DR. A.P.J ABDUL KALAM TECHNICAL UNIVERSITY, LUCKNOW

EVALUATION SCHEME & SYLLABUS
FOR
B. TECH. THIRD YEAR
(CIVIL ENGINEERING)

(Effective from session 2020-21)
### FIFTH SEMESTER CIVIL ENGINEERING SESSION 2020-21

The Mini Project or Internship (4 weeks) conducted during semester break after IV semester and will be assessed during V semester.

#### NOTE:

1. Regular classroom interaction with industry experts is to be ensured in all theory courses (minimum two expert talks from relevant Industry).
2. Working on experiments using virtual labs is to be ensured in lab courses.
3. Student’s visit to Industry/Industry Expert’s project site must be arranged as & when possible.

<table>
<thead>
<tr>
<th>S.No</th>
<th>Subject Code</th>
<th>Subject</th>
<th>Periods L T P</th>
<th>Evaluation Scheme CT TA Total</th>
<th>End Semester</th>
<th>Total</th>
<th>Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>KCE 501</td>
<td>Geotechnical Engineering</td>
<td>3 1 0</td>
<td>30 20 50</td>
<td>100</td>
<td>150</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>KCE 502</td>
<td>Structural Analysis</td>
<td>3 1 0</td>
<td>30 20 50</td>
<td>100</td>
<td>150</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>KCE 503</td>
<td>Quantity Estimation and Construction Management</td>
<td>3 1 0</td>
<td>30 20 50</td>
<td>100</td>
<td>150</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>KCE 051</td>
<td>Concrete Technology</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>KCE 052</td>
<td>Modern Construction Materials</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>KCE 053</td>
<td>Open Channel Flow</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>KCE 054</td>
<td>Engineering Geology</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>KCE-055</td>
<td>Engineering Hydrology</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>KCE-056</td>
<td>Sensor and Instrumentation Technologies for Civil Engineering Applications</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>KCE-057</td>
<td>Air and Noise Pollution Control</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>KCE-058</td>
<td>GIS and Advance Remote Sensing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>KCE-551</td>
<td>CAD Lab</td>
<td>0 0 2</td>
<td>25</td>
<td>25</td>
<td>50</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>KCE-552</td>
<td>Geotechnical Engineering Lab</td>
<td>0 0 2</td>
<td>25</td>
<td>25</td>
<td>50</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>KCE-553</td>
<td>Quantity Estimation and Management Lab</td>
<td>0 0 2</td>
<td>25</td>
<td>25</td>
<td>50</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>KCE-554</td>
<td>Mini Project or Internship Assessment*</td>
<td>0 0 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>KNC501/ KNC502</td>
<td>Constitution of India, Law and Engineering / Indian Tradition, Culture and Society</td>
<td>2 0 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>MOOCs (Essential for Hons. Degree)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Total</td>
<td></td>
<td>17 3 8</td>
<td></td>
<td>950</td>
<td>22</td>
<td></td>
</tr>
</tbody>
</table>

* The Mini Project or Internship (4 weeks) conducted during semester break after IV semester and will be assessed during V semester.
<table>
<thead>
<tr>
<th>S.No</th>
<th>Subject Code</th>
<th>Subject</th>
<th>Periods</th>
<th>Evaluation Scheme</th>
<th>End Semester</th>
<th>Total</th>
<th>Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>L</td>
<td>T</td>
<td>P</td>
<td>CT</td>
<td>TA</td>
</tr>
<tr>
<td>1</td>
<td>KCE 601</td>
<td>Design of Concrete Structures</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>KCE 602</td>
<td>Transportation Engineering</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>KCE 603</td>
<td>Environmental Engineering</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Departmental Elective-III</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>KCE 606</td>
<td>Advance Structural Analysis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>KCE 607</td>
<td>River Engineering</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>KCE 608</td>
<td>Repair and Rehabilitation of Structures</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>KCE 609</td>
<td>Foundation Design</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>Open Elective-I</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>KCE 610</td>
<td>Transportation Engineering Lab</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>KCE 611</td>
<td>Environmental Engineering Lab</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>KCE 612</td>
<td>Structural Detailing Lab</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>KCE 613</td>
<td>MOOCs (Essential for Hons. Degree)</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>KNC601/</td>
<td>Constitution of India, Law and Engineering /</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>KNC602</td>
<td>Indian Tradition, Culture and Society</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>MOOCs (Essential for Hons. Degree)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Total</strong></td>
<td>17</td>
<td>3</td>
<td>6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:**

1. Regular classroom interaction with industry experts is to be ensured in all theory courses (minimum two expert talks from relevant Industry).
2. Working on experiments using virtual labs is to be ensured in lab courses.
3. Student’s visit to Industry/Industry Expert’s project site must be arranged as & when possible.
KCE 501 GEOTECHNICAL ENGINEERING (L-T-P 3-1-0) Credit – 4

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

CO-1 Classify the soil and determine its Index properties.
CO-2 Evaluate permeability and seepage properties of soil.
CO-3 Interpret the compaction and consolidation characteristics & effective stress concept of soil.
CO-4 Determine the vertical and shear stress under different loading conditions and explain the phenomenon of soil liquefaction.
CO-5 Interpret the earth pressure and related slope failures.

