. & Kovacs, W.D., "An Introduction to Geotechnical Engineering", Prentice Hall, 1981.
4. Lambe, T.W. & Whitman, R.V., "Soil Mechanics", John Wiley & Sons, 1979.
5. Mitchell, J.K. & Soga, K., "Fundamentals of Soil Behaviour", John Wiley & Sons, 2005.
6. Ranjan, Gopal & Rao, A.S.R., "Basic and Applied Soil Mechanics", New Age Int. Pvt. Ltd., 2004.
7. Bolton, M.D. "A Guide to Soil Mechanics", Universities Press, 2003.
8. Das, B.M. "Principles of Geotechnical Engineering", Thomson Books, 2006.
9. Murthy, V. N. S. "Geotechnical Engineering: Principles and Practices of Soil Mechanics and Foundation Engineering", CRC Press, 2002.
10. Coduto, D.P. "Geotechnical Engineering: Principles and Practices", Pearson Education, Prentice Hall, 2007.

CE-332 Structural Design II

Introduction: steel structures and steelmaking; Introduction to steel design: design, standards, load path, load calculations and combinations, structural analysis methods, steel sections; Connections in steel structures: bolted and welded, connection between various member types; Design of tension members: basics, tensile sections (angles, etc.), gussets; Plastic and buckling behaviour of steel sections: material nonlinearity, classification of sections, various types of buckling; Design of compression members: buckling issues, design of columns; Design of beams: design against flexure and shear for rolled sections; Brief introduction to other designs and issues

References:

1. Bureau of Indian Standards IS 800:2007, General Construction in Steel – Code of Practice, BIS, 2007.
2. Bureau of Indian Standards IS 808:1989, Dimensions of Hot Rolled Steel Beam, Column, Channel and Angle Sections, BIS, 1989.
3. Bureau of Indian Standards, SP:6(1), Handbook for Structural Engineers: Structural Steel Sections, BIS, 1964.
4. Subramanian N, Design of Steel Structures (1st Ed.), Oxford University Press, 2008.
5. Gambhir ML, Fundamentals of Structural Steel Design (1st Ed.), Tata McGraw-Hill, 2013.

CE-334 TRANSPORTATION ENGINEERING II

Traffic Operations: Traffic stream components and characteristics; Theories of traffic flow; Traffic studies; Design of control strategies for simple systems like intersections, roundabouts, freeways, etc.; Capacity and level of services of various transportation facilities. Transportation Planning: Introduction to urban and regional transportation planning; Urban transportation planning process; Introduction to urban transportation model system; Evaluation of Transportation Systems: Economic analysis; Environmental impact assessment; Financial analysis. Laboratory testing of sub grade soils, aggregates, bituminous binders and mixes for their suitability in road construction with reference to IRC/BIS specifications; Traffic studies; Pavement evaluation tests.

References:

1. J.H. Banks, Introduction to Transportation Engineering, McGraw Hill, New York, 2002.
2. C.S. Papacostas and P.D. Prevedouros, Transportation Engineering and Planning, 3rd Ed., Prentice Hall,New Jersey, 2001.
3. R.P. Roess, E.S. Prassas and W.R. McShane, Traffic Engineering, 3rd Ed., Prentice Hall, New Jersey, 2004.
4. Highway Capacity Manual, Transportation Research Board, National Research Council, Washington, D.C., 2000.
5. J.D. Ortuzar and L.G. Willumsen, Modelling Transport, 3rd Ed., Wiley, New York, 2002.
6. M. Meyer and E.J. Miller, Urban Transportation Planning, 2nd Ed., McGraw Hill, New York, 2001

CE-336 GEOTECHNICAL ENGINEERING LAB II

Shear strength of soils and rocks, direct shear test of soils, UCC test on soils, Triaxial test - UU, CU type tests on soils, UCS & Triaxial test on rocks; Laboratory vane shear test for soils.

References:

1. B.M. Das, "Soil Mechanics Laboratory Manual", 6th Ed., London, University Press, 2001.
2. J.E. Bowles, "Physical Properties of Soils", 2nd Ed., McGraw Hill International, Singapore, 1990.
3. 3.K.H. Head and R. J. Epps, "Manual of Soil Laboratory Testing vol II", 3rd Edition, Whittles Publishing, 2011

CE-338 ESTIMATION AND MATERIALS TESTING LABORATORY

Tension Test on Tor-Steel (IS 1786)**,** ***T***esting of Tiles (Wet Transverse strength, Water absorption test)(IS 1237)**,** Testing of Bricks (Compressive strength, Water Absorption, Efflorescence) (IS 3495- Part 1,2,3)**,** Compression Test on Plain Concrete Cube & Cylinder (IS 516)**,** Ultrasonic Test on Concrete Cube (IS 13311 Part 1)**,** ***S***chmitz Rebound Hammer Test (NDT) on Concrete Cube(IS 13311 Part 2)**,** Water Permeability Test for concrete (IS 3085)**,** Consistency Test on Cement (IS 4031 Part 4)**,** Initial and Final setting time of Cement (IS 4031 Part 5)**,** Compressive Strength of Cement Mortar Cube (IS 4031 Part 6)**,** Effect of chemical admixtures on Fresh Concrete Properties(IS 9103, IS 1199, IS 8142)**,** Slump, Slump retention, Setting time of concrete (with and without *superplasticizers*)**,** Estimation of quantities and costing**.**

References:

1. IS 1786 (1985 – reaffirmed 1990) Specification for high strength deformed steel bars and wires for reinforcement, Indian Standards.
2. IS 1237 (1980- reaffirmed 1996) Specification for cement concrete flooring tiles, Indian Standards.
3. IS 3495- Part 1,2,3 (1992- reaffirmed 2002) Methods of tests of burnt clay building bricks, Indian Standards.
4. IS 516 (1959- reaffirmed 1999) Methods of tests for strength of concrete, Indian Standards.
5. IS 13311 - Part 1 & 2 (1992- reaffirmed 2004) Non-destructive testing of concrete - Methods of test, Indian Standards.
6. IS 3085 (1965-reaffirmed 1997) Method of test for permeability of cement mortar and concrete, Indian Standards.
7. IS 4031 - Part 4, 5 & 6 (1988-reaffirmed 2005) Methods of physical tests for hydraulic cement, Indian Standards.
8. IS 9103 (1999- reaffirmed 2004) Concrete admixtures – Specification, Indian Standards.
9. IS 1199 (1959- reaffirmed 1999) Methods of sampling and analysis of concrete, Indian Standards.
10. IS 8142 (1976 –reaffirmed 2002) Method of test for determining setting time of concrete by penetration resistance, Indian Standards.
11. Dutta, B. N. Estimating and Costing in Civil Engineering- Theory and Practice, 27th revised edition, UBS publishers` Distributors Pvt. Ltd., India, 2013.

CE 340 - BUILDING MATERIALS AND STRUCTURES

Building Materials: Engineering properties of materials - Stone, Bricks, Tiles, Structural Steel, Cement Concrete. IS/ASTM recommended procedures for assessing the Engineering properties of materials

Structures: Structural Systems for Industrial Buildings, Masonry Buildings, Fundamentals of Mechanics, Equilibrium requirements for 2D and 3D Systems, Design requirements of various components, Performance evaluation.

References:

1. M. S. Mamlouk and J. P. Zaniewski, “Materials for Civil and Construction Engineers,” 3rd Ed., Prentice Hall, USA, 2010.
1. W. D. Callister, Jr., “Materials Science and Engineering – An Introduction,” 3rd Ed., John Wiley and Sons, USA, 1994.
2. W. B. McKay, “Building Construction – Volumes 1 - 4,” 5th Edition, Orient Longman, UK, 1993.
3. P. C. Varghese, “Building Construction”, PHI Learning Pvt. Ltd., India, 2007.
4. P. Spence and E. Kultermann, “Construction Materials, Methods and Techniques: Building for a Sustainable Future”, 3rd Ed., Cengage Learning, USA, 2010.
5. F. P. Beer, E. R. Johnston, D. F. Mazurek and P. J. Cornwell, “Vector Mechanics for Engineers: Statics and Dynamics,” 9th Ed., McGraw Hill, 2010.
6. R. G. Drysdale, A.A. Hamid and L. R. Baker, “Masonry Structures: Behavior and Design,” Masonry Society, 1999.
7. Best Practice in Steel Construction: Industrial Buildings, The Steel Construction Institute, 2008.

CE 342 - INTRODUCTION TO GEOTECHNICS

Origin of Soils; Phase relationships; Index properties of soils; Soil classification; Concept of effective stress; Capillarity; Compaction of soils–Laboratory and field compaction, factors affecting compaction; Permeability of soils–Laboratory and field methods for determination of permeability of soils; Factors affecting permeability of soils; Seepage forces; Quick sand condition; Estimation of stresses in soils due to external loads; Consolidation–Estimation of primary and secondary consolidation settlements; Time rate of consolidation; Coefficient of consolidation; Estimation of pre-consolidation pressure; Normally and Over-consolidated clays; Introduction to shear strength of soils; Mohr-Coulomb failure criterion; Methods for determining shear strength of soils in the laboratory; Overview of geotechnical site investigations; Types and Properties of rocks; Standard Penetration test; Static Cone Penetration Test; Field Vane shear test; Estimation of earth pressures on retaining walls; Ranking and Coulomb's earth pressure theories; Stability analysis of finite and infinite slopes; Bearing capacity; Introduction to basics of shallow and deep foundations; Geotechnical challenges and Case studies.

References

1. Terzaghi, K., Peck, R. B. & Mesri, G., "Soil Mechanics in Engineering Practice", Wiley, 1996.
2. Craig, R.F. "Craig's Soil Mechanics", 7th Ed., Spon Press, 2004.
3. Holtz, R.D. & Kovacs, W.D., "An Introduction to Geotechnical Engineering", Prentice Hall, 1981.
4. Lambe, T.W. & Whitman, R.V., "Soil Mechanics", John Wiley & Sons, 1979.
5. Mitchell, J.K. & Soga, K., "Fundamentals of Soil Behaviour", John Wiley & Sons, 2005.
6. Ranjan, Gopal & Rao, A.S.R., "Basic and Applied Soil Mechanics", New Age Int. Pvt. Ltd., 2004.
7. Bolton, M.D. "A Guide to Soil Mechanics", Universities Press, 2003.
8. Das, B.M. "Principles of Geotechnical Engineering", Thomson Books, 2004.
9. Murthy, V. N. S. "Geotechnical Engineering: Principles and Practices of
10. Soil Mechanics and Foundation Engineering", CRC Press, 2002.
11. Som, N. N. & Das, S. C. "Theory and Practice of Foundation Design", Prentice-Hall India, 2004.
12. Nayak, N. V. "Foundation Design Manual", Dhanpat Rai Pub. Pvt. Ltd., 2001.

CE 344 - INTRODUCTION TO WATER RESOURCES ENGINEERING

Hydrologic cycle, water budget equation, basic concepts of precipitation, evaporation and infiltration, introduction to hydrographs, factors affecting flood hydrographs, unit and instantaneous unit hydrograph, Introduction to basic concepts of groundwater hydrology, applications of Darcy's law, exploration of groundwater, steady and time variant well hydraulics, Analytical solutions to simplified governing equations, introduction to groundwater modeling, contamination of groundwater, sources and remediation, introduction to the concepts of environmental impact of water resources systems, discharge measurements in pipes and channel, head loss and friction factor in pipes, introduction to evolutionary algorithms wrt to certain water resources problems

References:

1. Engineering Hydrology by K Subramanya (1994) or later Ed.
2. Numerical Groundwater Hydrology (2012) by Rastogi A K
3. Fluid Mechanics by Streeter, Wylie and Bedford (1998)
4. Environment Impact Assessment by L W Canter (1996)

CE-401 WATER RESOURCES ENGINEERING

Rainfall and runoff, hydrograph analysis, peaks flows. Reservoir planning and operation, run-of the river schemes, storage schemes. Dams and spillways, intakes, water-conductory systems, tunnels, surge-tanks, penstocks and anchor blocks. Hydro-electric power classification and investigations. Turbines, power house, irrigation, crop requirements and yields, water planning. Weirs on permeable foundations. Canals layout, stable channels, and silt control, canal losses and water-logging.

References:

1. R.K. Linsley and J.L.H. Paulhus: Water Resources Engineering, McGraw Hill Book Co., 1992.
2. W.P. Creager and J.D. Justin: Hydroelectric Handbook John Wiley, 1968.
3. Bharat Singh: Fundamentals of Irrigation Engineering Nemchand Bros., Roorkee, 1957.
4. P.N. Modi, Irrigation Water Resources and Water Power Engineering Standard Book House, New Delhi, 1990.

CE-402 Introduction to Geotechnical Earthquake Engineering

Introduction to Geotechnical Earthquake Engineering; Seismology and earthquakes; Strong ground motions; Earthquake hazards related to geotechnical engineering; Wave propagation; Liquefaction; Seismic slope stability; Seismic design of retaining walls; Force based pseudo-static and pseudo-dynamic analysis; Displacement based analysis; Seismic design of shallow foundations; Seismic design of pile foundations; Seismic uplift capacity of anchors; Soil improvement for remediation of seismic hazards; Design guidelines in codes.

References:

1. S. L. Kramer, Geotechnical Earthquake Engineering, Prentice Hall International Series, Pearson Education, New Delhi, 2003.

2. R. W. Day, Geotechnical Earthquake Engineering Handbook, McGraw Hill, New York, 2002.

3. IS 1893, Indian Standard Criteria for Earthquake Resistant Design of Structures, 2016.

4. B.M. Das, Principles of Foundation Engineering, 7th Ed. SI Units, Cengage Learning, USA, 2011.

5. R. Katzenbach, S. Leppla and D. Choudhury; Foundation Systems for High-Rise Structures, CRC Press, Taylor & Francis Group, UK, ISBN: 978-1-4987-4477-5, pp. 1-298, 2016.

6. D. Choudhury, Geotechnical Earthquake Engineering, NPTEL Video course, 2013. https://nptel.ac.in/courses/105/101/105101134/

CE-403 Design of Structures III

Design of RCC water tanks, silos, bunkers and simple bridges - Design of steel roof trusses, steel frames - Design of industrial buildings - Design of residential buildings - Design of arches and shells.

References:

1. J. Krishna and O.P. Jain, Plain and Reinforced Concrete, Vol. I and II Nemchand Bros. Roorkee, 1968.
2. IS 456, 1978. Code of Practice for Plain and Reinforced concrete.
3. Design Aids for R.C. to IS 456-1978, ISI-SP-16-sand-T, 1980.
4. A.S. Arya and J.L. Ajmani : Design of Steel Structures, Nemchand Bros. Roorkee, 1990.
5. A.S. Arya and J.L. Ajmani : Design of Steel Structures, Nemchand Bros. Roorkee, 1990.
6. S.M.A. Kazimi and R.S. Jindal - `Design of Steel Structures, Prentice Hall (India), New Delhi, 1981.
7. S.K. Duggal - `Design of Steel Structures, Tata McGraw Hill, New Delhi, 1993.
8. P. Dayaratnam - `Design of Reinforced Concrete Structures, Third Edition, Oxford - IBM Publishing Co., New Delhi, 1989.
9. S.N. Sinha - `Reinforced Concrete Design, Tata McGraw Hill, New Delhi, 1990.

CE-407 FOUNDATION ENGINEERING

Site investigations- spacing/depth of boreholes, disturbed/undisturbed soil sampling, geophysical exploration, electrical resistivity method, preparation of borehole logs and final report. Shallow foundations- theories of bearing capacity, standard penetration test, design of a footing in cohesionless/cohesive soil based on settlement and bearing capacity criteria, plate load test, combined footings, eccentrically loaded footings. Analysis and design of raft based on settlement and bearing capacity criteria. Retaining walls - various types, size proportioning and stability analysis. Pile foundations- driven piles in cohesive/cohesionless soil, bearing capacity/settlement aspects, analysis and design of pile groups, bored cast-in-situ piles, pile driving equipment. Ground improvement- sand drains and surcharging.

References:

1. A. Singh, Modern Geotechnical Engineering, 3rd Ed., CBS Publishers, New Delhi, 1999.
2. B.M. Das, Principles of Foundation Engineering, 7th Ed. SI Units, Cengage Learning, USA, 2011.
3. N. Som, Theory and Practice of Foundation Design, Prentice Hall, New Delhi, 2003.
4. J.E. Bowles, Foundation Analysis and Design, McGraw-Hill International Edition, Fifth Edition, 2001.
5. R. Katzenbach, S. Leppla and D. Choudhury; Foundation Systems for High-Rise Structures, CRC Press, Taylor & Francis Group, UK, ISBN: 978-1-4987-4477-5, pp. 1-298, 2016.
6. D. Choudhury, Foundation Engineering, NPTEL Web course, 2009. https://nptel.ac.in/courses/105/101/105101083/

CE-410 INTRODUCTION TO OFFSHORE ENGINEERING

Offshore environment, types of structures; Wave theories - linear and nonlinear; Wave induced forces - on fixed and floating structures; Stability of floating structures; Submarine pipelines; Offshore construction - installation, repairs, maintenance and operation.

References:

1. C.A. Brebbla and S. Walker, Dynamic analysis of Offshore Structures, Newnes Butterworth, London, 1979.
2. T. Sarapkaya and M. Isaacson, Mechanics of Wave Forces on Offshore Structures, Van Nostrand Reinhold, New York, 1981.
3. B.C. Gerwick, Offshore Construction, Buttersworth, 2000. S. Narasimhan, S Kathiroli and T Nagendrakumar, Harbor and Coastal Engineering, National Institute of Ocean Technology, Chennai, 2001.

CE-418 Introduction to Finite Elements Methods

Introduction - Overview of different methods, background of finite element method, general steps, advantages and disadvantages; One-dimensional analysis - Linear spring, truss, beam, plane frame, grid, torsion, steady state heat conduction, flow through porous media, flow through pipes; Two-dimensional analysis - two dimensional flow through porous media, stress analysis, review of theory of elasticity, plane stress analysis, plane strain analysis, axisymmetric analysis, isoparametric formulation, numerical integration; Computer implementation of finite element method - solution of large set of equations, use of symmetry and anti-symmetry conditions, sub-structuring, application of boundary conditions.

References:

1. T.R. Chandrupatla and A.D. Belegundu, Introduction to Finite Elements in Engineering, 3rd Ed., Prentice-Hall, New Delhi, 2002.
2. J.N. Reddy, Introduction to the Finite Element Method, 2nd Ed., McGraw-Hill, New York, 2005.
3. C.S. Krishnamoorthy, Finite Element Analysis: Theory and Programming, Tata McGraw Hill, New Delhi, 1987.
4. O.C. Zienkiewicz, R.L. Taylor and J.Z. Zhu, Finite Element Method: Its Basis and Fundamentals, 6th Ed., Elsevier Butterworth Heinemann, Oxford, 2005.
5. Finite Element Method with Applications in Engineering by Y. M. Desai, T. I. Eldho and A. H. Shah, Pearson, 2011.

CE-419 PHYSICAL MODELLING IN GEOTECHNICS

Introduction to Modelling; Modelling techniques; Physical Modelling; Dimensional analysis Similitude in Geotechnics; Physical Modelling using Centrifuge, Rotational acceleration and stress field, Centrifuge equipment – Machine configurations; Dependency of the soil behaviour on Stress level and Stress History; Coriolis effect in Centrifuge; Scaling laws for static, dynamic loading and Diffusion phenomena; Physical model preparation, Boundary effects, Grain size effects, Modelling of Models technique, Scale conflicts. Introduction to Instrumentation and Data acquisition in Physical model tests; Centrifuge-based physical modelling of climatic events, construction processes and other complex geotechnical problems; Soil characterization techniques in physical model tests.

References:

1. W.H. Craig (Editor-in-Chief), International symposium on the application of centrifuge modelling to Geotechnical design, Balkema publishers, Manchester, 1984.
2. R. N. Taylor, Geotechnical Centrifuge Technology, Ist Edition, Blackie Academic & Professional publishers, London, 1995.
3. D. M. Wood, Geotechnical Modelling, Ist Edition, Spon Press Taylor & Francis Group, London and New York, 2004.
4. S.P.G. Madabhushi, Centrifuge Modelling for Civil Engineers, CRC Press ISBN 9780415668248 - CAT# Y117656, Ist Edition, 2014.

CE-422 HYDRAULIC STRUCTURES

Detailed stress analysis of gravity dam, stress concentration around openings. Principles of design of outlets and galleries. Design of pen stocks and anchor blocks. Detailed design of high head and spillway gates. Analysis and design of surge chambers. Design of locks and jetties. Design of beams on elastic foundations as applied to dock floors.

References:

1. W.P. Creager, J.D. Justin and J. Hinds, Engineering for Dams, Vol. II and III, John Wiley, New York, USA, 1968.
2. D.Quinn, Design and Construction of Ports and Marine Structures, McGraw Hill, New York, USA, 1973.
3. C.V. Davis, Handbook of Applied Hydraulics, McGraw Hill, New York, USA, 1993.
4. U.S. Dept. of Interior, Design of Small Dams, U.S. Govt. Printing Press, Washington DC, USA, 1975.
5. L. Tancev, Dams and Appurtenant Hydraulic Structures, Balkema, Netherlands, 2004.
6. R.S. Varshney, S.C. Gupta and R.L. Gupta, Theory and Design of Irrigation Structures, Volume-I, Channels and Tube Wells, New Chand Bros., Roorkee, 2000.
7. R.S. Varshney, S.C. Gupta and R.L. Gupta, Theory and Design of Irrigation Structures, Volume-II, Canal and Storage Works, New Chand Bros., Roorkee, 2000.

