ANNA UNIVERSITY, CHENNAI

AFFLIATED INSTITUTIONS

M.E. SOIL MECHANICS AND FOUNDATION ENGINEERING

REGULATIONS – 2017

CHOICE BASED CREDIT SYSTEM

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	Advanced Mathematical Methods	✓									
		Soil Properties and Behaviour				✓	✓					
		Strength and Deformation Behaviour of Soils		✓		✓		✓			✓	
		Subsurface Investigation and Instrumentation			✓	✓	✓				✓	
		Theoretical Soil Mechanics	✓	✓								
		Professional Elective I										
	SEM 2	Deep Foundations				✓	✓	✓	✓		✓	
		Earth and Earth Retaining Structures		✓			✓	✓	✓		✓	
		Ground Improvement Techniques		✓		✓		✓	✓		✓	
		Shallow Foundations				✓	✓	✓	✓		✓	
		Professional Elective II										
		Professional Elective III										
		Advanced Soil Mechanics Laboratory -I				✓	✓					
YEAR 2	SEM 3	Professional Elective IV										
		Professional Elective V										
		Professional Elective VI Advanced Soil Mechanics Laboratory -II		✓		✓	✓					
		Design Studio		✓			✓					✓
		Practical Training (2 weeks)				✓			✓	✓	✓	✓
		Project Work Phase I		✓		✓	✓		✓	✓		✓
	SEM 4	Project Work Phase II		✓		✓	✓	✓	✓	✓	✓	✓

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CHOICE BASED CREDIT SYSTEM

CURRICULA AND SYLLABI

SEMESTER I

S.No.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	MA5151	Advanced Mathematical Methods	FC	4	4	0	0	4
2.	SF5101	Soil Properties and Behaviour	PC	3	3	0	0	3
3.	SF5102	Strength and Deformation Behaviour of Soils	PC	3	3	0	0	3
4.	SF5103	Subsurface Investigation and Instrumentation	PC	3	3	0	0	3
5.	SF5104	Theoretical Soil Mechanics	PC	4	4	0	0	4
6.		Professional 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.	SF5201	Deep Foundations	PC	3	3	0	0	3
2.	SF5202	Earth and Earth Retaining Structures	PC	3	3	0	0	3
3.	SF5203	Ground Improvement Techniques	PC	3	3	0	0	3
4.	SF5204	Shallow Foundations	PC	3	3	0	0	3
5.		Professional Elective II	PE	3	3	0	0	3
6.		Professional Elective III	PE	3	3	0	0	3
PRACTICAL								
7.	SF5211	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.		Professional Elective IV	PE	3	3	0	0	3
2.		Professional Elective V	PE	3	3	0	0	3
3.		Professional Elective VI	PE	3	3	0	0	3
PRACTICAL								
4.	SF5311	Advanced Soil Mechanics Laboratory - II	PC	4	0	0	4	2
5.	SF5312	Design Studio	EEC	2	0	0	2	1
6.	SF5313	Practical Training (2 weeks)	EEC	-	-	-	-	1
7.	SF5314	Project Work (Phase I)	EEC	12	0	0	12	6
			TOTAL	**27**	**9**	**0**	**18**	**19**

SEMESTER IV

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
PRACTICAL								
1.	SF5411	Project Work (Phase II)	EEC	24	0	0	24	12
			TOTAL	**24**	**0**	**0**	**24**	**12**

TOTAL NO. OF CREDITS: 71

FOUNDATION COURSES (FC)

S.No.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	MA5151	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.	SF5101	Soil properties and Behaviour	PC	3	3	0	0	3
2.	SF5102	Strength and Deformation Behaviour of Soils	PC	3	3	0	0	3
3.	SF5103	Subsurface Investigation and Instrumentation	PC	3	3	0	0	3
4.	SF5104	Theoretical Soil Mechanics	PC	4	4	0	0	4
5.	SF5201	Deep Foundations	PC	3	3	0	0	3
6.	SF5202	Earth and Earth Retaining Structures	PC	3	3	0	0	3
7.	SF5203	Ground Improvement Techniques	PC	3	3	0	0	3
8.	SF5204	Shallow Foundations	PC	3	3	0	0	3
9.	SF5211	Advanced Soil Mechanics Laboratory -I	PC	4	0	0	4	2
10.	SF5311	Advanced Soil Mechanics Laboratory -II	PC	4	0	0	4	2

