DEPARTMENT OF CIVIL ENGINEERING

ANNA UNIVERSITY, CHENNAI

OUR VISION:

Department of Civil Engineering, Anna University, shall strive hard to develop and impart technical knowledge and professional skills required for Civil Engineering practice through excellence in teaching, research, and consultancy to address sustainable infrastructure development needs at local, national, and international levels.

OUR MISSION:

Department of Civil Engineering, Anna University shall contribute to technological and social development by

1. Providing a firm scientific and technological base in Civil Engineering to achieve self- reliance.
2. Providing quality education through innovation in teaching practices at par with global standards.
3. Nurturing leadership and entrepreneurship qualities with ethical values.
4. Developing and disseminating latest knowledge and technologies in emerging areas of Civil Engineering.
5. Sharing intellectual resources and infrastructure facilities through collaborative partnership.
6. Ensuring supporting conditions for enhancing the employability skills.

ANNA UNIVERSITY, CHENNAI

UNIVERSITY DEPARTMENTS

REGULATIONS – 2023

CHOICE BASED CREDIT SYSTEM

M. E. SOIL MECHANICS AND FOUNDATION ENGINEERING (FULL-TIME)

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs) :

Graduates of the programme M. E., Soil Mechanics and Foundation Engineering will

PEO1 Gain knowledge and skills in geotechnical engineering which will enable them to have a professionally accomplishing career in public or private sector organizations.

PEO2 Become consultants on complex real-life problems related to geotechnical and geo-environmental engineering

PEO3 Become tech entrepreneurs capable of developing processes and technologies for sound, feasible and acceptable solutions to ensure the safety and stability of geotechnical infrastructure.

PEO4 Perform research-based investigations for solving geotechnical engineering problems using modern equipment and software tools.

PEO5 Function in multi-disciplinary teams to advocate policies, systems, processes and equipment for control and remediation of ground and foundation of structures.

Programme Outcomes (POs):

Graduates of the programme M. E., Soil Mechanics Foundation Engineering will be able to

PO1	Research Aptitude	An ability to independently carry out research /investigation and development work to solve practical problems.
PO2	Technical Documentation	An ability to write and present a substantial technical report/document.
PO3	Technical Competence	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	Knowledge of Geotechnical Engineering discipline	Demonstrate in-depth knowledge of Geotechnical Engineering discipline, with an ability to evaluate, analyze and synthesize existing and new knowledge.
PO5	Critical analysis of Geotechnical Engineering problems and innovation	Critically analyze complex Geotechnical Engineering problems, apply independent judgment for synthesizing information and make innovative advances in a theoretical, practical and policy context.
PO6	Conceptualization and evaluation of engineering solutions to geotechnical engineering issues	Conceptualize and solve Geotechnical Engineering problems, evaluate potential solutions, and arrive at technically feasible, economically viable and environmentally sound solutions with due consideration of safety.

Attested

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PEO / PO Mapping:

PROGRAMME EDUCATIONAL OBJECTIVES	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
PEO1	3	3	3	3	3	3
PEO2	3	3	3	3	3	3
PEO3	3	2	3	2	3	3
PEO4	3	1	3	2	2	3
PEO5	1	1	1	1	3	2

1- Low, 2 – Medium, 3 – High

MAPPING OF COURSE OUTCOME AND PROGRAMME OUTCOME

		Course Name	PO1	PO2	PO3	PO4	PO5	PO6
YEAR I	SEMESTER I	Advanced Mathematical Methods	2	3	3	2	2	2
		Soil Properties and Behaviour	3	3	3	3	3	3
		Constitutive Behaviour of Soils	2	1	2	3	3	2
		Subsurface Investigation and Instrumentation	2	1	3	3	3	2
		Computational Geomechanics	3	1	3	3	3	3
		Research Methodology and IPR	2	3	2	2	2	2
	SEMESTER II	Deep Foundations	3	1	2	3	3	3
		Earth and Earth Retaining Structures	2	1	3	2	3	3
		Finite Element Method in Geotechnical Engineering	3	3	3	3	3	3
		Shallow Foundations	3	1	3	3	2	3
		Professional Elective I						
		Professional Elective II						
		Soil Mechanics Laboratory	3	3	3	3	3	2
YEAR II	SEMESTER III	Professional Elective III						
		Professional Elective IV						
		Professional Elective V						
		Practical Training (4 weeks)	3	1	2	3	3	3
		Project Work I	2	3	3	2	2	2
	SEMESTER IV	Project Work II	3	3	3	3	3	2

1- Low, 2 – Medium, 3 – High

MAPPING FOR PROFESSIONAL ELECTIVE COURSES [PEC]

S. No.	Course Title	PO1	PO2	PO3	PO4	PO5	PO6
1.	Geoenvironmental Engineering	2	1	3	3	4	4
2.	Geology for Geotechnical Applications	2	1	2	2	2	2
3.	Pavement Analysis and Design	2	1	2	3	2	2
4.	Earthquake Resistant Design of Foundations	3	2	2	3	3	3
5.	Ground Improvement Techniques	3	1	2	3	3	3
6.	Soil Structure Interaction	3	2	3	2	2	3
7.	Dynamics of Soils and Foundations	3	1	3	3	3	3
8.	Geotechnical Earthquake Engineering	2	1	3	3	2	3
9.	Mechanics of Unsaturated Soils	2	1	2	3	2	3
10.	Geosynthetics and Reinforced Soil Structures	3	2	3	3	3	3
11.	Rock Mechanics and Applications	3	1	3	3	2	3
12.	Earth and Rock Fill Dams	2	1	3	3	2	3
13.	Geotechnics of Underground Structures	2	1	3	3	2	3
14.	Marine Geotechniques	3	1	2	3	3	2

• 1-low, 2-medium, 3-high

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UNIVERSITY DEPARTMENTS
M.E., SOIL MECHANICS AND FOUNDATION ENGINEERING (FULL-TIME)
REGULATIONS – 2023
CHOICE BASED CREDIT SYSTEM
CURRICULUM AND SYLLABI FOR SEMESTERS I TO IV

SEMESTER I

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA3153	Advanced Mathematical Methods	FC	4	0	0	4	4
2.	SF3101	Soil Properties and Behaviour	PCC	3	0	4	7	5
3.	SF3102	Constitutive Behaviour of Soils	PCC	3	0	0	3	3
4.	SF3103	Subsurface Investigation and Instrumentation	PCC	3	0	0	3	3
5.	SF3104	Computational Geomechanics	PCC	3	0	0	3	3
6.	RM3151	Research Methodology and IPR	RMC	2	1	0	3	3
			TOTAL	**18**	**1**	**4**	**23**	**21**

SEMESTER II

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	SF3201	Deep Foundations	PCC	3	0	0	3	3
2.	SF3202	Earth and Earth Retaining Structures	PCC	3	0	0	3	3
3.	SF3203	Finite Element Method in Geotechnical Engineering	PCC	3	0	4	7	5
4.	SF3204	Shallow Foundations	PCC	3	0	0	3	3
5.		Professional Elective I	PEC	3	0	0	3	3
6.		Professional Elective II	PEC	3	0	0	3	3
PRACTICALS								
7.	SF3211	Soil Mechanics Laboratory	PCC	0	0	4	4	2
			TOTAL	**18**	**0**	**8**	**26**	**22**

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SEMESTER III

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Professional Elective III	PEC	3	0	0	3	3
2.		Professional Elective IV	PEC	3	0	0	3	3
3.		Professional Elective V	PEC	3	0	0	3	3
PRACTICALS								
4.	SF3311	Practical Training (4 weeks)	EEC	0	0	0	0	2
5.	SF3312	Project Work I	EEC	0	0	12	12	6
			TOTAL	**9**	**0**	**12**	**21**	**17**

SEMESTER IV

S. NO.	COURSE CODE	COURSETITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	SF3411	Project Work II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL CREDITS TO BE EARNED FOR AWARD OF THE DEGREE: 72

FOUNDATION COURSES (FC)

S. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	MA3153	Advanced Mathematical Methods	4	0	0	4	I

PROFESSIONAL CORE COURSES (PCC)

S. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	SF3101	Soil Properties and Behaviour	3	0	4	5	I
2.	SF3102	Constitutive Behaviour of Soils	3	0	0	3	I
3.	SF3103	Subsurface Investigation and Instrumentation	3	0	0	3	I
4.	SF3104	Computational Geomechanics	3	0	0	3	I
5.	SF3201	Deep Foundations	3	0	0	3	II
6.	SF3202	Earth and Earth Retaining Structures	3	0	0	3	II
7.	SF3203	Finite Element Method in Geotechnical Engineering	3	0	4	5	II
8.	SF3204	Shallow Foundations	3	0	0	3	II
9.	SF3211	Soil Mechanics Laboratory	0	0	4	2	II
					TOTAL CREDITS	**30**	

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PROFESSIONAL ELECTIVE COURSES [PEC]

S. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS
			L	T	P	
1.	SF3001	Geoenvironmental Engineering	3	0	0	3
2.	SF3002	Geology for Geotechnical Applications	3	0	0	3
3.	SF3003	Pavement Analysis and Design	3	0	0	3
4.	SF3004	Earthquake Resistant Design of Foundations	3	0	0	3
5.	SF3005	Ground Improvement Techniques	3	0	0	3
6.	SF3006	Soil Structure Interaction	3	0	0	3
7.	SF3007	Dynamics of Soils and Foundations	3	0	0	3
8.	SF3008	Geotechnical Earthquake Engineering	3	0	0	3
9.	SF3009	Mechanics of Unsaturated Soils	3	0	0	3
10.	SF3010	Geosynthetics and Reinforced Soil Structures	3	0	0	3
11.	SF3011	Rock Mechanics and Applications	3	0	0	3
12.	SF3012	Earth and Rock Fill Dams	3	0	0	3
13.	SF3013	Geotechnics of Underground Structures	3	0	0	3
14.	SF3014	Marine Geotechniques	3	0	0	3

RESEARCH METHODOLOGY AND IPR COURSES (RMC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	RM3151	Research Methodology and IPR	2	1	0	3	I
					TOTAL CREDITS	3	

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1	SF3311	Practical Training (4 weeks)	0	0	0	2	III
2	SF3312	Project Work I	0	0	12	6	III
3	SF3411	Project Work II	0	0	24	12	IV
					TOTAL CREDITS	20	

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SUMMARY

	NAME OF THE PROGRAMME: M.E., SOIL MECHANICS AND FOUNDATION ENGINEERING					
S. NO.	**SUBJECT AREA**	**CREDITS PER SEMESTER**				**CREDITS TOTAL**
		I	**II**	**III**	**IV**	
1.	FC	04	00	00	00	04
2.	PCC	14	16	00	00	30
3.	PEC	0	06	09	00	15
4.	RMC	03	00	00	00	03
5.	EEC	00	00	08	12	20
6.	**TOTAL CREDIT**	**21**	**22**	**17**	**12**	**72**

MA3153 **ADVANCED MATHEMATICAL METHODS** **L T P C**
4 0 0 4

UNIT I ALGEBRAIC EQUATIONS 12

Systems of linear equations: Gauss Elimination method, pivoting techniques, Thomas algorithm for tridiagonal system – Jacobi, Gauss Seidel, SOR iteration methods - Systems of nonlinear equations: Fixed point iterations, Newton Method, Eigenvalue problems: power method, Faddeev – Leverrier Method

UNIT II LAPLACE TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS 12

Laplace transform: Definitions, properties -Transform of error function, Bessel's function, Dirac Delta function, Unit Step functions – Convolution theorem – Inverse Laplace Transform: Complex inversion formula – Solutions to partial differential equations: Heat equation, Wave equation

UNIT III FOURIER TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS 12

Fourier transform: Definitions, properties – Transform of elementary functions, Dirac Delta function– Convolution theorem – Parseval's identity – Solutions to partial differential equations: Heat equation, Wave equation, Laplace and Poison's equations.

UNIT I CALCULUS OF VARIATIONS 12

Concept of variation and its properties – Euler's equation – Functionals dependant on first and higher order derivatives – Functionals dependant on functions of several independent variables – Variational problems with moving boundaries -Direct methods – Ritz and Kantorovich methods.

UNIT V TENSOR ANALYSIS 12

Summation convention – Contravariant and covariant vectors – Contraction of tensors – Inner product – Quotient law – Metric tensor – Christoffel symbols – Covariant differentiation –Gradient, divergence and curl.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

CO1 On successful completion of the course, the students will be able to
CO2 get familiarized with the methods which are required for solving system of linear, Non linear equations and eigenvalue problems.
CO3 develop the mathematical methods of applied mathematics and mathematical physics
CO4 solve boundary value problems using integral transform methods apply the concepts of calculus of variations in solving various boundary value problems
CO5 familiarize with the concepts of tensor analysis.