CE-424 GROUNDWATER HYDROLOGY

Occurrence of groundwater aquifer types. Exploration of groundwater. Groundwater budget. Resistivity method. Darcy's law and its limitations. Formulation of governing equations for groundwater movement. Flow nets and its uses. Hydraulics of flow towards wells, aquifer unsteady flow. Theis, Jacob and Chow's methods multiple well system. Artificial recharge. Infiltration. Mechanics of recharge, stream aquifer interaction. Water logging. Theory of subsurface drainage. Seawater intrusion and its control, approximate solution, Digital, Analog and Simple finite difference models for groundwater flow. Groundwater quality, groundwater development and management.

References:

1. H.M. Raghunath, Groundwater, 2nd Ed., Wiley Eastern, Singapore, 1987.
2. D.B. McWhorteer, and D.K. Sundada, Groundwater Hydrology and Hydraulics, Water Resources Publications, Fort Collins Colorado, USA, 1977.
3. C.W. Fetter, Applied Hydrogeology, 2nd Ed., CBS Publishers and Distributors, New Delhi, 1990.
4. D.K. Todd and L.W. Mays, Ground Hydrology, 3rd Ed., Wiley, New York, USA, 2004.

CE-429 URBAN HYDROLOGY AND DRAINAGE SYSTEMS

Introduction; Hydrology for drainage system design and analysis; Design of stormwater inlets; Design of detention systems; Design of infiltration basins; Design of pumps and pump facilities; Design of culverts; Computer models for urban drainage design; Best Management Practices (including rainwater harvesting); Removal of urban waste and sediment deposits from stormwater conduits and drains; Management of urban lakes, rivers and wetlands; Formulation of drainage master plans; Economic analysis; Case studies.

References:

1. FHWA Manual "Urban Drainage Design Manual" Aug 2013, D/L from
2. http://www.fhwa.dot.gov/engineering/hydraulics/pubs/10009/10009.pdf
3. Gribbin, J.E., Introduction to hydraulics and hydrology, 4/e, Cengage Learning India Pvt Ltd., Delhi, 2014
4. Butler, D. and Davis, J.W., Urban Drainage, 3/E, Spon Press, 2011
5. Rossmiller, R.L., Stormwater Design for Sustainable Development, McGraw Hill, 2013
6. Debo, T.N. and Reese, A.J., Municipal Stormwater Management, Lewis Publishers/CRC Press, 2nd edn, 2000;
7. Kolsky, P., Storm Drainage, Intermediate Technology Publications, U.K., 1998.
8. Mays, L.W. Stormwater Collection Systems Design Handbook, McGraw Hill, 2001 (Reference Book)
9. Chow, V.T., Maidment, D.R., and Mays, L.R., Applied Hydrology, McGraw Hill, 1988.
10. Parkinson, J. and Mark, O., Urban Stormwater Management in Developing Countries, IWA Publishing, UK, 2005.
11. ASCE Journals: www.pubs.asce.org
12. Journal sites: www.sciencedirect.com; pubs.asce.org
13. Additional material as recommended in class from time to time
14. Your own findings!!

CE-433 WATER SUPPLY AND WASTE WATER ENGINEERING

Part A: Water Supply Engineering

Introduction to water supply engineering, water demands, population projections, water quantity estimation, water quality, sources of water, water treatment system units and operations: aeration, sedimentation and coagulation, softening, filtration, disinfection, water conveyance and distribution networks; Intake structure and pumping installations; Hydraulic design aspects; Water supply and plumbing; Comprehensive planning , designing, execution, operation and maintenance of water supply and sewerage projects

Part B: Wastewater engineering

Wastewater engineering: basic concepts; waste water quantity estimation; wastewater characteristics: BOD, COD, DO, TOC heavy metals; Modeling in rivers, Streeter-Phelps equation; Introduction to Domestic waste water treatment; Primary, secondary and Tertiary treatments; Industrial Waste Water Treatment; Natural treatment systems: Lakes and wetlands; Wastewater treatment plant design; Waste water disposal and reuse; advanced waste water treatment; sanitary sewerage systems; storm water sewerage systems.

References:

1. S.K. Garg, Water Supply and Sanitary Engineering, 5th Editions, Khanna Publishers Delhi, 2010.
2. B.C. Punmia, Water Supply and Sanitary Engineering, 1st Edition, Laxmi Publication 2005
3. G.S. Birdie and JS Birdie, Water Supply and Sanitary Engineering, 6th Edition, Dhanpat Rai Publishers Delhi 2002
4. Metcalfe and Hp Eddy, Wastewater treatement and resuse, Tata McGraw Hill, New Delhi, 2003

CE-434 Traffic Analysis and Design

Introduction and scope; Traffic stream components and characteristics; Theoretical techniques for describing traffic flow; Traffic studies and analysis of traffic data; Highway capacity, level of service and performance characteristics; Planning and design of facilities; Simulation in traffic engineering; Traffic forecasting principles and techniques.

References:

1. R.P. Roess, E.S. Prassas and W.R. McShane, Traffic Engineering, 3rd Ed., Prentice Hall, New Jersey, 2004.
2. Highway Capacity Manual, Transportation Research Board, National Research Council, Washington, D.C., 2000.
3. C.F. Daganzo, Fundamentals of Transportation and Traffic Operations. Pergamon, New York. 1997.
4. M. Wohl, and B.V. Martin, Traffic System Analysis for Engineers and Planners. McGraw Hill, 1983.
5. D.R. Drew, Traffic Flow Theory, McGraw Hill, New York, 1964

CE-442 MACHINE FOUNDATIONS

Principles of SHM, forced and damped vibrations in soil media, Dynamic properties of soil, Liquefaction, Tests for evaluation of dynamic coefficients. Design of simple foundations for turbogenerators, reciprocating engines of horizontal and vertical type, forge hammer etc. Machine foundation on sands and clays, Provisions in design codes.

References:

1. D.D. Barkan, Dynamics of Bases and Foundations, McGraw-Hill, New York, 1962.

2. E.E. Rihcart et al., Vibrations of Soils and Foundations, Prentice Hall Inc., 1970.

3. S.P. Timoshenko, D.H. Young and William Weaver, Jr., Vibration Problems in Engineering, John Wiley and Sons, 1974.

4. Braja M. Das and G. V. Ramana, Principles of Soil Dynamics, 2nd Edition, Cengage Learning, 2010.

5. Shamsher Prakash, Soil Dynamics, 3rd Edition, John Wiley, 2000.

6. D. Choudhury, Soil Dynamics, NPTEL Video course, 2012. https://nptel.ac.in/courses/105/101/105101005/

CE-444 ADVANCED GEOTECHNICAL ANALYSIS

Stress, strain and effective stress; stress and strain paths; critical state concept; stress dilatancy; elasticity and elasto-plastic behaviour; constitutive models and Cam Clay; finite element programming; use of a geotechnical finite element code.

References:

1. Atkinson, J.H. and Bransby, P.L., "The Mechanics of Soils – An Introduction to Critical State Soil Mechanics", McGraw-Hill, London, 1978.
2. Bathe, K.J., "Finite Element Procedures in Engineering Analysis", Prentice Hall, New Jersey, 1982.
3. Bolton, M.D., "A Guide to Soil Mechanics", McMillan, London, 1984.
4. Britto, A.M. and Gunn, M.J., "Critical State Soil Mechanics via Finite Elements", Ellis Horwood, Chichester, 1987.
5. Schofield, A.N. and Wroth, C.P., "Critical State Soil Mechanics", McGraw-Hill, London, 1968.
6. Smith, I.M. and Griffiths, D.V., "Programming the Finite Element Method", 2nd ed., John Wiley, Chichester, 1988.
7. Wood, D.M., "Soil Behaviour and Critical State Soil Mechanics", Cambridge University Press, New York, 1990.

CE-448 Pre-stressed Concrete Design

Prestressing concepts, materials, systems of prestressing and losses. Introduction to working stress method, limit state analysis and design of members for bending. Shear torsion and axial forces. End block design. Deflections, use of relevant codes of practice.

References:

1. T.Y. Lin and N.H. Burns, Design of Prestressed Concrete Structures, 3rd Ed., Wiley, New York, 1981.
2. A.E. Naaman, Prestressed Concrete Analysis and Design: Fundamentals, 2nd Ed., Technopress, New York, 2004.
3. N. Krishnaraju, Prestressed Concrete, Tata McGraw Hill, New Delhi, 1981.
4. Y. Guyan, Limit State Design of Prestressed Concrete, Applied Science Publishers, 1972

CE-462 Elements of Structural Dynamics

SDOF System - Equation of Motion; Generalized SDOF system; Free Vibration; Harmonic Load; Periodic Load; Impulse Load; General Loads (Time and Frequency Domain Analysis); Introduction to Nonlinear Analysis; Seismic Analysis. MDOF System - Systems - Property matrices; Undamped Free Vibration; Mode Superposition Techniques ; Practical Free-Vibration Analysis; Buildings; Seismic Analysis; Code Provision.

References:

1. R.W. Clough, J. Penzlen, Dynamics of Structures, McGraw Hill, 2nd ed. 1993
2. M. Paz, Structural Dynamics - Theory and Computation, Van Nostrand, 1985
3. IS : 1893-1984 Criteria for Earthquake-Resistant Design of Structures.

CE-463 PROBABILITY AND STATISTICS FOR CIVIL ENGINEERS

Role of probability in Civil Engineering; Random events, random variables; Functions of random variables; Moments and expectations; Common probabilistic models – normal, lognormal, Poisson, extermal; Estimation of parameters; Goodness of fit test; Regression and correlation analyses, introduction to structural reliability, FORM; Elements of quality assurance and acceptance sampling.

References:

1. H.S. Ang and W.H. Tang, Probability Concepts in Engineering Planning and Design, Wiley, New York, 1975.
2. J.R. Benjamin and C.A. Cornell, Probability Statistics and Decision for Civil Engineers, McGraw Hill, New York, 1975.
3. R. Ranganathan, Reliability Analysis and Design of Structures, Tata McGraw Hill, New Delhi, 1990.

CE-465 Numerical Methods in Civil Engineering

Programming fundamentals; Fundamentals of numerical methods; Error analysis; Curve fitting; Interpolation and extrapolation; Differentiation and integration; Solution of nonlinear algebraic and transcendental equations; Elements of matrix algebra; Solution of systems of linear equations; Eigen value problems; Solution of differential equations. Computer oriented algorithms; Numerical solution of different problems

References:

1. J. H. Wilkinson, The Algebraic Eigen value Problem, Oxford University Press, London, 1965.
2. K.E. Atkinson, An Introduction to Numerical Analysis, Wiley, New York, 1989.
3. G. E. Golub and C.F. Van Loan, Matrix Computations, Johns Hopkins University Press, Baltimore, 1989.
4. W.H. Press, S.A. Teukolsky, W.T. Vetterling, B.P. Flannery (Eds.), Numerical Recipes in C: The Art of Scientific Computing, Cambridge University Press, Cambridge, 1993.
5. W.H. Press, S.A. Teukolsky, W.T. Vetterling, B.P. Flannery (Eds.), Numerical Recipes in Fortran: The Art of Scientific Computing, Cambridge University Press, Cambridge, 1992.
6. B.N. Datta, Numerical Linear Algebra and Applications, Brookes/Cole Publishing Company, Pacific Grove, California, 1995.
7. J.D. Hoffman, Numerical Methods for Engineers and Scientists, Marcel Dekker, New York, 2001.

CE-469 Advanced Solid Mechanics

Elasticity fundamentals: Stress and Strain; Constitutive, compatibility, and equilibrium equations, boundary conditions; Types of boundary value problems; Plane stress and plane strain, 2-D problems in rectangular, polar, and curvilinear coordinates; Elementary 3-D problems; Torsion of non-circular members; Unsymmetrical bending of straight beams, shear center; Curved beams. Beams on elastic foundation; Thermal stresses; Energy methods: Castigliano's theorems, statically indeterminate structures; Introduction to Viscoelasticity; Introduction to plasticity, failure theories, formulation for elasto-plastic problems; Numerical techniques.

References:

1. A.C. Ugural and S. K. Fenster, Advanced Strength and Applied Elasticity, Prentice-Hall, New York, 1995.
2. A.P. Boresi and O. M. Sidebottom, Advanced Mechanics of Materials, 5th Ed., Wiley, Singapore, 1992.
3. C.R. Calladine, Plasticity for Engineers - Theory and Applications, Horwood Publishing, Chichester, 2000.
4. I.S. Sokolnikoff, Mathematical Theory of Elasticity, McGraw Hill, New York, 1956.
5. L.S. Srinath, Advanced Mechanics of Solids, 2nd Ed., Tata McGraw Hill, New Delhi, 2003.
6. S.P. Timoshenko and J. N. Goodier, Theory of Elasticity, 3rd Ed., McGraw Hill, Tokyo, 1970

CE-478 Plastic Analysis and Design

Yield conditions and concepts of simple plastic collapse, collapse criterion, virtual work in elasto-plastic state, theorems of plastic collapse, methods of analysis and design. Graphical method, method of combining mechanisms, computer aided elasto-plastic analysis, interaction diagrams, applications to planar and space structures – multibay frames, multistoreyed frames, grids, arches, virendeel girders, deflection at collapse, incremental collapse, minimum weight analysis, variable repeated loads, shakedown analysis, combined stress problems.

References:

1. B.G. Neal, Plastic Method of Structural Analysis, 3rd Ed., Wiley, New York, USA, 1977.
2. M.R. Horne, Plastic theory of structures, 2nd Ed., Pergamon Press, 1979.
3. J. Baker and J. Heyman, Plastic Design of Frames, Vol. I – Fundamentals, Cambridge University Press, 1969.
4. J. Heyman, Plastic Design of Frames, Vol. II – Applications, Cambridge University Press, 1971.
5. M.L. Gambhir, Stability Analysis and Design of Structures, Springer Verlag, Berlin, Germany, 2004.

CE-480 Computer Aided Design in Civil Engineering

Essential features in design software, user-machine interface, computer graphics – coordinate systems and transformations, automatic generation of input-mapping techniques, display of response quickness, use of object oriented programming. Software for various design tasks, Heuristic approaches in Civil Engineering. Tools for developing programmes involving heuristic search Expert System shells and object oriented languages, Rule based systems, Neural networks.

References:

1. W.M. Newman, and R.F. Sproull, Principles of Interactive Computer Graphics, McGraw Hill, New York, 1988.
2. H. Adeli, Interactive Microcomputer-aided Structural Steel Design – A New Generation, Prentice Hall, New Jersey, 1990.
3. H. Adeli, and K.V. Balasubramanyam, Expert Systems for Structural Design, Prentice Hall, New Jersey, 1991.
4. B Strousstrup, The C++ programming language, 3rd Ed., Addison-Wesley, 2003.

CE-482 Construction Management

Fundamentals of construction project management: Introduction, Project Initiation and Planning, Time Value of Money, Investment Analysis, Cost-Benefit Analysis; Construction schedule management: Work Breakdown Structures, Development of project activity networks, Precedence Diagram Method, Critical Path Method (CPM), Program Evaluation and Review Technique (PERT), Line Balance Methods in scheduling; Construction material management: Resources in construction, Resource levelling, crashing of project schedules, earned value analysis; Construction Quality and safety: Safety and occupational hazards in construction, Fundamentals of quality control in construction; Introduction to Construction Contracts: Contracts in construction, fundamentals of delay analysis and claims; Advances in construction management: Introduction to Building Information Modelling (BIM), Lean construction, and Integrated Project Delivery in construction.

References:

1. Bennett, F. Lawrence., The management of construction: a project life cycle approach. Routledge, 2003.
2. Oberlender, Garold D., Project management for engineering and construction. Vol. 2. New York: McGraw-Hill, 1993.
3. Peurifoy, Robert Leroy, Cliff J. Schexnayder and Shapira A.. Construction planning, equipment, and methods. No. 696 pp. McGraw-Hill, 2010.
4. Riggs, James L., David D. Bedworth, and Sabah U. Randhawa., Engineering economics. 4th Ed., McGraw-Hill, 2004.
5. Jha, Kumar Neeraj. Construction project management: theory and practice. Pearson Education India, 2011.
6. Chitkara, K. K. Construction Project Management. Tata McGraw-Hill Education, 2014.

CE-484 CONCRETE TECHNOLOGY

Cements, aggregates, water. Fresh concrete. Workability, consolidation and curing. Strength, elasticity, shrinkage and creep of concrete. Concrete mix-design. Destructive and non-destructive testing of hardened concrete, admixtures. Lightweight concrete. High density concrete (for nuclear shielding). Hot-weather and cold weather concreting. Quality control. Durability of concrete. Corrosion and protection of concrete. Polymer concrete

References:

1. F.M. Lue, Chemistry of Cement and Concrete, Edward Arnold, 3rd Edition, 1970.
2. A.M. Neville, Properties of Concrete, Pitman, 1968.
3. D.F. Orchardi, Concrete Technology, John Wiley, 1992.

CE-488 Environmental Geotechnics

Hazardous wastes, Physical, Chemical and Mineralogical characterization, Geoenvironmental hazards: Natural and man-made, Recycle and Reuse of Industrial waste(s). Role of Geotechnical engineering in environmental protection, Surface and subsurface contamination, Characterization of contaminated ground, Geoenvironmental site investigation and site assessment technologies.

References:

1. Y B Acar and D E Daniel, Geoenvironmental 2000: Characterization, Containment, Remediation & Performance in Environmental Geotechnics, ASCE, NY. 2000.
2. D S Hari and R R Krishna, Geoenvironmental Engineering: Site Remediation, Waste Containment, and Emerging Waste Management Technologies, Wiley, 2005.
3. I S Oweis and R P Khera, Geotechnology of Waste Management, 2nd Ed, PSW Publishing, 2004.
4. J F Rees, Contaminated Land Treatment Technologies, Elsevier Applied Science, NY, 1992

CE-490 Elements of Remote Sensing

Radiation principles and interactions; Photography, photogrammetry, photo-interpretation elements and applications; Satellite imaging; Multispectral, thermal, hyperspectral scanners and radiometers; Microwave radar imaging; Visual interpretation and digital analysis of imagery and applications.

References:

1. T.M. Lillesand and R.W. Kiefer, Remote Sensing and Image Interpretation, 5th Ed., John Wiley, New York, 2004.
2. J.B. Campbell, Introduction to Remote Sensing, Taylor & Francis, London, 1996.
3. F.F. Sabins, Remote Sensing: Principles and Interpretation, W.H. Freeman and Co., New York, 1997.
4. R.N. Colwell (Editor-in-Chief), Manual of Remote Sensing, Vol. I & II, American Society of Photogrammetry, Falls Church, Virginia, 1983.
5. G. Joseph, Fundamentals of Remote Sensing, University Press, Hyderabad, India, 2003

CE-492 Reinforced Earth

Introduction, polymer materials, overview of geotextiles, geogrids, geonets, geomembranes, geocomposites. geocells, geojutes, geocoir, geocontainers, geobags, geotubes, geosynthetic clay liners and geofoams, design methods, geosynthetic properties and test method, geosynthetic functions, designing for geosynthetic reinforced soil walls, embankments on soft soils, steep slopes, roadway, asphalt overlay, filtration, drainage, erosion control, landfill liners, prefabricated vertical drains and bearing capacity

References:

1. R.M. Koerner, Designing with Geosynthetic, 5th Ed., Prentice Hall, New Jersey, 2005.
2. P.H. Delmas, J.P. Gourc and A. Girard (Editors), Geosynthetics State of the Art Recent Developments, Vol.1,2 & 3, A.A. Balkema Publishers, Netherlands, 2002.
3. J.N. Mandal and D. Choudhury (Editors), International Conference on Geosynthetics and Geoenvironmental Engineering, Quest Publications, Mumbai, 2004.

CE-496 IRRIGATION ENGINEERING AND TECHNOLOGY

Introduction to irrigation engineering- fundamental principles, irrigation interaction with hydrological cycle, irrigation systems and irrigation system design process, Soil-water-plant relations, Principles of soil physics, Principles of soil chemistry, soil water measurement, infiltration; Soil moisture and plant growth; Crop water requirements: evapotranspiration and its estimation methods, crop consumptive use, irrigation scheduling, Computer models for CWR estimation, duty and delta, irrigation efficiencies; Water conveyance systems and Irrigation structures; project planning, economics in irrigation management and project evaluation; Surface irrigation systems: irrigation planning factors, design of Furrow system, Level basins, Graded borders and other surface irrigation systems, Computer models for analysis and design of surface irrigation systems; Sprinkler irrigation system: types of sprinkler systems, sprinkler irrigation planning factors, uniformity and efficiency, Pipeline hydraulics and economics, design of laterals and main delivery system, Center pivot system, Linear move system, and other types of design with examples; Drip irrigation system: types of drip systems, Drip irrigation planning factors, layout, Filtration and water treatment systems, and Fertilizer injection systems, Emitter selection and design criteria, Drip lateral and manifold design with examples; Landscape irrigation& management: Smart irrigation technologies for landscaping, Computer models for design, and Case studies

References:

1. A.M. Michael, Irrigation: Theory and Practice- 2nd Edition, Vikas Publishing House, 2001.
2. R.H. Cuenca, Irrigation System Design. Prentice Hall, Englewood Cliffs, NJ.552pp, 1989.
3. M. H. Ali, Fundamentals of Irrigation and On-farm Water Management: Volume 1. 1st Edition., 2010, 556 p.
4. W.R. Walker, and G.V. Skogerboe, Surface Irrigation - Theory and Practice. Prentice Hall, Inc. Englewood Cliffs, Newjersy, 1987.
5. J. Keller, and R.D. Bliesner, Sprinkle and trickle irrigation. Published by Van Nostrand Reinhold. New York (USA), 1990.
6. Other readings from selected journal papers/book chapters

CE 603 Numerical Methods

Programming fundamentals; Fundamentals of numerical methods; Error analysis; Curve fitting; Interpolation and extrapolation; Differentiation and integration; Solution of nonlinear algebraic and transcendental equations; Elements of matrix algebra; Solution of systems of linear equations; Eigenvalue problems; Solution of differential equations. Computer oriented algorithms; Numerical solution of different problems.

