UNIVERSITY OF MUMBAI
No. UG/44 of 2018-19

CIRCULAR:-

Attention of the Principals of the affiliated Colleges and Directors of the recognized Institutions in Science & Technology Faculty is invited to this office Circular No. UG/248 of 2010, dated 12th August, 2010 relating to syllabus of the Bachelor of Engineering (B.E.) degree course.

They are hereby informed that the recommendations made by the Board of Studies in Civil Engineering at its meeting held on 9th April, 2018 have been accepted by the Academic Council at its meeting held on 5th May, 2018 **vide** item No. 4.55 and that in accordance therewith, the revised syllabus as per the (CBCS) for the T.E. in Civil Engineering (Sem - V & VI) has been brought into force with effect from the academic year 2018-19, accordingly. (The same is available on the University's website www.mu.ac.in).

(Dr. Dinesh Kamble)
I/c REGISTRAR

MUMBAI – 400 032
25th June, 2018

To

The Principals of the affiliated Colleges & Directors of the recognized Institutions in Science & Technology Faculty. (Circular No. UG/334 of 2017-18 dated 9th January, 2018.)

A.C/4.55/05/05/2018

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No. UG/44 -A of 2018 MUMBAI-400 032 25th June, 2018

Copy forwarded with Compliments for information to:-

1) The I/c Dean, Faculty of Science & Technology,
2) The Chairman, Board of Studies in Civil Engineering,
3) The Director, Board of Examinations and Evaluation,
4) The Director, Board of Students Development,
5) The Co-Ordinator, University Computerization Centre,

(Dr. Dinesh Kamble)
I/c REGISTRAR

AC
Item No.

UNIVERSITY OF MUMBAI

Revised syllabus (Rev- 2016) from Academic Year 2016 -17
Under

FACULTY OF TECHNOLOGY

Civil Engineering

Third Year with Effect from **AY 2018-19**

As per **Choice Based Credit and Grading System**
with effect from the AY 2016–17

University of Mumbai
Scheme of Instructions and Examination
Third Year Engineering (Civil Engineering)
(With effect from 2018-19) (Semester-V)

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credit Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
CEC501	Structural Analysis – II	4	2		4	1	-	5
CEC502	Geotechnical Engineering – I	3	2	-	3	1	-	4
CEC503	Applied Hydraulics	3	2	-	3	1	-	4
CEC504	Environmental Engineering – I	3	2	-	3	1	-	4
CEC505	Transportation Engineering – I	3	2	-	3	1	-	4
CEDLO506X	Department Level Optional Course-I	3	2	-	3	1	-	4
CE-C507	Business and Communication Ethics	-	4#	-	-	2	-	2
	Total	**19**	**16**		**19**	8		**27**

Course Code	Course Name	Examination Scheme					TW	Pract.	Oral	Total
		Theory								
		Internal Assessment			End Sem	Exam Duration (Hrs.)				
		Test 1	Test 2	Avg						
CEC501	Structural Analysis – II	20	20	20	80	3	25	-	25	150
CEC502	Geotechnical Engineering - I	20	20	20	80	3	25	-	25	150
CEC503	Applied Hydraulics	20	20	20	80	3	25	-	25	150
CEC504	Environmental Engineering – I	20	20	20	80	3	25	-	25	150
CEC505	Transportation Engineering – I	20	20	20	80	3	25	-	25	150
CEDLO506X	Department Level Optional Course-I	20	20	20	80	3	25	-	25	150
CE-C507	Business and Communication Ethics	-	-	-	-	-	25	-	25*	50
	Total	**120**	**120**	**120**	**480**		**175**		**175**	**950**

University of Mumbai
Scheme of Instructions and Examination
Third Year Engineering (Civil Engineering)
(With Effect from 2018-19) (Semester-VI)

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credit Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
CEC601	Geotechnical Engineering-II	3	2	-	3	1	-	4
CEC602	Design and Drawing of Steel Structures	4	2	-	4	1	-	5
CEC603	Transportation Engineering-II	3	2	-	3	1	-	4
CEC604	Environmental Engineering-II	3	2	-	3	1	-	4
CEC605	Water Resources Engineering-I	3	2	-	3	1	-	4
CEDLO606X	Department Level Optional Course-II	3	2	-	3	1	-	4
CEC607	Software Applications in Civil Engineering	-	2	-	-	1	-	1
Total		**19**	**14**	**-**	**19**	**7**	**-**	**26**

Course Code	Course Name	Examination Scheme					TW	Pract.	Oral	Total
		Theory								
		Internal Assessment			End Sem	Exam Duration				
		Test 1	Test 2	Avg						
CEC601	Geotechnical Engineering-II	20	20	20	80	3	25	-	25	150
CEC602	Design and Drawing of Steel Structures	20	20	20	80	4	25	-	25@	150
CEC603	Transportation Engineering-II	20	20	20	80	3	25	-	-	125
CEC604	Environmental Engineering-II	20	20	20	80	3	25	-	25	150
CEC605	Water Resources Engineering-I	20	20	20	80	3	25	-	25	150
CEDLO606X	Department Level Optional Course-II	20	20	20	80	3	25	-	25	150
CEC607	Software Applications in Civil Engineering	-	-	-	-	-	25	-	-	25
Total		**120**	**120**	**120**	**480**		**175**		**125**	**900**

For the course 'Business and Communication Ethics (CE- C507), although 04 (Four) clock hours are mentioned under the head of Practicals, 02 (Two) clock hours out of these 04 (Four) clock hours may be utilized as the Theory at the Institute/ College Level so as to enable the instructor (teacher) to impart the theoretical aspects of the said course. Accordingly, the provision may be made in the Time Table.

* Further, the oral examination in respect of the course 'Business and Communication Ethics (CE-C 507)' will be conducted in conjunction with seminar/ presentation.

@ For the course, Design and Drawing of Steel Structures (CE-C 602), the oral examination will be conducted in conjunction with sketching.

List of Department Level Optional Courses for Vth&VIth Semester

Department Level Optional Course – I (Semester V)		**Department Level Optional Course – II** (Semester VI)	
CE-DLO5061	Advanced Surveying	CE-DLO6061	Advanced Construction Equipments
CE-DLO5062	Advanced Concrete Technology	CE-DLO6062	Traffic Engineering and Management
CE-DLO5063	Building Services and Repairs	CE-DLO6063	Ground Improvement Techniques
CE-DLO5064	Advanced Structural Mechanics	CE-DLO6064	Advanced StructuralAnalysis

Semester V

Subject Code	Subject Name	Credits
CEC501	Structural Analysis-II	5

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorials**	**Total**
4	-	2	4	1	-	5

Theory					Term Work/ Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test 1	Test 2	Average						
20	20	20	80	3 Hrs.	25	-	25	150

Rationale

There are various types of components in civil engineering structures, which are subjected to different types of loading or combinations thereof. The knowledge gained in the subjects such as Engineering Mechanics, Strength of Materials and Structural Analysis -I is extended in this subject. The scope of the subject is to evaluate the response in the form of shear forces, bending moments, axial forces, and displacement parameters in various statically indeterminate structures such as beams, rigid and pin jointed frames. The course involves the concept of the displacement and flexibility approach for analysing the indeterminate structures. The course also involves the analysis of the indeterminate structures using the concept of plastic analysis and approximate analysis.

Objectives

- To revise the various concepts involved in the analyses of the structures studied in the course Structural Analysis-I.
- To analyze the statically determinate structures with reference to the variation in the temperature.
- To understand the concept of static and kinematic indeterminacy (degrees of freedom) of the structures such as beams & rigid pin jointed frames.
- To understand the concepts/ broad methods, sub-methods involved in the analysis of indeterminate structures.
- To apply various methods for analyzing the indeterminate structures to evaluate the response of such structures in the form of bending moment, shear force, axial force etc.
- To study the analyses of frame by approximate method.

Detailed Syllabus

Module	Sub Modules/Contents		Periods
1.	**General**		**04**
	Types of structures occurring in practice, their classification. Stable and unstable structures, static and kinematic determinacy and indeterminacy of structure. Symmetric structures, symmetrical & anti-symmetrical loads, distinction between linear and non-linear behaviors of material and geometric non-linearity. Two hinged arches: Introduction, classification and structural behavior (no numerical).		
2.	**Deflection of statically determinate structures**		**04**
	Introduction to the concept of complimentary energy, absolute & relative deflection caused by loads, temperature changes settlement of supports, application to beams, pin jointed frames, rigid jointed frames.		
3.	**Analysis of indeterminate structures by Force Method**		**14**
	3.1	Application of the Clapeyron's Theorem of Three Moments. Castigliano's theorem of least work. Fixed Beams	
	3.2	Flexibility coefficients and their use in formulation of compatibility equations. Application to propped cantilevers, fixed beams, continuous beam and rigid jointed frames.	
	3.3	Application of flexibility method to simple pin jointed frames including effect of lack of fit for members.	
4.	**Analysis of indeterminate structures by Displacement Methods**		**18**
	4.1	Direct stiffness method: Stiffness coefficients for prismatic members, their use for formulation of equilibrium equations. Application to indeterminate beams & simple rigid jointed frames with inclined member but having only one translation degree of freedom.	
	4.2	Slope deflection method: Development of slope deflection equation, their use for formulation of equilibrium equations. Application to indeterminate beams & simple rigid jointed frames with inclined member but having only one translation	

		degree of freedom including the effect of settlement of supports.	
	4.3	Moment distribution method: Stiffness factor, distribution factor, Application to indeterminate beams & simple rigid jointed frames, having only one translation degree of freedom including the effect of settlement of supports.	
	4.4	Kani's Method: Fundamental equation of Kani's Method, application to simple beams and frames with single storey with two bays	
5.	**Plastic analysis of Steel structures**		**06**
	5.1	Introduction to plastic analysis, Concept of plastic hinge, plastic moment carrying capacity, shape factor.	
	5.2	Determination of collapse load for single and multiple span beams.	
6.	**Approximate Method for Analysis of Building Frames**		**06**
	6.1	Approximate method for gravity loads:Substitute frame method and equivalent frames.	
	6.2	Approximate method for lateral loads:Portal and cantilever method.	
		Total	**52**

Contribution to Outcomes

On completion of this course, the students will be able to:

- Understand the behavior of various statically indeterminate structures subjected to static loads and variation in temperature.
- Analyze the structures using displacement parameters to find out the internal forces such as axial force, shear force, bending moment, twisting moments, etc. for beams, 2D portal frames with various loads and boundary conditions, which becomes the basis for structural design.
- Contrast between the concept of force and displacement methods of analysis of indeterminate structures. Also, the elastic curve in beams and frames under the action of loads.
- Understand the concept of plastic hinge, plastic moment carrying capacity, shape factor and collapse load for single and multiple span beams.
- Find out the approximate dimensions of beams and columns using the approximate method for giving the input in design software. The knowledge gained in this subject shall also be useful for application in the structural design in later years and also useful in the civil engineering field for the analysis purpose.

