DETAIL

COURSE CURRICULUM

FOR

POSTGRADUATE PROGRAMME

M.TECH

IN

CIVIL ENGINEERING

Specialization in

GEOTECHNICAL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY AGARTALA

TRIPURA (WEST), INDIA

PIN: 799046

PREFACE

Civil Engineering Department of NIT Agartala, awards the degree of Master of Technology (M. Tech) in seven different specializations viz, Environmental Engineering, Geotechnical Engineering, Hydro-Informatics Engineering, Structural Engineering, Seismic Science and Engineering, Transportation Engineering and Water Resources Engineering.

The course structures of all post graduate degree programmes are carrying a total of 80 credits and 2000 marks. Semester wise distribution of course and credits are as follows: First semester: 25 credits and 800 marks for five theory subjects (comprises basic core, core and elective subjects), two laboratory subjects and seminar; Second semester: 25 credits and 800 marks for four theory subject (comprises basic core, core and elective subjects), two laboratory subjects, comprehensive viva-voce and project preliminaries; Third semester: 10 credits and 100 marks; and Fourth semester: 20 credits and 300 marks. Third and fourth semester of PG courses will be fully devoted to project works. Minimum requirement of number of class hours for each theory course is 40 hours per semester.

There will be continuous assessment of the performance of students throughout the semester. Each theory subject in a semester is evaluated for 100 marks, with the following weightages. Sub-component weightage:Continuous evaluation: 30 Marks (Attendance: 5 Marks, Quiz: 5 Marks, Class test: 10 Marks, Assignment: 10 Marks); Mid-semester Examination: 20 Marks; and End-semester Examination: 50 Marks

The course curriculum of M Tech Geotechnical Engineering programme is designed considering the following six Programme Outcomes (POs).

PO1: An ability to independently carry out research /investigation and development work to solve practical problems.

PO2: An ability to write and present a substantial technical report/document.

PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

PO4: An ability to identify, formulate and solve Geotechnical Engineering related problems using advanced level computing techniques

PO5: An ability to understand the impact of Geotechnical Engineering solutions in a global, economic, environmental and societal context

PO6: Ability to demonstrate the knowledge of Geotechnical Engineering and management principles and apply these to multidisciplinary environments.

The course curriculum of M Tech Geotechnical Engineering programme is also designed considering two Program Specific Outcome (PSOs).

PSO1: Analysis, design, investigation of complex problems in ways which are sustainable and environmental friendly.
PSO2: Handling of any Civil Engineering projects ethically either as an individual or as a team.

Expert opinions are being taken in regular basis in order to improve the quality of teaching learning process and to attain the programme outcomes efficiently.
In the Final year of M.Tech programmes (Third and Fourth Semesters) students may also opt for industrial research. If any student desire to pursue his/her research in reputed industries, he/she may be allowed to do so, provided:

a. The selected industry is a permanent member of NASSCOM, FICCI and other such industry bodies.
b. The selected industry needs is approved by the DPPC of the concerned Department.
c. The student selects one supervisor from industry and another supervisor from the Institute.
d. If any student opts for such industrial research he/she will not receive any scholarship from the institute in this tenure, even if he/she wants to return back. In such cases the student will be allowed to complete his/her project in the institute but without any scholarship.

Syllabus: M.Tech. (Geotechnical Engineering)

Sl. No.	Subject	Page Nos.
	First Semester	
1	**Basic Core** **PCE21B01**: Advanced Mathematics	GE-4 to GE-6
2	**Core Subject-I** **PCE21C01**: Mechanics of Soil	GE-7 to GE-9
3	**Core Subject-II** **PCE21C02**: Soil Dynamics and Machine Foundations	GE-10 to GE-12
4	**Elective Paper-I (Any one)** **PCE21E01**: Ground Improvement Technique **PCE21E02**: Numerical methods and computer programming in Engineering **PCE22E03**: Elastic Analysis in Geotechnical Engineering	GE-13 to GE-19
5	**Elective Paper-II (Any one)** **PCE21E04:** Reinforced Soil Structures **PCE21E05:** Rock Mechanics and Tunnelling **PCE21E06**: Soil Investigation and Exploration	GE-20 to GE-27
6	**PCE21P01**: Soil Mechanics Laboratory	GE-28 to GE-30
7	**PCE21P02**: Foundation Engineering Laboratory	GE-31 to GE-32
8	**PCE11P03**: Seminar	GE-33
	Second Semester	
1	**Basic Core** **PCE22B01**: Finite Element Method	GE-35 to GE-37
2	**Core Subject-I** **PCE22C01**: Advanced Foundation Design	GE-38 to GE-39
3	**Core Subject-II** **PCE22C02**: Soil Structure Interaction	GE-40 to GE-42
4	**Elective Paper-III (Any one)** **PCE22E01**: Environmental Geotechnique **PCE22E02**: Earthquake Geotechnical Engineering **PCE22E03**: Computer Aided Design	GE-43 to GE-50
5	**PCE22P02**: Foundation Design and Drawing	GE-51 to GE-52
6	**PCE22P03**: Computer Aided Geotechnical Design Laboratory	GE-53 to GE-54
7	**PCE22P01**: Project Preliminary	GE-55
8	**PCE22P04**: Comprehensive Viva-voce	GE-55
	Third Semester	
1	**PCE23P01**: Project & Thesis - I	GE-56
	Fourth Semester	
1	**PCE23P04**: Project & Thesis - II	GE-56

01/09/201

Sl. No.	Subject	Credit	Class Hours per Week	Marks
	First Semester			
1	**Basic Core** **PCE21B01**: Advanced Mathematics	4	4	100
2	**Core Subject-I** **PCE21C01**: Mechanics of Soil	4	4	100
3	**Core Subject-II** **PCE21C02**: Soil Dynamics and Machine Foundations	4	4	100
4	**Elective Paper-I (Any one)** **PCE21E01**: Ground Improvement Technique **PCE21E02**: Numerical methods and computer programming in Engineering **PCE22E03**: Elastic Analysis in Geotechnical Engineering	4	4	100
5	**Elective Paper-II (Any one)** **PCE21E04:** Reinforced Soil Structures **PCE21E05:** Rock Mechanics and Tunnelling **PCE21E06**: Soil Investigation and Exploration	4	4	100
6	**PCE21P01**: Soil Mechanics Laboratory	2	3	100
7	**PCE21P02**: Foundation Engineering Laboratory	2	3	100
8	**PCE11P03**: Seminar	1	2	100
	Total	**25**	**28**	**800**
	Second Semester			
1	**Basic Core** **PCE22B01**: Finite Element Method	4	4	100
2	**Core Subject-I** **PCE22C01**: Advanced Foundation Design	4	4	100
3	**Core Subject-II** **PCE22C02**: Soil Structure Interaction	4	4	100
4	**Elective Paper-III (Any one)** **PCE22E01**: Environmental Geotechnique **PCE22E02**: Earthquake Geotechnical Engineering **PCE22E03**: Computer Aided Design	4	4	100
5	**PCE22P02**: Foundation Design and Drawing	2	3	100
6	**PCE22P03**: Computer Aided Geotechnical Design Laboratory	2	3	100
7	**PCE22P01**: Project Preliminary	3	6	100
8	**PCE22P04**: Comprehensive Viva-voce	1	0	100
	Total	**25**	**28**	**800**
	Third Semester			
1	**PCE23P01**: Project & Thesis - I	**10**	**-----**	**100**
	Fourth Semester			
2	**PCE23P04**: Project & Thesis - II	**20**	**-----**	**300**
	 **01/09/2021**		**Total Marks**	**2000**

First Semester

Sl. No.	Subject	Credit	Class Hours per Week	Marks
1	**Basic Core** **PCE21B01**: Advanced Mathematics	4	4	100
2	**Core Subject-I** **PCE21C01**: Mechanics of Soil	4	4	100
3	**Core Subject-II** **PCE21C02**: Soil Dynamics and Machine Foundations	4	4	100
4	**Elective Paper-I (Any one)** **PCE21E01**: Ground Improvement Technique **PCE21E02**: Numerical methods and computer programming in Engineering **PCE22E03**: Elastic Analysis in Geotechnical Engineering	4	4	100
5	**Elective Paper-II (Any one)** **PCE21E01:** Reinforced Soil Structures **PCE21E02:** Rock Mechanics and Tunnelling **PCE21E03**: Soil Investigation and Exploration	4	4	100
6	**PCE21P01**: Soil Mechanics Laboratory	2	3	100
7	**PCE21P02**: Foundation Engineering Laboratory	2	3	100
8	**PCE11P03**: Seminar	1	2	100
	Total	**25**	**28**	**800**

01/09/21

Basic Core

ADVANCED MATHEMATICS
(PCE21B01)

Total Credit: 04 **Contact Periods: 04 (4L+0T+0P)**

Course Objective

1. Introduce students to ordinary differential equations and the methods for solving these equations Use differential equations as models for real world phenomena

2. Integrate the knowledge accumulated in the calculus sequence to solve applied problems

3. Introduce the fundamentals of Linear Algebra and Complex Analysis

4. Provide a rigorous introduction to upper level mathematics which is necessary for students of engineering, physical sciences and mathematics.

Course Content

Unit-1
Calculus of Variations – Variation and its properties – Euler's equation – Conditional extreme – Isoperimetric problems – Functional dependant on first and higher order derivatives – Functional dependent on functions of several independent variables – some applications – Direct methods – Ritz and Kantorovich methods, Euler's finite difference method.

Unit-2
Laplace Transforms and Fourier Transforms. Application of Fourier Transform in solving initial and boundary value problems. Laplace Equation, Heat equation and wave equation.

Unit-3
Hankel's Transform, elementing properties of Hankel transforms, Hankel inversion and transform theorems. Hankel transforms of derivatives of functions. Parsevel's theorem. Hankel transforms of $\frac{d^2f}{d\,x^2} + \frac{1}{x}\frac{df}{dx} = \frac{n^2}{x^2}f$.

Unit-4
Simulation – Types, case studies in various fields using simulation techniques, simulation softwares used, use of mathematical models based on probabilistic and statistical methods.
Partial Differential Equations – Formation of PDE, Solutions of PDE, Equations solvable by direct integration, Linear equations of the first order, Non-linear equations of the first order, Charpit's

Method, Homogeneous Linear equations with constant coefficient, Non-Homogeneous Linear equations, Non-Linear equations of the second order.

Unit-5

Solution of Parabolic and Hyperbolic equations – Implicit and Explicit Schemes, ADI methods, Non Linear parabolic equations – Iteration method, Solution of elliplic equation – Jacobi method, Gauss - Seidel & SOR method. Richardson method, RKF4.

Unit-6

Introduction to finite element method and its scope.

References:

1. Kreyszig Erwin, Advanced Engineering Mathematics, John Wiley & Sons (Asia) Pvt Ltd.

2. Krishnamurthy &Sen, Numerical Algorithms, Afiliated East-west press private Limited, New Delhi.

3. Ramana, B. V., Higher Engineering Mathematics, The McGraw-Hill Companies, New-Delhi.

Course Outcome

1. To utilize various methods for solving ODEs and solve initial value problems, understand the existence and uniqueness of such solutions and to Recognize ODEs of varying order and use these to solve problems involving population dynamics, oscillation of a spring and resistance in a circuit

2. Ability to Work with and solve homogeneous and non-homogeneous ODEs and systems of ODEs. Moreover, to learn additional methods for solving ODEs including Euler's method, the power series method and Laplace transforms.