Unit 1
Origin and classification: Preview of Geotechnical field problems in Civil Engineering, Soil formation, transport and deposit, Soil composition, Basic definitions, Weight volume relationships, Clay minerals, Soil structure, Index properties, sensitivity and thixotropy, Particle size analysis, Unified and Indian standard soil classification system. [8]

Unit 2
Soil Hydraulics: Stress conditions in soil- total, effective and neutral stresses and relationships. Permeability - Darcy's Law, hydraulic conductivity, equivalent hydraulic conductivity in stratified soil.
Seepage, flow nets, seepage calculation from a flow net, flow nets in anisotropic soils, seepage through earth dam, capillarity, critical hydraulic gradient and quick sand condition, uplift pressure, piping. [8]

Unit 3
Soil compaction, water content - dry unit weight relationships. Factors controlling compaction. Field compaction equipment; field compaction control; Proctor needle method. Consolidation: Primary and secondary consolidation, Terzaghi's one dimensional theory of consolidation, Consolidation test, Normal and Over Consolidated soils, Over Consolidation Ratio, determination of coefficient of consolidation. [8]

Unit 4
Stress Distribution in soil: Elastic constants of soils and their determination, Boussinesq equation for vertical stress, The Westergaard equation, Stress distribution under loaded areas, Concept of pressure bulb, contact pressure. Shear Strength: Mohr-Coulomb failure criterion, shear strength parameters and determination; direct and tri-axial shear test; unconfined compression test; pore pressure, Skempton's pore pressure coefficients, and Soil liquefaction. [8]
Unit 5

Earth pressure: Classical theories, Coulomb and Rankine’s approaches for frictional and \( c-\phi \) soils, inclined backfill, Graphical methods of earth pressure determination. Stability of slopes - finite and infinite slopes, types of slope failure, Culmann’s method & Method of slices, Stability number & chart, Bishop’s method.

Text & References Books

1. V.N.S. Murthy – Soil Mechanics and Foundation Engineering (Fifth Edition)
4. Alam Singh – Modern Geotechnical Engineering
5. Brij Mohan Das – Geotechnical Engineering , CENGAGE Learning
6. I.H. Khan – Text Book of Geotechnical Engineering
7. C. Venkataramaiah – Geotechnical Engineering

KCE502 STRUCTURAL ANALYSIS (L-T-P 3-1-0) Credit – 4

Course Outcomes:

After completion of the course student will be able to:
CO-1 Explain type of structures and method for their analysis.
CO-2 Analyze different types of trusses for member forces.
CO-3 Compute slope and deflection in determinate structures using different methods.
CO-4 Apply the concept of influence lines and moving loads to compute bending moment and shear force at different sections.
CO-5 Analyze determinate arches for different loading conditions.

Unit 1

Classification of Structures, Types of structural frameworks and Load transfer Mechanisms, stress resultants, degrees of freedom, Static and Kinematic Indeterminacy for beams, trusses and building frames. Analysis of cables with concentrated and continuous loadings, Effect of Temperature upon length of cable.

Unit 2

Classification of Pin jointed determinate trusses, Analysis of determinate plane trusses (compound and complex). Method of Substitution, Method of tension coefficient for analysis of plane trusses.

Unit 3


Unit 4

Rolling loads and influence line diagrams for determinate beams and trusses, Absolute maximum bending moment and shear force. Muller-Breslau’s principal & its applications for determinate structures.

Unit 5

Arches, Types of Arches, Analysis of three hinged parabolic and circular Arches. Linear arch, Eddy’s theorem, spandrel braced arch, moving load & influence lines for three hinged parabolic arch.

References
1. Hibbler, “Structural Analysis”, Pearson Education
13. Devdas Menon “Advanced Structural Analysis” Narosa
KCE 503 QUANTITY ESTIMATION AND CONSTRUCTION MANAGEMENT

(L-T-P 3-1-0) Credit – 4

Course Outcomes:

After completion of the course student will be able to:

CO-1 Understand the importance of units of measurement and preliminary estimate for administrative approval of projects.

CO-2 Understand the contracts and tender documents in construction projects.

CO-3 Analyze and assess the quantity of materials required for civil engineering works as per specifications.

CO 4 Evaluate and estimate the cost of expenditure and prepare a detailed rate analysis report.

CO-5 Analyze and choose cost effective approach for civil engineering projects.

Unit 1
Quantity Estimation for Buildings Measurement units for various building materials, Centreline method, Long and short wall method of estimates, Types of estimates, PWD schedule of rate. [8]

Unit 2
Rate Analysis, Specification and Tenders Analysis of rates knowing cost of material, labour, equipment, overheads, profit, taxes etc, Specifications – Preparation of detailed and general specifications, Legal aspects of contracts, laws related to contracts, land acquisition, labour safety and welfare. Different types of contracts, their relative advantages and disadvantages. Elements of tender preparation, process of tendering, pre-qualification of contracts, Evaluation of tenders, contract negotiation and award of work, monitoring of contract extra items. [8]

Unit 3
Elements of Management & Network Techniques Project cycle, Organization, planning, scheduling, monitoring, updating and management system in construction, Bar charts, milestone charts, work break down structure and preparation of networks. Network Techniques like PERT & CPM in construction management. Project monitoring and resource allocation through network techniques. [8]

Unit 4

Unit 5
Project Cost Management Budgeting, Cost planning, Direct Cost, Indirect cost, Total Cost Curve, Cost Slope. Time value of money, Present economy studies, Equivalence concept,
financing of projects, economic comparison, present worth method, Equivalent annual cost method, discounted cash flow method, Depreciation and its type, depletion, Arbitration, and break even cost analysis.

**References:**

4. Construction Management by Ojha
6. Construction Technology by Sarkar, Oxford
7. Delhi Schedule of Rates (latest version)
KCE-551 CAD LAB

1. Working on latest version of geotechnical engineering software (Open source/commercial software)

2. Working on latest version of surveying software (Open source/commercial software)

NOTE:-

For open source software the following link of FOSSEE may be used apart from other available resources:

https://fossee.in

FOSSEE: (Free/Libre and Open Source Software for Education), National mission on education through ICT, MHRD, Govt. of India.