References:

5. **J. H. Wilkinson**, The Algebraic Eigenvalue Problem, Oxford University Press, London, 1965.
6. **K.E. Atkinson**, An Introduction to Numerical Analysis, John Wiley and Sons, New York, 1989.
7. **G. E. Golub** and **C.F. Van Loan**, Matrix Computations, Johns Hopkins University Press, Baltimore, 1989.

CE 605 - APPLIED STATISTICS

Introduction to Probability and Random Variables: Probability Space; Axioms of Probability; Joint Probability; Conditional probability; Independence; Baye's Rule; Sequential Continuity; Union of Events; Numerical examples; Random Variable (RV): Definition, Notation and Inverse Image; Discrete and Continuous Random variables. Probability Distribution: Cumulative Distribution Function; Distribution Function of Indicator RV; Probability Density Function; Probability Mass Function; Examples of Probability Mass Function: Bernoulli Trials, Binomial Distribution, Hypergeometric Distribution, Negative Binomial Distribution, Poisson's Distribution, Geometric Distribution; Examples of Probability Density Function: Uniform Distribution, Gamma Distribution, Erlang Distribution, Exponential Distribution, Rayleigh Distribution, Laplace Distribution, Gaussian Distribution, Lognormal Distribution and Extreme Value Distribution; Generation of RV, Probability Plotting, Fitting a Distribution, Nonparametric pdf.Conditional and Joint Distribution Function: Conditional CDF, Joint Distribution Function, Marginal Distribution Function; Condtional Distribution and Independence; Gaussian Random vector. Function of RV: Function of a RV; Monotonically Increasing and Decreasing Functions; Function of Jointly Distributed RVs; Function of iid RVs.

Moments: Moments of a RV; Joint Central Moments; Covariance Matrix; Correlation Co-efficient; Ecological Correlation; Moment Generating Function; Probability Generating Function; Characteristic Function; Moment Inequalities, Central Limit Theorem.

Linear Regression: Linear Regression, Hypothesis Testing, Multiple Regression Analysis, Dummy Variable Regression Analysis, Assumptions of Regression: Multicollinearity, Heteroscedasity, Autocorrelation among Residuals; Introduction to SPSSMultivariate Statistics, Principal Component Analysis, Introduction to Clustering.

Introduction to Stochastic Process.

References:

1. **Gujarati**, Basic Econometrics, Mc Grawhill.
2. **Hoel, Port** and **Stone**, Introduction to Probability Theory, Universal Book Stall.
3. **Papoulis, A.** and **Pillai, S. U**., Probability, Random Variables and Stochastic Processes, Tata Mc-Grawhill.
4. **Wilks, D S.**, Statistical Methods in Atmospheric Sciences, Academic Press 2011.

CE 607 - NUMERICAL TECHNIQUES IN HYDRAULIC ENGINEERING

• Mathematical Modeling: Mathematical tools and techniques, Advanced modeling applications to water resources and environmental engineering problems.

• System of Equations & Solutions– Linear equations; Iterative methods, direct methods, conjugate gradient method; Newton Raphson method; sparse matrices and compact storage schemes; Inversion of matrices; Non-linear equations and solutions; Gauss Jordan method; Gauss Siedel method; Eigen Values and Vectors & applications;

Numerical Solution of Ordinary Differential Equations: Single step method, multi-step method; Runge-Kutta methods; Numerical differentiation and integration; boundary value and initial boundary value problems – Applications in water resources/ ocean/ environmental engineering.

• Partial differential equations & Solutions: different types and solution approaches.

• Finite Difference Method: Various Finite difference schemes, implicit and explicit methods, ADI method; Method of Characteristics - Applications in water resources/ ocean/ environmental engineering.

• Approximate Methods – Method of weighted residuals (Sub-domain, Collocation, Least squares, Galerkin, Raleigh-Ritz methods), Applications to solve linear and nonlinear differential equations.

• Finite Element Method: Discretization of domain – Grid generation, Interpolating polynomials, Integration of shape functions over the domain; Formulation of element matrices and its global assembly - Applications in water resources/ ocean/ environmental engineering.

• Introduction to boundary element method and Meshfree methods - Applications in water resources/ ocean/ environmental engineering.

• Applications of various computer software based on finite difference method & finite element method – Applications in groundwater flow, Fluid dynamics, Pollutant transport in surface and subsurface water

References

1. K. A. Hoffmann and S. T. Chiange, Computational Fluid Dynamics for Engineers, Vol. I, Engineering Education System, Wichita, Kanasas, 1993.
2. S. C. Chapra and R. P. Canale, Numerical Methods for Engineers, McGraw-Hill, New York, 1990.
3. M.K. Jain, S.R.K. Iyengar & R.K Jain, Numerical Methods for Scientific & Engineering Computation, Wiley Easter Ltd., New Delhi, 1995.
4. O.C. Zienkiewics, Finite Element Method, McGraw Hill Book Co., New York, 1991.

5. T.R. Chandrupatla, Introduction to Finite Elements in Engineering, Prentice Hall, Englewood Cliffs, New Jersey, 1991.
6. K.J. Bathe, Finite Element Procedure in Engineering Analysis, Prentice Hall of India, New Delhi, 1990.
7. C.A. Brebbia, J.C.F. Telles, L.C. Wrobel, Boundary Element Techniques- Theory and Applications in Engineering, Springer-Verlag, Berlin , 1984.
8. J.N. Reddy, Finite Element Method, McGraw-Hill Inc, New York, 1993.
9. Wang, H., and Anderson, M. P. (1982). Introduction to Groundwater Modeling Finite Difference and Finite Element Methods, W. H. Freeman and Company, New York.
10. Pinder, G. F., and Gray, W. G. (1977). Finite Element Simulation in Surface and Subsurface Hydrology, Academic press, New York.
11. Desai, Y.M., Eldho T.I., Shah A.H. (2011). Finite Element Method with Applications in Engineering, Pearson Education, New Delhi.

CE-608 ECO HYDROCLIMATOLOGY

Introduction to Eco-hydro-climatology: an interdisciplinary framework; Climate system; climate, weather and climate change; overview of earth's atmosphere; vertical structure of atmosphere; radiation and temperature; laws of radiation; head-balance of earth atmosphere system; Random temperature variation; modeling vertical variation in air temperature; temporal variation of air temperature; temperature change in soil; thermal time and temperature extremes.

Hydrologic cycle: Introduction; Global water balance; cycling of water on land, a simple water balance model; climate variables affecting precipitation, precipitation and weather, humidity, vapor pressure, forms of precipitation, types of precipitation; cloud; atmospheric stability; monsoon; wind pattern.

Thermodynamics and cloud micro-physics: 1st and 2nd law of thermodynamics with application to meteorology. C-C theory, Cloud microphysics (Introduction) climate Variability: Floods, droughts, drought indicators, heat waves, climate extremes

Climate change: Introduction; causes of climate change; modeling of climate change, global climate models, general circulation models, downscaling; IPCC scenarios

Commonly used statistical methods in hydro-climatology: Trend analysis; Empirical orthogonal functions, principal component analysis; canonical correlation; statistical downscaling with regression

Ecological climatology: Leaf energy fluxes and leaf photosynthesis; plant canopies, ecosystem and vegetation dynamics; coupled climate vegetation dynamics, carbon cycle climate feedbacks, introduction to precipitation recycling.

References

1. Bonan G. B., Ecological climatology, Cambridge university press, 2002
2. Campbell, G. G. and Norman J. M., An introduction to environmental biophysics, Springer, 1998
3. IPCC Assessment report 4
4. Recent articles in journal, specifically water resources research, journal of geophysical research, journal of climate, climatic change, nature geoscience, nature climate change etc.

CE 610 - INTRODUCTION TO EARTHQUAKE ENGINEERING

Characterisation of ground motion, Earthquake intensity and magnitude; Recording instruments and base line correction; Predominant period and amplification through soil; Earthquake spectra for elastic and inelastic systems; Idealisation of structural systems for low, medium and high rise buildings; Lateral force evaluation by mode superposition and direct integration; Reserve energy technique; Effect of foundation/soil on earthquake response; Analysis for torsion; Review of damages during past earthquakes and remedial measures; Reinforcement detailing for members and joints coupling; Codal provisions.

References:

1. **A. K. Chopra**, Dynamics of Structures: Applications to Earthquake Engineering, Prentice-Hall, New York, 1995.
2. **R.W. Clough** and **J. Penzien**, Dynamics of Structures, 2nd edition, McGraw-Hill, New York, 1992.
3. **N.M. Newmark** and **E. Rosenblueth**, Fundamentals of Earthquake Engineering, Prentice Hall, New York, 1971.
4. **D. Key**, Earthquake Design Practice for Building, Thomas Telford, London, 1988.
5. **R.L. Wiegel**, Earthquake Engineering, 2nd edition, Prentice Hall, London, 1989.
6. J**.A. Blume, N.M. Newmark,** and **L.H. Corning**, Design of Multi-storied Buildings for Earthquake Ground Motions, Portland Cement Association, Chicago, 1961.
7. Proceedings of World Conferences on Earthquake Engineering, 1956-2000.
8. I.S. Codes No.1893, 4326,13920.

CE 615 - STRUCTURAL OPTIMIZATION

Formulation of different types of structural optimisation problems; Optimality criteria based structural optimisation; Computational of derivatives of response quantities with respect to design variables; Classical optimisation; Lagrange multiplier technique and Kuhn-Tucker conditions; Solution of NLP by direct methods and by series of unconstrained optimisation problems and by series of linear programming problems.

References:

1. **S.S.Rao**, Optimisation, Theory and Applications, 2nd Edition, Wiley Eastern Ltd., New Delhi, 1991.
2. **J.S.Arora**, Introduction to Optimum Design, McGraw-Hill International Edition, New York, 1989.
3. **A.J.Morris** (Editor), Foundations of Structural Optimisation - A Unified Approach; John Wiley and Sons, Chichester, 1982.
4. **G.V.Reklaitis, A.Ravindran** and **K.M.Ragsdell**, Engineering Optimisation Methods and Applications, John Wiley, New York, 1983.

CE 616 - STRUCTURAL DYNAMICS

SDOF System : Equation of motion; Free vibration; Harmonic load; Evaluation of damping,; Periodic load; General load (time domain, frequency domain); Response spectrum load. MDOF Systems : Structural matrices; Un-damped free vibration; Generation of damping matrix, Mode superposition analysis; Practical considerations. Continuous Systems : Equation of motion; Un-damped free vibration; Forced response. Random Vibrations : Random variables and random recesses; Models of random dynamic loads; Stochastic response of SDOF and MDOF systems.

References:

1. **A. K. Chopra**, Dynamics of Structures Applications to Earthquake Engineering, Prentice Hall, 1994.
2. **R. W. Clough** and **J. Penzien**, Dynamics of Structures, 2nd ed., McGraw-Hill, Singapore, 1993.
3. **L. Meirovitch**, Elements of Vibration Analysis, 2nd edition, McGraw-Hill, Singapore, 1986

CE 617 - PLATES AND SHELLS

Plate equation and behaviour of thin plates in cartesian, polar and skew coordinates; Curvilinear coordinates and coordinate transformation; Isotropic and orthotropic plates, bending and twisting of plates; Navier's solution and Energy method, rectangular, circular plates and plates with variable rigidity in cartesian and polar coordinates; Numerical solutions. Shell behaviour, shell surfaces and characteristics, classifications of shells, equilibrium equations in curvilinear coordinates, force displacement relations; Membrane analysis of shells of revolution and cylindrical shells under different loads, shallow shells, concept of pseudo-stresses, membrane solution of elliptic paraboloids and hyperboloids, solutions of typical problems.

References:

1. **S. P. Timoshenko** and **S. W. Krieger**, Theory of Plates and Shells, McGraw-Hill, 1959.
2. **R. Szilard**, Theory and Analysis of Plates: Classical and Numerical Methods, Prentice Hall, New York, 1974.
3. **N. K. Bairagi**, Shell Analysis, Khanna Publishers, New Delhi, 1990.
4. **V.V. Novozhilov**, Thin Shells, Groringen Publications, Netherlands, 1959.

CE 619 - STRUCTURAL STABILITY

Concepts of stability, static, dynamic and energy criteria; Buckling Snap through and post-buckling; stability of columns and beams; Inelastic buckling; Beam-columns; stability of frames; Matrix stiffness and finite element methods applied to stability problems; introduction to stability of plates, shells and stiffened plates.

References:

1. **Don O. Brush** and **B.O.Almorth**, Buckling of Bare, Plates and Shells, McGraw-Hill, New York 1975.
2. **S.P.Timoshenko** and **J.M.Gere**, Theory of Elastic Stability, 2nd Edition, McGraw Hill New York, 1961.
3. **A.Chajes**, Principles of Structural Stability Theory, Prentice Hall, New York, 1974.
4. **N.G.R.Iyengar**, Structural Stability of Plates and Shells (Ellis Horwood Series in Civil Engineering), East-West Press, New Delhi.
5. **G.J.Simitses**, An Introduction to the Elastic Stability of Structures, Prentice Hall, New York, 1976.
6. **Z.P.Bazant** and **L.Cedolin**, Stability of Structures: Elastic, Inelastic, Fracture and Damage theories, Oxford University Press, New York, 1991.

CE-620 Advanced Finite Element Methods

Principles of discretisation; Element stiffness mass formulation based on direct, variational and weighted residual techniques and displacements, hybrid stress and mixed approaches, shape functions and numerical integrations, convergence, Displacement formulations for rectangular, triangular and isoparametric elements for two dimensional and axisymmetric stress analysis; Thin and Thick plates and shells, Semi-analytical formulations; Three dimensional elements and degenerated forms; Stiffener elements and modifications such as use of different coordinate systems, use of nonconforming modes and penalty functions; Application to layered composite plate/shells, bridge, roof, nuclear and offshore structures; Hybrid stress and mixed formulations for plates

References:

1. O.C. Zienkiewicz, The Finite Element Method, Tata McGraw-Hill, New Delhi, 1977.
2. K. J. Bathe, Finite Element Procedures, Prentice Hall, New York, 1995.
3. Finite Element Method with Applications in Engineering by Y. M. Desai, T. I. Eldho and A. H. Shah, Pearson, 2011

CE 621 - PLASTIC ANALYSIS

Yield condition and concepts of simple plastic collapse, idealisational collapse criteria, virtual work in the elastic-plastic state; Theorems of plastic collapse; Methods of analysis and design, Applications to planar and simple space structures; Deflection at collapse; Minimum weight analysis; Variable repeated loads; Combined stress problems; Introduction to stability.

References:

1. **J.F. Baker, M.R. Home** and **J. Heyman**, Steel Skeleton, Vol.II, Cambridge Univ. Press, London, 1961.
2. **B.G. Neal**, The Plastic Methods of Structural Analysis, Champman and Hall.
3. **P.G. Hodge (Jr.)**, Plastic Analysis of Structures, McGraw-Hill, New York, 1959.
4. **J. Heyman**, Beams and Framed Structures, Pergamon Press, 1974.
5. SP: 6(6)-1972, Applications of Plastic Theory in Design of Steel Structures, Indian Standards Institution, New Delhi, 1972.
6. **A. Mrazik, M. Skaloud**and **M. Tochacek**, Plastic Design of Steel Structures, Ellis Horwood, Chichester, 1987.

CE 623 - Advanced Solids Mechanics

Linear elasticity, Stress, strain, constitutive relations; Boundary conditions, Description of an Elasticity problem as a boundary value problem, Plane stress, strain, axi-symmetric problems, Large displacements and large strains; Cartesian, cylindrical and spherical coordinates; Introduction to curvilinear coordinates; Thermal strains. Introduction to plasticity; Yield condition; Ideal elasto-plastic material; complete formulation for an elasto-plastic problem.

References:

1. **N. Filonenko-Borodich**, Theory of Elasticity, Mir Publishers, Moscow, 1965.
2. **S.P. Timoshenko** and **J.N. Goodier**, Theory of Elasticity, 3rd edition, McGraw Hill, Singapore, 1970.
3. **C.R. Calladine**, Plasticity for Engineers, Ellis Herwood, Chichester, U.K., 1985.

CE 626–GROUNDWATER SYSTEMS PLANNING AND MANAGEMENT

Concept of Groundwater System, Definition of input and out put to the system and system's parameters, Generalized governing equations for groundwater flow in confined, phreatic and sloping base aquifers involving heterogeneous anisotropic flow domains,

Steady state and time variant problems in groundwater flow, Applicable boundary conditions to the flow regions and derivation of free surface boundary conditions. Importance of numerical modeling, Finite difference and finite element modeling of regional aquifers

Application of simulation optimisation models, Optimisation of collective well drawdown in heterogeneous anisotropic systems. Optimisation of groundwater fed irrigation regions,

Concept of Inverse modeling and its application to aquifer systems incorporating auto calibration, sea water intrusion in coastal aquifers, Introduction to the emerging techniques of genetic algorithm, simulated annealing, ant colony, differential evolution and particle swarm with reference to groundwater system optimisation.

Aquifer remediation, bioremediation, pump and treat.

Reference:

1. Bjerg P L et al. (Eds), Groundwater 2000, A ABalkema, Rotterdam, 2000.
2. Freeze R. & Cherry J. Groundwater, 1979, Englewood Cliffs, New York
3. Karamouz M et al. Groundwater Hydrology, Engineering, Planning and Management,
4. CRC Press, Taylor and Francis, 2011.
5. Rastogi A K., Numerical Groundwater Hydrology, Penram International Publication,2012 (Reprint)

CE 627 - STRUCTURAL DESIGN

Complete design and structural detailing for standard structures like framed structures for residential, industrial, public utility and recreational purposes; Trusses, bridges, storage vessels, underground structures etc. in concrete, steel and other materials.

References:

1. **F. Mark**, Handbook of Concrete Engineering, V.N.R.Co., New York, 1974.
2. Handbook on Civil Engg. such as Merritt, Gaylord, Kemp etc.
3. Relevant I.S. Codes of practices, Bureau of Indian Standards, New Delhi.

CE-630 GIS IN CIVIL ENGINEERING

Introduction - Geographical concepts and terminology - Difference between image processing system, other information systems and GIS - utility of GIS - Various GIS packages and their salient features - Essential components of GIS.

Data: Spatial and Non-Spatial Data – Spatial Data: Points, Lines, Polygons/Area and Surface - Non-Spatial Data - Levels of Measurement: Nominal, Ordinal, Interval, Ratio – Data Base – Functions - Data Base Structures – Hierarchical, Network, Relational- Relational Data Base Management System – Normalization, E-R Diagram- data manipulation and analysis.

Data acquisition - Raster data model- Introduction, Description, Data Compression-run length, chain, block and quadtree coding - Vector Data Model – Topology, Euler equation, Rules for topological consistency – arc-node data structure - Raster to vector conversion - Topology and spatial relationships - Data storage verification and editing - Raster vs. vector comparison

Coordinate systems – Datums - Map projections - Coordinate transformation – Georeferencing – Ditigization- Methods of digitization, Common errors in digitization

Discrete and continuous surfaces – Interpolation techniques - Digital elevation models – sources of DEM – DEM representation – Gridded DEM, TIN structure – Extraction of topographic parameters: slope, aspect, delineation of watershed and drainage network - DEM applications.

Spatial and mathematical operations in GIS - Overlay, Query based measurement and statistical modelling, Buffers, Spatial analysis, Network analysis, Statistical reporting and graphing - Application of GIS to various natural resources mapping and monitoring and other civil engineering related problems

References:

1. Burrough P.A. and McDonnell R.A., “Principles of Geographical Information Systems”, Oxford University Press, 2006.
2. Ian Heywood Sarah, Cornelius and Steve Carver, “An Introduction to Geographical Information Systems”. 3rd Edition, Pearson Education. New Delhi, 2006.
3. Michael Worboys and Matt Duckham, GIS: A Computing Perspective -2nd edition, CRC Press, Boca Raton, 2004.
4. Lo, C.P. and Yeung, Albert K.W., Concepts and Techniques of Geographic Information Systems Prentice Hall, 2002.

CE-632 Ground Improvement

Problematic soils; Need for ground improvement; Various ground improvement techniques; Embankment construction on soft soils; Preloading with and without vertical drains; Prefabricated Vertical (PV) Drains; Design of ground improvement scheme with PV drains and preloading; Vacuum consolidation; Vacuum consolidation along with PV drains; Theory of electro-kinetic dewatering of soils and its applications; Grouting; Grouting methods; Permeating grouting; Displacement grouting; Jet grouting; Grout mixes and their selection criteria; Deep mixing methods; Densification techniques for cohesion-less soils – Vibro floatation; Vibro-replacement technique; Blasting; Design of blasting scheme; Dynamic compaction and application; Design of dynamic compaction scheme; Stone columns and their design; Test methods for verification of ground improvement techniques – Standard Penetration Test; Cone Penetrometer Test; Vane shear strength test; Pressuremeter test, Packer test, Load tests, etc. Theory and applications of Ground Penetrating Radar (GPR) technique

References:

1. Bowles, J.E. (1996). Foundation Analysis and Design, 5th Edition, McGraw-Hill International Editions, publishers, New York.
2. Hausmann, M.R. (1990). Engineering Principles of Ground modification. McGraw-Hill Inc.,USA
3. Mooseley, M.P. and Kirsch, K. (2004). Ground Improvement. 2nd Edition, Spon Press, Taylor and Francis Group, London, United Kingdom.
4. Xanthakos, P.P., Abramson, L.W., and Bruce, D.A. (1994). Ground control and Improvement. Wiley Interscience Edition, John-Wiley & Sons, Inc, Newyork, USA.

