

ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
REGULATIONS – 2015
CHOICE BASED CREDIT SYSTEM
M. E. SOIL MECHANICS AND FOUNDATION ENGINEERING

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs) :

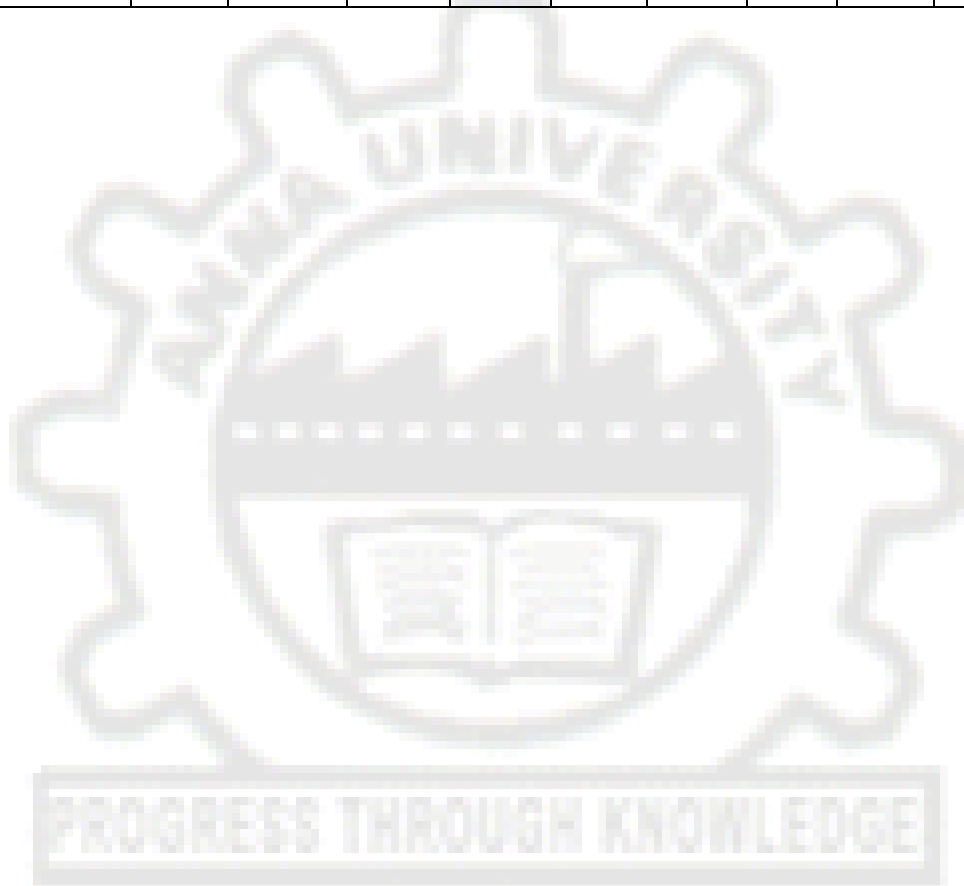
- I. To prepare students to excel in research or to succeed in soil mechanics and foundation engineering profession through global, rigorous post graduate education.
- II. To provide students with a solid foundation in mathematical, scientific and engineering fundamentals required to solve soil mechanics and foundation engineering problems
- III. To train students with good scientific and engineering knowledge so as to comprehend, analyze, design, and create novel products and solutions for the real life problems.
- IV. To inculcate students in professional and ethical attitude, effective communication skills, teamwork skills, multidisciplinary approach, and an ability to relate soil mechanics and foundation engineering issues to broader social context.
- V. To provide student with an academic environment aware of excellence, leadership, written ethical codes and guidelines, and the life-long learning needed for a successful professional career

PROGRAMME OUTCOMES (POs):

On successful completion of the programme,

1. Graduates will demonstrate knowledge of mathematics and science associated with soil mechanics and foundation engineering applications.
2. Graduates will demonstrate an ability to identify, formulate and solve soil mechanics and foundation engineering problems.
3. Graduate will demonstrate an ability to have the necessary knowledge for performing subsurface investigation.
4. Graduates will demonstrate an ability to critically analyze and interpret soil mechanics and foundation engineering data.
5. Graduates will demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks.
6. Graduate will demonstrate skills to use modern engineering tools, software and equipment to analyze soil mechanics and foundation engineering problems.
7. Graduates will demonstrate knowledge of professional and ethical responsibilities.
8. Graduate will be able to communicate effectively in both verbal and written form.
9. Graduate will show the understanding of the impact of soil mechanics and foundation engineering solutions on the society and also will be aware of contemporary issues.
10. Graduate will develop confidence for self education and ability for life-long learning.

Programme Educational Objectives	Programme Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
I	√	√		√					√	
II		√	√	√	√	√	√			
III			√	√	√	√	√			
IV	√	√		√	√		√	√	√	
V	√	√					√	√	√	√



			PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	
YEAR 1	SEM 1	Soil Properties and Behaviour				√	√						
		Strength and Deformation Behaviour of Soils		√		√		√			√		
		Theoretical Soil Mechanics	√	√									
		Advanced Mathematical Methods	√										
		Subsurface Investigation and Instrumentation			√	√	√					√	
		Elective I											
	SEM 2	Deep Foundations					√	√	√	√		√	
		Shallow Foundations					√	√	√	√		√	
		Ground Improvement Techniques		√			√		√	√		√	
		Earth and Earth Retaining Structures		√				√	√	√		√	
		Elective II											
		Elective III											
Advanced Soil Mechanics Laboratory -I			√			√	√						
YEAR 2	SEM 3	Elective IV											
		Elective V											
		Advanced Soil Mechanics Laboratory -II		√			√	√					
		Practical Training (2 weeks)					√			√	√	√	√
		Project Work Phase I		√			√	√		√	√		√
		Design Studio		√				√					√
	SEM 4	Project Work Phase II		√			√	√	√	√	√	√	

PROGRESS THROUGH KNOWLEDGE

Attested

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CURRICULA AND SYLLABI
SEMESTER I

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	MA7161	Advanced Mathematical Methods	FC	4	4	0	0	4
2.	SF7101	Soil Properties and Behaviour	PC	3	3	0	0	3
3.	SF7102	Strength and Deformation Behaviour of Soils	PC	3	3	0	0	3
4.	SF7103	Subsurface Investigation and Instrumentation	PC	3	3	0	0	3
5.	SF7104	Theoretical Soil Mechanics	PC	4	4	0	0	4
6.		Elective I	PE	3	3	0	0	3
TOTAL				20	20	0	0	20