REFERENCES:

1. Andrew L.C. and Shivamoggi B.K., "Integral Transforms for Engineers", Prentice Hall of India Pvt. Ltd., New Delhi, 2003.
2. Elsgolts L., "Differential Equations and the Calculus of Variations", MIR Publishers, Moscow, 2003.
3. Grewal B.S., "Higher Engineering Mathematics", Khanna Publishers, 44th Edition, New Delhi, 2017.
4. Gupta A.S., "Calculus of Variations with Applications", Prentice Hall of India Pvt. Ltd., New Delhi, 2004.
5. James G., "Advanced Modern Engineering Mathematics", Pearson Education, 4th Edition, Horlow, 2016.
6. Burden, R.L., and Faires, J.D., "Numerical Analysis – Theory and Applications", Cengage Learning, India Edition, New Delhi, 2010.
7. O'Neil P.V., "Advanced Engineering Mathematics", Thomson Asia Pvt. Ltd., 8th Edition, Singapore, 2017.

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9. Sankara Rao K., “Introduction to Partial Differential Equations”, Prentice Hall of India Pvt. Ltd., 3rd Edition, New Delhi, 2010.
10. Sastry S.S., "Introductory Methods of Numerical Analysis", Prentice - Hall of India Pvt. Limited, 5th Edition, New Delhi, 2012.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2

• 1-low, 2-medium, 3-high

SF3101 SOIL PROPERTIES AND BEHAVIOUR

L	T	P	C
3	0	4	5

UNIT I SOIL DEPOSITS AND CLAY MINERALS 8

Formation of soils – weathering process – different soil deposits and their engineering properties – Genesis of clay minerals – classification and identification – Anion and Cation exchange capacity of clays – specific surface area – bonding in clays – significance of index properties.

UNIT II PHYSICAL AND PHYSIO CHEMICAL BEHAVIOUR OF SOILS 9

Physical and physio chemical behaviour of soils – diffused double layer theory – computation of double layer distance – effect of ion concentration, ionic valency, pH, dielectric constant, temperature on double layer – stern layer – attractive and repulsive forces in clays – types of soil water – mechanism of soil – water interactions - soil fabric and structure.

UNIT III SWELLING, SHRINKAGE AND COMPACTION BEHAVIOUR OF SOILS 10

Swelling and shrinkage behaviour of soils – Causes, consequences, and mechanisms – factors influencing swell – shrink characteristics – swell potential – osmotic swell pressure – case studies – soil fabric and measurement – sensitivity, thixotrophy of soils – soil suction – soil compaction – factors affecting compaction of soil.

UNIT IV COMPRESSIBILITY, SHEAR STRENGTH AND PERMEABILITY BEHAVIOUR OF SOILS 10

Compressibility, shear strength and permeability behaviour of fine – and coarse-grained soils – mechanisms – factors influencing engineering properties – liquefaction of soil – causes and consequences – case studies.

UNIT V CONDUCTION PHENOMENA AND PREDICTION OF SOIL BEHAVIOUR 8

Conduction in soils – hydraulic, electrical, chemical, and thermal flows in soils – applications - coupled flows – Electro-kinetic process – thermo-osmosis - electro osmosis – prediction of engineering properties of soils using index properties – empirical equations and their applicability.

TOTAL: 45 PERIODS

LIST OF EXPERIMENTS

1. DETERMINATION OF INDEX PROPERTIES **12**

a. Specific gravity of soil solids
b. Grain size distribution – (Sieve analysis & Hydrometer analysis)
c. Liquid limit and Plastic limit tests
d. Shrinkage limit and Differential free swell tests

2. CHEMICAL TESTS **12**

a. pH and Conductivity
b. Quantification of CEC through flame Photometer
c. Determination of organic, sulphate and chlorite content

3. COMPACTION AND CBR TESTS **16**

a. Field density Test (Sand replacement method)
b. Determination of moisture – density relationship – Influence of compaction energy.
c. CBR Test

4. CONSOLIDATION AND PERMEABILITY TESTS **8**

a. Permeability determination (constant head and falling head methods)
b. One dimensional consolidation test (Determination of consolidation parameters)

5. SWELL TESTS **12**

Determination of percent swell – swell pressure by

a. Constant volume method
b. Expanded - loaded method
c. Double odometer test

TOTAL: 105 PERIODS

COURSE OUTCOMES:

- On successful completion of the course, the students will be able to

CO1 classify the suitable and unsuitable soil based on index properties and classification

CO2 understand the micro level understanding of the clay mineralogy and its intricacies and consequences apart from conventional procedures of handling fine- and coarse-grained soil

CO3 explain the peculiar behaviour of clays which exhibits extreme volume changes (Swelling and shrinkage) owing to the presence of swelling mineral, in addition to field reclamation geotechnical projects through compaction techniques

CO4 interpret the engineering behaviour of soils such as compressibility, permeability, and shear strength with index properties so as to design the safe foundation system.

CO5 understand the various geotechnical applications of conduction phenomenon which are of great significance in the case of ground contamination and decontamination, ground improvement methods and land reclamation projects

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REFERENCES:

1. Alam Singh and Chowdary, G.R., Soil Engineering in Theory and Practice (Vol.2) Geotechnical Testing and Instrumentation, CBS Publishers, and Distributors, NewDelhi, 2014.
2. Al-Khataji, A.W. and Anderstand, O.B., Geotechnical Engineering & Soil Testing, Sounders College Publishing, Fort Worth, 1992.
3. Bowles, J.E., Engineering properties of soils and their measurements, McGraw Hill, 2001.
4. Braja, M. Das, "Principles of Geotechnical Engineering", Cengage Learning, Tenth Edition, 2020.
5. Coduto, D.P., Geotechnical Engineering – Principles and practices, Prentice Hall of India Pvt. Ltd., New Delhi, 2002.
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9. I.S. Code of Practice (2720): Relevant Parts, as amended from time to time.
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11. Lambe T.W., Soil Testing for Engineers", John Wiley and Sons, New York, 1966.
12. Lambe, T.W. and Whitman, R.V. Soil Mechanics, Wiley India Pvt. Ltd., 2012.
13. McCarthy D.F., Essentials of Soil Mechanics & Foundations – Basic Geotechnics, Pearson India Education Services Pvt. Ltd., 2016.
14. Mitchell, J.K., Soga, K., Fundamentals of Soil Behaviour, John Wiley, 3rd Edition (Reprint) 2013.
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16. Perloff, W.H. and Baron, W, Soil Mechanics, The Ronal Press Company, 1976.
17. Yong, R.N. and Warkentin, B.P., Introduction to Soil Behaviour, Macmillan, Limited, London, 1979.
18. Robert D. Holtz., William D. Kovacs., Thomas C. Sheahan., "An Introduction to Geotechnical Engineering" Dorling Kindersley India Pvt. Ltd., Second edition, 2013.
19. Soil Engineering Laboratory Instruction Manual, Published by the Engineering College Cooperative Society, Chennai, 1996.
20. SP: 36 (Part I) – 1987, 'Compendium of Indian Standards on Soil Engineering', Bureau of Indian Standards, New Delhi.
21. SP: 36 (Part 2) – 1988, 'Compendium of Indian Standards on Soil Engineering', Bureau of Indian Standards, New Delhi.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	3	2
CO2	3	3	3	3	3	3
CO3	3	3	3	3	3	3
CO4	3	3	3	3	3	3
CO5	3	3	3	3	3	2
Avg	3	3	3	3	3	3

• 1-low, 2-medium, 3-high

SF3102 **CONSTITUTIVE BEHAVIOUR OF SOILS**

L	T	P	C
3	0	0	3

UNIT I SHEAR STRENGTH OF COHESIONLESS SOILS 9

Introduction-Shear strength of soil-cohesion-angle of internal friction-Shear strength of granular soils - Direct shear - Triaxial Testing- Drained and undrained Stress-strain behaviour - Dilation, contraction and critical states - Liquefaction and cyclic mobility of saturated sands. Factors influencing stress – strain characteristics – shear strength - field application.

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UNIT II SHEAR STRENGTH OF COHESIVE SOILS 9

Shear strength of normally consolidated and over consolidated clays - Stress-strain behaviour - Total stress and effective stress approach - Triaxial testing and stress path plotting - pore pressure parameters of Skempton and Henkel - shear strength of partially saturated clay in terms of stress state variables. Factors influencing stress – strain characteristics – shear strength - field application.

UNIT III FAILURE THEORIES 9

Concepts of yield and failure in soils- Failure theories of Von Mises, Tresca and their extended form, their applicability to soils - Detailed discussion of Mohr - Coulomb failure theory.

UNIT IV CONSTITUTIVE MODEL AND DEFORMATION MODULUS OF SOILS 9

Constitutive law for soil – linear, nonlinear model- hyperbolic idealisation – Mohr-Columb model- Hardening law-Hardening soil model- Hardening soil model with small strain stiffness- Soft soil - Soft soil model - limitation of all models- Deformation modulus for different type of loadings – Poisson's ratio.

UNIT V CRITICAL STATE SOIL MECHANICS 9

The critical state line- Roscoe's surface- Hvorslev's surface- Behavior of sand- Effects of dilation- Limitations of Taylor model- Elastic and plastic deformation-Camclay critical state model- Modified Camclay model- Parameters for design

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- On successful completion of the course, the students will be able to

CO1 Select the shear strength parameters of cohesionless soil based on mode of shear, drainage conditions and differentiate the cyclic stress – strain behaviour of cohesionless soil due to earthquake loading.

CO2 Select the shear strength parameters of cohesive soil based on mode of shear, drainage conditions, degree of saturation and degree of consolidation

CO3 Apply different failure criteria and its applicability based on drainage conditions and type of soil.

CO4 Apply constitutive models for soils and their applicability for different type of drainage conditions.

CO5 Explain critical state behaviour, modelling of soils and to select the respective design parameters.

REFERENCES:

1. Robert D. Holtz., William D. Kovacs., Thomas C. Sheahan., "An Introduction to Geotechnical Engineering" Dorling Kindersley India Pvt. Ltd., Second edition, 2013.
2. Braja, M, Das., "Advanced Soil Mechanics", CRC Press, fifth edition, 2019.
3. Atkinson J.H. and Brandsby P.L. "Introduction to critical state soil mechanics" McGraw Hill, 1978.
4. Lambe, T.W. and Whitman R.V. "Soil Mechanics in S.I. Units John Wiley, India, Pvt Ltd. 2008.
5. Wood, D.M., "Soil behaviour and Critical State Soil Mechanics", Cambridge University Press, New York, 1991.
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7. Braja, M. Das, "Principles of Geotechnical Engineering", Cengage Learning, Tenth Edition, 2020.
8. Malcolm D. Bolton, "A guide to soil mechanics", Universities Press (India) Private Ltd., Hyderabad, India, 2003.
9. Ian Smith, "Elements of Soil Mechanics", John Wiley & Sons, UK, 10th edition, 2021.
10. Braja, M. Das, "Fundamentals of Geotechnical Engineering", Cengage Learning, 2017.
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12. Punmia, B.C., Ashok K. Jain, Arun K. Jain, "Soil Mechanics and Foundations", Lakshmi Publications, seventeenth edition, 2017.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	2	3	2	2
CO2	2	-	2	3	2	2
CO3	2	-	2	3	3	3
CO4	2	-	2	3	3	3
CO5	2	2	2	3	3	2
Avg	2	1	2	3	3	2

• 1-low, 2-medium, 3-high

SF3103 SUBSURFACE INVESTIGATION AND INSTRUMENTATION

L	T	P	C
3	0	0	3

UNIT I PLANNING OF EXPLORATION AND GEOPHYSICAL METHODS 8

Scope and objectives, planning an exploration program, methods of exploration, exploration for preliminary and detailed design, spacing and depth of bores, data presentation. Geophysical exploration and interpretation, seismic method, Multichannel Analysis of Surface Waves *(*MASW*),* spectral analysis of surface waves (SASW) methods and electrical methods, cross hole– up hole - down hole methods.

UNIT II EXPLORATION TECHNIQUES 7

Methods of boring and drilling, non-displacement and displacement methods, drilling in difficult subsoil conditions, offshore drilling, limitations of various drilling techniques, stabilization of boreholes, bore logs.

UNIT III SOIL SAMPLING 8

Sampling Techniques – quality of samples – factors influencing sample quality - disturbed and undisturbed soil sampling advanced sampling techniques, offshore sampling, shallow penetration samplers, preservation, and handling of samples – Advanced Sampling for Rocks.

UNIT IV FIELD TESTING IN SOIL EXPLORATION 12

Field tests, penetration tests - SPT, SCPT, Field vane shear, Insitu shear and bore hole shear test, pressuremeter test, dilatometer test - plate load test–monotonic and cyclic; field permeability tests – block vibration test. Procedure, limitations, correction, and data interpretation of all methods.

UNIT V INSTRUMENTATION 10

Instrumentation in soil engineering, functional components of data acquisition system - strain gauges, resistance and inductance type, load cells, earth pressure cells, settlement and heave gauges, pore pressure measurements - slope indicators, sensing units, case studies.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- On successful completion of the course, the students will be able to

CO1 Plan the subsurface investigation program for a given project also capable of extending consultancy service for real time Soil Mechanics and Foundation Engineering problems.

CO2 Apply the knowledge of different methods of exploration to select appropriate method of boring for investigating real field condition.

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CO3 Apply the knowledge of different sampling techniques to collect, store and transport soil samples from onshore and offshore to meet specified needs and to characterize the soil.