- Demonstrate the ability to extend the knowledge gained in this subject for their higher years UG Programme subjects such as Advanced Structural Analysis and Advanced Structural Mechanics in which they will be dealing with the indeterminate structures.

Theory examination:

1. The question paper will comprise of **six** questions; each carrying 20 marks.
2. The first question will be **compulsory** and will have short questions having weightage of 4-5 marks covering the entire syllabus.
3. The remaining five questions will be based on all the modules of the entire syllabus. For this, the modules shall be divided proportionately and further, the weightage of the marks shall be judiciously awarded in proportion to the importance of the sub-module and contents thereof.
4. The students will have to attempt any **three** questions out of remaining five questions.
5. Total four questions need to be attempted.

Oral Examination:

The oral Examination shall be based upon the entire syllabus and the term work consisting of the tutorials and assignments.

Term Work:

The term work shall comprise of neatly written report based on tutorials and assignments. The term work shall cover the entire syllabus in such a way that the students would attempt at least four problems on each sub-modules and contents thereof.
At least twenty solved problem have to be validated by using available computer software.

Or

At least ten solved problem (validated by using available computer software) and Analysis of (G+2) portal frame with minimum three bays.

Distribution of the Term Work Marks:

The marks of the term work shall be judiciously awarded depending upon the quality of the term work. Final certification, acceptance of term work warrants a satisfactorily appropriate completion of assignments the minimum passing marks to be obtained by the students. The following weightage of marks shall be given for different components of the term work:

- Assignments: 20 marks

- Attendance: 5 marks

Further, while giving weightage of marks on the attendance, following guidelines shall be resorted to:

75%- 80%: 03 Marks; 81%- 90%: 04 Marks 91% onwards: 05 Marks

Recommended Books:

1. Basic Structural Analysis: C.S. Reddy, Tata McGraw Hill New Delhi.
2. Structural analysis: A Matrix Approach, Pandit and Gupta, Tata McGraw Hill publications.
3. Mechanics of Structures: Vol-I: S. B. Junnarkar and H.J. Shah, Charotar Publishers, Anand.
4. Analysis of Structures: Vol. I and II, Vazirani and Ratwani
5. Basic Structural Analysis: K.U. Muthu, Azmi Ibrahim, I K International publishing house, Pvt. ltd.
6. Theory of Structures: S. Ramamrutham, Dhanpatrai and Sons, Delhi
7. Comprehensive structural analysis (Vol. I and II), Vaidyanathan R., Laxmi publications
8. Structural Analysis: Bhavikatti, Vikas publisher house Pvt, ltd.
9. Structural Analysis: Devdas Menon, Narosa Publishing House.
10. Structural Analysis: L.S. Negi and R.S. Jangid, Tata Mc-Graw Hill India
11. Fundamentals of Structural Analysis: Sujit Kumar Roy and Subrota Chakrabarty, S. Chand Publications.
12. Structural analysis: Mohandas and Bhargab Mohan, Prentice hall international
13. Structural analysis: T. S. Thandavmoorthy, Oxford University Press

Reference Books:

1. Structural Analysis: Hibbler, Pentice Hall International.
2. Structural Analysis: Chajes, ElBS London.
3. Theory of Structures: Timoshenko and Young, Tata McGraw Hill New Delhi.
4. Element of Structural Analysis: Norries and Wilbur, McGraw Hill.
5. Structural Analysis: Laursen H.I, McGraw Hill Publishing Co.
6. Structural theorem and their application: B.G. Neal, Pergaman Press.
7. Structural Analysis: Kassimali, TWS Publications
8. Fundamentals of Structural analysis: K.M. Leet, C.M. Uang and A.M. Gilbert, Tata McGraw Hill New Delhi.
9. Elementary theory of Structures: Heish, Prentice Hall

Semester V

Subject Code	Subject Name	Credits
CEC502	Geotechnical Engineering-I	4

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorials**	**Total**
3	2	-	3	1	-	4

Theory					Term Work/ Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test 1	Test 2	Average						
20	20	20	80	3 Hrs.	25	-	25	150

Rationale

All civil engineering structures rest on ground i.e. supported by soil and rock. Rock is rarely occurring and hence mostly the supporting medium is soil. Hence the stability of structure depends on the stability of supporting medium. Therefore, geotechnical analysis is required to be carried out. Geotechnical analysis depends on the basics of physical properties which are useful for determining the strength, compressibility, drainage etc. The soil mechanics is the basic tool for geotechnical engineering which is the specialized section of civil engineering. Soil is also used as construction material to make various civil structures, viz., dams, embankment etc.Thus, it is very essential to understand various concepts involved in this course of Geotechnical Engineering-I

Objectives

- To study the types of soil and relationships involving the weight, volume and other parameters of soil.
- To study the index properties of soil which is measure of the engineering properties.
- To classify the soil based on different classification systems.
- To study the properties of soil related to flow of water.
- To study the concept of total stress, neutral stress & effective stress in soil.
- To understand the load deformation concept through compaction process.
- To understand the techniques of soil exploration, assessing the subsoil conditions & engineering properties of various strata along with presentation of report.
- To perform different laboratory tests on soil.

Detailed Syllabus

Module	Sub-Modules/ Contents		Periods
1.	**Introduction to Geotechnical Engineering, Basic Definitions & Relationships**		**07**
	1.1	Definitions: Rocks, Soil, origin & mode of formation and type of soil obtained, soil mechanics, rock mechanics, soil engineering, geotechnical engineering	
	1.2	Scope of soil engineering: Importance of field exploration and characterization	
	1.3	Cohesionless & cohesive soils	
	1.4	Soil as three phase& two phase system in terms of weight, volume, void ratio, porosity	
	1.5	Weight-volume relationship: water content, void ratio, porosity, degree of saturation, air voids, air content, different unit weights, specific gravity of solids, and mass, absolute specific gravity.	
	1.6	Relationship between: different unit weights with void ratio, degree of saturation, specific gravity; different unit weights with porosity, void ratio, water content; different unit weights with water content, unit weights air voids.	
	1.7	Mention different methods to find water content, specific gravity, unit weight of soil (Detailed description to be covered during practical)	
2.	**Plasticity Characteristics of soils**		**06**
	2.1	Plasticity of soil: Definition of plasticity of soil, reason of plasticity, consistency of soil, explanation about idea set by Atterberg in defining the three states of soil, definition & determination of liquid limit, plastic limit, shrinkage limit.	
	2.2	Definitions of shrinkage parameters; plasticity index, shrinkage index, liquidity index, consistency index, flow index, toughness index, activity, sensitivity and thixotropy of soils. Use of consistency limits	
	2.3	Explanation about clay minerals e.g. montmorillonite, illite, and kaolinite; there formation and role in producing the plastic behavior in	

		soil	
3.	**Classification of soils**		**06**
	3.1	Necessity of soil classification, Indian standard particle size classification, Indian standard soil classification system as per IS: 1498, boundary classification	
	3.2	Mechanical sieve analysis: wet & dry sieve analysis, combined sieve & sedimentation analysis, Stokes's law, hydrometer method of analysis, relation between percent finer and hydrometer reading. Limitation of sedimentation analysis, particle size distribution curve/gradation curve and its use	
	3.3	Relative density	
4.	**Permeability of soils & seepage analysis**		**10**
	4.1	Introduction about ground water flow: water table, types of aquifers, types of soil water, explanation of surface tension with capillary rise in small diameter tubes, capillary rise in soils	
	4.2	Definition of hydraulic head, hydraulic gradient, Darcy's law, laminar flow through soil, validity of Darcy's law.	
	4.3	Definition of permeability of soil, numerical values for different types of soils, determination of coefficient of permeability of soil in lab using constant head and variable head methods. Determination of in-situ permeability with pumping out and pumping in test. Permeability from indirect methods e.g. empirical equation & from consolidation data	
	4.4	Permeability of stratified soil deposits	
	4.5	Definition of seepage and its importance for the study of analysis & design of hydraulic structures. Derivation of Laplace equation for two-dimensional flow, its analytical solution representation by stream & potential function; Graphical representation by flow net, definition of flow line, equipotential lines, flow channel, field, characteristics of flow net, use of flow net	
	4.6	Solution of Laplace equation by other methods e. g. numerical methods	
5.	**Effective stress principle**		**03**
	5.1	Definition of geostatic stresses, vertical stress/total stress, neutral	

		stress/pore water pressure, effective stress.	
	5.2	Effect of water table fluctuations, surcharge, capillary action, seepage pressure on effective stress; quick sand condition.	
6.	**Compaction of soils & soil exploration**		**07**
	6.1	Theory of compaction, determination of Optimum Moisture Content (OMC) & Maximum Dry Density (MDD) in laboratory by conducting the light and heavy compaction test.	
	6.2	Factors affecting the compaction, effect of compaction on properties of soil, relative compaction	
	6.3	Necessity of soil exploration, methods of investigation, methods of boring, types of soil samples, soil samples sampling, number and spacing of bore holes, depth of bore holes.	
	6.4	Penetrometers tests: SPT, SCPT, and DCPT.	
	6.5	Representation of data with borehole logs.	
		Total	**39**

Contribution to Outcomes

With the completion of this course, the students will be able to:

- Understand the soil types, index and engineering properties and relationship between various unit weights & other parameters.
- Classify the soil with a view towards assessing the suitability of a given soil for use; either to use if to support a structure (e.g. embankment) or to construct a structure therein (e.g. foundation)
- Understand the use of geosynthetics in soil to improve soil properties.
- Evaluate the compaction characteristics in laboratory & field and hence interpret the results with compaction specifications.
- Interpret soil boring data for foundation design.
- Conduct laboratory experiments to collect, analyze, interpret and present the data

Theory Examination:

1. Question paper will comprise of **six** questions: each having 20 marks.
2. The **first** question will be **compulsory** will have the short questions having weightage of 4-5 marks covering the entire syllabus.

3. The **remaining 5** questions will be based on all the modules of entire syllabus. For this module shall be divided proportionately further, the weightage of the marks shall be judiciously awarded in proportion to the importance of the sub-module contents thereof.
4. There can be an internal choice in various sub-questions/questions in order to accommodate the questions on all the topics/sub-topics.
5. The students will have to attempt **any three** questions out of **remaining 5** questions.
6. **Total four** questions need to be attempted.

