DELHI TECHNOLOGICAL UNIVERSITY

SCHEME OF TEACHING AND EVALUATION

MASTER OF TECHNOLOGY IN GEOTECHNICAL ENGINEERING (GTE)

The following alphanumeric coding scheme has been adopted
Core Courses XXXYMN
Elective Courses XXXYCMN
XXX abbreviates a particular M. Tech. program, Y – (5 for M. Tech. 1 st year, 6 for M. Tech. 2 nd year),
C – credit of the course (4/3/2),
MN – Subject code (Odd number for odd semester and even number for even semester courses

Semester-I

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group A	1	GTE501	Advanced Soil mechanics	Core	4	3	0	2	15	25	20	40	-	
	2	GTE503	Advance Foundation Engineering	Core	4	3	0	2	15	25	20	40	-	
Group B	3	GTE5401/5403/……	Elective 1	Elective	4	3	0	2	15	25	20	40	-	17
	4	GTE5301/5303/……	Elective 2	Elective	3	3	0	0	20	-	30	50	-	
	5	GTE5201/5203/……/ UEC5201/5203/……	Elective 3/University Elective I	Elective	2	2	0	0	20	-	30	50	-	

Semester-II

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group C	1	GTE502	Rock Mechanics	Core	4	3	0	2	15	25	20	40	-	17
	2	GTE504	Soil dynamics and machine foundation	Core	4	3	0	2	15	25	20	40	-	

Group D	3	GTE5402/5404/……	Elective 4	Elective	4	3	0	2	15	25	20	40	-	
	4	GTE5302/5304/……	Elective 5	Elective	3	3	0	0	20	-	30	50	-	
	5	GTE5202/5204/……/ UEC5202/5204/……	Elective 6/University Elective II	Elective	2	2	0	0	20	-	30	50	-	

Semester-III

	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
	Track 1													
Group E	1	GTE651	Research Project	Core	12	0	0	12	0	-	0	100	0	
	Track 2													
	1	GTE601	Major Project I	Core	3						40	60		
	2	GTE6401/6403/……	Elective 7	Elective	4	3	0	2	15	25	20	40	15	
	3	GTE6301/6303/……	Elective 8	Elective	3	3	0	0	20	-	30	50	-	
	4	GTE6201/6203/……	Elective 9	Elective	2	2/0	0	0/4	20/0	0/40	30/0	50/0	0/60	

Semester-IV

	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group F	**Track 1**													
	1	GTE652	Research Project	Core	12	0	0	12	0	-	0	100	0	
	Track 2													
	1	GTE602	Major Project II	Core	12	0	0	12	0	-	0	100	0	

LIST OF ELECTIVES :														
	S.No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**	
Elective 1	1	GTE5401	Geo-environmental Engineering	Elective	4	3	0	2	15	25	20	40	-	
	2	GTE5403	Geotechnical Exploration		4	3	0	2	15	25	20	40	-	
	3	GTE5405	Application of remote sensing and GIS in Geotechnical Engineering		4	3	0	2	15	25	20	40	-	
	4	GTE5407	Cost Management of Engineering Project		4	3	0	2	15	25	20	40	-	
	S.No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**	
Elective 2	1	GTE5301	Geotechnical Earthquake Engineering	Elective	3	3	0	0	20	0	30	50	-	
	2	GTE5303	Stability Analysis of Slopes		3	3	0	0	20	0	30	50	-	
	3	GTE5305	Earth Pressure & Earth Retaining Structures		3	3	0	0	20	0	30	50	-	
	4	GTE5307	Pavement analysis and Design		3	3	0	0	20	0	30	50	-	
	S.No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**	
Elective 3	1	GTE5201	Seminar	Elective	2	0	0	2	-	100	-	-	-	
	2	GTE5203	FEM in Geotechnical Engineering		2	2	0	0	20	0	30	50	-	
	3	GTE5205	Offshore Geotechnical Engineering		2	2	0	0	20	0	30	50	-	
	4	GTE5207	Composite Material		2	2	0	0	20	0	30	50	-	
	S.No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**	
Elective 4	1	GTE5402	Theoretical Soil Mechanics	Elective	4	3	0	2	15	25	20	40	-	
	2	GTE5404	Unsaturated Soil Mechanics		4	3	0	2	15	25	20	40	-	
	3	GTE5406	Critical State Soil Mechanics		4	3	0	2	15	25	20	40	-	
	4	GTE5408	Operational Research		4	3	0	2	15	25	20	40	-	
	S.No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**	
Elective 5	1	GTE5302	MINOR PROJECT	Elective	3	0	0	-	-	40	-	-	60	
	2	GTE5304	Soil Structure Interaction		3	3	0	0	20	0	30	50	-	
	3	GTE5306	Disaster Mitigation and Management		3	3	0	0	20	0	30	50	-	
	4	GTE5308	Uncertainties, risk and reliability in Geotechnical Engineering		3	3	0	0	20	0	30	50	-	
	S.No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**	