CO4 Carryout appropriate field test to arrive at required soil parameters for the design of geotechnical structures considering all the influential parameters

CO5 Plan the instrumentation programme, execute the same in the field and monitor the performance of geotechnical structures to ensure its stability during its life time. Also conduct research pertinent to soil mechanics and foundation engineering as well as engage in independent life-long learning

REFERENCES:

1. Hunt, R.E., Geotechnical Engineering Investigation Handbook, CRC Press, 2005.
2. Winterkorn, H.F. and Fang, H.Y., Foundation Engineering Hand Book, a Nostrand Reinhold 1994.
3. Alam Singh and Chowdhary, G.R., Soil Engineering in Theory and Practice, Volume-2, Geotechnical testing and instrumentation, CBS Publishers and Distributors, New Delhi, 2006.
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5. Dunnicliff, J., and Green, G.E., Geotechnical Instrumentation for Monitoring Field Performance, John Wiley, 1993.
6. Hanna, T.H., Field Instrumentation in Geotechnical Engineering, Trans Tech., 1985.
7. Day, R.N., Geotechnical and Foundation Engineering, Design and Construction, McGraw-Hill, 1999.
8. Bowles, J.E., Foundation Analysis and Design, Fifth Edition, The McGraw-Hill companies, Inc., New York, 2001.
9. Clayton C. R. I., Matthews M. C. and Simons N. E., Site Investigation, Second Edition Halsted Press, 1982

SF3104	**COMPUTATIONAL GEOMECHANICS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

UNIT I THEORY OF ELASTICITY 9

Basic Concepts –Mechanics of continua: Stress and strain - concept of stress and strain – Three dimensional and two-dimensional state of stress – Plane stress, plane strain and axisymmetric problems – equilibrium and compatibility conditions, constitutive relations, stress functions – Two dimensional problems in Cartesian and polar co-ordinates.

UNIT II STRESS AND DISPLACEMENT 9

Elastic half-space medium – Stress by external loads – Isotropic, anisotropic, and non-homogeneous elastic continuum – Boussinesq, Frochlich, Westergaard solutions for force on the surface of semi-infinite medium –solutions by influence charts – Elastic displacement – Layered soil.

UNIT III THEORY OF PLASTICITY 9

Perfect plastic material- theory of plasticity – Hardening law, flow rule. Theorem of plastic collapse – bound theorems – Mechanism for plane plastic collapse – slip fans, stress fans – discontinuities – Simple solutions for undrained and drained loading – Stability of foundations and retaining walls.

UNIT IV FLOW THROUGH POROUS MEDIA 9

Flow through porous media – Darcy's law – General equation of flow, seepage through isotropic anisotropic and non-homogeneous conditions – Steady state condition, confined and unconfined flow – solution by flow net – seepage pressure – piping.

UNIT V RISK ANALYSIS IN GEOMECHANICS 9

Spatial variability and random field theory - soil variability and uncertainty quantification- Simple probabilistic methods for reliability analysis in geotechnical engineering - Reliability based design in geotechnical engineering.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- On successful completion of the course, the students will be able to

CO1 Explain the basic concept of elasticity, understand the mechanics of continuum, and solve field problems.

CO2 Analyse stress distribution and displacement in homogeneous, nonhomogeneous, and anisotropic soil medium under the given loading conditions.

CO3 Explain the basic concept of plasticity, understand the mechanism of collapse, and solve field problems.

CO4 Understand the liquid flow theory, analyse the flow of liquid in different soil medium and verify the stability of geotechnical engineering problems

CO5 Analyse various parameters using probabilistic methods and perform reliability-based design in geotechnical engineering related problems

REFERENCES:

1. Aysen, A., Problem solving in Soil Mechanics, Taylor & Francis, London, First Indian Print, 2011.
2. Chowdhury, I., Dasgupta S.P., Dynamics of Structure and Foundations, Taylor & Francis Group, London, 2009.
3. Bolton, M.D; A Guide to Soil Mechanics, University press (India) Pvt.Ltd., 2009
4. Atkinson, J.H; The Mechanics of Soils and Foundations, Taylor and Francis, London, 2007.
5. Aysen, A., Soil Mechanics, Basic concepts and Engineering Applications, A.A.Balkema Publishers, 2002.
6. Ulrich Smoltc, YK, Geotechnical Engineering Handbook (Vol.1), Ernot&Sohn, 2003.
7. Muni Budhu, Soil Mechanics and Foundations, John Wiley and Sons, Inc., Network, 2011.
8. Cedergren, H.R., Seepage, Drainage and Flownets, John Wiley, 1997.
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11. Atkinson, J.H., Foundations and Slopes, McGraw Hill, 1981.
12. Kok-Kwang PhoonJianyeChing., Risk and Reliability in Geotechnical Engineering, CRC Press, Taylor and Francis Group, 2015.
13. Gordon A. Fenton and D. V. Griffiths, Risk Assessment in Geotechnical Engineering, John Wiley and Sons, Inc., 2008.
14. Gregory B. Baecher and John T. Christian, Reliability and Statistics in Geotechnical Engineering, John Wiley and Sons, Inc., 2003.
15. Braja M. Das, 'Advanced Soil Mechanics', 4th edition, CRC Press Taylor & Francis Group, 2014.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	3	3	2	3
CO2	3	-	2	2	3	2
CO3	3	-	3	3	2	3
CO4	2	-	3	3	3	2
CO5	3	2	2	2	3	3
Avg	**3**	**1**	**3**	**3**	**3**	**3**

• 1-low, 2-medium, 3-high

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RM3151 RESEARCH METHODOLOGY AND IPR **L T P C**
2 1 0 3

UNIT I RESEARCH PROBLEM FORMULATION 9
Objectives of research, types of research, research process, approaches to research; conducting literature review- information sources, information retrieval, tools for identifying literature, Indexing and abstracting services, Citation indexes, summarizing the review, critical review, identifying research gap, conceptualizing and hypothesizing the research gap

UNIT II RESEARCH DESIGN AND DATA COLLECTION 9
Statistical design of experiments- types and principles; data types & classification; data collection - methods and tools

UNIT III DATA ANALYSIS, INTERPRETATION AND REPORTING 9
Sampling, sampling error, measures of central tendency and variation,; test of hypothesis- concepts; data presentation- types of tables and illustrations; guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript; guidelines for writing thesis, research proposal; References – Styles and methods, Citation and listing system of documents; plagiarism, ethical considerations in research

UNIT IV INTELLECTUAL PROPERTY RIGHTS 9
Concept of IPR, types of IPR – Patent, Designs, Trademarks and Trade secrets, Geographical indications, Copy rights, applicability of these IPR; , IPR & biodiversity; IPR development process, role of WIPO and WTO in IPR establishments, common rules of IPR practices, types and features of IPR agreement, functions of UNESCO in IPR maintenance.

UNIT V PATENTS 9
Patents – objectives and benefits of patent, concept, features of patent, inventive steps, specifications, types of patent application; patenting process - patent filling, examination of patent, grant of patent, revocation; equitable assignments; Licenses, licensing of patents; patent agents, registration of patent agents.

TOTAL: 45 PERIODS

COURSE OUTCOMES
Upon completion of the course, the student can
CO1: Describe different types of research; identify, review and define the research problem
CO2: Select suitable design of experiment s; describe types of data and the tools for collection of data
CO3: Explain the process of data analysis; interpret and present the result in suitable form
CO4: Explain about Intellectual property rights, types and procedures
CO5: Execute patent filing and licensing

REFERENCES:

1. Cooper Donald R, Schindler Pamela S and Sharma JK, “Business Research Methods”, Tata McGraw Hill Education, 11e (2012).
2. Soumitro Banerjee, “Research methodology for natural sciences”, IISc Press, Kolkata, 2022,
3. Catherine J. Holland, “Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets”, Entrepreneur Press, 2007.
4. David Hunt, Long Nguyen, Matthew Rodgers, “Patent searching: tools & techniques”, Wiley, 2007.
5. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, “Professional Programme Intellectual Property Rights, Law and practice”, September 2013.

SF3201 **DEEP FOUNDATIONS**

	L	T	P	C
	3	0	0	3

UNIT I PILE CLASSIFICATIONS AND LOAD TRANSFER PRINCIPLE **10**

Necessity of pile foundation – classification of piles – Factors governing choice of type of pile – Load transfer mechanism – piling equipment and methods – effect of pile installation on soil condition – pile raft system – basic interactive analysis - criteria for pile socketing - responsibility of engineer and contractor.

UNIT II AXIAL LOAD CAPACITY OF PILES AND PILE GROUP **10**

Allowable load capacity of piles and pile groups – Static and dynamic methods – for cohesive and cohesionless soil – negative skin friction – group efficiency – limitation – Wave equation application – evaluation of axial load capacity from field test results – pile integrity test – Settlement of piles and pile group –IS codal provisions and IRC guide lines – case studies.

UNIT III LATERAL AND UPLIFT LOAD CAPACITIES OF PILES **10**

Piles under Lateral loads – Broms method, elastic, p-y curve analyses – Batter piles – response to moment – piles under uplift loads – under reamed piles – Drilled shaft – Lateral and pull-out load tests – pile load test – IS codal provision – IRC guide lines – case studies.

UNIT IV STRUCTURAL DESIGN OF PILE AND PILE GROUP **9**

Structural design of pile – structural capacity – pile and pile cap connection – pile cap design – shape, depth, assessment, and amount of steel – truss and bending theory – Reinforcement details of pile and pile caps – pile subjected to vibration – IS codal provision – IRC guide line.

UNIT V CAISSONS **6**

Necessity of caisson – type and shape - Stability of caissons – principles of analysis and design – tilting of caisson – construction - seismic influences - IS codal provision.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- On successful completion of the course, the students will be able to

CO1 Explain the importance of pile foundation and various functions and responsibilities of geotechnical engineer and contractor, in addition to the piling equipment.

CO2 Determine the vertical load carrying capacity of pile and pile group- keeping the settlement of pile as an important criterion based on field practices and codal provisions.

CO3 Apart from vertically loaded piles, the structures are exposed to the peculiar pile subjected to lateral and uplift load with reference to codal provision and case studies.

CO4 Understand the design of pile and pile caps, considering the wind and seismic loads.

CO5 Explain the importance of caisson foundation and checking the stability of caissons based on codal provisions.

REFERENCES:

1. Das, B.M., Principles of Foundation Engineering, Cengage Learning India Pvt. Ltd. 2016.
2. Poulos, H.G., Davis, E.H., Pile foundation analysis and design, John Wiley and Sons, New York, 1980.
3. Tomlinson, M.J. Pile Design and Construction Practice, 4th Edition, Spon Press, New York, 2004.
4. Cernica, J.N. Geotechnical Engineering Foundation Design, John Wiley and Sons, Inc. 1995.
5. Bowles, J.E., Foundation Analysis and Design, Fifth Edition, McGraw Hill, New York, 2001.
6. Donald, P., Coduto, Foundation Design Principles and Practices, Pearson India Education Services Pvt. Ltd., 2014.
7. Varghese P.C.," Foundation Engineering", PHI Learning Private Limited, New Delhi, 2012.
8. Reese, L.C., Isenhower, W.M. and Wang, S.T. Analysis and Design of Shallow and Deep Foundations, John Wiley and Sons, New York, 2005.

9. Varghese P.C.," Limit State Design of Reinforced Concrete Foundations", PHI Learning Private Limited, New Delhi, 2011.
10. Reese, L. C. and Van Impe, W. F., Single Piles and Pile Groups Under Lateral Loading, Taylor and Francis, London, 2011.
11. Satyendra Mittal, Pile Foundation – Design and Construction including Well Foundation, CBS Publishers and Distributers Pvt. Ltd., 2019.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	2	3	3	2
CO2	3	2	2	2	2	3
CO3	3	-	2	3	2	3
CO4	2	-	2	2	3	2
CO5	3	-	2	3	3	3
Avg	**3**	**1**	**2**	**3**	**3**	**3**

1-low, 2-medium, 3-high

SF3202 EARTH AND EARTH RETAINING STRUCTURES

L	T	P	C
3	0	0	3

UNIT I EARTH PRESSURE THEORIES **10**

State of stress in retained soil mass – Earth pressure theories – Classical and graphical techniques (Culmann's method) – Active and passive cases – Earth pressure due to external loads.

UNIT II STABILITY OF RETAINING STRUCTURES **8**

Retaining structure – Selection of soil parameters - Lateral pressure due to compaction, strain softening, wall flexibility, drainage arrangements and its influence. – Stability analysis of retaining structure both for regular and earthquake forces.

UNIT III SHEET PILE WALLS **8**

Types of sheet piles - Analysis and design of cantilever and anchored sheet pile walls – free earth support method – fixed earth support method. Design of anchor systems - isolated and continuous.

UNIT IV SUPPORTED EXCAVATIONS **9**

Lateral pressure on sheeting in braced excavation, stability against piping and bottom heaving. Earth pressure around tunnel lining, shaft, and silos – Soil anchors – Soil pinning – Basic design concepts - Slurry Supported Trenches-Basic principles – Slurry characteristics – Specifications – Diaphragm walls – stability Analysis – Combi-wall.

