KURUKSHETRA UNIVERSITY KURUKSHETRA
SCHEME OF STUDIES/EXAMINATION

Bachelor of Technology (Civil Engineering)

Semester- V (w.e.f. session 2017-2018)

S. N.	Course No.	Course Title	Teaching Schedule				Allotment of Marks				Duration of Exam (Hrs.)
			L	T	P	Hrs/ Wk	Theory	Sessional	Practical	Total	
1	CE-301N	Structural Analysis-III	4	2	0	6	75	25	0	100	3
2	CE-303N	Design of Concrete Structures-I	4	2	0	6	75	25	0	100	**4**
3	CE-305N	Hydrology	3	1	0	4	75	25	0	100	3
4	CE-307N	Geotechnology-I	3	1	0	4	75	25	0	100	3
5	CE-309N	Project Planning & Management	3	1	0	4	75	25	0	100	3
6	CE-311N	Concrete Technology	3	1	0	4	75	25	0	100	3
7	CE-313N	Structural Mechanics-II (P)	0	0	2	2	0	40	60	100	3
8	CE-315N	Concrete Technology (P)	0	0	2	2	0	40	60	100	3
9	CE-317N	Geotechnology (P)	0	0	2	2	0	40	60	100	3
10	CE-319N	Survey Camp / Field Training-I	1	0	0	1	0	0	100	100	
		Total	21	8	6	35	450	270	280	1000	

Survey Camp/Field Training-I undergone by the students after IV sem is to be evaluated during V sem as **(CE-319N)** through submission of certified report to the H.O.D. followed by conduct of viva-voce & seminar/presentation.

Code	Nomenclature of Subject	L	T	Int.	Ext.	Total	Time
CE-301N	**STRUCTURAL ANALYSIS-III**	**4**	**2**	**25**	**75**	**100**	**3 Hr**

Course Objective	Students will acquire the knowledge about the methods of analysis of different structures.

Unit	**Course Outcome**
I	Students will be able to study behavior in the form of S.F and B.M for continuous beams by influence line method
II	Students will be able to analyze the behavior of rolling load on structures and fixed arches
III	Students will be able to analyze the frames structures
IV	Students will be able to study about methods for stiffness and flexibility.

UNIT-I

Influence lines:

Introduction, influence lines for three hinged and two hinged arches, load position for Max. S.F. and B.M. at a section in the span.

Influence Line for statically indeterminate Beams:

Muller-Breslau Principle, I.L. for B.M. & S.F. for continuous Beams.

UNIT-II

Rolling Loads:

Introduction, Single concentrated load, uniformly distributed load longer than span, shorter than span, two point loads, several point loads, Max. B.M. and S.F. Absolute, Max. B.M.

Fixed Arches:

Expression for Horizontal Thrust and Bending Moment at a section, Elastic centre

UNIT-III

Kani's Method:

Analysis of continuous beams and simple frames, analysis of frames with different column lengths and end conditions of the bottom story.

UNIT-IV

Approximate Analysis of frames:

(i) For vertical loads, (ii) for lateral loads by Portal method & Cantilever method.

Matrix Methods

Introduction, Stiffness Coefficients, Flexibility Coefficients, development of flexibility & stiffness matrices for plane frame, Global axis and local axis, analysis of plane frame, pin jointed and rigid jointed.

Paper Setter Note: 8 questions of 15 marks each distributed in four sections are to be set taking two questions from each unit. The candidate is required to attempt five questions in all, taking at least one from each of the four sections.

Books Recommended:

1. Indeterminate structures, R.L.Jindal S.Chand & Co.,N.Delhi.
2. Advanced Structural Analysis-A.K.Jain, Nem Chand & Bros.,Roorkee.
3. Structural Analysis-A Unified Approach, D.S. Prakash Rao,, University Press, Hyderabad.
4. Structural Analysis-A unified classical & Matrix Approach, A.Ghali & A.M. Neville, Chapman & Hall London.
5. Theory of Structures- Vol. I&II- S.P. Gupta & G.S.Pandit, Tata McGraw Hill, N.Delhi.
6. Basic Structural Analysis – C.S. Reddy, Tata McGraw Hill, New Delhi.
7. Structural Analysis –III, Amit Raheja. Professional Publication, Ambala cantt.