Elective 6	1	GTE5202	Ground Water Hydrology	Elective	2	2	0	0	20	0	30	50	-	
	2	GTE5204	Physical Modelling in Geomechanics		2	2	0	0	20	0	30	50	-	
	3	GTE5206	Numerical and Analytical Method in Geomechanics		2	2	0	0	20	0	30	50	-	
	4	GTE5208	Waste to Energy		2	2	0	0	20	0	30	50	-	
	S.No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**	
Elective 7	1	GTE6401	Plasticity & Fracture Mechanics in Rock Structures	Elective	4	3	0	2	15	25	20	40	-	
	2	GTE6403	Theory of Elasticity and Plasticity in Geomechanics		4	3	0	2	15	25	20	40	-	
	3	GTE6405	Design of Underground/Sub Structures		4	3	0	2	15	25	20	40	-	
	4	GTE6407	Structural Geology		4	3	0	2	15	25	20	40	-	
	S.No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**	
Elective 8	1	GTE6301	Geosynthetics	Elective	3	3	0	0	20	0	30	50	-	
	2	GTE6303	Ground Improvement Techniques		3	3	0	0	20	0	30	50	-	
	3	GTE6305	Excavation Technology		3	3	0	0	20	0	30	50	-	
	4	GTE6307	Probability and Statistical Methods in Engineering		3	3	0	0	20	0	30	50	-	
	S.No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**	
Elective 9	2	GTE6201	Design of Underground Excavations		2	2	0	0	20	0	30	50	0	
	3	GTE6203	Foundations on Weak Rocks		2	2	0	0	20	0	30	50	0	
	4	GTE6205	Geotechnical Design Studio		2	0	0	4	-	40	-	-	60	

SEMESTER I

Courses

GTE 501 Advanced Soil mechanics

Clay mineralogy, clay-water electrolyte system, soil structure and fabric, Special soils: collapsible & sensitive clays, loessic, bouldary, and expansive soils Effective stress, pore pressure, hydraulic conductivity and its directional variation, electro osmosis Seepage behavior of soil-flow net constructions by various technique, seepage in layered soils, filter design, seepage through dam body Consolidation: one-dimensional and generalized consolidation theories, primary and secondary consolidation, determination of Cv by various methods, visco- elastic models, sand drains, effect of smear, numerical solutions, consolidation settlements. Shear behavior of soils, pore pressure parameters, UU, CU & CD tests, stress path method for settlement analysis. Total & effective stress- path, water content contours, stress history, anisotropy of strength, thixotropy, creep, determination of in situ undrained shear strength, stress-strain characteristics of soils, determination of modulus values

Suggested Books:

1. Soil Mechanics: Principle and Practice: GE Barnes, (2000) (ISBN 9-03-088753-7)
2. Advance Soil Mechanics: BM Das (1997), (ISBN 0-77-04915-8)
3. Soil Mechanics: TW Lambe and RV Whitman (1987), (ISBN 0-71-6059714-1)
4. Fundamentals of Soil Behaviour: James K. Mitchell (1993), (ISBN 7-83-4697512-6)
5. Principles of Soil Mechanics: RF Scott (1963), (ISBN 9-54-3564799-8)