Oral Examination:

The oral examination shall be based upon the entire syllabus and the term work consisting of the report of experiments performed in the laboratory and assignment.

List of Experiments/Practical: (At least 10 to be performed)

1. Determination of natural moisture content using oven drying method

Following other methods to find moisture content shall be explained briefly:

a) Pycnometer method
b) Sand bath method
c) Alcohol method
d) Torsional balance method
e) Radio activity method
f) Moisture meter

2. Specific gravity of soil grains by density bottle method or pycnometer method
3. Field density using core cutter method
4. Field density using sand replacement method
5. Field identification of fine grained soils
6. Grain size distribution by sieve analysis
7. Grain size distribution by hydrometer analysis
8. Determination of liquid & plastic limit
9. Determination of shrinkage limit
10. Liquid limit by cone penetrometer method
11. Permeability using constant head method
12. Permeability using falling head method
13. Compaction test, IS light compaction test/ Standard Proctor test
14. Compaction test, IS heavy compaction test/ Modified Proctor test

15. Relative density test

Term Work:

a) The term work shall be comprised of the neatly written report based on the experiments performed in the laboratory as well as assignments. The assignments shall be given covering the entire syllabus in such a way that the students would attempt at least two problems on each modules/ sub-module content thereof further.

b) One assignment should be given on Geosynthetics. The teacher is expected to deliver extra lectures on geosynthetics for the entire class, thereby conveying the importance of the same to the students. The questions related to this concept shall not be asked in the theory examination. However, it shall be treated as a part of term work submission. It shall preferably cover the following points:

- Definition of geosynthetics, types of geosynthetics: geotextiles, geogrids, geo cells, geomembranes, geo composites; types of geotextiles: woven and non-woven etc.; physical properties: apparent opening size (AOS), specific gravity, mass per unit area, thickness; basic hydraulic properties: permittivity, transmissivity of geotextile
- Filter design criteria for graded soil & geotextile filters

Distribution of Term-work Marks

The marks of the term work shall be judiciously awarded depending upon the quality of the term work, assignments, and experiment reports. The final certification acceptance of term work warrants the satisfactory and appropriate completion of assignments the minimum passing marks to be obtained by the students. The following weightage of marks shall be given for different components of the term work.

- Report of the Experiments : 10 Marks
- Assignments : 10 Marks
- Attendance : 05 Marks

Further, while giving weightage of marks on the attendance, following guidelines shall be resorted to:

75%- 80%: 03 Marks; 81%- 90%: 04 Marks 91% onwards: 05 Marks

Recommended Books:

1. Soil Engineering in Theory and Practice; *Alam Singh,* CBS Publishers Distributors, New Delhi
2. Soil Mechanics and Foundation Engineering: *V. N. S. Murthy*; Saitech Publications

3. Soil Mechanics and Foundation Engineering: *K. R. Arora*; Standard Publishers and Distributors, New Delhi
4. Soil Mechanics and Foundations: *Dr. B. C. Punmia, Ashok Kumar Jain, Arun Kumar Jain*; Laxmi Publications, New Delhi
5. Geotechnical Engineering: *C. Venkatramaiah*; New Age International
6. Fundamentals of Soil Engineering; *D. W. Taylor*, Johm Wiley & Sons.
7. An Introduction to Geotechnical Engineering: *R. D. Holtz*, Prentice Hall, New Jersy
8. Soil Mechanics: *R. F. Craig*, Champion & Hall
9. Soil Mechanics: *T. W. Lambe, R. V. Whitman*, Johm Wiley & Sons.
10. Designing with Geosynthetics: *R. M. Koerner*, Prentice Hall, New Jersy.
11. An Introduction to soil reinforcement geosynthetics: *G. L. Sivakumar Babu*, Universities Press.
12. Relevant Indian Standard Specifications Codes, BIS Publications, New Delhi.

Semester V

Subject Code	Subject Name	Credits
CEC503	Applied Hydraulics	4

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorials**	**Total**
3	2	-	3	1	-	4

Theory					Term Work/ Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test 1	Test 2	Average						
20	20	20	80	3 Hrs.	25	-	25	150

Rationale

The knowledge of this course is essential to understand facts, concepts and design parameters of dynamics of fluid flow, application of momentum equation in lawn sprinklers and pipe bends, dimensional analysis and impact of jets. Further it helps to understand the design aspects, components, function and uses of centrifugal pump, turbines and design of open channels and flow through open channels.

Objectives

- To introduce the concept of dynamics of fluid flow and dimensional analysis
- To study hydraulic machines like centrifugal pumps, reciprocating pumps and turbines.
- To study the mathematical techniques used in research work for design for conducting model tests.
- To impart the dynamic behavior of the fluid flow analyzed by the Newton's second law of motion.
- To understand the uniform and non-uniform flow through open channels.
- To study design of open channel and understand concept of surface profile with hydraulic jump.

Detailed Syllabus

Module	Sub-Modules/ Contents	Periods
1.	**Dynamics of Fluid Flow**	**04**
	Momentum principle (applications: pipe bends), moment of momentum equation (applications: sprinkler).	

2.	**Dimensional Analysis:**		**05**
	Dimensional homogeneity, Buckingham's π theorem, Reyleigh's method, dimensionless numbers and their significance, Model (or similarity) laws, application of model laws: Reynold's model law, Froude's model law, scale effect in models.		
3.	**Impact of Jets:**		**06**
	Introduction, force exerted on stationary flat plate: held normal to jet, held inclined to jet, curved plate: symmetrical and unsymmetrical (jet striking at centre tangentially), jet propulsion of ships.		
4.	**Hydraulic Turbines:**		**08**
	General layout of hydro-electric plant, heads, efficiencies of turbine, classification, working of Pelton Wheel Turbine, Reaction Turbine, Francis Turbine, Kaplan Turbine (excluding velocity triangle diagram) and draft tube theory, specific speed, unit quantities, Characteristic curves, Cavitation.		
5.	**Centrifugal pumps:**		**06**
	Work done, heads, efficiencies, Minimum speed: series parallel operation, Multistage pumps, specific speed, model testing, priming, characteristic curves, cavitation (Excluding velocity triangle). Brief introduction to reciprocating pump.		
6.	**Flow through open channels**		**10**
	6.1	Uniform Flow: Flow through open channel: Definition, types of channels, Types of flows in channels, Prismatic, non-prismatic channels, Uniform flow: steady flow and unsteady flow, laminar and turbulent flow, subcritical flow, supercritical flow, Chezy's formula, Manning's formula, hydraulically efficient channel cross-section (most economical section).	
	6.2	Non-Uniform Flow: Specific energy and specific energy curve, Dimensionless specific energy discharge curve, applications of specific energy and Momentum principle to open channel flow, specific force. Hydraulic jump and standing wave. Gradually varied flow, equation for gradually varied flow, back water curve and afflux, Introduction to surface profiles.	
		Total	**39**

Contribution to Outcomes

On completion of this course the student will be able to:

- Apply the concepts of fluid dynamics to solve pipe bend and sprinkler problems.
- Analyze dimensional problems and explain model laws.
- Explain the working and functions of Francis, Kaplan and Pelton wheel turbines.
- Explain the basic concepts of open channel hydraulics and measure discharge through open channels.
- Identify the occurrence of hydraulic jump and its parameters
- Explain uniform flow, non-uniform flow and establish mathematical relationships.

Theory Examination:

1. The question paper will comprise of **six** questions; each carrying 20 marks.
2. The **first** question will be **compulsory** and will have short questions having weightage of 4-5 marks covering the entire syllabus.
3. The **remaining five** questions will be based on all the modules of the entire syllabus. For this, the modules shall be divided proportionately and further, the weightage of the marks shall be judiciously awarded in proportion to the importance of the sub-module and contents thereof.
4. The students will have to attempt **any three** questions **out of remaining five** questions.
5. **Total four** questions need to be attempted.

Oral Examination:

The oral examinations shall be based on the entire syllabus, the report of the experiments conducted by the students including assignments.

List of Experiments (Any six):

1. Impact of jet on flat plate/inclined plate/curved plate.
2. Performance of Pelton wheel- full gate opening.
3. Performance of Centrifugal pumps.
4. Performance of Kaplan turbine.
5. Performance of Francis turbine.
6. Determination of Chezy's roughness factor.
7. Study of gradually varied flow.
8. Study of hydraulic jump and its characteristics.

9. Calibration of Venturiflume/Standing wave flume.

Term Work:

The term work shall comprise of the neatly written report based on the afore-mentioned experiments and assignments. The assignments shall comprise of the minimum 20 problems covering the entire syllabus divided properly module wise.

Distribution of the Term Work Marks:

The marks of the term work shall be judiciously awarded for the various components of the term work and depending upon the quality of the term work. The final certification and acceptance of term work warrants the satisfactory performance of laboratory work by the student, appropriate completion of the assignments. The following weightage of marks shall be given for different components of the term work.

- Report of the Experiments: 10 Marks
- Assignments: 10 Marks
- Attendance: 05 Marks

Further, while giving weightage of marks on the attendance, following guidelines shall be resorted to: 75%- 80%: 03 Marks; 81%- 90%: 04 Marks 91% onwards: 05 Marks

Recommended Books:

1. Hydraulics and Fluid mechanics: *Dr P.M. Modi* and *Dr. S.M. Seth*, Standard Book House, Delhi
2. Theory and Application of Fluid Mechanics: *K. Subramanya*, Tata McGraw hill publishing company, New Delhi.
3. Fluid Mechanics: *A.K Jain*, Khanna Publishers.
4. Fluid Mechanics and Hydraulics: *S.K. Ukarande*, Ane's Books Pvt. Ltd. (Revised Edition 2012), ISBN 97893 8116 2538
5. Fluid Mechanics and fluid pressure engineering*: D.S. Kumar, F.K. Kataria* and sons 6. Fluid Mechanics: *R.K. Bansal*, Laxmi Publications (P) Ltd.
6. Flow in Open Channels: *K. Subramanya*; Tata Mc-Graw Hill Publishing House Pvt. Ltd.
7. Irrigation and Water Power Engineering: *B. C. Purnnia*.; Standard Publishers, New Delhi

Reference Books:

1. Fluid Mechanics: *Frank M. White*, Tata Mc-Graw Hill International Edition.
2. Fluid Mechanics: *Streeter White Bedford*, Tata Mc-Graw International Edition.