SEMESTER II

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	SF7201	Deep Foundations	PC	3	3	0	0	3
2.	SF7202	Earth and Earth Retaining Structures	PC	3	3	0	0	3
3.	SF7203	Ground Improvement Techniques	PC	3	3	0	0	3
4.	SF7204	Shallow Foundations	PC	3	3	0	0	3
5.		Elective II	PE	3	3	0	0	3
6.		Elective III	PE	3	3	0	0	3
PRACTICAL								
7.	SF7211	Advanced Soil Mechanics Laboratory - I	PC	4	0	0	4	2
TOTAL				22	18	0	4	20

SEMESTER III

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.		Elective IV	PE	3	3	0	0	3
2.		Elective V	PE	3	3	0	0	3
PRACTICAL								
3.	SF7311	Advanced Soil Mechanics Laboratory - II	PC	4	0	0	4	2
4.	SF7312	Design Studio	EEC	2	0	0	2	1
5.	SF7313	Practical Training (2 weeks)	EEC	-	-	-	-	1
6.	SF7314	Project Work(Phase-I)	EEC	12	0	0	12	6
TOTAL				24	6	0	18	16

SEMESTER IV

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
PRACTICALS								
1.	SF7411	Project Work(Phase-II)	EEC	24	0	0	24	12
TOTAL				24	0	0	24	12

TOTAL NO. OF CREDITS:68

PROGRESS THROUGH KNOWLEDGE

FOUNDATION COURSES (FC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.		Advanced Mathematical Methods	FC	4	4	0	0	4

PROFESSIONAL CORE (PC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.		Soil properties and Behaviour	PC	3	3	0	0	3
2.		Strength and Deformation Behaviour of Soils	PC	3	3	0	0	3
3.		Theoretical Soil Mechanics	PC	4	4	0	0	4
4.		Deep Foundations	PC	3	3	0	0	3
5.		Ground Improvement Techniques	PC	3	3	0	0	3
6.		Shallow Foundations	PC	3	3	0	0	3
7.		Advanced Soil Mechanics Laboratory -I	PC	4	0	0	4	2
8.		Advanced Soil Mechanics Laboratory -II	PC	4	0	0	4	2
9.		Subsurface Investigation and Instrumentation	PC	3	3	0	0	3
10.		Earth and Earth Retaining Structures	PC	3	3	0	0	3

PROFESSIONAL ELECTIVES (PE)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	SF7001	Dynamics of Soils and Foundations	PE	3	3	0	0	3
2.	SF7002	Earth and Rock Fill Dams	PE	3	3	0	0	3
3.	SF7003	Earthquake Resistant Design of Foundations	PE	3	3	0	0	3
4.	SF7004	Finite Element Methods and Applications	PE	3	3	0	0	3
5.	SF7005	Geoenvironmental Engineering	PE	3	3	0	0	3

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6.	SF7006	Geology for Geotechnical Applications	PE	3	3	0	0	3
7.	SF7007	Geosynthetic and Reinforced Soil Structures	PE	3	3	0	0	3
8.	SF7008	Geotechnical Earthquake Engineering	PE	3	3	0	0	3
9.	SF7009	Geotechnics for Design of Underground Structures	PE	3	3	0	0	3
10.	SF7010	Mechanics Of Unsaturated Soils	PE	3	3	0	0	3
11.	SF7011	Pavement Engineering	PE	3	3	0	0	3
12.	SF7012	Rock Mechanics and Applications	PE	3	3	0	0	3
13.	SF7013	Soil Structure Interaction	PE	3	3	0	0	3

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.		Practical Training (2 weeks)	EEC	-	-	-	-	1
2.		Design Studio	EEC	2	0	0	2	1
3.		Project Work(Phase I)	EEC	12	0	0	12	6
4.		Project Work(Phase II)	EEC	24	0	0	24	12

PROGRESS THROUGH KNOWLEDGE

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OBJECTIVE:

- To familiarize the students in the field of differential equations to solve boundary value problems associated with engineering applications.
- To expose the students to calculus of variation, conformal mappings and tensor analysis.

UNIT I 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 II 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 Poisson's equations.

UNIT III CALCULUS OF VARIATIONS 12

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

UNIT IV CONFORMAL MAPPING AND APPLICATIONS 12

Introduction to conformal mappings and bilinear transformations – Schwarz Christoffel transformation – Transformation of boundaries in parametric form – Physical applications : Fluid flow and heat flow problems.

UNIT V TENSOR ANALYSIS 12

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

TOTAL : 60 PERIODS**OUTCOME:**

- This subject helps to develop the mathematical methods of applied mathematics and mathematical physics with an emphasis on calculus of variation and integral transforms.

TEXTBOOKS:

1. Sankara Rao K., "Introduction to Partial Differential Equations", Prentice Hall of India Pvt. Ltd., New Delhi, 1997.
2. Gupta A.S., "Calculus of Variations with Applications", Prentice Hall of India Pvt. Ltd., New Delhi, 1997.
3. Spiegel M.R., "Theory and Problems of Complex Variables and its Application" (Schaum's Outline Series), McGraw Hill Book Co., Singapore, 1981.
4. Ramanaiah, G.T., "Tensor Analysis", S. Viswanathan Pvt. Ltd., 1990.
5. James G., "Advanced Modern Engineering Mathematics", Pearson Education, Third Edition, 2004.
6. O'Neil P.V., "Advanced Engineering Mathematics", Thomson Asia Pvt. Ltd., Singa

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, 1973.
3. Mathews J.H. and Howell R.W., "Complex Analysis for Mathematics and Engineering", Narosa Publishing House, New Delhi, 1997.
4. Grewal B.S., "Higher Engineering Mathematics", Khanna Publishers, Fortieth Edition, 2007

SF7101**SOIL PROPERTIES AND BEHAVIOUR****L T P C
3 0 0 3****OBJECTIVES:**

- To impart knowledge on the various factors governing the Engineering behaviour of soils and the suitability of soils for various Geotechnical Engineering applications.

UNIT I SOIL DEPOSITS AND CLAY MINERALS 8

Introduction – formation of soils – 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.

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 structure.