GTE 503 Advance Foundation Engineering

Planning of soil exploration for different projects, methods of subsurface exploration, methods of borings along with various penetration tests, Shallow foundations, requirements for satisfactory performance of foundations, methods of estimating bearing capacity, settlements of footings and rafts, proportioning of foundations using field test data, IS codes. Pile foundations, methods of estimating load transfer of piles, settlements of pile foundations, pile group capacity and settlement, negative skin friction of piles, laterally loaded piles, pile load tests, analytical estimation of load-settlement behavior of piles, proportioning of pile foundations, lateral and uplift capacity of piles. Well foundation, IS and IRC codal provisions, elastic theory and ultimate resistance methods, Coffer dams, various types, analysis and design Foundations under uplifting loads. Foundations on problematic soils: Foundations for collapsible and expansive soil

Suggested Books:

1. Bowles. J.E., (1997),"Foundation Analysis and Design, Tata McGraw-Hill International Edition"

2. Das B.M., (1999), “Shallow Foundations: Bearing capacity and settlement, CRC Press,”
3. Tomlinson M.J.,(1994),” Pile design and construction Practice, Chapman and Hall Publication,”.
4. Poulos, H. G. and Davis, F. H., (1980) “Pile Foundation Analysis and Design”, Wiley and Son

GTE5401 Geo-environmental Engineering

Soil as a multiphase system; Soil-environment interaction; Properties of water in relation to the porous media; Water cycle with special reference to soil medium. Soil mineralogy; significance of mineralogy in determining soil behavior; Mineralogical characterization. Mechanisms of soil-water interaction: Diffuse double layer models; Force of attraction and repulsion; Soil-water-contaminant interaction; Theories of ion exchange; Influence of organic and inorganic chemical interaction. Concepts of waste containment; Sources, production and classification of wastes, Environmental laws and regulations, physico-chemical properties of soil, ground water flow and contaminant transport, desirable properties of soil; contaminant transport and retention; contaminated site remediation. Soil characterization techniques; volumetric water content; gas permeation in soil; electrical and thermal properties; pore-size distribution; contaminant analysis. contaminated site characterization, estimation of landfill quantities, landfill site location, design of various landfill components such as liners, covers, leachate collection and removal, gas generation and management, ground water monitoring, end uses of landfill sites, slurry walls and barrier systems, design and construction, stability, compatibility and performance, remediation technologies, stabilization of contaminated soils and risk assessment approaches.

Suggested Books:

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

GTE5403 Geotechnical Exploration

Surface and sub-surface exploration methods. Aerial and remote sensing techniques, Geophysical methods, electrical resistivity, seismic refraction, applications. Rock drilling, Core samplers, Core boxes, Core orientations. Sampling techniques, Sampling disturbances, storage, labelling and transportation of samples, sampler design Logging, stratigraphic profile, scan line survey. Laboratory tests, report. Stresses in rocks. Stress anisotropy and stress ratio. Stress relief and compensation techniques, USBM, door stopper cells, flat jack, hydro fracture, strain rosette and dilatometers. Deformability, pressure tunnel and bore hole tests. Strength tests, insitu compression, tension and direct shear tests. Pull out tests. Borehole extensometers, piezometers, embedment gauges, inclinometers, Slope indicators, packer tests for in-situ permeability, Codal provisions Standard penetration, plate load, static and dynamic cone penetration, field vane shear and pressure meter tests, Pile load tests, Pile integrity tests,

Codal provisions, Laterally Loaded Piles, uplift capacity of piles. Processing of soil exploration data and its interpretation, instrumentation scheme for monitoring of critical sites

1. Bowles, J.E., (1997), Foundation Analysis and Design, McGraw-Hill International Edition"
2. Schnaid, F., (2008), "In Situ Testing in Geomechanics, Taylor and Francis"
3. Roy E. Hunt, (2005) "Geotechnical Engineering Investigation Handbook, Taylor and Francis"
4. Burt G. Look , (2014) "Handbook of Geotechnical Investigation and Design Tables, CRC press"

GTE 5405 Application of Remote Sensing & GIS in Geotechnical Engineering

Introduction, Geographical concepts and Terminology, Difference between Image Processing system and GIS, Utility of GIS Various GIS packages and their salient features, Essentials components of GIS, Data acquisition through scanners and digitizers Raster and Vector Data: Introduction, Descriptions: Raster and Vector data, Raster Versus Vector, Raster to Vector conversion, Remote Sensing Data in GIS, Topology and Spatial Relationships, Data storage verification and editing Data pre-processing, Georeferencing, Data compression and reduction techniques, Run length encoding, Interpolation of data, Database Construction, GIS and the GPS, Data Output Database structure, Hierarchical data, Network systems, Relational database, Database management, Data manipulation and analysis Spatial and mathematical operations in GIS, Overlay, Query based, Measurement and statistical modelling, Buffers, Spatial Analysis, Statistical Reporting and Graphing, Application of GIS to various natural resources mapping and monitoring and engineering problems

