RCOEM

Shri Ramdeobaba College of
Engineering and Management, Nagpur

SHRI RAMDEOBABA COLLEGE OF ENGINEERING AND MANAGEMENT, NAGPUR – 440013

An Autonomous College affiliated to
Rashtrasant Tukadoji Maharaj Nagpur University,
Nagpur, Maharashtra (INDIA)

PROGRAMME SCHEME & SYLLABI
2023 – 2024

M. Tech. (Geotechnical Engineering)

Published By

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ISO 9001 : 2015 CERTIFIED ORGANISATION

About the Department

Civil Engineering Department was established in 1984 at the time of inception of Shri Ramdeobaba College of Engineering & Management (previously RKNEC) with intake of 60 students. The department has experienced and highly qualified faculty; it is equipped with sophisticated laboratories and latest computational softwares which helps the students to develop expertise in Civil Engineering. Civil Engineering Department offers Undergraduate Programme B. E. in Civil Engineering (1st shift and 2nd shift) and two Post Graduate Programmes namely M. Tech., Structural Engineering (Full Time) and M. Tech., Geotechnical Engineering (Part Time).

The Department of Civil Engineering is one of the prime partners in success stories of the institute. The department has all the state of the art laboratories and faculties that provide excellent opportunities for students as well as researchers. The department is accredited by the National Board of Accreditation and well recognized by Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur. The department is closely associated with industry and extending its testing & consulting services. For overall development of the student, the department provides a conducive atmosphere for organization & conduction of various co-curricular and extra-curricular programs while imparting outcome based quality education.

Departmental Vision

To be a knowledge centre in civil engineering education, training, research, entrepreneurship and industry outreach services for creating sustainable infrastructure and enha00ncing quality of life.

Department Mission

M1: To generate quality civil engineers with strong engineering fundamentals.

M2: To provide civil engineers with strong technical and managerial skills with ethical values.

M3: To provide conducive environment for creative learning, research and innovations in association with stakeholders.

Programme Educational Objectives

1. The Programme will prepare graduates to perform analysis and design of various geotechnical structures.

2. The Programme will prepare graduates to take up industrial project in the field of geotechnical engineering and allied area and also research work in the relevant domain.

Program Outcomes

1. The graduates are expected to have an ability to apply knowledge of mathematics; science and engineering while analysis and design of geotechnical structure ant its components.

2. The graduates are expected to have ability to predict geotechnical problems and adopt innovative solutions.

3. The graduates are expected to solve complex geotechnical engineering problems and able to propose optimal, feasible and economical design solution.

Scheme of Examination of Master of Technology
M. Tech. (Geotechnical Engineering)
(Semester - I)

Sr. No.	Category	Course Name	L	P	Credits	Maximum marks			Exam Duration	Category
						Continuous Assessment	End Sem Exam	Total		
1.	CET781	Advanced Soil Mechanics	4	-	4	50	50	100	3 Hours	PC
2.	CEP781	Advanced Soil Mechanics (P)	-	2	1	50	--	50	--	PC
3.	CET782	Geotechnical Investigation & Exploration	4	-	4	50	50	100	3 Hours	PC
4.	CEP782	Geotechnical Investigation & Exploration (P)	-	2	1	50	--	50	--	PC
5.	CET783	Engineering Rock Mechanics	4	-	4	50	50	100	3 Hours	FC
		TOTAL	**12**	**4**	**14**					

Scheme of Examination of Master of Technology
M. Tech. (Geotechnical Engineering)
(Semester - II)

Sr. No.	Code	Course Name	L	P	Credits	Maximum marks			Exam Duration	Category
						Continuous Assessment	End Sem Exam	Total		
1.	CET784	Applied Soil Engineering	4	-	4	50	50	100	3 Hours	PC
2.	CEP784	Applied Soil Engineering Lab (P)	-	2	1	50	--	50	--	PC
3.	CET796	Research Methodology	3	-	3	50	50	100	3 Hours	PC
4.	CET797	Group Elective - I	4	-	4	50	50	100	3 Hours	PC
5.	CEP797	Group Elective - I (P)	-	2	1	50	--	50	--	PC
6.	CET799	Open Elective	3	-	3	50	50	100	3 Hours	PC
		TOTAL	**14**	**4**	**16**					

Course Code	Group Elective I (T + P)
CET / CEP797-1	Instrumentation and Design of supports
CET / CEP797-2	Finite Element Method
CET / CEP797-3	Instrumentation & Material Science
CET / CEP797-4	Soil Dynamics
CET / CEP797-5	Engineering Computational Techniques

Course Code	Open Elective
CET799-1	Advanced Construction Materials & Techniques
CET799-2	Geoscience
CET799-3	Prestressed Concrete Structure
CET799-4	Watershed Management
CET799-5	Introduction to Numerical Modeling
CET799-6	Rock Excavation Engineering

Scheme of Examination of Master of Technology
M. Tech. (Geotechnical Engineering)
(Semester - III)

Sr. No.	Code	Course Name	L	P	Credits	Maximum marks			Exam Duration	Category
						Continuous Assessment	End Sem Exam	Total		
1.	CET898	Group Elective - II	4	-	4	50	50	100	3 Hours	GE
2.	CET881	Ground Improvement	4	-	4	50	50	100	3 Hours	PC
3.	CEP881	Ground Improvement	-	2	1	50	--	50	-	PC
4.	CET882	Earth and Rockfill Dams and Design of Slopes	4	-	4	50	50	100	3 Hours	PC
5.	CET883	Tunnel Engineering	4	-	4	50	50	100	3 Hours	PC
		TOTAL	**16**	**2**	**17**					

Course Code	Group Elective II
CET898-1	Design of Bridges
CET898-2	Design of Environmental Structures
CET898-3	Geo-Environmental Engineering
CET898-4	Soil Structure Interaction
CET898-5	Advance Foundation Engineering

Scheme of Examination of Master of Technology
M. Tech. (Geotechnical Engineering)
(Semester - IV)

Sr. No.	Category	Course Name	L	P	Credits	Maximum marks			Exam Duration	Category
						Continuous Assessment	End Sem Exam	Total		
1.	CET884	Program Elective I	4	-	4	50	50	100	3 Hours	PE
2.	CET885	Program Elective II	4	-	4	50	50	100	3 Hours	PE
3.	CEP886	Project Phase I	-	12	6	50	50	100	-	PC
		TOTAL	**8**	**12**	**14**					

Course Code	Program Elective I (T)
CET 884-1	Special Geotechnical Construction
CET 884-2	Geotechnical Earthquake Engineering
CET 884-3	Design of Underground Structures

Course Code	Program Elective II (T)
CET885-1	Pavement Analysis and Design
CET885-2	Advanced Methods of Working

Scheme of Examination of Master of Technology
M. Tech. (Geotechnical Engineering)
(Semester - V)

Sr. No.	Category	Course Name	L	P	Credits	Maximum marks			Exam Duration	Category
						Continuous Assessment	End Sem Exam	Total		
1.	CEP981	Project Phase II	–	24	12	100	100	200	–	PC
		TOTAL	**–**	**24**	**12**					

Semester	L	T	P	Credits	Maximum Marks		
					Internal Assessment	End Semester Examination	Total
First Semester	12	0	4	14	250	150	400
Second Semester	14	0	4	16	300	200	500
Third Semester	16	0	2	17	250	200	450
Fourth Semester	8	0	3	14	150	150	300
Fifth Semester	0	0	6	12	100	100	200
Total	**50**	**0**	**19**	**73**	**1050**	**800**	**1850**

Syllabus of Semester I
M. Tech. (Geotechnical Engineering)

Course Code : CET781 **Course : Advanced Soil Mechanics**

L:4 Hrs., P:0 Hrs., Per Week **Total Credits : 4**

Course Outcomes

On successful completion of the course students will be able to;

1. Identify and classify the types of soil.
2. Understand stress distribution concept.
3. Determination of shear strength parameters.
4. Understand the concept of earth pressure & bearing capacity of soil.

Syllabus

Concept of stress, strain, Principal stresses & strains, Invariant, Octahedral Stresses & strains. Stress-strain relations, Special Matrices, Plane stress, Plane strain problems, Mohr's diagram.

Stresses & displacements in elastic soil mass - Line force, Distributed line loads, Concentrated force and distributed loads at the surface of semi-infinite mass, Soil bodies exhibiting non-homogeneous attributes, Influence of anisotropy in soil bodies, constitutive equations and models.

Soil strength - Yield criteria, Theories of failure, Effective stress principle, Stress path in various drainage conditions Limiting equilibrium for analysis of slopes stability.

Earth pressure and retaining walls - Earth pressure theories, Analytical and graphical methods for determination of earth pressure, Proportioning of retaining walls.

Stability analysis of retaining walls - Stability against sliding, overturning, bearing capacity and settlement.

Braced cuts - Lateral earth pressure in cuts, Stability of braced cuts.

Three dimensional consolidation - Equation, Solution of 3-D consolidation equation, Consolidation by vertical sand drain and its design aspects, Free strain consolidation with no smear, Effect of smear zone on radial consolidation, Calculation of degree of consolidation with radial drains and solutions of problems based on it.