KCE-552 GEOTECHNICAL ENGINEERING LAB

PART -A (To be performed in lab)

1. Determination of water content of a given moist soil sample by (i) oven drying method, (ii) pycnometer method.
2. Determination of specific gravity of a given soil sample by (i) density bottle, (ii) pycnometer method.
3. Determination of in situ dry density of soil mass by (i) core-cutter method, (ii) sand replacement method.
4. Determination of relative density of a given soil sample.
5. Determination of complete grain size distribution of a given soil sample by sieve analysis and sedimentation (hydrometer) analysis.
6. Determination of consistency limits (liquid, plastic and shrinkage limits) of the soil sample used in experiment no. 5 (grain-size analysis).
7. Determination of shear strength of soil by Direct shear test.
8. Determination of compaction characteristics (OMC & MDD) of a given soil sample.
9. Determination of permeability of a remoulded soil sample by constant head &/or falling head method.
10. Determination of consolidation characteristics of a remoulded soil sample by an odometer test.
11. Determination of shear strength characteristics of a given soil sample by U/U test from Triaxial Compression Machine.
12. Retrieving soil samples and conducting SPT tests by advancing boreholes through hand-held auger.

Note: Any 8 experiments are to be performed from the list of experiments.
PART B

It is mandatory to perform experiments using virtual lab where ever applicable.

References:


KCE - 553: QUANTITY ESTIMATION AND MANAGEMENT LAB

(L-T-P 0-0-2) Credit- 1

1. Study of DSR, CPWD specifications and NBC.
2. Estimation of quantities for any one of the following: Building/ Septic tank/Water supply pipe line/road/bridge.
3. Preparation of Bill of Quantities (BOQ) for above project.
4. Practice on open source project management software / MS Project/Primavera software for same problem.
5. Study of any full set of tender documents (Institute shall provide the set from ongoing/ completed tenders).

NOTE:--
1. Suitable software must be used to complete above exercises in 8-10 hours.
2. For open source software the following link of FOSSEE may be used apart from other available resources:
   https://fossee.in

References:
1. FOSSEE: (Free/Libre and Open Source Software for Education), National mission on education through ICT, MHRD, Govt. of India
5. Construction Management by Ojha
7. Construction Technology by Sarkar, Oxford
KCE 051 CONCRETE TECHNOLOGY (L-T-P 3-0-0) Credit – 3

Course Outcomes:

After completion of the course student will be able to:

CO-1 Understand the properties of constituent material of concrete.
CO-2 Apply admixtures to enhance the properties of concrete.
CO-3 Evaluate the strength and durability parameters of concrete.
CO-4 Design the concrete mix for various strengths using difference methods.
CO-5 Use advanced concrete types in construction industry.

Unit 1

Unit 2
Introduction & study of accelerators, retarders, water reducers, air entrainers, water proofers, super plasticizers. Study of supplementary cementing materials like fly ash, silica fume, ground granulated blast furnace slag, metakaoline and pozzolana; their production, properties and effect on concrete properties. [8]

Unit 3

Unit 4
Principle of mix proportioning, properties related to mix design, Mix design method (IS method and ACI method). Mix design of concrete, Rheology, mix design examples [8]

Unit 5
Study and uses of high strength concrete, self-compacting concrete, fibre reinforced concrete, ferro cement, ready Mix Concrete, recycled aggregate concrete and status in India. [8]
References

10. Concrete mix proportioning as per IS 10262:2009 – Comparison with IS 10262:1982 and ACI 211.1-91 M.C. Nataraja and Lelin Das
Course Outcomes:

After completion of the course student will be able to:

CO-1 Understand the use of modern construction materials.
CO-2 Use geosynthetics and bituminous materials in constructions.
CO-3 Apply knowledge of modern materials in production of variety of concrete.
CO-4 Apply knowledge of composites and chemicals in production of modern concrete.
CO-5 Use modern water proofing and insulating materials in constructions.

Unit 1
Introduction, properties and uses of modern building materials: fly ash bricks, soil – cement blocks, calcium silicate bricks, red mud jute fibre polymer composite (RFPC), glass reinforced gypsum.

Unit 2
Introduction, properties and use of: geosynthetics, bituminous material, fire resistant materials (chemicals, paints, tiles, bricks, glass), metals, light – weight concrete, mass concrete, waste material based concrete.

Unit 3
Introduction, properties and use of: Ferro cement & fibre reinforced concrete, different types of fibres, high density concrete, Nuclear concrete, heat resisting & refractory concretes, prefabricated systems.

Unit 4

Unit 5

Reference Book:
2) A.R. Santhakumar, Concrete Technology, Oxford University Press.
4) Shetty, M. S., "Concrete Technology" S. Chand Publication.
5) Krishnaraju .N., Advanced Concrete Technology, CBS Published.
7) Neville. A.M., Concrete Technology, Prentice Hall, Newyork.
9) Materials Science and Engineering, V. Raghavan, Prentice Hall.
KCE-053 : OPEN CHANNEL FLOW (L-T-P 3-0-0) Credit – 3

Course Outcomes:

After completion of the course student will be able to:

CO-1 Apply knowledge of fluid flow for designing of channel sections.
CO-2 Analyze the gradually varied flow in channel section.
CO-3 Analyze the rapidly varied flow in channel sections.
CO-4 Apply numerical methods for profile computation in channels.
CO-5 Design channels for sub critical and super critical flows.

Unit 1
Introduction: Basic concepts of free surface flows, velocity and pressure distribution, Mass, energy and momentum principle for prismatic and non-prismatic channels, Review of Uniform flow: Standard equations, hydraulically efficient channel sections, compound sections

Unit 2
Gradually Varied Flow (GVF): Equation of gradually varied flow and its limitations, flow classification and surface profiles, Control sections, Computation methods and analysis: Integration of varied flow equation by analytical, graphical and advanced numerical methods, Transitions of subcritical and supercritical flow, flow in curved channels.