3. Perform basic operations with matrices, find the inverse of a matrix, determinant of a square matrix, as well as Eigen values and Eigen vectors and investigate associated applications, and to use matrices to solve systems of equations.

4. Express complex numbers in trigonometric and polar form, and to perform operations with complex numbers, including finding the roots of unity.

5. Explore functions of a single complex variable and calculate derivatives of analytic functions

6. Calculate line integrals in the complex plane, and Study Cauchy-Riemann equations, Cauchy's integral theorem and Cauchy's integral formula.

To establish the co-relation between COs &POs

Table-1: Numbering of Course Outcome

No. of Course Outcome (CO)	Course Outcome
PCE21B01.1	To utilize various methods for solving ODEs and solve initial value problems, understand the existence and uniqueness of such solutions and to Recognize ODEs of varying order and use these to solve problems involving population dynamics, oscillation of a spring and resistance in a circuit
PCE21B01.2	Ability to Work with and solve homogeneous and non-homogeneous ODEs and systems of ODEs. Moreover, to learn additional methods for solving ODEs including Euler's method, the power series method and Laplace transforms
PCE21B01.3	Perform basic operations with matrices, find the inverse of a matrix, determinant of a square matrix, as well as eigen values and eigen vectors and investigate associated applications, and to use matrices to solve systems of equations
PCE21B01.4	Express complex numbers in trigonometric and polar form, and to perform operations with complex numbers, including finding the roots of unity
PCE21B01.5	Explore functions of a single complex variable and calculate derivatives of analytic functions
PCE21B01.6	Calculate line integrals in the complex plane, and Study Cauchy-Riemann equations, Cauchy's integral theorem and Cauchy's integral formula

Table-2: Co-relation between COs &POs

1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE21B01.1	2	2	3	2	2	2
PCE21B01.2	2	2	3	2	2	2
PCE21B01.3	2	2	3	2	2	2
PCE21B01.4	2	2	3	2	2	2
PCE21B01.5	2	2	3	2	2	2
PCE21B01.6	2	2	3	2	2	2
Total	12	12	18	12	12	12
Average	2	2	3	2	2	2
Equivalent Avg. Attainment	2	2	3	2	2	2

To establish the correlation between COs & PSOs

Table-3

CO	PSO1	PSO2
PCE21B01.1	3	3
PCE21B01.2	3	3
PCE21B01.3	3	3
PCE21B01.4	3	3
PCE21B01.5	3	3
PCE21B01.6	3	3
Total	**18**	**18**
Average	**3**	**3**
Equivalent Avg. Attainment	**3**	**3**

Core Subject-I

MECHANICS OF SOIL (PCE21C01)

Total Credit: 04 **Contact Periods: 04 (3L+1T+0P)**

Courses Objective:

1. To understand clay mineralogy of soil.
2. To know the basic fundamental of soil mechanics.
3. To understand the capillary phenomenon/permeability and flow behaviour of soil.
4. To know the field application based on compaction for geotechnical problems
5. To understand the application of consolidation to geotechnical problem
6. To understand the compressibility behaviour of saturated/unsaturated soil.

Course Content:

Unit-1
Introduction, formation of soil, clay mineralogy, structures of common clay minerals.

Unit-2
Identification and classification of soil, soil weight volume relationship, index properties of soils, surface tension and capillary phenomenon. Measurement of capillary rise in soil, soil moisture, soil-water potential, measurement of soil-water potential.Mechanism of swelling potential and pressure.

Unit-3
Soil compaction, standard and modified Proctor compaction, theories of soil compaction; compaction control in field. Permeability, Darcy's law, Theories of wells, flownets and their properties, seepage flownet in dams, flownet by relaxation method, seepage forces, uplift, piping phenomenon, problems.

Unit-4
Consolidation of soils, Introduction, Terzaghi's theory of one dimensional consolidation, application to geotechnical problems.Two and three dimensional consolidation of soils, secondary consolidation

Unit-5
Shear strength of soils; unsaturated soil Skempton pore pressure theory, compressibility of unsaturated soil, Rowes stress dilatancy theory.
Different shear parameters; special consolidation and shear tests, application to geotechnical problems;

References:

1. Atkinson, J.H. and Bransby, P.L, The Mechanics of Soils: An introduction to critical soil
mechanics, McGraw Hill, 1978.
2. Atkinson J. H, An introduction to the Mechanics of soils and Foundation, McGraw-Hill
Co., 1993.
3. Das, B. M., Advanced Soil Mechanics, Taylor and Francis, 2nd Edition, 1997
4. Wood, D.M.,Soil Behavior and Critical State Soil Mechanics, Cambridge University Press, 1990.
5. Craig, R. F., Soil Mechanics, Van Nostrand Reinhold Co. Ltd., 1987.
6. Terzaghi, K., and Peck, R. B., Soil Mechanics in Engineering Practice, John Wiley & Sons, 1967.
7. Lambe, T. W. and Whitman, R. V., Soil Mechanics, John Wiley & Sons, 1979.

Course Outcome:

1. Students will be able to understand the clay mineralogy of soil.
2. Students will be able to understand the basic fundamental of soil mechanics.
3. Students will be able to understand the capillary phenomenon/permeability and flow behaviour of soils.
4. Students will be able to understand the field application based on compaction for geotechnical problem
5. Students will be able to understand the application of consolidation to geotechnical problem
6. Students will be able to understand the compressibility behaviour of saturated/unsaturated soil.

To establish the co-relation between COs &POs

Table-1

No. of Course Outcome (CO)	Course Outcome
PCE21C01.1	Students will be able to understand the clay mineralogy of soil.
PCE21C01.2	Students will be able to understand the basic fundamental of soil mechanics
PCE21C01.3	Students will be able to understand the capillary phenomenon/permeability and flow behaviour of soils.
PCE21C01.4	Students will be able to understand the field application based on compaction for geotechnical problem
PCE21C01.5	Students will be able to understand the application of consolidation to geotechnical problem
PCE21C01.6	Students will be able to understand the compressibility behaviour of saturated/unsaturated soil.

Table-2: Co-relation between COs &POs

1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE21C01.1	2	2	3	2	2	2
PCE21C01.2	2	2	3	2	2	2
PCE21C01.3	2	2	3	2	2	2
PCE21C01.4	2	2	3	2	2	2
PCE21C01.5	2	2	3	2	2	2
PCE21C01.6	2	2	3	2	2	2
Total	12	12	18	12	12	12
Average	2	2	3	2	2	2
Equivalent Avg. Attainment	2	2	3	2	2	2

To establish the correlation between COs & PSOs
Table-3

CO	PSO1	PSO2
PCE21C01.1	3	3
PCE21C01.2	3	3
PCE21C01.3	3	3
PCE21C01.4	3	3
PCE21C01.5	3	3
PCE21C01.6	3	3
Total	**18**	**18**
Average	**3**	**3**
Equivalent Avg. Attainment	**3**	**3**

Core Subject-II

SOIL DYNAMIC AND MACHINE FOUNDATIONS (PCE21C02)

Total Credit: 04 **Contact Periods: 04 (3L+1T+0P)**

Courses Objective:

1. To know about the dynamic behaviour of soil and machine foundation
2. To learn about theory of vibration, wave propagation through soil, dynamic properties of soil
3. To know about the analysis of foundation, slope, retaining wall under seismic loading condition
4. To know about the liquefaction of soil
5. To know about the different types of machine foundation and their analysis under dynamic loading condition
6. To evaluate safe response of Geotechnical Engineering Structures under dynamic loading condition.

Course Content:

Unit 1:
Theory of Vibration: Elements of vibration, damped and undamped vibration, Effect of vibration on soil properties, Theory of vibration isolation, Vibration measuring instruments, Mode shapes and Multi-degree freedom system.

Unit 2:
Wave Propagation and Internal Structure of Earth: Theory of elasticity; Wave equation; Body and surface waves; Laws of reflection, refraction, attenuation, diffraction and dispersion; Local site effects; Seismic phases; Ray parameter; Travel time curves; Internal structure of earth; Reference models.

Unit 3:
Dynamic Properties of Soil: Factors affecting dynamic behavior of soil. Determination of Dynamic properties of soil- Field methods, Laboratory methods.

Unit 4:
Analysis of Geotechnical Structures: Pseudo-static, Pseudo-dynamic, modified pseudo-dynamic and IS code method of analysis of shallow foundation, slope and retaining wall.

Unit 5:
Liquefaction: Introduction, pore pressure, liquefaction related phenomena – flow liquefaction and cyclic mobility: Factors affecting liquefaction, liquefaction of cohesionless soils and sensitive clays, liquefaction susceptibility; State Criteria –CVR line, SSL, FLS; Evaluation of liquefaction potential: characterization of earthquake loading and liquefaction resistance, cyclic stress ratio, Seed and Idriss method; Effects of liquefaction.

Unit 6:

Machine Foundation: Various types of machine foundations; Permissible amplitudes of vibrations, factors affecting the resonant frequency and amplitudes of vibrations; Estimation of damping and plastic coefficients. Resonant frequency of the block foundations; Weightless spring and weighted spring method, elastic half space method, miscellaneous methods; Behaviour and design of block foundations, permissible amplitudes. Hammer foundations, classification, natural frequencies and amplitudes of foundation vibrations; Design principles, permissible amplitudes.

References

1. Swami Saran,"Soil dynamics and machine foundations",Golgatiapublishers,New Delhi.
2. Arya S. D, O'Neil, M. and Pincus, G., Design of structures and foundations for vibrating machines, Gulf Publishing Co., 1979.
3. Prakash, S. and Puri, V. K., Foundation for machines: Analysis and Design, John Wiley & Sons, 1998
4. Prakash, S., Soil Dynamics, McGraw Hill, 1981.
5. Kameswara Rao, N. S. V., Vibration analysis and foundation dynamics, Wheeler Publication Ltd., 1998.
6. Major, A., Dynamics in Civil Engineering: Analysis and Design Vol. I-III, AkademiaiKiado, 1980.
7. Richart, F. E. Hall J. R and Woods R. D., Vibrations of Soils and Foundations, Prentice Hall Inc., 1970.

Course Outcome:

1. The students will know about the dynamic behaviour of soil and machine foundation
2. They will learn about theory of vibration, wave propagation through soil, dynamic properties of soil
3. They will know about the analysis of foundation, slope, retaining wall under seismic loading condition
4. They will also know about the liquefaction of soil
5. They will learn about the different types of machine foundation and their analysis under dynamic loading condition
6. They can evaluate safe response of Geotechnical Engineering Structures under dynamic loading condition.