PROFESSIONAL ELECTIVES

SEMESTER I

ELECTIVE I

S.No.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	SF5001	Geology for Geotechnical Applications	PE	3	3	0	0	3
2.	SF5002	Earth and Rock Fill Dams	PE	3	3	0	0	3
3.	SF5003	Mechanics of Unsaturated Soils	PE	3	3	0	0	3

SEMESTER II

ELECTIVE II & III

S.No.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	SF5004	Finite Element Methods and Applications	PE	3	3	0	0	3
2.	SF5005	Dynamics of Soils and Foundations	PE	3	3	0	0	3
3.	SF5006	Earthquake Resistant Design of Foundations	PE	3	3	0	0	3
4.	SF5007	Pavement Engineering	PE	3	3	0	0	3

SEMESTER III

ELECTIVE IV, V & VI

S.No.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	SF5008	Geotechnical Earthquake Engineering	PE	3	3	0	0	3
2.	SF5009	Geotechnics for Design of Underground Structures	PE	3	3	0	0	3
3.	SF5010	Geoenvironmental Engineering	PE	3	3	0	0	3
4.	SF5011	Rock Mechanics and Applications	PE	3	3	0	0	3
5.	SF5012	Soil Structure Interaction	PE	3	3	0	0	3
6.	SF5013	Geosynthetic and Reinforced Soil Structures	PE	3	3	0	0	3

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S.No.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	SF5312	Design Studio	EEC	2	0	0	2	1
2.	SF5313	Practical Training (2 weeks)	EEC	-	-	-	-	1
3.	SF5314	Project Work(Phase I)	EEC	12	0	0	12	6
4.	SF5411	Project Work(Phase II)	EEC	24	0	0	24	12

MA5151 ADVANCED MATHEMATICAL METHODS L T P C
4 0 0 4

OBJECTIVES :

- The main objective of this course is to provide the student with a repertoire of mathematical methods that are essential to the solution of advanced problems encountered in the fields of applied physics and engineering. This course covers a broad spectrum of mathematical techniques such as Laplace Transform, Fourier Transform, Calculus of Variations, Conformal Mapping and Tensor Analysis. Application of these topics to the solution of problems in physics and engineering is stressed.

UNIT I LAPLACE TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS 12

Laplace transform : Definitions – Properties – Transform 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 – Isoperimetric problems – 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 – Inner product – Quotient law – Metric tensor – Christoffel symbols – Covariant differentiation – Gradient - Divergence and curl.

TOTAL : 60 PERIODS

OUTCOMES :

After completing this course, students should demonstrate competency in the following skills:

- Application of Laplace and Fourier transforms to initial value, initial–boundary value and boundary value problems in Partial Differential Equations.
- Maximizing and minimizing the functional that occur in various branches of Engineering Disciplines.
- Construct conformal mappings between various domains and use of conformal mapping in studying problems in physics and engineering particularly to fluid flow and heat flow problems.
- Understand tensor algebra and its applications in applied sciences and engineering and develops ability to solve mathematical problems involving tensors.
- Competently use tensor analysis as a tool in the field of applied sciences and related fields.

REFERENCES :

1. Andrews L.C. and Shivamoggi, B., "Integral Transforms for Engineers", Prentice Hall of India Pvt. Ltd., New Delhi, 2003.
2. Elsgolc, L.D., "Calculus of Variations", Dover Publications Inc., New York, 2007.
3. Kay, D. C., "Tensor Calculus", Schaum's Outline Series, Tata McGraw Hill Edition, 2014.
4. Mathews, J. H., and Howell, R.W., "Complex Analysis for Mathematics and Engineering", 5th Edition, Jones and Bartlett Publishers, 2006.
5. Naveen Kumar, "An Elementary Course on Variational Problems in Calculus ", Narosa Publishing House, 2005.
6. Ramaniah. G. "Tensor Analysis", S. Viswanathan Pvt. Ltd., 1990.
7. Saff, E.B and Snider, A.D, "Fundamentals of Complex Analysis with Applications in Engineering, Science and Mathematics", 3rd Edition, Pearson Education, New Delhi, 2014.
8. Sankara Rao, K., "Introduction to Partial Differential Equations", Prentice Hall of India Pvt. Ltd., New Delhi, 1997.
9. Spiegel, M.R., "Theory and Problems of Complex Variables and its Applications", Schaum's Outline Series, McGraw Hill Book Co., 1981.