UNIT III SWELLING, SHRINKAGE AND COMPACTION BEHAVIOUR OF SOILS 10

Problems associated with swelling and shrinkage behaviour of soils – Causes, consequences and mechanisms – factors influencing swell – shrink characteristics – swell potential – osmotic swell pressure – soil fabric and measurement – sensitivity, thixotrophy of soils – soil suction – soil compaction – factors affecting soil compaction.

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

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

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 behaviour of soils using index properties – empirical equations and their applicability.

TOTAL: 45 PERIODS**OUTCOME:**

- Students are able to select suitable soils for various geotechnical applications based on the factors governing the Engineering behaviour of soils.

REFERENCES:

1. Mitchell, J.K., Fundamentals of Soil Behaviour, John Wiley, New York, 1993.
2. Yong, R.N. and Warkentin, B.P., Introduction to Soil Behaviour, Macmillan, Limited, London, 1979.
3. Coduto, D.P., Geotechnical Engineering – Principles and practices, Prentice Hall of India Pvt. Ltd., New Delhi, 2002.
4. Perloff, W.H. and Baron, W, Soil Mechanics, The Ronal Press Company, 1976.
5. Van Olphen, H., Clay colloid Chemistry, John Wiley, 1996
6. Grim, R.E., Applied Clay Mineralogy, McGraw Hill, New York, 1966.
7. Lambe, T.W. & Whitman, R.V. Soil Mechanics, John Wiley & Sons, New York, 1979.
8. Das, B.M., Principles of Geotechnical Engg, PWS Publishing Comp, Boston, 1998
9. McCarthy D.F., Essentials of Soil Mechanics & Foundations, Prentice-Hall, 2002.
10. Robert D. Holtz and William D. Kovacs, “An Introduction to Geotechnical Engineering”, Prentice Hall (UK) International, London, 1981.

SF7102

STRENGTH AND DEFORMATION BEHAVIOUR OF SOILS

L T P C
3 0 0 3

OBJECTIVES:

- To impart knowledge to characterize stress-strain behaviour of soils, the failure criteria and to evaluate the shear strength and compressibility parameters of soils.

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.

UNIT II SHEAR STRENGTH OF COHESIVE SOILS 9

Shear strength of NC and OC 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.

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, non linear 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: 4

OUTCOME:

- Students are able to select the shear strength and compressibility parameters to design different structures for different conditions of loading, drainage and failure criteria.

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", McGraw Hill, 1997.
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, 1979.
5. Wood, D.M., "Soil behaviour and Critical State Soil Mechanics", Cambridge University Press, New York, 1990.
6. Graham Barnes, "Soil Mechanics Principles and Practices", Macmillan Press Ltd., London, 2002.
7. Braja, M. Das, "Principles of Geotechnical Engineering", Brooks/Cole, Thomson Learning Academic Resource, Center, Fifth Edition, 2002.
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, 9th edition, 2014.
10. Braja, M. Das, "Fundamentals of Geotechnical Engineering", Brooks/Cole, Thomson Learning Academic Resource, Center, 2000.

SF7103**SUBSURFACE INVESTIGATION AND INSTRUMENTATION****L T P C
3 0 0 3****OBJECTIVES:**

- Students are expected to understand the importance of site investigation, planning of sub soil investigation, interpretation of investigated data to design suitable foundation system.

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) method and electrical methods, cross bore hole, single bore 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, 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.

UNIT IV FIELD TESTING IN SOIL EXPLORATION**12**

Field tests, penetration tests, 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, 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**OUTCOME:**

- Students are capable of planning and executing the sub soil investigation programme. They are also capable of interpreting the investigated data and can design suitable foundation system.

REFERENCES:

1. Hunt, R.E., Geotechnical Engineering Investigation Manual, McGraw Hill, 1984.
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.
4. Nair, R.J. and Wood, P.M., Pressuremeter Testing Methods and Interpretation, Butter-worths, 1987.
5. Dunicliff, 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, 1995.
9. Clayton C. R. I., Matthews M. C. and Simons N. E., Site Investigation, Second Edition Halsted Press, 1982

SF7104**THEORETICAL SOIL MECHANICS****L T P C
4 0 0 4****OBJECTIVES:**

- To impart knowledge required for computing stress and settlement at any point in the semi-infinite elastic soil medium, anisotropic medium and layered deposits due to foundation loads and evaluation of stability of foundations, slopes, cuts and retaining structures both for the conditions of undrained and drained loading through theorems of plastic collapses.

UNIT I THEORY OF ELASTICITY**12**

Material behavior – Basic Concepts – Elastic, Viscous and Plastic idealization, 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 co-ordinates.

UNIT II STRESS AND DISPLACEMENT IN ELASTIC – HALF SPACE MEDIUM 14

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 – Kelvin, Cerruti and Mindlin's method for force in interior of semi-infinite medium, solutions by influence charts – Elastic displacement – Layered soil – Burmister method.

UNIT III THEOREMS OF PLASTIC COLLAPSE AND THEIR APPLICATIONS 10

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, retaining walls, slopes and cuts.

UNIT IV STABILITY OF SOIL STRUCTURE BY SLIP LINE METHOD AND LIMIT EQUILIBRIUM ANALYSIS 14

Introduction – stress – strain relationship in a perfectly plastic material – discontinuous slipping – stress and displacement field calculations – associated field calculation – Slip line solutions for undrained and drained conditions – limit equilibrium solutions for stability of foundation, retaining walls and slopes.

UNIT V FLOW THROUGH POROUS MEDIA 10

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.

TOTAL : 60 PERIODS

OUTCOME:

- At the end of the course students will have the capacity to estimate the stresses in soil medium of any type due to foundation load and settlement of foundation. Further they will be in a position to evaluate bound and true collapse loads of soil structures.

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, 2002.
7. Muni Budhu, Soil Mechanics and Foundations, John Wiley and Sons, Inc., Network, 2000.
8. Cedergren, H.R., Seepage, Drainage and Flownets, John Wiley, 1997.
9. Davis, R.O and Selvadurai, A.P.S., Elasticity and Geomechanics, Cambridge University Press, 1996.
10. Wai-Fah Chen, and Liu, X.L., Limit Analysis in Soil Mechanics, Elsevier Science Ltd., 1991.
11. Atkinson, J.H., Foundations and Slopes, McGraw Hill, 1981.

OBJECTIVES:

- The student will be exposed to the design of piles, pile groups and caissons with respect to vertical and lateral loads for various field conditions.