To establish the co-relation between COs &POs

Table-1

No. of Course Outcome (CO)	Course Outcome
PCE21C02.1	The students will know about the dynamic behaviour of soil and machine foundation
PCE21C02.2	They will learn about theory of vibration, wave propagation through soil, dynamic properties of soil
PCE21C02.3	They will know about the analysis of foundation, slope, retaining wall under seismic loading condition
PCE21C02.4	They will also know about the liquefaction of soil
PCE21C02.5	They will learn about the different types of machine foundation and their analysis under dynamic loading condition
PCE21C02.6	They can evaluate safe response of Geotechnical Engineering Structures under dynamic loading condition

Table-2
1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE21C02.1	2	2	3	2	2	2
PCE21C02.2	2	2	3	2	2	2
PCE21C02.3	2	2	3	2	2	2
PCE21C02.4	2	2	3	2	2	2
PCE21C02.5	2	2	3	2	2	2
PCE21C02.6	2	2	3	2	2	2
Total	12	12	18	12	12	12
Average	2	2	3	2	2	2
Equivalent Avg. Attainment	2	2	3	2	2	2

To establish the correlation between COs & PSOs
Table-3

CO	PSO1	PSO2
PCE21C02.1	3	3
PCE21C02.2	3	3
PCE21C02.3	3	3
PCE21C02.4	3	3
PCE21C02.5	3	3
PCE21C02.6	3	3
Total	**18**	**18**
Average	**3**	**3**
Equivalent Avg. Attainment	**3**	**3**

Elective Paper-I (Any one)

PCE21E01: Ground Improvement Technique
PCE21E02: Numerical methods and computer programming in Engineering
PCE21E03: Elastic Analysis in Geotechnical Engineering

GROUND IMPROVEMENT TECHNIQUES (PCE21E01)

Total Credit: 04 **Contact Periods: 04 (3L+1T+0P)**

Courses Objective:

1. To understand the necessity of ground improvement techniques
2. To understand the details of mechanical stabilization
3. To understand the ground improvement by drainage
4. To understand the applications of admixtures for ground improvement
5. To understand the applications of grouting techniques
6. To understand the in situ soil treatment methods
7. To understand the case studies of ground improvement projects.

Course Content:

Unit-1
Introduction: Need for Ground Improvement, Different types of problematic soils, Emerging trends in ground
Improvement.

Unit-2
Mechanical stabilization: Shallow and deep compaction requirements, Principles and methods of soil compaction, Shallow compaction and methods. Properties of compacted soil and compaction control, Deepcompaction and Vibratory methods Dynamic compaction.

Unit-3
Hydraulic modification: Ground Improvement by drainage, Dewatering methods. Design of dewatering systems, Preloading, Vertical drains, vacuum consolidation, Electro-kinetic dewatering, design andconstruction methods.

Unit-4
Modification by admixtures: Cement stabilization and cement columns, Lime stabilization and lime columns. Stabilization using bitumen and emulsions, Stabilization using industrial wastes Construction techniques andapplications.

Unit 5
Grouting: Permeation grouting, compaction grouting, jet grouting, different varieties of grout materials,grouting under difficult conditions.

Unit-6

In situ soil treatment methods: Soil nailing, rock anchoring, micro-piles, design methods, construction techniques.

Unit-7

Case studies: Case studies of ground improvement projects.

References:

Sl No.	Name of the Books	Authors	Publishers
1.	Ground Improvement Techniques	P. Purushothama Raj	Laxmi Publications (P) Ltd.
2.	Engineering Principles of Ground Modification	Manfired R. Hausmann	McGraw-Hill Pub, Co.
3.	Designing with geosynthetics	R. M. Koerner	Prentice Hall Inc.
4.	Guidelines on ground improvement for structure and facilities	U. S. Army Corps of Engineers	U. S. Army Corps of Engineers, Washington DC
5.	Ground Control and Improvement	Petros P. Xanthakos, Lee W. Abramson and Donald A. Bruce	John Wiley, New York

Additional Readings:

Journal and Conference papers in the area of Ground Improvement, Ground Engineering, Geotextiles andgeomembranes, Geosynthetics, etc.

Course Outcome:

1. Students will be able to understand the necessity of ground improvement techniques
2. Students will be able to understand the details of mechanical stabilization
3. Students will be able to understand the ground improvement by drainage
4. Students will be able to understand the applications of admixtures for ground improvement
5. Students will be able to understand the applications of grouting techniques
6. Students will be able to understand the in situ soil treatment methods
7. Students will be able to understand the case studies of ground improvement projects.

To establish the correlation between COs &POs
Table-1

No. of Course Outcome (CO)	Course Outcome
PCE21E01.1	Students will be able to understand the necessity of ground improvement techniques
PCE21E01.2	Students will be able to understand the details of mechanical stabilization
PCE21E01.3	Students will be able to understand the ground improvement by drainage
PCE21E01.4	Students will be able to understand the applications of admixtures for ground improvement
PCE21E01.5	Students will be able to understand the applications of grouting techniques
PCE21E01.6	Students will be able to understand the in situ soil treatment methods
PCE21E01.7	Students will be able to understand the case studies of ground improvement projects

Table-2
1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE21E01.1	2	2	3	2	2	2
PCE21E01.2	2	2	3	2	2	2
PCE21E01.3	2	2	3	2	2	2
PCE21E01.4	2	2	3	2	2	2
PCE21E01.5	2	2	3	2	2	2
PCE21E01.6	2	2	3	2	2	2
PCE21E01.7	2	2	3	2	2	2
Total	14	14	21	14	14	14
Average	2	2	3	2	2	2
Equivalent Avg. Attainment	2	2	3	2	2	2

To establish the correlation between COs & PSOs
Table-3

CO	PSO1	PSO2
PCE21E01.1	3	3
PCE21E01.2	3	3
PCE21E01.3	3	3
PCE21E01.4	3	3
PCE21E01.5	3	3
PCE21E01.6	3	3
PCE21E01.7	3	3
Total	**21**	**21**
Average	**3**	**3**
Equivalent Avg. Attainment	**3**	**3**

NUMERICAL METHODS AND COMPUTER PROGRAMMING IN ENGINEERING
(PCE21E02)

Total Credit: 04 **Contact Periods: 04 (3L+1T+0P)**

Courses Objective:

1. To understand the linear and nonlinear equations
2. To understand the Eigen value problems
3. To understand the differentiation and evaluation of single and multiple integrals
4. To understand the finite element methods
5. To understand the fundamental of statistical distribution
6. To understand the computer programming in geotechnical engineering problem.

Unit-1:
Linear equations and Eigen value problems, Accuracy of approximate calculations, Nonlinear equations, interpolation.

Unit-2:
Differentiation and evaluation of single and multiple integrals, initial and boundary value problems by finite difference method.

Unit-3:
Newton's method, variation and weighted residual methods, introduction to finite element methods, fundamental of statistical distribution.

Unit-4:
Computer programming in geotechnical engineering problem.

References

1. J. B. Scarborough, Numerical mathematical analysis, Oxford & IBH Publishing Co. Pvt., 2000
2. K. K. Jain, S. R. K Iyengar and R. K. Jain Numerical methods-problem and solutions, Wiley eastern limited, 2001
3. R.W. Hamming, Numerical methods for scientist and engineers, McGraw Hill, 1998.
4. J. H. Mathews and K.D. Fink, Numerical methods using MATLAB, Pearson Education, 2004
5. A. J. Hayter, Probability and statistics, Duxbury, 2002.

Course Outcome:

1. Students will be able to understand the linear and nonlinear equations
2. Students will be able to understand the eigen value problems
3. Students will be able to understand the differentiation and evaluation of single and multiple integrals
4. Students will be able to understand the finite element methods
5. Students will be able to understand the fundamental of statistical distribution

6. Students will be able to understand the computer programming in geotechnical engineering problem.

To establish the co-relation between COs &POs

Table-1

No. of Course Outcome (CO)	Course Outcome
PCE21E02.1	Students will be able to understand the linear and nonlinear equations
PCE21E02.2	Students will be able to understand the eigen value problems
PCE21E02.3	Students will be able to understand the differentiation and evaluation of single and multiple integrals
PCE21E02.4	Students will be able to understand the finite element methods
PCE21E02.5	Students will be able to understand the fundamental of statistical distribution
PCE21E02.6	Students will be able to understand the computer programming in geotechnical engineering problem

Table-2
1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE21E02.1	2	2	3	2	2	2
PCE21E02.2	2	2	3	2	2	2
PCE21E02.3	2	2	3	2	2	2
PCE21E02.4	2	2	3	2	2	2
PCE21E02.5	2	2	3	2	2	2
PCE21E02.6	2	2	3	2	2	2
Total	12	12	18	12	12	12
Average	2	2	3	2	2	2
Equivalent Avg. Attainment	2	2	3	2	2	2

To establish the correlation between COs & PSOs
Table-3

CO	PSO1	PSO2
PCE21E02.1	3	3
PCE21E02.2	3	3
PCE21E02.3	3	3
PCE21E02.4	3	3
PCE21E02.5	3	3
PCE21E02.6	3	3
Total	**18**	**18**
Average	**3**	**3**
Equivalent Avg. Attainment	**3**	**3**

ELASTIC ANALYSIS IN GEOTECHNICAL ENGINEERING
(PCE21E03)

Total Credit: 04 **Contact Periods: 04 (3L+1T+0P)**

Courses Objective:

1. To understand the concepts of stress and strain, stress invariants
2. To understand the concepts of plane state of stress and plane state of strain
3. To understand the concepts of stresses and displacements in soil
4. To understand the application of fundamental solutions for problems of practical interest in geotechnical engineering
5. To understand the concepts of elastic solutions for layered soil systems
6. To understand the concepts of settlement and contact stress under rigid and flexible foundations.

Course Content:

Unit-1:
Concepts of stress and strain; Principal stresses and strains; Invariants; Octahedral stresses and strains; Mohr's diagrams; Plane state of stress and Plane state of strain.

Unit-2:
Stress strain relations for linearly elastic solids; Stresses and displacements in soil, Basic solutions of Boussinesq, Cerutti, Mindlin and Westergaard.

Unit-3:
Application of fundamental solutions for problems of practical interest in geotechnical engineering: foundations, stress applied to surface of a circular opening, Inclusions in infinite regions, surface loads in a semi-infinite region.

Unit-4:
Elastic solutions for layered soil systems, settlement and contact stress under rigid and flexible foundations, Computation of immediate settlements for shallow and deep foundations.

References

1. Harr, M. E, Foundations of Theoretical Soil Mechanics, McGraw-Hill Inc., 1996.
2. Das, B. M, Advanced Soil Mechanics, McGraw-Hill Book Co., 1987.
3. Poulos, H. G. and Davis, E. H , Elastic Solutions for Soil and Rock Mechanics, Wiley, 1974.

Course Outcome:

1. Students will be able to understand the concepts of stress and strain, stress invariants
2. They will understand the concepts of plane state of stress and plane state of strain
3. They will understand the concepts of stresses and displacements in soil
4. They will understand the application of fundamental solutions for problems of practical interest in geotechnical engineering
5. They will understand the concepts of elastic solutions for layered soil systems
6. They will understand the concepts of settlement and contact stress under rigid and flexible foundations.