Code	Nomenclature of Subject	L	T	Int.	Ext.	Total	Time
CE-303N	**DESIGN OF CONCRETE STRUCTURES-I**	**4**	**2**	**25**	**75**	**100**	**4 Hr**

Course Objective To learn about the design of different types of structures by using reinforced cement concrete (RCC)

Unit	Course Outcome
I	Students will be able to study the design philosophies of different methods for RCC structures.
II	Students will be able to design of RCC beams using working stress and limit state method.
III	Students will be able to design of RCC columns and footing using working stress and limit state method.
IV	Students will be able to design of RCC slab and retaining walls and detailing of steel using working stress and limit state method.

UNIT-I

Elementary treatment of concrete technology:
Physical requirements of cement, aggregate, admixture and reinforcement, Strength and durability, shrinkage and creep. Design of concrete mixes, Acceptability criterion, I.S. Specifications,

Design Philosophies in Reinforced Concrete:
Working stress and limit state methods, Limit state v/s working stress method, Building code, Normal distribution curve, characteristic strength and characteristics loads, design values, Partial safety factors and factored loads, stress -strain relationship for concrete and steel.

UNIT-II

Working Stress Method:
Basic assumptions, permissible stresses in concrete and steel, design of singly and doubly reinforced rectangular and flanged beams in flexure, steel beam theory, inverted flanged beams, design examples.

Limit State Method:
Basic assumptions, Analysis and design of singly and doubly reinforced rectangular flanged beams, minimum and maximum reinforcement requirement, and design examples.

UNIT-III

Analysis and Design of Sections in shear bond and torsion:
Diagonal tension, shear reinforcement, development length, Anchorage and flexural bond, Torsional, stiffness, equivalent shear, Torsional reinforcement, Design examples.

Columns and Footings:
Effective length, Minimum eccentricity, short columns under axial compression, Uniaxial and biaxial bending, slender columns, Isolated and wall footings, Design examples.

Serviceability Limit State:
Control of deflection, cracking, slenderness and vibrations, deflection and moment relationship for limiting values of span to depth, limit state of crack width, Design examples.

UNIT-IV

Concrete Reinforcement and Detailing:
Requirements of good detailing cover to reinforcement, spacing of reinforcement, reinforcement splicing, Anchoring reinforcing bars in flexure and shear, curtailment of reinforcement.

One way and Two Ways Slabs:
General considerations, Design of one way and two ways slabs for distributed and concentrated loads, Nonrectangular slabs, openings in slabs, Design examples.

Retaining Walls:
Classification, Forces on retaining walls, design criteria, stability requirements, Proportioning of cantilever retaining walls, counterfort retaining walls, criteria for design of counterforts, design examples.

Paper Setter Note: 8 questions of 15 marks each distributed in four sections are to be set taking two questions from each unit. The candidate is required to attempt five questions in all, taking at least one from each of the four sections. **Time Duration: 4 Hours.**

Books:

1. Design of Reinforced Concrete Structures,P.Dayaratnam,Oxford & IBH Pub.,N.Delhi.
2. Reinforced Concrete-Limit State Design, A.K.Jain, Nem Chand & Bros.,Roorkee.
3. Reinforced Concrete, I.C.Syal & A,K,Goel, A.H,Wheeler & Co.Delhi.
4. Reinforced Concrfete Design, S.N.Sinha, TMH Pub.,N.Delhi.
5. SP-16(S&T)-1980, 'Design Aids for Reinforced Concrete to IS:456, BIS, N.Delhi.
6. SP-34(S&T)-1987 'Handbook on Concrete Reinforcement and Detailing', BIS, N.Delhi.
7. Reinforced Concrete Design – Pillai and Menon, TMH, New Delhi.

Code	Nomenclature of Subject	L	T	Int.	Ext.	Total	Time
CE-305N	**HYDROLOGY**	**3**	**1**	**25**	**75**	**100**	**3 Hr**

Course Objective	Hydrology is the scientific study of the movement, distribution, and quality of water on Earth and other planets, including the water cycle, water resources and environmental watershed sustainability.

UNIT	Course Outcome
I	Students will be able to get better knowledge about the total precipitation in the particular area using different rain gauges
II	Students will be able to measure the evaporation, transpiration and infiltration and can analyze the measured data.
III	Students will be able to calculate the total runoff and able to draw hydrographs for the different durations of rainfall and can predict the future runoff.
IV	Students will be able to get the knowledge of ground water, its quality and efficiency of the ground storage.