Suggested Books:

1. Burrough, P.A. and Mc Donnel, R.A., (2000) "Principles of Geographic Information System", Oxford University Press.
2. Chrisman, Nicholas R., (2002) "Exploring Geographic Information Systems", John Wiley
3. Demers, Michael N., (2008)"Fundamentals of Geographic Information System", 2nd Ed. Wiley.
4. Ghosh, S.K. and Chandra, A.M., (2008) "Remote Sensing and GIS", Narosa Publishing House.
5. Lo, C.P. and Young, A.K.W., (2002) "Concepts and Techniques of Geographical Information System", Prentice Hall India.

GTE5407 Cost Management of Engineering Project

Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain

Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing. Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation

Suggested Books:

1. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting (2003)
2. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
3. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd. (2015)

GTE5301 Geotechnical Earthquake Engineering

Introduction to engineering seismology, seismic risks and hazards, causes and strength of earthquakes, social and economic consequences, Theory of dynamic and seismic response, the nature and attenuation of earthquake magnitude, Ground motion, determination of site characteristics, local geology and soil condition, Determination of design earthquake, response spectra and accelerograms. Site response to earthquake site investigation and soil test; dynamic behavior of soils, liquefaction and cyclic mobility, analysis of pore pressure development In-situ test for liquefaction, analysis and design of slopes, embankments, seismic response of soil structure system, foundation Earth retaining structures for seismic loading, case histories, mitigation techniques

Suggested Books:

1. Steven Kramer, (2008) “Geotechnical Earthquake Engineering”, Pearson
2. Naeim, F., (2001) “The Seismic Design Handbook, Kluwer Academic Publication, 2ndEdition,”
3. Ferrito, J.M, (1997) “Seismic design criteria for soil liquefaction, Tech. Report of Naval Facilities service centre, Port Hueneme,”

GTE 5303 Stability Analysis of slopes

Slopes: Types and causes of slope failures, mechanics of slope failure, failure modes.
Stability analysis: infinite and finite slopes with or without water pressures; concept of factor of safety, pore pressure coefficients, Mass analysis, Wedge methods, friction circle method ; Method of slices, Bishop’s method, Janbu’s method, Morgenstern and Price, Spencer’s method Stability analysis in the presence of seepage: two dimensional flow – Laplace equation and it’s solution, graphical method, determination of phreatic line, flow nets in homogeneous and zoned earth dams under steady seepage and draw-down conditions, seepage control in earth dams, influence of seepage on slope stability stability analysis of dam body during steady seepage Strengthening measures: stabilization of slopes by drainage methods, surface and subsurface drainage, use of synthetic filters, retaining walls, stabilization and strengthening of slopes, shotcreting, rock bolting and rock anchoring, instrumentation and monitoring of slopes, slope movements, warning devices, maintenance of slopes

Suggested Books:

1. Chowdhary R and ChowdharyI , ”Geotechnical Slope Analysis”, CRCPress. (2009)
2. Harr M.E.,” Ground Water and Seepage”, McGraw Hill. (1962)

GTE5305 Earth Pressure & Earth Retaining Structures

Earth Pressure: Rankine and Coulomb theories, active, passive and pressure at rest; concentrated surcharge above the back fill, earth pressure due to uniform surcharge, earth pressure of stratified backfills, saturated and partially saturated backfill. Retaining walls: Proportioning of retaining walls, stability of retaining walls, mechanically stabilized retaining walls/reinforced earth retaining walls Sheet Pile wall: free earth system, fixed earth system Bulkheads: bulkheads with free and fixed earth supports, equivalent beam method, Anchorage of bulkheads and resistance of anchor walls, spacing between bulkheads and anchor walls, resistance of anchor plates. Tunnel and Conduit: Stress distribution around tunnels, Types of conduits, Load on projecting conduits; Arching and Open Cuts: Arching in soils, Braced excavations: Earth pressure against bracings in cuts, Heave of the bottom of cut in soft clays