To establish the co-relation between COs &POs
Table-1

No. of Course Outcome (CO)	Course Outcome
PCE21E03.1	Students will be able to understand the concepts of stress and strain, stress invariants
PCE21E03.2	They will understand the concepts of plane state of stress and plane state of strain
PCE21E03.3	They will understand the concepts of stresses and displacements in soil
PCE21E03.4	They will understand the application of fundamental solutions for problems of practical interest in geotechnical engineering
PCE21E03.5	They will understand the concepts of elastic solutions for layered soil systems
PCE21E03.6	They will understand the concepts of settlement and contact stress under rigid and flexible foundations.

Table-2
1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE21E03.1	2	2	3	2	2	2
PCE21E03.2	2	2	3	2	2	2
PCE21E03.3	2	2	3	2	2	2
PCE21E03.4	2	2	3	2	2	2
PCE21E03.5	2	2	3	2	2	2
PCE21E03.6	2	2	3	2	2	2
Total	12	12	18	12	12	12
Average	2	2	3	2	2	2
Equivalent Avg. Attainment	2	2	3	2	2	2

To establish the correlation between COs & PSOs
Table-3

CO	PSO1	PSO2
PCE21E03.1	3	3
PCE21E03.2	3	3
PCE21E03.3	3	3
PCE21E03.4	3	3
PCE21E03.5	3	3
PCE21E03.6	3	3
Total	**18**	**18**
Average	**3**	**3**
Equivalent Avg. Attainment	**3**	**3**

Elective Paper-II (Any one)

PCE21E04: Reinforced Soil Structures
PCE21E05: Rock Mechanics and Tunneling
PCE21E06: Soil Investigation and Exploration

REINFORCED SOIL STRUCTURES (PCE21E04)

Total Credit: 04 **Contact Periods: 04 (3L+1T+0P)**

Courses Objective:

1. To understand the principles, concepts and mechanism of reinforced earth
2. To understand the composition of geosynthetics
3. To understand the applications in reinforced earth structures
4. To understand the design of reinforced soil structures like retaining walls, embankments, foundation beds etc.
5. To understand the designing for landfill liners and barrier applications
6. To understand the case histories of applications of design.

Course Content:

Unit-1
Historical background; Principles, concepts and mechanism of reinforced earth; Design consideration for reinforced earth and reinforced soil structures.

Unit-2
Geosynthetics-their composition, manufacture, properties, functions, testing and applications in reinforced earth structures.

Unit-3
Design of reinforced soil structures like retaining walls, embankments, foundation beds etc.

Unit-4
Designing for Separation, Filtration, Drainage and Roadway Applications; Designing for Landfill Liners and Barrier Applications; Case histories of applications.

References:
1. Clayton, C. R. I., Milititsky, J. and Woods, R. I., Earth Pressure and Earth Retaining Structures, Blackie Academic & Professional, 1993.
2. Ingold, T, Reinforced Earth, Thomas Telford Ltd., 1982.
3. Jones, C. J. F. P, Earth Reinforcement and Soil Structures, Butterworth, 2005.
4. Koerner, R. M, Designing with Geosynthetics, Prentice Hall, 1993.

Course Outcome:

1. Students will be able to understand the principles, concepts and mechanism of reinforced earth
2. Students will be able to understand the composition of geosynthetics
3. Students will be able to understand the applications in reinforced earth structures
4. Students will be able to understand the design of reinforced soil structures like retaining walls, embankments, foundation beds etc.
5. Students will be able to understand the designing for landfill liners and barrier applications
6. Students will be able to understand the case histories of applications of design.

To establish the correlation between COs &POs
Table 1

No. of Course Outcome (CO)	Course Outcome
PCE21E04.1	Students will be able to understand the principles, concepts and mechanism of reinforced earth
PCE21E04.2	Students will be able to understand the composition of geosynthetics
PCE21E04.3	Students will be able to understand the applications in reinforced earth structures
PCE21E04.4	Students will be able to understand the design of reinforced soil structures like retaining walls, embankments, foundation beds etc.
PCE21E04.5	Students will be able to understand the designing for landfill liners and barrier applications
PCE21E04.6	Students will be able to understand the case histories of applications of design

Table-2
1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE21E04.1	2	2	3	2	2	2
PCE21E04.2	2	2	3	2	2	2
PCE21E04.3	2	2	3	2	2	2
PCE21E04.4	2	2	3	2	2	2
PCE21E04.5	2	2	3	2	2	2
PCE21E04.6	2	2	3	2	2	2
Total	12	12	18	12	12	12
Average	2	2	3	2	2	2
Equivalent Avg. Attainment	2	2	3	2	2	2

To establish the correlation between COs & PSOs
Table-3

CO	PSO1	PSO2
PCE21E04.1	3	3
PCE21E04.2	3	3
PCE21E04.3	3	3
PCE21E04.4	3	3
PCE21E04.5	3	3
PCE21E04.6	3	3
Total	**18**	**18**
Average	**3**	**3**
Equivalent Avg. Attainment	**3**	**3**

ROCK MECHANICS AND TUNNELLING
(PCE21E05)

Total Credit: 04 **Contact Periods: 04 (3L+1T+0P)**

Courses Objective:

1. To understand the scope and problems of Rock Mechanics
2. To understand the different laboratory tests of rocks
3. To understand the different in-situ tests on rock mass
4. To understand the analysis of stresses in case of rocks
5. To understand the concepts of lined and unlined tunnels
6. To understand the concept of underground excavation and subsidence
7. To understand the applications of Rock Mechanics.

Course Content:

Unit-1
Introduction, objective, scope and problems of Rock Mechanics. Classification by origin, Lithological, Engineering. Rock exploration- rock coring, geophysical methods.

Unit-2
Laboratory testing of rocks- all types of compressive strength, tensile strength and flexural strength tests.
Strength and failure of rocks- Griffith's theory, Coulombs theory, rheological methods.
In-situ tests on rock mass. Deformation characteristics of rocks, instrumentation and measurement of deformation of rocks. Permeability characteristics- interstitial water on rocks, unsteady flow of water through jointed rock mass. Mechanical, thermal and electrical properties of rock mass. Correlation between laboratory and field properties.

Unit-3
Analysis of stresses. Thick wall cylinder, formulae, Kreish equation, Green span method. Openings in rock mass and stresses around openings. Pressure tunnels, development of plastic zone. Rock support needed to avoid plastic deformation. Lined and unlined tunnels. Underground excavation and subsidence.

Unit-4
Rock mechanics applications. Bearing capacity of homogeneous as well as discontinuous rocks. Support pressure and slip of the joint. Delineation of types of rock failure. Unsupported span of underground openings, pillars. Rock slopes. Rock bolting. Plastic mechanics. Tunnels, shapes, usages, Methods of Construction, Problems associated with tunnels, tunnelling in various subsoil conditions and rocks.

References:

1. Mukerjee, P. K., A text book of Geology, World Press, 1995.
2. Brady, B. H. G. and Brown, E. T, Rock Mechanics for Underground Mining, Chapman & Hall, 1993.
3. Brown, E. T, Rock Characterisation, Testing and Monitoring, Pergamon Press, 1986.
4. Herget, G, Stresses in Rock, Balkema, 1988.

5. Hoek, E. and Brown, E. T, Underground Excavation in Rock, Institution of Mining and Metallurgy, 1982.
6. Goodman, R. E, Introduction to Rock Mechanics, John Wiley & Sons, 1989.
7. Bieniawski, Z. T, Engineering Rock Mass Classification, John Wiley and Sons, 1989.
8. Coates, D. F, Rock Mechanics Principles, Canada Centre for Mineral and Energy Technology, 1981.
9. Jaeger, J. C. and Cook, N. G. W, Fundamentals of Rock Mechanics, Champman and Hall, 1976.
10. Wyllie, D. C, Foundations on Rock, E & FN Spon. 2nd Edition, 1992.

Course Outcome:

1. Students will be able to understand the scope and problems of Rock Mechanics
2. Students will be able to understand the different laboratory tests of rocks
3. Students will be able to understand the different in-situ tests on rock mass
4. Students will be able to understand the analysis of stresses in case of rocks
5. Students will be able to understand the concepts of lined and unlined tunnels
6. Students will be able to understand the concept of underground excavation and subsidence
7. Students will be able to understand the applications of Rock Mechanics.

To establish the co-relation between COs &POs

Table-1

No. of Course Outcome (CO)	Course Outcome
PCE21E05.1	Students will be able to understand the scope and problems of Rock Mechanics
PCE21E05.2	Students will be able to understand the different laboratory tests of rocks
PCE21E05.3	Students will be able to understand the different in-situ tests on rock mass
PCE21E05.4	Students will be able to understand the analysis of stresses in case of rocks
PCE21E05.5	Students will be able to understand the concepts of lined and unlined tunnels
PCE21E05.6	Students will be able to understand the concept of underground excavation and subsidence
PCE21E05.7	Students will be able to understand the applications of Rock mechanics

Table-2

1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE21E05.1	2	2	3	2	2	2
PCE21E05.2	2	2	3	2	2	2
PCE21E05.3	2	2	3	2	2	2
PCE21E05.4	2	2	3	2	2	2
PCE21E05.5	2	2	3	2	2	2
PCE21E05.6	2	2	3	2	2	2
PCE21E05.7	2	2	3	2	2	2
Total	14	14	21	14	14	14
Average	2	2	3	2	2	2
Equivalent Avg. Attainment	2	2	3	2	2	2

To establish the correlation between COs & PSOs

Table-3

CO	PSO1	PSO2
PCE21E05.1	3	3
PCE21E05.2	3	3
PCE21E05.3	3	3
PCE21E05.4	3	3
PCE21E05.5	3	3
PCE21E05.6	3	3
PCE21E05.7	3	3
Total	**21**	**21**
Average	**3**	**3**
Equivalent Avg. Attainment	**3**	**3**

SOIL INVESTIGATION AND EXPLORATION
(PCE21E06)

Total Credit: 04 **Contact Periods: 04 (3L+1T+0P)**

Courses Objective:

1. To understand the different methods of site investigation and sub-soil exploration
2. To understand the different methods of offshore exploration
3. To understand the basic about of shallow foundations and deep foundations
4. To understand the theory of stresses in soil
5. To update the knowledge of latest technology on stability of finite and infinite slope
6. To understand the different analyses and design of retaining walls to resist earth pressure.

Course Content:

Unit-1
Site Investigation and Sub-soil Exploration: Planning of geotechnical exploration; Methods of boring; Types of samples & sampling; Non-destructive testing;Field tests: standard penetration, plate load, static and dynamic cone penetration, field vane shear and pressure meter tests, electrical resistivity and seismic refraction tests; Location of ground water table;Processing of soil exploration data and its interpretation.

Unit-2
Offshore Exploration: Offshore site investigations; Sampling and drilling; In-situ soil testing; Offshore structures and geotechnical considerations- Floating structures, Bottom founded platforms, Subsea structures.

Unit-3
Introduction to Bearing Capacity of Shallow Foundations: Prandtl, Terzaghi and Meyerhof's method of analysis; Safe and allowable bearing pressures;
Introduction to Shallow Foundations and Deep Foundations: Settlement calculations; Skempton Bjerrum modification and Martin's method related to shallow foundation.
Mechanics of load transfer in piles; Load carrying capacity; Pile load test.