SF5101 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. Coduto, D.P., Geotechnical Engineering – Principles and practices, Prentice Hall of India Pvt. Ltd., New Delhi, 2002.
2. Das, B.M.,Principles of Geotechnical Engg, PWS Publishing Comp, Boston, 1998
3. Grim, R.E., Applied Clay Mineralogy, McGraw Hill, New York, 1966.
4. Lambe, T.W. & Whitman, R.V. Soil Mechanics, John Wiley & Sons, New York, 1979.
5. McCarthy D.F., Essentials of Soil Mechanics & Foundations, Prentice-Hall, 2002.
6. Mitchell, J.K., Fundamentals of Soil Behaviour, John Wiley, New York, 1993.
7. Perloff, W.H. and Baron, W, Soil Mechanics, The Ronal Press Company, 1976.
8. Robert D. Holtz and William D. Kovacs, "An Introducion to Geotechnical Engineering", Prentice Hall (UK) International, London, 1981.
9. Van Olphen, H., Clay colloid Chemistry, John Wiley, 1996
10. Yong, R.N. and Warkentin, B.P., Introduction to Soil Behaviour, Macmillan, Limited, London, 1979.

SF5102 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: 45 PERIODS

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. Atkinson J.H. and Brandsby P.L. "Introduction to critical state soil mechanics" McGraw Hill, 1978.
2. Braja, M, Das., "Advanced soil mechanics", McGraw Hill, 1997.
3. Braja, M. Das, "F undamentals of Geotechnical Engineering", Brooks/Cole, Thomson Learning Academic Resource, Center, 2000.
4. Braja, M. Das, "Principles of Geotechnical Engineering", Brooks/Cole, Thomson Learning Academic Resource, Center, Fifth Edition, 2002.
5. Graham Barnes, "Soil Mechanics Principles and Practices", Macmillan Press Ltd., London, 2002.
6. Ian Smith, “Elements of Soil Mechanics”, John Wiley & Sons, UK, 9th edition, 2014.
7. Lambe, T.W. and Whitman R.V. "Soil Mechanics in S.I. Units John Wiley, 1979.
8. Malcolm D. Bolton, "A guide to soil mechanics", Universities Press (India) Private Ltd., Hyderabad, India, 2003.
9. Robert D. Holtz., William D. Kovacs., Thomas C. Sheahan., “An Introduction to Geotechnical Engineering” Dorling Kindersley India pvt. Ltd., Second edition, 2013.
10. Wood, D.M., "Soil behaviour and Critical State Soil Mechanics", Cambridge University Press, New York, 1990.

SF5103 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. 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.
2. Bowles, J.E., Foundation Analysis and Design, Fifth Edition, The McGraw-Hill companies, Inc., New York, 1995.
3. Clayton C. R. I., Matthews M. C. and Simons N. E., Site Investigation, Second Edition Halsted Press, 1982
4. Day, R.N., Geotechnical and Foundation Engineering, Design and Construction, McGraw-Hill, 1999.
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. Hunt, R.E., Geotechnical Engineering Investigation Manual, McGraw Hill,1984.
8. Nair, R.J. and Wood, P.M., Pressuremeter Testing Methods and Interpretation, Butter-worths, 1987.
9. Winterkorn, H.F. and Fang, H.Y., Foundation Engineering Hand Book, a Nostrand Reinhold 1994.