Seepage - Flow net for anisotropic soil media, Construction of flow net for hydraulic structures on non-homogeneous soil, Directional variation of permeability in anisotropic medium.

Anisotropy governing differential equations for flow through porous media in Cartesian co- ordinate & polar co-ordinate systems for Laplace Equations, Numerical analysis of seepage in layered soil, computation of seepage force.

Text Books

1. Fundamentals of soil mechanics: Taylor D.W., Asia Publishing House (1964).
2. Principles of Soil Mechanic: Scott R.F., Addison-Wesley Publication co. (1963).
3. T.B. of Soil Mechanics & Foundation Engineering: Murthy VNS, CBS pub.(2004).

Reference Books

1. Geotechnical Engineering-principles & practices: Coduto D.P., Peavson Edn. Asia, (2002).
2. Basic and Applied soil mechanics: Gopal Ranjan & A.S. Rao, New Edge Int. Ltd., (2004).
3. Principles of Geotechnical Engineering: Das B.M., Thomson Bks, Cengage publication (2002).

Syllabus of Semester I
M. Tech. (Geotechnical Engineering)

Course Code : CEP781 **Course : Advanced Soil Mechanics Lab**

L: 0 Hrs., P: 2 Hrs., Per Week **Total Credits : 1**

Course Outcomes

1. Student will have an ability to perform different laboratory investigations on soil.
2. Student will have an ability to determine the various index and engineering properties.

List of Experiments

1. Collection of Undisturbed / Disturbed Sample for laboratory testing.
2. Determination of granulometry by sedimentation analysis.
3. Determination of Relative density of sand.
4. Determination OMC & MDD of soil.
5. Determination of permeability of soil.
6. Determine shear strength parameters by Direct Shear Test.
7. Triaxial shear test on saturated soil (UU, CU-test) with pore pressure measurement.
8. Unconfined compressive test on soil & Rock.
9. FSI and FSR test for clay soils.

Reference

1. Das, B.M., Soil Mechanics Laboratory Manual, Oxford University Press, Sixth Ed.
2. Relevant IS, British and ASTM Standards.

Syllabus of Semester I
M. Tech. (Geotechnical Engineering)

Course Code : CET782 **Course : Geotechnical Exploration and Investigation**

L: 4 Hrs., P: 0 Hrs., Per Week **Total Credits : 4**

Course Outcomes

1. Students will able to determine solving real problems related to Geotechnical engineering.
2. To familiarize the students with principles of exploration, geophysical methods, modern methods of drilling, sampling and instrumentation.
3. Students will able to undertake various field techniques used in geotechnical engineering for ascertaining the nature and behavior of soil strata.

Syllabus

Method of Exploration

Planning of sub-surface programs, Stages in sub-surface exploration, Reconnaissance, Lateral extent and depth of exploration, Methods of exploration – trial pits, open excavation, boring etc. Types of borings, selection of suitable boring type; stabilization of boreholes; the number, location and depth of boring. Types of soil samples, Sample disturbance, storage, labeling and transportation of samples; Types of soil samples and their suitability for different soils, hand carved samples.

Planning of subsurface exploration program for major civil engineering project.

Indirect methods of exploration

Seismic refraction method, electrical resistivity method, qualitative and quantitative interpretation of test results, limitations; Test Determination of ground water table.

Field investigation

Standard Penetration test, cone penetration tests interpretation of test results and correlations for obtaining design soil parameters of cohesive and cohesion less soil, field vane shear test, Plate load test, Pressure meter test & interpretation of results,

Sub-surface Investigation Report: Salient features and boring logs Soil survey and Mapping: methods of soil survey introduction of remote sensing. Field Instrumentation: Rollers, Sensors, Inclinometers. Equipments used for boring. Basics of Rocks

Introduction to formation of rocks; types of rocks, physical and mechanical properties of rocks; its determination to identify rock quality designation.

Text Books

1. Basic and Applied soil mechanics: Gopal Ranjan & A.S. Rao, New Edge Int. ltd., (2004)
2. Soil Mechanics and Foundation Engineering: K.R. Arora, Standard Publisher and Distributor, 1949 and later.
3. Foundation Analysis & Design: Bowles, J.E., McGraw Hill (1996)
4. Quarterly Journal of Engineering Geology – Relevant articles

Reference Books

1. Soil Mechanics in Theory and Practice: Alam Singh, Asia Publisher and Distributor, 1975
2. Advanced Foundation Engineering: Murthy VNS, CBS publishing, (2007)
3. Foundation Engineering Handbook: Fang, H.Y., CBS publishing, (2004)
4. Indian, British and ASTM Standards on site investigation and field tests

Syllabus of Semester I
M. Tech. (Geotechnical Engineering)

Course Code : CEP782 **Course : Geotechnical Exploration and Investigation Lab**

L: 0 Hrs., P: 2 Hrs., Per Week **Total Credits : 1**

Course Outcomes

1. Student will have an ability to perform different laboratory investigations on soil.
2. Students will able to conduct various field test and its applications related to geotechnical engineering.
3. Student will have an ability to determine the various index and engineering properties.

List of Experiments

I) Laboratory test on C- soil

1. Consolidation Test
2. Swell Pressure Tests

II) Field tests any Two from the following.

1. Standard penetration test.
2. Static Cone Penetration test
3. Plate load test. (Demonstration)
4. Pressure meter test

III) Preparation of Detail soil Investigation Report

Reference

1. Das, B.M., Soil Mechanics Laboratory Manual, Oxford University Press, Sixth Ed.
2. Relevant IS, British and ASTM Standards

Syllabus of Semester I
M. Tech. (Geotechnical Engineering)

Course Code : CET783 **Course : Engineering Rock Mechanics**

L: 4 Hrs., P: 0 Hrs., Per Week **Total Credits : 4**

Course Outcomes

1. The graduate will be able to understand engineering properties of rock, classification of rocks.
2. The graduate will be able to carry out laboratory testing of rocks, failure criteria, tunneling in rocks.
3. The graduate will be able to understand and adopt various techniques to improve the in situ strength of rocks.

Course Content

1. Classification of Intact rock and Rock masses, Strength and modulus from classifications.
2. Physico mechanical properties, Laboratory tests for various physical and mechanical properties. Field shear test, Deformability tests in rock mass, State of stress in the ground.
3. Insitu stress, various methods of stress measurement, Hydrofracturing technique, Flat jack technique, Overcoring technique.
4. Rock mass classifications : different classifications commonly used in field, stresses around mine opening , Planes of weakness in rocks, rock fractures and fractured rock.
5. Stability of rock slopes, Modes of failure, Plane failure, Wedge failure, Circular failure, Toppling failure.
6. Foundation on rocks, Estimation of bearing capacity, Methods to improve rock mass responses, Grouting in Rocks, Rock bolting, Rock Anchors.

References

1. Introduction to Rock Mechanics by R.E.Goodman, John Wiley & Sons.
2. Engineering in Rocks for Slopes, Foundation and Tunnels, Editor T.Ramamurthy, Prentice Hall India Pvt. Ltd.
3. Fundamentals of Rock Mechanics, Fourth Edition, by Jaeger, Cook and Zimmerman, Blackwell Publishing.
4. Rock mechanics and the design of structures in rock, L. Obert and Wilbur I. Duvall, John Wiley & Sons, Inc.

Syllabus of Semester II
M. Tech. (Geotechnical Engineering)

Course Code : CET784 **Course : Applied Soil Engineering**

L: 4 Hrs., P: 0 Hrs., Per Week **Total Credits : 4**

Course Outcomes

1. The graduate will be able to apply basic concepts in soil engineering for analysis of complex geotechnical problems.
2. The graduate will have knowledge in geotechnical design of different types of earth retaining structures.
3. The graduate will be able to understand and analyze various slope failure issues and suggest appropriate remedial measures. (add)

Syllabus

Earth pressure theories : Theories of earth pressure, general and local states of plastic equilibrium, Active and passive states in cohesive and cohesion less soils, Rankine's and Coulomb,s approaches, effects of wall movement, uniform surcharge, wall angle, wall friction, back fill slope; lateral pressure on wall due to concentrated construction, Culmann's method; , earth pressure at rest.

Retaining Walls : Types of retaining wall, Stability analysis of rigid type and R. C. cantilever type retaining walls, introduction of Georeinforce wall, Gabion wall, soil nailing.

Sheets pile walls : Types, analysis and design of cantilever and anchored sheet pile walls in cohesive and cohesion less soil, bulkheads, analysis with free earth and fixed earth supports. Rowe`s moment reduction factors, location of deadman and its anchorage capacity.

Cofferdams : Types, suitability, stability analysis and design of cellular and diaphragm type cofferdams, TVA method for various failures, interlock stress, stability of cellular cofferdams in deep sands and clays.