UNIT-I

Introduction:

Hydrologic cycle, scope and application of hydrology to engineering problems, drainage basins and its characteristics, stream geometry, hypsometric curves.

Precipitation:

Forms and types of precipitation, characteristics of precipitation in India, measurement of Precipitation, recording and non-recording rain gauges, rain gauge station, rain gauge network, estimation of missing data, presentation of rainfall data, mean precipitation, depth -area –duration relationship, frequency of point rainfall, intensity-duration- frequency curves, probable max. precipitation.

UNIT-II

Evaporation & Transpiration:

Process, evaporimeters and empirical relationships, analytical method, reservoir evaporation and methods of its control, transpiration, evapotranspiration and its measurement, Penman's equation and potential evapotranspiration.

Infiltration:

Infiltration process, initial loss, infiltration capacity and measurement of infiltration, infiltration indices.

UNIT-III

Runoff:

Factor affecting run-off, estimation of runoff, rainfall-run off relationships, measurement of stage-staff gauge, wire gauge, automatic stage recorder and stage hydrograph, measurement of velocity-current meters, floats, area velocity method, moving boat and slope area method, electromagnetic, ultra-sonic and dilution methods of stream flow measurement, stage discharge relationship.

Floods and Flood Routing:

Flood frequency studies, recurrence interval, Gumbel's Method, flood routing, reservoir flood routing, channel flood routing and flood plain mapping.

Hydrograph:

Discharge hydrograph, components and factors affecting shape of hydrograph, effective rainfall, unit hydrograph and its derivation, unit hydrograph of different durations, use and limitations of UH, triangular UH, Snyder's synthetic UH, floods, rational methods, empirical formulae.

UNIT-IV

Ground Water:

Occurrence, types of aquifers, compressibility of aquifers, water table and its effects on fluctuations , wells and springs, movement of ground water, Darcy's law, permeability and its determination, porosity, specific yield and specific retention, storage coefficient, transmissibility.

Ground Water Quality:

Indian and International standards, pollution of ground water and possible source, remedial and preventive measures.

Paper Setter Note: 8 questions of 15 marks each distributed in four sections are to be set taking two questions from each unit. The candidate is required to attempt five questions in all, taking at least one from each of the four sections.

Books:

1. Engineering Hydrology by K.Subramanya, TMH, New Delhi
2. Hydrology by H.M.Raghunath.
3. Hydrology for Engineers by Linsely, Kohler, Paulhus.
4. Elementary Hydrology by V.P.Singh.

Code	Nomenclature of Subject	L	T	Int.	Ext.	Total	Time
CE-307N	**GEOTECHNOLOGY-I**	**3**	**1**	**25**	**75**	**100**	**3 Hr**

Course Objective	The subject gives a better idea about the soil and its properties & also design of types of foundation.
UNIT	**Course Outcome**
I	Students will be able to study the sub-surface soil and its properties and methods of sampling and testing.
II	Students will be able to study the different types of shallow foundation and its design.
III	Students will be able to study the different types of pile foundation and its design.
IV	Students will be able to study the different types of. Drilled Piers and Caisson Foundations and their design.

UNIT-I

Sub-Surface Exploration: Purpose, stages in soil exploration, depth and lateral extent of exploration, guidelines for various types of structures, ground water observations, excavation and boring methods, soil sampling and disturbance, major types of samplers, sounding methods-SCPT, DCPT, SPT & interpretation, geo-physical methods, pressure-meter test, exploration logs.
Drainage & Dewatering: Introduction, ditches and sumps, well point systems, shallow well system, deep well drainage, vacuum method, Electro-osmosis, consolidation by sand piles, Eductor method.

UNIT-II

Shallow Foundations-I: Design criteria for structural safety of foundation (i) location of footing, (ii) shear failure criterion, (iii) settlement criterion, ultimate bearing capacity, modes of shear failure, Rankine's analysis Tergazi's theory, Skempton's formula, effect of fluctuation of G.W.T. , effect of eccentricity on bearing capacity, I.S Code recommendations, factors affecting bearing capacity, methods of improving bearing capacity.
Shallow Foundations-II: Various causes of settlement of foundation, allowable bearing pressure based on settlement, settlement calculation, elastic and consolidation settlement, allowable settlement according to
I.S.Code. Plate load test and its interpretation, bearing capacity from penetration tests, design bearing capacity.
Shallow Foundations-III: Situation suitable for the shallow foundations, types of shallow foundations and their relative merits, depth of foundation, footing on slopes, uplift of footings, conventional procedure of proportioning of footings, combined footings, raft foundations, bearing capacity of raft in sands and clays, various methods of designing rafts, floating foundations.