UNIT V STABILITY OF SLOPES **9**

Stability of infinite and finite slopes, Limit Equilibrium method, Wedge analysis, Method of Slices, Bishop's method, Janbu's method etc. Special aspects of slope analysis, stability charts.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- On successful completion of the course, the students will be able to

CO1 Analyse the earth pressure acting on retaining structures by applying classical theories considering all influencing parameters and suggest the earth pressure to be considered for the design of retaining structures.

CO2 Apply the knowledge of engineering and earth pressure to analyse and design rigid retaining structures considering effect of compaction, wall flexibility, pore water pressure and earth quake forces.

CO3 Apply the knowledge of engineering and earth pressure to analyse and design flexible earth retaining walls and acquire the knowledge of design of anchors

CO4 Apply the knowledge on lateral earth pressure behind and around excavation to analyse and design braced excavations, slurry supported excavations and underground utilities.

CO5 Analyse the stability of infinite and finite slopes through total stress and effective stress analysis by considering the actual shape of failure surface expected in the field.

REFERENCES:

1. Clayton, C.R.I., Militisky, J. and Woods, R.I., Earth pressure and Earth-Retaining structures, Third Edition, CRC Press Taylor & Francis Group, 2013.
2. Das, B.M., Principles of Geotechnical Engineering, Eighth Edition, Cengage Learning, 2014.
3. Militisky, J. and Woods, R., Earth and Earth retaining structures, Third Edition, CRC Press Taylor & Francis Group, 2013.
4. Winterkorn, H.F. and Fang, H.Y., Foundation Engineering Handbook, Galgotia Book-source, 2010.
5. Rowe, R.K., Geotechnical and Geoenvironmental Engineering Handbook, Springer Science & Business Media, 2012.
6. Koerner, R.M. Designing with Geosynthetics, Fifth Edition, Pearson College Div, 2005.
7. Day, R.W., Geotechnical and Foundation Engineering: Design and Construction, McGraw Hill, 1999.
8. Mandal, J.N., Reinforced Soil and Geotextiles, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 1993.
9. McCarthy, D.F., Essentials of Soil Mechanics and Foundations: Basic Geotechnics, Seventh Edition, Prentice Hall, 2006.
10. Hajnal, I., Marton, J. and Regele, Z., Construction of diaphragm walls, A Wiley – Interscience Publication, 1984.
11. Petros P. Xanthakos., Slurry walls as structural systems, McGraw-Hill, Inc., New York, 2016.
12. Bramhead, E.N., The Stability of Slopes, Blacky Academic and Professionals Publications, Glasgow, 1986.
13. Muni Budhu, Soil Mechanics and Foundation, John Wiley and Sons, INC 2007.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	3	3	3
CO2	2	-	2	2	2	2
CO3	2	-	2	2	2	2
CO4	2	-	3	3	3	3
CO5	2	2	3	2	3	3
Avg	**2**	**1**	**3**	**2**	**3**	**3**

1-low, 2-medium, 3-high

Attested

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SF3203	FINITE ELEMENT METHOD IN GEOTECHNICAL ENGINEERING	L	T	P	C
		3	0	4	5

UNIT I BASIC CONCEPTS 9

Basic concepts - discretization of continuum, typical elements, the element characteristic matrix, element assembly and solution for unknowns – applications. variational principles, variational formulation of boundary value problems, variational methods of approximation such as Ritz and weighted residual (Galerkin) methods.

UNIT II DISPLACEMENT MODELS 9

Displacement based elements - element equations, convergence requirements, shape functions – element stresses and strains – element stiffness matrix - global equations – boundary conditions – solution of global equations – finite elements for axi-symmetric problem – one dimensional problem of stresses and strains – finite element analysis for two – dimensional problems.

UNIT III ISOPARAMETRIC FORMULATION 8

Isoparametric element - Local and Natural Co-ordinates systems, Line, Triangular, Quadrilateral and Tetrahedral Element-Interpolation - Displacement Models Formulation of Isoparametric - Finite element matrices in Local and Global Coordinate system – refined elements – numerical integration techniques.

UNIT IV GEOTECHNICAL CONSIDERATIONS 9

Total stress analysis – pore pressure calculation – FEM to model structural components, strain definitions, constitutive equation, finite element formulation, membrane elements – Finite elements to model interfaces – basic theory – finite element formulation – boundary conditions – finite element theory for nonlinear behaviour of soils.

UNIT V APPLICATION IN GEOTECHNICAL ENGINEERING 10

Use of FEM to problems in soils – description and application to consolidation – seepage - FEM to simulate soil – structure interaction problems – finite element theory for simulating and analyzing the real foundation problem such as footing, pile foundation and deep excavations.

DESIGN STUDIO LAB 60

Students must work individually with software packages for simulating and analyzing the various geotechnical engineering problems;

- Soil – structure interaction such as Foundations and Retaining walls
- Ground improvement related problems.
- Analyze and design real challenging problems - deep excavation – impact on adjacent structures
- Stability analysis of slope and embankment - surcharge adjacent to an existing structure

A detailed report on the work done should be submitted by individual students at least 10 days before the last working day of the semester. The students will be evaluated through a viva-voce examination by a team of internal staff.

TOTAL: 105 PERIODS

COURSE OUTCOMES:

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

CO1 understand the basic concept in finite element method using variational principles

CO2 differentiate various types of displacement models, select suitable finite element model and able to solve geotechnical problems

CO3 understand the basic concept of isoparametric finite element formulation and its use in solving geotechnical related problems

CO4 consider the various geotechnical concept in the finite element formulations including interfacial behavior

CO5 develop finite element formulation for different geotechnical engineering related problems

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REFERENCES:

1. Cook, R.D., Malkus, D.S., and Plesha, M.E., Concepts and applications of finite element analysis, 4^{TH} Edition, John Wiley, New York., 2001.
2. Desai and Abel, Introduction to the finite element method, Van Nostrand Reinhold Company, New York, 1972.
3. Krishnamoorthy.C.S., Finite element analysis Theory and Programming, Tata McGraw-Hill, New Delhi, 1990.
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5. Zienkiewicz, O.C., The Finite Element Method, 5^{th} Edition, Tata McGraw-Hill publishing Co., New Delhi, 2000.
6. Logan, D.L., A First Course in the Finite Element Method, 6^{th} edition, Cengage-Learning, United States, 2015.
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10. Reddy, J.N., An introduction to the finite element method, McGraw Hill, New York, 2017.
11. Rao, S.S., The Finite Element Methods in Engineering, Pergamon, New York, 1998.
12. Zienkiewicz, O. C., Taylor, R. L. and Zhu, J. Z., The Finite Element Method Its Basis and Fundamentals, Elsevier, Amsterdam, 2014.
13. Shen, J. and Kushwahs, R.L., Soil-machine introduction – A finite element perspective, Moral Dikker, Inc., 1998.
14. Smith, I.M., Programming the Finite Element Method with application to Geomechanics, 5^{th} Edition, John Wiley and Sons Ltd, 2014.
15. Web link for open source and shareware software using the link http://www.ggsd.com.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	2	2	2
CO2	3	3	3	3	3	3
CO3	3	3	2	2	3	3
CO4	2	3	3	3	2	2
CO5	2	3	2	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**3**

1-low, 2-medium, 3-high

SF3204	SHALLOW FOUNDATIONS	L	T	P	C
		3	0	0	3

UNIT I FOUNDATION DESIGN DECISIONS 6

Geotechnical triangle – Geotechnical design triangle – Types of foundation – Types of Shallow foundation, their applicability – Selection of type of foundation – conceptual design principles – General and additional considerations – Depth of foundations – Hostile Environment – holistic approach – circumstances.

Attested

UNIT II BEARING CAPACITY 9

Theories of bearing capacity – Ultimate Bearing capacity - Homogeneous - Layered soils – Rocks - Evaluation of bearing capacity from in-situ tests – Safe bearing capacity – Bearing capacity of foundations in slope – Bearing capacity under eccentric loading –partial safety factor approach - Serviceability criteria - Codal provisions.

UNIT III SETTLEMENT AND ALLOWABLE BEARING PRESSURE 9

Component of settlement – Influence of foundation stiffness approach to settlement computations - immediate, primary, and secondary consolidation settlement - stress path method of settlement evaluation - layered soil - construction period correction- Serviceability criteria. Evaluation from in-situ tests – Allowable settlement – Allowable bearing pressure - Serviceability criteria - codal provisions.

UNIT IV INTERACTIVE ANALYSIS AND DESIGN OF FOUNDATIONS 12

Analysis of foundation - isolated - strip - combined footings - Flat raft – Stiffened raft foundations. Conventional - elastic approach - Soil Structure Interaction Principles – Winkler foundation – Elastic half space approach – Structural design of Shallow foundation – Codal provisions.

UNIT V FOUNDATION FOR SPECIAL CONDITIONS 9

Shell foundations - Foundation design in relation to ground movements - Foundation on compressible fills – Foundation for tower – Foundation for earthquake effects – bucket foundation – Machine foundation - Codal Provisions.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- On successful completion of the course, the students will be able to

CO1 Differentiate different type of shallow foundations, their selection, design principles for different ground conditions

CO2 Apply appropriate bearing capacity theory and factors for different type of loading and ground conditions

CO3 Decide the design bearing pressure based on settlement, mode of loading and ground conditions

CO4 Perform interactive analysis for different types of shallow foundation and ground conditions

CO5 Perform analysis for different types of special foundation and special ground conditions

REFERENCES:

1. Bowles, J.E., "Foundation Analysis and Design, 5th Edition, McGraw Hill, New York, 1995.
2. Swami Saran, "Soil Dynamics and Machine Foundation, Galgottia Publications Pvt. Ltd., New Delhi-110002, 1999.
3. Nainan P. Kurian, "Design of Foundation Systems, Principles and Practices, Narosa Publishing House, Third Edition, 2006.
4. Ian Smith, “Elements of Soil Mechanics”, John Wiley & Sons, UK, 9th edition,2014
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6. Edward Tsudik, Analysis of Structures on Elastic Foundations, J.Ross Publishing, Cengage Learning India Private limited, Delhi, 2013.
7. Som.N.N., Das.S.C., “Theory and Practice of Foundation Design” PHI learning private Ltd, Delhi, 2013.
8. Karuna Moy Ghosh, “Foundation Design in Practice” PHI learning private Ltd, Delhi, 2009.
9. Varghese, P.C. "Design of Reinforced Concrete Foundations”, Prentice-Hall of India, New Delhi, 2009.
10. Reese,L.C., Isenhower,W.M. and Wang,S.T. Analysis and Design of Shallow and Deep Foundations, John Wiley and Sons, New York, 2005.
11. John Burland, Tim Chapman, Hilary Skinner, Michael Brown., “Geotechnical Design Construction and verification – ICE Manual of Geotechnical Engineering volume-II” ICE Publishing, UK., 2012.

Attested

12. Salgado,R., "The Engineering of Foundations", Tata McGraw Hill Education Private Limited, New Delhi, 2011.
13. Donald P. Coduto, ‘ Foundation Design: Principles and Practices’, 2nd edition,
14. BrajaM.Das., “Shallow foundation - Bearing capacity and settlement”, CRC Press, third edition, 2017.
15. Varghese, P.C. "Design of Reinforced Concrete Foundations”, Prentice-Hall of India, New Delhi, 2009.

CO - PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
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CO3	3	-	3	3	3	3
CO4	3	2	2	3	2	3
CO5	2	2	2	2	2	3
Avg	**3**	**1**	**3**	**3**	**2**	**3**

1-low, 2-medium, 3-high

SF3211 **SOIL MECHANICS LABORATORY**

L	T	P	C
0	0	4	2

UNIT I SHEAR STRENGTH TESTS **12**

Direct shear – Triaxial compression (UU, CU, and CD) test – Unconfined compression test –Vane shear test.

UNIT II SUCTION TESTS **8**

Soil water characteristic curves of soil by Pressure Plate apparatus – Filter paper technique.