Stability of slopes : Finite and infinite slopes, analysis for stability of slopes of embankments, cuts and earth dams. Critical conditions, plane and curved failure surfaces, centre of critical slip circle; slices method with inter slices forces, pore pressures and seepage forces, Ø-circle method, Taylor's stability numbers & stability curves; Bishop's method, Bishop-Morgenstern stability coefficient, Use of design charts based on Ø-circle method and Bishop`s method. Stability of earth dam slopes during steady seepage and sudden drawdown conditions, Filters types, selection and design criteria, Remedial measures to improve the slop stability.

Text Books

1. T. B. of soil mechanics and foundation engineering: Murthy VNS, CBS pub. (2004)
2. Principles of Geotechnical Engineering: Das B.M.,Thomson Bks, Cengage publ.(2002)
3. Geotechnical Engineering-principles & practices: Coduto D. P., Peavson edn. Asia, (2002)

Reference Books

1. Principles of Foundation Engineering: Das B. M., PWS publication co., (1999)
2. Foundation Analysis & Design: Bowles, J. E., McGraw Hill (1996)
3. Theory & practice of Foundation Design: Som N. N. & Das S. C., Prentice Hall Edn, Asia (2002)

Syllabus of Semester II
M. Tech. (Geotechnical Engineering)

Course Code : CEP784 **Course : Applied Soil Engineering Lab**

L: 0 Hrs., P: 2 Hrs., Per Week **Total Credits : 1**

Course Outcomes

1 The graduate will have an ability to calculate lateral pressure on retaining structures. (add) The graduate will have an ability to design different types of earth retaining structures.

2 The graduate will have an ability to determine soil engineering for analysis of complex geotechnical problems.

Work out the Design/ solution of minimum 6 problems/ assignments from the following

1) Design of cantilever bulkhead in cohesive soil retaining granular backfill.

2) Design of anchored bulkhead by free earth support method.

3) Design of anchored bulkhead by fixed earth support method.

4) Design of braced cofferdam.

5) Culmann's graphical method for active or passive pressure on cantilever wall retaining broken surface backfill with concentrated load.

6) Poncelet construction for active and passive pressure on gravity retaining wall with sloping backfill.

7) Stability of homogeneous C- Ø soil slope by slices method of F - circle method (for min. F. S.) (software based)

8) Stability of homogeneous C-Ø soil slope by Bishop method (for min. F. S.) (software based)

The work shall be submitted in the form of Journal of above, and same shall be assessed by the concerned teacher/s through viva-voce examination.

Syllabus of Semester II
M. Tech. (Geotechnical Engineering)

Course Code : CEP796 **Course : Research Methodology**

L: 3 Hrs., P: 0 Hrs., Per Week **Total Credits : 3**

Course Outcomes

1. The graduates will be able to define research problems describe the research process and research methods for execution of research project in relevant field.
2. The graduates will be able to know how to apply the basic aspects of the research process in order to plan and execute a research project.
3. The graduates will be able to adopt various numerical method and mathematical tools for analysis of research data.
4. The graduates will be able to understand ethics in research.

What is Research?, How to do Research, The Objective of Research, Motivation in Research, Types of Research, Various Research Approaches, Significance of Research.

Research Methods, What is Research Methodology, Research Process, What is Research Problem, Various Components of Research Problem, How to Identify the Research Problem, Steps involved in formulation of Research Problem, Necessity and Techniques involved in Defining Research Problem, Feasibility Check.

What is Hypothesis?, its Characteristics, Examples and Types, Hypothesis Testing, Concepts and Procedure of Hypothesis Testing.

Data Collection, Methods of data collection, Primary Data, Secondary Data, Analysis of data, Simple regression, Multiple regression, linear and nonlinear correlation and regression .

Optimization, Principle, linear programming technique, simplex method, evolutionary programming techniques.

Model analysis of structures, direct and indirect method, dimensionless terms and their significance, Geotechnical similitude's, optimization of model.

Research Paper and its contents, Choice on topic, Method of writing research paper, Plagiarism including rules of plagiarism.

Reference Books

1. Research Methodology- Methods and Techniques: Kothari C.K. (2004), 2/e, New Age International, New DelhiProgramme Scheme & Syllabi M. Tech. (Geotechnical Engineering)
2. Simulation Modeling and Analysis, 2nd ed.: Law, A. M., and W. D. Kelton, 1991, , McGraw Hill
3. Applied Statistics & Probability for Engineers: Montgomery, Douglas C. & Runger, George C. (2007), 3/e, (Wiley India)
4. Research Methods: A Modular Approach: 2nd edition, Sherri L. Jackson, Wadsworth Cengage Learngin, Belmont, USA
5. Schaum's Quick Guide to Writing Great Research Papers: Laurie Rozakis, 2nd edition, McGraw Hill, New York, US

Syllabus of Semester II
M. Tech. (Geotechnical Engineering) (Group Elective - I)

Course Code : CET797-1 **Course : Instrumentation and Design of Supports**

L: 4 Hrs., P: 0 Hrs., Per Week **Total Credits : 4**

Course Outcome

At the end of this course students will be able to

1. Understand application of instrumentation in strata control
2. Gain knowledge about working and application of different types of supports used in underground workings
3. Apply knowledge for design of support system for underground workings

Syllabus

Instrumentation : Use of different types of sensors, load cells, strain gauges, extensometers, data acquisition systems.

Wooden supports : Types, application, typical capacities.

Steel supports : Lining types, cast iron-steel linings, RSJ supports, rigid and yielding type arches, design and selection of arches.

Rock bolts and wire mesh : Introduction, mechanism of support, review of typical rock bolt & cable bolt systems, rock bolt & cable bolt installations, wire mesh, Pre-tensioning.

Concrete and Shotcrete Lining : Engineering properties of concrete, concrete segmental supports, cast in situ or monolithic concrete lining, water proofing of concrete lining; engineering properties of shotcrete, design of steel fiber reinforced shotcrete, Grouting and Freezing Methods.

Underground excavation support design : Rock support interaction analysis, use of rock mass classifications for estimating support requirement, classification of supports, passive and active supports, temporary and permanent supports.

Syllabus of Semester II
M. Tech. (Geotechnical Engineering) (Group Elective - I)

Course Code : CEP797-1 **Course : Instrumentation and Design of Supports Lab**

L: 2 Hrs., P: 2 Hrs., Per Week **Total Credits : 1**

Course Outcome

At the end of this course students will be able to

1. Calculate rock load and will be able to design support system for coal mining using rock mass classification.
2. Calculate rock load and will be able to design support system for hard rock mining using rock mass classification

List of Assignment

1. Calculation of rock load and design of support system for Board and Pillar coal mining using rock mass classification.
2. Calculation of rock load and design of support system for Longwall coal mining using rock mass classification.
3. Calculation of rock load and design of support system for Hard Rock mining using rock mass classification.

Syllabus of Semester II
M. Tech. (Geotechnical Engineering)

Course Code : CET797-2 | **Course : Group Elective - I : Finite Element Method**

L: 4 Hrs., P: 0 Hrs., Per Week | **Total Credits : 4**

Course Outcomes

1. The graduates will be able to understand solution methodologies for solving complex stress analysis problems.
2. The graduates will be able to understand the general steps of finite element methods and be able to derive equations in finite element methods for 1D, 2D and 3D problems.
3. The graduates will be able to develop element stiffness matrix equation, Assemble element matrix equations into a global matrix, solve the resulting system and interpret the results obtained.
4. The graduates will be able to learn advanced topics and techniques in finite element methods and implement of these techniques to solve advanced stress analysis problems.

Syllabus

Principles and discretization, Elements stiffness formulation based on direct and variational techniques, Raleigh Ritz Method for Bar and Beam analysis.

Shape functions, Finite Element Formulation using Cartesian Coordinates, Application to 1D problems, Convergence criteria.

Triangular and Rectangular element formulation using Cartesian Coordinates, Application to 2D stress analysis.

Natural coordinates, Numerical integration, Isoparametric elements, Application to 1D Problems, Isoparametric elements for two-dimensional stress analysis

Axisymmetric Stress Analysis

Tetrahedral and hexahedral element formulation, Application to 3D stress analysis.

Modeling techniques and solution techniques, Computer Implementation of FEM Procedure for 1D, 2D & 3D problems.

Text Books

1. Introduction to Finite Element Method, P. N. Godbole, I. K. International Publishing House Pvt. Ltd., (2013).
2. Introduction to Finite Elements in Engineering: Chandrapatla T. R. and Belegundu A. D., Prentice Hall, India, (1991).
3. A First Course in the Finite Element Method: Logan D. L, Thomson Publishing (2007)

4. "Finite Element Analysis: Theory and Programming", 2nd ed.: Krishnamurthi C. S., Tata Mc Graw Hill Publishing Company Limited, 1994, Reprint 2005.

5. Concepts and Applications of Finite Element Analysis, 3rd ed.: Cook R. D., Wiley India Text books, Wiley India Pvt. Limited, New Delhi, (1989).

Reference Books

1. The Finite Element Method (Volume -I), 1st ed.: Zienkiewicz O. C. and Taylor R. L., Tata McGraw Hill Publishing Company Limited, New Delhi, (1989).

