VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM CHOICE BASED CREDIT SYSTEM (CBCS)

SCHEME OF TEACHING AND EXAMINATION 2020-2021

M.Tech. - Geotechnical Engineering

I Semester **CREDIT BASED**

Subject Code	Name of the Subject	Teaching hours/week		Duration of Exam in Hours	Marks for		Total Marks	CREDITS
		Lecture	Practical / Field Work / Assignment		I.A.	Exam		
20CGT11	Forensic Geotechnical Engineering	4	-	3	40	60	100	4
20CGT12	Sub surface Investigations and Ground Improvement Techniques	4	--	3	40	60	100	4
20CGT13	Design of Shallow Foundations	4	--	3	40	60	100	4
20CGT14	Advanced Soil Mechanics	4	--	3	40	60	100	4
20CGT15	Geotechnology and Advanced Soil Testing	4	--	3	40	60	100	4
20CGT16	Advanced Geotechnical Engineering Laboratory - 1	--	**4 (3 hrs lab + 1 hr instruction)**	3	40	60	100	2
20RMI17	**Research Methodology and IPR**	2	--	3	40	60	100	2
	Total	**22**	**4**	**21**	**280**	**420**	**700**	**24**

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
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SCHEME OF TEACHING AND EXAMINATION 2020-2021

M.Tech.- Geotechnical Engineering

II Semester **CREDIT BASED**

Subject Code	Name of the Subject	Teaching hours/week		Duration of Exam in Hours	Marks for		Total Marks	CREDITS
		Lecture	Practical / Field Work / Assignment/ Tutorials		I.A.	Exam		
20CGT21	Reinforced Soil Structures	4	--	3	40	60	100	4
20CGT22	Soil Dynamics	4	--	3	40	60	100	4
20CGT23	Design of Deep Foundations	4	--	3	40	60	100	4
20CGT24X	Foundation Elective - 1	4	--	3	40	60	100	4
20CGT25X	Core Elective – 1	4	--	3	40	60	100	4
20CGT26	Advanced Geotechnical Engineering Laboratory-2	--	**4(3 hrs lab+ 1 hr instruction)**	3	40	60	100	2
20CGT27	Seminar	--	2	--	100	--	100	2
	Total	**20**	**6**	**18**	**340**	**360**	**700**	**24**

Foundation Elective – 1		**Core Elective -1**	
20CGT241	Case history in Geotechnical Engineering	20CGT251	Environmental Geotechnical Engineering
20CGT242	Pavement Analysis and Design	20CGT252	Ground water hydrology
20CGT243	Critical state Soil Mechanics	20CGT253	Rock Mechanics
20CGT244	Foundation Engineering in difficult ground	20CGT254	Soil structure interaction

1. Core subject: This is the course which is to be compulsorily studied by a student as a core requirement to complete the requirement of a programme in a said discipline of study.

2a. Foundation Core: The courses based upon the content that leads to Knowledge enhancement.

2b. Foundation Elective: Elective Foundation courses are value-based and are aimed at developing decision making education

3. Elective: **This is the course, which can be chosen from the pool of papers. It may be supportive to the discipline/providing extended scope/Enabling an Exposure to some other discipline/domain/nurturing student proficiency skills**.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM CHOICE BASED CREDIT SYSTEM (CBCS)

SCHEME OF TEACHING AND EXAMINATION 2020-2021

M.Tech:- Geotechnical Engineering

III Semester: INTERNSHIP **CREDIT BASED**

Course Code	Subject	No. of Hrs./Week		Duration of the Exam in Hours	Marks for		Total Marks	CREDITS
		Lecture	Practical / Field Work		I.A.	Exam		
20CGT31	Unsaturated Soil Mechanics	4	-	03	40	60	100	4
20CGT32X	Foundation Elective - 2	4	-	03	40	60	100	4
20CGT33X	Core Elective – 2	4	-	03	40	60	100	4
20CGT34	**Evaluation of Project Phase - 1**	-	2	-	100	-	100	2
20CGT35	**Internship**	-	-	03	40	60	100	6
	Total	**12**	**2**	**12**	**260**	**240**	**500**	**20**

Foundation Elective - 2		**Core Elective -2**	
20CGT321	Earth and Earth Retaining Structures	20CGT331	Finite Elements in Geotechnical Engineering
20CGT322	Earth quake Resistant Design of Foundations	20CGT332	Expansive Soil Engineering
20CGT323	Earth and Rockfill dams and slope stability	20CGT333	Offshore Geotechnical Engineering
20CGT324	Optimization Techniques in Geotechnical Engineering	20CGT334	Ground water contamination and remediation

Note:

1. **Project Phase-1:** Students in consultation with the guide/co-guide if any, shall pursue literature survey and complete the preliminary requirements of selected Project work. Each student shall prepare relevant introductory project document, and present a seminar.
   CIE marks shall be awarded by a committee comprising of HOD as Chairman, Guide/co-guide if any, and a senior faculty of the department. The IA marks awarded for project work phase-1, shall be based on the evaluation of Project Report, Project Presentation skill and Question and Answer session in the ratio 50:25:25.
   SEE (University examination) shall be as per the University norms.
2. **Internship:** Those, who have not pursued /completed the internship, shall be declared as failed and have to complete during subsequent University examinations after satisfying the internship requirements.

Internship SEE (University examination) shall be as per the University norms.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM CHOICE BASED CREDIT SYSTEM (CBCS) SCHEME OF TEACHING AND EXAMINATION 2020-2021

M.Tech.- Geotechnical Engineering

IV Semester **CREDIT BASED**

Subject Code	Subject	No. of Hrs./Week		Duration of Exam in Hours	Marks for		Total Marks	CREDITS
		Lecture	Practical/Field work/Assignment		I.A.	Exam		
20CGT41	Project Phase-II	-	4	3	40	60	100	20
Total		**-**	**4**	**3**	**40**	**60**	**100**	**20**
Grand Total (I to IV Sem.) : 2000 Marks; 88 Credits								

Note:

1. Project Phase-2:

IA marks shall be awarded by a committee comprising of HOD as Chairman, Guide/co-guide, if any, and a Senior faculty of the department. The CIE marks awarded for project work phase -2, shall be based on the evaluation of Project Report subjected to plagiarism check, Project Presentation skill and Question and Answer session in the ratio 50:25:25.

Semester End Exam (SEE) shall be at the end of IV semester. Project work evaluation and Viva-Voce examination (SEE), after satisfying the plagiarism check, shall be as per the University norms.

SYLLABUS FOR M. Tech., GEOTECHNICAL ENGINEERING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Subject: Forensic Geotechnical Engineering

Subject Code	**20CGT11**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03
CREDITS – 04			

Course objectives: This course will enable students to

- Know the characteristics of the soil for design of earthen dam.
- Effect of pore pressure in earthen dams.
- Effect of fissures and folds of rock on foundation of earthen dam.

Modules	**Teaching Hours**
Module -1	
Earth and Rock fill Dams: General features, Selection of site; Merits and demerits of the earth and rock fill dams, Classification of earth dams, Causes of failure, Safe design criteria. Instrumentation in earth dams: Pore pressure measurements, Settlement gauges, Stress measurements, Seismic measurements. Failures, Damages and Protection of Earth Dams: Nature and importance of failure, piping through embankment and foundations, Methods of seepage control through embankments and foundations, Design Criteria for filters.	**10 Hours**
Module -2	
Embankment Construction: Equipment for excavating, hauling, spreading, blending, compacting and separating oversized rocks and cobbles, construction procedures and quality control of impervious and semi-pervious embankment sections, handling dry and wet materials, construction problems caused by fines, construction procedures of hard and soft rock fill embankments, field test on rock fill embankments, slope treatment and rip-rap.	**10 Hours**
Module -3	
Slope Stability Analysis: Types of Failure: Failure surfaces - Planar surfaces, Circular surfaces, Non-circular surfaces, Limit equilibrium methods, Total stress analysis versus effective Stress analysis, Use of Bishop's pore pressure parameters, Short term and Long term stability in slopes. Taylor Charts. Special Design problems and details**:** Design considerations in earthquake, ground movements, earthquake intensity scales, periods and amplitudes of ground motion, influence of foundation material, earthquake waves, slope stability analysis during earthquake as per BIS, problems in loose sand, soft clay and silt foundation.	**10 Hours**
Module -4	
Method of Slices, Effect of Tension Cracks, Vertical Cuts. Bishop's Analysis, Bishop and Morgenstern Analysis, Non-circular Failure Surfaces: Janbu Analysis, Sliding Block Analysis, Introduction to Seismic stability, Stabilization of slopes: Soil reinforcement (geosynthetics/soil nailing/micro piles etc), soil treatment (cement/lime treatment), surface protection (vegetation/erosion control mats/shotcrete).	**10 Hours**
Module -5	
Slope Protection and Rockfill Dams: Stabilization of slopes: Soil reinforcement (geosynthetics/soil nailing/micro piles etc), soil treatment (cement/lime treatment), surface protection (vegetation/erosion control mats/shotcrete). Requirements of compacted rockfill, Shear strength of rockfill, Rockfill mixtures, Rockfill embankments, Earth-core Rockfill dams, Stability, Upstream & Downstream slopes	**10 Hours**

Course outcomes:

During this course, students will be trained:

- To design the rock and earth fill dams.
- To understand the mechanism of grouting and its application in rocks.
- For analyzing the complex geotechnical problems for the design of earth and rock fill dams.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. **Earth and earth-rock dams** - Sherard J L, Woodward R J, Gizienski S F and Clevenger W A, John Wiley & Sons, NY
2. **Earth and rockfill dam engineering** – Sowers G P and Sally H L, Asia Publishing House, New Delhi
3. **Engineering for Dams** – Creager W P, Justin J D and Hinds J, John Wiley & Sons, NY

Reference Books:

1. Sherard, Woodward, Gizienski and Clevenger. Earth and Earth-Rock Dams. John Wiley &. Sons. 1963.
2. Bharat Singh and Sharma, H. D. – Earth and Rockfill Dams, 1999
3. 1. Indian storage resources with earthen dams – Strange W L, R&FN Spon Ltd., London

SYLLABUS FOR M Tech., GEOTECHNICAL ENGINEERING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Subject: Sub-surface Investigations and Ground Improvement Techniques

Subject Code	**20CGT12**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- Identify the soil type of soil from a job site or in a professional setting, determine that soil's properties based on type and evaluate design decisions from your understanding of that soil's properties.
- To explore the scientific principles used to describe the major engineering properties of soil, and the engineering testing methods used to quantify these properties.
- To explore the site improvement techniques.