UNIT III TEST ON GEOSYNTHETICS **12**

Opening size of Geotextiles – Tensile strength of Geosynthetic materials – Interfacial friction – Permeability

UNIT IV TEST ON ROCKS **12**

Point load index – Brazilian test – Direct shear test – Uniaxial compressive strength test

UNIT V MODEL AND FIELD TESTS (demonstration only) **16**

Model test on foundation elements - strain gauges - load cells. Field tests - Plate load test – static cone penetration test – standard penetration test – pressure meter test - Block vibration test – Cyclic triaxial test.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

- On successful completion of the course, the students will be able to

CO1 assess the shear strength of soils by conducting appropriate tests
CO2 analyse the soil water characteristic curves of different soils
CO3 analyse and assess the characteristics of soils using the geosynthetics
CO4 evaluate the strength characteristics of rocks
CO5 Understand the concept of conducting model tests and use data acquisition system for conducting model test in laboratory

REFERENCES:

1. Alam Singh and Chowdary, G.R., Soil Engineering in Theory and Practice (Vol.2) Geotechnical Testing and Instrumentation, CBS Publishers and Distributors, NewDelhi,2006.
2. Head, K.H., Manual of Soil Laboratory Testing Vol.I and II, Pentech Press, London 1990.
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5. Kameswara Rao, N.S.V., Dynamics Soil Tests and Applications, Wheeler Publishing, New Delhi, 2000.
6. Das, B.M., Soil Mechanics Laboratory Manual, Engineering Press, Austin,1997
7. Al-Khataji, A.W. and Anderstand, O.B., Geotechnical Engineering & Soil Testing, Sounders College Publishing, Fort Worth, 1992.
8. Koerner, R.M., Designing with Geosynthetics, Third Edition, Prentice Hall, 1997.
9. "Soil Engineering Laboratory Instruction Manual", Published by the Engineering College Co-operative Society, Chennai, 1996.
10. Lambe T.W., Soil Testing for Engineers", John Wiley and Sons, New York, 1990.
11. I.S. Code of Practice (2720): Relevant Parts, as amended from time to time.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	3	3	3	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	3
CO4	3	3	3	3	3	2
CO5	2	3	2	2	3	2
Avg	**3**	**3**	**3**	**3**	**3**	**2**

1-low, 2-medium, 3-high

SF3311 **PRACTICAL TRAINING (4 WEEKS)**

L	T	P	C
0	0	0	2

SYLLABUS:

- Students individually undertake training in reputed Soil Mechanics and Foundation Engineering Companies during the summer vacation for a specified period of four weeks.
- Students allowed to get field exposure and effectively interact with geotechnical engineers
- At the end of training, a detailed report on the work done should be submitted to the course coordinator
- Students will be evaluated through a viva-voice examination by a team of internal staff.

TOTAL: 4 WEEKS

COURSE OUTCOMES:

- On completion of the course, the student is expected to be able to

CO1 Understand the real field problem and compare the theoretical knowledge with field
CO2 Solve Soil Mechanics and Foundation engineering problems in the field either individually or in team.
CO3 Understand the professional ethics
CO4 Work in a team to obtain the solution for various field problems

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	2	3	3	3
CO2	3	2	3	3	2	3
CO3	2	-	2	2	3	2
CO4	3	2	3	2	3	3
Avg	**3**	**1**	**2**	**3**	**3**	**3**

1-low, 2-medium, 3-high

Attested

SF3312 **PROJECT WORK I**

L	T	P	C
0	0	12	6

SYLLABUS:

The student individually works on a specific topic approved by faculty member who is familiar in this area of interest. The student can select any topic which is relevant to his/her specialization of the programme. The topic may be experimental or analytical or case studies. At the end of the semester, a detailed report on the work done should be submitted which contains clear definition of the identified problem, detailed literature review related to the area of work and methodology for carrying out the work. The students will be evaluated through a viva-voice examination by a panel of examiners including one external examiner.

TOTAL: 180 PERIODS

COURSE OUTCOMES:

- On completion of the course, the student will be able to

CO1 Recognize the importance of literature review

CO2 Develop a clear outline and methodology for the project

CO3 Identify the potential research gap and list parameters to work with filling the gap

CO4 Report and present the findings of the work conducted.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	3	2	2
CO2	2	3	3	2	2	2
CO3	2	3	2	2	3	2
CO4	3	3	2	2	2	2
Avg	**2**	**3**	**3**	**2**	**2**	**2**

1-low, 2-medium, 3-high

SF3411 **PROJECT WORK II**

L	T	P	C
0	0	24	12

SYLLABUS:

The student should continue the Project Work I work on the selected topic as per the formulated methodology. At the end of the semester, after completing the work to the satisfaction of the supervisor and review committee, a detailed report should be prepared and submitted to the head of the department. The students will be evaluated through based on the report and the viva-voce examination by a panel of examiners including one external examiner.

TOTAL: 360 PERIODS

COURSE OUTCOMES:

- On completion of the course, the student will be able to

CO1 Apply the knowledge gained from theoretical and practical courses in solving problems

CO2 Represent data acquired in graphical and reader-friendly formats

CO3 Derive detailed conclusions from work carried out

CO4 Write thesis and present the findings of the work conducted

Attested

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	3	3	2
CO2	2	3	3	3	3	2
CO3	3	3	3	3	3	2
CO4	3	3	2	3	3	2
Avg	**3**	**3**	**3**	**3**	**3**	**2**

1-low, 2-medium, 3-high

PROFESSIONAL ELECTIVE COURSES

SF3001 GEOENVIRONMENTAL ENGINEERING

L	T	P	C
3	0	0	3

UNIT I SOIL – WASTE INTERACTION 9

Role of Geoenvironmental Engineering – sources, generation and classification of wastes – causes and consequences of soil pollution – case studies in soil failure – factors influencing soil-pollutant interaction – modification of index, chemical and engineering properties – diffuse double layer – physical and physio-chemical mechanisms.

UNIT II CONTAMINANT TRANSPORT AND SITE CHARACTERISATION 9

Transport of contaminant in subsurface – advection, diffusion, dispersion – chemical process – biological process, sorption, desorption, precipitation, dissolution, oxidation, complexation, ion exchange, volatization, biodegradation – characterization of contaminated sites – soil and rock data – hydrological and chemical data – analysis and evaluation – risk assessment – case studies.

UNIT III WASTE CONTAINMENT AND REMEDIATION OF CONTAMINATED SITES 9

Insitu containment – vertical and horizontal barrier – surface cover – ground water pumping system on subsurface drain – soil remediation – soil vapour extraction, soil waste stabilization, solidification of soils, electrokinetic remediation, soil heating, vitrification, bio remediation, phyto remediation – ground water remediation – pump and treat , Insitu flushing, permeable reacting barrier, Insitu air sparging - case studies.

UNIT IV LANDFILLS AND SURFACE IMPOUNDMENTS 9

Source and characteristics of waste - site selection for landfills – components of landfills – liner system – soil, geomembrane, geosynthetic clay, geocomposite liner system – leachate collection – final cover design – monitoring landfill - Environmental laws and regulations.

UNIT V STABILISATION OF WASTE 9

Evaluation of waste materials – flyash, municipal sludge, plastics, scrap tire, blast furnace slag, construction waste, wood waste and their physical, chemical and biological characteristics – potential reuse – utilization of waste and soil stabilization – case studies.

TOTAL: 45 PERIODS

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

COURSE OUTCOMES:

- On successful completion of the course, the students will be able to

CO1 Understand the various causes and consequences of waste interaction with soil and their modification.

CO2 Understand the various mechanism of transport of contaminants into the subsurface and characterization of contaminated sites and their risk analysis.

CO3 Understand on how to decontaminate the site so as to reuse the site for human settlement

CO4 Understand how to safely dispose the waste through different containment process.

CO5 Expose on how to convert the waste into a resource material through soil waste stabilization techniques with or without chemical stabilization.

REFERENCES:

1. Daniel B.E, Geotechnical Practice for waste disposal, Chapman & Hall, London, 1993.
2. Hari D. Sharma and Krishna R. Reddy, Geo-Environmental Engineering – John Wiley and Sons, INC, USA, 2004.
3. Krishna R. Reddy and Jeffrey A. Adams, Sustainable Remediation of Contaminated Sites, Momentum Press, 2015.
4. Krishna R. Reddy and Claudio Cameselle, Electrokinetic Remediation Technologies for Polluted Soils, Sediments and Groundwater, John Wiley and Sons, 2009.
5. Westlake, K., Landfill Waste pollution and Control, Albion Publishing Ltd., England, 1995.
6. Wentz, C.A., Hazardous Waste Management, McGraw Hill, Singapore, 1989.
7. Proceedings of the International symposium of Environmental Geotechnology (Vol.I and II), Environmental Publishing Company, 1986 and 1989.
8. Lagrega, M.d., Buckingham, P.L., and Evans, J.C., Hazardous Waste Management, McGraw Hill, Inc. Singapore, 1994.

CO - PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	2	3		
CO2	2	-	3	3		3
CO3	2	-	3	3	3	4
CO4	4	-	2	4		4
CO5	3	2	3	2	3	3
Avg	**2**	**1**	**3**	**3**	**4**	**4**

1-low, 2-medium, 3-high

SF3002 **GEOLOGY FOR GEOTECHNICAL APPLICATIONS**

L	T	P	C
3	0	0	3

UNIT I ENGINEERING PROPERTIES OF ROCKS AND MINERALS 9

Geology for foundation engineering – Types of rocks, rock description-texture, structure, composition and its relation to quality and strength of rocks, engineering classification of rocks – weathering grade and its significance in engineering site – Engineering properties of rocks – Physical and chemical properties of minerals and their relation to strength and durability of rock-Physical, chemical, and thermal properties of clays – identification – effects of clay minerals.

UNIT II SURFACE AND SUBSURFACE GEOLOGICAL INVESTIGATIONS 9

Surface investigations: Bed rock attitudes - Strike and dip of rocks-Field mapping- thickness, calculation of True thickness and vertical thickness of bed rock-pitting and trenching-Subsurface investigations: electrical and seismic geophysical methods in subsurface geological investigations for foundation engineering- applications of GPR in subsurface strata studies.

UNIT III CORE SAMPLING AND LOGGING TECHNIQUES 9

Rocks and soil sampling methods-Drilled core sections - Bore hole logging methods, Core logging techniques – Resistivity log, Neutron log, Sonic log, Gamma log etc., and interpretation. Description of discontinuities-Fence diagrams, RQD and RMR.

UNIT IV GEOLOGICAL INVESTIGATIONS FOR FOUNDATION SITES 9

Ground stability studies - Scour and erosion studies-stability of slopes: Geological information for slope stabilization and geological solution for slope stability in landslides areas-Overview of rocks of Tamil Nadu.

UNIT V GEOLOGICAL CONSIDERATIONS FOR ENGINEERING STRUCTURES AND GEOHAZARDS 9

Geological conditions necessary for design of major engineering structures. Geological hazards-causes and mitigation- Case studies from India – Earthquake – Seismic zones of India.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- On successful completion of the course, the students will be able to

CO1 Identify various rock types and understand the strength and durability of different rock types.

CO2 Map the surface and subsurface geological formations using geological and geophysical exploration techniques.

CO3 Explore and analyse the subsurface rocks and their discontinuities for design and construction of major Civil engineering structures.

CO4 Analyse the suitable methods for improving slope stability and manage unstable slopes efficiently

CO5 Understanding the various geological conditions necessary for design of major engineering structures.

REFERENCES:

1. Roy E. Hunt, Geotechnical Engineering Investigation Handbook, CRC Press, 2005.
2. Varghese P.C. Engineering Geology for civil engineers, PHI learning Pvt. Ltd. New Delhi, 2012
3. Krynine and Judd, Principles of Engineering Geology and Geotechnics, CBS Publishers and Distributors Pvt ltd., ebook edition, 2008.
4. Bell FG. Engineering Geology, Second Edition by, 2007 Butterworth-Heinemann, Oxford
5. Sathya Narayanaswami, Engineering Geology, Dhanpat Raj and Co.1710, Nai Sarak, Delhi, 2000.
6. Waltham, A.C. Foundations of Engineering Geology, Blackie Academic Professional Pub.1 Ed.UK.1994
7. Venkata Reddy, Engineering Geology, Vikas Publishing House Pvt Ltd, New Delhi, 1st edition, 2010.

CO - PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	2	2	2	2
CO2	3	2	2	2	2	2
CO3	2	2	2	3	3	3
CO4	3	2	2	2	3	3
CO5	2	-	2	2	2	2
Avg	**2**	**1**	**2**	**2**	**2**	**2**

1-low, 2-medium, 3-high

Attested

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Centre for Academic Courses
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SF3003 **PAVEMENT ANALYSIS AND DESIGN**

L	T	P	C
3	0	0	3

UNIT I BASIC CONCEPTS **9**

Historical development of pavements – types, classification, components, and principle of load transfer – Approaches to pavement design – vehicle and traffic considerations – behaviour of road materials under repeated loading–Stresses and deflections in layered systems.

UNIT II FLEXIBLE PAVEMENT **9**

Factors affecting flexible pavements – material characterization for analytical pavement design – AASHO, CBR, group index methods – Importance of Resilient modulus – Fatigue subsystem – failure criteria for bituminous pavements – IRC design guidelines.

UNIT III RIGID PAVEMENT **9**

Factors affecting rigid pavements - Design procedures for rigid pavement – Slab thickness, dowel bar, tie bar, spacing of joints – IRC guidelines – Airfield pavements – Comparison of highway and airfield pavements.

UNIT IV PAVEMENT EVALUATION AND REHABILITATION **9**

Pavement evaluation – surface and structural - causes and types of failures in flexible and rigid pavements – Presents serviceability index of roads – Overlay design - pavements maintenance, management and construction – Drainage and its importance in pavements.

UNIT V STABILIZATION OF SOILS FOR ROAD CONSTRUCTIONS **9**

Need for a stabilized soil – Design criteria – Mechanisms - factors influencing choice of stabilizers - Testing and field control – Applications of Geosynthetics in road construction - Case studies

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- On successful completion of the course, the students will be able to

CO1 Explain different types of pavements, wheel load, serviceability and design strategies of pavement.
CO2 Design flexible pavements based on different guidelines.
CO3 Design rigid pavements based on different guidelines.
CO4 Explain the various types of failure in different components of pavement and assess the pavement conditions and rehabilitation.
CO5 Select suitable stabilizers based on mechanism and requirements for construction with quality control in the field.