2. Introduction to Finite Element Method: Desai C. S. and Abel J. F., Van Nostrand Reinhold, New York (1972)

3. "Finite Element Procedure": Bathe K. J., Prentice-hall of India, New Delhi,(1997).

4. Finite Element Analysis in Engineering Design: Rajasekaran S, S. Chand & Co.Ltd. New Delhi, (1999).

Syllabus of Semester II
M. Tech. (Geotechnical Engineering)

Course Code : CEP797-2 **Course : Group Elective - I : Finite Element Method Lab**

L: 0 Hrs., P: 2 Hrs., Per Week **Total Credits : 1**

Course Outcomes

1. The graduates will be able to identify the necessary information required to conduct a structural analysis using finite element software
2. The graduates will be able to interpret the solutions obtained from finite element analyses.
3. The graduates will have basic skills in using commercial finite element software and effective presentation of their analysis results.
4. The graduates will be able to communicate effectively in writing to report (both textually and graphically) the method used, the implementation and the numerical results obtained.

Syllabus

Analytical solution and computer simulation of following problems

- Truss
- Bar
- Beam
- 2D plane stress problem
- 2D plain stain problem
- 2D axisymmetric stress problem
- 3D problem

Syllabus of Semester II
M. Tech. (Geotechnical Engineering) Group Elective - I

Course Code : CET797-3 **Course : Instrumentation and Material Science**

L: 4 Hrs., P: 0 Hrs., Per Week **Total Credits : 4**

Course Outcomes

1. The graduates will have fundamental understanding of the theoretical basis of various measuring instruments used in structural health monitoring.
2. The graduates will be able to select and apply appropriate instrument, method of analysis for measurement of quantities like strain, strength, etc.
3. The graduates will be able to carry out meaningful interpretation of data obtained from various instruments and produce quantities report of measured parameter.

Syllabus

Study of various transducers & Principle of their working, displacement velocity acceleration.

Stress-strain measurement, strain gauges static and dynamics strain measurement, Calculation of stresses from measurement of strain, deflections etc.

Special materials for building constructions i. e. steel fibre reinforced concrete, fibre reinforced plastics. Non-destructive testing of concrete / steel / ultrasonic techniques etc, model Analysis related to structures. Admixture for concrete, theories of corrosion and its preventions.

Special concrete like lightweight concrete, no fines concrete, Ferro cement, fly ash concrete etc. high performance concrete.

References Books

1. Experimental Stress Analysis: Singh, Sadhu Khanna Publishers.
2. Instrumentation in Industry: Soisson, H. E. John Willey & Sons, NY, 1975.
3. Corrosion of Steel in Concrete: Boon Field, J. P. E & FN SPON, 1997.
4. Modal Analysis of Structures: Ganesan, T. P., University Press,2000.
5. "IS: 13925 Repair and Seismic Strengthening of Buildings- Guidelines", Bureau of Indian Standard, New Delhi, 1993.
6. "SP: 25 Causes and Prevention of Cracks in Buildings", Bureau of Indian Standard, New Delhi, 1984.

Syllabus of Semester II
M. Tech. (Geotechnical Engineering) Group Elective - I

Course Code : CEP797-3 **Course : Instrumentation and Material Science Lab**

L: 0 Hrs., P: 2 Hrs., Per Week **Total Credits : 1**

Course Outcomes

1. The graduates will able to identify suitable measuring instruments for structural health monitoring.
2. The graduate will be able to operate various instruments, interpret the results and will be able to prepare a report.

Syllabus

Minimum Six practical's based on Theory syllabus.

Syllabus of Semester II
M. Tech. (Geotechnical Engineering) Group Elective - I

Course Code : CET797-4 **Course : Soil Dynamics**

L: 4 Hrs., P: 0 Hrs., Per Week **Total Credits : 4**

Course Outcomes

1. To enhance Student's knowledge in dynamic loading, theory of vibrations, dynamic soil properties, dynamic earth pressure, dynamic bearing capacity, vibration isolation, liquefaction of soils
2. To train the students in machine foundation design.
3. To realize the occurrence of liquefaction and the analyzing it.

Syllabus

Dynamic properties of soil

Idealization of soil as elastic material for dynamic analysis, elastic constant (E,G) and damping property, coefficient of elastic uniform compression and shear, their determination from elasticity theory; Laboratory test and field test to determine dynamic properties. Salient feature and interpretation of resonant column test. Ultrasonic pulse test, block resonance test and cyclic plate load test, factor affecting elastic properties of soil, damping form hysteresis loop, shear models of cohesive and cohesion less soils for low and high strain amplitude problems, application Hooke's law to soil, influence of initial stresses in soil on its elastic deformation, Cross hole propagation test.

Theory of vibration and machine foundation

Time dependent forces on soil foundation system and their frequency ranges, nature of dynamic forces from m/c forces and earth quake, mass-spring analogy for m/c foundation analysis, theory of free and forced vibration with and without damping, dynamic response characteristics, concept of apparent soil mass, elastic half space approach, Richart's solutions, correlation and comparison of dynamic response evaluation from mass-spring analogy and elastic half space approach.

Machine Foundation Design

Type of machines, dynamic force characteristics, Analysis and design of single engine reciprocating and impact type machine foundation under vertical dynamic forces; Design and analysis of block foundation, frame foundation (Turbo engine). Computation of dynamic force, method of decreasing vibration of foundation, Analysis and design of m/c foundation with dynamic dampness and absorbers. Vibration isolation and vibration screening. Permissible amplitude of vibration.

Liquefaction of soil

Phenomenon, liquefaction induced failures, factors affecting liquefaction, Evaluation of potential, concept of cyclic stream ratio (CSR), CSR developed by design earthquake and that required to produce liquefaction, SPT based approaches, CPT based approach, remedial measures to prevent liquefaction.

Text Books

1. Geotechnical Earthquake Engineering: S. L. Kramer, Prentice Hall of India (1996).
2. Vibration of soil and foundation: Richarts, Hall and Woods, Prentice Hall of India (1970).
3. Advanced Foundation Engineering (Chapter 15): VNS Murthy, CBS Publisher (2007).

Reference Books

1. Geotechnical Engineering: D. P. Coduto, Pearson Education Asia, (2002)
2. Soil Dynamics: Shamsher Prakash
3. Theory and Practice of Foundation Design: N. N. Som and S. C. Das, Prentice Hall of India (2003)
4. Basic of Soil Dynamics: Das B. M. , Ramana G. V.
5. NPTEL Videos on Soil Dynamics.

Syllabus of Semester II
M. Tech. (Geotechnical Engineering) Group Elective - I

Course Code : CEP797-4 **Course : Soil Dynamics Lab**

L: 0 Hrs., P: 2 Hrs., Per Week **Total Credits : 1**

Course Outcomes

1. To enhance Student's knowledge in dynamic loading, theory of vibrations, dynamic soil properties, dynamic earth pressure, dynamic bearing capacity, vibration isolation, liquefaction of soils
2. To train the students in machine foundation design.
3. To realize the occurrence of liquefaction and the analyzing it.

Syllabus

Each student shall complete the following design assignments indivisually (with different data)

1. Analysis and design of reciprocating machine foundation by;

a. Barken's approach using Cu, with and without apparent soil mass consideration.

b. Pauw's method for spring constant and apparent soil mass.

2. Analysis and design of reciprocating machine foundation with spring absorber system.
3. Analysis and design of forge hammer foundation.
4. Evaluation of liquefaction potential of given ground for a known design earthquake.

The work record shall be submitted in the form of journal and the same shall be assumed by concerned teacher through viva voce examination.

Syllabus of Semester II
M. Tech. (Geotechnical Engineering) Group Elective - I

Course Code : CET797-5 | **Course : Engineering Computational Techniques**

L: 4 Hrs., P: 0 Hrs., Per Week | **Total Credits : 4**

Course Outcomes

1. The graduate will be able to understand and apply various mathematical techniques to analyze various geotechnical engineering problems.
2. The graduates will be able to solve mathematical equations, matrices, eigne value problems, integrations, etc.

Syllabus

Solution of algebraic equations : Bisection Method, Regula Falsi Method, Newton-Raphson method. Solution of linear algebraic equations : Direct methods and iterative methods.

Eigen values problems : Direct, Jacobi, LR method, QR method.

Initial & two point boundary value problem : Euler's, Runge-Kutta, Milne's Methods Numerical Integration : Trapezoidal Method, Simpson's Method, Gauss Quadrature.

Direct Integration Methods : Central difference method, Houbolt method, Newmark's method, Wilson - method.

Text Books

1. Numerical methods, Principles, Analyses and Algorithms: Srimanth Pal, Oxford University Press, New Delhi.
2. Numerical Methods in Finite Element Analysis: Bathe K. J., Wilson E. L., Prentice-Hall of India Private Limited, New Delhi, (1987).