UNIT-III

Pile Foundations-I: Introduction, necessity of pile foundations, classification of piles, load capacity, static analysis, analysis of pile capacity in sands and clays, dynamic analysis, pile load tests, negative skin friction, batter piles, lateral load capacity, uplift capacity of single pile, under-reamed pile.
Pile Foundations-II: Group action in piles, pile spacing, pile group capacity, stress on lower strata, settlement analysis, design of pile caps, negative skin friction of pile group, uplift resistance of pile group, lateral resistance, batter pile group.

UNIT-IV

Drilled Piers and Caisson Foundations: Drilled piers-types, uses, bearing capacity, settlement, construction procedure. Caissons-Types, bearing capacity and settlement, construction procedure. well foundations-shapes, depth of well foundations, components, factors affecting well foundation design lateral stability, construction procedure, sinking of wells, rectification of tilts and shifts, recommended values of tilts & shifts as per I.S.3955.

Paper Setter Note: 8 questions of 15 marks each distributed in four sections are to be set taking two questions from each unit. The candidate is required to attempt five questions in all, taking at least one from each of the four sections.

Books Recommended:

1. Analysis and Design of Foundation and Retaining Structures by S. Prakash, Gopal Ranjan & S.Saran, Sarita Prakashan.
2. Analysis and Design of Sub Structures by Swami Saran, IBH Oxford
3. Basic and Applied Soil Mechanics by Gopal Ranjan and ASR Rao, Newage Int.Pub.
4. Soil Dynamic by Shamsher Prakash, McGraw Hill
5. Foundation Design by Teng, Prentice Hall
6. Soil Mechanics & Foundation Engineering by Bharat Singh, Shamsher Prakash, Nem Chand & Bros, Roorkee.
7. Soil Mechanics and Foundation Engineering by Alam Singh.

Code	Nomenclature of Subject	L	T	Int.	Ext.	Total	Time
CE-309N	**PROJECT PLANNING & MANAGEMENT**	**3**	**1**	**25**	**75**	**100**	**3 Hr**

Course Objective	To have better understanding about the planning and management of construction. Projects.
I	Students will be able to study the construction contracts and their management.
II	Students will be able to plain the construction projects and job layout.
III	Students will be able to study the time management of the construction projects by different methods.
IV	Students will be able to study the cost management and quality control analysis of the construction projects.

UNIT-I

Construction Management

Significance, objectives and functions of construction management, types of constructions, resources for construction industry, stages for construction, construction team, engineering drawings.

Construction Contracts & Specifications

Introduction, types of contracts, contract document, specifications, important conditions of contract, arbitration.

UNIT-II

Construction Planning

Introduction, work breakdown structure, stages in planning-pre-tender stages, contract stage, scheduling, scheduling by bar charts, preparation of material, equipment, labour and finance schedule, limitation of bar charts, milestone charts.

Construction Organization

Principles of Organization, communication, leadership and human relations, types of Organizations, Organization for construction firm, site organization, temporary services, job layout.

UNIT-III

Network Techniques in Construction Management-I: CPM

Introduction, network techniques, work break down, classification of activities, rules for developing networks, network development-logic of network, allocation of time to various activities, Fulkerson's rule for numbering events, network analysis , determination of project schedules, critical path, ladder construction, float in activities, shared float, updating, resources allocation, resources smoothing and resources leveling.

Network Techniques in Construction Management-II-PERT

Probability concept in network, optimistic time, pessimistic time, most likely time, lapsed time, deviation, variance, standard deviation, slack critical path, probability of achieving completion time, central limit theorem.

UNIT-IV

Cost-Time Analysis

Cost versus time, direct cost, indirect cost, total project cost and optimum duration, contracting the network for cost optimization, steps in time cost optimization, illustrative examples.

Inspection & Quality Control

Introduction, principles of inspection, enforcement of specifications, stages in inspection and quality control, testing of structures, statistical analysis.