REFERENCES:

1. Khanna S.K., Justo C.E.G and Veeraraghavan, A., Highway Engineering, Tenth Edition, Nem Chand and Brothers, Roorkee, 2018.
2. Yoder R.J and Witchak M.W., Principles of Pavement Design, Second Edition (Reprint), Wiley India Pvt. Ltd., 2012.
3. Design and Specification of Rural Roads (Manual), Ministry of rural roads, Government of India, New Delhi, 2001.
4. Guidelines for the Design of Flexible Pavements, IRC:37 - 2018, The Indian roads Congress, New Delhi.
5. Guideline for the Design of Rigid Pavements for Highways, IRC:58 - 2015, The Indian Roads Congress, New Delhi.
6. O' Flaherty, C.A., Highways – The location, Design, Construction & Maintenance of Pavements, Fourth Edition, Elsevier, 2006.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	2	3	2	2
CO2	2	2	2	3	2	2
CO3	2	2	2	3	2	2
CO4	2	-	2	3	3	3
CO5	2	-	2	3	3	3
Avg	**2**	**1**	**2**	**3**	**2**	**2**

1-low, 2-medium, 3-high

SF3004 EARTHQUAKE RESISTANT DESIGN OF FOUNDATIONS **L T P C**
3 0 0 3

UNIT I BASIC DESIGN PARAMETERS **9**
Dynamic properties of soils and its evaluation, strength, and deformation characteristics of soils under earthquake loading, liquefaction hazard evaluations and remedial measures, geotechnical failure of foundations during earthquake, provision of IS 1893 and IS 13920

UNIT II SHALLOW FOUNDATION **9**
Design requirements – bearing capacity theory under earthquake loading – bearing capacity analysis for liquefied soil – bearing capacity analysis for cohesive and cohesionless soils - seismic settlement of foundation.

UNIT III DEEP FOUNDATION **10**
Earthquake loading – inertial and kinematic loading - performance of piles during earthquake loading – theories of pile failure in liquefiable soils – failure based on bending mechanism/buckling instability – methods of analysis – force based or limit equilibrium method – p-y method – pile settlement - guidelines for designing of piles under kinematic loading due to liquefaction – seismic design of well/cassion foundations

UNIT IV SEISMIC DESIGN OF RETAINING WALL **9**
Seismic passive lateral earth pressure, behaviour of retaining wall during earthquakes, modification of Coulomb's Theory, Modified Culmann's Theory, displacement analysis, Indian standard code of practice.

UNIT V STRUCTURAL DESIGN OF FOUNDATION **8**
Loads acting on foundations during earthquake – fundamental failure mechanisms of foundations – essential criteria for design of foundations in liquefiable soils – structural design of foundations subjected to earthquake loading

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- On successful completion of the course, the students will be able to

CO1 Evaluate the dynamic properties of soils and relevant design parameters
CO2 Design the shallow foundation subjected to earthquake loading by including the effect of soil liquefaction
CO3 Analyse and design the deep foundation by considering various earthquake forces
CO4 Analyse and design the retaining wall by incorporating earthquake force
CO5 Perform structural design of foundations subjected to both static and dynamic loading

REFERENCES:

1. Design of foundation in seismic areas: Principles and some applications by Bhattacharya S. (eds), Published by NICEE [National Centre for Earthquake Engineering (India)]. ISBN: 81-904190-1-3, 2007.
2. Day R. W., Geotechnical Earthquake Engineering handbook, McGraw – Hill, New York, 2002.
3. Gopal Madabhushi, Jonathan Knappett and Stuart Haigh, Design of Pile Foundations in Liquefiable Soils, Imperial College Press, London WC2H 9HE, 2010.
4. Kamalesh Kumar, Basic geotechnical earthquake engineering, New Age International Publishers, New Delhi, 2008.
5. Terzaghi and Peck, R. B, Soil Mechanics in Engineering Practice, John Wiley & Sons, New York, 1967.
6. Poulos H.G. and Davis E.H., Pile foundation analysis and design, John Wiley and Sons, 1980.
7. Prakash, S., Soil dynamics, McGraw Hill, New York, 1981.
8. Srbulov, M., Geotechnical Earthquake Engineering Simplified Analyses with Case Studies and Examples, Springer, Dordrecht. 2008.
9. Steven L. Kramer, Geotechnical Earthquake Engineering, Prentice Hall, New Delhi, 1996.
10. Tomilinson M.J., Foundation design and construction, Longman Scientific & Technical, England, 1986.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	3	3	3
CO2	3	2	2	3	3	3
CO3	3	2	2	3	3	3
CO4	3	2	2	3	3	3
CO5	3	2	2	3	3	3
Avg	**3**	**2**	**2**	**3**	**3**	**3**

1-low, 2-medium, 3-high

SF3005 **GROUND IMPROVEMENT TECHNIQUES**

L	T	P	C
3	0	0	3

UNIT I HYDRAULIC MODIFICATIONS **9**

Scope and necessity of ground improvement in Geotechnical engineering basic concepts. Drainage – Ground Water lowering by well points, deep wells, vacuum, and electro-osmotic methods. Stabilization by thermal and freezing techniques - Applications.

UNIT II MECHANICAL MODIFICATIONS **9**

Insitu compaction of granular and cohesive soils, Shallow and Deep compaction methods – Sand piles – Concept, design, factors influencing compaction. Blasting and dynamic consolidation - design and relative merits of various methods – Soil liquefaction mitigation methods - Case studies.

UNIT III PHYSICAL MODIFICATION **9**

Preloading with sand drains, fabric drains, wick drains – theories of sand drain - Stone column with and without encasement, lime stone – functions – methods of installation – design, estimation of load carrying capacity and settlement. Root piles and soil nailing – methods of installation – Design and Applications - case studies.

UNIT IV MODIFICATION BY INCLUSIONS **9**

Reinforcement – Principles and basic mechanism of reinforced earth, simple design: Synthetic and natural fiber-based Geotextiles and their applications. Filtration, drainage, separation, erosion control – case studies.

Attested

UNIT V CHEMICAL MODIFICATION 9

Grouting – Types of grouts – Suspension and solution grouts – Basic requirements of grout. Grouting equipment – injection methods – jet grouting – grout monitoring – Electro – Chemical stabilization – Stabilization with cement, lime - Stabilization of expansive clays – case studies.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- On successful completion of the course, the students will be able to

CO1 identify and evaluate the deficiencies in the deposits of the given project area and improve its characteristics by hydraulic modifications

CO2 improve the ground characteristics by mechanical modifications using various method and design the system

CO3 improve the ground characteristics by physical modifications using various method and design the system

CO4 improve the characteristics of soils by various reinforcement techniques and design

CO5 Analyse the ground and decide the suitable chemical method for improving its characteristics

REFERENCES:

1. Puppala, A.J., Huang,J., Han, J., and Hoyos, L.R., Ground Improvement and Geosynthetics; Geotechnical special publication No.207, Geo Institute, ASCE, 2010
2. Cox, B.R., and Grifiths S.C., Practical Recommendation for Evaluation, and mitigation of Soil Liquefaction in Arkansas, (Project Report), 2011.
3. Day, R.W., Foundation Engineering Handbook, 2nd Edition McGraw – Hill Companies, Inc. 2010.
4. Rowe, R.K., Geotechnical and Geoenvironmental Engineering Handbook, Kluwer Academic Publishers, 2001.
5. Das, B.M., Principles of Foundation Engineering, 8th Edition, Cengage Learning, 2016.
6. Moseley, M.P., Ground Treatment, Blackie Academic and Professionals, 1998.
7. Koerner, R.M., Designing with Geosynthetics, Third Edition, Prentice Hall 1997.
8. Hehn, R.W., Practical Guide to Grouting of Underground Structures, ASCE, 2010.
9. Jewell, R.A., Soil Reinforcement with Geotextiles, CIRIA, London, 1996.
10. Koerner, R.M. and Welsh, J.P., Construction and Geotechnical Engineering using Synthetic Fabrics, John Wiley, 1990.
11. Han,J., Principles and Practice of Ground Improvement, John Wiley and Sons, New Jersey, Canada 2015.
12. Jones, J.E.P., Earth Reinforcement and Soil Structure, Butterworths, 1996.
13. Manfred R. Hausmann, Engineering Principles of Ground Modifications, McGraw-Hill Publishing Company, New York, 1990.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	3	3	2
CO2	3	-	2	3	3	3
CO3	3	-	2	3	3	3
CO4	3	-	2	3	3	3
CO5	3	2	2	3	3	3
Avg	**3**	**1**	**2**	**3**	**3**	**3**

1-low, 2-medium, 3-high

SF3006 **SOIL STRUCTURE INTERACTION**

L	T	P	C
3	0	0	3

UNIT I SOIL RESPONSE MODELS OF INTERACTION ANALYSIS 9

Introduction to soil – Foundation interaction problems, Soil behavior, Foundation behavior, Interface behavior, soil-foundation interaction analysis, soil response models, Elastic continuum, Winkler, Two parameter elastic models, Elastic – plastic behavior, Time dependent behavior.

UNIT II INFINITE AND FINITE BEAMS ON ELASTIC FOUNDATIONS 9

Infinite beam, General solution of the elastic line – concentrated and distributed loads on beams – Idealization of semi-infinite and finite beams. Classification of finite beams, different end conditions and loads – solutions - General method.

UNIT III PLATE ON ELASTIC MEDIUM 9

Infinite plate, elastic continuum, Winkler, Two parameters, thin and thick plates, Analysis of finite plates, rectangular and circular plates, simple solution, ACI method, Analysis of highway and airfield pavements – solutions - General method.

UNIT IV ANALYSIS OF PILE AND PILE GROUPS 12

Elastic analysis of single pile – Solutions for settlement and load distribution – Simplified method for constructing load settlement curve to failure – Analysis of group settlement – Two pile interaction Analysis, Analysis of general groups – Theoretical solutions for free standing groups – Settlement of groups caused by compressible underlying strata – Use of design charts – Surface settlement around a group – Observed and predicted group behaviour.

UNIT V LATERALLY LOADED PILE 6

Load - deflection prediction for laterally loaded piles, subgrade reaction and elastic analysis, Analysis of pile group, pile raft system, solutions through influence charts.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- On successful completion of the course, the students will be able to

CO1 Select appropriate soil response model for interactive analysis.
CO2 Differentiate and perform interactive analysis for different beams.
CO3 Differentiate and perform interactive analysis for different plates.
CO4 Perform interactive analysis for single pile, two pile and multiple groups subjected to vertical loading
CO5 Perform interactive analysis for single pile and multiple groups subjected to lateral loading.

REFERENCES:

1. Salgado, R., "The Engineering of Foundations", Tata McGraw Hill Education Private Limited, New Delhi, 2011.
2. Saran, S, "Analysis and Design of Substructures", Taylor & Francis Publishers, 2006
3. Hemsley, J.A, "Elastic Analysis of Raft Foundations", Thomas Telford, 1998.
4. Poulos, H.G., and Davis, E.H., "Pile Foundation Analysis and Design", John Wiley, 1980.
5. Selvadurai, A.P.S., "Elastic Analysis of Soil Foundation Interaction", Elsevier 2013.
6. Kurien, N.P., "Design of Foundation Systems: Principles and Practices", Third edition, Alpha Science International Ltd, 2005.
7. Michael J Tomlinson, John C Woodward., Pile Design and Construction Practice, Sixth Edition, CRC Press, 2014
8. Edward Tsudik, "Analysis of Structures on Elastic Foundations", J. Ross Publishing, Cengage learning India Private limited, Delhi, 2013.

Attested

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	3	2	2	
CO2	2	2	3	2	2	
CO3	3	2	3	2	2	
CO4	3	2	3	3	2	3
CO5	3	2	3	3	2	3
Avg	**3**	**2**	**3**	**2**	**2**	**3**

1-low, 2-medium, 3-high

SF3007 DYNAMICS OF SOILS AND FOUNDATIONS

L	T	P	C
3	0	0	3

UNIT I THEORY OF VIBRATION 9

Nature of dynamic loads – vibrations of single degree freedom system – free vibrations of spring – mass systems – forced vibrations – viscous damping, Transmissibility – Principles of vibration measuring instruments effect of Transient and Pulsating loads – vibrations of multi degree freedom system.

UNIT II DYNAMIC SOIL PROPERTIES AND BEHAVIOUR 9

Dynamic stress – strain characteristics – principles of measuring dynamic properties – Laboratory Techniques – Field tests – Factors affecting dynamic properties - Typical values-Dynamic bearing capacity – Dynamic earth pressure.