Reference Books

1. Numerical Methods: Kandasamy P., Thilagavathy K. and Gunavathi K., S. Chand & Company Ltd, New Delhi, (1997)
2. Numerical Methods for Engineers with Programming and Software Applications: Chapra. S. C. and Canale R. P.,3rd ed., Tata McGraw Hill, New Delhi, (2009).
3. Numerical Mehtods: Salvadori M., PHI learning Pvt, ltd., New Delhi, (1987)

Syllabus of Semester II
M. Tech. (Geotechnical Engineering) Group Elective - I

Course Code : CEP797-5 **Course : Engineering Computational Techniques Lab**

L: 0 Hrs., P: 2 Hrs., Per Week **Total Credits : 1**

Course Outcomes

1. The graduates will be able to develop computer programs for various mathematical techniques used in analyzing various problems in geotechnical engineering.
2. The graduates will be able to develop algorithm and remove programming errors in computer programs.

Syllabus

Development of computer program for any six methods covered in theory syllabus using FORTRAN/ C/ Python.

Text Books

1. Numerical methods, Principles, Analyses and Algorithms: Srimanth Pal, Oxford University Press, New Delhi.
2. Numerical Methods in Finite Element Analysis: Bathe K. J., Wilson E. L., Prentice-Hall of India Private Limited, New Delhi, (1987).

Reference Books

1. Numerical Methods: Kandasamy P., Thilagavathy K. and Gunavathi K., S. Chand & Company Ltd, New Delhi, (1997).
2. Numerical Methods for Engineers with Programming and Software Applications: Chapra. S. C. and Canale R. P.,3rd ed., Tata McGraw Hill, New Delhi, (2009).
3. Numerical Mehtods: Salvadori M., PHI learning Pvt, ltd., New Delhi, (1987).

Syllabus of Semester II
M. Tech. (Geotechnical Engineering) Open Elective

Course Code : CET799-1 **Course : Advanced Construction Material and Techniques**

L: 3 Hrs., P: 0 Hrs., Per Week **Total Credits : 3**

Course Outcomes

1. The graduate will be able to classify and select advance construction materials on the basis of their properties.
2. The graduate will be able to demonstrate the use slip formwork technique in construction.
3. The graduate will be able to understand launching techniques of different civil engineering structures.
4. The graduate will be able to identify and suggest advance construction materials for improvement in functional performance of building components

Syllabus

Construction Materials

Classifications, selection criteria for construction materials. Materials Engineering concept: Consideration of physical, Mechanical, thermal, and other Properties. nature of materials.

Ceramic Materials

Properties, Processing of ceramic, classification, refractories, glass, uses and application Engineering wood products Types of Plastics, Properties & Manufacturing process, Advantages of Reinforced polymers Types of FRP, FRP on different Geotechnical elements, Applications of FRP.

Composites

Requirements, classification, microscopic composites, macroscopic composites, their applications.

Thermal performance of materials and insulating materials Acoustics and sound proofing methods and materials False ceiling.

Types and properties of Water Proofing Compounds, Types of Flooring and Facade Materials and its application.

Launching Techniques

Suspended formwork - erection techniques of tall structures, Large span structures - in high rise structures. Erection of Lift.

Slip formwork techniques, Grouting methods.

Text Books

1. Engineering materials: Polymers, Ceramics and composites, Bhargava A K, PHI Publications, Second edition, 2012
2. Engineering Materials, Rangawala S. C., Chortor Publications
3. Building Materials, S.K. Duggal, New Age International Publications, Fourth edition, 2012
4. Building Materials Technology Geotechnical Performance & Environmental Impact, L. Reed Brantley, Ruth T. Brantley, McGraw Hill Inc Publications.

Reference Books

1. Materials for Civil and Construction engineers, Michael S Mamlouk, John P Zeniewski, Pearson Publications, Third edition, 2014.
2. Rai Mohan and Jai Singh.M.P," Advances in Building Materials and construction " CBRI Roorkee.
3. Jerry Irvine, " Advanced Construction Techniques ", California Rocketry, 1984.

Syllabus of Semester II
M. Tech. (Geotechnical Engineering) Open Elective

Course Code : CET799-2 **Course : Geoscience**

L: 3 Hrs., P: 0 Hrs., Per Week **Total Credits : 3**

Course Outcomes

1. The graduate will be able to understand the different behavior of soil.
2. The graduate will be able to understand the swelling and shrinkage characteristics of soil.
3. The graduate will be able to analyse the mechanism of clay and the phenomena of flow.
4. The graduate will be aware of modern instrumentation methods and also thermal, electro-magnetic identification techniques of soil

Syllabus

Overview of Basic Geotechnical Engineering

Broad perspective of geotechnical engineering, rational solution to problems associated with soil, & rock soil as engineering material, Soil formation & its geomorphology. Soil properties, granulomettry, consistency, relative density, permeability, shear strength, compressibility. IS soil classification, suitability of various soil groups, field identification.

Physico-Chemical properties of clay

Formation, lattice structures and classification of clay minerals, causes of electro-chemical activity of clays, specific surface, dipole water molecule, adsorption of ions and dipoles, isomorphic substitution, Inter-particle forces in clay-water-electrolyte system, clay structure, force distance, law, force fields between clay particles and exchangeable ions, adsorption complex, base exchange, physico - chemical mechanisms controlling strength, compressibility, permeability, plasticity and shrinkage behavior of clays; sensitivity and thixotropy; capillary phenomenon and hygroscopic moisture. Identification of clay minerals, X-ray diffraction, electron microscope and differential thermal analysis.

Expansive Soils

Mechanism of swelling, moisture migration, soil suction characterization of swelling soil by free swell indices, swelling potential & free swell ratio, field & laboratory identification of swelling soil, swelling pressure, factors affecting volume change and swelling pressure, vertical soil movement & estimation of ground heave, concept and application of unit swell potential, feature and preparation of black cotton soil, properties and uses of bentonite slurry. Nature of damages to different structures causes of damages, conversional design approaches to construction in black cotton soil (excluding under reamed piles), stabilization of black cotton soil with cement, lime, fly ash and chemical admixtures. Concepts and principle of CNS technique, application, specification of CNS material, thickness of CNS Layer

Text Books

1. Foundation on Expansive Soil: Chen F.H. , Elsevier Publication co. (1975).
2. Principles of Soil Mechanics: Scott R. F., Addison-Wesley Publication co. (1963).
3. Basic and Applied soil Mechanics: Gopal Ranjan & A.S. Rao, New Edge International Ltd., (2004)

Reference Books

1. Geotechnical Engineering–Principles & Practices: Coduto, D. P. Peavson Edn. Asia (2002).
2. Soil Mechanics: Jumikis, A.R., D. Van Nostr and co., (1965).
3. Soil Mechanics in Theory and Practices: Alam Singh, Asia publisher and distributor, 1975.

Syllabus of Semester II
M. Tech. (Geotechnical Engineering) Open Elective

Course Code : CET799-3 **Course : Prestressed Concrete Structure**

L: 3 Hrs., P: 0 Hrs., Per Week **Total Credits : 3**

Course Outcomes

1. The graduates will be able to understand codal provisions and apply them while designing prestressed concrete structures.
2. The graduates will be able to design various prestressed concrete structural components.

Syllabus

Basic concepts of prestressing, need for high strength steel & concrete, material and prestressing systems. Limit state design criteria, limit state of collapse and limit state of serviceability.

Design of section for flexure, axial tension, compression & bending, shear & torsion, bond and bearing. Design of post tensioned flexural members.

Design of prestressed concrete pipes Design of prestressed concrete slabs.

Reference Books

1. Design of Pre-stressed Concrete Structures, Lin, T.Y. and Burns, N.H, John Wiley & Sons, New York.
2. Design of Pre-stressed Concrete Structures, 4th ed.: Krishna Raju, Tata McGraw-Hill, New Delhi.

Syllabus of Semester II
M. Tech. (Geotechnical Engineering) Open Elective

Course Code : CET799-4 **Course : Watershed Management**

L: 3 Hrs., P: 0 Hrs., Per Week **Total Credits : 3**

Course Outcomes

At the end of the course students will be able to;

1. The graduates will be able to identify problems associated with water management
2. The graduates will be able to suggest suitable techniques for watershed management

Syllabus

Watershed types, Rainfall-Runoff relationship, Necessity of soil and water conservation, Soil-Water-Plant relationship, Land use capability classification, soil erosion definition, processes and forms, factors influencing soil erosion, Erosion hazard assessment, effects on water yield, soil and water conservation practices in catchments. Soil and water conservation practice in commands, Agro-forestry, Soil conservation on private land, Watershed development: ridge-to-valley concept, Water harvesting techniques for life saving irrigations, Land Treatment, Drainage line treatment, Role of geology, Design of structures, Estimation of water harvested, impact on environment, Hydrology of micro– watershed, Case studies

Reference Books

1. Soil and Water Conservation Engineering by Glen O. Schawb et al Wiley Publications.
2. Soil and Water Conservation by F. R. Troeh et al Prantice Hall Int. Publication.
3. Soil Conservation by N. Hudson, Batsford Academic Publications.
4. Soil Erosion and Conservation by Morgan, R. P. C. Longman scientific Publication.
5. Watershed Hydrology by V. S. R. Murthy.
6. ICRISAT Manual on Watershed.