UNIT I PILE CLASSIFICATIONS & LOAD TRANSFER PRINCIPLE 10

Necessity of pile foundation – classification of piles – Factors governing choice of type of pile – Load transfer mechanism – piling equipments 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 PILES AND PILE GROUPS 10

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

UNIT III LATERAL AND UPLIFT LOAD CAPACITY 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 – codal provision – IRC guide lines – case studies.

UNIT IV STRUCTURAL DESIGN OF PILE AND PILE GROUPS 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 – 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 - codal provision.

TOTAL: 45 PERIODS**OUTCOME:**

- Students are able to select, analyse and design individual pile, group piles and caissons for different subsoil conditions.

REFERENCES:

- Das, B.M., Principles of Foundation Engineering, Design and Construction, Fourth Edition, PWS Publishing, 1999.
- Poulos, H.G., Davis, E.H., Pile foundation analysis and design, John Wiley and Sons, New York, 1980.
- Tomlinson, M.J. Foundation engineering, ELBS, Longman Group, U.K. Ltd., England 1995.
- Michael Tomlinson and John Woodward, Pile design and construction practice, Taylor & Francis Group, London & New York, 2008.
- Cernica, J.N. Geotechnical Engineering Foundation Design, John Wiley and Sons, Inc. 1995.
- Bowles, J.E., Foundation Analysis and Design, Fifth Edition, McGraw Hill, New York, 1996.
- Donald, P., Coduto, Foundation Design Principles and Practices, Prentic Englewood Cliffs, New Jersey, 1996.

8. Varghese P.C., "Foundation Engineering", PHI Learning Private Limited, New Delhi, 2005.
9. Varghese P.C., "Design of Reinforced Concrete Foundations", PHI Learning Private Limited, New Delhi, 2009.

SF7202

EARTH AND EARTH RETAINING STRUCTURES

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3 0 0 3**

OBJECTIVES:

- At the end of this course, students are expected to analyse and design rigid, flexible earth retaining structures, slurry supported trenches and deep cuts.

UNIT I EARTH PRESSURE THEORIES

10

Introduction – 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 COMPACTION, DRAINAGE AND 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.

UNIT V STABILITY OF SLOPES

9

Introduction, 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. Role of geosynthetics in stabilization of slopes.

TOTAL: 45 PERIODS

OUTCOME:

- Students will be capable of analyzing and designing rigid, flexible earth retaining structures, slurry supported trenches and deep cuts.

REFERENCES:

1. Clayton, C.R.I., Militisky, J. and Woods, R.I., Earth pressure and Earth-Retaining structures, Second Edition, Survey University Press, 1993.
2. Das, B.M., Principles of Geotechnical Engineering, Fourth Edition, The PWS series in Civil Engineering, 1998.
3. Militisky, J. and Woods, R., Earth and Earth retaining structures, Routledge, 1992.
4. Winterkorn, H.F. and Fang, H.Y., Foundation Engineering Handbook, Galgotia Book- source, 2000.
5. Rowe, R.K., Geotechnical and Geoenvironmental Engineering Handbook, Kluwer Academic Publishers, 2001.
6. Koerner, R.M. Designing with Geosynthetics, Third Edition, Prentice Hall, 1997.

Attested

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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, Sixth Edition, Prentice Hall, 2002.
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, 1994.
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.

SF7203

GROUND IMPROVEMENT TECHNIQUES

L T P C
3 0 0 3

OBJECTIVES:

- Students will be exposed to various problems associated with soil deposits and methods to evaluate them. The different techniques will be taught to them to improve the characteristics of difficult soils as well as design techniques required to implement various ground improvement methods.

UNIT I DEWATERING

9

Introduction – 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 COMPACTION AND SAND DRAINS

9

Insitu compaction of granular and cohesive soils, Shallow and Deep compaction methods – Sand piles – Concept, design, factors influencing compaction. Blasting and dynamic consolidation – Preloading with sand drains, fabric drains, wick drains etc. – Theories of sand drain – design and relative merits of various methods – Case studies.

UNIT III STONE COLUMN, LIME PILES AND SOIL NAILING

9

Stone column with and without encased, lime piles – Functions – Methods of installation – design, estimation of load carrying capacity and settlement. Root piles and soil nailing – methods of installation – Design and Applications - Soil liquefaction mitigation methods - case studies.

UNIT IV GEOSYNTHETICS AND ITS APPLICATIONS

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.

UNIT V GROUTING

9

Grouting – Types of grout – 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

OUTCOME:

- Based on the knowledge gained student will be in a position to identify and evaluate the deficiencies if any in the deposits of the given project area and capable of providing alternative methods to improve its quality so that the structures built on it will be stable and serve the intended purpose.

REFERENCES:

1. Pappala, 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 Griffiths S.C., Practical Recommendation for Evaluation and mitigation of Soil Liquefaction in Arkansas, (Project Report), 2010.
3. Day, R.W., Foundation Engineering Handbook, McGraw – Hill Companies, Inc. 2006.
4. Rowe, R.K., Geotechnical and Geoenvironmental Engineering Handbook, Kluwer Academic Publishers, 2001.
5. Das, B.M., Principles of Foundation Engineering, Fourth Edition, PWS Publishing, 1999.
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, 1996.
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. Jones, J.E.P., Earth Reinforcement and Soil Structure, Butterworths, 1985.

SF7204

SHALLOW FOUNDATIONS

L T P C
3 0 0 3

OBJECTIVES:

- To impart knowledge to select, analyse, geotechnical and structural design of shallow foundation depending on ground conditions.

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.

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 - 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. Evaluation from in-situ tests settlement – Allowable bearing pressure - codal provisions.

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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 – Offshore foundation – Machine foundation - Codal Provisions.

TOTAL: 45 PERIODS**OUTCOME:**

- Students are able to select, analyse and design the shallow foundation based on both the type of soil and the loading.

REFERENCES:

1. Bowles, J.E., "Foundation Analysis and Design, 5th Edition, McGraw Hill, New York, 1995.
2. Swami Saran, "Soil Dynamics and Machine Foundation, Galgotia 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
5. Braja M.Das, "Geotechnical Engineering Handbook" J.Ross Publishing, Cengage Learning India Pvt Ltd, 2010
6. Edward Tsodik, 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. John Burland, Tim Chapman, Hilary Skinner, Michael Brown., "Geotechnical Design Construction and verification – ICE Manual of Geotechnical Engineering volume-II" ICE Publishing, UK., 2012.
11. Salgado,R., "The Engineering of Foundations", Tata McGraw Hill Education Private Limited, New Delhi, 2011.