UNIT III FOUNDATIONS FOR RECIPROCATING MACHINES 9

Types of Machines and Foundations – General requirements – Modes of vibration of a rigid foundation, block method of analysis – Linear Elastic weightless spring method – Elastic half – space method – Analog models; Design of Block foundation -- Codal Provisions

UNIT IV FOUNDATION FOR IMPACT AND ROTARY MACHINES 9

Dynamic analysis of impact type machines – Design of Hammer foundations – use of vibrator Absorbers – design – Codal recommendation. Special consideration for Rotary machines – Design criteria – Loads on Turbo Generator Foundation – method of analysis – Design; Dynamic soil – structure – Interaction, Codal Provisions.

UNIT V INFLUENCE OF VIBRATION AND REMEDIATION 9

Mechanism of Liquefaction–Influencing factors--Evaluation of Liquefaction potential based on SPT-Force Isolation – Motion Isolation – use of spring and damping materials – vibration control of existing machine foundation – screening of vibration – open trenches – Pile Barriers – salient construction aspects of machine Foundations.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- On successful completion of the course, the students will be able to

CO1 Differentiate different type of dynamic loads and theory of vibration of different systems
CO2 Select different dynamic properties from different testing principles and applications
CO3 Perform analysis and design of reciprocating machines based on different methods.
CO4 Perform analysis and design of impact and rotary machines based on different
CO5 Asses influence of vibration from different dynamic source and design suitable remediation

REFERENCES:
1. Kameswara Rao, N.S.V., "Dynamics soil tests and applications", Wheeler Publishing, New Delhi, 2000.
2. Moore, P.J., "Analysis & Design of Foundations for Vibrations", Oxford & IBH, 2006.
3. Krammer S.L., "Geotechnical Earthquake Engineering", Prentice hall, International Series, Pearson Education (Singapore) Pvt. Ltd., 2004.
4. Prakash, S and Puri, V.K., Foundations for machines, McGraw Hill, 1987.
5. Swami Saran, "Soil Dynamics and Machine Foundation", Galgotia publications Pvt. Ltd., New Delhi 1999.
6. Kameswara Rao, "Vibration Analysis and Foundation Dynamics", Wheeler Publishing, New Delhi, 1998.
7. A. K. Chopra, Dynamics of Structures, Theory and Applications to Earthquake Engineering, 5th edition, Pearson Education*, 2017*.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	2	2	2	
CO2	2	-	2	2	2	
CO3	3	2	3	3	3	3
CO4	3	2	3	3	3	3
CO5	3	2	3	3	3	3
Avg	**3**	**1**	**3**	**3**	**3**	**3**

1-low, 2-medium, 3-high

SF3008 GEOTECHNICAL EARTHQUAKE ENGINEERING

L	T	P	C
3	0	0	3

UNIT I ELEMENTS OF EARTHQUAKE SEISMOLOGY 6

Mechanism of Earthquakes - Causes of earthquake - Earthquake Fault sources - Elastic Rebound theory - Seismic wave in earthquake shaking - Definition of earthquake terms - Locating an earthquake - Quantification of earthquakes.

UNIT II THEORY OF VIBRATION 9

Nature of dynamic loads – vibrations of single degree freedom system – free vibrations of spring – mass systems – forced vibrations – viscous damping, Transmissibility – Principles of vibration measuring instruments effect of Transient and Pulsating loads – vibrations of multi degree freedom system.

UNIT III GROUND MOTION CHARACTERISTICS 10

Strong Motion Records -characteristics of ground motion - Factors influencing ground motion - Estimation of frequency content parameters - Seismic site investigations - Evaluation of Dynamic soil properties.

UNIT IV DESIGN GROUND MOTION 10

Wave propagation Analysis - Site Amplification, Ground Response Analysis - Method of analysis - One Dimensional Analysis - Equivalent linear Analysis – shear beam Analysis - site effects - Design Ground Motion - Developing Design Ground Motion. Application of software package - codal recommendations.

UNIT V SEISMIC STABILITY ANALYSIS 10

Assessment of liquefaction potential based on SPT-N value – permanent settlement – displacement prediction – Mitigation of liquefaction induced damage – Microzonation for intensity – liquefaction – Bearing capacity analysis – Effects of Pile foundation – Response of slopes –

Evaluation of slope stability – Pseudostatic – Newmark's study of Block analysis – Dynamic analysis – Earth pressure due to ground shaking – Dynamic analysis
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TOTAL: 45 PERIODS

COURSE OUTCOMES:

- On successful completion of the course, the students will be able to

CO1 Explain interior structure of earth, different causes, location and quantification of earthquake

CO2 Differentiate different type of dynamic loads and theory of vibration of different systems

CO3 Evaluate dynamic properties of soils and ground motion characteristics

CO4 Estimate the design ground motion based on the ground response analysis

CO5 Analyze and design different types of foundations, slopes and retaining walls for seismic loading and assess liquefaction potential and mitigation of liquefaction induced damage.

REFERENCES:

1. Kameswara Rao, N.S.V., Dynamics soil tests and applications, Wheeler Publishing - New Delhi, 2000.
2. Krammer S.L., Geotechnical Earthquake Engineering, Prentice Hall, International Series, Pearson Education (Singapore) Pvt. Ltd., 2004.
3. Kameswara Rao, Vibration Analysis and Foundation Dynamics, Wheeler Publishing, New Delhi, 1998.
4. Wai-Fah Chen and CgharlesScawthem, Earthquake Engineering Hand book, Caspress,2003.
5. Robert W. Day, Geotechnical Earthquake Engineering Hand book, Second Edition, McGraw Hill, 2012.
6. IkuoTowhata, "Geotechnical Earthquake Engineering" Springer series in Geomechanics and Geoengineering, Scientific Publishing services Pvt. Ltd., 2008.
7. Swami Saran, "Soil Dynamics and Machine Foundation, Galgottia Publications Pvt. Ltd., New Delhi-110002, 1999.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	2	3	2	
CO2	3	-	3	3	2	
CO3	2	2	3	3	2	
CO4	2	2	3	3	3	3
CO5	3	2	3	3	3	3
Avg	**2**	**1**	**3**	**3**	**2**	**3**

1-low, 2-medium, 3-high

SF3009	**MECHANICS OF UNSATURATED SOILS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

UNIT I STATE OF UNSATURATED SOIL 6

Definition – Interdisciplinary nature of unsaturated soil – soil classification – Nature and practice – stress profiles, stress state variables - material variables – constitutive law – suction potential of soil water

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UNIT II PHYSICS OF SOIL WATER SYSTEM 9

Physical properties of Air and water – partial pressure and relative Humidity Density of moist air – surface Tension – cavitations of water. Solubility of Air in water – Air – water solid interface – vapor pressure lowering – soil water characteristic-curve. Capillary tube model – contacting sphere model. Young Laplace equation – Height of capillary rise – Rate of capillary rise – capillary pore size distribution – theoretical basis – determination – laboratory method.

UNIT III STRESS STATE VARIABLES AND SHEAR STRENGTH 12

Effective-stress – stress between two spherical particles – Hysteresis in SWCC – stress parameter, stress tensor – stress control by Axis Translation - analytical representation of stress – volume change characteristics. Extended Mohr – Coulomb criterion – shear strength parameters – Interpretation of Direct shear test results and Tri axial test results – unified representation of failure envelope – Influence of suction in earth pressure distribution.

UNIT IV STEADY AND TRANSIENT FLOWS 9

Driving mechanism – Permeability and Hydraulic conductivity – capillary barriers – steady infiltration and evaporation – Vapor flow – Air diffusion in water. Principles for pore liquid flow – Rate of infiltration, Transient suction and moisture profiles. Principles for Pore Gas flow – Barometric pumping Analysis.

UNIT V MATERIAL VARIABLE MEASUREMENT AND MODELLING 9

Measurement of total suction – psychrometers – Filter paper measurement of matric suction – High Air Entry disks – Direct measurements – Tensiometers – Air-translation technique – Indirect measurements – Thermal conductivity sensors – measurement of osmotic suction – squeezing technique – soil water characteristic curves and Hydraulic conductivity models.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- On completion of the course, the students is expected to be able to

CO1 Explain stress state variables, material variables and constitutive law of unsaturated soil
CO2 Explain the physics of soil-water mechanism, relationship of models.
CO3 Explain and determine the soil-water characteristic curve and the shear strength of unsaturated soil
CO4 Explain the principles of vapour flow, air diffusion, pore liquid flow and rate of infiltration in unsaturated soil.
CO5 Measure the material variables and select the suitable soil models.

REFERENCES:

1. Fredlund, D.G., Rahardjo, H. and Fredlund, M.D., Unsaturated Soil Mechanics in Engineering Practice, John Wiley & Sons, INC, New Jersey, 2012.
2. Ning Lu and William, J. Likes, Unsaturated Soil Mechanics, John Wiley & sons, INC. New Jersey, 2004
3. Ng Charles, W.W., Menzies Bruce, Advanced unsaturated Soil Mechanism and Engineering, Taylor & Francis Group, 2007.
4. Ning Lu, Laureano R. Hoyes and Lakshmi Reddi, Advances in unsaturated soil, seepage and Environmental Geotechnics, ASCE., Geotechnical special publication No.148.
5. Jean- Louis Briaud., Geotechnical Engineering: Unsaturated and Saturated soils, John Wiley & Sons, INC, New Jersey, 2013.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	2	3	2	2
CO2	2	-	2	2	2	3
CO3	2	-	2	3	2	2
CO4	2	-	2	3	2	3
CO5	3	2	2	3	3	3
Avg	**2**	**1**	**2**	**3**	**2**	**3**

1-low, 2-medium, 3-high

SF3010	GEOSYNTHETICS AND REINFORCED SOIL STRUCTURES	L	T	P	C
		3	0	0	3

UNIT I PRINCIPLES AND MECHANISMS OF SOIL REINFORCEMENT 9

Historical Background – Principles - Concepts and Mechanisms of reinforced earth – Soil – Geosynthetics interaction mechanism – interface resistance – Factors influencing interaction – Strain compatibility.

UNIT II REINFORCING MATERIALS AND THEIR PROPERTIES 9

Materials used in reinforced soil structures, fill materials, reinforcing materials metal strips, Geotextile, Geogrids, Geomembranes, Geocomposites and Geojutes, Geofoam, Natural fibers - facing elements – Influence of environmental factors on the performance of Geosynthetic materials – Physical – Mechanical – Hydraulic and Endurance properties testing.

UNIT III DESIGN FOR SOIL REINFORCEMENT AND SEPARATION 9

Reinforcing the soil - Geotextiles and Geogrids –Retaining wall – Embankments – Basal reinforcement – piled embankment – unpaved roads – paved roads – railway tracks – Shallow foundations – seismic aspects.

UNIT IV DESIGN FOR FILTRATION, DRAINAGE AND CONTAINMENT 9

Geotextile filter – Filtration Mechanism – Factors affecting filter behaviour – Filtration design – Drains – Drainage in embankments – erosion control silt fences – Containment ponds – Reservoirs and Canals – Hydraulic tunnels – River bed and bank protection.

UNIT V DESIGN OF SLOPES 9

Type and orientation of Geosynthetics – Function of reinforcement against slope failure – Stability analysis – Design aspects – Seismic aspects – General construction aspects.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- On successful completion of the course, the students will be able to

CO1 Explain various principles and mechanism of soil reinforcement.
CO2 Select different reinforcing materials based on functions to determine their properties
CO3 Design geosynthetics as a reinforcement and/or a separator for different reinforced structures.
CO4 Design geosynthetics as a filter, drainer and as a containment for different reinforced structures.
CO5 Analyze and design reinforced slopes for static and seismic loading.

Attested

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REFERENCES:

1. Jewell, R.A., Soil Reinforcement with Geotextile, CIRIA, London, 1996.
2. Jones, C.J.F.P., Earth Reinforcement and Soil Structures, Earthworks, London, 1982.
3. Koerner, R.M., Designing with Geosynthetics, Third Edition, Prentice Hall, 1997.
4. Muller, W.W. HDPE Geomembranes in Geotechnics, Springer, New York 2007.
5. John, N.W.M., Geotextiles, John Blackie and Sons Ltd., London, 1987.
6. SivakumarBabu, G.L., An Introduction to Soil Reinforcement and Geosynthetics, University Press (India), Pvt. Ltd., Hyderabad, 2006.
7. Kerry Rowe.R., "Geotechnical and GeoEnvironmental Engineering handbook" Kluwer Academic Publishers, 2001
8. Cheng.Y.M., Lau.C.K., "Slope Stability Analysis and Stabilization" Routledge Taylor & Francis Group, London., 2008.
9. Sanjay Kumar Shukla., "Handbook of Geosynthetic Engineering" ICE publishing, London., Second edition., 2012
10. John Burland, Tim Chapman, Hilary Skinner, Michael Brown., "Geotechnical Design Construction and verification – ICE Manual of Geotechnical Engineering volume-II" ICE Publishing, UK., 2012.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	2	2	2	
CO2	2	-	2	2	2	
CO3	3	2	3	3	3	3
CO4	3	2	3	3	3	3
CO5	3	2	3	3	3	3
Avg	**3**	**2**	**3**	**3**	**3**	**3**

1-low, 2-medium, 3-high

SF3011	ROCK MECHANICS AND APPLICATIONS	L	T	P	C
		3	0	0	3

UNIT I CLASSIFICATION OF ROCKS 9

Types of Rocks - Index properties and classification of rock masses, competent and incompetent rock - value of RMR and ratings in field estimations.