CE-633 Soil Structure Interaction

Critical study of conventional methods of foundation design; Nature and complexities of soil structure interaction; Application of advanced techniques of analysis such as the finite element method, finite differences, relaxation and interaction for the evaluation of soil-structure interaction for different types of structures under various conditions of loading and subsoil characteristics; Preparation of comprehensive design oriented computer programmes for specific problems. Interaction problems based on the theory of sub-grade reaction such as beams, footings, rafts, bulkheads etc. Analysis of different types of frame structures founded on stratified natural deposits with linear and nonlinear stress-strain characteristics. Determination of pile capacities, negative skin friction and group action of piles considering stress-strain characteristics of real soils; Anchor piles and determination of pull out resistance; Well foundations

References:

1. J.E., Bowles, Analytical and Computer Methods in Foundation Engineering, McGraw-Hill Book Co., New York, 1974.
2. C.S. Desai and J.T. Christian (Eds.), Numerical Methods in Geotechnical Engineering, McGraw-Hill Book Co., Yew York.
3. Elastic Analysis of Soil-foundation Interaction, Developments in Geotechnical Engineering, Vol.17, Elsevier Scientific Publishing Co.

CE-637 Rock Mechanics

Engineering properties of rock masses, subsurface investigations in rock deposits, field and laboratory testing of rocks, stress-deformation characteristics of rock masses under heavy loads, flow of water through rock masses, failure theories, shear strength of rock under high pressure, friction in rocks, time dependent properties of rock masses, stability of rock slopes, idealised rock system, anisotropic rock system, deep cuts, deep bore-holes, stability of bounder fills and embankment, lateral pressure on retaining structures for high hill slopes, bearing capacity of rock masses, opening in rocks, lines and unlined tunnels, pressure tunnels and tunnels for other purposes

References:

1. J.C. Jaeger and N.G.W. Cook, Fundamentals of Rock Mechanics, Methuen and Co., London, 1971.
2. Obert, Leonard and W.I. Duvall, Rock Mechanics and Design Structures of Rock, 1967.
3. J.A. Hudson et al. (Ed.), Comprehensive Rock Mechanics, in 5 volumes, Pergamon Press, 1993.

CE 639 - GREEN BUILDING DESIGN

Buildings are like living organisms that contribute to the life in the cities. A well-designed building that uses natural materials, passive heating and cooling systems can not only make the life of its inhabitants healthier, but also contribute to preserving the environment and natural resources. This course aims to teach the fundamentals of sustainable and energy efficient building design, by focusing on Building envelopes Building materials and properties Building systems and operations (HVAC, lighting, water supply, sewage, garbage disposal, recycling and composting) Clean & renewable energy in buildings Rainwater harvesting Water and energy conservation Energy modeling and performance evaluation of buildings Smart buildings (Sensing and control systems) Net Zero buildings, Passive house standards Building Rating systems (LEED, BREEAM, IGBC etc)

References:

1. **Hong, Wen** et. al., Building Energy Efficiency - Why Green Buildings Are Key to Asia`s Future. The Asia Business Council (2007)
2. **Yudelson**, **Jerry**, Green Building A to Z: Understanding the Language of Green Building. New Society Publishers (June 2007).
3. **Mendler, Sandra F., Odell, William, Lazarus, Mary Ann**, The HOK Guidebook to Sustainable Design Second Edition. Wiley (November 2005) ISBN 97804716961314.
4. **McDonough, William and Braungart, Michael**, Cradle to Cradle. Farrar, Straus & Giroux (April 2002) ISBN 9780865475878
5. **Snell, Clarke and Callahan, Tim**, Building Green: A Complete How-To Guide to Alternative Building Methods Earth Plaster, Straw Bale, Cordwood, Cob, Living Roofs. Lark Crafts(August 2009) ISBN 978-1600595349
6. **Keeler, Marian and Burke, Bill** - Fundamentals of Integrated Design for Sustainable Building. Wiley (May 2009) ISBN 9780472935
7. **Hindrichs, Dirk U.**, Plusminus 20/40 Latitude: Sustainable Building Design in Tropical and Subtropical Regions. Axel Menges (October 2007) ISBN 9783930698837
8. **Kibert, Charles J.**, Sustainable Construction: Green Building Design and Delivery, III edition. Wiley (October 30, 2) ISBN 9780470904459
9. **McHarg, Ian L.,** Design with Nature, I edition. Wiley (February 1995) ISBN 9780471114604
10. **Mazria, Edward,** The Passive Solar Energy Book. Rodale Press (1980) ASIN B000VNM20C
11. **Kwok, Alison and Grondzik, Walter**, The Green Studio Handbook: Environmental Strategies for Schematic Design, II edition. Architectural Press (April 2011) ISBN 9780080890524

12. **Shurcliff, William A.,** Thermal Shutters & Shades - Over 100 Schemes for Reducing Heat Loss through Windows, 1st edition. Brick House Publishing Co (April 1981) ISBN 9780931790140 \
13. Indian Green Building Council: www.igbc.inIGBC Green Homes Abridged Reference Guide
14. IGBC Green Factory Building Abridged Reference Guide
15. LEED India NC Reference Guide / LEED India CS Reference Guide
16. Background material of green building training programme conducted by IGBC
17. Green Rating for Integrated Habitat Assessment: http://grihaindia.org/
18. United States Green Building Council: http://www.usgbc.org/
19. The Whole Building Design Guide: http://www.wbdg.org/Technical Manual,
20. Australia home: http://www.yourhome.gov.au/technical/index.html
21. United States Department of Energy: http://energy.gov/

CE-641 ENVIRONMENTAL GEOMECHANICS

General Principles: Introduction, Nature of soil and environment, Soil technology, Soil-water-air interaction, Shrinkage, Swelling, and Cracking characteristics of soil, Hydraulic conductivity and mass transport phenomena, Thermal and electrical properties of soils, Radiation effects on soil. Environmental geotechnical applications

References:

1. Dixon, J.B. and Weed, S.B., Minerals in Soil Environments, SSSA, 1989.
2. Rees, J.F., Contaminated Land Treatment Technologies, SCI, Elsevier Applied Science, London, 1992.
3. Acar, Y.B. and Daniel, D.E., Geoenvironmental 2000: Characterisation, Containment, Remediation & Performance in Environmental Geotechnics, ASCE, New York, 2000.
4. Methods of Soil Analysis, SSSA, 2nd Edition, Physical and Chemical Processes of Water and Solute Transport/Retention in Soils, SSSA.

CE-643 EXPERIMENTAL GEOTECHNICS

Processing of the soil, determination of hygroscopic moisture content, sieve analysis, hydrometer test, specific gravity test, liquid, plastic, and shrinkage limit tests, standard proctor compaction test, field density measurement tests (Sand replacement and core cutter), permeability test, oedometer test, direct shear test, consolidated undrained triaxial test, vane shear test, determination of free swell index for fine grained soils, evaluation of swelling pressure of soils, soil suction measurement, block vibration test, cyclic plate load test

References:

1. Head, K.H. (2006). Manual of soil laboratory testing, Volume I – Soil Classification and Compaction Tests, 3rd Edition, Whittles Publishing, Scotland, UK.
2. Head, K.H. and Epps, R. J. (2011). Manual of soil laboratory testing, Permeability, shear strength and compressibility tests, Volume II, 3rd Edition, Whittles Publishing, Scotland, UK.
3. Head, K.H. and Epps, R. J. (2014). Manual of soil laboratory testing, Vol.III – Effective stress tests, Whittles Publishing, Whittles Publishing, Scotland, UK.
4. Das, B.M. (2009). Soil Mechanics Laboratory Manual, 7th Edition, Oxford University Press, New York.
5. Relevant Indian and ASTM standards.

CE-645 GEOTECHNICAL CENTRIFUGE MODELLING

Modelling and simulation - Dimensional analysis; Physical modelling using Centrifuge, historical perspectives, developments in hardware; Equipment - type of centrifuges; Principles of centrifuge modelling: scaling laws for static, dynamic loading and scaling laws for diffusion phenomena, Scale effects: Dependency of soil behaviour on stress level and stress history; Rotational acceleration and stress field, Modelling of models, Coriolis effect in Centrifuge, Grain size effects; Instrumentation in centrifuge modelling; Data acquisition systems; Applications of centrifuge modelling -Embankments and Dams, Shallow foundations, Deep foundations, Retaining structures, Anchorages, Ground improvement, Environmental geotechnics, Earthquake effects

References:

1. Craig, W.H., The application of centrifuges modelling to Geotechncial Design, Proceedings of a Symposium, Manchester, Balkema, April, 1984,
2. Proceedings of the International Conferences- Centrifuge `88, Centrifuge `91, Centrifuge `94, Centrifuge `98, Centrifuge 2002, Balkema.
3. Taylor, R.N., (ed.), Geotechnical Centrifuge Technology, Blackie Academic & Professional, 1995.

CE-647 Soil Dynamics and Machine Foundations

Vibration of elementary systems, degrees of freedom, analysis of systems with several degrees of freedom, natural frequencies of continuous systems, elastic constants of soil and their experimental determination, damping of soil, effect of vibration on residual soil settlements, effect on porosity and hydraulic methods to reduce residual dynamic settlement of foundations, stress distribution in soil under dynamic loading. Influence on shearing strength, vibro-viscous soil resistance, liquefaction, bearing capacity of dynamically loaded foundations, such as those of water towers, chimneys and high rise buildings, response of pile foundations, wave propagation in elastic half space, waves in layered systems and in saturated media, vibration isolation methods

References:

1. D.D. Barkan, dynamics of Bases and Foundations, McGraw-Hill, New York, 1952.
2. E.E. Rihcart et al., Vibrations of Soils and Foundations, Prentice Hall Inc., 1970.
3. S.P. Timoshenko, D.H. Young and William Weaver, Jr., Vibration Problems in Engineering, John Wiley and Sons, 1974.
4. Braja M. Das and G. V. Ramana, Principles of Soil Dynamics, 2nd Edition, Cengage Learning, 2010.
5. Shamsher Prakash, Soil Dynamics, 3rd Edition, John Wiley, 2000.
6. D. Choudhury, Soil Dynamics, NPTEL Video course, 2014. http://nptel.ac.in/courses/105101005/.

CE-648 Finite Element Methods in Geotechnical Engineering

Theory: energy concepts and variational principles, discretization of continuous media, two and three dimensional analysis, stiffness of simple elements, Isoparametric elements and interface elements, assembly and solution techniques, computerisation, introduction to nonlinear problems, plasticity problems and no tension analysis, applications to problems such as stress distribution and deformations in isotropic and anisotropic soil and rock media, stress and deformations around excavations and built-up embankments, seepage through porous media, one dimensional consolidation, stress distribution around openings in intact and fissured rock

References:

1. Robert D. Cook, Concepts and Applications of Finite Element Analysis, Third Edition, John Wiley and Sons.
2. C.S. Desai, J.F. Abel, Introduction to the Finite Element Method, A numerical Method for Engineering Analysis, East-West Edition, 1972.
3. O.C. Zienkiewicz and R.L. Taylor, Finite Element Method, McGraw-Hill, 1991.

CE-652 Foundations of Offshore Structures

Nature and magnitude of loads on foundations of offshore structures, criteria of foundation design in offshore environment, features of foundations of gravity structures, bearing capacity and settlement under dynamic loads, immediate and long term behaviour, liquefaction under cyclic loads, problems relating to jack-up platforms, dynamic stress in pile driving, pile behaviour under cyclic lateral loads, development of p-y curves, analysis of single piles and pile groups, finite element and other numerical methods of interactive analysis using linear and nonlinear foundation response, geotechnical aspects of anchors and submarine pipelines.

References:

1. Proceedings of the Conference on Behaviour of Offshore Structure, 1976.
2. Proceedings of the Conference on Finite Element Methods in Geotechnical Engineering (Ed.),
3. C.S. Desai. Proceedings of Offshore Technology Conference, Houston, Texas.

CE 654 - ADVANCED HYDROLOGICAL ANALYSIS AND DESIGN

Review of Various Processes in the Hydrological Cycle: Precipitation, Abstracts, Evaporation, Infiltration, Evapotranspiration, Runoff, Streamflow and its measurements, floods, flood routing.

Problems and Models in Hydrology: Systems Approach, Parameter Estimation methods, Watershed Runoff Modeling, Response Time Characteristics, Linear Models: Rational Method, Time Area Methods, Unit Hydrograph Method, Derivation of UH and IUH, Clark Model, Nash Model, Time-Variant Linear Reservoir, Time-Area Method.

Hydrologic Time Series Models: Time series introduction, Introduction to stochastic models like AR, ARMA and ARIMA. Rainfall-runoff models-case studies, case studies of other hydrological time series models.

Hydrologic and Hydraulic Design: Design of Water Supply, Sewerage and Storm Water Networks: standards and case studies, finding the capacity of reservoir, rain water harvesting systems, case studies on conventional water storage structures.

Soft Computing and Recent Techniques in Hydrologic Models: Introduction and applications of soft computing techniques like, Artificial neural networks, Genetic programming, Model tree, chaos theory, singular spectrum analysis.

References:

1. Mc.Cuen, R.H., (1989) Hydrologic Analysis and Design, Prentice Hall, New Jersey, 1989.
2. Chow, V.T., (1964) Handbook of Applied Hydrology, McGraw - Hill, 1964.
3. Vijay, P. Singh (1989) Hydrologic systems, Vol. I & II, Prentice Hall, New Jersey, 1989.
4. Kottegoda, N. T., (1980) *Stochastic Water Resources Technology,* The Macmillan Press Ltd. London
5. Salas, J.D., J.W. Delleur., V. Yevjevich and W.L. Lane, (1980) *Applied Modelling of Hydrologic Time Series*, Water Resources Publications, Colorado.
6. Yevjevich, (1972) *Stochastic Process in Hydrology,* Water Res. Publ., Colorado.
7. Subramanya K, (2008) *Engineering Hydrology (3rd Edition),* Tata McGraw Hill Publishing Company, New Dehli, 2008.

CE-656 Plasticity Theory and Applications in Geomechanics

This course aims to provide fundamental understanding of several conceptual building blocks that form the foundation for plasticity theory and its implication on material constitutive behavior. Course content includes discussions on Cartesian tensors and indicial notation; tensor calculus; tensorial treatment of stresses and strains; rate-independent plasticity; flow rule and work-hardening; yield criteria; hardening rules; contained plastic deformation (e.g. cavity expansion problem); plastic flow and collapse; slip line theory; plastic dissipation; Drucker's postulate; limit analysis; lower bound and upper bound theorems and other methods to solve collapse problems.

References*:*

1. **Davis, O.** and **Salvadurai, A. P. S.** Plasticity and Geomechanics. Cam. Univ. Press, 2002
2. **Lubliner, J.** Plasticity Theory. Macmillan Publishing Company, 1990.
3. **Malvern, L.E.** Introduction to the Mechanics of a Continuous Medium. Prentice-Hall, NJ, 1969.
4. **Y. C. Fung.** A First Course in Continuum Mechanics, Prentice-Hall Inc., 1992
5. **Yu, H.S.** Plasticity and Geotechnics, Springer, 2006

CE-657 COMPUTING IN CIVIL ENGINEERING

Computer Programming in Civil Engineering context with emphasis on data science. Solution of Civil Engineering Problems with C/C++, Matlab/R and python

Data Analysis including filtering, linear regression, machine learning specific to domains of civil engineering like hydrology, environment, geospatial, transportation, structures, geotechnical and numerical experiments.

Computational methods drawing examples from Civil Engineering: Visualization of scientific data, solution of linear systems of equations and ordinary differential equations.

Basic and advanced scripting languages for pre and post processing of Civil Engineering data

Solving typical Civil Engineering problems in statistical analysis, optimization tools or numerical models

Introduction to important Civil Engineering Software and its applications

References:

1. **Chandra B. (2013),** "Object Oriented Programming using C++",New Delhi,Narosa Pub.
2. **Rajaraman, V. (1994),** "Computer programming in C, Delhi: PHI learning
3. **Lutz, Mark (2004**), "Learning Python, Mumbai: Shorff Pub.
4. **Quarteroni, A., Saleri, F., and Gervasio P. (2010).** Scientific Computing with MATLAB and Octave (4th Edition), Springer.
5. **Langtangen, Hans Peter (2014).** "Python scripting for computational science", Berlin: Springer-Verlag.
6. **Albright, S. Christian(2007).** VBA modelers: developing decision support systems with Microsoft excel, Australia: Thomson/Brooks/Cole
7. **Albright, Brian (2010)** "Mathematical modeling with excel, Boston: Jones and Bartlett India
8. **Robbins, Arnold (2004**), Linux programming by example, Delhi: Pearson Education**.**
9. **Spinder Paul (1991),** Computer Applications in Civil Engineering, New York, Van Nostrand Reinhold Co.

CE 658 – HYDROGEOMORPHOLOGY

A quantitative glance at river basins

Hillslopes and channels. The problem of defining channel heads. Drainage density and the hillslope scale. Horton-Strahler stream ordering scheme. Horton's law. Hack's law. Discharge-area relationships. Magnitude-area relationship. Slope-area relationship. The width function. The source function.

Fractal characteristics of river basins

The box counting dimension. The cluster dimension. The correlation dimension. Self-similarity and power Laws. Self-similarity in river basins. Horton's laws and the fractal structure of drainage networks. Power-law scaling in river basins. Hack's law and self-affinity. Generalized scaling laws for river networks.

Multi-fractal characteristics of river basins

Peanos basin and the binomial multiplicative process. Multifractal spectra. multifractal spectra of width functions. Multiscaling and multifractality. Multifractal topographies. Random cascades.

Landscape evolution modelling

Experimental fluvial-geomorphology. Statistical models of drainage network evolution. Deterministic models for drainage network evolution. The principles of minimum energy expenditure in river networks. Optimal channel networks. Thermodynamics of optimal channel networks.

Geomorphological origin of hydrologic response

Travel time distributions in channel links. The geomorphological unit hydrograph. The width-function unit hydrograph. Can one gauge the shape of a basin? Tothian flow system vs. Dupuit-Boussinesq flow system. Geomorphological recession flow model. Storage-discharge non-linearity. The general geomorphological recession flow model. Geomorphological origins of storage-discharge relationships. Estimation of drainable storage – a geomorphological approach. Channel networks in hydrological response modelling.

Self organization in hydrological systems

The concept of self organized criticality. Bak's sandpile model. Fractals and self-organized criticality. Self-organization of river networks. Geomorphic signatures of climate. Chaos vs. self-organization. The concept of dominant processes. The Budyko framework and the concept of catchment co-evolution. Self-organization in water-controlled ecosystems. The dynamic Budyko model

References:

1) Rodriguez-Iturbe, I., & Rinaldo, A. (2001). Fractal river basins: chance and self-organization. Cambridge University Press (ISBN: 9780521004053).

2) Mandelbrot, B. B. (1983). The fractal geometry of nature. New York: WH freeman (ISBN: 9781441918970).

3) Bak, P. (2013). How nature works: the science of self-organized criticality. Springer Science & Business Media (ISBN: 9781475754261).

4) Rodríguez-Iturbe, I., &Porporato, A. (2007). Ecohydrology of water-controlled ecosystems: soil moisture and plant dynamics. Cambridge University Press (ISBN: 9780511535727).

5) Sivakumar, B. (2016). Chaos in hydrology: bridging determinism and stochasticity. Springer (ISBN: 9789048125517).

6) Recently published relevant research papers

CE 659–ADVANCED SURVEYING

Total Station- Basics, Different types of surveying methods; Different sources of errors, Error adjustments; LiDAR concepts- Terrestrial LiDAR, Airborne LiDAR overview; Unmanned Aerial System (UAS) Photogrammetry & Remote Sensing overview; GNSS- Basic concepts, Different types of GPS errors, Different types of GNSS based surveying techniques; Ground Penetrating RADAR- Basics, Survey techniques, GPR Radargram Interpretation

References:

1. **Satheesh Gopi, R. Sathikumar, and N. Madhu**. Advanced Surveying: Total Station, GIS and Remote Sensing 1st Edition, 2007, Pearson India
2. **Pinliang Dong, Qi Chen**. LiDAR Remote Sensing and Applications, 1st Edition, CRC Press
3. **Hofmann-Wellenhof, Bernhard, Lichtenegger, Herbert, Wasle, Elmar**. GNSS – Global Navigation Satellite Systems. 1st Edition. 2008, Springer-Verlag Vienna
4. **Harry M. Jol.** Ground Penetrating Radar Theory and Applications, 1st Edition, 2009, Elsevier publications.
5. Journal articles as informed by the Instructor

CE 667 - HYDRAULIC STRUCTURES

Hydraulic and structural design of storage reservoirs,

Dams, spillways, outlet works, river training and regulations, conduit systems, transition structures, fluid elasticity,

Irrigation structures and designs

Design, Fundamental and engineering aspects of fluid structure iteration, static and dynamic response of elastic structures.

References:

1. **Bourgin**, Design of Dams and Sons, Ltd., 1953,
2. **Sir Issac Pitman.S. Leliavsky**, Irrigation and Hydraulic Design, Vols.I, II, and III, Chapman and Hall, Ltd., London, 1957.
3. **M.M. Grishin**(Ed.), Hydraulic Structures, Vol.II, Mir Publishers, Moscow, 1982.
4. F. M. Henderson, Open Channel Flow, MacMillan, New York, 1996.
5. H. H. Chang, Fluvial Processes in River Engineering, John Wiley, 1988.