Paper Setter Note: 8 questions of 15 marks each distributed in four sections are to be set taking two questions from each unit. The candidate is required to attempt five questions in all, taking at least one from each of the four sections.

Books Recommended

1. Construction Planning & Management by P.S.Gehlot & B.M.Dhir, Wiley Eastern Ltd.
2. PERT & CPM -Principles & Applications by L.S.Srinath. Affiliated East-west Press (P)Ltd.
3. Project Planning & Control with PERT & CPM by B.C.Punmia & K.K.Khandelwal,Lakshmi Pub. Delhi
4. Construction Management & Planning by B.sengupta & H.Guha, Tata McGraw -Hills.

Code	Nomenclature of Subject	L	T	Int.	Ext.	Total	Time
CE-311N	**CONCRETE TECHNOLOGY**	**3**	**1**	**25**	**75**	**100**	**3 Hr**

Course Objective	To have better understanding about the various properties of materials and ingredients of concrete.

UNIT	**Course Outcome**
I	Students will be able to study the construction materials like Cement & Aggregates and its properties
II	Students will be able to design concrete and perform test on concrete on various strength parameters, modifying its properties using other substances.
III	Students will be able to study various effects on concrete & its non-destructive tests for properties evaluation.
IV	Students will be able to study about methods of repairing and design of special concrete.

UNIT-I

Introduction: Introduction of Concrete, preparation of concrete, grades of concrete, advantages of concrete, concept of quality control.

Cement: Introduction of Cement, ingredient in cement. basic chemistry, types of cement, ordinary Portland cement, rapid hardening cement, low heat cement, sulphate resistant cement, Portland-pozzolona cement, high strength Portland cement, high alumina cement, waterproof cement, white Portland cement, hydrophobic cement, colored Portland cement, Field and laboratory tests on cement. Pozzolanic materials, Fly ash, metakaoline, GGBS, iron slag, rise husk ash - its types, properties, applications & limitations.

Aggregates: Aggregates, classification of aggregates based on petrography, size, shape and textures, deleterious substances in aggregates, bulking of fine aggregates, sieve analysis, grading of aggregates as per IS-383-1970, fineness modulus, Maximum size of aggregate, Quality of mixing water, curing water.

UNIT-II

.**Production of Concrete:** Introduction, Design of mix by IS & ACI methods including batching of materials, mixing of concrete materials, transportation of concrete, compaction of concrete, ready mixed concrete, vibrators, Internal vibrators, external vibrators, concrete curing and formwork removal.

Properties of Concrete: Introduction, workability, factors influencing workability, measurement of workability, requirements of workability, properties of hardened concrete, stress and strain characteristics of concrete, Young's modulus of concrete, creep and shrinkage of concrete, permeability of concrete, durability of concrete sulphate attack, fire-resistance, thermal properties of concrete, construction joints, expansion and contraction joints.

UNIT-III

Non-Destructive Testing of Concrete: Significance of Non-Destructive Testing, Rebound Hammer, Ultrasonic pulse velocity techniques, Penetration techniques, pullout tests, vibration methods, radioactive techniques, Cover meter, core-tests.

Deterioration of Concrete & its Prevention: Causes of concrete deterioration, deterioration by water, surface weir, frost action, deterioration by chemical reactions, sulphate attack, alkali-aggregate reaction, corrosion of embedded steel in concrete, Prevention of deterioration of concrete.

UNIT-IV

Repair Technology for Concrete Structures: Symptoms and diagnosis of distress, evaluation of cracks, repair of cracks, common types of repairs, distress in fire damaged structures, underwater repairs.

Special Concrete: Light weight concrete, definition and its properties, applications, high strength concrete, definitions, its properties and applications, Mass Concrete, waste material based concrete, shortcrete, fiber reinforced concrete: Materials Fibres types and properties, ferrrocement, polymer concrete composites, heavy weight concrete for radiation shielding.

Prestressed Concrete: Introduction, basic concepts, classifications and types of prestressing, prestressing systems, and properties of materials, pre tensioned and post tensioned concrete elements.

Paper Setter Note: 8 questions of 15 marks each distributed in four sections are to be set taking two questions from each unit. The candidate is required to attempt five questions in all, taking at least one from each of the four sections.