Unit 3
Rapidly Varied Flow (RVF): Characteristics of rapidly varied flow, Classical hydraulic jump, Evaluation of the jump elements in rectangular and non-rectangular channels on horizontal and sloping beds, Hydraulic jump in gradually and suddenly expanding channels, submerged hydraulic jump, rolling and sky jump, use of jump as an energy dissipater, Flow measurement: by sharp crested and broad crested weirs, critical depth flumes, sluice gate, Free over fall.
Rapidly varied unsteady flow: Equation of motion for unsteady flow, “Celerity” of the gravity wave, deep and shallow water waves, open channel positive and negative surge.

Unit 4
Spatially Varied Flow (SVF): Basic principles, Differential SVF equations for increasing and decreasing discharge, Classifications and solutions, Numerical methods for profile computation, low over side-weir and Bottom-rack.

Unit 5
Flow in channel of non-linear alignment and non-prismatic channel sections, Design considerations for sub critical and super critical flows, Design of culvert.

References:
4. Ranga Raju, K.G., Flow through open channels, T.M.H.
5. M. Hanif Chaudhry, Open Channel Flow, PHI
6. French, R.H., Open channel Hydraulics, McGraw Hill International
7. Srivastava, Flow through Open Channels, Oxford University Press.
8. Open Channel Flow by Madan Mohan Das
KCE 054 ENGINEERING GEOLOGY

Course Outcomes:

After completion of the course student will be able to:

CO-1 Understand the scope of geological studies.
CO-2 Understand the rocks and its engineering properties.
CO-3 Understand the minerals and constituents of rocks.
CO-4 Understand the rock deformations, their causes effects and preventive measures.
CO-5 Understand the ground water reserves, Geophysical exploration methods and site selection for mega projects.

Unit 1
Introduction-Branches of geology useful to civil engineering, scope of geological studies in various civil engineering projects. Department dealing with this subject in India and their scope of work- GSI, Granite Dimension Stone Cell, NIRM. Mineralogy-Mineral, Origin and composition. Physical properties of minerals, susceptibility of minerals to alteration, basic of optical mineralogy, SEM, XRD., Rock forming minerals, mega scopic identification of common primary & secondary minerals.

Unit 2

Unit 3

Unit 4
Rock Deformation & Earthquake Folds, Faults, Joints and unconformities: Their classification, causes and relation to engineering behavior of rock masses. Landslides, its causes and preventive measures. Earthquake, its causes, classification, seismic zones of India and its geological consideration.

Unit 5
References:
Course Outcomes:

After completion of the course student will be able to:

- CO-1 Understand the basic concept of hydrological cycle and its various phases.
- CO-2 Understand the concept of runoff and apply the knowledge to construct the hydrograph.
- CO-3 Apply the various methods to assess the flood.
- CO-4 Assess the quality of various forms of water and their aquifer properties.
- CO-5 Understand the well hydraulics and apply ground water modelling techniques.

Unit 1
Introduction: hydrologic cycle, water budget equations, world water balance, Precipitation: Forms of precipitation, measurement. Introduction to characteristics of storm. Abstraction from Precipitation: Evaporation – process, measurement and estimation; Evapotranspiration- measurement and estimation; Initial Losses- Interception & Depression storage; Infiltration-process, capacities indices, measurement & estimation.

Unit 2
Runoff and Hydrographs: Runoff characteristics of stream, mass curve. Hydrograph, Factors affecting flood hydrographs, unit hydrograph and its analysis, s-curve hydrograph, synthetic and instantaneous unit hydrographs.

Unit 3
Flood: Rational method, empirical formulae, flood frequency studies, statistical analysis, regional flood frequency analysis, design storm & design flood, risk/reliability and safety factor; Flood Routing: Basic equation, hydrologic storage routing & attenuation, hydrologic channel routing, flood forecasting & control, hydraulic method of flood routing.

Unit 4
Groundwater: Introduction, forms of subsurface water, aquifers & its properties, Occurrence of ground water, hydro-geology& aquifers, Ground water movement. Steady and unsteady flow through confined and unconfined aquifers. Well Hydraulics: Single& Multiple well system, partially penetrating wells, Image wells, Mutual interference of wells, well losses, specific capacity.

Text Books:
- ‘Groundwater Hydrology’ by Todd D. K., Wiley
- ‘Groundwater’ by Raghunath H. M., New Age Publisher
- ‘Engineering Hydrology’ by K. Subramanya, Mc Graw Hill Education
- ‘Handbook of Applied Hydrology’ by Chow V. T., Mc Graw Hill Education

Reference:
- ‘Groundwater’ by S.Ramakrishnan, Scitech Publications
- ‘Engineering Hydrology’ by Ojha, Oxford University Press.
- ‘Introduction to Hydrology’ by Viessman& Lewis by Pearson Publication.
- ‘Applied Hydrology’ by Fetter, by Pearson Publication
Course Outcomes:

After completion of the course student will be able to:

CO-1 Analyze the errors during measurements
CO-2 Describe the measurement of electrical variables
CO-3 Describe the requirements during the transmission of measured signals
CO-4 Construct Instrumentation/Computer Networks
CO-5 Suggest proper sensor technologies for specific applications
CO-6 Design and set up measurement systems and do the studies

Unit 1

Fundamentals of Measurement, Sensing and Instrumentation covering definition of measurement and instrumentation, physical variables, common types of sensors; Describe the function of these sensors; Use appropriate terminology to discuss sensor applications; and qualitatively interpret signals from a known sensor type, types of instrumentation, Sensor Specifics, Permanent installations, Temporary installations;

Unit 2

Sensor Installation and Operation covering to: i) Predict the response of sensors to various inputs; ii) Construct a conceptual instrumentation and monitoring program; iii) Describe the order and methodology for sensor installation; and iv) Differentiate between types of sensors and their modes of operation and measurement and v) Approach to Planning Monitoring Programs, Define target, Sensor selection, Sensor siting, Sensor Installation & Configuration, Advanced topic, Sensor design, Measurement uncertainty