Suggested Books

1. Das, Braja M., (1998) "Principles of Foundation Engineering", PWS Publishing
2. Bowles. J.E.,(1997) " Foundation Analysis and Design, Tata McGraw-Hill International Edition, 5th Edn"

GTE5307 Pavement analysis and design

Philosophy of design of flexible and rigid pavements, Analysis of pavements using different analytical methods, Selection of pavement design input parameters – traffic loading and volume, Material characterization, drainage, failure criteria, reliability, Design of flexible and rigid pavements using different methods, Comparison of different pavement design approaches, design of overlays and drainage system.

Suggested Books:

1. Yang and H. Huang, (2004) "Pavement Analysis and Design, Pearson Prentice Hall"
2.Yoder and Witzech ,(1982) " Pavement Design, McGraw-Hill,"

GTE5201 SEMINAR

GTE5203 FEM in Geotechnical Engineering

Stress-deformation analysis: One dimensional, Two dimensional and Three-dimensional formulations
Discretization of a Continuum, Elements, Strains, Stresses, Constitutive, Relations, Hooke's Law, Formulation of Stiffness Matrix, Boundary Conditions, Solution Algorithms. Principles of discretization, element stiffness and mass formulation based on direct, variational and weighted

residual techniques and displacements approach, Shape functions and numerical integrations, convergence Displacement formulation for rectangular, triangular and iso parametric elements for two dimensional and axisymmetric stress analysis.

Suggested Books:

1. O.C. Zienkiewicz and R.L. Taylor, (1992) "Finite element methods Vol I & Vol II, McGraw Hill,"
2. K.J. Bathe, (1996) "Finite element procedures, PHI Ltd.,"
3. David M Potts and Lidija Zdravkovic, (1999) "Finite Element Analysis in Geotechnical Engineering Theory and Apllication", Thomas Telford.

GTE5205 Offshore Geotechnical Engineering

Marine soil deposits: Offshore environment, Offshore structures and foundations, Specific problems related to marine soil deposits, Physical and engineering properties of marine soils Behavior of soils subjected to repeated loading: Effect of wave loading on offshore foundations, Behavior of sands and clays under cyclic loading, Laboratory experiments including repeated loading, Cyclic behavior of soils based on fundamental theory of mechanics, Approximate engineering methods which can be used for practical cases Site Investigation in the case of marine soil deposits: Challenges of site investigation in marine environment, Different site investigation techniques, sampling techniques, Geophysical methods, Recent advancements in site investigation and sampling used for marine soil deposits Foundations in marine soil deposits: Different offshore and nearshore foundations, Gravity platforms, Jack-up rigs, pile foundations. cassions, spudcans Numerical modeling of marine foundations subjected to wave loading: Numerical modeling of cyclic behavior of soils, empirical models, elastic-plastic models, FEM analysis of marine foundations subjected to wave loading

Suggested Books:

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

GTE5207 Composite Material

Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance. REINFORCEMENTS: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.Introduction to manufacturing of Composites

Suggested Books

1.Hand Book of Composite Materials-ed-Lubin. (1982)
2.Composite Materials – K.K.Chawla (1987)
3.Composite Materials Science and Applications – Deborah D.L. Chung (2010)

SEMESTER II

Courses

GTE502 Rock Mechanics

Introduction ; problems of rock mechanics; classifications of rock masses Rock exploration – rock coring, geophysical methods; laboratory testing of rocks; fraction in rocks; elasticity & strength of rocks; strength & failure of rocks; Griffith's theory, Coulomb's theory, in-situ tests on rock mass; deformation characteristics, instrumentation and measurement of deformation of rocks; permeability. Mechanical, thermal and electrical properties of rock mass openings in rock mass and stresses around openings; pressure tunnels, development of plastic zone; rock support needed to avoid plastic deformation;

lined and unlined tunnels; support pressure and slip of the joint; underground excavation and subsidence; foundation on rocks; bearing capacity of intact and jointed rocks; rock slopes; slope stability, rock bolt anchors & grouting Underground openings, pillars, tunnels, methods of construction; problems associated with tunnels, tunnelling in various subsoil conditions and rocks.