Unit-4
Stress in soil and Stability of slope: Elastic stresses in soil; Stress-strain behaviour of soils; Mohr Circle of Stress; Principal Stresses. Stress distribution in homogeneous, non-homogeneous, layered and anisotropic deposits. Effect of non-linearity; Stability of slopes; stability number, method of slices.

Unit-5
Earth Pressure: Earth pressure computations on retaining walls and their design.

References:

1. Bowles, J. E, Physical and Geotechnical Properties of Soil, McGraw-Hill Book Company, 1985.
2. Bowles, J. E, Foundation Analysis and Design, McGraw-Hill International edition, 1997.
3. Dunnicliff, J. and Green, G. E, Geotechnical Instrumentation for Monitoring Field Performance, John Wiley & Sons, 1982.
4. GopalRanjan and Rao, A. S. R, Basic and Applied Soil Mechanics, Wiley Eastern Limited, 1991.
5. Lunne, T., Robertson, P. K. and Powell, J. J. M, Cone Penetration Testing in Geotechnical Practice, Blackie Academic & Professional, 1997.
6. Compendium of Indian Standards on Soil Engineering Parts 1 and II 1987 - 1988.

Course Outcome:

1. Students will be able to understand the different methods of site investigation and sub-soil exploration
2. Students will be able to understand the different field tests of sub-soil exploration
3. Students will be able to understand the different methods of offshore exploration
4. Students will be able to understand the basic about shallow and deep foundations.
5. Students will be able to understand the theory of stress in soil.
6. Students will be able to understand latest technology on stability of finite and infinite slope.
7. Students will be able to understand the different analyses and design of retaining walls to resist earth pressure

To establish the co-relation between COs &POs

Table 1

No. of Course Outcome (CO)	Course Outcome
PCE21E06.1	Students will be able to understand the different methods of site investigation and sub-soil exploration
PCE21E06.2	Students will be able to understand the different field tests of sub-soil exploration
PCE21E06.3	Students will be able to understand the different methods of offshore exploration
PCE21E06.4	Students will be able to understand the basic about shallow and deep foundation
PCE21E06.5	Students will be able to understand the theory of stress in soil
PCE21E06.6	Students will be able to understand latest technology on stability of finite and infinite slope.
PCE21E06.7	Students will be able to understand the different analyses and design of retaining walls to resist earth pressure

Table-2: Co-relation between COs and POs
1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE21E06.1	2	2	3	2	2	2
PCE21E06.2	2	2	3	2	2	2
PCE21E06.3	2	2	3	2	2	2
PCE21E06.4	2	2	3	2	2	2
PCE21E06.5	2	2	3	2	2	2
PCE21E06.6	2	2	3	2	2	2
Total	**12**	**12**	**18**	**12**	**12**	**12**
Average	2	2	3	2	2	2
Equivalent Avg. Attainment	2	2	3	2	2	2

To establish the correlation between COs & PSOs
Table-3

CO	PSO1	PSO2
PCE21E06.1	3	3
PCE21E06.2	3	3
PCE21E06.3	3	3
PCE21E06.4	3	3
PCE21E06.5	3	3
PCE21E06.6	3	3
Total	**18**	**18**
Average	**3**	**3**
Equivalent Avg. Attainment	**3**	**3**

SOIL MECHANICS LABORATORY
(PCE21P01)

Total Credit: 02 **Contact Periods: 03 (0L+0T+3P)**

Courses Objective:

1. To understand the different tests to know the physical properties of soils in the laboratory
2. To understand the different tests to know the physical properties of soils in the field
3. To understand the different compaction tests of soils in the laboratory
4. To understand the different permeability tests of soils in the laboratory
5. To understand the different shear strength tests of soils in the in the laboratory
6. To understand the different shear strength tests of soils in the in the field
7. To understand the consolidation tests in the laboratory.

Course Content:

Unit-1

Identification and Physical description; Specific gravity; Mechanical analysis.

Unit-2

Proctor's Compaction test; Permeability- Constant head, Variable head,

Field Permeability test

Unit-3

Direct Shear test- Cohesionless soil, Cohesive soil; Unconfined Compression test; Tri-axial test- Undrained, Drained; Tri-axial test with pore pressure measurements; Vane Shear test.

Unit-4

1D and 3D Consolidation tests.

References:

1. B.M. Das, 'Soil mechanics laboratory manual', OUP USA.

Additional Readings:

Relevant I.S. Codes for the soil testing in the laboratory and field.

Course Outcome:

1. Students will be able to understand the different tests to know the physical properties of soils in the laboratory

2. Students will be able to understand the different tests to know the physical properties of soils in the field
3. Students will be able to understand the different compaction tests of soils in the laboratory

4. Students will be able to understand the different permeability tests of soils in the laboratory

5. Students will be able to understand the different shear strength tests of soils in the in the laboratory

6. Students will be able to understand the different shear strength tests of soils in the in the field

7. Students will be able to understand the consolidation tests in the laboratory.

To establish the co-relation between COs &POs

Table-1

No. of Course Outcome (CO)	Course Outcome
PCE21P01.1	Students will be able to understand the different tests to know the physical properties of soils in the laboratory
PCE21P01.2	Students will be able to understand the different tests to know the physical properties of soils in the field
PCE21P01.3	Students will be able to understand the different compaction tests of soils in the laboratory
PCE21P01.4	Students will be able to understand the different permeability tests of soils in the laboratory
PCE21P01.5	Students will be able to understand the different shear strength tests of soils in the in the laboratory
PCE21P01.6	Students will be able to understand the different shear strength tests of soils in the in the field
PCE21P01.7	Students will be able to understand the consolidation tests in the laboratory

Table-2

1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE21P01.1	2	2	3	2	2	2
PCE21P01.2	2	2	3	2	2	2
PCE21P01.3	2	2	3	2	2	2
PCE21P01.4	2	2	3	2	2	2
PCE21P01.5	2	2	3	2	2	2
PCE21P01.6	2	2	3	2	2	2
PCE21P01.7	2	2	3	2	2	2
Total	14	14	21	14	14	14
Average	2	2	3	2	2	2
Equivalent Avg. Attainment	2	2	3	2	2	2

To establish the correlation between COs & PSOs
Table-3

CO	PSO1	PSO2
PCE21P01.1	3	3
PCE21P01.2	3	3
PCE21P01.3	3	3
PCE21P01.4	3	3
PCE21P01.5	3	3
PCE21P01.6	3	3
PCE21P01.7	3	3
Total	**21**	**21**
Average	**3**	**3**
Equivalent Avg. Attainment	**3**	**3**

FOUNDATION ENGINEERING LABORATORY
(PCE21P02)

Total Credit: 02 **Contact Periods: 03 (0L+0T+3P)**

Courses Objective:

1. To understand the samplings of disturbed and undisturbed soils
2. To understand the standard penetration test & static cone penetration test
3. To understand the plate bearing test
4. To understand in-situ dynamic properties
5. To understand the model footing test
6. To understand the model pile loading test
7. To understand the laboratory vibration test.

Course Content:

Unit-1

Disturbed and undisturbed sampling; Standard penetration test; Static cone penetration test.

Unit-2

Plate bearing test; In-situ dynamic properties.

Unit-3

Model footing test; Model pile loading test.

Unit-4

Laboratory vibration test; Determination of In situ Modulus by Pressuremeter.

References:

1. B.M. Das, 'Soil mechanics laboratory manual', OUP USA.

Additional Readings:

Relevant I.S. Codes for the soil testing in the laboratory and field.

Course Outcome:

1. Students will be able to understand the samplings of disturbed and undisturbed soils
2. Students will be able to understand the standard penetration test & static cone penetration test
3. Students will be able to understand the plate bearing test
4. Students will be able to understand in-situ dynamic properties
5. Students will be able to understand the model footing test
6. Students will be able to understand the model pile loading test

7. Students will be able to understand the laboratory vibration test.

To establish the co-relation between COs &POs

Table-1

No. of Course Outcome (CO)	Course Outcome
PCE21P02.1	Students will be able to understand the samplings of disturbed and undisturbed soils
PCE21P02.2	Students will be able to understand the standard penetration test & static cone penetration test
PCE21P02.3	Students will be able to understand the plate bearing test
PCE21P02.4	Students will be able to understand in-situ dynamic properties
PCE21P02.5	Students will be able to understand the model footing test
PCE21P02.6	Students will be able to understand the model pile loading test
PCE21P02.7	Students will be able to understand the laboratory vibration test

Table-2
1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE21P02.1	2	2	3	2	2	2
PCE21P02.2	2	2	3	2	2	2
PCE21P02.3	2	2	3	2	2	2
PCE21P02.4	2	2	3	2	2	2
PCE21P02.5	2	2	3	2	2	2
PCE21P02.6	2	2	3	2	2	2
PCE21P02.7	2	2	3	2	2	2
Total	14	14	21	14	14	14
Average	2	2	3	2	2	2
Equivalent Avg. Attainment	2	2	3	2	2	2

To establish the correlation between COs & PSOs
Table-3

CO	PSO1	PSO2
PCE21P02.1	3	3
PCE21P02.2	3	3
PCE21P02.3	3	3
PCE21P02.4	3	3
PCE21P02.5	3	3
PCE21P02.6	3	3
PCE21P02.7	3	3
Total	**21**	**21**
Average	**3**	**3**
Equivalent Avg. Attainment	**3**	**3**

SEMINAR
(PCE21P03)

Total Credit: 01 **Contact Periods: 02 (0L+0T+2P)**

Each Student shall prepare a Report and present a Se-minar on topic related to the branch of specialization under the guidance of a Faculty member. The student shall submit copy of the paper to the Department. Grades will be awarded on the basis of contents of the paper and the presentation.

Second Semester

Sl. No.	Subject	Credit	Class Hours per Week	Marks
1	**Basic Core** **PCE22B01**: Finite Element Method	4	4	100
2	**Core Subject-I** **PCE22C01**: Advanced Foundation Design	4	4	100
3	**Core Subject-II** **PCE22C02**: Soil Structure Interaction	4	4	100
4	**Elective Paper-III (Any one)** **PCE22E01**: Environmental Geotechnique **PCE22E02**: Earthquake Geotechnical Engineering **PCE22E03**: Computer Aided Design	4	4	100
5	**PCE22P02**: Foundation Design and Drawing	2	3	100
6	**PCE22P03**: Computer Aided Geotechnical Design Laboratory	2	3	100
7	**PCE22P01**: Project Preliminary	3	6	100
8	**PCE22P04**: Comprehensive Viva-voce	1	0	100
	Total	**25**	**28**	**800**

01/09/21

Basic Core

FINITE ELEMENT METHOD
(PCE22B01)

Total Credit: 04 **Contact Periods: 04 (3L+1T+0P)**

Course Objective:

1. Understand the mathematical and physical principles underlying the Finite Element Method (FEM) focussed on stress analysis of common geotechnical engineering problems.
2. Demonstrate the ability to formulate and implement to solve geotechnical engineering problems using Finite Element Analysis.
3. Be able to evaluate accuracy of the Finite Element solutions using a range of techniques.
4. Be able to create his/her own FEM computer programs, for simple problems.
5. Understand the importance of analysis, using FEM, in the broader context of engineering practice.