3. Fluid Mechanics with Engineering Applications: *R.L. Daugherty, J.B. Franzini, E.J. Finnemore*, Tata Mc-Graw Hill, New Delhi.
4. Hydraulics: James F. Cruise, *Vijay P.Singh and Mohsen M. Sherif*, CENGAGE Learning India (Pvt.) Ltd.
5. Introduction to Fluid Mechanics: *Edward J. Shaughnessy, Jr, Ira M. Katz, James P. Schaffer*. Oxford Higher Education.

Semester V

Subject Code	Subject Name	Credits
CEC504	Environmental Engineering-I	4

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorials**	**Total**
3	2	-	3	1	-	4

Theory					Term Work/ Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test 1	Test 2	Average						
20	20	20	80	3 Hrs.	25	-	25	150

Rationale

Environmental engineering is important for all human endeavours not simply about construction within the environment. This subject lays emphasis on the practical application of knowledge, while at the same time recognizing the importance of theoretical knowledge in developing the intellectual capacity of the engineer. Knowledge of this subject is useful for planning, designing, execution monitoring water supply sanitary schemes for the towns/cities. The scope of the subject is also solves the issues related to air and noise pollution.

Objectives

- To prepare students who can accomplish planning, design and construction of water systems and related infrastructural facilities.
- To provide the necessary knowledge on quality of water, concepts in the field of water supply and treatment.
- To impart necessary skill for the design and operation of water treatment plants also to prepare students for higher studies and research in the field of water treatment technology.
- To introduce new developments in the field of water treatment and to inculcate the students with sound theoretical knowledge in engineering sciences as well as in research consultancy skills.
- To give a practical oriented knowledge so that they can give the practical solutions to environmental problems in the society and alsoto provide basic understanding of air pollution and monitoring.
- To impart positive responsive vocational attitudes, initiative creative thinking in their mission as an Engineers. Also provide the basic understanding of noise pollution

Detailed Syllabus

Module		Sub Modules / Contents	Periods
1		**Water Supply and Distribution of Water** Water resources, Water supply systems, distribution systems of water, types of intake structures, water demands.	03
2		**Quality of Water** Wholesomeness and palatability, physical, chemical, Biological standards. Treatment of water,drinking water standards, environmental chemistry, Eutrophication, Primary, Secondary and Tertiary treatment of water. Typical water treatment flow diagram.	04
3	**3.1**	**Aeration and Sedimentation** Aeration, Types of Aeration systems, Theory and factors affecting efficiency of sedimentation, design of sedimentation tank and tube settlers	04
	3.2	**Coagulation and flocculation** Mechanisms, common coagulations, rapid mixing and flocculating devices, Jar test, coagulant aids – PAC.	06
	3.3	**Filtration** Classification, slow and rapid sand filters, dual media filters, under drainage system, mode of action, cleaning, limitations, operational difficulties, performance, basic design consideration, head loss in filters and numerical on head loss, pressure filters: construction and operation.	05
	3.4	**Water Softening** Lime soda and base exchange methods, Principle reactions, design considerations, sludge disposal.	02
	3.5	**Disinfection** Chlorination, chemistry of chlorination, kinetics of disinfection, chlorine demand, free and combined chlorine, break point chlorination, super chlorination, dechlorination, chlorine residual, uses of iodine, ozone, ultra violet rays and chlorine dioxide as disinfectants, well water disinfection	03
	3.6	**Advanced and Miscellaneous Treatments** Reverse Osmosis, Activated carbon, Membrane filtration, Removal of Iron and Manganese, taste, odour and colour, principles and methods, de-fluoridation	03
4	**4.1**	**Building Water supply** Introduction – Per Capita Supply, Determination of storage capacity, Service connection from main, water meter	02
	4.2	**Sanitary Fixtures** Sanitary Fixtures and fittings: Introduction, classification of fixtures, soilfixtures, bathroom accessories, special accessories, fittings	

5		**Rainwater Harvesting** Need for rainwater harvesting, Annual potential, Collection of rain water for direct use or ground water recharge, Roof-top rain water harvesting	02
6	**6.1**	**Air Pollution**: Air-Composition and properties of air, Quantification of air pollutants,Monitoring of air pollutants, Air pollution- Occupational hazards, Urban air pollution-automobile pollution, Air quality standards, Control measures for Air pollution, construction and limitations	03
	6.2	**Noise**-Basic concept, measurement and various control methods. Thermal pollution.	02

Contribution to Outcomes

After completion of the course the student will be able to:

- Understand the water supply system, its components and water demand by various consumers
- Understand and analyze the quality of water and will be able to conduct the quality control test on samples.
- Understand the different processes in the water treatment facility.
- Design the different units of treatment for water treatment plants.
- Understand the components of building water supply system, storage and rain water harvesting
- Understand the problems of air and noise pollution. Besides, they will be prepared to contribute practical solutions to environmental problems in our society.

Theory Examination:

1. Question paper will comprise of six questions; each carrying 20 marks.
2. The first question will be compulsory which the short questions will have having weightage of 4-5 marks covering the entire syllabus.
3. The remaining five questions will be based on all the modules of entire syllabus. For this, the module shall be divided proportionately further, the weightage of the marks shall be judiciously awarded in proportion to the importance of the sub-module contents thereof.
4. The students will have to attempt any three questions out of remaining five questions.
5. Total four questions need to be attempted.

List of Practicals: (Any eight to be performed)

1. Determination of pH of Water.
2. Determination of Alkalinity in water.
3. Determination of Hardness in water.
4. Determination of Turbidity in water.
5. Determination of Optimum dose of coagulant by using Jar Test Apparatus.
6. Determination of Dissolved Oxygen.
7. Determination of Residual chlorine in water.
8. Determination of chlorides in water.
9. Most probable Number.
10. High Volume Sampler.
11. Determination of Level equivalent of Noise.

Site Visit:

The students will visit the Water Treatment Plant in the nearby vicinity or in the city and prepare detailed report thereof. This report will form a part of the term work.

Mini Project: (Any one)

A mini project shall comprise of

1. Design a basic plumbing system for water supply for residential/commercial building.
2. A case study for any existing structure.
3. Model making.
4. Software based design of water distribution system.

Term Work:

The term-work shall comprise of the neatly written report based on the experiments performed in the laboratory and Mini Project report. A detailed report on the visit to water treatment plant will also be submitted as a part of the term work.

Oral Examination:

Oral examination will be based on entire syllabus and the afore-mentioned term work.

Distribution of the Term Work Marks:

The marks of the term work shall be judiciously awarded for the various components depending upon the quality of the term work. The final certification acceptance of term work warrants the satisfactory performance of the experiments by the student, properly compiled report thereof and the report on the site visit and the minimum passing marks to be obtained by the student.

The following weightage of marks shall be given for different components of the term work.

- Assignments & Experiments: 05 Marks
- Internal Oral examination based on Experiments and Assignments: 05Marks
- Mini Project: 10 Marks
- Attendance: 05 Marks

Further, while giving weightage of marks on the attendance, following guidelines shall be resorted to: 75%- 80%: 03 Marks; 81%- 90%: 04 Marks; 91% onwards: 05 Marks

Recommended Books:

1. Water Supply and Sanitary Engineering: S.K. Hussain, Oxford & IBH Publication, New Delhi.
2. Manual on Water Supply and Treatment, (latest Ed.): Ministry of Urban Development, New Delhi
3. Plumbing Engineering Theory and Practice: S.M. Patil, Seema Publication, Mumbai.
4. Water Supply and Sewage: E.W. Steel, McGraw Hill, New York.
5. Water Supply and Sewage: T.J. McGhee, McGraw Hill, New York.
6. CPHEEO Manual on Water Supply and Treatment.
7. Water Supply Engineering: P.N. Modi, Rajsons Publication.
8. Water Supply Engineering: S. K. Garg, Khanna Publication.
9. Environmental Engineering (Vol. II)- Sewage Dispoal and Air Pollution Engineering: S. K. Garg, Khanna Publication
10. Introduction to Environmental Engineering: Vesilind, PWS Publishing company.
11. Water supply and pollution control: J.W. Clark, W. Veisman, M.J. Hammer, International textbook company.
12. Relevant Indian standard specifications.
13. Environmental Pollution: Gilbert Masters.
14. Basic Environmental Engineering: J.A. Nathanson, Prentice Hall of India.
15. Environmental Engineering: Sincero And Sincero.

16. Air pollution: *M. N Rao.*, Tata Mc Graw Hill, New Delhi.

Semester V

Subject Code	Subject Name	Credits
CEC505	Transportation Engineering-I	4

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorials**	**Total**
3	2	-	3	1	-	4

Theory					Term Work/ Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test 1	Test 2	Average						
20	20	20	80	03 Hrs.	25	-	25	150

Rationale

Transportation contributes to the economical, industrial, social and cultural development of any country. The adequacy of transportation system of a country indicates its economic and social development. Three basic modes of transportation include land, water and air. The land mode further gives rise to highways and railways. The highways owing to its flexibility in catering door-to- door service forms one of the important modes. This course deals with the investigation, planning, design, construction and maintenance of highways for urban and rural areas. This course also deals with the planning, operation and control of the traffic.

Objectives

- To give insight of the development in the field of highway engineering, right from inception up to construction and maintenance and to familiarize the students with different surveys required to be carried out for the implementation of the highway project.
- To enable the students to understand the phase of engineering which deals with the planning and geometrics design of streets, highways and abutting land and with traffic operations thereon w.r.t. safe, convenient and economic transportation of people and goods.
- To enable the students to understand the properties of the different materials to be used in the construction of highways and other allied structures, characterize the materials and evaluate their suitability; to understand the principle of soil stabilization along with its significance and different types of stabilization techniques; and also, to study the concept of reinforced soil in the construction of highway and allied structures.

- To enable the students to understand the classification and behaviour of different types of pavements, factors to be considered in the design of pavements, approaches for designing the different types of pavements and design methodologies for design of different types of pavements.
- To study the various methods of construction of different types of pavements including semi-rigid pavements and composite pavements, to study the different types of distresses in pavements, evaluation of existing pavements and methods to strengthen the distressed pavements, low volume and low-cost road and also to understand the significance of the drainage in the field of highway engineering including different methods of providing the drainage in the highways.