PROGRESS THROUGH KNOWLEDGE

OBJECTIVES:

- At the end of the course student attains adequate knowledge in assessing index properties, compaction, CBR, Compressibility, Swell characteristics and permeability of soils by conducting laboratory tests.

LIST OF EXPERIMENTS

UNIT I	INDEX TESTS	12
Specific gravity of soil solids-Grain size distribution (Sieve analysis and Hydrometer analysis) - Liquid limit and Plastic limit tests - Shrinkage limit and Differential free swell tests - Field density Test		
UNIT II	CHEMICAL TESTS	12
Chemical analysis – pH – Conductivity – quantification of ions through flame Photometer – Determination of organic, sulphate and chlorite content.		
UNIT III	COMPACTION AND CBR TESTS	12
Compaction tests - Determination of moisture – density relationship – Influence of compaction energy – CBR Test.		
UNIT IV	COSOLIDATION AND PERMEABILITY TESTS	12
One dimensional consolidation test, C_v , C_c and m_v determination. Permeability of soil – constant and falling head methods.		
UNIT V	SWELLTESTS	12
Determination of percent swell – swell pressure, constant volume method; expanded - loaded method.		

TOTAL: 60 PERIODS**OUTCOME:**

- Students will be capable of assessing various properties of soils by conducting appropriate tests.

REFERENCES:

- Alam Singh and Chowdary, G.R., Soil Engineering in Theory and Practice (Vol.2) Geotechnical Testing and Instrumentation, CBS Publishers and Distributors, NewDelhi,2006.
- Head, K.H., Manual of Soil Laboratory Testing Vol.I and II, Pentech Press, London 1990.
- Head, K.H., Manual of Soil Laboratory Testing Vol.III, Second Edition, John Wiley & Sons, 1998.
- Bowles, J.E., Engineering properties of soils and their measurements, McGraw Hill, 1992.
- Das, B.M., Soil Mechanics Laboratory Manual, Engineering Press, Austin, 1997
- Al-Khatiji, A.W. and Anderstand, O.B., Geotechnical Engineering & Soil Testing, Sounders College Publishing, Fort Worth, 1992.
- “Soil Engineering Laboratory Instruction Manual”, Published by the Engineering College Cooperative Society, Chennai, 1996.
- Lambe T.W., Soil Testing for Engineers”, John Wiley and Sons, New York, 1990.
- I.S. Code of Practice (2720): Relevant Parts, as amended from time to time.

OBJECTIVES:

- At the end of the course student attains adequate knowledge in assessing Shear Strength, dynamic properties of soil and shear strength, indirect tensile strength and compressive strength of Rocks. Student learns to assess the different properties of geosynthetics. Student is trained to gain knowledge in assessing the properties of soils through field tests and also by conducting model tests.

UNIT I	SHEAR STRENGTH TESTS	12
Direct shear – Triaxial compression (UU and CU) 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	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 (demonstration only).		

TOTAL: 60PERIODS**OUTCOME:**

- Students will be capable of assessing shear strength, dynamic properties of soils by conducting appropriate tests. They will be in a position to assess the properties of geosynthetics and rocks. They can also supervise different field tests.

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.
3. Head, K.H., Manual of Soil Laboratory Testing Vol.III, Second Edition, John Wiley & Sons, 1998.
4. Bowles, J.E., Engineering properties of soils and their measurements, McGraw Hill, 1992.
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-Khatiji, 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.

SF7312

DESIGN STUDIO

L T P C
0 0 2 1

OBJECTIVES:

- Train the students to use various software packages for simulating and analyzing the real field problems in Geotechnical Engineering.

SYLLABUS:

Students have to work individually with software packages for simulating and analyzing the soil – structure interaction such as Foundations, Retaining walls, and Ground improvement related problems. Software use to analyze and design real challenging problems such as a deep excavation adjacent to an existing structure and slope stability analysis. Also, to predict the response of any other field problems like an embankment or 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: 30 PERIODS

OUTCOME:

- At the end of the course the students will have a clear idea to use software programs for arriving solutions to various practical design problems in Geotechnical Engineering

SF7313

PRACTICAL TRAINING

L T P C
0 0 0 1

OBJECTIVES:

- To train the students in field work so as to have a firsthand knowledge of practical problems in carrying out Soil Mechanics and Foundation engineering tasks. To develop skills in facing and solving the geotechnical engineering field problems.

SYLLABUS:

The students individually undertake training in reputed Soil Mechanics and Foundation Engineering Companies during the summer vacation for a specified period of four weeks. At the end of training, a detailed report on the work done should be submitted within ten days from the commencement of the semester. The students will be evaluated through a viva-voce examination by a team of internal staff.

OUTCOME:

- Students are able to solve Soil Mechanics and Foundation engineering problems in the field either individually or in team.

SF7314

PROJECT WORK (PHASE I)

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0 0 12 6

OBJECTIVES:

- To identify a specific problem for the current need of the society and collecting information related to the same through detailed review of literature.
- To develop the methodology to solve the identified problem.
- To train the students in preparing project reports and to face reviews and viva-voce examination.

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-voce examination by a panel of examiners including one external examiner.

TOTAL: 180PERIODS

OUTCOME:

- At the end of the course the students will have a clear idea of his/her area of work and they are in a position to carry out the remaining phase II work in a systematic way.

SF7411

PROJECT WORK (PHASE II)

L T P C
0 0 24 12

OBJECTIVES:

- To solve the identified problem based on the formulated methodology.
- To develop skills to analyze and discuss the test results, and make conclusions.

SYLLABUS:

The student should continue the phase 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

OUTCOME:

- On completion of the project work students will be in a position to take up any research and challenging practical problem for finding better solutions.

OBJECTIVES:

- To understand the basics of dynamics – dynamic behaviour of soils – effects of dynamic loads and the various design methods.

UNIT I THEORY OF VIBRATION**9**

Introduction – 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**OUTCOME:**

- Students are able to design foundation for different machines, assess the influence of vibrations and selection of remediation methods based on the nature of vibration, properties and behaviour of soil.