Suggested Books

1. Rock Mechanics Design in Mining and Tunellig, by Z.T. Bieniawski, (1984), Pub: A.A. Balkema
2.Engineering Rock Mass Classification by Z.T. Bieniawski,(1989).
3.Introduction to Rock Mechanics by R.E.Goodman,(1989)
4.Design and Construction of Tunnels by Pietro Lunardi Pub: Springer, (2008)
5.Engineering Rock Mechanics an Introduction to the Principles by Hudson and Harrision,(2000)

GTE504 Soil dynamics and machine foundation

Introduction, fundamentals of vibrations, vibration of elementary spring, mass, dashpot systems, degrees of freedom, Dynamic properties of geo-materials, wave propogation; Laboratory and field tests for evaluation of dynamic soil properties; vibration sensors. Vibration of foundations on elastic half space; design procedures for foundations with dynamic loads Dynamic stiffness of single pile and pile groups; Lumped parameter solutions, analysis and design of foundations for hammers, reciprocating engines and turbo generators Vibration isolation; retaining walls, small and large deformation problems, dynamic instrumentation.

Suggested Books

1. Das, B.M.,(1983) "Fundamentals of Soil Dynamics", Elsevier
2. Steven Kramer, (2008), "Geotechnical Earthquake Engineering", Pearson
3. Prakash, S., (1981), Soil Dynamics, McGraw Hill,
4. Kameswara Rao, N.S.V., (1998), "Vibration analysis and foundation dynamics,

GTE5402 Theoretical Soil Mechanics

Stresses and strains: elastic equilibrium analysis for plane strain and three dimensional cases. Effective stress, analysis of deformation and strain, state of stress and strain, constitutive relations, equilibrium and compatibility, general theorem. Drained and undrained loading, state boundary surface, plastic flow, yield and hardening, failure theorems for soils.Failures and plastic flow at critical state, associative and non-associative flow, residual strength; anisotropic compressions; ideal elastic behavior-two and three dimensional systems; theorems of plastic collapse Application to soil interaction, elasto- plastic theory

of soil, rheological models; non linear viscoelasticity; problems and solutions.

Suggested Books:

1. Fundamental of Theoretical Soil Mechanics: ME Harr, (1966) (ISBN 978-0-070267411)
2. Elastic Solutions for Soils and Rock Mechanics :HG Poulos and EH Davis, (1974), (ISBN 9780471695653)
3. Theory of Elasticity & Plasticity: SP Timoshenko & JN Goodier (1982), (ISBN 978-0-9791865-0-9)
4. Critical State Soil Mechanics: AN Schofield & CP Wroth, (1968), (ISBN 978-0641940484)
5. Geotechnical Modelling: DM Wood ,(2004),(ISBN-978-0419237303)

GTE5404 Unsaturated soil mechanics

Introduction: Definition, scope, nature, moisture, pore pressure, and stress profiles, suction and potential of soil water, physical properties of unsaturated soilsSuction measurement and control, laboratory techniques, interfacial equilibrium: air-water-solid, vapour pressure, soil-water characteristic curve (SWCC), volume-mass relations. Capillarity and pore size distribution.State of stress, effective stress, strains, hysteresis, graphical representation of stress, stress state variables. Shear strength, extended Mohr-Coulomb criterion, shear strength parameters, constitutive modelling, and capillary cohesion.. Suction and earth pressure profiles, steady suction and water content profiles, earth pressure at rest, active earth pressure, and passive earth pressure. Flow through unsaturated soils, hydraulic conductivity functions, capillary barriers, infiltration and evaporation, vapour flow, air diffusion in water. Transient Flow, saturated and unsaturated, transient suction and moisture. Measurement of variables, suction measurement, hydraulic conductivity measurement, measurement of state variables: soil suction, total suction, osmotic suction, in-situ water content, measurement of SWCC. Triaxial testing of unsaturated soils

Suggested Books

1. “Unsaturated Soils: A fundamental interpretation of soil behaviour” by E. J. Murray and V. Sivakumar, Wiley – Blackwell, (2010).
2. “Unsaturated Soil Mechanics” by Ning Lu and William J. Likos, John Wiley & Sons, Inc.(2014)
3. “Unsaturated Soil Mechanics in Engineering Practice” by D. G. Fredlund, H. Rahardjo, and M. D. Fredlund, John Wiley & Sons Inc., (2012).