Detailed Syllabus

Module	Sub-Modules/ Contents		Periods
1.	**Highway Planning and Development/ Highway Alignment and Surveys**		**03**
	1.1	Classification of roads based on the different criteria; brief history of road developments in India; present status of roads development Programme in the country in India including different programmes being executed by various agencies.	
	1.2	Highway alignment, basic requirement of ideal alignment, factors governing highway alignment.	
	1.3	Different types of surveys for Highway location survey, map study, reconnaissance, topographic surveys, highway alignment in hilly area, drawing report preparation.	
2.	**Geometric Design of Highway**		**07**
	2.1	Terrain classification, vehicular characteristics, highway cross section elements, salient dimensions, clearances, width of carriage way, shoulders, medians, width of road way, right of way, camber along with its profile (IRC Standards).	
	2.2	Design speed, sight distance, perception time, break reaction time, analysis of safe sight distance, analysis of overtaking sight distance, intersection sight distance.	
	2.3	Horizontal curves: design of super elevation, its provisions, minimum radius of horizontal curves, widening of pavement, transition curves.	
	2.4	Gradients: Different types of gradients (maximum, minimum, ruling, exceptional) grade compensation in curves, vertical curves: design factors, comfort sight distance, summit curve, valley curve.	

3.	**Traffic Engineering**		**05**
	3.1	Different Traffic Studies: Speed Studies (Spot Speed and Speed and Delay Studies), Traffic Volume, Parking Studies, Significance/ applications of these studies; different methods of conducting traffic studies, Methods of the presentation of data.	
	3.2	Introduction to relationship between Speed, density and volume; Capacity: Different types and factors affecting the capacity, concept of Passenger Car Units (PCU) and Level of Service (LoS).	
	3.3	Introduction to different types of Traffic Control Devices: Traffic signs, signals (no design), road marking.	
	3.4	Different types of intersections: At grade and grade separated; grade separated interchanges; rotary intersections.	
4.	**Highway Materials**		**06**
	4.1	Subgrade materials: desirable properties, modulus of elasticity, modulus of subgrade reaction, classification of subgrade soils, different strengths, various tests to be conducted to evaluate the suitability of the soil as the highway material.	
	4.2	Subcase material: desirable properties, different tests to be conducted on aggregate, requirement of aggregate for different types of pavements.	
	4.3	Bituminous materials: types of bituminous material, test on bituminous material, desirable properties, grade of bitumen.	
	4.4	Soil Stabilization: Significance; principle of soil stabilization; different methods of soil stabilization, use of Geosynthetics in highways and allied structures.	
5	**Highway Pavement Design**		**09**
	5.1	Types of pavements: Flexible, Rigid, Semi-Rigid and composite; comparison between them vis-à-vis based on the structural behavior and other parameters; Factors affecting design of pavements including traffic factors (Design wheel load, equivalent single wheel load, equivalent wheel load factor/VDF)	
	5.2	Flexible pavement: Various approaches of designing the pavement and methods falling under each category (theoretical, semi-theoretical or semi-empirical, empirical, mechanistic empirical and methods based on	

		road performance); Overview of the method prescribed by IRC along with the modifications incorporated therein time to time (IRC: 37- 1970, 1984, 2001 and 2012); Design of the pavement using IRC: 37- 2001 andIRC: 37- 2012 with a more emphasis on latest IRC Code); Introduction to the design of low volume flexible pavement (IRC: SP 72-2007/2015 and IRC: 77-2008).	
	5.3	Rigid Pavements: Introduction to the different types rigid pavements (plain jointed, plain jointed reinforce, continuous reinforced, fiber reinforced, roller compacted concrete); Analysis of the stresses to be developed in the pavement (wheel load, warping and frictional); critical combination of the loading; Overview of the various approaches (Analytical, Empirical and Mechanistic empirical) of designing the pavements and methods falling under the respective category; overview of the methods prescribed by IRC along with modifications incorporated therein time to time (IRC: 58-1974, 58-1988; 58-2002 and 58-2015); Design of plain jointed rigid pavements (IRC: 58- 2002 and IRC: 58- IRC: 58- 2015 with more emphasis on IRC: 58-2015) including design of joints; Introduction to the design of low volume rigid pavement using (IRC: SP- 62-2004 andIRC: SP- 62-2014)	
	5.4	Types of pavements: Flexible, Rigid, Semi-Rigid and composite; comparison between them vis-à-vis based on the structural behavior and other parameters; Factors affecting design of pavements including traffic factors (Design wheel load, equivalent single wheel load, equivalent wheel load factor/VDF)	
6.	**Highway Construction/ Drainage/ Rehabilitation and maintenance**		**09**
	6.1	Construction of different types of roads: Introduction to the water bound	

		macadam (WBM), wet mix macadam (WMM), bituminous pavements, plain jointed cement concrete pavements and along with various joints (as per IRC/ MORTH specifications), jointed reinforced, continuously reinforced; fiber reinforced, roller compacted concrete pavements.	
	6.2	Pavement failure: Classification of distresses in pavements (functional and structural); different types of distresses in flexible and rigid pavements along with the causes and remedial measures; various types of maintenance pavements; evaluation of pavements: functional and non-destructive evaluation of pavement, various equipment used in evaluation of pavements along with their principles (Profilometer, bump integrator, Benkelman beam, lacroixdeflectograph, falling weight deflectometer) and utility in the evaluation.	
	6.3	Strengthening of existing pavement: Objective of strengthening, different types of overlay, design of flexible overlays on flexible pavement using effective thickness approach, and deflection approach resorting to Benkelman Beam method (IRC: 81-1981) and Mechanistic Empirical approach using deflection (IRC: 81-1997); Introduction to the design of other types of overlays.	
	6.4	Highway drainage: Necessity/ Significance, mode of ingress of water in highway structure, Different methods of drainage- surface and subsurface drainage inkling for the roads in hilly areas.	

On successful completion of the course, the students shall be able:

- To get an insight of the development in all the fields of highway engineering and familiarized with different surveys required to be carried out for the implementation of the highway project; to understand the phase of engineering which deals with the planning and geometrics design of streets, highways and abutting land in the context of safe and convenient traffic operations thereon.
- To know the required properties of the different materials to be used in the construction of highways and other allied structures, to understand characterization of the materials and to evaluate their suitability; understand the principle of soil stabilization, utilization of geosynthetics in the construction of highway and allied structures

- To understand the classification of different types of pavements, factors to be considered in the design of pavements, approaches for designing the different types of pavements and can the flexible and rigid pavements be using IRC Specifications.

Contribution to the Outcomes

- To get an insight into the methods of construction of different types of pavements; along with the importance of highway drainage and various methods of providing the drainage; also, to understand the elements of bridge engineering.
- To understand different distresses in the pavements, evaluate the pavements in terms of its functional and structural adequacy and arrive upon the rehabilitation measures.
- To study the different types of distresses in pavements, evaluation of existing pavements and methods to strengthen the distressed pavements, low volume and low-cost road and also to understand the significance of the drainage in the field of highway engineering including different methods of providing the drainage in the highways.

Theory Examination:

1. Question paper will comprise of **six** questions; each carrying 20 marks.
2. The **first** question will be **compulsory** which the short questions will have having weightage of 4-5 marks covering the entire syllabus.
3. The **remaining five** questions will be based on all the modules of entire syllabus. For this, the module shall be divided proportionately further and the weightage of the marks shall be judiciously awarded in proportion to the importance of the sub-module contents thereof.
4. There can be **an internal choice** either in the main question or sub-question to accommodate the contents of all the modules.
5. The students will have to attempt **any three** questions **out** of **remaining five** questions.
6. **Total four** questions need to be attempted.

Oral Examination:

The oral examinations shall be based on the entire syllabus the report of the experiments conducted by the students including assignments and the Traffic Survey Report.

List of practicals:

Although it is recommended that 12 experiments are desirable, at least nine should be performed.

1. Impact test on aggregates
2. Abrasion test on aggregates
3. Crushing test on aggregates
4. Shape test on aggregates
5. Soundness test
6. Polished stone value test
7. Stripping value or bitumen adhesion test (water sensitivity)
8. Penetration test on bitumen
9. Ductility test on bitumen
10. Softening point test on bitumen
11. Viscosity test on bitumen
12. Flash point and fire point test on bitumen
13. Marshall stability test on the bituminous mix
14. CBR test on subgrade soil material (Laboratory or Field)
15. Plate bearing test on subgrade soil

Term Work:

The term-work shall comprise of the neatly written report based on the afore-mentioned experiments and the assignments. There shall be at least 10 assignments which will comprise of numerical problems and lay-out sketches, covering the entire syllabus divided properly module wise. In addition to this, the students shall conduct any one of the traffic surveys and will prepare a detail report thereof. This report shall also form a component part of the term work.

Distribution of Term Work Marks:

The marks of the term work shall be judiciously awarded for the various components depending upon the quality of the term work. The final certification acceptance of term work warrants the satisfactory performance of drawing work by the student, appropriate completion of the report on the said drawing sheets minimum passing marks to be obtained by the student. The following weightage of marks shall be given for different components of the term work.

- Report of the Experiments: 08 Marks
- Assignments: 08 Marks
- Traffic Study Report: 04 Marks
- Attendance: 05 Marks

Further, while giving weightage of marks on the attendance, following guidelines shall be resorted to: 75%-80%: 03, Marks: 81%-90%: 04, Marks: 91% onwards: 05 Marks.

Recommended Books:

1. Highway Engineering: *Khanna, S.K., Justo, C. E. G. and Veeraraghavan A*; Nem Chand and Bros., Roorkee (Revised 10th Edition)
2. Principles and Practice of Highway Engineering: *Kadiyali, L. R.*; Khanna Publishers, Delhi
3. A Text Book of Highway and Traffic Engineering: *Saxena, Subhash Chandra*; CBS Publishers and Distributors (2014)
4. A Text Book of Highway Engineering: *Sriniwasakumar, R.*; University Press, Hyderabad (First Published in 2011; Reprinted in 2013)
5. Transportation Engineering (Vol.-I)- Highway Engineering: *Venkatramaiah, C.*; University Press, Hyderabad (2016).
6. Principles of Transportation and Highway Engineering, *Rao, G.V.;* Tata McGraw Hill Publishing House Pvt. Ltd., New Delhi.
7. Principles, Practice and Design of Highway Engineering (Including Airport Engineering): *Sharma, S.K.;* S. Chand and Company Pvt. Ltd., New Delhi.
8. Principles of Transportation Engineering:*Chakrabory, Partha and Das, Animesh*; Prentice Hall India Learning Pvt. Ltd., New Delhi (Eighth Printing: January 2013).

Reference Books:

1. Transportation Engineering and Planning: *Papacostas, C.S. and Prevedouros, P.D.*; Prentice Hall India Learning Pvt. Ltd., New Delhi.
2. Transportation Engineering: *Khisty, C.J. and Lall, Kent, B.;* Prentice Hall India Learning Pvt. Ltd., New Delhi.
3. Traffic Engineering and Transport Planning: *Kadiyali, L.R.*, Khanna Publishers, Delhi
4. Pavement Design: *Srinivasakumar, R*; University press, Hyderabad (First vPublished 2013; Preprinted in 2015).
5. Highway Material and Pavement Testing*: Khanna, S.K., Justo, C.E.G. and Veeraragavan, A.;* Nem Chand and Bros., Roorkee, India.