Unit 3

Data Analysis and Interpretation covering a) Fundamental statistical concepts, b) Data reduction and interpretation, c) Piezometer, Inclinometer, Strain gauge, etc. d) Time domain signal processing, e) Discrete signals, Signals and noise and f) a few examples of statistical information to calculate are: Average value (mean), On average, how much each measurement deviates from the mean (standard deviation), Midpoint between the lowest and highest value of the set (median), Most frequently occurring value (mode), Span of values over which your data set occurs (range)

Unit 4

Frequency Domain Signal Processing and Analysis covering Explain the need for frequency domain analysis and its principles; Draw conclusions about physical processes based on analysis of sensor data; Combine signals in a meaningful way to gain deeper insight into physical phenomena, Basic concepts in frequency domain signal processing and analysis,
Fourier Transform, FFT (Fast Fourier Transform), Example problems: Noise reduction with filters, Leakage, Frequency resolution

Text/Reference Books:
Alan S Morris (2001), Measurement and Instrumentation Principles, 3rd/e, Butterworth Hienemann
David A. Bell (2007), Electronic Instrumentation and Measurements 2nd/e, Oxford Press
S. Tumanski (2006), Principle of Electrical Measurement, Taylor & Francis
Ilya Gertsbakh (2010), Measurement Theory for Engineers, Springer
Course Outcomes:

After completion of the course student will be able to:

CO-1 Understand air pollutants and their impacts.
CO-2 Explain air pollution chemistry and meteorological aspects of air pollutants.
CO-3 Demonstrate methods for controlling particulate air pollutants.
CO-4 Demonstrate methods for controlling gaseous air pollutants.
CO-5 Understand automotive emission standards.
CO-6 Apply methods for controlling noise pollution.

Unit 1

Unit 2
Air pollution chemistry, meteorological aspects of air pollution dispersion; temperature lapse rate and stability, wind velocity and turbulence, plume behaviour, dispersion of air pollutants, the Gaussian Plume Model, stack height and dispersion. [8]

Unit 3
Ambient air quality and standards, air sampling and measurements. Control of particulate air pollutants using gravitational settling chambers, cyclone separators, wet collectors, fabric filters (Bag-house filter), electrostatic precipitators (ESP). [8]

Unit 4

Unit 5
Noise pollution: Basics of acoustics and specification of sound; sound power, sound intensity and sound pressure levels; plane, point and line sources, multiple sources; outdoor and indoor noise propagation; psychoacoustics and noise criteria, effects of noise on health, annoyance rating schemes; special noise environments: Infrasound, ultrasound, impulsive sound and sonic boom; noise standards and limit values; noise instrumentation and monitoring procedure. Noise indices. Noise control methods. [8]
References:
1. Peavy, Rowe and Tchobanoglous: Environmental Engineering.
2. Martin Crawford: Air Pollution Control Theory.
5. Nevers: Air Pollution Control Engineering.
7. C.S. Rao, Air pollution and control
8. Advanced Air and Noise Pollution Control by Lawrence K. Wang, Norman C. Pereira & Yung IseHung.
9. Noise Pollution and Control by S. P. Singhal, Narosa Pub House
Course Outcomes:

After completion of the course student will be able to:

CO-1 Understand the concepts of Photogrammetry and compute the heights of objects
CO-2 Understand the principles of aerial and satellite remote sensing, Able to comprehend the energy interactions with earth surface features, spectral properties of water bodies
CO-3 Understand the basic concept of GIS and its applications, know different types of data representation in GIS
CO-4 Understand and Develop models for GIS spatial Analysis and will be able to know what the questions that GIS can answer are
CO-5 Illustrate spatial and non-spatial data features in GIS and understand the map projections and coordinates systems
CO-6 Apply knowledge of GIS and understand the integration of Remote Sensing and GIS

Unit 1

Introduction to photogrammetry Principles and types of aerial photographs, geometry of vertical and aerial photograph, Scale and Height measurement on single and vertical aerial photograph, Height measurement based on relief displacement, Fundamentals of Stereoscopy, fiducial points, parallax measurement using fiducial line. [8]

Unit 2

Remote sensing Basic concepts and foundation of Remote Sensing elements, Data information, Remote sensing data collection, Remote sensing advantages and Limitations,

Remote sensing process. Electromagnetic spectrum, Energy interaction with atmosphere and with earth surface features (soil, water, and vegetation) Indian Satellites and Sensors characteristics, Map and Image false color composite, introduction to digital data, elements of visual interpretations techniques. [8]

Unit 3

Geographic Information Systems Introduction to GIS, Components of GIS, Geospatial data: Spatial Data – Attribute Data- Joining Spatial and Attribute Data, GIS Operations: Spatial Data input- Attribute Data Management–Data Display–Data Exploration–Data Analysis. COORDINATE SYSTEMS: Geographic Coordinate system; Approximation of Earth, Datum: Map Projections; Types of Map Projections–Map Projection Parameters-Commonly used Map Projections – Projected Coordinate Systems. [8]

Unit 4

Vector data model Representation of simple features- Topology and its importance: coverage and its data structure, shape file; data models for composite features Object Based Vector
Data Model; Classes and their Relationships: The geobased data model: Geometric representation of Spatial feature and data structure: Topology rules. [8]

**Unit 5**

Raster data model Elements of Raster data model: Types of Raster data: Raster data structure: Data conversion, Integration of Raster and Vector data. Data Input: Metadata: Conversion of Existing data, Creating new data, Remote sensing data, Field data, Digitizing, Scanning, on screen digitizing, importance of source map, Data Editing. [8]

**TEXT BOOKS:**


**REFERENCES:**

Course Outcomes:

After completion of the course student will be able to:

CO-1 Analyse and Design RCC beams for flexure by IS methods.
CO-2 Analyse and Design RCC beams for shear by IS methods.
CO-3 Analyse and Design RCC slabs and staircase by IS methods.
CO-4 Design the RCC compression members by IS methods.
CO-5 Design various types of footings and cantilever retaining wall

Unit 1

Unit 2
Behaviour of RC beam in Shear, Shear Strength of beams with and without shear reinforcement, Minimum and Maximum shear reinforcement, design of beam in shear. Introduction to development length, Anchorage bond, flexural bond. (Detailed Examples by Limit State Design Method), Failure of beam under shear, Concept of Equivalent Shear and Moments. [8]

Unit 3
Design of one way, One way continuous and cantilever solid slabs by Limit State Design Method, Design of Dog-legged staircases.