SF5104 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 and polar 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. Atkinson, J.H., Foundations and Slopes, McGraw Hill, 1981.
2. Atkinson, J.H; The Mechanics of Soils and Foundations, Taylor and Francis, London, 2007.
3. Aysen, A., Problem solving in Soil Mechanics, Taylor & Francis, London, First Indian Print, 2011.
4. Aysen, A., Soil Mechanics, Basic concepts and Engineering Applications, A.A.Balkema Publishers, 2002.
5. Bolton, M.D; A Guide to Soil Mechanics, University press (India) Pvt.Ltd., 2009
6. Cedergren, H.R., Seepage, Drainage and Flownets, John Wiley, 1997.
7. Chowdhury, I., Dasgupta S.P., Dynamics of Structure and Foundations, Taylor & Francis Group, London, 2009.
8. Davis, R.O and Selvadurai, A.P.S., Elasticity and Geomechanics, Cambridge University Press, 1996.
9. Muni Budhu, Soil Mechanics and Foundations, John Wiley and Sons, Inc., Network, 2000.
10. Ulrich Smoltc, YK, Geotechnical Engineering Handbook (Vol.1), Ernot & Sohn, 2002.
11. Wai-Fah Chen, and Liu, X.L., Limit Analysis in Soil Mechanics, Elsevier Science Ltd., 1991.

SF5201 DEEP FOUNDATIONS

L	T	P	C
3	0	0	3

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 AND 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 OF 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:

1. Bowles, J.E., Foundation Analysis and Design, Fifth Edition, McGraw Hill, New York, 1996.
2. Cernica, J.N. Geotechnical Engineering Foundation Design, John Wiley and Sons, Inc. 1995.
3. Das, B.M., Principles of Foundation Engineering, Design and Construction, Fourth Edition, PWS Publishing, 1999.
4. Donald, P., Coduto, Foundation Design Principles and Practices, Prentice Hall, Inc. Englewood Cliffs, New Jersey, 1996.
5. Michael Tomlinson and John Woodward, Pile design and construction practice, Taylor & Francis Group, London & New York, 2008.
6. Poulos, H.G., Davis, E.H., Pile foundation analysis and design, John Wiley and Sons, New York, 1980.
7. Reese, L. C. and Van Impe, W. F., Single Piles and Pile Groups Under Lateral Loading, Taylor and Francis, London, 2011.
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.
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11. Varghese P.C.," Foundation Engineering", PHI Learning Private Limited, New Delhi, 2005.

SF5202 EARTH AND EARTH RETAINING STRUCTURES L T P C
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 9

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:

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2. Clayton, C.R.I., Militisky, J. and Woods, R.I., Earth pressure and Earth-Retaining structures, Second Edition, Survey University Press, 1993.
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11. Petros P. Xanthakos., Slurry walls as structural systems, McGraw-Hill, Inc., New York, 1994.
12. Rowe, R.K., Geotechnical and Geoenvironmental Engineering Handbook, Kluwer Academic Publishers, 2001.
13. Winterkorn, H.F. and Fang, H.Y., Foundation Engineering Handbook, Galgotia Book-source, 2000.

SF5203 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. Cox, B.R., and Grifiths S.C., Practical Recommendation for Evaluation and mitigation of Soil Liquefaction in Arkansas, (Project Report), 2010.
2. Das, B.M., Principles of Foundation Engineering, Fourth Edition, PWS Publishing, 1999.
3. Day, R.W., Foundation Engineering Handbook, McGraw – Hill Companies, Inc. 2006.
4. Han,J., Principles and Practice of Ground Improvement, John Wiley and Sons, New Jersey, Canada2015.
5. Hehn, R.W., Practical Guide to Grouting of Underground Structures, ASCE, 1996.
6. Jewell, R.A., Soil Reinforcement with Geotextiles, CIRIA, London, 1996.
7. Jones, J.E.P., Earth Reinforcement and Soil Structure, Butterworths, 1985.
8. Koerner, R.M. and Welsh, J.P., Construction and Geotechnical Engineering using Synthetic Fabrics, John Wiley, 1990.
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10. Moseley, M.P., Ground Treatment, Blackie Academic and Professionals, 1998.

11. Pappala, A.J., Huang,J., Han, J., and Hoyos, L.R., Ground Improvement and Geosynthetics; Geotechnical special publication No.207, Geo Institute, ASCE, 2010
12. Rowe, R.K., Geotechnical and Geoenvironmental Engineering Handbook, Kluwer Academic Publishers, 2001.