GTE5406 Critical state soil mechanics

Soil Behavior: State of stress and strain in soils, Stress and strain paths and invariants, behavior of soils under different laboratory experiment. The Critical state line and the Roscoe surface: Families of undrained tests, Families of drained tests, the critical state line, drained and undrained surfaces, The Roscoe surface Behavior of Over consolidated samples: The Hvorslev surface: Behaviour of over consolidated samples, drained and undrained tests, The Hvorslev surface, complete State Boundary Surface, Volume changes and pore water pressure changes Behaviour of Sands: The critical state line for sands, Normalized

plots, the effect of dilation, Consequences of Taylor's model Behaviour of Soils before Failure: Elastic and plastic deformations, Plasticity theory, Development of elastic-plastic model based on critical state soil mechanics, The Cam-clay model, The modified Cam-clay model

Suggested Books:

1. J. H. Atkinson and P. L. Bransby, (1978),"The mechanics of soils: An introduction to critical state soil mechanics", McGraw Hill
2. D. M. Wood, (1990) "Soil behaviour and critical state soil mechanics", Cambridge University Press,
3. B. M. Das, (2013)"Fundamental of geotechnical engineering", Cengage Learning,

GTE5408 Operational Research

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming. Competitive Models, Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

Suggested Books:

1. H.A. Taha, (2008), Operations Research, An Introduction, PHI,
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, (1982).
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, (2008
4. Hitler Libermann Operations Research: McGraw Hill Pub,(2009)

GTE5302 Minor Project

GTE5304 Soil Structure Interaction

General soil-structure interaction problems: Contact pressures and soil-structure interaction for shallow foundations. Concept of sub-grade modulus, effects/parameters influencing subgrade modulus. Analysis of foundations of finite rigidity, Beams on elastic foundation concept, introduction to the solution of beam problems. Analytical Methods of Analysis of Finite Beams on Wrinkler Foundation: Introduction, analysis of finite and infinite beam on wrinkle foundation, method of super position, method of initial parameters and its application to analysis of regular beams, analysis of continuous beams and frames on wrinkle foundation, analysis of frames on wrinkle foundation, analysis of rigid piles with horizontal and vertical loads. Analysis of Beams on Elastic Half Space: Introduction, analysis of Rigid Beams, short beam analysis, long beam Analysis,

Analysis of Frame on Elastic Half Space. Dynamic Soil Structure Interaction: Direct and Sub-structure method of Analysis, Equation of Motion for flexible and rigid base, kinematic interaction, inertial interaction and effect of embedment, Temporal and special variation of external loads including seismic loads, continuous models, discrete models and finite element models. Wave Propagation for SSI: Waves in Semi-Infinite Medium, one two and three dimensional wave propagation, dynamic stiffness matrix for out of plane and in plane motion. Free Field Response of Site: Control point and control motion for seismic analysis, dispersion and attenuation of waves, half space, single layer on half space, modelling of boundaries, elementary, local, consistent and transmitting boundaries. Engineering Application of Soil-Structure Interaction: Low rise residential building, multi-storey building, bridges and dams, soil-pile structure interaction.

Suggested Books:

1. Tsudik, E. (2012)"Analysis of Structures on Elastic Foundations"- J. Ross Publishing
2. Wolf, J. P. (1985)"Dynamic soil-structure interaction"- Prentice Hall int..
3. Wolf, J. P., & Song, C. (1996) "Finite-element modelling of unbounded media"- Chichester: Wiley.
4. Kramer, S. L. (1996)"Geotechnical earthquake engineering (Vol. 80). Upper Saddle River"- NJ: Prentice Hall.
5. "Structure Soil Interaction" - State of Art Report, Institution of structural Engineers. (1978)