Design of two way slabs by limit state method, Serviceability Limit States, Control of deflection, cracking and vibrations. [8]

Unit 4
Design of Columns by Limit State Design Method- Effective height of columns, Assumptions, Minimum eccentricity, Short column under axial compression, requirements for reinforcement, Column with helical reinforcement, Short column under axial load and uni-axial bending, Design of columns under bi-axial loading by Design Charts. [8]

Unit 5
Structural behaviour of footings, Design of isolated footings, combined rectangular and trapezoidal footings by Limit State Method, Design of strap footings.

Structural behaviour of retaining wall, stability of retaining wall against overturning and sliding, Design of cantilever retaining wall by Limit State Method. [8]
References

2. Reinforced Concrete Design by S. U. Pillai & D. Menon, Tata Mc.-Graw, New Delhi
7. Reinforced Concrete Design by P. Dayaratnam.
8. Reinforced Concrete Design by M.L. Gambhir
9. Reinforced Concrete Design by S.N. Sinha, TMH
11. SP-16: Design Aid to IS- 456.
Course Outcomes:

After completion of the course student will be able to:

CO-1 Understand the history of road development, their alignment & Survey.
CO-2 Design the various geometric parameters of road.
CO-3 Study the traffic characteristics & design of road intersections & signals.
CO-4 Examine the properties of highway materials & their implementation in design of pavements.
CO-5 Learn methods to construct various types of roads.

Unit 1
Introduction: Role of Transportation, Modes of Transportation History of road development, Road types and pattern, Nagpur road plan, Bombay road plan & 3rd 20 Year Road Plan, Highway Alignment & Location Survey: Horizontal Profile, Vertical Profile, Factors Controlling the alignment, Survey for route location.

Unit 2

Unit 3
Traffic Engineering: Traffic Characteristics, Traffic studies on flow, speed, travel time - delay and O-D study, PCU, peak hour factor, accident study, traffic capacity, density, traffic control devices: signs, Island, signal design by Webster’s and IRC method. Intersection at grade and grade separated intersections, design of roundabouts as per IRC:65-2017. Highway capacity and level of service of rural highways and urban roads as per latest IRC recommendation.

Unit 4

Unit 5
Highway Construction: Construction of Subgrade, Water Bound Macadam (WBM), Wet mix macadam (WMM), Granular Sub Base (GSB), Tack Coat, Prime Coat, Seal Coat, Surface
Dressing, Bituminous Macadam (BM), Semi dense bituminous concrete (SDBC) and Bituminous concrete, Dry lean concrete (DLC), Cement Concrete (CC) road construction.

Note: All designs and procedure are to be done with reference to latest revision of IRC as given below in reference section.

Text Book:

References:
5. Chakraborty Partha & Das Animesh., “Principles of Transportation Engineering”, Prentice Hall (India), New Delhi,
6. IRC : 37- Latest revision, “Tentative Guidelines for the design of Flexible Pavements” Indian Roads Congress, New Delhi
8. IRC:65-2017 Guidelines for Planning and Design of Roundabouts (First Revision)
10. IRC:106-1990 Guidelines for Capacity of Urban Roads in Plain Areas
12. IRC:92-2017 Guidelines for Design of Interchanges in Urban Areas (First Revision)
15. MORTH, “Specifications for Road and Bridge Works”, Ministry of Shipping, Road Transport & Highways, Published by Indian Roads Congress, New Delhi.
KCE 603 ENVIRONMENTAL ENGINEERING (L-T-P 3-1-0) Credit – 4

Course Outcomes:

After completion of the course student will be able to:

CO-1 Assess water demand and optimal size of water mains.
CO-2 Layout the distribution system & assess the capacity of reservoir.
CO-3 Investigate physical, chemical & biological parameter of water.
CO-4 Design treatment units for water and waste water.
CO-5 Apply emerging technologies for treatment of waste water.

Unit 1
Fresh water, water demands, variation in demands, population forecasting by various methods, basic needs and factors affecting consumption, design period.
Transmission of water: Various types of conduits, capacity and sizes including economical sizes of rising main, structural requirements; laying and testing of water supply pipelines; pipe materials, joints, appurtenances and valves; leakages and control.  [8]

Unit 2
Storage and distribution of water: Methods of distribution, pressure and gravity distribution systems, Concept of service and balancing reservoirs.
Capacity of distribution reservoirs: general design guidelines for distribution system.  [8]

Unit 3
Physical, chemical and bacteriological examination of water and wastewater: Temperature, pH, colour and odour, solids, nitrogen and phosphorus, chlorides, toxic metals and compounds, BOD, COD etc. quality requirements, standards of water and waste water, disposal of wastewater on land and water bodies.  [8]

Unit 4
Objectives of water treatment: unit operations, processes, and flow sheets.
Water treatment: screening, sedimentation, determination of settling velocity, efficiency of ideal sedimentation tank, design of settling tanks, grit chamber.
Primary sedimentation and coagulation, filtration: theory of filtration; hydraulics of filtration; slow sand, rapid sand and pressure filters, backwashing; design of slow and rapid sand filters.
Disinfection: requirements of an ideal disinfectant; various disinfectants, chlorination and practices of chlorination, water softening and ion-exchange process  [8]

Unit 5
Objectives of waste water treatment: unit operations, processes, and flow sheets.