SF5204 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 – Allowable settlement – Allowable bearing pressure - 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 – 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. Braja M.Das, “Geotechnical Engineering Handbook” J.Ross Publishing, Cengage Learning India Pvt Ltd, 2010
3. Edward Tsudik, Analysis of Structures on Elastic Foundations, J.Ross Publishing, Cengage Learning India Private limited, Delhi, 2013.
4. Ian Smith, “Elements of Soil Mechanics”, John Wiley & Sons, UK, 9th edition,2014

5. John Burland, Tim Chapman, Hilary Skinner, Michael Brown., “Geotechnical Design Construction and verification – ICE Manual of Geotechnical Engineering volume-II” ICE Publishing, UK., 2012.
6. Karuna Moy Ghosh, “Foundation Design in Practice” PHI learning private Ltd, Delhi, 2009.
7. Nainan P. Kurian, "Design of Foundation Systems, Principles and Practices, Narosa Publishing House, Third Edition, 2006.
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. Salgado,R., "The Engineering of Foundations", Tata McGraw Hill Education Private Limited, New Delhi, 2011.
10. Som.N.N., Das.S.C., “Theory and Practice of Foundation Design” PHI learning private Ltd, Delhi, 2013.
11. Swami Saran, "Soil Dynamics and Machine Foundation, Galgottia Publications Pvt. Ltd., New Delhi-110002, 1999.
12. Varghese, P.C. "Design of Reinforced Concrete Foundations”, Prentice-Hall of India, New Delhi, 2009.

SF5211 ADVANCED SOIL MECHANICS LABORATORY - I L T P C
0 0 4 2

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, Cv , Cc and mv 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:

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

SF5311 ADVANCED SOIL MECHANICS LABORATORY - II L T P C
0 0 4 2

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: 60 PERIODS

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. "Soil Engineering Laboratory Instruction Manual", Published by the Engineering College Co-operative Society, Chennai, 1996.
2. Alam Singh and Chowdary, G.R., Soil Engineering in Theory and Practice (Vol.2) Geotechnical Testing and Instrumentation, CBS Publishers and Distributors, NewDelhi,2006.
3. Al-Khataji, A.W. and Anderstand, O.B., Geotechnical Engineering & Soil Testing, Sounders College Publishing, Fort Worth, 1992.
4. Bowles, J.E., Engineering properties of soils and their measurements, McGraw Hill, 1992.
5. Das, B.M., Soil Mechanics Laboratory Manual, Engineering Press, Austin,1997
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10. Koerner, R.M., Designing with Geosynthetics, Third Edition, Prentice Hall, 1997.
11. Lambe T.W., Soil Testing for Engineers", John Wiley and Sons, New York, 1990.

SF5312 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

REFERENCES:

1. Web link for open source and shareware software using the link http://www.ggsd.com.

SF5313 PRACTICAL TRAINING (2 weeks) 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.

SF5314 **PROJECT WORK (PHASE I)** **L T P C**
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: 180 PERIODS

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.

SF5411 **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.

SF5001 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 strata studies, Description of structural discontinues, Strike and dip of rocks, folds, faults and joints.

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:

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2. Chenna Kesavulu. N., Text book of engineering geology, II edition, MacMillan Publishers India Ltd. Delhi, 2009.
3. Krynine and Judd Principles of Engineering Geology and Geotechnology McGraw Hill, New York 1962.
4. Sathya Narayanaswami, Engineering Geology, Dhanpat Raj and Co.1710, Nai Sarak, Delhi-110 006, 2000.
5. Varghese P.C. Engineering Geology for civil engineers, PHI learning Pvt.Ltd. New Delhi-1, 2012
6. Venkata Reddy. D., Engineering geology, Vikas Publishing Home, Noida, 2010
7. Waltham, A.C. Foundations of Engineering Geology, Blackie Academic Professional Pub.1 Ed.UK.1994

SF5002 **EARTH AND ROCK FILL DAMS** **L T P C**
3 0 0 3

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

SF5003 **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. Jean- Louis Briaud., Geotechnical Engineering: Unsaturated and Saturated soils, John Wiley & Sons, INC, New Jersey, 2013.
3. Ng Charles, W.W., Menzies Bruce, Advanced unsaturated Soil Mechanism and Engineering, Taylor & Francis Group, 2007.
4. Ning Lu and William, J. Likes, Unsaturated Soil Mechanics, John Wiley & sons, INC. New Jersey, 2004
5. Ning Lu, Laureano R. Hoyes and Lakshmi Reddi, Advances in unsaturated soil, seepage and Environmental Geotechnics, ASCE., Geotechnical special publication No.148.