Syllabus of Semester II
M. Tech. (Geotechnical Engineering) Open Elective

Course Code : CET799-5 **Course : Introduction to Numerical Modelling**

L: 3 Hrs., P: 0 Hrs., Per Week **Total Credits : 3**

Course Outcomes

1. Student will be able to perform tasks such as integration, solution of linear algebraic equations, Eigen system, regression analysis, etc.
2. Student will be able to apply numerical methods to obtain approximate solutions
3. Student will be exposed to advanced numerical methods like Finite Element Method and Numerical Optimization.

Contents

Numerical integration

Solution of Linear Algebraic Equations: Direct Methods and Iterative methods Eigen values and Eigen vectors

Regression Analysis, Simple and multiple regression analysis

Introduction to Finite Element Method, General Steps of Finite Element Method, One Dimensional Finite Element Analysis

Introduction to Numerical Optimization

Reference Books

1. Numerical Optimization - Theoretical and Practical Aspects, J. Charles Gilbert and Claudia A. Sagastizabal, Springer, 2000
2. Introduction to Finite Element Method, P. N. Godbole, IK International Publising House Pvt. Ltd. 2013.
3. Introduction to Numerical Analysis, J. Store and R. Bulirsch, Springer, 1991.
4. Elementary Numerical Analysis – An Algorithmic Approach, S. D. Conte and Carl de Boor, McGraw Hill, 1980.
5. Numerical methods - Principles, Analyses and Algorithms: Srimanth Pal, Oxford University Press, New Delhi.
6. Numerical Methods: Salvadori M., PHI learning Pvt, ltd., New Delhi, (1987).
7. Introductory Methods of Numerical Analysis, S. S. Sastry, Prentice Hall of India 2012.

Syllabus of Semester II
M. Tech. (Geotechnical Engineering) Open Elective

Course Code : CET799-6 **Course : Rock Excavation Engineering**

L: 3 Hrs., P: 0 Hrs., Per Week **Total Credits : 3**

Course Outcomes

At the end of this course students will be able to

1. Understand mechanisam of drilling and can apply knowledge to select drilling machine.
2. Select explosive for a given geomine condition and will be able to design a blast
3. Do instrumentation for blast performance analysis and modification

Drilling : Blasthole drills - types, classification, applicability and limitations; Mechanics of drilling, performance parameters, Selection of drilling systems, drilling errors, organization of drilling.

Explosives : Chemistry and physics of explosives; Properties of explosives; Explosives and blasting agents; Initiation and priming systems; Bulk explosives; Explosives selection.

Selection of Initiating system : Electric, Non electric initiating system, digital detonators, selection of initiating system. Safety in usages and handling of explosives & initiating systems.

Priming and Charging : Selection of primer and its effect on the blast performance. Influence of shape, size and quantity of primer on explosive performance.

Rock breakage by explosives : Theories, methods for prediction and assessment of fragmentation.

Blast Design : Design of blasting round for small and large diameter blast holes, cast blasting.

Special blasting techniques : Advanced theory and application of explosives in excavation. Secondary breakage, pre-splitting, blasting in mixed rock types.

Environmental Considerations : Control of noise, vibration, air blast and fly rock. Blast Instrumentation: Blast instrumentation for blast performance assessment and modification.

Syllabus of Semester III
M. Tech. (Geotechnical Engineering) (Group Elective - II)

Course Code : CET898-1 **Course : Design of Bridges**

L: 4 Hrs., P: 0 Hrs., Per Week **Total Credits : 4**

Course Outcomes

1. The graduates will be able to understand the philosophy of analysis and design of bridge
2. The graduates will be able to understand the loading conditions, codal provisions and behavior under earthquake of bridge superstructure and substructure

Syllabus

Types of bridge superstructure and introduction to their design, sub-structure, bearings, IRC / IRS Bridge loadings and other codal recommendations, Performance of Bridges in past earthquakes. Seismic design philosophy for Bridges, State of art Modeling of bridges, Seismic Design of Substructures, Capacity design of substructures and ductile detailing, Seismic design of well and pile foundations, Modeling soil flexibility. Earthquake behavior and Design of retaining wall and Abutments, IS code recommendations. Design of Bearings (Free, Guided and Restrained).

Reference Books

1. Chen, W. F. and Duan, L, "Bridge Engineering Handbook", CRC Press, 1999.
2. Fintel, M., "Handbook of Concrete Engineering" 2nd Edition, CBS Publishers Delhi, 1986.

Syllabus of Semester III
M. Tech. (Geotechnical Engineering) (Group Elective - II)

Course Code : CET898-2 **Course : Design of Environmental Structures**

L: 4 Hrs., P: 0 Hrs., Per Week **Total Credits : 4**

Course Outcomes

1. The graduates will be able to understand the basic principles used in design of environmental structures like water tanks, pump house, water treatment units, etc.
2. The graduates will be able to understand the behavior of structural components of various environmental structures under standard loading conditions and design them as per codal provisions.
3. The graduates will be able to estimate primary design loads on structural elements consulting appropriate standards and handbooks and combine primary design load cases as per design standards to find critical load combination that governs design.
4. The graduates will be able to employ design procedure as per code of practice for design calculations and prepare drawings in appropriate formats.

Syllabus

Design of Underground Water Tanks

Design of Jack Well/Pump House/Approach Bridge

Design of Pretreatment Unit i.e. Clarifloculators, Aerators, Flash Mixers, Sand Filters, etc.

References Books

1. Guidelines for seismic design of liquid storage tanks: Jain, S. K., Jaiswal, O.R., NICEE, IITK, 2004.
2. Design of liquid retaining concrete structure: Anchor, R.D., Edward Arnold, London, 1992.
3. BIS, IS 3370, "Indian Standard code of practice for concrete structures for the storage of liquids", Part I to IV.
4. Ghali, A, "Circular Storage Tanks and Silos", E & F N Spon, London, 1979.

Syllabus of Semester III
M. Tech. (Geotechnical Engineering) (Group Elective - II)

Course Code : CET898-3 **Course : Geo-Environmental Engineering**

L: 4 Hrs., P: 0 Hrs., Per Week **Total Credits : 4**

Course Outcomes

1. The graduate will be aware about Geo-Environmental techniques, landfill engineering, and contaminant transport.
2. The graduate will be able to understand the concept of design of waste containment facilities like landfill and waste containment pond.
3. The graduate will be able to understand the importance of recycled and reuse of waste material.
4. The graduate will be able to understand the problem of land erosion and to give the effective solution.

Syllabus

Surface & subsurface contamination, biological & chemical contamination sources & effect of subsurface contamination, Fate & transport of underground contamination, advection, dispersion, diffusion, sorption, vertilization, chemical reaction, biodegradation radioactive decay. Geo-environmental soils characterization & remediation methods.

Contaminants of solid waste in land fills, characteristics of solid wastes, types of land fills, site selection, shape of size of land fills, liners, covers characteristics of solid wastes, types of land fills, site selection, shape & size of land fill, liners, covers and Leachete collection, waste containment principles, Types of barrier materials, planning & design aspects related to waste disposal. Land fill in ash ponds, infilling ponds & in rocks. Stability of land fills, sustainable waste management. Monitoring surface contamination, stabilization & modification of waste. Case studies in waste handling, soil-waste interaction.

Contaminable of slurry waste; Slurry transported wastes, slurry ponds, operation embankment construction & planning, design aspects, environmental impact & control.

Vertical barriers system & cutoff walls, slurry trench cutoff, backfill design & potential defects, use of bentonite & cement in slurry. Constructional features, use of geosynsthetics in land fills, barriers & cutoff, installation of soil mixed wall barrier by deep soil mixing.

Environmental monitoring around landfills, detection, control & remediation of subsurface contamination; engineering properties & geotechnical reuse of waste materials. Demolition waste dumps, regulations.

Soil erosion and land conservation; causes of soil erosion, factors contributory to erosion, erosion control measures.

Text Book

1. Geoenvironmental Engineering- Principles and Applications: L.N. Reddy & H.F. Inyang, Marcel Dekkar (2004)
2. Geotechnical Practice for Waste Disposal: D.E. Daniel Chapman and Hall, London(1993)
3. Construction and Monitoring of Landfills: A. Bagchi, John Wiley and Pone N.Y.,(1994)

Reference Book

1. Geotechnical Engineering (Chapter 09): D.P. Coduto, Pearson Education Asia,(2002)
2. Foundation Engineering Handbook (Chapter 20): H.Y. Fang, CBS Publishers (2004)

Syllabus of Semester III
M. Tech. (Geotechnical Engineering) (Group Elective - II)

Course Code : CET898-4 | **Course : Soil-Structure Interaction**

L: 4 Hrs., P: 0 Hrs., Per Week | **Total Credits : 4**

Course Outcomes

1. The graduate will be able to understand the soil behavior and the methods to analyze the models.
2. The graduate will be able to solve the problems for beam and plate on elastic medium.
3. The graduate will be able to analyze the pile for its settlement and load distribution.

Syllabus

Critical study of conventional methods of foundation designs, nature and complexities of soil-structure interaction.