Course Content:

Unit- 1
Introduction: Boundary Value Problem - Approximate Solution - Variational and Weighted Residual Methods - Ritz and Galerkin Formulations - Concepts of Piecewise Approximation and Finite Elements - Displacement and Shape Functions - Weak Formulation - Minimum Potential Energy - Generation of Stiffness Matrix and Load Vector.

Unit- 2
Stress Analysis: Two Dimensional problems - Plane Stress, Plain Strain and Axisymmetric Problems - Triangular and Quadrilateral Elements - Natural Coordinates - Isoparametric Formulation - Numerical Integration - Plate Bending and Shell Elements - Brick Elements - Elements for Fracture Analysis.

Unit- 3
Meshing and Solution Problems: Higher Order Elements - p and h Methods of refinement - IIL conditioned Elements - Discretization Errors -Auto and Adaptive Mesh Generation Techniques - Error Evaluation.

Unit- 4
Nonlinear and Vibration Problems: Material and Geometric Nonlinearity - Methods of Treatment - Consistent System Matrices – Dynamic Condensation - Eigen Value Extraction.

Unit- 5
Thermal Analysis: Thermal analysis problems.

References:

Sl. No.	Name of the Book	Author	Publisher
1	Finite Element Method	Zeinkiewicz, O. C.	Tata Mcgraw Hill, 1988
2	The Finite Element Method-Vol. I	Zeinkiewicz& Taylor	Mcgraw-Hill International Editions
3	The Finite Element Method-Vol. II	Zeinkiewicz& Taylor	Mcgraw-Hill International Editions
4	The Finite Element Method-Vol. III	Zeinkiewicz& Taylor	Mcgraw-Hill International Editions
5	Vibrations, Dynamics and Structural System	Mukhopadhyay, M.	Oxford and IBH
6	An Introduction to the Finite Element Method	Reddy, J. N.	Mcgraw-Hill International Editions
7	The Finite Element Analysis	Seshu, P.	PHI
8	Finite Element Procedures	Bathe, K. J.	Prentice Hall, 1996
9	A First Course in Finite Elements	Fish, J. and Belytschko, T.	John Willey & Sons, 2007
10	Concepts and Applications of Finite Element Analysis	Cook, R. D.	John Willey & Sons
11	Finite Element Analysis-Theory and Programming	Krishnamurthy, C. S.	Tata Mcgraw Hill
12	Introduction to Finite Element Vibration Analysis	Petyt, M.	Cambridge University Press

Course Outcome:

At the end of the course, a student will be able to

1. Analyze linear 1D problem such as bars, beams, 2D problems using CST element, 4 node quadrilateral element, axi-symmetric problems with triangular elements, 3 and 4 node plate elements.
2. Write shape functions for 8 node quadrilateral, 6 node triangular (LST) elements, 8 node brick element, shell element, and apply numerical integration to solve; 1D and 2D; stiffness integrations.
3. Understand p and h Methods of refinement, discretization Errors and auto and adaptive mesh generation techniques.
4. Apply suitable boundary conditions to a global equation for various geotechnical engineering problems and solve them to determine displacements, stresses and strains.
5. Understand the finite element method to solve problems with material and geometric nonlinearity and vibration problems.
6. Critically assess a finite element analysis for correctness.

To establish the co-relation between COs & POs

Table 1

No. of course outcome (CO)	Course Outcome
PCE22B01.1	Student will be able to analyze linear 1D problem such as bars, beams, 2D problems using CST element, 4 node quadrilateral element, axi-symmetric problems with triangular elements, 3 and 4 node plate elements.
PCE22B01.2	Student will be able to write shape functions for 8 node quadrilateral, 6 node triangular (LST) elements, 8 node brick element, shell element, and apply numerical integration to solve; 1D and 2D; stiffness integrations.
PCE22B01.3	Student will be able to understand p and h Methods of refinement, discretization Errors and auto and adaptive mesh generation techniques.
PCE22B01.4	Student will be able to apply suitable boundary conditions to a global equation for various geotechnical engineering problems and solve them to determine displacements, stresses and strains.
PCE22B01.5	Student will be able to understand the finite element method to solve problems with material and geometric nonlinearity and vibration problems.
PCE22B01.6	Student will be able to critically assess a finite element analysis for correctness.

Table-2

1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE22B01.1	3	2	2	2	2	2
PCE22B01.2	3	2	2	2	2	2
PCE22B01.3	3	2	2	2	2	2
PCE22B01.4	3	2	2	2	2	2
PCE22B01.5	3	2	2	2	2	2
PCE22B01.6	3	2	2	2	2	2
Total	18	12	12	12	12	12
Average	3	2	2	2	2	2
Equivalent Avg. Attainment	3	2	2	2	2	2

To establish the correlation between COs & PSOs

Table-3

CO	PSO1	PSO2
PCE22B01.1	3	3
PCE22B01.2	3	3
PCE22B01.3	3	3
PCE22B01.4	3	3
PCE22B01.5	3	3
PCE22B01.6	3	3
Total	**18**	**18**
Average	**3**	**3**
Equivalent Avg. Attainment	**3**	**3**

Core Subject-I

ADVANCED FOUNDATION DESIGN
(PCE22C01)

Total Credit: 04 **Contact Periods: 04 (3L+1T+0P)**

Courses Objective:

1. To understand the design criteria of different types of shallow foundations
2. To update knowledge on settlement calculations of shallow foundations
3. To know the details design criteria of different types of deep foundations
4. To study the analysis of pile foundation
5. Detail design criteria of pile foundations
6. To update the knowledge about analysis of well foundation

Course Content:

Unit-1
Shallow foundations- selection of type and depth of foundations, isolated footings, combined footings, mat foundations including floating raft, settlement calculations.

Unit-2
Deep foundations- well foundations, coffer dams, pier foundations, earth pressure computations on retaining walls and their design, and Pile Foundation.

Unit-3
Pile Foundation- Introduction, estimation of pile capacity by static and dynamic formulae, wave equation method of analysis of pile resistance-load-transfer method of estimating pile capacity, settlement of single pile, elastic methods. Laterally loaded pile- modulus of sub grade reaction method, ultimate lateral resistance of piles.

Unit-4
Pile Groups- consideration regarding spacing, efficiency of pile groups, stresses on underlying soil strata, approximate analysis of pile groups, settlement of pile groups, pile caps, pile load tests, negative skin friction.

References:

1. Lambe and Whitman, Soil Mechanics, Wiley Eastern., 1976.
2. Das B.M., Advanced Soil Mechanics, Mc. Graw-Hill, NY, 1985.
3. Winterkorn H.F. and Fang H.Y. Ed., Foundation Engineering Hand Book, Van-Nostrand Reinhold, 1975.
4. Bowles J.E., Foundation Analysis and Design (4th Ed.), Mc.Graw –Hill, NY, 1996.
5. Poulose H.G. and Davis E.H., Pile foundation Analysis and Design, John-Wiley & Sons, NY, 1980.
7. Leonards G. Ed., Foundation Engineering, Mc.Graw-Hill,NY, 1962.

Course Outcome:

1. Students will be able to understand the design criteria of different types of shallow foundations
2. Students will be able to understand the settlement calculations of shallow foundations
3. Students will be able to understand the design criteria of different types of deep foundations
4. Students will be able to understand the analysis of pile foundations
5. Students will be able to understand the detail design criteria of pile foundations
6. Students will be able to update the knowledge about analysis of well foundation.

To establish the co-relation between COs & POs
Table-1

No. of Course Outcome (CO)	Course Outcome
PCE22C01.1	Students will be able to understand the design criteria of different types of shallow foundations
PCE22C01.2	Students will be able to understand the settlement calculations of shallow foundations
PCE22C01.3	Students will be able to understand the design criteria of different types of deep foundations
PCE22C01.4	Students will be able to understand the analysis of pile foundation
PCE22C01.5	Students will be able to understand the detail design criteria of pile foundations
PCE22C01.6	Students will be able to update the knowledge about analysis of well foundation

Table-2
1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE22C01.1	3	2	2	2	2	2
PCE22C01.2	3	2	2	2	2	2
PCE22C01.3	3	2	2	2	2	2
PCE22C01.4	3	2	2	2	2	2
PCE22C01.5	3	2	2	2	2	2
PCE22C01.6	3	2	2	2	2	2
Total	18	12	12	12	12	12
Average	3	2	2	2	2	2
Equivalent Avg. Attainment	3	2	2	2	2	2

To establish the correlation between COs & PSOs
Table-3

CO	PSO1	PSO2
PCE22C01.1	3	3
PCE22C01.2	3	3
PCE22C01.3	3	3
PCE22C01.4	3	3
PCE22C01.5	3	3
PCE22C01.6	3	3
Total	**18**	**18**
Average	**3**	**3**
Equivalent Avg. Attainment	**3**	**3**

Core Subject-II

SOIL STRUCTURE INTERACTION
(PCE22B02)

Total Credit: 04 **Contact Periods: 04 (3L+1T+0P)**

Courses objective:

1. To understand about the importance of interaction mechanics.
2. To understand the effect of soil-structure interaction on response of structural system.
3. To know the SSI modeling techniques and analysis.
4. To understand the design implications.

Course Content:

Unit-1
General soil-structure interaction problems, Contact pressures and soil-structure interaction for shallow foundations, Concept of sub grade modulus, effects/parameters influencing subgrade modulus. Soil behaviour, Foundation behaviour, Interface behaviour.

Unit-2
Scope of soil foundation interaction analysis, soil response models, Winkler, Elastic continuum, Two parameter elastic models, Elastic plastic behaviour, Time dependent behaviour. Isotropic elastic half space.

Unit-3
Beam on Elastic Foundation-Soil Models: Infinite beam, Two parameters, Analysis of beams of finite length, Classification of finite beams in relation to their stiffness. 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. Laterally Loaded Pile: Load deflection prediction for laterally loaded piles, Subgrade reaction and elastic analysis, Interaction analysis, Pile-raft system, Solutions through influence charts. Uplift capacity of piles and anchors.

Unit-4
Plate on Elastic Medium: Thin and thick plates, Analysis of finite plates, Numerical analysis of finite plates, simple solutions.

Unit- 5
Dynamic Soil Structure interaction, Inertial and Kinematic Interaction, Direct and substructure approach of model analysis, Dynamic stiffness, Dynamic equilibrium equation.

References:

Sl No.	Name of Book	Author	Publisher
1.	AdvancedGeotechnicalEngineeringSoil–Structure Interaction UsingComputer and Material Models	Chandrakant S. Desai Musharraf Zaman	CRC Press Taylor and Francis Group 2014
2.	Elastic Analysis of Soil-Foundation Interaction	SelvaDurai, A. P. S	Elsevier, 1979.
3.	Pile Foundation Analysis and Design	Poulos, H. G., and Davis, E. H.	Prentice Hall, 1981
4.	Structure Soil Interaction		State of Art Report, Institution of Structural Engineers, 1978
5	Suggested Analysis and Design Procedures for combined footings and Mats	ACI 336. (1988)	American Concrete Institute,1988.
6	Foundation Analysis	Scott, R. F.	Prentice-Hall
7	Dynamic Soil Structure Interaction	John P Wolf	Prentice-Hall Inc, Englewood Cliffs N.J

Course Outcome:

1. Students will be able to learn the behavior of whole system.
2. Students will be able to learn linear and nonlinear behavior of soil-structure system.
3. Students will be able to develop in depth idea about design of foundation.
4. Students will be able to learn both static and dynamic SSI based design.