SF5004 FINITE ELEMENT METHODS AND APPLICATIONS L T P C
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 in various Geotechnical Engineering applications and in a capacity to use FEM based software programs for arriving solutions to various practical design problems in Geotechnical Engineering.

REFERENCES:

1. Cook, R.D., Malkus, D.S., and Plesha, M.E., Concepts and applications of finite element analysis, John Wiley, New York., 1989.
2. Desai and Abel, Introduction to the finite element method, Van Nostrand Reinhold Company, New York, 1972.
3. Desai, Y. M., Eldho, T. L. and Shah, A. H., Finite element method with applications in engineering, Dorling Kindersley (India) Pvt. Ltd., New Delhi, 2014.
4. Krishnamoorthy.C.S., Finite element analysis Theory and Programming, Tata McGraw-Hill, New Delhi, 1990.
5. Logan, D.L., A First Course in the Finite Element Method, 5th edition, Cengage-Learning, United States, 2012.

6. Naylor, Pande, Finite elements in geotechnical engineering, Simpson and Tabb., Pineridge Press Ltd, Swansea, U. K, 1981.
7. Potts, D.M. and Zdravkovic, L., Finite element analysis in geotechnical engineering – theory. Thomas Telford, London, 1999.
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9. Rao, S.S., The Finite Element Methods in Engineering, Pergamon, New York, 1998.
10. Reddy, J.N., An introduction to the finite element method, McGraw Hill, New York, 1984.
11. Shen, J. and Kushwahs, R.L., Soil-machine introduction – A finite element perspective, Moral Dikker, Inc., 1998.
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SF5005 DYNAMICS OF SOILS AND FOUNDATIONS L T P C
3 0 0 3

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.

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1. Kameswara Rao, "Vibration Analysis and Foundation Dynamics", Wheeler Publishing, New Delhi, 1998.
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SF5006 EARTHQUAKE RESISTANT DESIGN OF FOUNDATIONS L T P C
3 0 0 3

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.

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1. Day R. W., Geotechnical Earthquake Engineering handbook, McGraw – Hill, New York, 2002.
2. 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.
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.
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6. Prakash, S., Soil dynamics, McGraw Hill, New York, 1981.
7. Srbulov, M., Geotechnical Earthquake Engineering Simplified Analyses with Case Studies and Examples, Springer, Dordrecht. 2008.
8. Steven L. Kramer, Geotechnical Earthquake Engineering, Prentice Hall, New Delhi, 1996.
9. Terzaghi and Peck, R. B, Soil Mechanics in Engineering Practice, John Wiley & Sons, New York, 1967.
10. Tomilinson M.J., Foundation design and construction, Longman Scientific & Technical, England, 1986.

SF5007 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. Bell. P.S., Developments in Highway Engineering, Applied Sciences publishers, 1978.
2. Croney, D., Design and Performance of Road Pavements, HMO Stationary Office, 1979.
3. Design and Specification of Rural Roads (Manual), Ministry of rural roads, Government of India, New Delhi, 2001.
4. Guideline for the Design of Rigid Pavements for Highways, IRC:58-1998, The Indian Roads Congress, New Delhi.
5. Guidelines for the Design of Flexible Pavements, IRC:37 - 2001, The Indian roads Congress, New Delhi.
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7. O' Flaherty, C.A., Highways – The location, Design, Construction & Maintenance of Pavements, Fourth Edition, Elsevier, 2006.
8. Wright, P.H., Highway Engineers, John Wiley & Sons, Inc., New York, 1996.
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SF5008 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. Ikuo Towhata, "Geotechnical Earthquake Engineering" Springer series in Geomechanics and Geoengineering, Scientific Publishing services Pvt. Ltd., 2008.
2. Kameswara Rao, N.S.V., Dynamics soil tests and applications, Wheeler Publishing - New Delhi, 2000.
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6. Swami Saran, "Soil Dynamics and Machine Foundation, Galgottia Publications Pvt. Ltd., New Delhi-110002, 1999.
7. Wai-Fah Chen and Cgharles Scawthem, Earthquake Engineering Hand book, Caspress,2003.