Anaerobic digestion of sludge: design of low and high rate anaerobic digesters and septic tank. Working of up flow anaerobic sludge blanket (UASB) reactor and other emerging technologies for wastewater treatment [8]

Text Books:
5. Garg: Sewage Disposal and Air Pollution Engineering (Environmental Engineering Vol. – II).

References:
3. Steel and McGhee: Water Supply and Sewerage
4. Fair and Geyer: Water Supply and Wastewater Disposal
5. Hammer and Hammer Jr.: Water and Wastewater Technology
6. Raju: Water Supply and Wastewater Engineering
7. Rao: Textbook of Environmental Engineering
8. Davis and Cornwell: Introduction to Environmental Engineering
12. Ramalho: Introduction to Wastewater Treatment Processes
15. Ramalho: Introduction to Wastewater Treatment Processes
16. Parker: Wastewater Systems Engineering
PART -A (To be performed in lab)
1. To Determine the Crushing Value of Coarse Aggregates.
2. To Determine the Impact Value of Coarse Aggregates.
3. To determine the Flakiness Index and Elongation Index of Coarse Aggregates.
4. To determine the Los Angeles Abrasion Value of Coarse Aggregates.
5. To determine the Stripping Value of Coarse Aggregates.
6. To determine the penetration Value of Bitumen.
7. To determine the Softening Point of Bituminous material.
8. To determine the Ductility Value of Bituminous material.
9. To determine the Flash and Fire Point of Bituminous material.
10. To determine the Stripping Value of Bituminous material.
11. Classified both directional Traffic Volume Study.
12. Traffic Speed Study. (Using Radar Speedometer or Enoscope).
13. Determination of CBR Value of soil sample in the Lab or in Field.

Note: A minimum of 8 experiments are to be performed from the list of Experiments.

PART B

1. It is mandatory to perform experiments using virtual lab where ever applicable.
2. Relevant IRC specifications and codes must be studied.

References:

PART -A (To be performed in lab)
1. Determination of turbidity and conductivity.
2. Determination of pH, alkalinity and acidity.
3. Determination of hardness and chlorides.
4. Determination of residual chlorine.
5. Determination of MPN (most probable number) of coliforms.
7. Measurement of sound level with sound level meter.
8. Determination of total, suspended and dissolved solids.
9. Determination of BOD.
10. Determination of COD.
14. Field Visit of Water/ Sewage Treatment Plant of a nearby area.

Note: 1. Experiment at S.NO. 14 is mandatory.
      2. Any 8 Experiments out of the S.NO 1 to 13 are to be performed.

PART B
1. It is mandatory to perform experiments using virtual lab where ever applicable.
2. Relevant specifications and IS codes must be studied.

References:
KCE 653 STRUCTURAL DETAILING LAB (L-T-P 0-0-2) Credit – 1

PART -A (To be performed in lab)
1. To verify Maxwell’s Reciprocal theorem.
2. To find horizontal thrust in a three-hinged arch and to draw influence line diagrams for Horizontal Thrust end Bending moment.
3. To find horizontal thrust in a two hinged arch and to draw influence line diagrams for horizontal Thrust and bending moment.
5. Preparation of working hand sketches and soft drawings using BIM software (Open source/Commercial) for the following-
   a) Simply supported, Continuous and Cantilever RCC Beams(T-beam and I-Beam)
   b) RCC Slabs – (Simply supported, Continuous, One way and two way).
   c) RCC Columns –(Tied columns and Spirally reinforced columns)
   d) Isolated and combined footings for RC Columns.
6. Preparation of bar bending schedule.
7. Detailing of buildings with respect to Earthquake Resistant Design
8. Study of full set of structural drawing of a building as made available by Institute.

PART B
It is mandatory to perform experiments using virtual lab where ever applicable.

NOTE:-
1. For open source software the following link of FOSSEE may be used apart from other available resources:

   https://fossee.in

References:
1. FOSSEE: (Free/Libre and Open Source Software for Education), National mission on education through ICT, MHRD, Govt. of India
KCE 061 ADVANCE STRUCTURAL ANALYSIS (L-T-P 3-0-0) Credit – 3

Course Outcomes:

After completion of the course student will be able to:

CO-1 Analyze indeterminate structure to calculate unknown forces, slope and deflections by different methods.
CO-2 Apply principle of influence lines to analyze indeterminate beams and arches.
CO-3 Analyze and design cable structure with their influence line diagram.
CO-4 Apply basics of force and stiffness methods of matrix analysis for beams, frames and trusses.
CO-5 Apply the basic of plastic analysis to analyze the structure by using different mechanism.

Unit 1
Analysis of fixed beams, Continuous beams and simple frames with and without translation of joint by Slope-Deflection method, Moment Distribution method and Strain Energy method. [8]

Unit 2
Muller-Breslau’s Principle and its applications for drawing influence lines for indeterminate beams, Analysis of two hinged and fixed arches, Influence line diagrams for maximum bending moment, Shear force and thrust in two hinge arches. Analysis of two and three hinged stiffening girders. [8]

Unit 3
Introduction to Suspension Bridges, Analysis of two and three hinged stiffening girders, Influence line diagrams for maximum bending moment and shear force for stiffening girders. [8]

Unit 4
Basic Force and Displacement Matrix method for analysis of beams, frames and trusses. [8]

Unit 5
Basics of Plastic Analysis. Applications of Static and Kinematic theorem for Plastic Analysis of Beams and Single Storied Frames. [8]

References:
5. Dayaratnam, P. “ Analysis of Statically Indeterminate Structures”, Affiliated East-West
Press.
17. Devdas Menon “Advanced Structural Analysis” Narosa
Course Outcomes:

After completion of the course student will be able to:

CO-1 Explain river morphology and its classification.
CO-2 Explain hydraulic geometry and behavior of river.
CO-3 Explain socio-cultural influences and ethics of stream restorations.
CO-4 Analyze flow and sediment transport in rivers and channels.
CO-5 Design guide band, embankments and flood protection systems.