Modules	Teaching Hours
Module -1 SITE INVESTIGATION: Planning and experimental programme, investigations, exploration for preliminary design, exploration for detailed design, Geo-physical explorations, soundings, probings, boring, boring methods, excavation methods for explorations, ground water investigations, rock boring, miscellaneous exploratory techniques. Numerical problems.	**10 Hours**
Module -2 SAMPLING AND IN-SITU FIELD TESTS: Types of samples, samplers, preservation, shipment and storage of samples, bore log, pore pressure measurements, core recovery, rock strength, rock quality designation In-situ field testing and laboratory investigation of soils and rock, measurement techniques: SPT, SCPT, DCPT, pressuremeter, dilatometer, plate load test. Numerical problems.	**10 Hours**
Module -3 DATA INTERPRETATION: Data interpretation for determination of engineering properties of soils and their application to geotechnical design, preparation of site investigation reports	**10 Hours**
Module -4 SITE IMPROVEMENT: General methods of stabilization – shallow and deep, factors governing suitable method, compaction, Drainage: soil and filter permeability, filter criteria, drainage layout and pumping system, Pre-compression and consolidation: principles, sand drains, pore pressure distribution, electro-osmotic and chemical osmotic consolidation. Numerical problems	**10 Hours**
Module -5 STABILIZATION: Mechanical stabilization, lime, cement, bitumen, chemical etc. Grouting: Injection and principles, grouting pressure criteria, grouting equipment, injection chemicals, Thermal methods: heating and cooling effects on soils, equipment, Miscellaneous: moisture barriers and preventing techniques	**10 Hours**

Course outcomes:

During this course, students will be trained:

- To explore and understanding the behaviour of soils using index, compaction and engineering properties for the design of foundations.
- To adopt suitable f ground improvement techniques to alter the geotechnical properties to suit any type of foundations based on the load coming from the super structure on to the foundation and soil

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. **Engineering Principles of Ground Modifications** – Hausmann, McGraw Hill.
2. **Foundation Analysis and Design** – J E Bowles, Tata McGraw Hill.
3. **Subsurface Exploration and Sampling of Soils for Civil Engg. Purposes** – Hvorslev M J,
4. **Ground Improvement Techniques by P**. Purushotham Raj.
5. **Foundation Engineering by S P Brahma**.

Reference Books:

1. **Soil Mechanics, T.W. Lambe and R.V. Whitman.** John Wiley & Sons, 1969.
2. **Geotechnical Engineering-** Donold P Coduto Phi Learning Private Limited, New Delhi
3. **Geotechnical Engineering-** Shashi K. Gulathi & Manoj Datta. (4009), "Tata Mc Graw Hill.
4. **Soil Mechanics and Foundation Engg.- Muni Budhu (4010)**, 3rd Edition, John Wiely & Sons
5. **Soil Mechanics for Road Engineers** – HMSO.

SYLLABUS FOR M Tech., GEOTECHNICAL ENGINEERING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Subject: Design of Shallow Foundations

Subject Code	**20CGT13**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- Understanding the capacity of the soil under different field conditions.
- Design of shallow foundations under different loading condition and different environment.
- Design of footings for uniform settlement of all shallow foundations.

Modules	**Teaching Hours**
Module -1	
Bearing Capacity of Foundations: Introduction, Types of shallow foundations, General reqirements of foundations, Modes of shear failure, Bearing capacity equations (Terzaghi's, Meyerhof's, Brinch Hansen's and IS code method), Footings with eccentric loadings, Effect of water table on bearing capacity. Bearing capacity from SPT, SCPT, DCPT and Field plate load tests. Evaluation from in-situ tests codal recommendations. Numerical Problems.	**10 Hours**
Module -2	
Bearing Capacity for footings on homogeneous and layered soils, slopes, Bearing capacity of foundations with uplift or tension forces, Bearing capacity of rock, Bearing capacity based on Building codes (Presumptive pressure), Safety factors in Foundation Design, Numerical Problems.	**10 Hours**
Module -3	
Settlement analysis: Immediate settlement, Consolidation settlement and Secondary consolidation settlements, With codal provisions. Numerical problems. Contact pressure under footings – Contact pressure under rigid rectangular footing, strip foundation, rigid circular footing, Principles of footing design, Design of non – rigid combined footings. Numerical problems.	**10 Hours**
Module -4	
Foundations on sanitary landfill site, recent refuge fills, residual soils, permafrost and adjoining to the river bed. Proportionating of shallow footings, Introduction to special foundations, Foundation design in relation to ground movements.	**10 Hours**
Module -5	
Design of Raft foundations- types of rafts, Bearing capacity of mat foundations, Mat settlements, Modulus of subgrade reactions for mats and subgrades, Numerical problems. Allowable soil pressures for rafts in cohesionless and cohesive soils, Design of raft by rigid beam method and Winkler method, Solution based on elastic half space and based on elastic theory.	**10 Hours**

Course outcomes:

During this course, students will be trained to:

- Analyse the bearing capacity of the soil for shallow foundations
- Design aspects of Raft foundations for achieving uniform settlement for special structures like watertanks
- Structural design of shallow foundations in all conditions like land-fills, pavements etc in varying conditions including seismic areas
- Proper communication with structural and other engineers

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. **Foundation Engineering,** Verghese P C**. (2011)**– PHI, India
2. **Foundation Engineering,** Teng (1992) - PHI, India
3. **Foundation Engineering,** Bajra M Das.(4012), Cengage Learning India
4. **Foundation Analysis and Design, J E Bowles(2012),** McGraw Hill, Inc.

Reference Books:

1. **Foundation Engineering,** Peck hanson & Thronburg (1974)**.** John Wiley & Sons,.
2. **Analysis and design of Subsructures**- Swami Saran (2009), Oxford & IBH
3. **Foundation Engineering** Naryana S Naik (2012)**,** Dhanphat Rai publishers, New Delhi
4. **Geotechnical Engg.-** P. Purushothamraj (2010), Tata McGraw Hill

SYLLABUS FOR M Tech., GEOTECHNICAL ENGINEERING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Subject: Advanced Soil Mechanics

Subject Code	**20CGT14**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students :

- To explore the scientific principles used to describe the major engineering properties of soil, and the engineering testing methods used to quantify these properties.
- To explain role of water in soil behavior with change in soil stresses, permeability and quantity of seepage including flow net are estimated.
- To determine shear parameters and stress changes in soil due to foundation loads.
- To estimate the magnitude and time-rate of settlement due to consolidation.

Modules	Teaching Hours
Module -1 Geostatic Stresses: Effective stress principle, Geostatic stresses, Soil water hydro statics and dynamics, Numerical Problems Lambe's compaction theory, Structural and Engineering properties of compacted soils, Laboratory compaction tests, Field compaction control related problems, Numerical Problems.	**10 Hours**
Module -2	
Immediate settlement – Methods of determination, Preconsolidation pressure, stress history, One and Three dimensional differential consolidation equation, Time rate of consolidation, pre compression of clay deposits with and without sand drains, Secondary consolidation, factors affecting, Numerical Problems.	**10 Hours**
Module -3	
Shear strength parameters of cohesionless and saturated cohesive soils, Principle of effective stress, effect of rate of strain on shear parameters, Stress – Strain relationship, Pore pressure coefficients, Concept of stress path, Laboratory and Field testing their limitations, Numerical Problems.	**10 Hours**
Module -4	
Stability Analysis of Slope: Effective and total stress approach, shape of slip surface, sweedish method, methods of slices, location of centre of critical slip circle, Friction circle method, Tayler's stability number, Bishop's rigours analysis, stability during critical conditions, Numerical Problems.	**10 Hours**
Module -5	
Elastic theories of stress distribution in soils -Bousinesq's, Westergaard's, Bermister's theories. Different conditions of loading, Isobars, Newmark's chart, Numerical problems.	**10 Hours**

Course outcomes:

During this course, students will be trained:

- To analyze the soil stresses, permeability and seepage for the existing field conditions
- To understand the compressibility behaviour of soil and consolidation settlement along with time rate of settlement.
- To develop suitable method for analyzing the slope stability.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. **An Introduction to the Mechanics of Soils and Foundation - Atkinson J. H.** - McGraw- Hill Co. **(1993)**
2. **Soil Mechanics SI version- Lambe, T. W. and Whitman, R. V,** John Wiley & Sons.(2011)
3. **Soil Mechanics and Foundations, Muniram Budhu(2007),** John Wiley & Sons, Inc.

Reference Books:

1. **Geotechnical Engineering**- Donold P Coduto Phi Learning Private Limited, New Delhi
2. **Soil Mechanics- J A Knappett and R F Craig Eighth Edition(4012), Spon Press Taylor & Francis.**

SYLLABUS FOR M Tech., GEOTECHNICAL ENGINEERING

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SEMESTER – I

Subject: Geotechnology and Advanced Soil Testing

Subject Code	**20CGT15**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students :

- To explore the scientific principles used to describe the major engineering properties of soil, and the engineering testing methods used to quantify these properties.
- To explain role of water in soil behavior with change in soil stresses, permeability and quantity of seepage including flow net are estimated.
- To determine shear parameters and stress changes in soil due to foundation loads.
- To estimate the magnitude and time-rate of settlement due to consolidation.