SF5009 GEOTECHNICS FOR DESIGN OF UNDERGROUND STRUCTURES L T P C

3 0 0 3

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. Bowles, J. E. Foundation Analysis and Design, 4th Ed. McGraw – Hill Book Company, New York, USA, 1988.
2. Chang – Yu Ou, Deep Excavation Theory and Practice, Taylor & Francis Group, London, UK, 2006.
3. 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.
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5. Hoek, E., Brown, E.T., Underground excavations in rock, The Institution of Mining and Metallurgy, London, SW7 2BP, England, 1980.
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7. John Burland, Tim Chapman, Hilary Skinner and Michael Brown, ICE manual of geotechnical engineering, Volume II, ICE publication, Londan, U.K, 2012.
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11. Peck, R. B., Hanson, W.E., and Thornburn, T.H., Foundation Engineering, John Wiley & Sons, New York, 1977.
12. Terzaghi, K. and Peck, R. B, Soil Mechanics in Engineering Practice, John Wiley & Sons, New York, 1967.

SF5010 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, 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.

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. ASTM Special Tech. Publication 874, Hydraulic Barrier in Soil and Rock, 1985.
2. Daniel B.E, Geotechnical Practice for waste disposal, Chapman & Hall, London, 1993.
3. Fried, J.J., Ground Water Pollution, Elsevier, 1975.
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SF5011 ROCK MECHANICS AND APPLICATIONS L T P C
3 0 0 3

OBJECTIVES:

- Students are expected to classify, understand stares-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 slop 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 stares-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. Bazant, Z.P., Mechanics of Geomaterials Rocks, Concrete and Soil, John Wiley and Sons, Chichester, 1985.
2. Goodman, R.E., Introduction to rock mechanics, John Willey and Sons, 1989.
3. Hoek, E and Bray, J., Rock slope Engineering, Institute of Mining and Metallurgy, U.K. 1981.
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6. Obvert, L. and Duvall, W., Rock Mechanics and the Design of structures in Rock, John Wiley, 1967.
7. Ramamurthy T. , “Engineering in Rocks for Slopes Foundations and Tunnels”, PHI Learning Pvt. Ltd., 2007.
8. Waltham, T, Foundations of Engineering Geology, Second Edition, Spon Press, Taylor & Francis Group, London and New York, 2002.
9. Wittke, W., Rock Mechanics. Theory and Applications with case Histories, Springerverlag, Berlin, 1990.

SF5012 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, 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 – Setttlement 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. Edward Tsudik, “Analysis of Structures on Elastic Foundations”, J. Ross Publishing, Cengage learning India Private limited, Delhi, 2013.
2. Hemsley, J.A, "Elastic Analysis of Raft Foundations", Thomas Telford, 1998.
3. Kurien, N.P., "Design of Foundation Systems: Principles and Practices Narosa Publishing House, New Delhi, 1999.
4. Michael J Tomlinson, John C Woodward., Pile Design and Construction Practice, Sixth Edition, CRC Press, 2014
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6. Salgado, R., "The Engineering of Foundations", Tata McGraw Hill Education Private Limited, New Delhi, 2011.
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SF5013 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 compatability.

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

OUTCOME:

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

REFERENCES:

1. Cheng.Y.M., Lau.C.K., “Slope Stability Analysis and Stabilization” Routledge Taylor & Francis Group, London., 2008.
2. Jewell, R.A., Soil Reinforcement with Geotextile, CIRIA, London, 1996.
3. John Burland, Tim Chapman, Hilary Skinner, Michael Brown., “Geotechnical Design Construction and verification – ICE Manual of Geotechnical Engineering volume-II” ICE Publishing, UK., 2012.
4. John, N.W.M., Geotextiles, John Blackie and Sons Ltd., London, 1987.
5. Jones, C.J.F.P., Earth Reinforcement and Soil Structures, Earthworks, London, 1982.
6. Kerry Rowe.R., “Geotechnical and GeoEnvironmental Engineering handbook” Kluwer Academic Publishers, 2001
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