To establish the co-relation between COs & POs

Table-1

No. of Course Outcome (CO)	Course Outcome
PCE22B02.1	Students will be able to learn the behavior of whole system.
PCE22B02.2	Students will be able to learn linear and nonlinear behavior of soil-structure system.
PCE22B02.3	Students will be able to develop in depth idea about design of foundation.
PCE22B02.4	Students will be able to learn both static and dynamic SSI based design.

Table-2

1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE22B02.1	3	2	3	2	2	2
PCE22B02.2	3	2	3	2	2	2
PCE22B02.3	3	2	3	2	2	2
PCE22B02.4	3	3	3	3	3	3
Total	12	9	12	9	9	9
Average	3	2.25	3	2.25	2.25	2.25
Equivalent Avg. Attainment	3	2	3	2	2	2

To establish the correlation between COs & PSOs
Table-3

CO	PSO1	PSO2
PCE22B02.1	3	3
PCE22B02.2	3	3
PCE22B02.3	3	3
PCE22B02.4	3	3
Total	**12**	**12**
Average	**3**	**3**
Equivalent Avg. Attainment	**3**	**3**

Elective Paper-III (Any one)

PCE22E01: Environmental Geotechnique
PCE22E02: Earthquake Geotechnical Engineering
PCE22E03: Computer Aided Design

ENVIRONMENTAL GEOTECHNIQUE (PCE22E01)

Total Credit: 04 **Contact Periods: 04 (3L+1T+0P)**

Courses Objective:

1. To understand the concept of soil as a multiphase system
2. To understand the concept of soil- environment interaction
3. To understand the concept of soil mineralogy
4. To understand the concept of soil-water-contaminant interaction
5. To understand the concept of unsaturated soil mechanics
6. To understand the concept of waste containment facilities
7. To understand the concept of advanced soil characterization techniques

Course Content:

Unit-1
Soil as a multiphase system; Soil-environment interaction; Properties of water in relation to the porous media; Water cycle with special reference to soil medium.

Unit-2
Soil mineralogy; significance of mineralogy in determining soil behaviour; Mineralogical characterization. Mechanisms of soil-water interaction: Diffuse double layer models; Force of attraction and repulsion;

Unit-3
Soil-water-contaminant interaction; Theories of ion exchange; Influence of organic and inorganic chemical interaction.

Unit-4
Introduction to unsaturated soil mechanics; water retention property and soil-water characteristic curve; flow of water in unsaturated soil.

Unit-5
Concepts of waste containment facilities; desirable properties of soil; contaminant transport and retention; contaminated site remediation.

Unit-6
Introduction to advanced soil characterization techniques; volumetric water content; gas permeation in soil; electrical and thermal properties; pore-size distribution; contaminant analysis, landfills liner systems.

References:

1. Mitchell, J. K and Soga, K Fundamentals of Soil Behavior, John Wiley and Sons Inc., 2005.
2. Fang, H-Y, Introduction to Environmental Geotechnology, CRC Press,1997.
3. Daniel, D. E, Geotechnical Practice for Waste Disposal, Chapman and Hall, 1993.
4. Rowe, R. K., Quigley, R. M. and Booker, Clay Barrier Systems for Waste Disposal Facilities, J. R., E & FN Spon, 1995.
5. Rowe, R. K, Geotechnical and Geoenvironmental Engineering Handbook, Kluwer Academic Publishers, 2001.
6. Reddi, L. N. and Inyang, H. F, Geoenvironmental Engineering-Principles and Applications, Marcel Dekker Inc, 2000.
7. Sharma, H. D. and Lewis, S. P, Waste Containment Systems, Waste Stabilization and Landfills: Design and Evaluation, John Wiley & Sons Inc., 1994.

Course Outcome:

1. Students will be able to understand the concept of soil as a multiphase system
2. Students will be able to understand the concept of soil- environment interaction
3. Students will be able to understand the concept of soil mineralogy
4. Students will be able to understand the concept of soil-water-contaminant interaction
5. Students will be able to understand the concept of unsaturated soil mechanics
6. Students will be able to understand the concept of waste containment facilities
7. Students will be able to understand the concept of advanced soil characterization techniques.

To establish the co-relation between COs &POs

Table-1: Numbering of COs

No. of Course Outcome (CO)	Course Outcome
PCE22E01.1	Students will be able to understand the concept of soil as a multiphase system
PCE22E01.2	Students will be able to understand the concept of soil-environment interaction
PCE22E01.3	Students will be able to understand the concept of soil mineralogy
PCE22E01.4	Students will be able to understand the concept of soil-water-contaminant interaction
PCE22E01.5	Students will be able to understand the concept of unsaturated soil mechanics
PCE22E01.6	Students will be able to understand the concept of waste containment facilities
PCE22E01.7	Students will be able to understand the concept of advanced soil characterization techniques

Table-2

1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE22E01.1	2	2	2	2	2	2
PCE22E01.2	3	2	2	2	2	2
PCE22E01.3	2	2	2	2	2	2
PCE22E01.4	3	2	2	2	2	2
PCE22E01.5	3	2	2	2	2	2
PCE22E01.6	2	2	2	2	2	2
PCE22E01.7	3	2	2	2	2	2
Total	18	14	14	14	14	14
Average	2.57	2	2	2	2	2
Equivalent Avg. Attainment	3	2	2	2	2	2

To establish the correlation between COs & PSOs
Table-3

CO	PSO1	PSO2
PCE22E01.1	3	3
PCE22E01.2	3	3
PCE22E01.3	3	3
PCE22E01.4	3	3
PCE22E01.5	3	3
PCE22E01.6	3	3
PCE22E01.7	3	3
Total	**21**	**21**
Average	**3**	**3**
Equivalent Avg. Attainment	**3**	**3**

EARTHQUAKE GEOTECHNICAL ENGINEERING
(PCE22E02)

Total Credit: 04 **Contact Periods: 04 (3L+1T+0P)**

Courses Objective:

1. To understand the necessity of geotechnical earthquake engineering
2. To understand the details of engineering seismology
3. To understand the concept of strong ground motion
4. To understand the concept of seismic hazard analysis
5. To understand the concept of ground response analysis
6. To understand the concept of liquefaction related phenomena
7. To understand the concept of seismic slope stability
8. To understand the seismic design considerations of retaining walls.

Course Content:

Unit-1

Introduction to Geotechnical Earthquake Engineering: Scope and objective; Nature and types of earthquake loading; Importance of Geotechnical Earthquake Engineering; Seismic hazards; Mitigation of seismic hazards.

Engineering Seismology: Causes of earthquake; Plate tectonics; Earthquake fault sources; Seismic waves; Elastic rebound theory; Quantification of earthquake; Intensity and magnitudes; Earthquake source models.

Unit-2

Strong Ground Motion: Introduction; Strong-motion measurement; Seismograph; Ground motion parameters and their estimation; Effect of local site conditions on ground motions; Design earthquake; Design spectra; Development of site specification and code-based design.

Seismic Hazard Analysis: Introduction; Identification and evaluation of earthquake sources; Deterministic seismic hazard analysis; Probabilistic seismic hazard analysis.

Unit 3

Wave Propagation: Introduction; Waves in unbounded media; Waves in a semi-infinite body; Waves in a layered body; Attenuation of stress waves.

Ground Response Analysis: Ground response analysis – One-dimensional ground response analysis: Linear approaches; Equivalent linear approximation of non-linear approaches; Computer code "SHAKE"; Two-dimensional ground response analysis; Three-dimensional ground response analysis.

Unit-4

Dynamic Soil Properties: Introduction; Measurement of Dynamic Soil Properties; Stress-strain behavior of cyclically loaded soils; Strength of cyclically loaded soils.

Liquefaction and Lateral Spreading: Liquefaction related phenomena; Liquefaction susceptibility: Historical, Geological, Compositional and State criteria; Evaluation of liquefaction by cyclic stress and cyclic strain approaches; Lateral deformation and spreading; Criteria for mapping liquefaction hazard zones.

Unit-5

Seismic Slope Stability: Internal stability and weakening instability.

Seismic Design Considerations of Retaining Walls: Dynamic Response of Retaining Walls; Seismic Design Considerations of Gravity Walls; Cantilever Walls; Braced Walls and Reinforced Soil Walls.

References:

Sl No.	Name of the Books	Authors	Publishers
1.	Geotechnical Earthquake Engineering	Steven L. Kramer	Prentice Hall
2.	Geotechnical Earthquake Engineering Handbook	Robert W. Day	McGraw Hill
3.	Geotechnical Earthquake Engineering	IkuoTowhata	Springer
4.	Soil Behaviour in Earthquake Geotechnics	Kenji Ishihara	Oxford University Press, USA
5.	Soil Dynamics	Shamsher Prakash	McGraw Hill
6.	Basic Geotechnical Earthquake Engineering	Kamalesh Kumar	New Age International (P) Limited, Publishers
7.	Seismic behaviour of ground and Geotechnical structure	Seco e Pinto	A. A. Balkema
8.	The Seismic Design Handbook	F. Naeim	Kluwer Academic Publication
9.	SPT-based Liquefaction Triggering Procedures	I. M. Idriss and Ross W. Boulanger	Center for Geotechnical Modeling, University of California
10.	IS 1893, Indian Standard Criteria for earthquake resistant Design of Structures	B.I.S.	B.I.S.

Additional Readings:

Journal and Conference papers in the area of Earthquake Geotechnical Engineering.

Course Outcome:

1. Students will be able to understand the necessity of geotechnical earthquake engineering
2. Students will be able to understand the details of engineering seismology
3. Students will be able to understand the concept of strong ground motion
4. Students will be able to understand the concept of seismic hazard analysis
5. Students will be able to understand the concept of ground response analysis
6. Students will be able to understand the concept of liquefaction related phenomena
7. Students will be able to understand the concept of seismic slope stability
8. Students will be able to understand the seismic design considerations of retaining walls.