REFERENCES:

- Kameswara Rao, N.S.V., "Dynamics soil tests and applications", Wheeler Publishing , New Delhi, 2000.
- Moore, P.J., "Analysis & Design of Foundations for Vibrations", Oxford & IBH, 2006.
- Krammer S.L., "Geotechnical Earthquake Engineering", Prentice hall, International Series, Pearson Education (Singapore) Pvt. Ltd., 2004.
- Prakash, S and Puri, V.K., Foundations for machines, McGraw Hill, 1987.
- Swami Saran, "Soil Dynamics and Machine Foundation", Galgotia publications Pvt. Ltd., New Delhi 1999.
- Kameswara Rao, "Vibration Analysis and Foundation Dynamics", Wheeler Publishing, New Delhi, 1998.

OBJECTIVES:

- Students are expected to learn reasons for failure and damages of embankments and slopes, various methods of analysis of slopes and remedial techniques to protect the slopes.

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**

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 IV FAILURE AND DAMAGES**9**

Failure and damages, Nature and importance of failures in embankment and foundation - Piping, Differential settlement, Foundation slides, Earthquake damage, creep and anisotropic effects, Reservoir wave action, Dispersive piping.

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**OUTCOME:**

- Students are capable of reasoning out the causes of failure and damages of embankments and slopes. They can carry out slope stability analysis using various methods. They are also capable of carrying out remedial measures and protection of slopes.

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, 2

OBJECTIVES:

- Focus is mainly on identifying the different kinds of loading induced on the foundation due to earthquake and soil - foundation interaction analysis with reference to various design parameters that including liquefaction of soil due to earthquake.

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**

Introduction – Seismic passive lateral earth pressure, behaviour of retaining wall during earthquakes, modification of Coulomb's Theory, Modified Culmann's Theory, displacement analysis, Indian standard code of practice.

UNIT V STRUCTURAL DESIGN OF FOUNDATION**8**

Introduction – loads acting on foundations during earthquake – fundamental failure mechanisms of foundations – essential criteria for design of foundations in liquefiable soils – structural design of foundations subjected to earthquake loading.

TOTAL: 45 PERIODS**OUTCOME:**

- Students will have the capacity to perform the analysis and design of foundation under earthquake loading by considering the influence of various design parameters that includes the liquefaction of soils due to earthquake.

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. Geotechnical Earthquake Engineering by Day R. W., handbook, McGraw – Hill, New York, 2002.
3. Design of Pile Foundations in Liquefiable Soils by Gopal Madabhushi, Jonathan Knappett and Stuart Haigh, Imperial College Press, London WC2H 9HE, 2010.
4. Basic geotechnical earthquake engineering by Kamalesh Kumar, New Age International Publishers, New Delhi, 2008.
5. Soil Mechanics in Engineering Practice by Terzaghi and Peck, R. B, John Wiley & Sons, New York, 1967.

6. Pile foundation analysis and design by Poulos H.G. and Davis E.H., John Wiley and Sons, 1980.
7. Soil dynamics by Prakash, S., McGraw Hill, New York, 1981.
8. Geotechnical Earthquake Engineering by Steven L. Kramer, Prentice Hall, New Delhi, 1996.
9. Foundation design and construction by Tomlinson M.J., Longman Scientific & Technical, England, 1986.

SF7004

FINITE ELEMENT METHODS AND APPLICATIONS

**LT PC
3 0 0 3**

OBJECTIVES:

- Students are focused on acquiring the basic knowledge and computational skills in terms of finite element formulation with respect to various kinds of Geotechnical Engineering problems.

UNIT I BASIC CONCEPTS 9

Introduction – 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 CONSIDERATION 9

Introduction – 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 behavior 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 – software package use for simulating and analyzing the real foundation problem using FEM such as footing, pile foundation and deep excavations.

TOTAL: 45 PERIODS

OUTCOME:

- Students will have the capacity to use advanced numerical techniques like FEM for Geotechnical Engineering applications and in a capacity to use FEM based software for arriving solutions to various practical design problems in Geotechnical Engineering.

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REFERENCES:

1. Concepts and applications of finite element analysis by Cook, R.D., Malkus, D.S., and Plesha, M.E., John Wiley, New York., 1989.
2. Introduction to the finite element method by Desai and Abel, Van Nostrand Reinhold Company, New York, 1972.
3. Finite element analysis Theory and Programming by Krishnamoorthy.C.S., Tata McGraw-Hill, New Delhi, 1990.
4. Finite element in geotechnical engineering by Naylor, Pande, Simpson and Tabb., Pineridge Press Ltd, Swansea, U. K, 1981.
5. The Finite Element Method by Zienkiewicz, O.C., 3rd Edition, Tata McGraw-Hill publishing Co., New Delhi, 1983.
6. Finite element analysis in geotechnical engineering – theory by Potts, D.M. and Zdravkovic, L., Published by Thomas Telford, London, 1999.
7. An introduction to the finite element method by Reddy, J.N., McGraw Hill, New York, 1984.
8. The Finite Element Methods in Engineering by Rao, S.S., Pergamon, New York, 1998.
9. Soil-machine introduction – A finite element perspective by Shen, J. and Kushwahs, R.L., Moral Dikker, Inc., 1998.
10. Programming the Finite Element Method with application to Geomechanics by Smith, I.M., John Wiley and Sons, New Delhi, 2000.

SF7005

GEOENVIRONMENTAL ENGINEERING

L T P C
3 0 0 3

OBJECTIVES:

- The student acquires the knowledge on the Geotechnical engineering problems associated with soil contamination, safe disposal of waste and remediate the contaminated soils by different techniques thereby protecting environment.

UNIT I SOIL – WASTE INTERACTION

8

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 – physical and physio-chemical mechanisms – Environmental laws and regulations.

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, volatilization, 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 a 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.

UNIT V STABILISATION OF WASTE**10**

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**OUTCOME:**

- Students are able to assess the contamination in the soil and to select suitable remediation methods based on contamination. Also they are able to prepare the suitable disposal system for particular waste.

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.
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4. Wentz, C.A., Hazardous Waste Management, McGraw Hill, Singapore, 1989.
5. Proceedings of the International symposium of Environmental Geotechnology (Vol.I and II), Environmental Publishing Company, 1986 and 1989.
6. Ott, W.R., Environmental Indices, Theory and Practice, Ann Arbor, 1978.
7. Fried, J.J., Ground Water Pollution, Elsevier, 1975.
8. ASTM Special Tech. Publication 874, Hydraulic Barrier in Soil and Rock, 1985.
9. Lagrega, M.d., Buckingham, P.L., and Evans, J.C., Hazardous Waste Management, McGraw Hill, Inc. Singapore, 1994.