Unit 1
Introduction, classification of Rivers, Mechanics of alluvial rivers including channel and flood plain features, Sediment transport and budgets, River morphology and various classification schemes.

Unit 2
Behavior of Rivers: Introduction, River Channel patterns, Straight river channels, causes, characteristics and shapes of meanders and control, cutoff, Braided Rivers, Bed forms, Instability of rivers, Hydraulic geometry, Delta formation and control.

Unit 3
Mechanics of Alluvial Rivers, Rivers and restoration structures, Socio-cultural influences and ethics of stream restoration.

Unit 4
Bio-engineering Techniques, Classification review, Natural Channel Design Analysis, Time Series, Analysis of flow, Sediment and channel geometry data.

Unit 5
River Training and Protection Works: Introduction, Classification of River Training, Types of training works, Protection for Bridges with reduced waterway, Design of Guide Band, embankment and spurs/dampners and other river/flood protection works.

Text book:
3. River Engineering by Margeret Peterson
4. Principles of River Engineering by (the non tidal alluvial) PH Jameen
KCE063 REPAIR AND REHABILITATION OF STRUCTURES  
(L-T-P 3-0-0) Credit – 3

Course Outcomes:

After completion of the course student will be able to:

CO-1 Understand the fundamentals of maintenance and repair strategies.
CO-2 Identify for serviceability and durability aspects of concrete.
CO-3 Know the materials and techniques used for repair of structures.
CO-4 Decide the appropriate repair and retrofitting techniques.
CO-5 Use appropriate health monitoring technique and demolition methods

Unit 1
Maintenance: Repair and rehabilitation, facts of maintenance, importance of maintenance various aspects of inspection, assessment procedure for evaluating damaged structure, causes of deterioration.
Repair Strategies: Causes of distress in concrete structures, construction and design failures, condition assessment and distress-diagnostic techniques, assessment procedure for inspection and evaluating a damaged structure. [8]

Unit 2
Serviceability and Durability of Concrete: Quality assurance for concrete construction, concrete properties – strength, permeability, thermal properties and cracking. effects due to climate, temperature, chemicals, corrosion. [8]

Unit 3

Unit 4
Repair, Rehabilitation and Retrofitting Techniques: Repairs to overcome low member strength, deflection, cracking, chemical disruption, weathering corrosion, wear, fire, leakage and marine exposure.

Unit 5
Health Monitoring and Demolition Techniques: Long term health monitoring techniques, engineered demolition techniques for dilapidated structures, use of sensors for building instrumentation. [8]

**References**

1. Concrete Technology by A.R. Santakumar, Oxford University press
3. Non-Destructive Evaluation of Concrete Structures by Bungey - Surrey University
Course Outcomes:

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

CO-1 Understand various methods of Soil Exploration and its importance.
CO-2 Analyze bearing capacity and settlement of soil for shallow foundation.
CO-3 Design the various types of shallow foundation and understand the basics of deep foundation.
CO-4 Understand the characteristics of well foundations and retaining wall.
CO-5 Understand the concept of soil reinforcement.

**Unit 1**
Introduction to soil exploration, methods of boring and drilling, soil sampling and sampler, in-situ tests, SPT, CPT, DCPT, geophysical methods; soil resistivity methods seismic refraction methods. [8]

**Unit 2**
Bearing capacity of shallow foundation, design criteria, factors affecting bearing capacity, factors influencing selection of depth of foundation, modes of shear failures, types of shallow foundations, contact pressure under rigid and flexible footings, Terzaghi’s, Meyerhof, Hansen’s bearing capacity theories, IS code method

Settlement of shallow foundations: components of settlement & its estimation, immediate, consolidation, & differential settlements. [8]

**Unit 3**
Design of shallow foundation; principles of design of footing, design of isolated footings and strip footing.

Deep foundation; introduction, necessity of deep foundations, pile installation, pile groups, group action of piles in sand and clay, group efficiency of piles, settlement of piles, negative skin friction, single and double under reamed piles. [8]

**Unit 4**
Introduction, shapes and characteristics of wells, components of well foundation, forces acting on well foundation, sinking of wells, causes and remedies of tilts and shifts.

Retaining walls: introduction, types of retaining structures, support systems for flexible retaining walls (struts, anchoring), construction methods, introduction and uses of sheet piles. [8]

**Unit 5**
Geotechnical properties of reinforced soil, use of soil reinforcement, shallow foundation on soil with reinforcement, design considerations, idealized soil, foundation and interface behaviour, elastic models of soil behaviour.

**Reference Books:**

1) Alamsingh; Soil Mechanics & Foundation Engineering; CBS Publishers & Distributors, Delhi
2) Taylor D.W.; Fundamentals of Soil Mechanics; Asia Publishing House, Mumbai
3) Das Braja M; Principles of Geotechnical Engineering; Thomson Asia Pvt. Ltd.
5) Gopal Ranjan, Rao A.S.R.; Basic and applied soil mechanics; New age int. (p) ltd.
6) Arora K.R.; Soil Mechanics & Foundation Engineering; Standard Pub., Delhi
8) V. N. S. Murthy; Soil Mechanics & Foundation Engineering; Sai Kripa Technical Consultants, Bangalore
9) P. Purushothama Raj; Soil Mechanics and Foundation Engineering; Pearson Education.
10) I.H. Khan – Text Book of Geotechnical Engineering
11) C. Venkataramaiah – Geotechnical Engineering
12) Shenbaga R Kaniraj- Design Aids in Soil Mechanics and Foundation Engineering