To establish the co-relation between COs &POs

Table-1: Numbering of COs

No. of Course Outcome (CO)	Course Outcome
PCE22E02.1	Students will be able to understand the necessity of geotechnical earthquake engineering
PCE22E02.2	Students will be able to understand the details of engineering seismology
PCE22E02.3	Students will be able to understand the concept of strong ground motion
PCE22E02.4	Students will be able to understand the concept of seismic hazard analysis
PCE22E02.5	Students will be able to understand the concept of ground response analysis
PCE22E02.6	Students will be able to understand the concept of liquefaction related phenomena
PCE22E02.7	Students will be able to understand the concept of seismic slope stability
PCE22E02.8	Students will be able to understand the seismic design considerations of retaining walls

Table-2

1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE22E02.1	3	2	2	2	2	2
PCE22E02.2	3	3	2	2	2	2
PCE22E02.3	3	2	2	2	2	2
PCE22E02.4	3	2	2	2	2	2
PCE22E02.5	3	3	2	2	2	2
PCE22E02.6	3	3	2	2	2	2
PCE22E02.7	3	3	2	2	2	2
PCE22E02.8	3	3	2	2	2	2
Total	24	21	16	16	16	16
Average	3	2.62	2	2	2	2
Equivalent Avg. Attainment	3	3	2	2	2	2

To establish the correlation between COs & PSOs

Table-3

CO	PSO1	PSO2
PCE22E02.1	3	3
PCE22E02.2	3	3
PCE22E02.3	3	3
PCE22E02.4	3	3
PCE22E02.5	3	3
PCE22E02.6	3	3
PCE22E02.7	3	3
PCE22E02.8	3	3
Total	**24**	**24**
Average	**3**	**3**
Equivalent Avg. Attainment	**3**	**3**

COMPUTER AIDED DESIGN (PCE22E04)

Total Credit: 04 **Contact Periods: 04 (3L+1T+0P)**

Courses Objective:

1. To understand the principles of computer aided design
2. To understand the computer peripherals for CAD
3. To understand the three-dimensional transformations and projections
4. To understand the surface modeling
5. To understand the representation of 3D objects
6. To understand the computer aided drafting system.

Unit-1:
Principles of computer aided design, computer configuration for CAD applications, Computer peripherals for CAD. Computer graphics fundamentals, points and lines.

Unit-2:
Three-dimensional transformations and projections, plane curve, space curves surface descriptions and generation.

Unit-3:
Hidden line algorithms for wire-frame modeling, Surface modeling, Solid modeling, Representation of 3D objects. B-rep solid modelers and constructive solid geometry.

Unit-4:
CAD system utilization and application Hidden surface algorithms and Shading, Finite element systems, Computer aided drafting system.

References

1. D. F. Rogers, Mathematical elements for computer graphics, McGraw Hill, 1990.
2. D. F. Rogers, Elements of computer graphics, McGraw Hill International edition, 1998.
3. M. E. Mortenson, Geometric modelling, John Wiley and Sons, 1989.

Course Outcome:

1. Students will be able to understand the principles of computer aided design
2. Students will be able to understand the computer peripherals for CAD
3. Students will be able to understand the three-dimensional transformations and projections
4. Students will be able to understand the surface modeling
5. Students will be able to understand the representation of 3D objects
6. Students will be able to understand the computer aided drafting system.

To establish the co-relation between COs &POs

Table-1

No. of Course Outcome (CO)	Course Outcome
PCE22E04.1	Students will be able to understand the principles of computer aided design
PCE22E04.2	Students will be able to understand the computer peripherals for CAD
PCE22E04.3	Students will be able to understand the three-dimensional transformations and projections
PCE22E04.4	Students will be able to understand the surface modeling
PCE22E04.5	Students will be able to understand the representation of 3D objects
PCE22E04.6	Students will be able to understand the computer aided drafting system

Table-2

1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE22E04.1	3	2	2	2	2	2
PCE22E04.2	3	2	2	2	2	2
PCE22E04.3	3	2	2	2	2	2
PCE22E04.4	3	2	2	2	2	2
PCE22E04.5	3	2	2	2	2	2
PCE22E04.6	3	2	2	2	2	2
Total	18	12	12	12	12	12
Average	3	2	2	2	2	2
Equivalent Avg. Attainment	3	2	2	2	2	2

To establish the correlation between COs & PSOs
Table-3

CO	PSO1	PSO2
PCE22E04.1	3	3
PCE22E04.2	3	3
PCE22E04.3	3	3
PCE22E04.4	3	3
PCE22E04.5	3	3
PCE22E04.6	3	3
Total	**18**	**18**
Average	**3**	**3**
Equivalent Avg. Attainment	**3**	**3**

FOUNDATION DESIGN AND DRAWING
(PCE22P02)

Total Credit: 02 **Contact Periods: 04 (0L+0T+3P)**

Courses Objective:

1. To understand the Structural design & drawing of different types of footings
2. To understand the Structural design & drawing of different types of single piles
3. To understand the Structural design & drawing of different types of pile groups
4. To understand the Structural design & drawing of different types of pile caps
5. To understand the Structural design & drawing of different types of well foundations
6. To understand the Structural design & drawing of different types of retaining walls.

Course Content:

Unit-1

Structural design& drawing: individual footings, strip footing, combined footing, rigid and flexible mat, buoyancy raft, basement raft and detailing in each case,

Unit-2

Structural design& drawing: deep foundation: design of single pile and pile groups, pile cap design and detailing,

Unit-3

Structural design& drawing: design of well foundation,

Unit-4

Structural design& drawing: design of retaining wall including detailing, design of cantilever and anchored sheet pile walls and ring foundations.

Course Outcome:

1. Students will be able to understand the Structural design & drawing of different types of footings
2. Students will be able to understand the Structural design & drawing of different types of single piles
3. Students will be able to understand the Structural design & drawing of different types of pile groups
4. Students will be able to understand the Structural design & drawing of different types of pile caps
5. Students will be able to understand the Structural design & drawing of different types of well foundations
6. Students will be able to understand the Structural design & drawing of different types of retaining walls.

To establish the co-relation between COs &POs

Table-1

No. of Course Outcome (CO)	Course Outcome
PCE22P02.1	Students will be able to understand the Structural design & drawing of different types of footings
PCE22P02.2	Students will be able to understand the Structural design & drawing of different types of single piles
PCE22P02.3	Students will be able to understand the Structural design & drawing of different types of pile groups
PCE22P02.4	Students will be able to understand the Structural design & drawing of different types of pile caps
PCE22P02.5	Students will be able to understand the Structural design & drawing of different types of well foundations
PCE22P02.6	Students will be able to understand the Structural design & drawing of different types of retaining walls

Table-2

1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE22P02.1	2	3	2	2	2	2
PCE22P02.2	2	3	2	2	2	2
PCE22P02.3	2	3	2	2	2	2
PCE22P02.4	2	3	2	2	2	2
PCE22P02.5	2	3	2	2	2	2
PCE22P02.6	2	3	2	2	2	2
Total	12	18	12	12	12	12
Average	2	3	2	2	2	2
Equivalent Avg. Attainment	2	3	2	2	2	2

To establish the correlation between COs & PSOs

Table-3

CO	PSO1	PSO2
PCE22P02.1	3	3
PCE22P02.2	3	3
PCE22P02.3	3	3
PCE22P02.4	3	3
PCE22P02.5	3	3
PCE22P02.6	3	3
Total	**18**	**18**
Average	**3**	**3**
Equivalent Avg. Attainment	**3**	**3**

COMPUTER AIDED GEOTECHNICAL DESIGN LABORATORY (PCE22P03)

Total Credit: 02 **Contact Periods: 03 (0L+0T+3P)**

Course objective:

1. To understand about the use of different commercial software for solution of Geotechnical Engineering related problems.
2. To understand about the numerical modeling of Soil Structure Interaction problems.
3. To understand the idea on material modeling and FEM based numerical analysis.

Course Content:

Unit-1
Modelling and analysis of static and dynamic Soil Structure interaction problems using commercial software

Unit-2
Modelling and Design of Geotechnical structure (Shallow, Deep foundation, Retaining Wall etc.) using Finite element method (FEM) based software

Unit-3
Numerical modelling and static and dynamic Analysis of Slope Stability Problems

Unit-4
Geotechnical Report preparation based on SubSoil Design parameters and design of foundation preparation using CASTeR software

References

Sl No.	Name Of Book	Author	Publisher
1	PLAXIS 3D Foundation Version 2 user's manual, PLAXIS	Brinkgreve, R.B.J., Swolfs, W.M., Engine, E.,	The Netherlands: Delft Univ. of Technology. 2008
2	Abaqus/CAE User's Manual	-	DS Simulia 2008.
3	CASTeR User's Manual	-	TDS 2008
4	Foundation Analysis and Design	Bowels, J. E.	*The McGraw-Hill Companies*, Inc. (1997)
5	Stability Modeling with SLOPE/W 2007 Version, An Engineering Methodology	-	GEO-SLOPE International Ltd. (2008)

Course Outcome:

1. Students will be able to learn application of different commercial software to solve various geotechnical problems.
2. Students will be able to learn numerical modeling of Soil Structure Interaction problems.
3. Students will be able to develop idea on material modeling and FEM based numerical analysis.

To establish the correlation between COs & POs

Table-1

No. of Course Outcome (CO)	Course Outcome
PCE22P03.1	Students will be able to learn application of different commercial software to solve various geotechnical problems.
PCE22P03.2	Students will be able to learn numerical modeling of Soil Structure Interaction problems.
PCE22P03.3	Students will be able to develop idea on material modeling and FEM based numerical analysis.

Table-2
1: Slight (LOW) 2: Moderate (MEDIUM) 3: Substantial (HIGH) and '-' for NO CORELATION

CO	PO1	PO2	PO3	PO4	PO5	PO6
PCE22P03.1	3	3	3	2	2	2
PCE22P03.2	3	3	3	2	2	2
PCE22P03.3	2	2	2	2	2	2
Total	**8**	**8**	**8**	**6**	**6**	**6**
Average	**2.67**	**2.67**	**2.67**	**2**	**2**	**2**
Equivalent Avg. Attainment	**3**	**3**	**3**	**2**	**2**	**2**

To establish the correlation between COs & PSOs
Table-3

CO	PSO1	PSO2
PCE22P03.1	3	3
PCE22P03.2	3	3
PCE22P03.3	3	3
Total	**9**	**9**
Average	**3**	**3**
Equivalent Avg. Attainment	**3**	**3**

PROJECT PRELIMINARY
(PCE22P01)

Each student will be given a Thesis/Project problem at the beginning of Second Semester. They will work on the literature survey, scope of work, equipment development etc. and submit a report/dissertation. The main Thesis/Project work will, however, is done in Third and Fourth Semester.

COMPREHENSIVE VIVA-VOCE
(PCE22P04)

Viva-voce will be conducted for all the students at the end of the Second Semester in the department by the board of examiners constituted by the Geotechnical Engineering Section of Civil Engineering Department.

Third& Fourth Semester

Sl. No.	Subject	Credit	Class Hours per Week	Marks
	Third Semester			
1	**PCE23P01**: Project & Thesis - I	**10**	**-----**	**100**
	Fourth Semester			
1	**PCE23P04**: Project & Thesis - II	**20**	**-----**	**300**

Third Semester

Project & Thesis
(PCE23P01)

Each student will devote full time in the Third Semester on a Thesis/Project on an assigned research problem of Design/Development work under the supervision of a Faculty Member. They will present a part of the Thesis/Project Report at the end of the Third Semester which will be evaluated by a Board of Examiners consisting of the Supervisor and External Examiner. The evaluation of the abovesaid Thesis will be followed by a viva-voce in front of faculty members and other post-graduate students.

Fourt Semester

Project & Thesis
(PCE24P01)

Each student will devote full time in the Fourth Semester on a Thesis/Project on an assigned research problem of Design/Development work under the supervision of a Faculty Member. They will present a Final Thesis/Project Report at the end of the Fourth Semester which will be evaluated by a Board of Examiners consisting of the Supervisor and External Examiner. The evaluation of the above said Thesis will be followed by a viva-voce in front of faculty members and other post-graduate students.

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1/09/21