Modules	**Teaching Hours**
Module -1 Factors influencing nature and formation of soils. Soils as a multiphase material, Complexity of soil nature, Typical soil deposits with special reference to Indian soils. Basic engineering properties of different soils and their uses. Study of rocks: Formation, basic types of rocks, igneous, sedimentary, metamorphic rocks and their classification. Geological structures: Folds, faults and joints, their classification, criterian for the identification of faults and other discontinuities.	**10 Hours**
Module -2 Soil structure – Types of bonds, Important clay minerals, atomic structure and symbolic representation. Base exchange capacity, Guoy-chapman diffuse double layer theory, clay structure measurement – X- ray diffraction, SEM studies, DTA, Pore size analysis.	**10 Hours**
Module -3 Tests for Index properties of soils – Specific gravity, grain size analysis (both sieve and hydrometer analysis), Atterberg's limits, Relative merits and Demerits of different methods. Numerical problems.	**10 Hours**
Module -4 Tests for engineering properties of soils – Compaction, Consolidation characteristics, Permeability, Shear tests including pore pressure measurements (UU, CU, CD tests). Numerical problems.	**10 Hours**
Module -5 Field tests for soils: Plate load test, SPT, SCPT, DCPT and their uses. Numerical problems.	**10 Hours**

Course outcomes:

During this course, students will be trained:

- Analyze the soil stresses, permeability and seepage for the existing field conditions
- To understand the compressibility behaviour of soil and consolidation settlement along with time rate of settlement
- To develop suitable method for analyzing the slope stability.
- To understand the behaviour of soils at critical state

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.

- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. **An Introduction to the Mechanics of Soils and Foundation - Atkinson J. H.** - McGraw- Hill Co. **(1993)**
2. **Soil Mechanics SI version- Lambe, T. W. and Whitman, R. V,** John Wiley & Sons.(4011)
3. **Soil Mechanics and Foundations, Muniram Budhu(2007),** John Wiley & Sons, Inc.

Reference Books:

4. **Geotechnical Engineering**- Donold P Coduto PHI Learning Private Limited, New Delhi
5. **Soil Mechanics and Foundation Engg.- Muni Budhu (2010)**, 3rd Edition, John Wiely & Sons
6. **Soil Mechanics- J A Knappett and R F Craig Eighth Edition(2012), Spon Press Taylor & Francis group, London & Newyork.**

SYLLABUS FOR M Tech., GEOTECHNICAL ENGINEERING

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SEMESTER – I

Subject: Advanced Geotechnical Engineering Laboratory - 1

Subject Code	**20CGT16**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Marks	60
Total Number of Lecture Hours	42	Exam Hours	03

CREDITS – 02

Course objectives: This course will enable students to

- The objective of this course is to make students to learn principles and design of experiments.
- To investigate the performance of various Soils

Modules	Teaching Hours
Determination of Specific gravity and Moisture content	**3 hours**
Determination of In-situ density	**3 hours**
Wet sieve analysis and hydrometer analysis	**3 hours**
Determination of Atterberg's Limits	**9 hours**
Determination of OMC and MDD (Standard and Modified Proctor test)	**6 hours**
Determination of coefficient of permeability (Variable head method and Constant head method)	**3 hours**
Determination of Undrained shear strength parameters from shear tests (Direct, UCS, Triaxial shear)	**9 hours**
California bearing ratio test	**3 hours**

Course outcomes:

During this course, students will be trained :

- Achieve Knowledge of Design and development of experimental skills.
- Understand the principles of design of experiments.

Question paper pattern:

- Individual experiments can be set as single experiment
- All questions are to be framed such that they should relate to field

Text Books:

1. Joesph E Bowles, "Engineering Properties of soil and their measurements", McGraw hill.
2. Manual of soil laboratory testing, K. H. Head, ELE International Ltd. Pentech press.

Reference Books:

1. John T. Germaine, Amy V. Germaine, (2009) "Geotechnical Laboratory Measurements", John Willey
2. William Lambe, (2003) "Soil Testing for Engineers", MIT.

SEMESTER – I

Subject	**RESEARCH METHODOLOGY AND IPR**		
Subject Code	**20RMI17**	CIE Marks	**40**
Teaching Hours/Week (L:P:SDA)	**2:0:0**	SEE Marks	**60**
Total Number of Lecture Hours	**25**	Exam Hours	**03**

CREDITS – 02

Course Objectives:

At the end of this course, students will be able to:

- Interpret research problem formulation
- Analyse research related information
- Follow research ethics and IPR provisions.
- Emphasise on ideas, concept, and creativity rather than on Computer, Information Technology.

Modules	**Teaching Hours**	**RBT Levels**
Module -1		
Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations.	**5 Hours**	**L1, L2**
Module -2		
Effective literature studies approaches, analysis, Reviews, Plagiarism, Research ethics.	**5 Hours**	**L1, L2**
Module -3		
Effective technical writing, how to write report, Paper. Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee	**5 Hours**	**L1, L2**
Module -4		
Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.	**5 Hours**	**L1, L2**
Module -5		
Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.	**5 Hours**	**L1, L2**

Question paper pattern:

The question paper will have ten questions, carrying equal marks. There will be two full questions with a maximum four sub questions from each module. Students shall answer five full questions selecting one full question from each module.

Course outcomes (CO):

At the end of the course the student will be able to:

1. Discuss research methodology and the technique of defining a research problem
2. Explain the functions of the literature review in research, carrying out a literature search, developing theoretical and conceptual frameworks and writing a review.
3. Explain various aspects of technical writing.
4. Emphasise on the importance of IPR.

Reference Books:

1. Stuart Melville and Wayne Goddard, Research methodology: an introduction, Juta and Co. 2004.
2. Ranjit Kumar, Research Methodology: A Step by Step Guide for beginners, Pearson Education, 2nd Edition, 2018
3. Halbert, Resisting Intellectual Property, Taylor & Francis Ltd, 2007
4. Mayall , Industrial Design, McGraw Hill, 1992
5. Niebel , Product Design, McGraw Hill, 1974
6. Asimov, Introduction to Design, Prentice Hall, 1962
7. Robert P. Merges, Peter S. Menell, Mark A. Lemley, Intellectual Property in New Technological Age, 2016.
8. T. Ramappa, Intellectual Property Rights Under WTO, S. Chand, 2008

SYLLABUS FOR M Tech., GEOTECHNICAL ENGINEERING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject: Reinforced Soil Structures

Subject Code	**20CGT21**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- Identify the soil suitable for reinforced earth.
- Identify the type of reinforcing material suitable for the project.
- Design the reinforced earth.

Modules	Teaching Hours
Module -1 Historical background: Introduction to reinforced soil structures, comparison with reinforced cement concrete structures. Reinforced Earth: Principles, concepts and Mechanisms of reinforced earth	**10 Hours**
Module -2 Materials used, properties, laboratory testing and constructional details, metallic strips, metallic grids, geotextiles, geogrids, geomembranes and geocomposites, their functions and design principles	**10 Hours**
Module -3 Geotextiles: Introduction, design methods, function and mechanism, geotextile properties and test methods – physical, mechanical and hydraulic properties, construction methods and techniques using geotextiles	**10 Hours**
Module -4 Design applications of reinforced soil structures in pavements, embankments, slopes, retaining walls and foundations, reinforced soil structures for soil erosion control problems, geosynthetic clay liners	**10 Hours**
Module -5 Design applications of reinforced soil structures : Slopes, Soil Nailing ,Case studies of reinforced soil structures, discussion on current literature and design problems	**10 Hours**

Course outcomes:

During this course, students will be trained to:

- Design and incorporate the reinforced earth for the sites at weak soil sites
- Design the pavements, embankments using reinforced earth to enhance the engineering properties of the soils

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. **Designing with Geosynthetics** – Koerner R H (1994), Prentice Hall Inc.
2. **Reinforcements and Soil Structures** – Jones, CJEP (1996), Butterworth Publications
3. **Membranes in ground engineering** – Rankilor, P R (1985), John Wiley & Sons.

Reference Books:

1. **Soil Reinforcement with Geotextiles** – Jewel R A (1996), CIRIA
2. **Geotextiles hand book** – Ingold J S and Miller K S (1988), Thomas Telford Ltd.

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[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject: Soil Dynamics

Subject Code	**20CGT22**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- To study vibration concepts in soils like damping, wave propagation, resonance and effect of modes of vibrations.
- To study dynamic soil properties. Determination of dynamic properties by field and laboratory tests
- Effect of liquefaction and anti liquefaction measures.
- To study vibration isolation, machine foundation design.

Modules	Teaching Hours
Module -1 Theory of vibration- single degree, two degree and multi degree of freedom system. Free and forced vibration, transient response, resonance and its effects.	**10 Hours**
Module -2 Wave Propagation – theory and application to dynamic problems, dynamic soil properties- general, laboratory and field methods, factors affecting. Different properties, vibration inducing and measuring instruments.	**10 Hours**
Module -3 Shear strength and liquefaction of soils- stress, strain, strength characteristics of soils under dynamic loads. Factors affecting, resonance column test, triaxial test under dynamic loads. Liquefaction of soils and factors influencing liquefaction, dynamic earth pressure, retaining wall problems under dynamic loads.	**10 Hours**
Module -4 General principles of machine foundation design- introduction, design criteria, types and requirements of machine foundations, foundations for reciprocating machines, foundations for forge hammers, foundations for turbo generators.	**10 Hours**
Module -5 Vibration isolation- introduction, mechanical isolators, isolation by artificial barriers, active and passive isolation, case histories of foundation of isolation.	**10 Hours**

Course outcomes:

During this course, students will be trained :

- To develop a mechanism to design the foundations for resisting vibrations and achieve static equilibrium conditions of structures
- To understand the classical geotechnical failures due to liquefaction and mitigate the same.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. **Soil Dynamics and Machine Foundation (4010),** Swami Saran, Galgotia Publications Pvt. Ltd.
2. **Soil Dynamics(1981)-** Prakash, S. McGraw Hill Book Company

Reference Books:

1. **Foundation for Machines (1998)** Prakash, S. and Puri, V. K.: Analysis and Design, John Wiley &

Sons,
2. **Vibration Analysis and Foundation Dynamics(1998)-**Kameswara Rao, N. S. V., Wheeler Publication Ltd.,
3. **Vibrations of Soils and Foundations(1970)** Richart, F. E. Hall J. R and Woods R. D., Prentice Hall Inc.,
4. **Principles of Soil Dynamics (4002)** Das, B. M., PWS KENT publishing Company, Boston.