TEXT BOOKS

1. Neville A M and Brookes J J "Concrete Technology" Pearson Publishers, New Delhi, 1994.
2. Neville A M "Properties of Concrete" Pearson Publishers, New Delhi, 2004.
3. Gambhir M L "Concrete Technology" Tata McGraw Hill, New Delhi, 1995.
4. Shetty M S "Concrete Technology" S. Chand & Company, New Delhi, 2002.
5. Mehta P K "Microstructure of Concrete" Indian Concrete Institute and ACC, Bombay.

Code	Nomenclature of Practical	P	External	Sessional	Total	Time
CE-313N	**STRUCTURAL MECHANICS –II (P)**	**2**	**60**	**40**	**100**	**3H**
Course Objective	To make students acquire the knowledge of methods of analysis of structure fitness for use, physical test and determining the effects of load in a structure					

LIST OF EXPERIMENTS

1. Experiment on a two hinged arch for horizontal thrust & influence line for Horizontal thrust
2. Experimental and analytical study of a 3-bar pin-jointed Truss.
3. Experimental and analytical study of deflections for unsymmetrical bending of a Cantilever beam.
4. Begg's deformeter- verification of Muller Breslau principle.
5. Experimental and analytical study of an elastically coupled beam.
6. Determine the Forces in members of redundant frames.
7. Sway in portal frames - demonstration.

References:

1. A Laboratory Manual on Structural Mechanics by Dr. Harwinder Songh; New Academic Publishing Comp. Ltd.

Code	Nomenclature of Practical	P	External	Sessional	Total	Time
CE-315N	**CONCRETE TECHNOLOGY (P)**	**2**	**60**	**40**	**100**	**3H**
Course Objective	To have better understanding about the various properties of materials used for preparation of concrete, Design of concrete by IS method and different tests to evaluate the strength of concrete.					

LIST OF EXPERIMENTS

1. To determine the standard consistency and initial and final setting time of cement using Vicat's apparatus.
2. To determine the Fineness of cement by Sieve analysis and Blaine's air permeability method.
3. To determine the (1) specific gravity of cement (2) Soundness of cement by Le Chatelier's apparatus.
4. To determine the Compressive strength of cement.
5. To Determine the Fineness Modulus, Bulk Density, Water Absorption and Specific gravity of Fine Aggregates.
6. To Determine the Fineness Modulus, Bulk Density, Water Absorption and Specific gravity of Coarse Aggregates.
7. Mix Design of Concrete by IS methods.
8. Workability of cement concrete by (1) Slump test, (2) Compaction factor test, (3) Flow table test.
9. To Determine the Compressive strength of concrete by (1) Cube test, (2)Cylinder test.
10. To Determine the Split Tensile and Flexural strength of Concrete.
11. To Determine the Bond strength between steel bar and concrete by pull-out test.
12. To evaluate the Non-destructive testing of concrete by (1) Rebound hammer, (2) ultrasonic pulse velocity test.
13. To Determine the Compressive strength of Brick and Tile as IS standard.

1. Concrete Manual-M.L.Gambhir, Dhanpat Rai & Sons, N.Delhi.
2. Concrete Technology-M.L.Gambhir, Tata McGeraw Hill, N.Delhi.
3. Concrete Technology – Nevellie, Pearson Education.

Code	Nomenclature of Practical	P	External	Sessional	Total	Time
CE-317N	**GEOTECHNOLOGY (P)**	**2**	**60**	**40**	**100**	**3H**
Course Objective	The subject gives better idea about the soil and its properties which are very useful in design of types of foundation.					

LIST OF EXPERIMENTS

1. Grain Size Analysis-Hydrometer method.
2. Shrinkage Limit Determination.
3. Relative Density of Granular Soils.
4. Consolidated Drained (CD) Triaxial Test.
5. Consolidated Undrained (CU) Triaxial Test with Pore Water Pressure measurement.
6. Consolidation Test.
7. Undisturbed Sampling.
8. Standard Penetration Test.
9. Dynamic Cone Penetration Test.
10. Model Plate Load Test.

Books:

1. Soil Testing for Engineers by S.Prakash & P.K.Jain, Nem Chand & Bros.,Roorkee.
2. Engineering Soil Testing by Lambi, Wiley-Eastern.
3. Engineering Properties of Soils & Their Measurement by JE Bowles, McGraw -Hill.
4. Soi l Engineer ing in Theory & Pract ice by Alam Singh, Vol. II, Geotechnical Testing & Instrumentation, CBS Pub.