CE 672 - River Mechanics & Control Structures

Open channel control structures; Varied flow profiles; River morphology, Sediment properties, hydrodynamics of fluid particle systems, setting velocity of particles, sediment transport in open channels;

Bed-load, Duboys, Einstein, Kalinske, Bagnold transport formulae, suspended load and the total load, design of stable channels-regime concept, bed forms, ripples, dunes and antiduness,

Principles of dimensional considerations, river models, sedimentation in reservoirs, coastal sediment problems.

References:

1. **C. T. Yang**, Sediment Transport-Theory and Practice, The McGraw Hill Companies, Inc. New Delhi, 1996.
2. **F. M. Henderson**, Open Channel Flow, MacMillan, New York, 1996.
3. **H. H. Chang**, Fluvial Processes in River Engineering, John Wiley, 1988.
4. **D. B. Simons** and **F. Senturk**, Sediment Transport Technology, Water Resources Publications, Fort Collins, Colorado, 1977.

CE 675 - ADVANCED EXPERIMENTAL FLUID MECHANICS

Open channel control structures; Varied flow profiles; River morphology, Sediment properties,

Experiments in open channel hydraulics – Flow measurements in channels; Hydraulic jump; surges and waves in channels; weirs and spillways; sedimentation and scouring.

Experiments in Fluid Mechanics: Basic fluid mechanics experiments; Drag and lift experiments; experiments in wind tunnel; pipe network experiments; water hammer experiments; potential flow experiments; vortex flows.

Hydraulic machinery experiments: Experiments on turbines (Francis, Pelton, Kaplan); centrifugal pump.

Hydrologic experiments: Rainfall intensity measurements; hydrology bench and watershed based experiments.

Errors in Experimentation, Uncertainty in experiments, law of propagation of errors, instruments for measurements of Stage, discharge and velocity, current meters, , data reduction and report preparation.

Reference:

1. **A.T. Troskolansky**, Hydrometry-Theory and Practice of Hydraulic Measurements, Pergamon Press, New York, 1970.P.R.
2. **Bevington**, Data Reduction and Error Analysis for Physical Sciences, McGraw Hill Book Co., New York, 1970.
3. **E.O. Doebelin**, Measurement Systems-Application and Design, McGraw-Hill Book Co., New York, 1980.
4. **Lab Manual on Fluid Mechanics, Department of Civil Engineering, IIT Bombay (unpublished)**

CE 676 - WATER RESOURCES SYSTEMS

Importance of Systems Approach in Water Resources; Introduction to system concepts, mathematical modeling, Simulation, Optimization, Unconstrained and Constrained Optimization.

Classical Optimization methods: Calculus based methods; Single and multiple variable optimization; Lagrange Multipliers; Kuhn Tucker conditions; applications in water resources.

Linear Programming: Definitions; Graphical solutions; Simplex method; Big-M Method; Duality theory; Sensitivity Analysis in LP; Numerical examples; applications in water resources.

Dynamic Programming: Definitions; recursive equations; numerical examples; applications in water resources: water allocation, capacity expansion, reservoir operation.

Reservoir Systems: Reservoir sizing, modeling of reservoir systems for flood control, hydropower, irrigation, water quality control; optimal operation for single and multireservoir systems; simulation models for hydropower systems and examples;

Performance evaluation of water resources projects- reliability, resiliency, vulnerability, sustainability measures.

Stochastic Optimization: Chance constrained optimization; stochastic dynamic programming; Applications in water resources & reservoir operation.

Evolutionary algorithms for optimization - Genetic algorithms (GA)and other EAs, applications in water resources.

Decision making with multiple objectives: conventional and non-conventional approaches; multi-objective GAs; applications in water resources.

References:

1. Vedula, S. and PP MujumdarWater Resources Systems , Tata McGraw-Hill, New Delhi, 2005.
2. Simonovic, S.P. Managing water resources: Methods and tools for a systems approach, UNESCO publishing, France, 2009.
3. Karamouz, M., Szidarovszky, F., Zahraie, B.Water resources systemsanalysis, CRC Press, Boca Raton, 2003.
4. Loucks, D.P. and Eelco van Beek. Water resources systems planning and management: An introduction to methods, models and applications., UNESCO Publ., 2005.
5. Mays, L.W., Y.K. Tung.Hydrosytems engineering and management, McGraw-Hill, New York, 1992.
6. Loucks, D. P., Stedinger, J. R., and Haith, D. A., Water Resources Systems Planning and Analysis, Prentice-Hall, Englewood Cliffs, NJ, 1981.
7. ReVelle, C. and McGarity, A. E., Design and Operation of Civil and Environmental Engineering Systems, John Wiley & Sons, New York, 1997.

CE-677 DESIGN AND TESTING OF PILE FOUNDATIONS

Types of piles and choice of pile type: Classification piles, large-displacement piles, small-displacement piles, replacement piles, special pile types; Design of piles: Building loads, Pile design in relation to geology, design philosophies, allowable stress design, Ultimate and serviceability limit state design, LRFD design concepts, axially loaded piles in soil, rock socketed piles, uplift capacity of piles, lateral load capacity of piles, negative skin friction, Settlement analysis; Pile group effects: ultimate capacity of pile groups, settlement of pile groups, negative skin friction of pile groups, piled raft foundations; Pile installation and construction control: equipment, liners, hammers and vibratory drivers, selection of method of pile installation, potential problems prior to and during pile installation, impact of installation techniques, damaging effects and mitigating measures; Design of basement walls and excavations: Walls types, design issues, design criteria, analysis and design methods, control measures; Integrity tests of piles: Role of integrity tests, types of non-destructive integrity tests, practical considerations in the use of integrity tests; Pile load tests: static and dynamic loading tests, vertical and lateral load testing, load tests using Osterberg cell, timing of load tests, design and construction of ground anchors, construction of test pile, equipment, reaction arrangement, instrumentation, test procedures, interpretation of test results; Hands-on experience to the students in pile testing and interpretation: Static pile load testing at large-scale pile testing setup at IIT Bombay, working with hydraulic jack and load cell, load maintenance, interpretation of ultimate capacity of pile and design capacity; Case studies and forensic aspects of pile foundations.

References:

1. M.J.Tomlinson and J Woodward, Pile Design and Construction Practice, 6th Edition, CRC Press, Taylor and Francis Group, 2014.
2. H.G.Poulos, Tall building Foundation Design, 1st Edition, CRC Press, Taylor and Francis Group, 2017.
3. K. Fleming, A. Weltman, M. Randolph, K.Elson, Piling Engineering, CRC Press, 2008.
4. M.Randolph and S.Gourvenec, Offshore Geotechnical Engineering, 1st Edition, Spon Press, Taylor and Francis Group, 2011.
5. J.E. Bowles, Foundation Analysis and Design, McGraw-Hill International Edition, Fifth Edition, 2001.
6. GEO Publication No. 1/2006: Foundation Design and Construction, Geotechnical Engineering Office, Hong Kong.
7. V.N.S. Murthy, Advanced Foundation Engineering, Geotechnical Engineering Series, CBS Publishers, 2010.
8. Design of Pile Foundations, US Army Corp of Engineers, University Press of the Pacific, 2005.

CE 680 - MECHANICS OF WATER WAVES

Introduction to wave phenomena. Wave classification, measurement, generation, forecasting. Wave theories: linear, non-linear. Wave spectrum: basic concepts, analysis and derivation. Statistical analysis of waves: short and long term. Propagation in shallow water-refraction, diffraction, reflection, breaking, current effects. Wave effects like, run-up, overtopping and transmission. Littoral transport under wave action.

References:

1. **T. Sarpkaya** and **M. Issacsson**, Mechanics of Wave Induced Forces on Offshore Structures, Van Nostrand Reinhold, London, UK, 1981.
2. Shore Protection Manual, U S Army Corps of Engineers, CERC, Washington, D.C., USA, 1984.
3. **R. L. Wiegel**, Oceanographical Engineering, Prentice Hall, New Jersey.

CE 681 ADVANCE PAVEMENT ENGINEERING LAB

The advance pavement engineering lab will cover various experiment on different types of pavement materials and field related exercise. The students will get exposure of advance instruments such as dynamic shear rheometer (DSR) for characterization of asphalt binder, brookfield viscometer for measuring viscosity of binders at high temperature, dynamic cone penetrometer (DCP) for insitu characterization of subgrade, light weight deflectometer (LWD) for evaluating in field strength of subgrade, aggregate image measurement system (AIMS) a digital method to capture shape characteristics of aggregates, MERLIN for field roughness measurement, Indirect tensile strength (ITS) on bituminous mixes, field demonstration of falling weight deflectometer.

References:

1. ASTM D7175: Standard Test Method for Determining the Rheological Properties of Asphalt Binder Using a Dynamic Shear Rheometer
2. ASTM D2170: Standard Test Method for Kinematic Viscosity of Asphalts
3. ASTM D6951 Standard Test Method for Use of the Dynamic Cone Penetrometer in Shallow Pavement Applications
4. ASTM E2583 -Standard Test Method for Measuring Deflections with a Light Weight Deflectometer (LWD)
5. ASTM D6931-Standard Test Method for Indirect Tensile (IDT) Strength of Asphalt Mixtures
6. ASTM D4694 -Standard Test Method for Deflections with a Falling-Weight-Type Impulse Load Device
7. AASHTO TP 81-12: Standard method of test for determining aggregate shape properties by means of digital image analysis. Washington, DC

CE 682 - FINITE ELEMENT APPLICATIONS TO FLOW PROBLEMS

Approximate methods: Method of weighted residuals (Sub-domain, Collocation, Least squares, Galerkin, Raleigh-Ritz methods), Applications to solve linear and nonlinear differential equations, Discretization of domain: Grid generation, Interpolating polynomials, Integration of shape functions over the domain, Formulation of element matrices and its global assembly for Laplace, Poisson, Diffusion, Advection-diffusion and Navier Stokes equations. Solution of system of equations: Linear and nonlinear equations, Solution procedure with compact storage schemes for sparse matrices. Boundary element method: Basic theory, Integral equations, Fundamental solutions, Applications in potential problems. Applications of finite element method and boundary element method: Applications in groundwater flow, Fluid dynamics, Pollutant transport in surface water and ground water, Computer packages.

References:

1. K. A. Hoffmann and S. T. Chiange, Computational Fluid Dynamics for Engineers, Vol. I, Engineering Education System, Wichita, Kanasas, 1993.
2. O.C. Zienkiewics, Finite Element Method, McGraw Hill Book Co., New York, 1991.
3. T.R. Chandrupatla, Introduction to Finite Elements in Engineering, Prentice Hall, Englewood Cliffs, New Jersey, 1991.
4. K.J. Bathe, Finite Element Procedure in Engineering Analysis, Prentice Hall of India, New Delhi, 1990.
5. C.A. Brebbia, J.C.F. Telles, L.C. Wrobel, Boundary Element Techniques- Theory and Applications in Engineering, Springer-Verlag, Berlin , 1984.
6. J.N. Reddy, Finite Element Method, McGraw-Hill Inc, New York, 1993.
7. Wang, H., and Anderson, M. P. (1982). Introduction to Groundwater Modeling Finite Difference and Finite Element Methods, W. H. Freeman and Company, New York.
8. Pinder, G. F., and Gray, W. G. (1977). Finite Element Simulation in Surface and Subsurface Hydrology, Academic press,New York.
9. Desai, Y.M., Eldho T.I., Shah A.H.. (2011). Finite Element Method with Applications in Engineering, Pearson Education, New Delhi.
10. Liu G R and Gu Y T 2005 An introduction to meshfree methods and their programming Springer New York.

CE-683 MARINE GEOTECHNICAL ENGINEERING

Origin and formation of submarine deposits, characteristics of continental shielding various parts of the world and around Indian coast, methods of exploration of submarine deposits, obtaining undistributed samples and determination of insitu strength, evaluation of physical and chemical properties of submarine soils, consolidation, settlement characteristics and shear strength characteristics under static and wave loading, pore pressure and liquefaction under dynamic and earthquake stresses, bearing capacity of large bases and tips, development of design parameters for use in pile soil and gravity platform soil, analysis both under static and dynamic conditions

References:

1. Proceedings of the Conferences on Behaviour of Offshore Structures.
2. Proceedings of Offshore Technology Conferences.
3. Proceedings of Annual Offshore Technology Conferences, Houston, Texas, 1969-1979.
4. Proceedings of First International Conference on Behaviour of Offshore Structures, Oslo, Published by the Institute of Technology, Norway, 1976.
5. Proceedings of Second International Conference on Behaviour of Offshore Structures, London, Published by BHRA Fluid Engineering, 1979.

CE-684 Advanced Geotechnical Earthquake Engineering

Introduction to Geotechnical Earthquake Engineering, Seismology and Earthquakes, Strong Ground Motion, Earthquake Hazards Related to Geotechnical Engineering, Wave Propagation, Liquefaction, Liquefaction computation from laboratory and field tests, Seismic Slope Stability, Behaviour of reinforced slope under seismic condition, Seismic Design of Retaining Walls, Force based Pseudo-Static Pseudo-Dynamic Analysis, bearing capacity and settlement, Seismic Design of Pile Foundations, Seismic Uplift Capacity of Anchors, Soil Improvement for Remediation of Seismic Hazards, Recommendations of Seismic Design Codes related to Geotechnical Earthquake Engineering.

References*:*

1. Steven L. Kramer (2003). Geotechnical Earthquake Engineering, Prentice Hall International Series, Pearson Education, New Delhi.
2. Ikuo Towhata (2010). Geotechnical Earthquake Engineering, Springer, ISBN-10: 3642071457, pp. 1-684.
3. R. W. Day (2002). Geotechnical Earthquake Engineering Handbook, McGraw Hill, New York.
4. IS 1893 (2016). Indian Standard Criteria for Earthquake Resistant Design of Structures, New Delhi.
5. B.M. Das (2011). Principles of Foundation Engineering, 7th Ed. SI Units, Cengage Learning, USA.
6. R. Katzenbach, S. Leppla and D. Choudhury (2016). Foundation Systems for High-Rise Structures, CRC Press, Taylor & Francis Group, UK, ISBN: 978-1-4987-4477-5, pp. 1-298.
7. D. Choudhury, K. M. El-Zahaby and I. M. Idriss (2018). Dynamic Soil-Structure Interaction for Sustainable Infrastructures. Springer, Switzerland, Online ISBN: 978-3-030-01920-4; Print ISBN: 978-3-030-01919-8, pp. 1-230.
8. D. Choudhury (2013). Geotechnical Earthquake Engineering, NPTEL Video course. http://nptel.ac.in/courses/105101134/

CE 687 - OFFSHORE CONSTRUCTION

Offshore environment: operational aspects of waves, currents, tides, wind. Structural material: types and properties of steel, concrete and synthetics. Construction equipments: specialized barges and OSVs. Common operations: surveying, diving, crew transfer, etc. Installation: Pile supported, gravity and complaint structures. Repair and maintenance: structures and pipelines. Rehabilitation: strengthening and salvage. Specialized constructions: OTEC, wave power devices, channel, etc.

References:

1. **B. C. Gerwick,** Construction of Offshore Structures, John Wiley and Sons, London, UK, 2000.
2. **J. B. Herbich**, Handbook of Coastal and Ocean Engineering, Gulf Pub., Houston, USA, 1990.
3. **B. McClleland and M. D. Reifel**, Planning and Design of Fixed Offshore Platforms, Van Nostrnad Reinhold, London, UK, 1986.

CE-688 Risk Assessment and Management in Geotechnical Engineering

Working stress and limit state design approaches, Ultimate and Service limit states, Basics of probability and statistics, Sources of uncertainty in Geotechnical design parameters, In-situ soil characterization, Sensitivity analysis, Modelling of uncertainty, Fragility curves, Probability of failure, FORM, Monte Carlo Simulation Techniques, Response Surface Method, Parallel and series systems, Explicit and implicit functions, Target reliability index, LRFD approach, Code calibration, Applications to shallow and deep foundations, landslides and embankments, liquefaction behaviour of soils

References:

1. Ang, A.H-S. And Tang, W.H. (2006). Probability Concepts in Engineering: Emphasis on Applications to Civil and Environmental Engineering, John Wiley & Sons.
2. Baecher, G. and Christian, J. (2005). Reliability and Statistics in Geotechnical Engineering, Wiley Publications, 618 p.
3. Haldar, A. and Mahadevan, S. (2000): Probability, Reliability and Statistical Methods in Engineering Design, John Wiley & Sons Inc., 304 p
4. Nowak, A.S. And Collins, D. R. (2000). Reliability of Structures, McGraw-Hill International Editions, Civil Engineering Series, Singapore, 338 p.
5. Ranganathan, R. (1990). Reliability Analysis and Design of Structures, Tata McGraw Hill, New Delhi.
6. Fenton, G.A. (1997). Probabilistic Methods in Geotechnical Engineering, ASCE Geotechnical Safety and Reliability Committee, 95 p.

CE 699TRANSPORTATIONS SYSTEMS STUDIO

Creation of zonal and network layer with attribute data using open source GIS resource, Processing of transportation planning data of a metropolitan area (study area) and produce P-A matrices, O-D matrices, zonal planning data and other relevant summary information using latest computing tools. Calibration and validation of four step travel demand models for the study area using transportation planning software. Generation of appropriate land use and transport scenarios and forecasting of travel demand for these scenarios. Evaluation of alternatives based on sustainability indicators.

Traffic Data Collection and Analysis: Study of Driver Testing Unit, Spot Speed Study, Travel time and Delay Studies, Moving Observer Method, O-D Survey, Parking Usage Survey, Traffic Volume Study, Saturation Flow Measurement, Intersection Delay Measurement, Gap Acceptance Study at Uncontrolled Intersection.

References

1. Ortuzar, J.D. and Willumsen, L.G., Modelling Transport, John Wiley & Sons, Ltd., 2011.
2. User manuals of transportation planning software like CUBE/TransCAD/Emme.
3. Murthy, A. S. N and Mohle, H. R., Transportation Engineering Basics, American Society of Civil Engineers, New York, NY.

CE 701 - REMOTE SENSING TECHNOLOGY

Electromagnetic radiation (EMR), concepts of radiometry, EMR interaction with atmosphere and terrain, remote sensing systems and platforms for remote sensing, remote sensing in the visible, near-infrared, thermal infrared and microwave portions of the EMR, digital classification of remote sensing data

References:

- Jensen, J. R. (2007), Remote sensing of the environment: An earth resource perspective, Second edition, Pearson
- Lillesand, T. M., Kiefer, R. W. and Chipman, J. W. (2008), Remote sensing and image interpretation, Sixth edition, Wiley
- Elachi, C. and Van Zyl, J., (2006), Introduction to the physics and techniques of remote sensing, Second edition, Wiley Interscience
- Rees, W.G. (2012), Physical principles of remote sensing, Third edition, Cambridge University Press.
- Schowengerdt. R. A. (2007), Remote sensing: Models and methods for image processing, Third edition, Elsevier
- Jensen, J.R. (2018), Introductory Digital Image Processing, a remote sensing perspective, Fourth Edition, Pearson
- Journal articles as informed by the Instructor

CE-702 GEOTECHNICAL CONSTITUTIVE MODELS

Introduction to shear strength of soils, Critical state line, Taylor302222s stress-dilatancy equation, Generalised Hooke302222s Law, isotropy and anisotropy, elastic and plastic deformation, ingredients of a plastic soil model, normality assumption and associated flow rule, compression behaviour and plasticity, behaviour of Cam Clay under drained and undrained loading, relationship between undrained shear strength, effective stress and over-consolidation ratio, generalised equations of state boundary surface

References:

1. A.N. Schofield, Disturbed soil properties and geotechnical design, Thomas Telford, 2006
2. A.M. Britto and M.J. Gunn, Critical State Soil Mechanics via Finite Elements, Ellis Horwood, Chichester, 1987
3. D.M. Wood, Soil Behaviour and Critical State Soil Mechanics, Cambridge University Press, New York, 1990
4. M.D. Bolton, A Guide to Soil Mechanics, McMillan, London, 1984
5. P.K. Banerjee and R. Butterfield, Advanced geotechnical analyses, Elsevier Science Publishers, Cambridge University Press, 1991

CE-703 Remote Sensing Laboratory

Remote sensing images, searching and downloading openly available satellite data, atmospheric correction of optical data, Spectral reflectance behavior analysis of various Earth features and vegetation indices, estimation of land surface temperature, processing of synthetic aperture radar data, land use/land cover classification.

References:

1. Jensen, J. R. (2007), Remote sensing of the environment: An earth resource perspective, Second edition, Pearson
2. Lillesand, T. M., Kiefer, R. W. and Chipman, J. W. (2008), Remote sensing and image interpretation, Sixth edition, Wiley
3. Schowengerdt. R. A. (2007), Remote sensing: Models and methods for image processing, Third edition, Elsevier
4. Jensen, J.R. (2018), Introductory Digital Image Processing, a remote sensing perspective, Fourth Edition, Pearson
5. Journal articles as informed by the Instructor

CE-705 PHOTOGRAMMETRIC ENGINEERING

Geometry of aerial photographs; Stereoscopy; Relief displacement; Coordinates; Stereoscopic parallax measurement and formula; Radial triangulation; Theory of inner, relative and absolute orientation; Numerical orientation; Model deformation; Plotting Instruments; Aerial triangulation; Base map and thematic map compilation; Analytical photogrammetry; UAV Photogrammetry, Digital Terrain Modelling generation and its applications. Advanced topics in Terrain Data Collection.