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[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject: Design of Deep Foundations

Subject Code	**20CGT23**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- Know the design of deep foundation.
- Type of deep foundations will be provided for different structures.
- Understand the special foundations.

Modules	**Teaching Hours**
Module -1 Single pile - Static capacity and lateral loads: Introduction, Timber, Concrete, Steel piles, Corrosion of steel piles, Soil properties for static pile capacity, Ultimate static pile point capacity, Skin resistance, Static load capacity using load transfer, load test data, Tension piles, Piles for resisting uplift, Laterally loaded piles, Numerical problems.	**10 Hours**
Module -2 Single pile – Dynamic analysis and load tests: Dynamic analysis, Pile driving, Rational pile formulae, other dynamic pile driving formulae and general considerations, Reliability of dynamic pile driving formulae. The wave equation, pile load tests, pile driving stresses, general comments on pile driving, Numerical problems.	**10 Hours**
Module -3 Pile foundations – Group, Single pile v/s Pile group, Pile group considerations, efficiency of pile groups, stresses on underlying strata from piles, settlements of pile groups, pile caps, Batter piles, Negative skin friction, Numerical problems.	**10 Hours**
Module -4 Well Foundation: Design and construction. Bearing capacity, settlement and lateral resistance. Tilts and shifts, Numerical problems. Drilled Shaft: Construction procedures, Design Considerations, Load Carrying Capacity and settlement analysis, Numerical problems.	**10 Hours**
Module -5 Special Topics of Foundation Engineering Foundations on Collapsible Soils: Origin and occurrence, Identification, Sampling and Testing, Preventive and Remedial measures. Foundations on Expansive Soils: The nature, origin and occurrence, Identifying, testing and evaluating expansive soils, typical structural distress patterns and Preventive design & construction measures, Numerical Problems.	**10 Hours**

Course outcomes:

During this course, students will be trained :

- To analyze and adopt design skills of vertical and batter piles for various types of loading and soil conditions.
- To design the sheet piles and under reamed piles in expansive soils.
- To design the well foundations (caissons).

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. **Analysis and design of Substructures (2009),** Swami Saran, Oxford & IBH Publications Pvt. Ltd**.**
2. **Foundation design in practices (2010)-** Kaurna Moy Ghosh. PHI
3. **Foundation engineering (2012)-** J E Bowles, McGraw Hill

Reference Books:

1. **Pile Foundation Analysis and Design** H.G. Poulos, and E.H.Davis, John Wiley and Sons, New York.
2. **Design of Foundation Systems (1992)**N.P. Kurien: Principles & Practices, Narosa, New Delhi
3. **Foundation Engineering Hand Book (1990),** H. F. Winterkorn and H Y Fang Galgotia Booksource

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[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject: Case Histories in Geotechnical Engineering

Subject Code	**20CGT241**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- Understanding the failure mechanism in geotechnical engineering.
- Evaluating the soil as different construction materials and its behavior.
- Role of soil in past and future in construction industry.

Modules	Teaching Hours
Module -1 Geotechnical problems in civil engineering and in foundations, Soil as construction material in slopes and excavations, Geotechnical problems in underground and earth retaining structures**.**	**10 Hours**
Module -2 Behaviour of different soils under different foundations and different environmental conditions. Calculated risk and safety factors in applied soil engineering.	**10 Hours**
Module -3 Past and future of applied soil mechanics, Effect of pore water pressure.	**10 Hours**
Module -4 New concepts in consolidation settlements, settlements and bearing capacity.	**10 Hours**
Module -5 Case histories- typical cases of performance failure of representative of soil engineering projects namely shallow and deep foundations, slope stability, earth dams, retaining structures , machine foundations etc.,	**10 Hours**

Course outcomes:

During this course, students will be trained:

- To develop a model for the behaviour of the soil from the existing or past data.
- To prediction the failures based on the material and soil behavior.
- To develop new approaches for design of stable structures by understanding the case histories for failure of foundation structures and arrive at classical geotechnical behaviour to contract the failures.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. **Fundamentals of soil behaviour –** J K Mitchel. (4012)- McGraw- Hill Co.
2. **Soil Mechanics SI version-** Lambe, T. W. and Whitman, R. V, .(4011) John Wiley & Sons
3. **Soil Mechanics and Foundations,** Muniram Budhu(4011), John Wiley & Sons, Inc.
4. **Soil Mechanics,** JE.Bowles (4012), McGraw Hill

Reference Books:

1. **Soil Mechanics, Terzaghi and Peck** (1969)**.** John Wiley & Sons,.
2. **Geotechnical Engineering**- Donold P Coduto Phi Learning Private Limited, New Delhi
3. **Literatures for Case Histories from known Journals (ASCE, Elsevior, Canadian Geotechnical Journal etc.,)**

4. Soil Mechanics- J A Knappett and R F Craig Eighth Edition(4012), Spon Press Taylor & Francis

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SEMESTER – II

Subject: PAVEMENT ANALYSIS AND DESIGN

Subject Code	**20CGT242**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- Identify the type of pavement and to know the stress distribution.
- Learn the deflection criteria in soils for different pavements.
- To know the characteristics of the rigid pavements and flexible pavements.

Modules	**Teaching Hours**
Module -1 **INTRODUCTION:** Types and component parts of pavements, factors affecting design and performance of pavements, highway and airport pavements.	**10 Hours**
Module -2	
STRESSES AND DEFLECTION IN FLEXIBLE PAVEMENTS: Stresses and deflections in homogeneous masses, two, three and multi-layer theories, wheel load stresses, various factors in traffic wheel loads, ESWL of multiple wheels, repeated loads and EWL factors, sustained loads, pavement behaviour under transient traffic loads.	**10 Hours**
Module -3	
FLEXIBLE PAVEMENT DESIGN METHODS FOR HIGHWAYS AND AIRPORTS: Empirical, semi-empirical and theoretical approaches, development, principle, design steps, advantages and application of the different pavement design methods including IRC, AASHTO and Asphalt Institute methods.	**10 Hours**
Module -4	
STRESSES AND DEFLECTIONS IN RIGID PAVEMENTS: Types of stresses and causes, factors influencing the stresses, general considerations in rigid pavement analysis, EWL, wheel load stresses, warping stresses, frictional stresses, combined stresses.	**10 Hours**
Module -5	
RIGID PAVEMENT DESIGN: Types of joints in cement concrete pavements and their functions, joint spacing, design of CC pavement for roads and runways, design of joint details for longitudinal joints, contraction joints and expansion joints, IRC method of design by stress ratio method, Design features of CRCP, SFRC and ICBP, Problems, design of continuously reinforced concrete pavements.	**10 Hours**

Course outcomes:

During this course, students will be trained :

- For the design of flexible and rigid pavements at different soil conditions.
- To understand the behaviour of the stresses and deflections at different loading and soil conditions.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.

- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. **Principles of Pavement Design** – Yoder E J, Witczak, John Wiley and Sons
2. **Soil Mechanics for Road Engineers** – RRl and DSIR, HMSO Publication
3. **Design of Functional Pavements** – Huang, McGraw Hill Book Co.
4. **Development in Highway Engineering** – Pell Peter S, Applied Science Publishers, London
5. **Pavement Analysis** – Huang, Elsever Publications.

Reference Books:

1. **IRC Publications.**
2. **CMA Handbook.**

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SEMESTER – II

Subject: Critical State Soil Mechanics

Subject Code	**20CGT243**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- Calculation of stress trajectories and deformations using stress invariants
- Elastic-plastic constitutive equation
- Approximate and exact method of solutions
- Constitutive models for unsaturated soils

Modules	**Teaching Hours**
Module -1 Basic concepts in critical stress concepts. Concepts of stress, strain, stress increment and strain increment, spherical and deviator tensors. Isotropic continuum for two elastic constants, Principal stress space, two alternate yield function, plastic potential function and normality condition. Isotropic hardening and stability criteria and numerical problems.	**10 Hours**
Module -2 Seepage with two and three dimensional seepage, Mathematical solutions for the seepage below the sheet piles. One dimension consolidation, approximate and exact solution to the consolidometer test, granta-gravel, numerical problem.	**10 Hours**
Module -3 Cam-clay model and critical state concept (including the compression, undrained tests on cam-clay), Plastic compressibility and the index tests, interpolation of data from axial tests on saturated clays with numerical problems.	**10 Hours**
Module -4 Coulomb's failure equation and the choice of strength parameter - Coulomb's failure equation, Hvorselv's experiments on strength of clay, principal stress ratio. Failure mechanism and the residual strength on the sliding surface with numerical problems.	**10 Hours**
Module -5 Two dimension fields of limiting stresses- Coulomb's analysis of active and passive earth pressure, friction circle method, stability due to cohesion. Discontinuous limiting stress field solutions to the bearing capacity problems, upper and lower bound to a plastic collapse load. Basic equation for limiting stresses and their characteristics in purely cohesive soils and numerical solutions.	**10 Hours**

Course outcomes:

During this course, students will be trained:

- To understand the behaviour of soil under normal and plastic condition.
- To develop a new models along with cam-clay.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. **An Introduction to the Mechanics of Soils and Foundation - through critical state soil mechanics-** Atkinson J. H. (1993) - McGraw- Hill Co.
2. **Soil Behavior and Critical State Soil Mechanics** Wood, D.M (1991)- Cambridge university press
3. **Crtical state Soil Mechanics-** Andrew Schofield and Peter Worth (1967), Cambridge University Press
4. **Soil Mechanics and Foundations,** Muniram Budhu(4010), John Wiley & Sons, Inc.