Interaction problems based on theory of sub-grade reaction and classic half space soil models, effects of parameters influencing subgrade modulus.

Application of finite difference and finite element techniques of analysis for evaluation of soil-structure interaction for beams, rafts, thin places, piles, etc, with Winkler foundation and Pasternak model, elastic half space soil support, Settlement of foundation, analysis and computation of initial settlement and consolidation settlement for layered deposit, settlement of raft on NCC, sand, Bowle's finite grid method.

Laterally loaded pile analysis, general equation of flexure, close form solutions, finite difference analysis of piles under lateral loads. Glessers recursive technique, procedure for accounting non-linear soil response. Finite element analysis of laterally loaded piles, effect of axial loading on piles response. Axially loaded piles analysis using stream transfer curve.

Pile head response under general loading, analysis of 2D piles group connected by rigid cap, introduction to elasto-plastic analysis.

Text Book

1. Foundation Engineering Handbook: H. Y. Fang, CBS Publishers (2004)
2. Numerical Methods in Geotechnical Engineering: C. S. Desai, McGraw Hill (1977)

Reference Book

1. Foundation Analysis and Design: J. E. Bowles, McGraw Hill (1996)

Syllabus of Semester III
M. Tech. (Geotechnical Engineering) (Group Elective - II)

Course Code : CET898-5 **Course : Advance Foundation Engineering**

L: 4 Hrs., P: 0 Hrs., Per Week **Total Credits : 4**

Course Outcomes

At the completion of this course,

1. The student shall acquire knowledge and ability - to select and design appropriate foundations based on various criteria;
2. To check the stability of various components of foundations.
3. Student will have an ability to predict and calculate settlement of foundation.

Shallow Foundations : Shallow foundations, methods of estimating bearing capacity of footings and rafts, foundations under eccentric loading. Foundations under inclined loading, foundations on slope, foundations with tilted base. Bearing capacity of foundations on layered soil.

Methods of estimating settlement of footings and rafts, concept of Beams on Elastic Foundation. Proportioning of foundations using field test data, IS codes.

Pile Foundations : Pile foundations, pile load tests, methods of estimating load transfer of piles, analytical estimation of load-settlement behavior of piles. Pile group capacity and settlement, negative skin friction of piles. Laterally loaded piles. Uplift capacity of piles, foundations/anchors under uplift loads.

Well Foundation : Well foundation, bearing capacity of well foundations, lateral stability of well foundations. IS and IRC codal provisions, elastic theory and ultimate resistance methods for well foundations.

Foundations on problematic soils:

Foundations for collapsible and expansive soil.

Text books

1. Principles of Foundation Engineering: Das B.M., PWS publishing co., (1999)
2. Foundation Analysis & Design: Bowles J.E., McGraw Hill, (1996)
3. Shallow Foundation: Das B.M., CRC Press, (2009)
4. V.N.S. Murthy, Advanced Foundation Engineering, CBS Publishers & Distributors,

Reference books

1. Principles of Foundation Engineering: Das B.M., PWS publication co., (1999)
2. Foundation Analysis & Design: Bowles, J.E., McGraw Hill (1996)
3. Theory & practice of Foundation Design: Som N.N. & Das S.C., Prentice Hall Edn, Asia (2002)

Syllabus of Semester III
M. Tech. (Geotechnical Engineering)

Course Code : CET881 | **Course : Ground Improvement**

L: 4 Hrs., P: 0 Hrs., Per Week | **Total Credits : 4**

Course Outcomes

1. To enable students to identify problematic soils and their associated issues.
2. Students will study the various ground improvement techniques.
3. Also, to propose suitable remedial techniques and design.

Syllabus

Introduction to ground improvement techniques : Concepts of and essential requirements of ground improvement, classification of ground improvement techniques, economic considerations and suitability.

Compaction and Consolidation : Theory of compaction, equipment's and control of field compaction, surface compaction and deep compaction, vibro floatation. Preloading by static loads and by vacuum, accelerated consolidation by sand drains, drainage wicks, fabric drains, and rope drains. Theory of radial consolidation by sand drains, free strain and equal strain cases, design of sand drain layout.

Stabilization : Methods of stabilization, mechanical stabilization, organic and inorganic stabilizing agents and their characteristics-lime, cement, flyash, bitumen and chemicals, stabilization by electro-osmosis.

Grouting : Materials and methods of grouting, grout volume and grouting pressure, grout requirements and tests.

Reinforced earth and Geotextiles : Basic theory of reinforced earth, materials, method, application and design of reinforced earth, characteristics of reinforced earth masses; geotextiles, geogrids and geosynthetics, their basic features, functions and applications.

Stone columns : Application, layout feature, procedures of installation, vibrofloat, rammed & vibrofloated column, quality control in construction; Analysis for stone column treated ground, unit cell concept, load transfer mechanism, load capacity and settlement analysis, Design for stone column layout for intended requirements, methods of improving the effectiveness of stone column, skirted and cemented stone column technique, geotextiles encased stone column.

Drainage and Dewatering : Methods, layout and design consideration of well point system; introduction to soil nailing and ground anchors.

Text Books

1. Ground Improvement Techniques: P. P. Raj, Prentice Hall of India (2005).
2. Engineering Principles of Ground Modification: M. R. Housmann, McGraw Hill (1990).

Reference Books

1. Constructional and Geotechnical Methods in Foundation Engineering: R. M. Koener, McGraw Hill (1945).
2. Design and Construction of Stone Column: FHWA Report no. RD 43/026, (1943).

Syllabus of Semester III
M. Tech. (Geotechnical Engineering)

Course Code : CEP881 **Course : Ground Improvement Lab**

L: 4 Hrs., P: 0 Hrs., Per Week **Total Credits : 4**

Course Outcomes

1. Student will have an ability to suggest suitable ground improvement techniques.
2. Student will have an ability to design and layout of propose techniques.

The term work shall consist of analysis and design for any THREE of the following design assignments to be carried out by each student individually (with different data).

1. Design of sand layout in soft compressible clay deposit for required (accelerated) rate of consolidation.
2. Design of a reinforced earth retaining wall.
3. Design of stone column layout (using conventional incremented fill material or cemented granular fill material) for intended degree of improvement in safe load carrying capacity of soft soil ground.
4. Analysis and design of skirted stone columns.

The work shall be submitted in the form of a journal and shall be assessed by concerned teacher/s through viva-voice examination.

Syllabus of Semester III
M. Tech. (Geotechnical Engineering)

Course Code : CET882 **Course : Earth and Rock fill Dams and Design of Slopes**

L: 4 Hrs., P: 0 Hrs., Per Week **Total Credits : 4**

Course Outcomes

1. The graduate will be able select a suitable site, materials and equipment for construction of earth/rockfill dams
2. The graduate will be able to Analyze seepage through a given earth/rockfill dam section and select effective seepage control measures for the prevailing site conditions.
3. The graduate will be able to Design earth and rock fill dams.

Syllabus

Introduction: Classification of dams- Selection of Site-Basic design requirements-Preliminary section.

Seepage through Dam section and its control : Tundamentals of seepage flow, flow nets, seepage through dam section and foundation, seepage control filters, Impervious core, drainage.

Control of Seepage Through Foundations : Types of foundations trench cutoff, upstream impervious blanket, horizontal drainage blanket, relief wells, drainage trenches, cut-off walls, downstream loading berm.

Foundation treatment : Treatment of pervious, impervious and rock foundations, core contact treatment, grouting, foundation excavation.

Stability analysis : Critical slip surfaces, test conditions, strength parameters, pore pressures, stability analysis-method of slices, bishops method, Morgenster- price method, jambu method.

Construction of earth dams : Construction equipment, procedures for pervious, semi-pervious, impervious and rock fill sections, construction supervision.

Failures and damages of earth dams : Nature of failures - piping, settlement cracks, slides, earthquake & miscellaneous damages - case studies.

Rock fill dams : General characteristics, rock fill materials, foundation, construction, deformations, types of dams.

Design of rock fill dams : Design of dam section, concrete face and earth core, Nature of failures and damages, case studies.

Reference Books

1. Earth And Rock Dams: Sherard, John Wiley Inc..1963.
2. Embankment Dams: H. D. Sharma, Oxford and IBH Publishing Co..1991.
3. Engineering for Embankment Dams: Bharath Singh and R. S. Varshney, A. A. Balekema Publications, 1995.

Syllabus of Semester III
M. Tech. (Geotechnical Engineering)

Course Code : CET883 **Course : Tunnel Engineering**

L: 4 Hrs., P: 0 Hrs., Per Week **Total Credits : 4**

Course Objectives

1. The students will learn theoretical aspects of tunnel excavation methods.
2. The subject will help in understanding the applicability of excavation techniques with respect to ground conditions.