UNIT II STRENGTH CRITERIA OF ROCKS 9

Behaviour of rock under hydrostatic compression and deviatric loading - Modes of rock failure - planes of weakness and joint characteristics - joint testing, Mohr - Coulomb failure criterion and tension cut-off.Hoek and Brown Strength criteria for rocks with discontinuity sets.

UNIT III INSITU STRESSES IN ROCKS 9

Insitu stresses and their measurements, Hydraulic fracturing, flat jack, over coring and under coring methods - stress around underground excavations – Design aspects of openings in rocks - case studies.

UNIT IV SLOPE STABILITY AND BEARING CAPACITY OF ROCKS 10

Rock slopes - role of discontinuities in slop failure, slope analysis and factor of safety - remedial measures for critical slopes – Bearing capacity of foundations on rocks – case studies

Attested

UNIT V ROCK REINFORCEMENT 8

Reinforcement of fractured and joined rocks - shotcreting, bolting, anchoring, installation methods - case studies.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- On successful completion of the course, the students will be able to

CO1 Classify the Rock mass and rate the quality of rock for tunnelling and foundations works and suggest the safer length of tunnelling and stand-up time.

CO2 Apply the knowledge of engineering and understand the stress – strain characteristics and failure criteria of rock and apply them to arrive at the shear strength parameters of rocks to be used for the design of structures resting on rock and for the design of underground excavation in rocks.

CO3 Apply the knowledge of engineering and assess the influence of insitu stress in the stability of various underground excavations and also acquire the knowledge of design of opening in rocks.

CO4 Apply the knowledge on rock mechanics and analyse the stability of rock slopes and arrive at the bearing capacity of shallow and deep foundations resting on rocks considering the presence of joints. design the foundations resting on rocks. Able to carry out suitable foundation for the structure resting on rock.

CO5 Improve the insitu strength of rocks by various methods such as rock reinforcement and rock support. Able to select suitable support system considering the interaction between rock and support. Also capable of executing the same in the field.

REFERENCES:

1. Goodman, R.E., Introduction to rock mechanics, John Willey and Sons, 2nd Edition, 2010.
2. Hudson, A. and Harrison, P., Engineering Rock mechanics – An introduction to the principles, Pergamon publications, 1997.
3. Hoek, E and Bray, J., Rock slope Engineering, Institute of Mining and Metallurgy, U.K. 1981.
4. Hoek, E and Brown, E.T., Underground Excavations in Rock, Institute of Mining and Metallurgy, U.K. 1981.
5. Obvert, L. and Duvall, W., Rock Mechanics and the Design of structures in Rock, John Wiley, 1967.
6. Bazant, Z.P., Mechanics of Geomaterials Rocks, Concrete and Soil, John Wiley and Sons, Chichester, 1985.
7. Wittke, W., Rock Mechanics. Theory and Applications with case Histories, Springerverlag, Berlin, 1990.
8. Waltham, T, Foundations of Engineering Geology, Second Edition, Spon Press, Taylor & Francis Group, London and New York, 2002.
9. Ramamurthy T., "Engineering in Rocks for Slopes Foundations and Tunnels", PHI Learning Pvt. Ltd., 2007.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	3	2	2
CO2	3	-	3	3	2	2
CO3	3	-	3	3	2	3
CO4	3	-	3	3	3	3
CO5	2	-	2	3	3	3
Avg	**3**	**1**	**3**	**3**	**2**	**3**

1-low, 2-medium, 3-high

SF3012 **EARTH AND ROCK FILL DAMS**

L	T	P	C
3	0	0	3

UNIT I DESIGN CONSIDERATION 9

Design consideration, Factors influencing design, Types of earth and rock fill dams, Design details, Provisions to control pore pressure.

UNIT II SLOPE STABILITY AND SEEPAGE ANALYSIS 8

Stability of infinite and finite slopes, Method of Slices, Bishop's method, Flow nets, Stability conditions during construction, Full reservoir and drawdown - cut off walls – Trenches – Importance of drainage and filters.

UNIT III HYDRAULIC FRACTURING 9

Sampling Techniques – quality of samples – factors influencing sample quality - disturbed and undisturbed soil sampling advanced sampling techniques, offshore sampling, shallow penetration samplers, preservation and handling of samples.

UNIT IV FIELD TESTING IN SOIL EXPLORATION 9

Introduction, Conditions and mechanisms for hydraulic fracturing, Failure criterion for hydraulic fracturing – cubic specimen with a crack – core with a transverse crack – core with a vertical crack, strike–dip of easiest crack spreading; factors affecting hydraulic fracturing, self-healing of a core crack.

UNIT V SLOPE PROTECTION MEASURES 10

Special design problems, Slope protection, Filter design, Foundation treatment, Earth dams on pervious soil foundation, Application of Geosynthetic materials in filtration. Treatment of rock foundation, Construction Techniques, Quality control and performance measurement.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- On successful completion of the course, the students will be able to

CO1 Assess the causes of failure and damage of embankments and slopes.
CO2 Apply the knowledge of engineering and analyse the stability of slopes for various seepage conditions and apply the concept in the design of earth and rock fill dams.
CO3 Apply the knowledge of engineering and assess the stability of dam against hydraulic fracturing and suggest suitable remedial measure.
CO4 Understand the nature of failures and damages in earth and rock fill dams and apply the concept in field to avoid distress.
CO5 Recommend suitable remedial measures to protect the slopes and implement quality control and monitor its performance

REFERENCES:

1. Rowe, R.K., Geotechnical and Geoenvironmental Engineering Handbook, Kulwer Academic Publishers, 2001.
2. Anderson, M.G., and Richards, K.S., Slope Stability, John Wiley, 1987.
3. Sherard, J.L., Woodward, R.J., Gizienski, R.J. and Clevenger, W.A., Earth and Earth rock dam, John Wiley, 1963.
4. Chowdhury, D.F., Slope analysis, Prentice Hall, 1988.
5. McCarthy, D.F., Essentials of Soil Mechanics and Foundations: Basic Geotechnics,Sixth Edition, Prentice Hall, 2002.
6. Bramhead, E.N., The Stability of Slopes, Blacky Academic and Professionals Publications, Glasgow, 1986.
7. Chandhar, R.J., Engineering Developments and Applications, Thomas Telford, 1991
8. Koerner, R.M. Designing with Geosynthetics, Third Edition, Prentice Hall, 1997.
9. Jun-Jie Wang, Hydraulic Fracturing in Earth-rock Fill Dams, John Wiley & Sons, 2014.

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CO – PO Mapping

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CO3	2	2	3	3	3	3
CO4	3	-	2	2	2	3
CO5	3	-	3	3	3	3
Avg	**2**	**1**	**3**	**3**	**2**	**3**

1-low, 2-medium, 3-high

SF3013	**GEOTECHNICS OF UNDERGROUND STRUCTURES**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

UNIT I GROUND MOVEMENTS AND ITS EFFECTS 9

Understanding of the ground – Building response to ground movements – concept of limiting tensile strain – strains in simple rectangular beams – ground movement due to tunneling and excavation - lateral supporting systems – retaining walls – factors influencing on the selection of the retaining system – case history.

UNIT II ANALYSIS OF UNDERGROUND SUPPORTING SYSTEMS 9

Underground supporting system analysis**-** free and fixed earth support method – shear failure of strutted walls – push in – basal heave - upheaval – sand boiling - Stress and deformation analysis of excavation: simplified method – beam on elastic foundation method – finite element method.

UNIT III DESIGN OF UNDERGROUND SUPPORTING SYSTEMS 9

Principles of retaining wall design – types of wall support systems - design of structural elements – Permanent situations – bottom-up/top-down construction sequences – Props – Tied systems – Soil berms – Design of ground anchors – Retaining wall as part of complete underground structure – resistance to vertical and lateral actions

UNIT IV DESIGN OF TUNNEL 10

Longitudinal and transverse profile of tunnel structure - tunnel protection against fire - advanced systems of anti-water insulation of underground structures - loading types of shallow and deep tunnels, rock mass classification - mining technologies of deep excavation - shield technology, execution technology of shallow underground structures, sewerage objects - trenchless technologies.

UNIT V PROTECTION OF ADJACENT BUILDINGS 8

Protection of building using the behaviour of excavation and tunneling induced deformation – building protection by auxiliary methods – construction defects and remedial measures – building rectification methods.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- On successful completion of the course, the students will be able to

CO1 Understand various types of supporting systems used for excavations and analyse ground movement due to various activities like excavations

CO2 Analyse underground supporting system using mathematical, analytical and numerical methods

Attested

CO3 Design various underground supporting systems using mathematical and numerical approach

CO4 Understand the concept of tunnelling, analyse, and design the tunnel in different ground conditions

CO5 protect the adjacent building due to underground construction using various methods

REFERENCES:

1. Chang – Yu Ou, Deep Excavation Theory and Practice, Taylor & Francis Group, London, UK, 2006.
2. Holtz, R.D. and Kovaces, W.D., An Introduction to Geotechnical Engineering, Prentice – Hall, Inc., Englewood Cliffs, NJ, 1981.
3. Terzaghi, K. and Peck, R. B, Soil Mechanics in Engineering Practice, John Wiley & Sons, New York, 1967.
4. Peck, R. B., Hanson, W.E., and Thornburn, T.H., Foundation Engineering, John Wiley & Sons, New York, 1977.
5. Hausman, M. R., Engineering Principles of Ground Modification, McGraw – Hill Publishing Company, New York, 1990.
6. Bowles, J. E. Foundation Analysis and Design, 4th Ed. McGraw – Hill Book Company, New York, USA, 1988.
7. Hoek, E., Brown, E.T., Underground excavations in rock, The Institution of Mining and Metallurgy, London, SW7 2BP, England, 1980.
8. Goel, R.K. and Dwivedi, R.D., A Short-Term course on Underground Engineering, Central Institute of Mining and Fuel Research Regional Centre, Roorkee, 2010.
9. Megaw T. M., and Bartlett, J.V., Tunnels: planning, design, construction. Ellis Horwood, 1983.
10. Kolymbas, D., Tunnelling, and tunnel mechanics: A rational approach to tunnelling, 2nd corrected printing © 2008, Springer – Verlag Berlin Heidelberg, Italy, 2005.
11. Lunardi, P., Design and construction of tunnels, Springer – Verlag Berlin Heidelberg, Italy, 2008.
12. John Burland, Tim Chapman, Hilary Skinner and Michael Brown, ICE manual of geotechnical engineering, Volume II, ICE publication, Londan, U.K, 2012.

CO – PO Mapping

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CO3	2	2	3	3	3	3
CO4	3	-	2	2	2	3
CO5	3	-	3	3	3	3
Avg	**2**	**1**	**3**	**3**	**2**	**3**

1-low, 2-medium, 3-high

SF3014 MARINE GEOTECHNIQUES

L	T	P	C
3	0	0	3

UNIT I MARINE SOIL DEPOSITS 9

Offshore environment, Offshore structures and foundations, Specific problems related to marine soil deposits, Physical and engineering properties of marine soils

UNIT II BEHAVIOR OF SOILS SUBJECTED TO REPEATED LOADING 9

Effect of wave loading on offshore foundations, Behavior of sands and clays under cyclic loading, Laboratory experiments including repeated loading, Cyclic behavior of soils based on fundamental theory of mechanics, Approximate engineering methods which can be used for practical cases

Attested

UNIT III SITE INVESTIGATION IN THE CASE OF MARINE SOIL DEPOSITS 9

Challenges of site investigation in marine environment, Different site investigation techniques, sampling techniques, Geophysical methods, Recent advancements in site investigation and sampling used for marine soil deposits

UNIT IV FOUNDATIONS IN MARINE SOIL DEPOSITS 9

Different offshore and nearshore foundations, Gravity platforms, Jack-up rigs, pile foundations. cassions, spudcans

UNIT V MARINE FOUNDATIONS SUBJECTED TO WAVE LOADING 9

Cyclic behavior of soils, empirical models, elastic-plastic models, FEM analysis of marine foundations subjected to wave loading

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- On completion of the course, the students are expected to be able to

CO1 Understand the physical and engineering properties of marine soil deposits
CO2 explain the effect of wave loading on physical and engineering properties of marine soil deposits
CO3 execute investigation program for marine soil deposits
CO4 design suitable marine foundation as per project requirement
CO5 develop numerical model and design marine foundation subjected to wave loading

REFERENCES:

1. H. G. Poulos. "Marine Geotechnics", Unwin Hyman Ltd, London, UK, 1988
2. D. V. Reddy and M. Arockiasamy, "Offshore Structures", *Volume: 1*, R.E. Kreiger Pub and Co., 1991
3. D. Thomson and D. J. Beasley, "Handbook of Marine Geotechnical Engineering", US Navy, 2012

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	3	2	2	2
CO2	3	-	2	2	2	2
CO3	2	-	2	3	3	3
CO4	3	2	2	3	3	3
CO5	3	2	2	3	3	3
Avg	**3**	**1**	**2**	**3**	**3**	**2**

1-low, 2-medium, 3-high