Reference Books:

1. **Soil Mechanics, T.W. Lambe and R.V. Whitman**(1969)**.** John Wiley & Sons,.
2. **Geotechnical Engineering**- Donold P Coduto Phi Learning Private Limited, New Delhi.

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[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – II

Subject: Foundation Engineering in Difficult Ground

Subject Code	**20CGT244**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- In-situ testing in difficult grounds.
- Design the foundations in earth movement conditions.
- Improve the ground conditions.

Modules	**Teaching Hours**
Module -1 **Introduction**: Classification, swelling and shrinkage, sensitivity, settlement and bearing capacity of clays, fissures in clay, glacial deposits and difficult rocks. **Site Investigation in difficult ground:** Objectives, difficulties in determining the characteristics of the ground, remedial measures.	**10 Hours**
Module -2 **In-situ testing and geophysical surveying**: Introduction, penetrometers, SPT, CPT, plate bearing tests, pressure meters, seismic surveying, resistivity surveying **Ground water and foundations:** Introduction, effective stress theory, oil tanks on poor ground, effect of raising the ground water level – reclaimed land, foundation on the sea bed.	**10 Hours**
Module -3 **Foundations and earth movements:** Introduction, creep of rock masses, landslides, earthquake – primary and secondary effects, earthquake resistant design. **Design of foundations:** Introduction, general principles, strip and pad foundations, building on shrinkable soil, building on fill, raft foundation – variable soil and make up gound, pile foundation – choice, types; construction problems.	**10 Hours**
Module -4 **Stability of slopes in difficult ground:** Introduction, mechanism of stability, strength of distorted clay, factor of safety, analysis, remedial measures	**10 Hours**
Module -5 **Ground treatment:** Introduction, ground water lowering techniques, electro-osmosis and electro-chemical stabilization, thermal techniques, grouts and grouting, reinforcements, other stabilization techniques, dynamic consolidation, pre loading, vibroflotation, stone columns.	**10 Hours**

Course outcomes:
During this course, students will be trained to:

- Develop the in-situ methods to evaluate the bearing capacity under different criteria.
- Analyse and design the grounds in shrinking areas.
- Overcome the construction problems by adopting suitable methods.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. **Foundation in difficult ground** – F G Bell, Butterworths & Co
2. **Foundation Analysis and design** – J E Bowles, Tata McGraw Hill

Reference Books:

1. Foundation Engineering – (4001) M J Tomlinson - PHI

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SEMESTER – II

Subject: Environmental Geotechnical Engineering

Subject Code	**20CGT251**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- Identify the contaminated soil and source contamination.
- Remedies for contaminated site.
- Study on Ground water contamination.
- Relation between contamination source and the soil & water.

Modules	**Teaching Hours**
Module -1 **FUNDAMENTALS OF ENVIRONMENTAL GEOTECHNICAL ENGINEERING:** Scope of environmental geotechnical engineering - multiphase behavior of soil – role of soil in geoenvironmental applications – importance of soil physics, soil chemistry, hydrogeology, biological process – sources and type of ground contamination – impact of ground contamination on geoenvironment - case histories on environmental geotechnical engineering problems.	**10 Hours**
Module -2 **SOIL-WATER-CONTAMINANT INTERACTION:** Soil mineralogy characterization and its significance in determining soil behavior – soil-water interaction and concepts of double layer – forces of interaction between soil particles, Concepts of unsaturated soil – importance of unsaturated soil in environmental geotechnical engineering problems - measurement of soil suction - water retention curves - water flow in saturated and unsaturated zone. Soil-water-contaminant interactions and its implications – Factors effecting retention and transport of contaminants.	**10 Hours**
Module -3 **WASTE CONTAINMENT SYSTEM:** Evolution of waste containment facilities and disposal practices – Site selection based on environmental impact assessment –different role of soil in waste containment – different components of waste containment system and its stability issues – property evaluation for checking soil suitability for waste containment – design of waste containment facilities.	**10 Hours**
Module -4 **CONTAMINANT SITE REMEDIATION:** Site characterization – risk assessment of contaminated site - remediation methods for soil and groundwater – selection and planning of remediation methods – some examples of in-situ remediation.	**10 Hours**
Module -5 **ADVANCED SOIL CHARACTERIZATION:** Contaminant analysis - water content and permeability measurements – electrical and thermal property evaluation – use of GPR for site evaluation - introduction to geotechnical centrifuge modeling.	**10 Hours**

Course outcomes:

During this course, students will be trained:

- To measure the amount of contamination in soils and water.

- To identify the source for contamination in soils and water.
- To know the interaction of soil, water and contaminants.
- Remedial measures for contaminated soils.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. **Geotechnical Practice for Waste Disposal** – Daniel D E, Chapman and Hall, London
2. **Hazardous Waste Management** – Lagrega M D, Buckingham P L, Evans J C, McGraw Hill Inc, Singapore.

Reference Books:

1. **Designing with Geosynthetics** - Koerner R M, Prentice Hall, New Jersey
2. **Proceedings of International Symposium on Environmental Geotechnology (1986)**

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SEMESTER – II

Subject: Ground Water and Hydrology

Subject Code	**20CGT252**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- To understand the behaviour of the ground water and its percolation in soils.
- Determination of ground water movement.
- Recharging of ground water.

Modules	**Teaching Hours**
Module -1 Groundwater: Groundwater hydrologic cycle. Origin of groundwater, quality of groundwater, vertical distribution of groundwater-zone of aeration and zone of saturation; Geologic formations as aquifers; types of aquifers, porosity, specific yield, specific retention; Permeability, Darcy's law, storage coefficient, Transmissibility. .	**10 Hours**
Module -2 Groundwater flow: Groundwater flow in one, two and three- dimensions; Groundwater flow contours and their applications; Steady groundwater flow towards a well in confined and unconfined aquifers- Dupuits' and Theism's equations, Formation constants, yield of an open well, interference and well tests; Unsteady flow towards a well – Non-Equilibrium equations – Theis's solution- Jacob and Chow's simplifications, Leaky aquifers.	**10 Hours**
Module -3 Modelling and Analysis of Aquifer Systems: Need, model calibration, single and multi-cell models, Inverse problems, estimation of regional aquifer problems; aquifer management; linear and non-linear programming methods.	**10 Hours**
Module -4 Investigations: Surface methods of exploration - Electrical resistivity and seismic refraction methods. Subsurface methods; Geophysical logging and resistivity logging; hydrologic maps; groundwater balance; contamination.	**10 Hours**
Module -5 Artificial Recharge of Groundwater: Concept of artificial recharge and recharge methods, relative merits, Saline water intrusion, Ghyben-Hergberg relation, shape of interface, control of sea water intrusion.	**10 Hours**

Course outcomes:

During this course, students will be trained to:

- Estimate the percolation of ground water in different soils and understand seepage mechanism.
- Estimate of the contamination in soils from the field tests.
- Suitable design methodology for recharging of ground water.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. **Foundations of Theoretical Soil Mechanics,** Harr, M.E (1966) McGraw Hill**,**
2. **Foundation Engineering Handbook,** Winterkorn, H.F., and Fang, H.Y(4000) Galgotia,

Booksource, 4000

3. **Theoretical Soil Mechanics- Karl Terzaghi (1943),** John Wiley & Sons.
4. **Soil Mechanics and Foundations, Muniram Budhu(4007),** John Wiley & Sons, Inc.

Reference Books:

1. **Soil Mechanics, T.W. Lambe and R.V. Whitman**(1969)**.** John Wiley & Sons,.
2. **Foundations and slopes**- Attikinson (1981), McGraw Hill, New Delhi
3. **Seepage, Drainage and Flownets – Cedergren H R(1997).-, John Wiely & Sons.**
4. **The Mechanics Basic concepts and Engineering Applications- Aysen A (4002), AA Balkema Publishers, 4002**

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[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject: Rock Mechanics

Subject Code	**20CGT253**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- Identify the type of the rock.
- Analyze the rock quality designation and also evaluate its strength.
- Determine the methods of tunneling and mining.

Modules	**Teaching Hours**
Module -1 Classification of rocks, geological petro graphic and engineering. Index properties of rocks-porosity, density, permeability, durability and slake. Core recovery, RQD and its importance in engineering. Stress-strain behaviour, factors influencing the strength of rock, temperature, confining pressure, strain rates, modes of failures of rocks.	**10 Hours**
Module -2 Failure theories of rocks Mohr's hypothesis, Griffith's Criteria, Mullerl's extension of griffith's theory, elementary theory of crack propagation, failure of rock by crack propagation, effects of cracks of elastic properties. Testing of rocks: Laboratory and field test, assessment of in-situ strength.	**10 Hours**
Module -3 Rock Foundation: Shallow and deep investigation for foundation design and construction aspect, slope stability analysis, mode of failures in rock. Design of slopes, excavation in rock and stabilization concepts.	**10 Hours**
Module -4 Strengthening of rocks: Foundation treatment for dams and heavy structures by grouting and rock reinforcement. Methods and principles of grouting, principles of design of rock bolts.	**10 Hours**
Module -5 Tunnels – Basic terminology and application, site investigations, methods of excavation of tunnels supports and stabilization, construction control and maintenance, tunnel ventilation, control of ground water and gas. Underground Mining; mining methods, planning and design, mining equipments and mining procedures, cause for subsidence and its remedial measures.	**10 Hours**

Course outcomes:

During this course, students will be trained to:

- Identify the type of rock and to evaluate the bearing capacity of the rock.
- Design and analyze the foundations and improvement techniques for the foundations on insitu rocks.
- Design methodologies for mining and tunneling where rock is encountered.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Introduction to Rock Mechnaics – Goodman (1976), John Wiley and Sons, NY

2. **Fundamentals of Rock Mechanics** – J C Jeager and N G W Cook (1976), Chapman and Hall, London
3. **Geotechnology** –Roberts , Pergamou Press ltd., Oxford

Reference Books:

1. **Principles of Engineering Geology and Geotechniques** – Krynine and Judd
2. **Rock Engineering** – Jhon A Franklin and Maurice b Dusseault, McGraw Hill
3. **Rock mechanics for Engineers:** Varma, B.P, Khanna Publishers
4. **Rock mechanics & Design of structures:** Obert, L & Duvall, W.I., John Wiley & Sons.