References:

1. **Moffit, F.,** Photogrammetry (3rd Edn.), International Text Book Co. Scranton, 1967.
2. **Wolf, P.R**., Elements of Photogrammetry, McGraw Hill, New York, 1974.
3. **Colwel, R.N.,** (Ed.), Manual of Remote Sensing: Vol. I, II, American Society of Photogrammetry and Remote Sensing, Falls Church, VA, USA, 1983.
4. Journal articles shared by the instructor.

CE 706 - OCEAN ENGINEERING LABORATORY

Wave flume experiments to study propagation, refraction, reflection, diffraction, wave forces. Hydraulic modeling for ports, harbours. Numerical modeling of waves, tides, currents, fluid-structure interaction.

References:

1. **Steven A. Hughes**. 1995. Physical models and laboratory techniques in coastal engineering, Advanced series on Ocean Engineering-Vol. 7,World Scientific, Singapore.
2. **Robert A. Darlymple**. 1985. Physical modelling in coastal engineering, A.A.Balkema, Rotterdam, Netherlands.
3. **Charles L. Mader**. 2004. Numerical modeling ofwater waves, CRC Press, Boca Raton, Florida.
4. **Subrata K. Chakrabarti**. 1994. Offshore Structure Modeling, Advanced Series on Ocean Engineering-Vol. 9, World Scientific.

CE 707 - COASTAL, PORT AND HARBOR ENGINEERING

Coastal protection works, Port and harbors - planning, design and construction aspects; harbor layout, model studies: physical and numerical breakwaters, wharf, jetty, mooring and dolphins, dry docks, shipyards, dredging, CRZ and guidelines, navigation, shipping: ship stability (static and dynamic); submarine pipelines: forces, laying, stresses, buckling; equipment.

References:

1. **Coastal Engineering Manual** (CEM). 2011. US Army Coastal Engineering Research Centre,Vicksburg, USA.
2. **Robert M. Sorenen**. 2006. Basic coastal engineering, Springer, USA.
3. **John W. Gaythwaite**. 2004. Design of Marine Facilities for the Berthing, Mooring, and Repair of Vessels, Amer Society of Civil Engineers.
4. **John B. Herbich** and Charles L. Bretschneider.1992. Handbook of Coastal and Ocean Engineering, Gulf publishing Company.
5. **Per Brunn**. 1989. Port engineering, Vol. 1, 2 and 3,Gulf Publishing Company.

CE 708 - OFFSHORE ENGINEERING

Types of offshore structures, planning and design aspects, wave loads regular and random, loads due to wind, tides and currents. Operational environment, equipments, materials and corrosion, repairs and maintenance, installation, common operations.

References:

1. **Subrata K. Chakrabarti**. 2003. Hydrodynamics offshore structures, WIT press.
2. **YashimiGoda**. 2010. Random seas and design of marine structures, World Scientific.
3. **Tugut S. Sarpkaya**. 2010. Wave Forces on Offshore Structures, Cambridge University Press.
4. **Ben C. Gerwick**. 2000. Construction of marine and offshore structures, CRC Press.
5. **Minoo H. Patel**. 1989. Dynamics of offshore structures, Buttersworth.

CE 710 Remote Sensing and Geographical Information Systems in Water Resources Management

Hydrologic cycle, relationship between water, energy and carbon cycles, Estimation of energy balance components, hydrologic modelling, remote sensing of rainfall, soil moisture estimation, evapotranspiration modelling, drought monitoring, Irrigation assessment, GIS based watershed modelling, Geospatial statistics, Remote sensing and GIS data sources for water resources, Case studies of remote sensing and GIS applications for various water resources projects.

Prerequisite: Knowledge in remote sensing and experience with different satellite

References:

1. **Chen, Y., Takara, K., Cluckie, I. and Smedt, F.H.** (Eds.), GIS and Remote sensing in Hydrology, Water resource and Environment, IAHS Publication 289, IAHS press. 2004.
2. **Burrough P.A. and McDonnell R.A.,** Principles of Geographical Information Systems, Oxford University Press, New York, 1998.
3. **David Maidment and Dean Djokic**, Hydrologic and Hydraulic Modelling Support with GIS, ESRI Press, 2000.
4. **Lillesand, T.M. and Kiefer, R.W.,** Remote Sensing and Image Interpretation, 6th Edition, John Wiley and Sons, New York. 2010.
5. Journal articles as given by instructor.

CE 712 Digital Image Processing of Remotely Sensed Data

Remotely Sensed Data: Satellite Systems & Acquisition, Data Storage, Concept of Resolution Digital Image: Fundamentals, Spatial Statistics (Univariate & Multivariate), Image Sampling and Quantization. Geometric Preprocessing: Image Registration, Sampling, Orthorectification, Image Mosaic Image Enhancement: Basics of Spatial Filtering, Edge Enhancement Image Transforms: Arithmetic Operations, PCA, Color Transforms Filtering Techniques: Low pass filters, High pass filters Image Classification for Land Use Mapping Geomorphology of Drainage basins: Digital Terrain Analysis and Watershed Analysis

References:

1. Lillesand T. M & Kiefer R. W., 2000. Remote Sensing and Image Interpretation, Wiley & Sons.
2. R. C. Gonzalez, R. E. Woods, 2008, Digital Image Processing, Prentice Hall.
3. R. C. Gonzalez, R. E. Woods, W. L. Eddins, 2009, Digital Image Processing using Matlab, Pearson.

CE 713 ADVANCED CONCRETE TECHNOLOGY

Cement – production - Composition & properties - Cement chemistry – Heat of hydration – Microstructure – Hydration products and pores; Aggregates – Geological classification - Physical classification – Characteristics and significance – Natural and Recycled aggregates; Mineral admixtures – Classification – Pozzolanic reaction – Natural and Industrial By-Products- effect on fresh and hardened concrete properties; Chemical admixtures – Classification - Water reducers, Set Controllers, Air entraining agents – Admixture chemistry – Mechanism of action - types - Optimisation – Compatibility issues - Speciality Admixtures

Advanced Mixture Design – Design Philosophy - Particle Packing & Rheology - Discrete and Continuous approach – Packing density of powders and aggregates - Experimental tests and Models – Ternary Packing Diagram – Mixture Design of Self - Compacting Concrete (SCC); Fresh Concrete Properties – Empirical test for SCC - Rheology – Basics – Parameters – Models – Rheometers – Rheology of Paste and concrete - Pumping – Setting – Curing – Plastic shrinkage – Strength Development – Maturity Method; Hardened Concrete Properties – Factors influencing strength – Interfacial Transition Zone – Stress strain relationship - Localisation – End effects – Loading Conditions; Dimensional Stability – Creep and Shrinkage

Durability – Permeability and Porosity – Chemical attack (Sulphate attack, Delayed Ettringite Formation, Chloride attack, Acid Attack, Sea Water attack, Carbonation, Freezing and Thawing, Alkali aggregate reaction, Alkali carbonate reaction Corrosion – Mode of action, failure – Tests – Protection methods.

References:

1. Neville, A.M., 'Properties of concrete', 4th ed., Pearson Education Limited, London, 2000.
2. P. Kumar Metha and P. J. M. Monterio, Concrete- Microstructures, Properties and Materials, Indian Edition, Indian Concrete Institute, Chennai, 1999.
3. Lea, F.M., Chemistry of cement and concrete, 3rd ed, Edward Arnold, London, 1970 .
4. De Larrard, F, Concrete Mixture proportioning – A scientific Approach, E&FN Spon, London, 1999.
5. Aitcin, P. C., High Performance Concrete, E&FN Spon, London, 1998.
6. Santhakumar, A. R., Concrete Technology, Oxford University Press, New Delhi, 2007.
7. Neville, A.M., and Brooks, J. J., Concrete Technology, Pearson Education Ltd., 2012.

CE 716 - Advanced Digital Image Processing of Remotely Sensed Data

Data collection, recording and handling, data storage and formats, analog and digital processing, image enhancement; Contrast, texture and edge enhancement, ratio images vegetation and soil indices; Classification - unsupervised, single pass and iterative; Supervised minimum distance to mean, maximum likelihood and Bayes methods, evaluation of accuracy, data transformation and compression techniques, applications.

References:

1. **R.O. Duda and P.E. Hart**, Pattern Classification and Scene Analysis, John Wiley and Sons, N.Y., 1973.
2. **J.T. Tou and R.C. Gonzalez**, Pattern Recognition Principles, Addison Wesly, 1974.
3. **P.H. Swain and S.M. Davis** (Ed.), Remote Sensing : The Quantitative Approach, McGraw-Hill Book Co., N., 1978.

CE 717 CONSTRUCTION PLANNING AND CONTROL

Planning for construction projects: Project conceptualization, project organization, Feasibility studies, Detail Project Reports, Planning for construction, Work method statements, and work breakdown structures.

Planning for time on projects: Project scheduling techniques, CPM and PERT, Limitations, Case studies, Constructability conditions during scheduling

Planning for resources and costs: Handling resources on projects, planning and levelling resources, Time-Cost trade-off on construction projects.

Project monitoring and control: Updating project schedules, Earned Value analysis, monitoring the progress, Daily progress reports, managing data on projects, course correction on projects.

References:

1. Bennet, F. Lawrence., The management of construction: a project life cycle approach, Routledge 2003
2. Oberlender, Garold D., Project Management for engineering and construction, Vol 2. New York: McGraw-Hill, 1993
3. Roger Miller and Donald Lessard, The strategic management of Large Engineering Projects: Shaping Institutions, Risks and Governance, The MIT Press, 2001
4. Peurifoy, Robert Leroy, Cliff J. Schexnayder and Shapira A., Construction Planning, equipment and methods, McGraw-Hill, 2010
5. Jha, Kumar Neeraj, Construction Project Management: Theory and Practice. Pearson India, 2011
6. Case studies on construction projects

CE 718 CONSTRUCTION MATERIALS LABORATORY

Exp No.	Name of the Experiment	Laboratory
1	Bricks/Blocks, Tiles - Strength and Water Absorption	SEMT Lab.
2	Mineral Admixtures – Particle size and Shape Analysis	CMMC Lab.
3	Chemical Admixture optimisation -Mini Slump and Marsh Cone	SEMT Lab.
4	Concrete - Slump, Slump retention, Setting Time	SEMT Lab.
5	Concrete - Strength (Normal Curing & Steam Curing)	SEMT Lab.
6	Concrete - Non Destructive Test (Rebound Hammer & UPV Test)	SEMT Lab.
7	Concrete - Carbonation Test, Water Permeability Test	SEMT Lab.
8	Concrete - Porosity (MIP)	SEMT Lab.
9	Concrete - Abrasion Resistance	SEMT Lab.
10	Steel (HYSD bars) - Tension Test	HS Lab.

References:

1. IS 3495 (1992) Methods of tests of burnt clay building bricks. Part 1 determination of compressive strength. Part 2 determination of water absorption, Bureau of Indian Standards, New Delhi.
2. IS 13630 (2006) Ceramic tiles – Methods of Test. Part 2 Determination of water absorption. Part 6 Determination of modulus of rupture, Bureau of Indian Standards, New Delhi.
3. IS 1786 (1990) Specification for high strength deformed steel bars and wires for concrete Reinforcement, Bureau of Indian Standards, New Delhi.
4. IS 9103 (2004) Concrete admixtures - Specification, Bureau of Indian Standards, New Delhi.
5. IS 10262 (2004) Recommended guidelines for concrete mix design, Bureau of Indian Standards, New Delhi.
6. IS 13311 (2004) Non-destructive testing of concrete - Methods of test. Part 1 ultrasonic pulse velocity. Part 2 rebound hammer, Bureau of Indian Standards, New Delhi.
7. IS 1199 (1999) Methods of sampling and analysis of concrete, Bureau of Indian Standards, New Delhi.
8. IS 8142 (2002) Method of test for determining setting time of concrete by penetration resistance, Bureau of Indian Standards, New Delhi.
9. IS 516 (1997) Method of test for strength of concrete, Bureau of Indian Standards, New Delhi.
10. IS 3085 (1997) Method of test for permeability of cement mortar and concrete, Bureau of Indian Standards, New Delhi.
11. Nanthagopalan, P and Santhanam, M (2008) A new approach to optimisation of paste composition in self-compacting concrete, The Indian Concrete Journal, vol. 82, 11 - 18.
12. de Larrard, F., F. Bosc, C. Catherine, and F. Deflorenne(1997) The AFREM method for the mix-design of high performance concrete. Materials and Structures, 30, 439 - 446.

CE 719 CONSTRUCTION CONTRACTS

Comprehensive study of different types of contracts and their working. Important clauses in the contracts. Standard forms of con***tracts used in India and abroad;*** Owner- construction contractor prime contract, labor agreements; purchase order and subcontract agreements; insurance contracts; surety bonds; joint-venture agreements; bid and proposals; mistakes in bids; breach of contract; contract changes; differing site conditions; delays, suspensions, and terminations; liquidated damages, force majeure, and time extensions; allocating responsibility for delays; constructive acceleration; common rules of contract interpretation;

Problems in the operation of contracts, Enforcement of contracts, I***ncentive mechanism in contracts;*** Claims and disputes, Claim process, Dispute resolutions, Arbitrations settlements, Litigations on contracts, Case studies on arbitration and litigations in contracts.

Professional practice ethics, duties and responsibilities of project managers in con***struction projects;*** Construction specifications - standard specifications, development, interpretation***.***

References:

1. Bartholomew, Stuart H. Construction contracting: Business and legal principles. 2nd ed. Prentice Hall, 2001.
2. Hughes,W., Champion, R. and Murdoch, J., Construction Contracts – Law and Management. 5th ed. Routeledge, Taylor and Francis, 2015.
3. Hinze, J., Construction contracts. 3rd edition, McGraw-Hill Science Publishers, 2000.
4. Central Public Works Department, General Conditions of Contract and The Arbitration and Conciliation Act, 1996
5. Case studies on contracts

CE 720 - NON-DESTRUCTIVE TESTING OF MATERIALS

Types of materials, tests and the variables involved, destructive and non-destructive testing correlation of properties obtained by NDT with the basic structure of matter and other properties; NDT of different materials by various techniques such as radiographic, sonic and ultrasonic, electrical and magnetic, soleoroscopic, microwave, eddy current penetrant, thermal optical, holographic etc., practical applications and advances in NDT.

References:

1. **J.F. Hinslay**, Non-Destructive Testing, MacDonald and Evants, 1959.
2. **H.B. Egerton**, Non-Destructive Testing, Oxford University Press, 1969.
3. **Krautkramer**: Ultrasonic Testing of Materials, Springer-Verlag, 1969.
4. **M.A. Novgoresky**, Testing of Building Materials and Structures, Mir Publishers, 1973.
5. American Society of Metals: Handbook, Vol II, Destructive Inspection and Quality Control, 1976.

CE 722 CONSTRUCTION MANAGEMENT STUDIO

Software used in construction management. Introduction to MS Project. Exercises on MS Project

Simulation Software, Discrete Event Simulations in Construction, Monte-Carlo Simulations.

Introduction to Building Information Modelling, Exercises with Building Information Modelling Software: Autodesk Revit.

Exercises on visualization, MEP modelling, clash detection, 4D-BIM, 5D BIM.

References:

1. Krygiel, E. and Vandezande J., Mastering Autodesk Revit Architecture 2015, Sybex and Autodesk, Joh Wiley and Sons, 2014.
2. Chatfield and Johnson, T., Step by Step Microsoft Project 2013, Microsoft Press, 2013.

CE-723 Construction Equipments and Personnel Management

Construction Equipments

- Factors affecting selection of equipment and methods - Technical and Economic.
- Analysis of production outputs and costs, equipment power requirements
- Equipment used in earthwork construction, compaction and stabilization, earthmoving, material transport, drilling.
- Equipment used in aggregate production, concrete production, asphalt mix production and placement
- Lifting equipment, Piling equipment, Pumps and forming systems.
- Case studies on equipment usage in construction

Personnel in construction

- Managing labour on construction sites.
- Productivity in construction, Analysis of productivity, Productivity measurement, Work sampling methods, Foreman Delay Survey, Crew Balance Charts, Process Charts.
- Introduction to wastes in construction sites.

References:

1. Peurifoy, Robert Leroy, Cliff J. Schexnayder and Shapira A., Construction Planning, equipment and methods, McGraw-Hill, 2010
2. Sharma, S. C., Construction Equipment and Its Management, Khanna Publishers 2002.
3. Jha, Kumar Neeraj, Construction Project Management: Theory and Practice. Pearson India, 2011
4. Case studies in construction equipment usage.

CE-725 CONSTRUCTION ECONOMICS AND FINANCE

Time value of money, Cash flows in construction projects. Evaluation of alternatives: Present Worth Comparisons, Rate of Return analysis, Incremental Rate of Return, Break –Even , Benefit-Cost Analysis, Replacement Analysis, Depreciation: Capital cost recovery, Accounting techniques, insurance costs

Taxes: Tax laws, Accounting treatment of taxes, Inflation: Nature of inflation, real interest rates, price indexes, taxes and inflation, Construction accounting, Sources of funding for finance, Infrastructure financing, Project finance techniques.

Life-cycle costing, Construction Cost Control, Personnel costs, Equipment costs, Job in directs and mark-up, Approximate estimates

References:

1. Collier C. A., and Ledbetter W. B., Engineering Cost Analysis, Harper and Row Publishers, 1982
2. Riggs, James L., David D. Bedworth, and Sabah U. Randhawa., Engineering economics. 4th Ed., McGraw-Hill, 2004.
3. Park, C. S., Fundamentals of Engineering Economics, Pearson Education Inc. 2004
4. Newnan, D. G., Ted G. E., Lavelle J. P., Engineering Economic Analysis, 9th edition, Oxford University Press, 2004.

CE-727 CONSTRUCTION MATERIALS

Science, Engineering and Technology of Materials - Atomic Bonding-Structure of solids - Development of Microstructure - Surface Properties - Response to stress - Failure Theories - Fracture Mechanics - Thermal properties - Review of Construction Materials and criteria for selection - wood - Polymers - Fibre reinforced composites - Metals - Concrete - Glass - Bituminous materials - Water proofing Materials.

References:

1. Materials Science and Engineering: An introduction, W.D. Callister, John Wiley,1994.
2. Properties of Engineering Materials, R.A. Higgins, Industrial Press, 1994.
3. Building Materials, P.C. Varghese, Prentice-Hall India, 2005.
4. Construction materials: Their nature and behaviour, Eds. J.M. Illston and P.L.J. Domone, 3rd ed., Spon Press, 2001.
5. The Science and Technology of Civil Engineering Materials, J.F. Young, S. Mindess, R.J. Gray & A. Bentur, Prentice Hall, 1998.
6. Engineering Materials 1: An introduction to their properties & applications, M.F. Ashby and D.R.H. Jones, Butterworth Heinemann, 2003.
7. The Science and Design of Engineering Materials, J.P. Schaffer, A. Saxena, S.D. Antolovich, T.H. Sanders and S.B. Warner, Irwin, 1995.
8. Concrete: Microstructure, properties and materials, P.K. Mehta and P.J.M. Monteiro, McGraw Hill, 2006.

CE 729 QUALITY AND SAFETY IN CONSTRUCTION

Quality in Construction

Need for quality in construction, Definition of Quality, Principles of Quality Assurance and Quality Control, Concepts of Total Quality Management, The Plan Do Check Act concept.Seven basic tools of quality – Cause and effect diagrams, Check Sheets, Control charts, Histograms, Pareto Charts, Scatter Diagrams, Run Charts. Sampling Techniques for quality, Standards on Quality – ISO 9001, Development of Quality Manuals in projects, Quality Audits.

Quality procedures for various materials and procedures used in construction.

Safety in Construction

Construction safety management systems, Safety culture, Performance measurements of safety – lead indicators, lag indicators, Injuries in construction, Cause analysis, Human error reduction. Hazard Analysis and risk assessment, Development of Safety management plans, Personnel protective Equipment, Safety strategies for various construction processes.Health issues in construction. Incident investigations, Audit requirements

***References*:**

1. Paul Watson and Tim Howarth, Construction Quality Management, Spon Press, 2011
2. J. L. Ashford, The Management of Quality in Construction, Spons Architecture, 1989
3. James J. O'Brien, Construction Inspection Handbook, Total Quality Management, Springer Science, 1997
4. Steve Rowlinson, Construction Safety Management Systems, Taylor & Francis 2003
5. P S Gahlot and Deep Gehlot, Quality Management in Cement Concrete Construction, CBS Publishers, 2010
6. R. K. Mishra, Construction Safety, AtibsPublishers, 2011
7. Fred A. Manuele, Advanced Safety Management, Wiley Interscience, John Wiley and Sons, 2008
8. International standards on quality and safety in construction - ISO-9001 Quality Management, ISO-45001 – Occupational Health and Safety.
9. Case studies on construction projects

CE 731 - MECHANICS OF FLUID FLOW

Fluid flow theories – an Introduction

Equation of motion, continuity and energy in differential forms, integral equations of momentum and energy and control volume approach

Navier Stokes Equations – Solution and Applications

Laminar flow in pipes and channels

Turbulent flow in pipes and channels

Elements of boundary layer concepts, boundary shear stress-skin-friction drag

Environmental fluid mechanics – diffusion, dispersion in open channels, transport mechanism &solutions

Unsteady flow in open channels, surges in channels

Transients in closed conduits, water hammer analysis

References:

1. R.A. Granger, "Fluid Mechanics", Dover Publications, 1995.
2. Daily and Harleman, “Fluid Dynamics”, Addition Wesley, New York, 1973.
3. James A. Fay,“Introduction to Fluid Mechanics”, Prentice Hall, New Delhi, 1996.
4. Wylie & Streeter, “Fluid Mechanics”, Mc Graw Hill, New York, 1998
5. R.H. French, “Open Channel Hydraulics”, Mc Graw Hill, New York, 1986.
6. Bruce R. Munson, D.F. Young, T.H. Okiishi, Fundamentals of Fluid Mecahnics, John Wiley, New York, 2002.
7. Daugherthy, R.L., Franzini, J.B., Finnemore, E.J. Fluid Mechanics with Engineering Applications, McGraw Hill, New York, 1985.
8. Douglas, J.F. ,Gasiorek, J.M. ,Swaffield, J.A., Fluid Mechanics, Addison-Wesley, Harlow 1999.
9. Shames, I.H., Mecahnics of Fluids, McGraw Hill, New York, 1992.
10. Video Course on Fluid Mechanics: Prof. T.I. Eldho, Dept. Civil Engg., IIT Bombay

(http://www.youtube.com/course?list=PL3F50D04B70A5B935&category=University/Engineering) (http://nptel.iitm.ac.in/video.php?subjectId=105101082)

CE 736 - ENVIRONMENT IMPACT ANALYSIS OF WATER RESOURCES SYSTEMS

Water resources projects that needs EIA, Sequence of studies in Environmental Impact assessment of water resources projects, Matrix, Checklists, Network, Overlays and other techniques of environmental impact assessment.