SF7006**GEOLOGY FOR GEOTECHNICAL APPLICATIONS****L T P C
3 0 0 3****OBJECTIVES:**

- To impart knowledge and skills in assessing the quality of foundation rocks, their aggregates and building materials derived from rock; and assess the geological suitability of sites.

UNIT I ENGINEERING PROPERTIES OF ROCKS AND MINERALS**12**

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 its relation to strength and durability of rock. Geotechnical properties of rocks of Tamilnadu.

UNIT II SURFACE AND SUBSURFACE GEOLOGICAL INVESTIGATIONS**9**

Field investigations - electrical and seismic geophysical methods in subsurface geological investigations for foundation engineering, applications of GPR in subsurface site
Description of structural discontinues, Strike and dip of rocks, folds, faults and joints.

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UNIT III DRILL HOLE AND CORE LOGGING 8

Logging techniques – Resistivity log, Neutron log, sonic log, gamma log. Rock core logging – rocks description, weathering grade, RMR, RQD and sampling methods for rock strength, and composition studies.

UNIT IV MAPPING TECHNIQUES 8

Preparation of profiles from contour map; lithological and structural mapping of shallow and deep excavated sites. Hand on exercises.

UNIT V GEOLOGICAL INVESTIGATIONS FOR FOUNDATION ENGINEERING 8

Ground stability studies - Scour and erosion studies-stability of slopes and geological solution for slope stability in landslides areas.

TOTAL: 45 PERIODS

OUTCOME:

- The students will be able to assess the suitability of a construction site and the construction materials with respect to the geological parameters.

REFERENCES:

1. Varghese P.C. Engineering Geology for civil engineers, PHI learning Pvt.Ltd. New Delhi-1, 2012
2. Krynine and Judd Principles of Engineering Geology and Geotechnology McGraw Hill, New York 1962.
3. Bell FG. by Engineering Geology, Second Edition, Butterworth-Heinemann, Oxford, 2007
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6. Venkata Reddy. D., Engineering geology, Vikas Publishing Home, Noida, 2010
7. Chenna Kesavulu. N., Text book of engineering geology, II edition, MacMillan Publishers India Ltd. Delhi, 2009.

**SF7007 GEOSYNTHETIC AND REINFORCED SOIL STRUCTURES L T P C
3 0 0 3**

OBJECTIVES:

- To understand the mechanism of the reinforcement, its influence in the shear strength and design concept for various applications in geotechnical engineering.

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, Geofom, 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

OUTCOME:

- Students are able to analyse and design the geotechnical reinforced structures based on interaction mechanism of reinforcement and soil.

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. Sivakumar Babu, 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.

SF7008

GEOTECHNICAL EARTHQUAKE ENGINEERING

**L T P C
3 0 0 3**

OBJECTIVES:

- To understand the dynamics of earth and its response, effect on earth structure and measures to mitigate the effects.

- 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**

Introduction – 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 – Earthpressure due to ground shaking – Dynamic analysis.

TOTAL: 45 PERIODS**OUTCOME:**

- Students are able to perform seismic stability analysis of geotechnical structures and in-situ soil by developing the design ground motion for an area based on bed rock motion and types of soils.

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 Charles Scawthorn, Earthquake Engineering Hand book, Caspress, 2003.
5. Robert W. Day, Geotechnical Earthquake Engineering Hand book, Second Edition, McGraw Hill, 2012.
6. Ikuo Towhata, "Geotechnical Earthquake Engineering" Springer series in Geomechanics and Geoengineering, Scientific Publishing services Pvt. Ltd., 2008.
7. Swami Saran, "Soil Dynamics and Machine Foundation, Galgotia Publications Pvt. Ltd., New Delhi-110002, 1999.

OBJECTIVES:

- Students mainly focused in visualizing and critically analyzing the behavior of underground structures with reference to various supporting systems under different loading conditions due to induced earth pressure on the underground structures.

UNIT I GROUND MOVEMENTS AND ITS EFFECTS 9

Introduction – understanding 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

Introduction - 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

Introduction – 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

Introduction - 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

Introduction – 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**OUTCOME:**

- Students will have the capacity to analyze and design the underground structures with reference to various supporting systems that needs for underground construction and also have an ability to protect the adjacent building due to underground construction.

REFERENCES:

1. Deep Excavation Theory and Practice by Chang – Yu Ou, Taylor & Francis Group, London, UK, 2006.
2. An Introduction to Geotechnical Engineering by Holtz, R.D. and Kovaces, W.D., Prentice – Hall, Inc., Englewood Cliffs, NJ, 1981.
3. Soil Mechanics in Engineering Practice by Terzaghi, K. and Peck, R. B, John Wiley & Sons, New York, 1967.
4. Foundation Engineering by Peck, R. B., Hanson, W.E., and Thornburn, T.H., John Wiley & Sons, New York, 1977.
5. Engineering Principles of Ground Modification by Hausman, M. R., McGraw – Hill Publishing Company, New York, 1990.

6. Foundation Analysis and Design by Bowles, J. E. 4th Ed. McGraw – Hill Book Company, New York, USA, 1988.
7. Underground excavations in rock by Hoek, E., Brown, E.T., The Institution of Mining and Metallurgy, London, SW7 2BP, England, 1980.
8. A Short-Term course on Underground Engineering by Goel, R.K. and Dwivedi, R.D., Central Institute of Mining and Fuel Research Regional Centre, Roorkee, 2010.
9. Tunnels: planning, design, construction by Megaw T. M., and Bartlett, J.V., Ellis Horwood, 1983.
10. Tunnelling and tunnel mechanics: A rational approach to tunneling by Kolymbas, D., 2nd corrected printing © 2008, Springer – Verlag Berlin Heidelberg, Italy, 2005.
11. Design and construction of tunnels by Lunardi, P., Springer – Verlag Berlin Heidelberg, Italy, 2008.
12. ICE manual of geotechnical engineering, Volume II and II by John Burland, Tim Chapman, Hilary Skinner and Michael Brown, ICE publication, London, U.K, 2012.

SF7010

MECHANICS OF UNSATURATED SOILS

**L T P C
3 0 0 3**

OBJECTIVES:

- To impart knowledge in assessing both physical and engineering behaviour of unsaturated soils, measurement and modeling of suction – water content and suction – hydraulic conductivity of unsaturated soils.

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

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

OUTCOME:

- Students are able to assess the engineering behaviour of unsaturated soil, and understand the modeling and measurement techniques.