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[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject: Soil Structure Interaction

Subject Code	**20CGT254**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- Make students understand soil structure.
- Understand stress-strain characteristics of soils.
- the mechanism of failure, the factors that affects the shear strength
- Structural behaviour with soils.

Modules	**Teaching Hours**
Module -1 Soil-Foundation Interaction: Introduction to soil-foundation interaction problems, Soil behavior, Foundation behavior, Interface behavior, Scope of soil foundation interaction analysis, soil response models, Winkler, Elastic continuum, Two parameter elastic models, Elastic plastic behavior, Time dependent behavior.	**10 Hours**
Module -2 Beam on Elastic Foundation- Soil Models: Infinite beam, Two parameters, Isotropic elastic half space, Analysis of beams of finite length, Classification of finite beams in relation to their stiffness. Plate on Elastic Medium: Thin and thick plates, Analysis of finite plates, Numerical analysis of finite plates, simple solutions.	**10 Hours**
Module -3 Plates on Elastic Continuum: Thin and thick rafts, Analysis of finite plates, Numerical analysis of finite plates.	**10 Hours**
Module -4 Elastic Analysis of Pile: Elastic analysis of single pile, Theoretical solutions for settlement and load distributions, Analysis of pile group, Interaction analysis, Load distribution in groups with rigid cap.	**10 Hours**
Module -5 Laterally Loaded Pile: Load deflection prediction for laterally loaded piles, Subgrade reaction and elastic analysis, Interaction analysis, Pile-raft system, Solutions through influence charts. An introduction to soil-foundation interaction under dynamic loads.	**10 Hours**

Course outcomes:

During this course, students will be trained to:

- Analyse the behaviour of the soil under elastic and plastic condition.
- Predict the behaviour of the pile under static and dynamic loads.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. **Foundation analysis and design** - J E Bowles, McGraw Hill, NY
2. **Soil Mechanics in Engineering Practice** – Karl Terzaghi and R B Peck (1967), John Wiley and Sons, NY
3. **Analysis and Design of Foundations and Retaining Structures** –S Prakash(1979), Sarita

Prakashana, Meerut

Reference Books:

1. **Soil Mechanics and Foundation Engineering** – S K Garg, Khanna Publications
2. **Geotechnical Engineering** – C Venkataramaiah, New Age International Publishers

SYLLABUS FOR M Tech., GEOTECHNICAL ENGINEERING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject: Advanced Geotechnical Engineering Laboratory-2

Subject Code	**20CGT26**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Marks	60
Total Number of Lecture Hours	42	Exam Hours	03

CREDITS – 02

Course objectives: This course will enable students to

- The objective of this course is to make students to learn principles and design of experiments.
- To investigate the performance of various Soils

Modules	**Teaching Hours**
Determination of shear strength parameters by Vane shear test	**3 hours**
Determination of shear strength parameters by CD and CU test	**3 hours**
To evaluate the bearing capacity and settlement of soils from --- by plate load test ---- by cone penetration test (static and dynamic) --- Standard penetration test	**9 hours**
To determine the ground water table --- Using electrical resistivity method --- seismic refraction method	**6 hours**
Determination of shear modulus, damping ratio and liquefaction of soils by resonant column method	**6 hours**
Determination of pH and organic solids	**3 hours**
Determination of Chemical Properties of soil such as chloride, phosphorous, Potassium, Magnesium, calcium, Sodium etc.,	**12 hours**

Course outcomes:

During this course, students will be trained :

- Achieve Knowledge of Design and development of experimental skills.
- Understand the principles of design of experiments.

Question paper pattern:

- Individual and one group experiment should be set

Text Books:

1. Manual of soil laboratory testing, K. H. Head, ELE International Ltd. Pentech press.
2. Shamsher Prakash, (1979) "Engineering Soil Testing ", Nemichand, New Delhi.
3. Joesph E Bowles, "Engineering Properties of soil and their measurements", McGraw hill

Reference Books:

1. John T. Germaine, Amy V. Germaine, (4009) "Geotechnical Laboratory Measurements", John Wiely
2. William Lambe, (4003) "Soil Tsting for Engineers", MIT.

SYLLABUS FOR M Tech., GEOTECHNICAL ENGINEERING
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – III

Subject: Unsaturated Soil Mechanics

Subject Code	**20CGT31**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- Understand concept of shear stress and its importance.
- Know the behaviour hydraulic conductivity of the soil.
- Know the importance of soil-water interaction in applied soil engineering.

Modules	**Teaching Hours**
Module -1 **Introduction to Unsaturated Soil Mechanics**: Types of problems, typical profiles of unsaturated, tropical and residual soil, expansive and collapsing type of soils. Origin and formation, identification and classification of expansive and collapsing soils, Contractile skin. **Collapse and Heave:** Collapse potential and swell potential, importance and their determination by different laboratory methods, Heave prediction based on oedometer tests, suction tests and empirical procedures, heave and collapse settlement.	**10 Hours**
Module -2 **Soil Suction:** Matric and osmotic suction, total suction, theory of soil suction, measurement by direct and indirect methods – Tensiometers, Axis translation technique, Pressure plate apparatus, Filter paper method, Psychrometers, Squeezing technique of measuring osmotic suction. **Flow through unsaturated soils** – flow laws, Darcy's law for unsaturated soils, coefficient of permeability with respect to water phase and air phase, air diffusion, measurement of permeability and air coefficient of permeability.	**10 Hours**
Module -3 **Phase properties and relations for unsaturated soils:** Properties of individual phases, interaction of air and water, volume-mass relations, changes in volume-mass properties, densities of mixtures subjected to compression of the air phase, piston porous stone analogy, effective stress concepts and stress state variables for unsaturated soils, equilibrium analysis for unsaturated soils: total or overall equilibrium, independent phase equilibrium – water phase, air phase, contractile skin(meniscus).	**10 Hours**
Module -4 **Design alternatives for structures on expansive soils:** Structural foundation alternatives, treatment of expansive soils – general considerations and guidelines, surcharge loading, prewetting, use of admixtures, electrochemical soil treatment, moisture control and soil stabilization, treatment alternatives for highways and airfield pavements.	**10 Hours**
Module -5 **Shear strength:** History of shear strength, failure envelope for unsaturated soils, use of effective stress parameters to define shear strength, Mohr-coulomb and stress points envelopes, triaxial tests on unsaturated soils, CD tests, constant water content tests, CU tests with pore pressure measurements, undrained tests, multistage testing, measurement of shear strength parameters.	**10 Hours**

Course outcomes:
During this course, students will be trained:

- To understand the concept of unsaturated soils and change in the behaviour of the soil properties

- To understand the contractual skin mechanism of partially saturate sols in the design of foundations by knowing the soil water interaction i.e., soil as a four phase system. Comparative study of basic properties in case of three and four phase system in soils
- To design the effective methods for foundations and structures

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. **Soil Mechanics for Unsaturated Soils** – DG Fredlund and H Rahardjo, Wiley Interscience Publication, John Wiley & Sons, NY
2. **Unsaturated Soil Mechanics** – Ning Lu and William J Likos, John Wiley & Sons, INC

Reference Books:

1. **Mechanics of Residual Soils** – G E Blight, A A Balkema Publishers, USA
2. **Expansive Soils – Problems & Practice in Foundations and Pavement Engineering –** John D Nelson and Debora J Miller, John Wiley & Sons, NY

SYLLABUS FOR M Tech., GEOTECHNICAL ENGINEERING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject: Earth and Earth Retaining Structures

Subject Code	**20CGT321**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- To study the geostatic stresses, shear strength of soils.
- To study the static earth pressure for retaining walls, etc.

Modules	**Teaching Hours**
Module -1 Earth Pressure: Introduction, Rankine's theory and Coulomb's wedge theory, Numerical problems, Culmann's and Rebhann's graphical methods for determination of active and passive earth pressures, earth pressure calculations for line load and/or uniform strip load acting on the ground surface.	**10 Hours**
Module -2 Retaining walls: Types of retaining walls, Failure of retaining walls by sliding, overturning and bearing. Stability and principles of the design of retaining walls – Gravity retaining walls, cantilever retaining walls, counterfort retaining walls, modes of failure of retaining walls, drainage from the backfill.	**10 Hours**
Module -3 Bulk heads: Cantilever sheet pile walls - Types of sheet pile walls, free cantilever sheet pile, cantilever sheet pile in cohesion less soils and in clay. Bulk heads: Anchored cantilever sheet pile walls - Anchored sheet pile with free earth support in cohesionless and cohesive soil. Bulk heads with fixed earth support method.	**10 Hours**
Module -4 Braced cuts: Introduction, lateral earth pressure on sheeting, different types of sheeting and bracing systems, design of various components of bracings.	**10 Hours**
Module -5 Coffer dams and Cellular coffer dams: Introduction, types of coffer dams, design of cellular coffer dams on rock by Tennes Valley Authority (TVA) method, safety against sliding, slipping, overturning, vertical shear and stability against bursting.	**10 Hours**

Course outcomes:

During this course, students will be trained:

- To analyze the field problems and encountering various failures due to shear geostatic stress etc.
- To design and analyze the retaining structures for earth pressures.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. **Foundation analysis and design** - J E Bowles, McGraw Hill, NY
2. **Soil Mechanics in Engineering Practice** – Karl Terzaghi and R B Peck (1967), John Wiley and Sons, NY
3. **Analysis and Design of Foundations and Retaining Structures** –S Prakash(1979), Sarita Prakashana, Meerut

Reference Books:

1. **Soil Mechanics and Foundation Engineering** – S K Garg, Khanna Publications
2. **Geotechnical Engineering** – C Venkataramaiah, New Age International Publishers

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[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject: Earthquake Resistant design of Foundations

Subject Code	**20CGT322**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- Focused mainly on identifying the dynamic loading induced on the foundation.
- Understand soil - foundation interaction, analysis with reference to various design parameters that including liquefaction of soil due to earthquake.