Oxygen sag models, Empirical and self-information models, Planning and management of impact studies, Prediction and assessment of impact on surface water environments,

Prediction and assessment of impact on groundwater environments, Sources of Contamination of groundwater environment, Development of solute transport equations for surface and sub-surface flows,

Finite differences and finite element models, Numerical dispersion, Solutions by particle tacking methods, Modified method of characteristics, Random walk transport models.

References:

1. **Canter L.W**., Environmental Impact Assessment, McGraw-Hill, New York, 1977.
2. **M. G. Stewart** (Ed.), Integrated Risk Assessment, Applications and Regulations, Balkema Publications, Rotterdam, 1998.
3. **R. S. Jose** and **C. A. Brebbia** (Ed.), Measurements and Modelling in Environmental Pollution, Comp. Mech. Publ., Barcelona, 1997.
4. **V. Novotny**, Water Quality: Prevention, Identification and Management of Diffuse Pollution, Van Nostrand Reinhold, New York, 1994.

CE 738 - IRRIGATION AND CONVEYANCE NETWORK

Irrigation fundamentals, types of irrigation, tank irrigation, lift irrigation, Principles of soil physics & soil chemistry.

Soil-plant-water relationships: Water relation of soils, soil moisture and plant growth, water requirement and yield response; Crop water requirements estimation; irrigation scheduling; irrigation efficiencies.

Irrigation economics: Economic analysis of on-farm irrigation; financial analysis – Central and State financing – Economic instruments- water charges, cess, taxes, subsidies and compensation- Irrigation water pricing – Cost Benefit analysis of irrigation projects; Irrigation project planning and management.

Water conveyance and control, Canal and pipe network planning - principles of branching network systems for flexibility, alignment of network components, determination of the network flows and demands

Analysis and design of different surface irrigation methods -furrow system, level basin, graded border and other types with examples; Computer models for surface irrigation design;

Planning and design of sprinkler irrigation systems- types of sprinklers, Pipeline hydraulics and economics, lateral design and main delivery system design, Pump and power unit selection, design of different types of sprinklers with examples;

Micro-irrigation system- types and components, Drip irrigation planning factors, Emitter selection and design criteria, Drip lateral and manifold design, Drip system design synthesis; examples. Computer models for micro irrigation design, and Case study applications.

References:

1. Michael, A.M. (2008). Irrigation: Theory and Practice, 2nd edition, Vikas Publishing House, 772p.
2. Ali, M. H. (2010). Fundamentals of Irrigation and On-farm Water Management: Volume 1. 1st Edition., 2010, 556 p.
3. Keller, J. and Bliesner, R.D. (2001). Sprinkle and trickle irrigation. Published by The Blackburn press, Springer-Verlag, 2001, 652p..
4. Cuenca, R.H. (1989). Irrigation System Design. Prentice Hall, Englewood Cliffs, NJ., 1989, 552p.
5. Walker, W.R. and Skogerboe, G.V. (1987). Surface Irrigation - Theory and Practice. Prentice Hall, Inc. Englewood Cliffs, Newjersy.
6. Jensen, P.A. and Barnes, J.W.(1980). Network Flow Programming, John Wiley and Sons, New York.

CE-740 TRAFFIC ENGINEERING

Traffic stream characteristics: Road user and vehicle characteristics, Fundamental parameters and relations, Traffic Stream Models, Modeling vehicle arrivals: Continuous distributions to model Headways and speed, Modeling vehicle arrivals: Discrete distributions to model flow and evaluation of distributions. Traffic measurement procedures: Measurement at a Point (Volume data collection and analysis, PCU, PHF etc), Measurement over a Short Section (Speed data collection and analysis), Measurement along a Length of Road (Density and travel time measurement and analysis), Moving Observer Method, Traffic forecasting and growth studies. Microscopic traffic flow modeling: Car Following Models: Linear models, Car Following Models: Non-linear models, Lane Changing Models, Microscopic Traffic Simulation (Vehicle generation, model frame work, calibration and validations, statistical error analysis, applications). Macroscopic and mesocopic models: Traffic Flow Modeling Analogies: First order models, analysis of shock waves, Traffic Flow Modeling Analogies: Numerical implementation and higher order models, Cell transmission models, Cellular automata models: Discrete Simulation , Traffic Progression and Platoon dispersion. Traffic Analysis and Management: Capacity and Level of Service concepts, Queuing models and applications, Basics of traffic management. Traffic intersection control: Principles of Traffic Control and Traffic Signs, Road Markings and Channelization, Uncontrolled Intersection: Gap acceptance and capacity concepts, Uncontrolled Intersection: Capacity and LOS analysis, Traffic Rotaries and Grade Separated Intersection. Traffic signal design: Design Principles of Traffic Signal, Evaluation of a Traffic Signal: Delay Models, Capacity and LOS Analysis of a Signalized I/S, Coordinated Traffic Signal, Vehicle Actuated Signals and Area Traffic Control.

References:

1. Adolf D. May. Fundamentals of Traffic Flow. Prentice - Hall, Inc. Englewood Cliff New Jersey 07632, second edition, 1990.
2. William R McShane, Roger P Roesss, and Elena S Prassas. Traffic Engineering. Prentice-Hall, Inc, 2010.
3. C. S. Papacostas and P. D. Prevedouros. Fundamentals of Transportation Engineering. Prentice-Hall, New Delhi, 2009.
4. C. JotinKhisty, B. Kent Lall, Transportation Engineering: An Introduction, Prentice Hall, 2003.
5. Nicholas J. Garber, Lester A. Hoel, Traffic and Highway Engineering, Cengage Learning, 2008.
6. L. R Kadiyali. Traffic Engineering and Transportation Planning. Khanna Publishers, New Delhi, 2008.
7. D R Drew. Traffic flow theory and control. McGraw-Hill Book Company, New York, 1968.

8. Highway Capacity Manual. Transportation Research Board. National Research Council, Washington, D.C., 2010.
9. Fred L. Mannering, Scott S. Washburn and Walter P. Kilareski, Principles of Highway Engineering and Traffic Analysis, Wiley India, 2011.
10. A. S. Narasimha Murthy and Henry R. Mohle. Transportation Engineering Basics, ASCE Press, USA. 2001.
11. Thomas R. Currin, Introductions to Traffic Engineering: A Manual for Data Collection and Analysis, Brooks/Cole Thomason Learning, Canada, 2001.

CE-741 FORMWORK FOR CONCRETE STRUCTURES

Introduction to formworks - Emphasis on formwork based design - Formwork management - Formwork materials - Pressure of concrete on formwork - Key aspects of formwork design - Failure of formworks (case studies) - Design of formworks for walls, slabs, columns - Design of back-propping - Modern formwork systems - Scope for research in the field of formworks.

References:

1. Peurifoy, R. L., and Oberlender, G. D., 2011, *Formwork for Concrete Structures*, 4th edition, McGraw-Hill.
2. Hurd, M. K. Formwork for Concrete. ACI 347, 6th edition, American Concrete Institute, Detroit, Michigan, 1995.
3. Ratay, Robert T. Handbook of Temporary Structures in Construction. 2nd edition, McGraw Hill, New York, 1996.
4. IS 14687 (2005) Falsework for concrete structures - Guidelines, Bureau of Indian Standards, New Delhi.
5. IS 883 (1994) Design of structural timber in building - Code of practice, Bureau of Indian Standards, New Delhi

CE-742 PAVEMENT SYSTEMS ENGINEERING

Historical development of pavements. Introduction to different types of flexible pavements and design factors, Stress and strain analysis of flexible pavements. Introduction to multi-layers elastic theory. Analysis of pavements using software such as IITPAVE and KENPAVE, Stress and strain (deflection) analysis of rigid pavements. Analysis of pavements using software such as IITRIGID and KENLAYER, and others. Introduction to traffic loading, Understanding the concept of equivalent standard axle load (ESAL), Design of flexible pavements as per IRC 37, AASHTO, and AI methods for stabilized and un-stabilized base and subgrade layers. Design of rigid pavements as per IRC 58, AASHTO, and PCA methods for stabilized and un-stabilized base and subgrade layers. Introduction to different types of overlays on flexible and rigid pavements (PCC over HMA, HMA over PCC, HMA over HMA, PCC over PCC) and their design philosophy. Introduction to Benkelman Beam method and design of HMA overlay as per IRC 81. Introduction to white-topping (conventional, thin, ultra-thin) and their design as per IRC:SP-76-2008. Introduction to drainage requirement for pavements. Pavement performance evaluation and distresses. Data requirement and database development. Different types of rehabilitation and maintenance strategies. Construction practices for building flexible and rigid pavements.

References:

1. Y.H. Huang "Pavement Analysis and Design," 2nd Edition, 2004, Pearson Prentice Hall, USA
2. N. Delatte "Concrete Pavement Design, Construction, and Performance" Taylor and Francis
3. MORT&H- Specifications for Roads and Bridges, 5th Revision, 2013.
4. IRC: 37-2012. "Tentative Guidelines for the Design of Flexible Pavements," Indian Road Congress, Delhi.
5. IRC: 58-2011. "Tentative Guidelines for the Design of Rigid Pavements," Indian Road Congress, Delhi.
6. IRC: 81-2012. "Guidelines for Strengthening of Flexible Road Pavements Using Benkelman Beam Deflection Technique," Indian Road Congress, Delhi
7. IRC: SP: 76-2008. "Tentative Guidelines for Conventional, Thin and Ultra-Thin White-topping," Indian Road Congress, Delhi

.

CE-743 CONDITION ASSESSMENT AND REHABILITATION OF CONSTRUCTED FACILITIES

Performance of construction materials and components in services - Causes of deterioration - preventive measurements and maintenance - Principles of assessment of weathering and durability - Diagnosis of construction failures - Dealing with cracks - Materials for Repair, Preparation of surface and strengthening techniques - Corrosion damage of reinforced concrete - repair and prevention measures - Surface deterioration, Efflorescence, causes, prevention and protection - Surface coatings and painting - Water proofing – Grouting - Strengthening of existing structures - Special repairs, maintenance, inspection and planning, Budgeting and management - Case Studies.

References:

1. Peter H. Emmons (1993), Concrete Repair and Maintenance Illustrated, RSMeans Company, Kingston, MA.
2. Handbook on repair and Rehabilitation of RCC buildings, Central Public works Department, Government of India, New Delhi, 2002.
3. ACI 546R-04 Concrete Repair Guide, American Concrete Institute, Detroit, Michigan, 2004.
4. ACI 562M-13, Code Requirements for Evaluation, Repair, and Rehabilitation of Concrete Buildings and Commentary, American Concrete Institute, Detroit, Michigan, 2013.

CE-744 Analysis of Transportation Systems

Introduction: transportation systems, transportation innovations, social and economic impacts of transportation, Decision makers and their options, demand modelling and predictions, Modelling transportation systems. Analysis of network flows: Shortest-Path Problems, Maximum-flow Problems, Minimum-cost network flow problems, Minimum Spanning tree problem, The network simplex method

Static Traffic Assignment: All-or-nothing (AON) assignment, Link cost function, Equilibrium principles: User Equilibrium (UE) and System Optimal (SO), Formulations of SO and UE, Uniqueness of UE and SO formulations, multi-mode traffic assignment, Variable Demand assignment, Stochastic Traffic Assignment, Solution of traffic assignment problems.

Dynamic Traffic Assignment (DTA): Introduction, Point queue model, Cell Transmission Model, Whole link model, Dynamic user equilibrium (DUE), Analytical Models of DUE, Solution of DUE formulations, Simulation based DUE. Public Transportation Systems: Transit Assignment, Transit route network planning, performance monitoring, vehicle and crew scheduling. Decision Making in Transportation Networks: Congestion pricing, network design problems, prioritizing investment

Optional Topics: Integrated land-use and transport modelling, Activity based travel demand modelling, Entropy in the analysis of utility maximizing systems, Entropy maximization and gravity models

References:

1. Cascetta, E. Transportation Systems Analysis: Models and Application, Springer, 2009
2. Sheffi, Y., Urban Transportation Networks: Equilibrium Analysis with Mathematical Programming Method. Prentice-Hall, Englewood Cliffs, 1985
3. Ran, B., and Boyce, D. E., Modeling Dynamic Transportation Network - An Intelligent Transportation System Oriented Approach, Springer-Verlag, Heidelberg, 1996.
4. de Neufville, R. Applied Systems Analysis: Engineering Planning and Technology Management, McGraw Hill, 1990,
5. Ortuzar J. Luis G. Willumsen, L. G. Modelling Transport, Willey, 2011
6. Manheim, Analysis of Transportation Systems, MIT, USA, 1980.
7. R.G. Weilson, Entropy in Urban and Regional Transportation, McGraw-Hill, 1980

CE-746 Reinforced Earth and Geotextiles

Basic introduction to the elements of Ground Engineering characteristics of reinforcing materials, definition of reinforced and advantage of RE, soil reinforcement interaction, behaviour of Reinforced earth walls, basis of wall design, the Coulomb force method, the Rankine force methods, internal and external stability condition, field application of RE, randomly reinforced earth and analysis of reinforced soils, testing of soil reinforcements. Definitions, functions, properties, and application of Geotextiles, design of Geotextile applications, definitions, functions, properties and applications of geo-membranes, design of geo-membranes applications, Geotextiles associated with geo-membranes, testing on geotextiles, environmental efforts, ageing and weathering.

References:

1. International Conference on Soil Reinforcement, RE and other techniques, Paris, March, 1979.
2. Second International Conference on Geotextiles, Las Vegas, August, 1982.
3. International Conferences in-situ soil and rock reinforcement, Paris, October, 1984.

CE-751 URBAN TRANSPORTATION SYSTEMS PLANNING

Introduction and scope; Definition and basic principles; Transportation problems; Types of models; Planning methodologies; Conventional transportation planning process; Sustainable urban transportation planning process; Study area delineation and data collection, Travel demand modelling and forecasting; Trip generation - regression, category analysis; Trip distribution - growth factor, Fratar and Furness methods, Gravity model, intervening opportunities model, competing opportunities model; Modal split models - aggregate and disaggregate models; Traffic Assignment – network representation, graph theory applications in transport network analysis, highway assignment, transit assignment; Land use - transport interaction.

References:

1. Ortuzar, J.D. andWillumsen, L.G., Modelling Transport, John Wiley & Sons, Ltd., 2011.
2. Meyer, M.D. and Miller, E.J., Urban Transportation Planning: A Decision-oriented Approach, Mc Graw Hill, New York, 2001.
3. Hutchinson, B.G., Principles of Urban Transport Systems Planning, McGraw Hill, New York, 1974.
4. Thomas, R., Traffic Assignment Techniques, Avebury Technical, Aldershot, 1991.
5. Yosef Sheffi, Urban transportation networks, Prentice-Hall, Englewood Cliffs, N.J., 1985.
6. Patriksson, M., The traffic assignment problem: models and methods, Dover Publications, New York, 2015.
7. Dickey, J.W., Metropolitan Transportation Planning, Taylor & Francis, 1983.

CE 764 –HYDROINFORMATICS

Module 1: Introduction: Introduction to data-driven modeling for water systems; Model classification; Introduction to Matlab and R Programming.

Module 2: Supervised Learning for classification/regression: Linear Models and Generalized Linear Models (GLM) including Logistic and Poisson Regression; k-Nearest Neighbor (k-NN) method; Polynomial Regression and Generalized Additive Models; Kernel-based Methods; Decision trees – Classification and Regression Trees (CART) – Bagging, Boosting and Random Forests; Support Vector Machines (SVM); Artificial Neural Networks (ANN); Resampling Methods - Bootstrap; Regularization and Machine Learning System Design.

Module 3: Unsupervised Learning: Clustering: i) hard (k-means) clustering and ii) fuzzy clustering (fuzzy c-means) with introduction to fuzzy logic; Multivariate analysis – dimension reduction, Singular Value Decomposition (SVD), Principal Component Analysis (PCA), Canonical Correlation Analysis (CCA).

Module 4: Applications: Hydroinformatics for Climate Change Impact Assessment and Regional Flood Frequency Analysis; Example of a Hydrologic Information System..

References:

1. James, G., Witten, D., Hastie, T., & Tibshirani, R. (2013). An introduction to statistical learning (Vol. 112). New York: Springer. (Or Hastie et al. for advanced)
2. von Storch and Zwiers, 1999, Statistical Analysis in Climate Research, Cambridge Univ. Press, U.K.
3. Myers, R. H., Montgomery, D. C., Vining, G. G., & Robinson, T. J. (2012). Generalized linear models: with applications in engineering and the sciences (Vol. 791). John Wiley & Sons.
4. Abbott, 1991, Hydroinformatics- Information Technology and the Aquatic Environment, Avebury Technical, Aldershot, U.K.
5. Nielsen, 2016, Neural Networks and Deep Learning, Web-book. http://neuralnetworksanddeeplearning.com/index.html
6. Other relevant research articles.

CE 765 - Environmental Fluid Mechanics

Introduction: The role of fluid mechanics in environmental planning, Transport of substances in the hydrologic cycle, Protection of water quality

Basic Relationships: Conservation of mass, energy and momentum, Law of fluid motion - Navier-Stokes equations -Turbulent flow, Diffusion process

Heat and Mass Transfer: Diffusive transport of substances (molecular diffusion), Heat transfer equations,

Relationships Turbulence: Properties of turbulent flow, Basic equations of turbulent momentum transport, turbulent hypothesis, Dispersion Stratification and Density Driven Flow: Density variations in fluids, Stability and stratification (hydrostatics, hydrodynamics), Stratified flow examples

Jets and Plumes: similarity theory, entrainment hypothesis, applications for different environmental conditions and source configurations

Emission Standards for Sewage and Heat Discharges; Flow, transport and mixing Process in lakes, Reservoirs and rivers

Water Quality Standards: River and estuarine water quality models (model formulation, dimensionality, applications), Integrated Water Quality management

References:

1. **Liggett, J.A.,** Fluid Mechanics, McGraw Hill International, Singapore, 1994.
2. **Wilkes, J.O**., Fluid Mechanics for Chemical Engineers, Prentice Hall, Englewood Cliffs, 1999.
3. **Douglas, J.F., Gasiorek, J.M.** and**Swaffield, J.A.,** Fluid Mechanics, Addison Wesley, Reading, 1999.
4. **Streeter, V.L., Wylie, E.B.** and **Bedford, K.W.,** Fluid Mechanics, WCB/McGraw-Hill, 1998.
5. **Papanastasiou, T.C.,** Applied Fluid Mechanics, Prentice-Hall, 1994.
6. **Gerhart, P.M., Gross, R.J.** and **Hochstein, J.I.,** Fundamentals of Fluid Mechanics, Addison Wesley, Reading, 1992.
7. **Brown, R.A**., Fluid Mechanics of the Atmosphere, Academic Press, 1991.
8. **Denn, M.M.,** Process Fluid Mechanics, Prentice Hall, Englewood Cliffs, 1980.

CE 766 - WATERSHED MANAGEMENT

Principles of Watershed Management: Basics concepts, Hydrology and water availability, Surface water, Groundwater, Conjunctive use, Human influences in the water resources system, Water demand, Integrated water resources system - River basins Watershed Management Practices in Arid and Semi-arid Regions, Watershed management through wells, Management of water supply - Case studies, short term and long term strategic planning Conservation of Water: Perspective on recycle and reuse, Waste water reclamation Social Aspects of Watershed Management: Community participation, Private sector participation, Institutional issues, Socio-economy, Integrated development, Water legislation and implementations, Case studies Sustainable Watershed Approach: Sustainable integrated watershed management, natural resources management, agricultural practices, integrated farming, Soil erosion and conservation Water Harvesting: Rainwater management - conservation, storage and effective utilisation of rainwater, Structures for rainwater harvesting, roof catchment system, check dams, aquifer storage Applications of Geographical Information System and Remote Sensing in Watershed Management, Role of Decision Support System in Watershed Management

References:

1. **Murty, J.V.S**., Watershed Management, New Age Intl., New Delhi 1998.
2. **Allam, G.I.Y**., Decision Support System for Integrated Watershed Management, Colorado State University, 1994.
3. **Vir Singh, R.,** Watershed Planning and Management, Yash Publishing House, Bikaner, 2000.
4. **Murthy, J.V.S.,** Watershed Management in India, Wiley Eastern, New Delhi, 1994.
5. **American Society of Civil Engineers**, Watershed Management, American Soc. of Civil Engineers, New York, 1975.