Additional Reading

Relevant specifications of Bureau of Indian Standards for Highway Material Testing, Indian Roads Congress (IRC) and Ministry of Road Transport and Highways (MoRTH) w.r.t. Planning related aspects in the context of Highway Geometrics/ Traffic Planning/ Pavement Design and Highway Construction)

Note: Some of the recent specifications may not have been incorporated in few books. For this, titles of multiple books are given in the list of the Recommended Books. The latest editions shall be used. In addition to this, relevant specifications/ codes shall be referred to.

Semester V

Subject Code	Subject Name	Credits
CE-DLO5061	Departmental Elective-I: Advanced Surveying	4

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorials**	**Total**
3	2	-	3	1	-	4

Theory					Term Work/ Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test 1	Test 2	Average						
20	20	20	80	03 Hrs.	25	-	25	150

Rationale

This is an advanced course which is intended to teach students applications of modern surveying instruments with their principles and uses in surveying for different civil engineering works. Students are exposed to the concept of Total Station, G.P.S., G.I.S. and Remote Sensing techniques. To make the students acquainted with the field problems, a forming a group not less than 2 and more than 4 based on use of Geospatial tools for tackling problems on any one stream viz., disaster management, construction management, project management, town planning, urban planning management and policy, water resources, utility mapping, land resource management etc.

Objectives

On completion of the course, the learners will be able to:

- Operate Total Station & GPS for desired accuracy in surveying.
- Establish survey control of determined accuracy using Total Station, GPS, GIS and remote sensing.
- Stake out the designed data by using modern high precision survey instruments.
- Generate and manipulate field survey data and incorporate design data using specialized softwares.
- Critically evaluate the use of advanced positioning instrumentation for surveying and setting out.
- Apply GIS for solving civil engineering problems

Detailed Syllabus

Module	Sub-Modules/ Contents		Periods
1	**Modern Surveying Equipment**		**4**
	1.1	Introduction.	
	1.2	Electronic Distance Measuring Instrument (EDMI), Lasers in Surveying	
	1.3	Electronic Theodolite, Total Station and Scan Station	
2	**Global Positioning System**		**8**
	2.1	Basics of GPS, Positioning using Satellites, GPS Principles, GPS receivers, GPS principles	
	2.2	GPS Errors and Accuracy Error sources in GPS observations Satellite geometry and Accuracy measures	
	2.3	GPS Measurements Techniques GPS Algorithms/Navigational Solutions Other Satellite navigation Systems and GPS Modernization	
	2.4	Civil Engineering Application of GPS	
3	**Photogrammetry**		**6**
	3.1	Introduction. Geometry of vertical photographs Geometry of tilted photographs, Photogrammetric terms; Applications; Type of photographs; Perspective geometry of near vertical and tilted photographs, heights and tilt distortions;	
	3.2	Flight planning; Stereoscopy, base lining, floating marks, parallax equation and stereo measurements for height determination; Developments in photogrammetry: analogue, analytical and digital methods; photogrammetric instruments.	
	3.3	Civil Engineering Application of Photogrammetry	

4	**Remote Sensing**		**10**
	4.1	Introduction Physical basis of remote sensing- Electro-magnetic radiation (EMR)- nature, nomenclature and radiation laws; Interaction in atmosphere- nature, its effects in various wavelength regions, atmospheric windows; Interaction at ground surface- soils and rocks, vegetation, water, etc.; Physical basis of remote sensing (Radiometry)	
	4.2	Geometric basis of interaction. Platform and sensors- Terrestrial, aerial and space platforms; Orbital characteristics of space platforms, sun- and geo-synchronous; Sensor systems- radiometers, optomechanical and push broom sensor; Resolution- spectral, spatial, radiometric and temporal; Data products from various air and spaceborne sensors- aerial photographs, LiDAR, Landsat, SPOT, IRS, ERS, IKONOS, etc. Image interpretation- Elements of interpretation; Manual and digital interpretation; Field verification	
	4.3	Remote sensing: Interpretation Introduction to image processing techniques Image enhancement Information extraction	
	4.4	Civil Engineering Application of Remote Sensing	
5	**Geographical Information System**		**8**
	5.1	Introduction to GIS, its hardware and software components Geographical data in computer: Data structures for GIS, Components of GIS- data acquisition, spatial and attribute data, pre-processing, storage and management; Data structures- raster and vector data; GIS analysis functions; Errors and corrections; Data presentation and generation of thematic maps. Introduction to QGIS software	
	5.2	GIS manipulation, query running, analysis and modelling, Errors and corrections	
	5.3	Civil Engineering Application of GIS	
6	**Hydrographic Survey**		**4**
	6.1	Introduction, Organizations, National and International Maritime	

		Hydrography, Hydrographic survey Methods, Lead lines, sounding poles, and single-beam, echo sounders	
	6.2	Civil Engineering Application of Hydrographic Survey	

Contribution to Outcomes

On completion of the course, the students shall be able to:

- Select appropriate methods and instruments in surveying based on accuracy and precision required, sophistication, availability of resources, economics and duration of project.
- Appreciate the superiority and leverage of using modern methods in surveying over conventional ones.
- Employ modern surveying methods, for solving complex surveying problems
- Apply different advance surveying methodologies to carry out large scale survey works as modern instruments have largely changed the approach to survey works with the principles being same.
- Collect and manipulate data using GIS for simplifying data management and also reducing labour.
- The knowledge of limits of accuracy will be obtained by making measurements with various surveying equipment employed in practice.

Theory examination:

1. The question paper will comprise of **six** questions; each carrying 20 marks.

2. The **first** question will be **compulsory** and will have short questions having weightage of 4-5 marks covering the entire syllabus.

3. The remaining five questions will be based on all the modules of the entire syllabus. For this, the modules shall be divided proportionately and further, the weightage of the marks shall be judiciously awarded in proportion to the importance of the sub-module and contents thereof.

4. The students will have to attempt **any three** questions out of remaining five questions.

5. Total **four** questions need to be solved.

Oral Examination:

The oral examination shall be based on the entire syllabus, the projects performed and practicals conducted. It will include a practical exam (10 marks), before proceeding for viva (15 marks)

List of Practicals:

1. Determination of co-ordinates of profile by GPS and length of profile.
2. Profile Leveling (Open Traverse) by Total Station and print output by using any software interface
3. Navigation of existing co-ordinates by GPS
4. Digitization work by any GIS software, like QGIS, ArcGIS, Gram++, etc.
5. Setting out a foundation plan of RC structure in the field using Total Station.
6. Mini Project on GIS using various software

Term work: It shall consist of the following:

1. **Mini Project** forming a group not less than 2 and more than 4 based on use of Geospatial tools for tackling problems on any one stream viz., disaster management, construction management, project management, town planning, urban planning management and policy, water resources, utility mapping, land resource management etc.
2. Presentation on any one modern tool
3. Practical write up, clearly stating aims, objectives, sketches, observations, results and subsequent discussion of results
4. The assignments shall comprise at least one assignment on each module.

Distribution of the Term Work Marks:

The marks of the term work shall be judiciously awarded for the various components of the term work and depending upon the quality of the term work. The final certification and acceptance of term work warrants the satisfactory performance of laboratory and field work by the student, appropriate completion of the assignments.

The following weightage of marks shall be given for different components of the term work.

- Mini-project: 05 Marks
- Report of the Experiments: 05 Marks
- Assignments: 05 Marks
- Presentation: 05 Marks
- Attendance: 05 Marks

Further, while giving weightage of marks on the attendance, following guidelines shall be resorted to: 75%- 80%: 03 Marks; 81%- 90%: 04 Marks 91% onwards: 05 Marks

Recommended Study Materials

(A) Recommended Books:

1. Higher surveying: *A.M. Chandra*, New Age International publishers.

2. Higher surveying: *B.C. Punimia, Ashok Join, Arun K. Jain*, Laxmi Publications(P), Ltd.

3. Geographic Information System and Science: *Longley, Paul A., Michael F. Goodchild, David J. Maguuire, David W. Rhind*, John Wiley and Sons, New York (2nd Ed.), 2005

4. Modeling Our World: The ESRI Guide to Geodata base Design: *Zeiler, M*. ESRI Press, Redlands, California, 1999.

5. GIS, Spatial Analysis, and Modeling: Maguire, *D., M. Batty, and M. Goodchild* 2005. ESRIPress (070.212.05842005)

6. Global Positioning System: Signals, Measurements, and Performance, *Pratap Misra and Per Enge*(2nd Ed.), 2006.

7. Remote Sensing Principles and Interpretation*: Floyd, F. Sabins, Jr:, Freeman* and Co., San Franscisco,1978.

8. A Remote Sensing Perspective: Introductory Digital Image Processing: *John, R. Jensen*, Prentice Hall.

9. Imaging Radar for Resource Survey: Remote Sensing Applications: *W. Travelt*, Chapman and Hall.

10. Remote Sensing and GIS, *B Bhatia*, Oxford University Press, New Delhi.

11. Remote sensing and Image interpretation, *T.M Lillesand,. R.W Kiefer and J.W Chipman*, 5th edition, John Wiley and Sons India

12. Concepts and Techniques of Geographic Information Systems, *Lo, C.P. & Yeung A.K.W.*, Prentice Hall of India, New Delhi, 2002

13.Remote Sensing and Geographical Information Systems, *M. Anji Reddy*, B.S. Publications, Hyderabad, 2001

(B) Web Materials:

1. http://nptel.ac.in/courses/105104100/1

2. http://www.surveyofindia.gov.in/

3. http://www.iism.nic.in/

4. http://bhuvan.nrsc.gov.in/bhuvan_links.php

5. http://igrmaharashtra.gov.in/#

Semester V

Subject Code	Subject Name	Credits
CE-DLO 5062	Departmental Elective-I: Advanced Concrete Technology	4

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorials**	**Total**
3	2	-	3	1	-	4

Theory					Term Work/ Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test 1	Test 2	Average						
20	20	20	80	03 Hrs.	25	-	25	150

Rationale

Basic concept of concrete technology is essential for civil engineering students to execute the civil engineering projects as per the standard laid down time to time. The concrete technology is the backbone of infrastructure of civil engineering field. The students must know various concreting operations and testing operations during and after construction. It is expected to know the properties of materials, especially concrete and to maintain quality in construction projects. The civil engineering students ought to know the selection of materials, its mix proportioning, mixing, placing, compacting, curing and finishing.