Introduction to Tunnelling (2 Lectures)

Scope and application, art of tunnelling, future tunneling considerations, Geo-engineering Investigations (8 Lectures): Topographical and geological survey, augering, drilling, soil and rock sampling and testing, preparing sub-surface geological cross section, georadar use and data analysis for shallow tunnels, geophysical investigations to prove deeper sub-surface features, Physico-mechanical properties and collection of rock mechanical data, stability analysis and identification of

Failure Excavation by Drilling and Blasting(10 Lectures)

Unit operations in conventional tunnelling; Drilling -drilling principles, drilling equipment, Blasting - explosives, initiators, blasting mechanics, blast holes nomenclature; types of cuts- fan, wedge and others; blast design, tunnel blast performance - powder factor, parameters influencing, models for prediction; mucking and transportation equipment selection.

Support design (8 lectures)

Rock mass characterization, support design using empirical relations, types of supports, shot creating, bolt and cable bolting.

Mechanized excavation Techniques (10 Lectures)

Introduction and advantages of shield tunnelling; classification; different types of shield tunneling techniques, Tunnelling with Roadheaders : Machines,types, capacities, design and operating features, Tunnelling with Tunnel Boring Machines: Machines, types, capacities, design and operating features.

Case studies of planning and design (4 lectures)

Metro, highway tunnel, hydro tunnels.

Text Book

1. Design and construction of tunnels by Pietro Lunardi, Springer-Verlag Berlin Heidelberg 2008.

References Book

1. Planning design and construction of tunnels - Whittaker and Frith Drilling and blasting of rocks - Jimeno, Carcedo, Jimeno.

Syllabus of Semester III / IV
M. Tech. (Geotechnical Engineering) (Program Elective - I)

Course Code : CET884-1 **Course : Special Geotechnical Constructions**

L: 4 Hrs., P: 0 Hrs., Per Week **Total Credits : 4**

Course Outcomes

1. The graduate will be aware of the latest trends, modern standards and state-of-the-art techniques for solving geotechnical engineering problems.
2. The graduate will be able to develop design a geosynthetic system to meet desired needs such as economic, environmental and sustainability related.
3. The graduate will be able to identify, formulates and solve soil stability related problems.

Syllabus

The special geotechnical constructions and process to be studied are:

Dewatering, Braced Excavation, Diaphragm walls, Ground (soil and rock) anchors, Soil nailing, Screw piles, Secant pile walls, Gabbion walls, Deep soil mixing walls, Geofoam and Geocells.

The state of the art, studying with respect to the following aspects is expected:

1. Types, uses and applications
2. Construction techniques / methods
3. Equipments, machineries required
4. General design considerations
5. Analysis and quantitative design solution
6. Important case studies (in India and Abroad)

Text Book

1. Construction of Diaphragm wall : I. Hajal, J. Morton and Z. Regals, series in Engineering Publications.
2. Foundation Engineering Handbook: Chapter no. 26, H.Y. Fang, CBS Publishers (2004).
3. Theory & practice of foundation Design: Som N.N. & Das S.C., Prentice Hall Edn, Asia (2002).

Reference Books

1. FHWA Reports and Publications.
2. Relevant IS codes and papers from various refereed journals and proceedings.

Syllabus of Semester III / IV
M. Tech. (Geotechnical Engineering) (Program Elective - I)

Course Code : CET884-2 **Course : Geotechnical Earthquake Engineering**

L: 4 Hrs., P: 0 Hrs., Per Week **Total Credits : 4**

Course Outcomes

1. The graduate will be able understand earthquake magnitude, ground motion.
2. The graduate will be able to estimate the damage potential to the structure
3. The graduate will be able to understand the effects of earthquake on soil-foundation systems

Syllabus

General introduction to earthquakes, magnitude and intensity of earthquake, elastic waves propagating in soil from source of disturbance, salient features and velocities of P, S and R-waves. Various effects of earthquake on soil-foundation-structure system. Ground motion during earthquake, accelerograms, influence of site profile and soil condition on shaking intensity & associated structural damages, Site response spectrum, induced seismic forces and damage potential of structures.

Text books

4. Geotechnical Earthquake Engineering: S. L. Kramer, Prentice Hall of India (1996)
5. Vibration of soil and foundation: Richarts, Hall and Woods, Prentice Hall of India (1970)
6. Advanced Foundation Engineering (Chapter 15): VNS Murthy, CBS Publisher (2007)

Reference Books

1. Geotechnical Engineering: D. P. Coduto, Pearson Education Asia, (2002)
2. Soil Dynamics: Shamsher Prakash
3. Theory and Practice of Foundation Design: N. N. Som and S. C. Das, Prentice Hall of India (2003)

Syllabus of Semester III / IV
M. Tech. (Geotechnical Engineering) (Program Elective - I)

Course Code : CET884-3 **Course : Design of Underground Structures**

L: 4 Hrs., P: 0 Hrs., Per Week **Total Credits : 4**

Introduction to different types of underground structures (4 Lectures)

Need for Underground Space,Engineering and Strategic Utilities.

Geo-engineering Investigations (8 Lectures)

Topographical and geological survey, augering, drilling, soil and rock sampling and testing, preparing sub-surface geological cross section, georadar use and data analysis for shallow tunnels, geophysical investigations to prove deeper sub-surface features, Physico- mechanical properties and collection of rock mechanical data, stability analysis and identification of failure.

Excavation by Drilling and Blasting(9 Lectures)

Different types of cuts, controlled blasting techniques, powder factor.

Mechanized excavation Techniques (9 Lectures)

Introduction and advantages of shield tunnelling; Roadheaders and by Tunnel Boring Machines:

Excavation of large and deep and Caverns(5 Lectures)

Introduction; purpose and use; excavation issues; excavation methods- unit operations, different equipment, types of rock pressure and methods to deal, roof and wall supports

Case studies of planning and design (5 Lectures)

Under ground Metro stations , storage of oil & gas, food, Water/sewage treatment plants.

Text Book

1. Underground Infrastructures, Planning, Design and construction by Goel, R. K., et. al. Elsevier, 2012.

References Books

1. Underground Spaces Unveiled, By Admiraal, H. et al., ICE, 2018.
2. Tunnelling : Design, Stability and Construction Books, by Barry N. Whittaker, Russell C. Frith, IMM publication, 1990.
3. Underground excavation of rocks - Hoek and Brown.

Syllabus of Semester III / IV
M. Tech. (Geotechnical Engineering) (Program Elective - II)

Course Code : CET885-1 **Course : Pavement Analysis and Design**

L: 4 Hrs., P: 0 Hrs., Per Week **Total Credits : 4**

Course Outcomes

1. Students will able to evaluate stresses and strains for various loading and environmental conditions for flexible and rigid pavements.
2. Students will able to design flexible and rigid pavements.
3. Students will able to analyze and evaluate pavement distresses and select best suited rehabilitation techniques.
4. Students will able to design reinforced flexible pavement.

Syllabus

Theories of pavement design, Factors affecting pavement design; Methods of flexible pavement design- applications of CBR, Burmister, Asphalt Institute, AASHTO and IRC methods. ; Load and temperature stresses in rigid pavements- Westergaard's, Bradburry's and Picket's concepts ; Design of rigid pavements by PCA, AASHTO and IRC methods ; Design of joints in rigid pavements ; Evaluation of pavement distress ; Design aspects of flexible and rigid overlays. Rehabilitations Techniques – Reflective Cracking, Reinforced Overlays, Ultra-Thin White Topping

Reference Books

1. Yoder and Witzack, Principles of Pavement Design, John Willey and Sons, October 1975.
2. Yang H. Huang, Pavement Analysis and Design, PH,2nd Edition, 2004.
3. RILIM Conference Proceedings.

Syllabus of Semester III / IV
M. Tech. (Geotechnical Engineering) (Program Elective - II)

Course Code : CET885-2 **Course : Advance Methods of Working**

L: 4 Hrs., P: 0 Hrs., Per Week **Total Credits : 4**

Course Outcomes

On successful compleation of course, students will be able to;

1. Undstantand engineering properties of rock, classification of rocks.
2. Laboratory testing of rocks, failure criteria, tunncling in rocks.
3. Various techniques to improve the in strength of racks.

Syllabus

A. Opencast Mining

1. Study of various element of Highwell mining, equipment details and method of working.
2. Study of various element of surface miner, equipment details and method of working.
3. Mine slopes, different type of mine slope failures, design and stabilization methods.
4. Use of OIDS and other mechanization techniques.

B. Underground Mining

1. Study of various elements of continuous miner and longwall and method of mining.
2. Underground gasification of coal.
3. Decline method in metal mining.
4. Instrumentation for stability analysis.

Syllabus of Semester III / IV
M. Tech. (Geotechnical Engineering)

Course Code : CET886 **Course : Project Phase - I**

L: 4 Hrs., P: 0 Hrs., Per Week **Total Credits : 4**

Course Outcomes

1. To train the students to address to a group of people and to present technical topics in a well organized manner to the audience.
2. It is also intended for improvement of communication skills of students, to make them confident in expressing their views with clarity and to make them capable of taking part in debates/ discussion.
3. This will help create self esteem and confidence that are essential for engineers.

Seminar and seminar report based on topic for research for project.

Syllabus of Semester V
M. Tech. (Geotechnical Engineering)

Course Code : CET981 **Course : Project Phase - II**

L: 24 Hrs., P: 0 Hrs., Per Week **Total Credits : 12**