Modules	**Teaching Hours**
Module -1	
BASIC DESIGN PARAMETERS: Dynamic properties of soils and its evaluation, strength and deformation characteristics of soils under earthquake loading, liquefaction hazard evaluations and remedial measures, geotechnical failure of foundations during earthquake, provision of IS 2093 and IS 13940.	**10 Hours**
Module -2	
Design requirements – bearing capacity theory under earthquake loading – bearing capacity analysis for liquefied soil – bearing capacity analysis for cohesive and cohesionless soils - seismic settlement of foundation.	**10 Hours**
Module -3	
Sesmic design of Pile foundations: Earthquake loading – inertial and kinematic loading - performance of piles during earthquake loading – theories of pile failure in liquefiable soils – failure based on bending mechanism/buckling instability – methods of analysis – force based or limit equilibrium method – p-y method – pile settlement - guidelines for designing of piles under kinematic loading due to liquefaction – seismic design of well/cassion foundations.	**10 Hours**
Module -4	
Sesmic design of retaining walls: Introduction – Seismic passive lateral earth pressure, behaviour of retaining wall during earthquakes, modification of Coulomb's Theory, Modified Culmann's Theory, displacement analysis, Indian standard code of practice.	**10 Hours**
Module -5	
Structural design of foundation: Introduction – loads acting on foundations during earthquake – fundamental failure mechanisms of foundations – essential criteria for design of foundations in liquefiable soils – structural design of foundations subjected to earthquake loading.	**10 Hours**

Course outcomes:

During this course, students will be trained to:

- Design of foundation under earthquake loading by considering the influence of various design parameters that includes the liquefaction of soils due to earthquake.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Design of foundation in seismic areas: Principles and some applications by (4007).Bhattacharya S. (eds), Published by NICEE [National Centre for Earthquake Engineering (India)].

2. **Geotechnical Earthquake Engineering (4002):** Day R. W., handbook, McGraw – Hill, New York
3. **Design of Pile Foundations in Liquefiable Soils (4010)** Gopal Madabhushi, Jonathan Knappett and Stuart Haigh, Imperial College Press, London
4. **Basic geotechnical earthquake engineering by (4008)** Kamalesh Kumar, New Age International Publishers, New Delhi

Reference Books:

1. **Soil dynamics (1981)** Prakash, S., McGraw Hill, New York,.
2. **Geotechnical Earthquake Engineering (1996),** Steven L. Kramer, Prentice Hall, New Delhi,.
3. **Foundation design and construction (1986),** Tomilinson M.J., Longman Scientific & Technical, England,

SYLLABUS FOR M Tech., GEOTECHNICAL ENGINEERING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject: Earth and Rockfill Dams and Slope Stability

Subject Code	**20CGT323**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- Know the characteristics of the soil for design of earthen dam.
- Effect of pore pressure in earthen dams.
- Effect of fissures and folds of rock on foundation of earthen dam.

Modules	**Teaching Hours**
Module -1	
Earth and Rock fill Dams: General features, Selection of site; Merits and demerits of the earth and rock fill dams, Classification of earth dams, Causes of failure, Safe design criteria. Instrumentation in earth dams: Pore pressure measurements, Settlement gauges, Stress measurements, Seismic measurements. Failures, Damages and Protection of Earth Dams: Nature and importance of failure, piping through embankment and foundations, Methods of seepage control through embankments and foundations, Design Criteria for filters.	**10 Hours**
Module -2	
Embankment Construction: Equipment for excavating, hauling, spreading, blending, compacting and separating oversized rocks and cobbles, construction procedures and quality control of impervious and semi-pervious embankment sections, handling dry and wet materials, construction problems caused by fines, construction procedures of hard and soft rock fill embankments, field test on rock fill embankments, slope treatment and rip-rap.	**10 Hours**
Module -3	
Slope Stability Analysis: Types of Failure: Failure surfaces - Planar surfaces, Circular surfaces, Non-circular surfaces, Limit equilibrium methods, Total stress analysis versus effective Stress analysis, Use of Bishop's pore pressure parameters, Short term and Long term stability in slopes. Taylor Charts. Special Design problems and details**:** Design considerations in earthquake, ground movements, earthquake intensity scales, periods and amplitudes of ground motion, influence of foundation material, earthquake waves, slope stability analysis during earthquake as per BIS, problems in loose sand, soft clay and silt foundation.	**10 Hours**
Module -4	
Method of Slices, Effect of Tension Cracks, Vertical Cuts. Bishop's Analysis, Bishop and Morgenstern Analysis, Non-circular Failure Surfaces: Janbu Analysis, Sliding Block Analysis, Introduction to Seismic stability, Stabilization of slopes: Soil reinforcement (geosynthetics/soil nailing/micro piles etc), soil treatment (cement/lime treatment), surface protection (vegetation/erosion control mats/shotcrete).	**10 Hours**
Module -5	
Slope Protection and Rockfill Dams: Stabilization of slopes: Soil reinforcement (geosynthetics/soil nailing/micro piles etc), soil treatment (cement/lime treatment), surface protection (vegetation/erosion control mats/shotcrete). Requirements of compacted rockfill, Shear strength of rockfill, Rockfill mixtures, Rockfill embankments, Earth-core Rockfill dams, Stability, Upstream & Downstream slopes	**10 Hours**

Course outcomes:

During this course, students will be trained:

- To design the rock and earth fill dams.
- To understand the mechanism of grouting and its application in rocks.
- For analyzing the complex geotechnical problems for the design of earth and rock fill dams.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

4. **Earth and earth-rock dams** - Sherard J L, Woodward R J, Gizienski S F and Clevenger W A, John Wiley & Sons, NY
5. **Earth and rockfill dam engineering** – Sowers G P and Sally H L, Asia Publishing House, New Delhi
6. **Engineering for Dams** – Creager W P, Justin J D and Hinds J, John Wiley & Sons, NY

Reference Books:

4. Sherard, Woodward, Gizienski and Clevenger. Earth and Earth-Rock Dams. John Wiley &. Sons. 1963.
5. Bharat Singh and Sharma, H. D. – Earth and Rockfill Dams, 1999
6. 1. Indian storage resources with earthen dams – Strange W L, R&FN Spon Ltd., London

SYLLABUS FOR M Tech., GEOTECHNICAL ENGINEERING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject: Optimization Techniques in Geotechnical Engineering

Subject Code	**20CGT324**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- The graduates are expected to adopt various numerical method and mathematical tools for analysis of research data.
- Learning the numerical methods in applied soil mechanics.
- Learning the bivariate data and Lagrangae's equation for the problems.
- Application of queuing theory.

Modules	**Teaching Hours**
Module -1 Recurrence Relation and Generating Functions : Formation of recurrence relation, Solution of linear and nonlinear recurrence relation, Properties of generating function and solve the recurrence relation using the generating function and related problems. Scatter Diagram; Karl Pearson's coefficient of linear correlation, Linear regression, Properties of regression and related problem.	**10 Hours**
Module -2 Numerical analysis: Introduction to interpolation, Newton's Forward and Backward interpolation(Statement only), Lagrange and Divided interpolation(Statement only), Simple problems. Numerical differentiation for equal and unequal interval. Matrix Eigen value and eigen vactor by power metods, simple problems. Curve fitting and problems. Statistics: Analysis of Bivariate data. Correlation Analysis – Meaning of correlation.	**10 Hours**
Module -3 Optimisation Technique: Linear programming problem (LPP) Formation of LPP, Graphical Method and related problems. Transportation Problems, assignment problem., Queuing Theory- Basic Structure, Exponential distribution, Birth-and-Death Model,	**10 Hours**
Module -4 Tucker condition, Penalty function method, Augmented Lagrangian method, sequential unconstrained minimization, cutting plane method; Introduction to Evolutionary algorithms: Need for evolutionary algorithms, Type of evolutionary methods, Introduction to Genetic algorithm (GA), Difference and similarities between GA and traditional methods. Basic operations of GA: reproduction, crossover, mutation and elitism. Binary coded and Real coded GA	**10 Hours**
Module -5 Artifical Intellegence : Introduction- Classification of artificial intelligence-expert systems-artificial neural networks basic concepts-uses in functional approximation and optimization applications in the design and analysis, building construction. Fuzzy logic-basic concepts-problem formulation using fuzzy logic-applications	**10 Hours**

Course outcomes:

During this course, students will be trained to:

- Analyise the data obtained from the field
- Develop an appropriate methods to solve logically and optimize the test or field results

Text Books:

1. **Introduction to Optimum Design** J.S. Arora (4004), Elsevier, 2nd Edition.

2. **Optimization for Engineering. Design: Algorithms & Examples** K. Deb (4006), Prentice Hall India, **,**
3. **Engineering Optimization: Theory & Practice, S.S. Rao (4008)** New Age International (P) Ltd, 3rd Edition,

Reference Books:

1. **Multi - Objective Optimization Using Evolutionary Algorithms,** K. Deb**(4003)** John Wiley
2. **Applied Statistics & Probability for Engineers:** Montgomery, Douglas C. & Runger, George C. (4007), 3/e,Wiley India.
3. **Parallel distributed processing Vol.1** (1986) Rumelhart, D.E and McClelland, J.L.,, M I T Press, 1986.
4. **Fuzzy logic implementation and applications(1996),** Patyra, M.J. and Mlynek Wiley,.