Objectives

This course mainly aims to develop the knowledge about properties/ design and testing of advanced cement concrete.

Expected Outcome: Upon completion of this course, the student will be able to

- Know the various materials and properties in concrete.
- Understand the various properties of special concrete
- Understand the Mix design by different methods.
- Get a thorough knowledge of Fibre Reinforced Concrete.
- Know the different procedures for testing concrete.
- Understand the concept of durability and cracking in concrete.

Detailed Syllabus

Module	Sub-Modules/ Contents		Periods
1.	**Properties of Concrete:**		**5**
	1.1	Cement and its types: general, hydration of cement, water requirement for hydration, alkali aggregate reaction. Aggregate: grading curves of aggregates.	
	1.2	Concrete: properties of concrete, w/c ratio, w/b ratio, gel space ratio, maturity concept, aggregate cement bond strength.	
2.	**Special Concrete:**		**5**
	Light weight concrete, ultra-light weight concrete, vacuum concrete, mass concrete, waste material-based concrete, shotcreting, guniting, sulphur concrete and sulphur infiltrated concrete, jet cement concrete (ultra-rapid hardening), gap graded concrete, no fines concrete, high strength concrete, high performance concrete.		
3.	**Concrete Mix Design:**		**9**
	3.1	Design of concrete mixes by IS code method - ACI method - Road Note No: 4 methods.	
	3.2	Design of high strength concrete mixes, design of light weight aggregate concrete mixes, design of flyash cement concrete mixes, design of high density concrete mixes.	
4.	**Fibre Reinforced Concrete:**		**6**
	Historical development of fibre reinforced concrete, properties of metallic fibre, polymeric fibres, carbon fibres, glass fibres and naturally occurring fibres. Interaction between fibres and matrix (uncracked and cracked matrix), basic concepts and mechanical properties: tension and bending.		
5.	**Testing of Concrete:**		**8**
	5.1	Properties of hardened FRC, behaviors under compression, tension and flexure of steel fibres and polymeric fibres.	
	5.2	Advanced non-destructive testing methods: ground penetration radar, probe penetration, pull out test, break off maturity method, stress wave propagation method, electrical/ magnetic methods, nuclear methods and infrared thermography, core test.	

6.	**Durability and cracking of Concrete:**	**6**
	Durability, Transport mechanism of fluids and gases in concrete, cracking in concrete - corrosion and carbonation induced cracking, Alkali Aggregate Reaction, degradation by freeze and thaw, sulphate and sea water attack (marine conditions). Hot and cold weather concreting.	
	Total	**39**

Contribution to Outcomes

On completion of the course, the students shall be able to:

- Know the various materials and properties in concrete.
- Understand the various properties of special concrete
- Understand the Mix design by different methods.
- Get a thorough knowledge of Fibre Reinforced Concrete.
- Know the different procedures for testing concrete.
- Understand the concept of durability and cracking in concrete.

Theory Examination:

1. The question paper will comprise of **six** questions; each carrying 20 marks.
2. The first question will be **compulsory** and will have short questions having weightage of 4-5 marks covering the entire syllabus.
3. The remaining five questions will be based on all the modules of the entire syllabus. For this, the modules shall be divided proportionately and further, the weightage of the marks shall be judiciously awarded in proportion to the importance of the sub-module and contents thereof.
4. The students will have to attempt **any three** questions out of remaining five questions.
5. Total **four** questions need to be attempted

Oral Examination:

The oral examination shall be based on the entire syllabus and the report of the experiments conducted by the students including assignments.

List of Practical (Any Eight to be performed):

1. Mix design in laboratory by ACI Method.
2. Mix design in laboratory by Road Note 4.

3. Split and Modulus of rupture of concrete.
4. Permeability test on concrete.
5. Rapid chloride penetration test
6. Tests on polymer modified concrete/mortar.
7. Tests on fiber-reinforced concrete.
8. Nondestructive testing of concrete- some applications (hammer, ultrasonic etc.).
9. Carbonation test on concrete.
10. Pull out/ pull off test on concrete.

Term Work:

The term work shall comprise of the neatly written report based on the afore-mentioned experiments (at least eight) and ten assignments covering the entire syllabus divided properly module wise.

Distribution of the Term Work Marks:

The marks of the term work shall be judiciously awarded for the various components of the term work and depending upon the quality of the term work. The final certification and acceptance of term work warrants the satisfactory performance of laboratory work by the student, appropriate completion of the assignments.

Recommended Books:

1. Concrete Technology: A. R. Shanthakumar, Oxford University Press.
2. Concrete Technology Theory and Practice: Shetty M.S., S. Chand.
3. Properties of concrete: Neville, Isaac Pitman, London.
4. Relevant I.S. codes: Bureau of Indian standard.
5. Special Publication of ACI on Polymer concrete and FRC.
6. Proceedings of International Conferences on Polymer Concrete and FRC.
7. Concrete Technology: Gambhir M.L., Tata McGraw Hill, New Delhi.
8. Concrete Technology: Neville A.M. & Brooks. J. J., ELBS-Longman.
9. Chemistry of Cement and Concrete: F.M. Lue, Edward Arnold, 3rd Edition, 1970.
10. Concrete Technology: D.F. Orchardi, Wiley, 1962.
11. Tentative Guidelines for cement concrete mix design for pavements (IRC: 44-1976): Indian Road Congress, New Delhi.
12. Concrete mix proportioning-guidelines (IS 10262:2009).

Semester V

Subject Code	Subject Name	Credits
CE-DLO 5063	Departmental Elective-I: Building Services & Repairs	4

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorials	Total
3	2	-	3	1	-	4

Theory					Term Work/ Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test 1	Test 2	Average						
20	20	20	80	03 Hrs.	25	-	25	150

Rationale

The building services are based on engineering principles that are applied to the construction of buildings & the built environment. In many respects, building services are responsible for the artificial environment in which we live & work & associated with that the environmental condition of our planet. Building service systems are complex. They are typically a major source of cost & potential coordination problems in building construction. Fundamental knowledge of how mechanical, electrical, plumbing & other systems work& interact is important to the construction professional. This course provides an introduction to building service systems which include the Study of design, interfaces & specifications of various building services in building construction.For an existing building to be in a good condition, so that it can continue to perform the intended functions, maintenance of the building plays a key role. Adequate maintenance improves aesthetic &functional values. Moreover; it facilitates extending the building life & ensures the safety of dwellers. Usually, the structures do perform well for about 50 years after the construction & thereafter, the deterioration begins. Insufficient maintenance & lack of repairs may lead to the limited life span of the structure. However, the regular maintenance & timely identification of deteriorated building elements for proper remedial measures may result in to the extension of life span of the structure up to 100 years also. Most of the modern structures built in India are becoming old as they have reached about 50 years of their age & are in the dire need of the repair and maintenance. Hence, there is a huge employment potential in conformity with the field of repair and maintenance. This course, therefore, finds its place in the curriculum such that the pupils can acquire the competency in this area. The course deals with the building maintenance, special materials, concrete repair chemicals, strengthening of RCC members by underpinning, plate bonding, shoring, RC jacketing, etc. Technical knowhow and skills developed

through this course may be helpful to preserve the historical buildings. Therefore, it is vital and imperative to get acquainted with the course for civil engineers.

Objectives

- To understand the concepts of building services & its applications.
- To understand design concepts of various machineries like lift, escalators, vibrators, concrete mixers, etc. &utility services in building like plumbing system, electrical system, etc.
- To get familiar with the causes of distress of concrete structures, seepage & leakage in concrete structures & the effect on steel corrosion.
- To study the condition survey, evaluation and assessment of damage through the visual inspection & various Non-Destructive Testing methods.
- To acquire the knowledge in connection with the special repair materials and crack repair methodologies to be applied in the field.
- To study the concrete protective materials, thermal protection coatings, etc.
- To implement the steel corrosion protection methods in the field

Detailed Syllabus

Module	Sub-Modules/ Contents		Periods
1.	**Machineries**		**05**
	Lifts & Escalators- Special features required for physically handicapped & elderly, Conveyors, Vibrators, Concrete mixers, DC/AC motors, Generators, Laboratory services, Gas, Water, air & electricity, Hot water boilers and pumps		
2.	**Plumbing Systems in Building**		**06**
	2.1	Plumbing Services: Water Distribution system, Material for service pipes, Service connection, Size of service pipe, Water meter, valves and storage tanks.	
	2.2	Drainage system: Pipe and traps, system of plumbing, House drainage plans, septic tanks and soak pit.	
3.	**Electrical systems & Illumination Design in Buildings**		**09**
	3.1	Electrical systems in buildings: Basics of electricity - Single / Three phase supply, Protective devices in electrical installations,Earthing for safety, Types of Earthing, ISI specifications, Types of wires, wiring systems &their choice, Planning electrical wiring for building, Main	

		&distribution boards, Transformers & switch gears, Layout of substations	
	3.2	Principles of Illumination Design: Visual task, Factors affecting visual task, Modern theory of light &colour, Synthesis of Light, Additive & Subtractive synthesis of colour, Luminous flux, candela, solid angle illumination, utilization factor, Depreciation factor, MSCP, MHCP, Lens of illumination, Classification of lighting, Artificial lights sources, spectralenergy distribution, Luminous efficiency,Colour temperature,Colour rendering.	
	3.3	Design of Modern lighting: Lighting for stores, offices, school, hospitals and house lighting. Elementary idea of special features required and minimum level of illumination required for physically handicapped and elderly in building types.	
4.	**Deterioration of Concrete Structures**		**05**
	4.1	Causes of deterioration of concrete structures, effects of climate, moisture, temperature, chemical, wear, erosion & loading on serviceability & durability. Design& construction errors.	
	4.2	Causes of seepage & leakage in concrete structures. Formation of cracks including those due to corrosion.	
5.	**Condition Survey, Evaluation & Damage Assessment**		**05**
	5.1	Diagnostic methods & analysis.	
	5.2	Destructive, semi-destructive and non-destructive methods: core test, carbonation test, chloride test, petrography, corrosion analysis, cover meter test, rebound hammer test, ultrasonic pulse velocity test, and crack measurement techniques, Concrete endoscopy & thermal imaging, pull-off test & pull-out test.	
6.	**Materials & Repair Methodologies, Protection of Concrete Structures & Rebar Corrosion Protection**		**09**
	6.1	Repair analysis & design.	
	6.2	Repair materials and their desired properties.	
	6.3	Methodologies for crack and patch repair: polymer modified mortar, polymer modified concrete, polymer concrete	
	6.4	Injection grouting, shortcreting, joints and sealants, rebar corrosion	

		crack repair 10.5	
	6.5	Protective materials and their properties for moisture barrier systems.	
	6.6	Above grade and below grade water-proofing of concrete structures.	
	6.7	Systems like integral, crystalline, coatings, membranes, etc.	
	6.8	Thermal protection coatings.	
	6.9	Methods of corrosion protection, corrosion inhibitors	
	6.10	Corrosion resistant steels, cathodic protection	
	6.11	Pre-packed zinc sacrificial anode, Snap-on zinc mesh anode CP system.	
		Total	**39**

Contribution to Outcomes

On successful completion of the course, it is expected that the course will enable the students to:

- Understand the importance & installation of utility services.
- Understand the drawbacks if all the service lines are not installed properly or if materials used are faulty.
- Choose appropriate systems & integrate the same into the building construction projects.
- Assess the structural health of the buildings & infrastructural works and also Inspect & evaluate the damaged structures.
- Implement the techniques for repairing the concrete structures and also decide whether or not the structure should be dismantled, if it is deteriorated beyond repair.
- Employ the methods of steel protection in the field.