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.

SF7011

PAVEMENT ENGINEERING

**L T P C
3 0 0 3**

OBJECTIVES:

- Student gains knowledge on designing rigid and flexible pavements for different serviceability conditions of roads.

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

OUTCOME:

- Students are able to design different new pavements and rehabilitate the existing roads using recent technology.

REFERENCES:

1. Wright, P.H., Highway Engineers, John Wiley & Sons, Inc., New York, 1996.
2. Khanna S.K and Justo C.E.G, Highway Engineering, Eighth Edition, New Chand and Brothers, Roorkee, 2001.
3. Yoder R.J and Witchak M.W., Principles of Pavement Design, John Wiley, 2000.
4. Croney, D., Design and Performance of Road Pavements, HMO Stationary Office, 1979.
5. Design and Specification of Rural Roads (Manual), Ministry of rural roads, Government of India, New Delhi, 2001.
6. Guidelines for the Design of Flexible Pavements, IRC:37 - 2001, The Indian roads Congress, New Delhi.
7. Guideline for the Design of Rigid Pavements for Highways, IRC:58-1998, The Indian Roads Congress, New Delhi.
8. O' Flaherty, C.A., Highways – The location, Design, Construction & Maintenance of Pavements, Fourth Edition, Elsevier, 2006.
9. Bell. P.S., Developments in Highway Engineering, Applied Sciences publishers, 1978.

**SF7012 ROCK MECHANICS AND APPLICATIONS L T P C
3 0 0 3**

OBJECTIVES:

- Students are expected to classify, understand stress-strain characteristics, failure criteria, and influence of insitu stress in the stability of various structures and various technique to improve the insitu strength of rocks.

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.

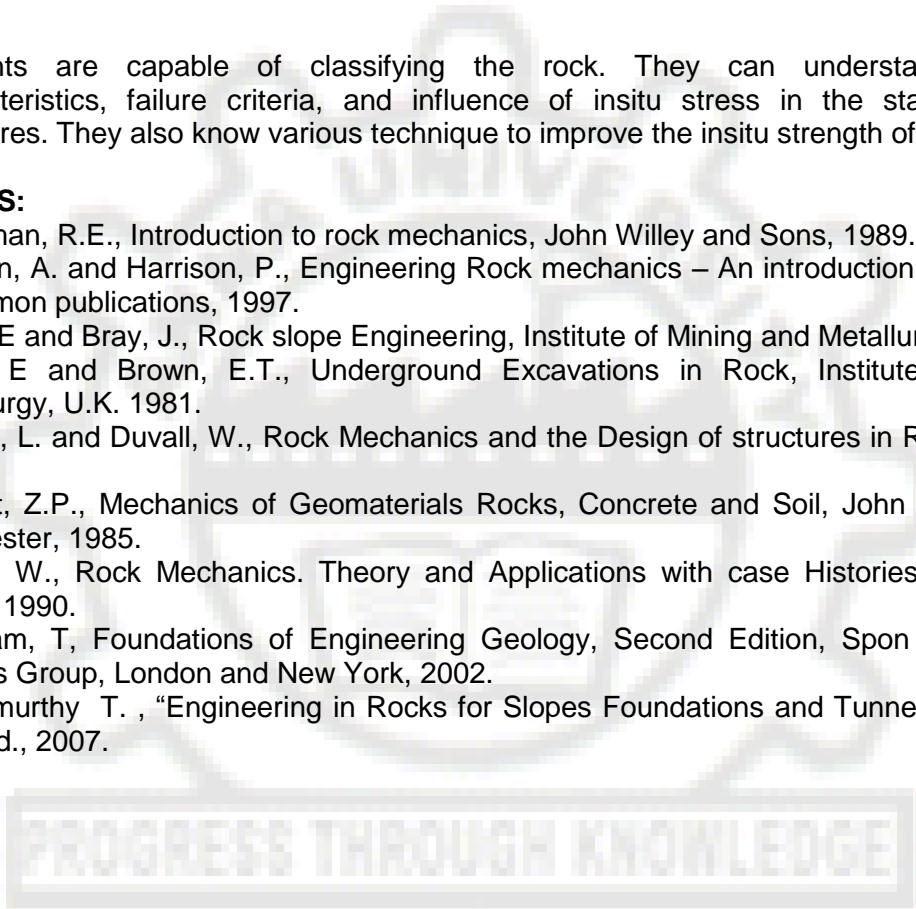
UNIT III	INSITU STRESSES IN ROCKS	10
Insitu stresses and their measurements, Hydraulic fracturing, flat jack, over coring and under coring methods - stress around underground excavations – Design aspects of openings in rocks - case studies.		
UNIT IV	SLOPE STABILITY AND BEARING CAPACITY OF ROCKS	9
Rock slopes - role of discontinuities in slope failure, slope analysis and factor of safety - remedial measures for critical slopes – Bearing capacity of foundations on rocks – case studies		
UNIT V	ROCK REINFORCEMENT	8
Reinforcement of fractured and joined rocks - shotcreting, bolting, anchoring, installation methods - case studies.		
TOTAL: 45 PERIODS		

OUTCOME:

- Students are capable of classifying the rock. They can understand stress-strain characteristics, failure criteria, and influence of insitu stress in the stability of various structures. They also know various technique to improve the insitu strength of rocks.

REFERENCES:

1. Goodman, R.E., Introduction to rock mechanics, John Willey and Sons, 1989.
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.



SF7013	SOIL STRUCTURE INTERACTION	L T P C
		3 0 0 3

OBJECTIVES:

- Focus is on idealization of soil response to closely represent continuum behavior and interaction analysis between the soil-structure with reference to relative stiffness of beams, slabs and piles under different loading conditions.

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, parameter elastic models, Elastic – plastic behavior, Time dependent behavior.		

Attested

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- 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

OUTCOME:

- At the end of this course students will have the capacity to idealize soil response in order to analyze and design the foundation elements subjected to different loadings.

REFERENCE:

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 1979.
6. Kurien, N.P., "Design of Foundation Systems: Principles and Practices Narosa Publishing House, New Delhi, 1999.
7. Michael J Tomlinson, John C Woodward., Pile Design and Construction Practice, Sixth Edition, CRC Press, 2014
8. Edward Tsodik, "Analysis of Structures on Elastic Foundations", J. Ross Publishing, Cengage learning India Private limited, Delhi, 2013.