SYLLABUS FOR M Tech., GEOTECHNICAL ENGINEERING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject: Finite Elements in Geotechnical Engineering

Subject Code	**20CGT331**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- Understanding the capacity of the soil under different field conditions.
- Design of shallow foundations under different loading condition and different environment.
- Design of footings for uniform settlement of all shallow foundations.

Modules	**Teaching Hours**
Module -1	
Introduction: General, General Description methods, Brief description of FEA for stress analysis problem, Finite element method v/s Classical method. FEM v/s FDM a brief history of FEM, need for studying FEM.	**10 Hours**
Module -2	
Basic equations in Elasticity: Introduction, Stress in typical element, Equations of equilibrium, Strains, Strain displacement equations, Linear constitutive law.	**10 Hours**
Module -3	
Finite element basics: Introduction, Elements, Shape functions, Co-ordinate transformation, Strain displacement relations, Stiffness equations, Body forces, Surface tractions, Geotechnical considerations: effective stress method loadings, Initial stresses, Excavation, fills.	**10 Hours**
Module -4	
Variable – Elastic stress – Strain laws: Introduction, Bi-linear elastic model, K-G model, Hyperbolic model, Comparison of models. Critical state model: Introduction, the geometric model, Hardening law, Yield function, Flow rule, Stress- strain invariant relation, Stress – strain component relation, Parameter values, Examples.	**10 Hours**
Module -5	
Seepage analysis: Introduction, Finite element discretization of seepage equation, computation of velocities and flows, treatment of free surface boundary. Analysis of jointed rock mass: Introduction, Characteristics and discontinuities in rock masses, models behaviour of jointed rocks, generalized plane strain analysis in rock Mechanics, effective stress analysis in undrained rock masses.	**10 Hours**

Course outcomes:

During this course, students will be trained:

- To understand the basic concepts of finite element analysis in general and the transition from structural engineering aspects to geotechnical engineering aspects.
- To understand the finite element techniques for seepage analysis and joint rock masses.
- In Finite element applications in design and Analysis of bearing capacity of the soil for shallow foundations.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. **Introduction to the Finite Element Method (1972),** Desai, C. S. and J.F, Abel. Van Nostrand Reinhold Company
2. **Finite element analysis in Geotechnical engineering Vol 1&2, (1999)** - D M Potts & L Zdravkovic, Thomas Telford publishing, London
3. **Finite element analysis in Geotechnical engineering,** D J Naylor & g N Pande (4012).
4. **Finite Element Analysis by S.S. Bhavikatti,** New Age International Publishers.

Reference Books:

1. **Introduction to the Finite Element Method (1993)** J. N. Reddy - McGraw-Hill Publishers,
2. **Finite element analysis - Theory and programming (1994)** Krishna Murthy, C. S.-Tata McGrawHill,
3. **Finite element Methods (1971)** Zienkiewicz, O. C. -, McGraw-Hill Publishers,

SYLLABUS FOR M Tech., GEOTECHNICAL ENGINEERING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject: Expansive Soil Engineering

Subject Code	**20CGT332**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- Identify the expansive soils.
- Understand the behaviour of such soils and to study the remedial measures for safety of structures.

Modules	Teaching Hours
Module -1 **INTRODUCTION:** Origin, distribution of expansive soils, recognition and identification of expansive soils – clay mineral, x-ray diffraction, DTA, electron microscopy, classification, free swell, shrinkage index, swelling potential and swelling pressure – methods of determination, factors influencing. **HEAVE PREDICTION:** Introduction, soil suction, measurement of soil suction – tensiometers, axis translation, filter paper method, psychrometers, osmotic method, and heave prediction based on oedometer tests, based on soil suction tests.	**10 Hours**
Module -2 **DESIGN ALTERNATIVES:** Introduction, drilled pier and beam foundation, mat Foundation, under-reamed pile foundation, general conditions for under reamed piles, design and construction. **DESIGN FOR HIGHWAY AND AIR-FIELD PAVEMENTS:** Introduction, general Principles of pavement design, design features and treatment methods for expansive soil sub grades, air-field procedures.	**10 Hours**
Module -3 **TREATMENT OF EXPANSIVE SOILS:** Introduction, removal and replacement, remoulding and compaction, pre-loading, pre-wetting, stabilization – lime, cement, fly ash, application methods, moisture control, electro chemical treatments. **REMEDIAL MEASURES:** Introduction, remedial measures for buildings and pavements, case histories.	**10 Hours**
Module -4 **METHODS OF CONSTRUCTION ON EXPANSIVE SOILS:** Introduction, sub-base preparation, constructional and water – protection measures, maintenance and rehabilitation of structures founded on expansive soils.	**10 Hours**
Module -5 **SWELL – SHRINK BEHAVIOUR OF EXPANSIVE SOILS:** Introduction, investigation of foundation movements, cyclic behaviours, factors affecting cyclic behaviour, case histories.	**10 Hours**

Course outcomes:

During this course, students will be trained to:

- Classify the heaving soils and to predict their swell and shrinkage behaviour.
- Provide proper remedy to the swelling soils.
- Design the appropriate foundation based on the swelling characteristics.

Question paper pattern:

- The question paper will have ten questions.

- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. **Foundations on Expansive Soil** - F H Chen, Elsevier Science Publishing Company, NY
2. **Construction of buildings on expansive soils** - E A Sorochan, Oxford & IBH Publications
3. **Expansive soils – Problems and practice in foundation and pavement engineering** – John D Nelson and Debora J Miller, John Wiley & Sons.

Reference Books:

1. **Soil Mechanics for Unsaturated Soils** – D J Fredlund and H Rahardjo, John Wiley & Sons

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[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject: Offshore Geotechnical Engineering

Subject Code	**20CGT333**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- Understand the type of soil strata available in offshore.
- Develop a structure under different environmental condition.
- Design the anchors in the sea.
- Design the pipelines and cable structures.

Modules	**Teaching Hours**
Module -1 **DESIGN OF OFFSHORE PLATFORMS:** Introduction, fixed and floating platforms, case studies and general features, elements of hydrodynamics and wave theory, fluid structure interaction, steel concrete and hybrid platforms, Consolidation and shear strength characteristics of marine sediments.	**10 Hours**
Module -2 Design Criteria: Environmental loading, wind, wave and current loads after installation, stability during towing. Foundations: Site investigations, piled foundation, foundations for gravity structures, pile-supported structures.	**10 Hours**
Module -3 Behaviour under dynamic loading, static and dynamic analysis of platforms and components.	**10 Hours**
Module -4 Dynamic response in deterministic and indeterministic environment, codes of practice, analysis of fixed platform and semisubmersible related topics.	**10 Hours**
Module -5 Anchor design, breakout resistance analysis and geotechnical aspects of offshore pipeline and cable design.	**10 Hours**

Course outcomes:

During this course, students will be trained to:

- Design the structure for wind, wave loads and dynamic loads.
- Design the structure for overturning.
- Design the pipeline and cable structures.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. **Offshore Geotechncial Engineering** – Mark Radolph and Susan Gourvenec, CRC Press.
2. **Construction of Marine and Offshore Structures** – Ben C Gerwick, CRC Press.
3. **Offshore Geotechnical Engineering** – ETR Dean

Reference Books:

1. **Frontiers in Offshore Geotechnics II** – Susan Gourvenec and David White, CRC Press.

2. **Frontiers in Offshore Geotechnics II** – Vaughan Meyer, CRC Press
3. **Geotechnical Aspects of Coastal and Offshore Structures: Proceedings of the Symposium, Bangkok** – A S Balasubramaniam, CRC Press

SYLLABUS FOR M Tech., GEOTECHNICAL ENGINEERING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject: Ground Water Contamination and Remediation

Subject Code	**20CGT334**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- Identify the type of Characterisation of contaminated site.
- To estimate the movement of contamination in the ground and to know the various remediation methods.

Modules	Teaching Hours
Module -1 **Introduction:** Sources and types of groundwater contamination, Characterisation of contaminated site, Contaminant transport mechanisms.	**10 Hours**
Module -2 **Sorption and Other Chemical Reactions:** Introduction, concept of sorption, factors influencing sorption, sorption isotherms, hydrophobic theory for organic contaminants, sorption effects on fate and transport of pollutants, Estimation of sorption.	**10 Hours**
Module -3 **Pollutant Transport:** Advection-Dispersion-Flow through low permeability soils, Retardation, fate of pollutant.	**10 Hours**
Module -4 **Non-Aqueous Phase Liquids:** Introduction, Types of NAPLs, NAPL transport-General processes, NAPL transport- computational methods- Fate of NAPLs in the subsurface, characterization.	**10 Hours**
Module -5 **Groundwater Remediation Technologies** – Methods of remediation of contaminated ground - pump and treat, in-situ flushing, permeable reactive treatment walls, air sparging, soil vapour extraction, natural attenuation, bioremediation and phytoremediation.	**10 Hours**

Course outcomes:

During this course, students will be trained to:

- Analyze the data obtained from the field
- Develop an appropriate methods to solve logically and optimize the test or field results
- Modeling the contaminant transport in the ground and able to identify most appropriate remediation technique for various types of contaminants and ground conditions.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Foundations of Theoretical Soil Mechanics, Harr, M.E (1966) McGraw Hill,
2. Foundation Engineering Handbook, Winterkorn, H.F., and Fang, H.Y(4000) Galgotia
3. Geoenvironmental Engineering, John Wiley & Sons (2004), Sharma, H. D. and Reddy,
4. Geoenvironmental Engineering Principles and Applications, Marcel. Dekker, Inc., New York (2000), Reddi, L. N. and Inyang, H. I.
5. Geotechnical Practice for Waste Disposal, Daniel, D. E.

Reference Books:

1. **Soil Reinforcement with Geotextiles** – Jewel R A (1996), CIRIA
2. **Geotextiles hand book** – Ingold J S and Miller K S (1988), Thomas Telford Ltd.