Theory examination:

1. Question paper will comprise of **six** questions; each carrying 20 marks.
2. The **first** question will be **compulsory.** It will have short questions, each carrying 4 to 5 marks, covering the entire syllabus.
3. The remaining **five** questions will be based on all the modules of entire syllabus. For this, the module shall be divided proportionately further, and the weightage of the marks shall be judiciously awarded in proportion to the importance of the sub-module and contents, thereof.
4. There can be options withinvarious sub-questions/ questions in order to accommodate the questions on all the topics/ sub-topics.
5. The students will have to attempt any **three** questions out of remaining five questions.
6. Total **four** questions need to be attempted.

Oral Examination:

The oral Examination shall be based upon the entire syllabus & the term work consisting of the assignments& experiments.

List of Practicals:(At least six to be performed).

1. Rapid chloride penetration test
2. Carbonation test by spraying phenolphthalein
3. Non -destructive testing of concrete structures by Rebound hammer, UPV meter etc.
4. Corrosion analyzer by half-cell potential meter
5. Tests on polymer modified mortar/concrete and coating for adhesion by Pull-off test method
6. Outdoor exposure test to measure weathering of coating
7. Test for flexibility of coating by applying on a tin sheet
8. Test for effectiveness by measuring temperature difference of a thermal protection coating and concrete substrate on terrace
9. Test for effectiveness by measuring water absorption of coating applied on a card board.

Condition Survey:

The students will carry out the condition survey of any damaged structure by visual observations& will prepare a detailed report thereof. This report will form a part of the term work.

Term Work:

The term-work shall comprise of the neatly written report based on the experiments/ practicals performed & the assignments along with the detailed report on the condition survey.

Distribution of Term Work Marks:

The marks of the term work shall be judiciously awarded for the various components depending upon its quality. The final certification and acceptance of the term work warrants the satisfactory performance of the experiments/ practicals by the student, properly compiled report thereof along with the assignments and the report on condition survey & the minimum passing marks to be obtained by the student. The assignments shall be given covering the entire syllabus in such a way that the students would attempt at least two problems/ questions on each sub-modules & contents thereof further.The following weightage of marks shall be given for different components of the term work.

- Report of the Experiments: 08 Marks

- Assignments: 08 Marks
- Report on the Condition Survey: 04 Marks
- Attendance: 05 Marks

Further, while giving weightage of marks on the attendance, following guidelines shall be resorted to. 75%- 80%: 03 Marks 81%- 90%: 04 Marks 91% onwards: 05 Marks.

Recommended Books:

1. Heat Pumps and Electric Heating: *E. R. Ambrose*, John and Wiley and Sons, Inc., New York, 1968.
2. Handbook for Building Engineers in Metric Systems, NBC, New Delhi, 1968.
3. Philips Lighting in Architectural Design, McGraw-Hill, New York, 1964.
4. The Lighting of Buildings: *R. G. Hopkinson and J. D. Kay*, Faber and Faber, London, 1969.
5. National Building Code.
6. Building Construction: *Dr. B. C. Punmia, Ashol K Jain*, A.K Jain
7. Construction Engineering and Management: *S. Seetharaman*, Umesh Publicatins, Delhi.
8. Water supply and Sanitory Installations: *A. C. Panchdhari*, New Age International Publication, Delhi
9. Concrete Repair and Maintenance: *Peter H. EmmonsandGajanan M. Sabnis*, Galgotia Publication.
10. Repairs and Rehabilitation-Compilation from Indian Concrete Journal-ACC Publication.
11. Guide to Concrete Repair and Protection, HB84-2006, A joint publication of Australia Concrete Repair Association, CSIRO and Standards Australia.
12. CPWD hand book on Repairs and Rehabilitation of RCC buildings published by DG(Works), CPWD, Government of India (Nirman Bhawan), http://www.cpwd.gov.in/handbook.pdf.
13. Guide to Concrete Repair, *Glenn Smoak*, US Department of the Interior Bureau of Reclamation, Technical Service Center, http://books.google.co.in.
14. Management of Deteriorating Concrete Structures: *George Somerville*, Taylor and Francis Publication.
15. Concrete Building Pathology: *Susan Macdonald*, Blackwell Publishing.
16. Testing of Concrete in Structures: *John H. Bungey, Stephen G. MillardandMichael G. Grantham*, Taylor and Francis Publication.
17. Durability of concrete and Cement Composites: *Page, C.L.*and Page, *M.M.*, Woodhead Publishers

Semester V

Subject Code	Subject Name	Credits
CE-DLO 5064	Departmental Elective-I: Advanced Structural Mechanics	4

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorials**	**Total**
3	2	-	3	1	-	4

Theory					Term Work/ Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test 1	Test 2	Average						
20	20	20	80	03 Hrs.	25	-	25	150

Rationale

The structures are subjected to various types of loading/ forces. These are axial force, shear force, bending moment, etc. This course enables the students with the knowledge in conformity with analysis of behaviour of structural members under different types of loading. The course facilitates in imparting theoretical concepts and physical understanding, which in turn will help in solving structural mechanics problems, mostly involving beams & thin-walled structures under different loading conditions.

Objectives

- To understand the concept of shear centre & evaluate the shear centre for symmetrical & un-symmetrical thin walled sections.
- To understand the concept & behavior of beams resting on elastic foundation.
- To study the behavior of beams curved in plan.
- To understand the concept of different theories of failure in regards of materials.
- To study the behavior of deep beams using different theories available for the analysis of different sections.

Detailed Syllabus

Module	Sub-Modules/ Contents		Periods
1	**Shear centre:**		**5**
	Shear Centre for symmetrical & unsymmetrical (about both axes) thin walled open sections.		
2	**Bending of beams with large initial curvature:**		**8**
	2.1	Bending of beams with large initial curvature, loaded in their plane of curvature.	
	2.2	Application to analysis of hooks, circular closed rings, chain links with straight length & semi-circular ends.	
3	**Beams on elastic foundation:**		**8**
	3.1	Analysis of beams of infinite length subjected to concentrated force/moment & semi-infinite length subjected to concentrated load/moment at one end.	
	3.2	Semi-infinite beam hinged at one end (origin) & subjected to UDL throughout.	
4	**Beams curved in plan:**		**5**
	4.1	Analysis of beams loaded perpendicular to their own plane.	
	4.2	Simply supported, fixed & continuous beams.	
5	**Theories of Failure:**		**7**
	5.1	Maximum principal stress theory, Maximum principal strain theory, Maximum shear stress theory.	
	5.2	Maximum total strain energy theory.	
6	**Analysis of deep beams:**		**6**
	6.1	Determination of deflection	
	6.2	Determination of shear correction factor for various sections: rectangular solid & hollow section, circular solid & hollow section & I-section	
	6.3	Stress concentration, stress concentration factor.	
		Total	**39**

Contribution to Outcomes

On successful completion of the course, the students shall be able to:

- Understand the concept of shear centre for thin walled open sections.
- Study the behavior of beam resting on elastic foundation with various loading conditions.
- Analyze the beam curved in plan for different support conditions.
- Understand the concept of different theories of failure in different sections.
- Determine deflection, shear correction factor for different sections like solid & hollow sections.

Theory Examination:

1. Question paper will comprise of **six** questions; each carrying **20** marks.
2. The **first** question will be **compulsory**, which will have the short questions having weightage of 4-5 marks covering the entire syllabus.
3. The **remaining five** questions will be based on all the modules of entire syllabus. For this, the module shall be divided proportionately further, and the weightage of the marks shall be judiciously awarded in proportion to the importance of the sub-module and contents thereof.
4. There can be an option within various sub-questions/ questions in order to accommodate the questions on all the topics/ sub-topics.
5. The students will have to attempt **any three** questions out of **remaining five** questions.
6. Total **four** questions need to be attempted.

Term Work:

The term-work shall comprise of the neatly written report based on the assignments. The assignments shall be given covering the entire syllabus in such a way that the students would attempt at least three problems and/ or questions on each modules/ sub-modules and contents thereof further.

Oral Examination:

The oral examination shall be based upon the entire syllabus & the term work.

Distribution of Term Work Marks:

The marks of term-work shall be judiciously awarded depending upon the quality of the term work. The final certification and acceptance of the term-work warrants the satisfactory and the appropriate completion of the assignments and the minimum passing marks to be obtained by the students.

The following weightage of marks shall be given for different components of the term work.

- Assignments: 20 Marks
- Attendance: 05 Marks

Further, while giving weightage of marks on the attendance, following guidelines shall be resorted to. 75%- 80%: 03 Marks; 81%- 90%: 04 Marks; 91% onwards: 05 Marks.

Recommended Books:

1. Mechanics of Materials: Popov, E.P. Prentice Hall of India Pvt. Ltd.
2. Mechanics of Materials: James Gere, M., Thomson Brooks.
3. Mechanics of Materials: Beer, F.P., E. Russell Jhonston and John T. DeWolf, TMH, New Delhi.
4. Advanced Mechanics of Materials: Arthur P. Boresi and Omar M. Sidebottom, Wiley and Sons.
5. Advanced Mechanics of Materials: Arthur P. Boresi and Richard Schmidt, John Wiley and sons.
6. Strength of Material Part I and Part II: Timoshenko, McGraw Hill, New York.
7. Mechanics of Solids: Shames, I and Pitarresi, J. M., Preentice Hall, New Delhi.
8. Beams on Elastic Foundation: Heteny M. 9. Strength of Materials: Subramanian, Oxford University Press.