CE 767 - HYDROLOGICAL HAZARD MITIGATION AND MANAGEMENT

Flood Hazard Mitigation: Basics of floods, Natural and man-made floods, Flood control structures, Flood management,

Applications of geographical information systems and remote sensing in flood management, Case studies Drought Hazard Mitigation: Basics of droughts, Natural and man-made droughts, Watershed management, Drought management, Applications of geographical information systems and remote sensing in drought management, Drought problems in arid and semi-arid regions, Case studies

Crisis and Emergency Management: Nature of extreme events, Cyclone and related flooding, Global problems of catastrophe solution and emergency situations, Mobilisation of communities, Community involvement, Case studies Risk Management: Risk assessment, Risk reduction and management, Role of insurance companies Advanced Warning Systems: Global positioning systems, Applications of remote sensing and GIS, Role of Information Technology in natural hazard mitigation management

References:

1. Centre for Science & Environment, Wrath of Nature: Impact of Environmental Destruction on Floods and Droughts, Centre for Science & Environment, New Delhi.
2. **Beven, K.** and **Carling, P.,** (eds.), Floods: Hydrological, Sedimentological and Geomorphological Implications, British Geomorphological Research Group Symposia Series, Wiley, Chichester, 1989.
3. **B.H.R.A.,** Hydraulic Aspects of Floods & Flood Control, B.H.R.A., England, 1983.
4. **Brown, J.P.,** Economic Effects of Floods, Springer-Verlag, Berlin, 1972.
5. **Prasad, P.,** Famines and Droughts: Survival Strategies, Rawat, Jaipur, 1998.
6. **A.K. Schwab, K. Eschelbach, David J. Brower,** Hazard Mitigation and Preparedness, John Wiley, 2007.

CE 768 - URBAN WATER AND ENVIRONMENTAL MANAGEMENT

Urban Water Demand- Basic requirements for water supply, drainage and sanitation; Present and future demand for Indian cities, Estimation and fulfillment-Feasibility and Case studies

Administrative and Legal Aspects and Financing: International, national and municipal legal aspects, Administrative structure for drainage planning, Financing for drainage projects, Preparation of ToR, Case studies

Introduction to Drainage Problems in Different Climates: Urbanisation - Its effects and consequences for drainage, Interaction between urban and peri-urban areas.

Planning concepts and System Planning, Drainage Master Plan: Objectives of urban drainage and planning criteria, Drainage options and system layout, Planning tools and data requirement, Drainage structures, Case studies

Urban Hydrologic and Hydraulic Procedures: Urban hydrologic cycle, Rainfall analysis, Design storm, Determination of peak flow rates, Hydraulic and hydrodynamic principles, Calculation methods and mathematical tools: Modeling formulas, Hydrologic models, Hydrodynamic models, Regression analysis, Urban runoff and water quality models, Case Studies

Best Management Practices - Source control techniques: Infiltration basins, Porous pavements, Rooftop rainwater harvesting, Detention basins/ ponds, Case studies

Design of Drainage System Elements: Hydraulic fundamentals, Design guidelines and considerations; Design of sewerage and drainage channels, Case studies

Detention and Retention Facilities: Design objectives and considerations, Storage facility types, On-site and off-site detention, Preliminary design computations, Orifices, Weirs, Discharge pipes, Emergency spillway, Routing procedures, Water budget, Land-locked retention, Case Studies

Pavement Drainage: Hydroplaning, Design frequency and spread, Surface drainage, Flow in gutters, Drainage inlet design,

Inlet types- selection considerations

Roadside Drains: Design parameters, Stable channel design, Design procedure for roadside and median channels, Case studies

Airport Drainage: Special considerations for airport drainage, Design example, Case studies

Culvert Design: Culvert Hydraulics, Objectives, Types of flow, Inlet control, Outlet control, Entrance efficiency, Design investigation, Design of new culvert, Culvert replacement, Case studies

Pumping Stations: Design considerations, Design criteria, Pump station storage requirements, Case studies

Control of Stormwater Pollution in Urban Areas: Pollution build-up and wash off processes with reference to urban drainage systems and eutrophication of urban lakes, Case studies

Operation and Maintenance of Urban Drainage Systems: Maintenance requirements and planning, Cleansing of sewers and drains, repair options, Case studies

Removal of Solid waste and silt from urban stormwater channels and drains, Case studies

Flood and Cyclone Early warning systems

References:

1. Gribbin,J.E., 2014, Introduction to Hydraulics and Hydrology with Applications for Stormwater Management, Cengage
2. Mays, L.W., 2001, Stormwater Collection Systems Design Handbook, McGraw Hill
3. Butler and Davis, Urban Drainage, 3rd edition, 2010
4. Haestad Publishers, 2003, Stormwater Conveyance Modeling and Design, 1/E
5. Haestad Publishers, 2002, Computer Applications in Hydraulic Engineering, 5/E.

CE 769 - COASTAL AND OCEAN ENVIRONMENT

Sea bed morphology; Wave mechanics - generation, forecasting, wave theories, shoaling, refraction, diffraction, breaking; Tidal propagation in estuaries; Coastal currents; Littoral processes; Sediment transport; Shore protection measures; Planning and operation of harbor, coastal and offshore structures.

References:

1. **Gaythwaite, J.,** The Marine Environment and Structural Design, Van Nostrand Reinhold, New York, 1981.
2. **Herbich, J.B.,** Handbook of Coastal and Ocean Engineering, Gulf publishing Co., 1990.
3. **Shore Protection Manual**, US Army Coastal Engineering Research Centre, Vicksberg, USA. 1984.
4. **Gerwick, B.C.,** Construction of Offshore Structures, Wiley, New York, 1986.

CE 770 - OCEAN RENEWABLE ENERGY

Introduction to Physical Oceanography, Ocean Processes: Waves, Tides, Currents. Need for Renewable Energy, Ocean Thermal Energy, Wave Energy, Tidal Energy, Tidal Stream Energy, Salinity Gradients, Ocean-Structure Interactions; Resource Assessment, Power Take-off, Wave Energy Devices, Tidal Energy Devices, Stream Energy Devices, Offshore Wind Energy and Devices, Environmental and Social Impacts.

References:

1. **G. Boyle**, Renewable Energy: Power for a Sustainable Future, Oxford University Press, 2012.
2. **J. Cruz**, Ocean Wave Energy: Current Status and Future Perspectives, Springer, 2008.
3. **J. Falnes**, Ocean Waves and Oscillating Systems, Cambridge University Press, 2004.
4. **R. Bhattacharyya** and M.E. McCormick, Wave Energy Conversion, Elsevier Ocean Engineering Book Series Volume 6, 2005.
5. **R.H. Charlier**and **C.W. Finkl**, Ocean Energy: Tide and Tidal Power, Springer Berlin Heidelberg, 2009.
6. **R.M. Sorensen**, Basic Coastal Engineering (3rd edition), Springer, 2006.

CE-771 Optimization in Civil Engineering

Linear Programming: Formulating linear programs, Graphical solution of linear programs, Special cases of linear program, The Simplex Method: Converting a problem to standard form, The theory of the simplex method, The simplex algorithm, Special situations in the simplex algorithm, Obtaining initial feasible solution, Duality and sensitivity analysis: Sensitivity analysis, Shadow prices, Dual of a normal linear program, Duality theorems, Dual simplex method

Integer Programming: Formulating integer programming problems, The branch-and-bound algorithm for pure integer programs, The branch-and-bound algorithm for mixed integer programs,

Non-linear Programming: Introduction to non-linear programming (NLP), Convex and concave functions, NLP with one variable, Line search algorithms, Multivariable unconstrained problems, constrained problems, Lagrange Multiplier, The Karush-Kuhn-Tucker (KKT) conditions, The method of steepest ascent, Convex combination method, penalty function methods, Quadratic programming, Dynamic programming, Evolutionary algorithms such Genetic Algorithm, concepts of multi-objective optimization, Markov Process, Queuing Models

References:

1. S. S. Rao, Engineering Optimization: Theory and Practice, Wiley & Sons, New Jersey, 2009.
2. F. H. Hillier and G. J. Liberman, Introduction to Operations Research, Tata McGraw-Hill, 2010.
3. W. L. Winston, Operations Research: Applications and Algorithm, 4th Edition, Cengage Learning, 1994.
4. A. Ravindran, D. T. Phillips, and J. J. Solberg, Operations Research: Principles and Practice, John Wiley and Sons, 1987.
5. K. Deb, Optimization for Engineering Design, Prentice Hall, 2013.
6. M. C. Joshi and K. M. Moudgalay, Optimization: Theory and Practice, Narosa, 2004.
7. K. Deb, Multi-objective Optimization using evolutionary algorithms, John Wiley and Sons, 2009.

CE-772 Pavement Materials

Introduction materials used for construction of subgrade, aggregate base course, bituminous base and surface courses of pavements. Understanding different tests: CBR, Durability, Freeze-Thaw, Resilient Modulus, soil-suction, relationship between DCP and CBR, CBR and Mr, and other parameters.

Characterization of aggregates for application in the pavements. Different types of rocks and aggregate production. Introduction to bitumen production and process, penetration and viscosity grading system for bitumen. Modification of bitumen using polymer and crumb rubber. Visco-elastic modeling (creep, mechanical models).

Introduction to Superpave grading system. Understanding mixing and compaction temperature of bitumen. Introduction to different types of mixes: Hot mix asphalt, cold mix asphalt. Understanding volumetric calculation. Marshall and Superpave mix designs of different types of mixes. Performance tests: fatigue and rutting tests, moisture induced damage and tests, resilient modulus, dynamic modulus/flow number/flow time. recycling, foam mix asphalt, recycle technologies, and warm mix asphalt, construction of perpetual pavements. Cement concrete mix design for pavements. Application of waste and locally materials for construction of pavements, quality control and assurance practices

References:

1. F.L. Roberts, P.S. Kandhal, E.R. Brown, D.Y. Lee, and T.W. Kennedy “Hot Mix Asphalt Materials, Mixture Design and Construction,” National Asphalt Pavement Association Research and Education Foundation, Second Edition, 1996, USA.
2. Y.H. Huang “Pavement Analysis and Design,” 2nd Edition, 2004, Pearson Prentice Hall, USA
3. Asphalt Institute, SP-1: Performance Grading of Asphalt Binder – Specifications and Testing.
4. MORT&H- Specifications for Roads and Bridges, 5th Revision, 2013.

CE 773 –GEOMETRIC DESIGN AND ANALYSIS OF HIGH-SPEED ROADWAYS

Introduction to highway geometric design: Development IRC and AASHTO geometric design polices, Definition and scope of geometric design, Primary and dependent design controls. Human and vehicle factors: Concepts and application of human factors in design and typical vehicle factors used in geometric design. Sight distance: Overview of different type of sight distance, sight distance index, scaling and recording sight distance from plans, sight distance profile. Longitudinal Features of Horizontal and Vertical Profile: Factors influencing profile selection, horizontal curve, vertical curve, curves for special situation, characteristics of highway alignment, general principles of horizontal and vertical profile coordination and technique, elements of highway cross sections, developing cross sections, methods of attaining super elevation and graphical development of super elevation.

Highway location and alignment design: Location study, developing trial alignment, evaluating impacts, translating graphical alignment to mathematical component, single line sketching technique. Principles of intersection and interchange design: Design objectives, driver expectancy, geometric design controls, alignment and profile, lane width, design for turning movements, treatments for right turns, unconventional intersection and interchange design, channelization, intersection design templates, interchange design templates.Introduction to highway design software: Developing sight distance profile for highway alignment, Evaluating existing horizontal and vertical curves, Super elevation development, Intersection design, Interchange design

References:

1. A policy on geometric design of highways and streets, American Association of State Highway Officials, 2011.
2. Geometric design standards for urban roads in plains (IRC: 86-1983), The Indian Roads Congress, 1983.
3. Geometric design standards for rural (non-urban) highways (IRC: 73-1980), The Indian Roads Congress, 1980.
4. Guidelines for expressways – Part I, Ministry of Road Transport & Highways, 2010.
5. Roadside design guide, American Association of State Highway Officials, 2002.
6. Manual of geometric design standards for Canadian roads, Transportation Associations of Canada, 1986.
7. Pline, J.L., Traffic Engineering Handbook, Institute of Transportation Engineers, 2009.
8. Manual on Uniform Traffic Control Devices, Federal Highway Administration, 2009.
9. S.K. Khanna and C.E.G. Justo, Highway Engineering, Khanna Publishers, Roorkee, 2001

CE-774 Traffic Management and Design

Traffic Impact: Transportation noise: standards, measurements and mitigation strategies. Parking Studies: Statistics and analysis. Fuel Consumption and vehicle operating cost. Vehicular emission and Air quality modelling. Environmental impact assessment. Traffic safety: Accident studies, Accident data analysis, Statistical methods for data analysis, Road safety principles and practice, Identification of hazardous locations. Capacity and LOS analysis: Two Lane Highways, Urban Streets, Multilane Highways, Transit systems, Pedestrians and bicycles. Design of Traffic Facilities: Transit route selection and design, Pedestrians and bicycles facilities, Intersection, roundabout configuration and design, Interchange design, Freeway Operations and design. Traffic Management: Traffic Management Strategies, Traffic Management Techniques, Work zone traffic management, Traffic calming, Congestion studies and Road pricing. Automated Data Collection Systems: Intrusive systems such as loop detectors, pneumatic, etc., Non-Intrusive systems such as video, infra-red, In-vehicle systems: GPS, Mobiles, Tracking; Positioning systems for location services, Geographical information systems. Intelligent Transportation System: ITS: User services and architecture, ITS: Standards and evaluation, Public transport and bus priority, Travel time estimation methods, Artificial intelligence in advanced traffic and ITS

References:

1. C. S. Papacostas and P. D. Prevedouros. Fundamentals of Transportation Engineering. Prentice-Hall, New Delhi, 2009.
2. C. JotinKhisty, B. Kent Lall, Transportation Engineering: An Introduction, Prentice Hall.
3. N. J. Garber, L. A. Hoel, Traffic and Highway Engineering, Cengage Learning, 2008.
4. L. R Kadiyali. Traffic Engineering and Transportation Planning. Khanna Publishers, New Delhi, 2008.
5. Highway Capacity Manual. Transportation Research Board, Washington, D.C., 2010.
6. F. L. Mannering, S. S. Washburn and W. P. Kilareski, Principles of Highway Engineering and Traffic Analysis, Wiley India, 2011.
7. T. R. Currin, Introductions to Traffic Engineering: A Manual for Data Collection and Analysis. Brooks/Cole Thomason Learning, Canada, 2001.
8. Hensher, D.A. and K.J. Button (eds) (2003) Handbook of Transport and the Environment, Handbooks in Transport #4, Amsterdam: Elsevier.
9. M A Chowdhary and A Sadek. Fundamentals of Intelligent Transportation systems planning. Artech House Inc., US, 2003.
10. Sussman, J. Perspectives on Intelligent Transportation Systems (ITS). New York, NY: Springer, 2005.

CE-775 Airport Planning and Design

History and organisation of air transport, Aircraft characteristics related to airport design, Airport configuration, Airport planning and air travel demand forecasting, Geometric design of the airside, Structural design of airfield pavements, airport drainage, Airport airside capacity and delay, Planning and design of the terminal area, Airport access, airport lighting and marking, Financial strategies for implementation, Environmental impacts of airports

References:

1. R. Horonjeff and F. X. Mckelvey, Planning & Design of Airports, 5th Edition, Mc Graw Hill, New York, 2010.
2. N. Ashford, S. Mumayiz and P. H. Wright, Airport Engineering, 4th Edition, John Wiley, New York, 2011.
3. International Civil Aviation Organization (ICAO) Design Manuals
4. Federal Aviation Administration (FAA) Advisory Circulars.

CE-776 TRANSPORTATION PROJECT EVALUATION AND DECISION MAKING

Introductory Concepts in Transportation Decision Making: Overall transportation project development, budgeting, financial planning, the process of transportation project development, models associated with transportation impact evaluation, procedural framework for transportation systems evaluation. Estimating Transportation Demand and Supply: Demand-supply equilibration, dynamics of transportation demand and supply, elasticity of travel demand and supply, classification of elasticity, consumer surplus and latent demand.

Transportation Costs: Classification of transportation costs, transportation agency costs, transportation user costs, general structure and behavior of cost functions and road pricing. Vehicle Operating Costs: Road user cost study in India, components of VOC, factors affecting VOC, fuel consumption relationships, procedural framework for assessing VOC impacts. Value of Travel Time Savings: Categorizations of travel time, framework for assessing travel time impacts, economic concept of evaluation of travel time savings, issues relating to travel time value estimation, methodology for monetary evaluation of passengers travel time, review of work in India on passengers' travel time.

Accidents Costs: Relevance of accident costing for a developing country, procedural framework for safety impact evaluation, review of alternative methodologies for accident costing, certain issues connected with accident costing, methods for estimating crash reduction factors, before and after case studies.

Economic Evaluation of Transportation Projects: Economic significance of transport, performance measures in transportation evaluation, costs and benefits of transport projects, basic principles of economic evaluation, elements of engineering economics, methods of economic evaluation, benefit-cost ratio method, first year rate of return, net present value method, internal rate of return method, comparison of the various methods of economic evaluation, life cycle cost analysis, case studies, software packages for economic efficiency analysis.(HDM-4). Evaluation of Transportation Projects and Programs using Multiple Criteria: Basic concepts, Single vs. multiple criteria, Evaluation, decision-making, and optimization, Steps in multi-criteria decision-making, Case study: evaluation of metro rail projects using multi-criteria. Financial Analysis of Transportation Projects: Financial analysis of highway project case study, PPP based transport project case study

References:

1. McCarthy, P. Transportation Economics, Blackwell, 2001
2. Meyer John Robert Meyer, José A. Gómez-Ibáñez, William B. Tye, Clifford Winston, Essays in Transportation Economics and Policy, Brookings Institution Press, 1999.
3. Kenneth Duncan Boyer, Principles of transportation economics, Addison-Wesley, 1998

4. Kumares C. Sinha, Samuel Labi, Transportation Decision Making: Principles of Project Evaluation and Programming, Wiley,2007
5. C. JotinKhisty, B. Kent Lall, Transportation Engineering: An Introduction, Prentice Hall, 2003.
6. L. R Kadiyali. Traffic Engineering and Transportation Planning. Khanna Publishers, New Delhi, 2008.
7. Indian Roads Congress, (1992) “Manual for Road Investment Decision Model”, Special Publication 38, New Delhi.
8. Indian Roads Congress, (2007) “Manual on Economic Analysis of Highway Projects”, Special Publication 30, New Delhi.
9. Stuart Cole, Applied Transport Economics: Policy, Management & Decision Making, Kogan Page Publishers, 2005
10. John Hibbs, Transport Economics & Policy: A Practical Analysis of Performance, Efficiency and Marketing Objectives, Kogan, 2003.
11. Herbert Mohring, Transportation economics, Ballinger, 1976.

CE-780 Behavioral Travel Modelling

Survey design and analysis: travel surveys and their role in transport planning, survey methods, precision and accuracy in travel surveys, sample design, sampling procedures, survey format, pilot surveys, survey administration, collection of stated and revealed preference data, survey data processing. Individual choice theory: binary choice models, multinomial and multi-dimensional choice models, issues in model specification, methods and statistics of model estimation with emphasis on maximum-likelihood estimation, aggregation and forecasting with discrete choice models, validation and transferability aspects, ordered multinomial models, nested logit models, introduction to advanced concepts such as accommodating unobserved population heterogeneity in choice behavior, mixed logit models, joint stated preference and revealed preference modeling, and longitudinal choice analysis; discrete choice models for integrated land use and transport modelling, review of state-of-the-art and future directions

References:

1. Ben-Akiva, M. and Lerman, S, Discrete Choice Analysis: Theory and Application to Travel Demand, MIT Press, 1985.
2. Oppenheim, N., Urban Travel Demand Modeling: From Individual Choices to General Equilibrium, John Wiley, 1995.
3. Borsch SupanAxel , Econometric analysis of discrete choice, Springer-Verlag, Berlin, 1987.
4. Richardson, Ampt, and Meyburg, Survey Methods for Transport Planning, Eucalyptus Press, 1995.
5. Domencich, T.A. and McFadden, D., Urban Travel Demand: A Behavioral Analysis, North-Holland, 1975.
6. Selected papers from journals such as Transportation Research, Transportation Science, and Transportation Research Record.

CE-781 ADVANCED FOUNDATION ENGINEERING

Subsoil exploration for foundation engineering, In situ tests and interpretation of their results, Types and selection of foundation elements, Foundation design framework, Tolerable foundation movement, Bearing capacity and settlement analysis of shallow foundations, Design of isolated and combined footings, Raft foundation, Analysis and design of axially-loaded piles, Laterally loaded piles, Piles in group, Pile driving analysis, Design of earth retaining structures, Special foundations, Foundation on problematic soils, Modeling soil-structure interaction for foundations

References:

1. **Salgado, R.** The Engineering of Foundations, Mc Graw Hill, 2006, ISBN: 9780072500585
2. **Coduto**, **D. P., Kitch**, **W. A.** and **Yeung, M. R.** Foundation Design: Principles and Practices. Pearson Education Inc. 2016, ISBN 0133411893
3. **Poulos, H. G.** and **Davis, E. H.** Pile Foundation Analysis and Design. John Wiley and Sons Inc., 1980.
4. **Das, B. M**. Principles of Foundation Engineering, 7th edition, Cengage Learning, Inc., 2010, ISBN: 0495668109
5. **Bowles, J. E**. Foundations Analysis and Design, 5th Ed., McGraw-Hill, New York, 1997.
6. **Peck, R.B.**, **Hanson, W.E.** and **Thornburn, T.H.** Foundation Engineering, 2nd Edition, John Wiley and Sons, New Jersey, 1974.