GTE5306 Disaster mitigation and management

Introduction to various hazard, vulnerability and risk, hazard estimation, hazard mapping, effect of site conditions on structures, event monitoring, processing and integration of data. Damages: Grade of damages, direct and indirect damages, damage to structures, lessons learnt Management and mitigation of earthquake: earthquake risk and vulnerability in India, traditional housing construction in rural and urban areas, critical areas of concern in earthquake management, past and present initiative in India, disaster management plan, approaches to seismic risk mitigation, seismic strengthening and retrofitting methods, awareness and preparedness, capacity building Management and mitigation of tsunamis: Tsunami Risk Assessment and Vulnerability Analysis, Coastal Zone Management, Tsunami Preparedness, Structural Mitigation Measures, Regulation and Enforcement of Techno-Legal Regime Management and mitigation of cyclones: Understanding cyclone and wind hazard in India, vulnerability and risk assessment, early warning systems, structural mitigation measures, management of coastal zones, disaster risk management and capacity development Management and mitigation of flood (including urban flooding): The Flood Hazard, Flash Floods, urban flooding, structural measures for flood management, design and management of urban drainage system, urban flood disaster risk management, early warning system and communication, capacity development
Management and mitigation of landslide: Introduction to landslide hazard, Landslide Vulnerability and Risk in India, Hazard Zonation Mapping, Geological and Geotechnical Investigations, Landslide Risk Treatment, Landslide Monitoring and Forecasting, Capacity building Disaster Management Act : Disaster management policy; Techno legal aspect: Techno-Legal and Techno-Financial work; Model Town and country planning legislation land use zoning regulation, development control regulations and building bye-laws registration, qualification and duties of professionals, disaster response policy.

Suggested Books:

1. Chester, D. K. (1993),Natural hazards by EA Bryant. Cambridge University Press, 1991
2. Blaikie, P., Cannon, T., Davis, I., & Wisner, B. (2014)," At risk: natural hazards, people's vulnerability and disasters. Routledge."
3. National Disaster Management Agency Documents, www. http://ndma.gov.in
4. Bommer, J. J. Earthquake protection: Andrew Coburn and Robin Spence, John Wiley & Sons, Ltd., Chichester, England, (2003)
5. Reiter, L. Earthquake hazard analysis: issues and insights. Columbia University Press.(1991)
6. Dowrick, D. J. Earthquake risk reduction. John Wiley & Sons. (2003)
7. Aki, K., & Richards, P. G. Quantitative Seismology: Theory and Methods. Volume I: WH Freeman & Co.(1980)
8. FEMA Documents, http://www.fema.gov
9. Mileti, D. Disasters by Design:: A Reassessment of Natural Hazards in the United States. Joseph Henry Press.(1999)
10. Bryant, E. A. Natural Hazards, © Cambridge University Press.Cambridge, New York,Melbourne.(2005)

GTE5308 Uncertainties, risk and reliability in Geotechnical Engineering

Risk, terminology, randomness, uncertainty, Basic Concept of Reliability, Measures of Reliability, Sources of Uncertainty, Steps in the Modeling of Uncertainty. Modeling of Uncertainty: Descriptors of Randomness, Histogram and Frequency Diagram, Analytical Models to Quantify Randomness, Introduction to probability. Commonly Used Probability Distributions, Determination of Distributions an Parameters from Observed Data, Interval estimation of Mean and Variance, Tests of goodness-of-fit (chi-square test, Kolmogorov-Smirnov test), Modeling random variables like loads, material properties etc. Reliability method: Introduction, Deterministic and Probabilistic approaches, basic variables and failure surface, first order second moment methods (FOSM).Simulation Methods: Basis of simulations methods, random number generation, concept of Monte Carlo simulation and applications, Practical reliability analysis and design by Monte Carlo Simulation. System reliability: Series, parallel and mixed system, Modelling of structural system. Risk assessment, Probabilistic risk assessment Application to Civil engineering problems using MATLAB

Suggested Books:

1.Haldar, A., and Mahadevan, S. (2000),"Probability, reliability and statistical methods in engineering design." John Wiley and Sons, New York.

2.J R Benjamin and C A Cornell, (1970), "Probability, statistics and decisions for civil engineers" John Wiley, New York.

3.A Papoulis, "Probability, random variables and stochastic processes" 3rd Edition, McGraw-Hill, New York. (1991).

GTE5202 Ground water hydrology

Introduction: Definition of groundwater, role of groundwater in hydrological cycle, groundwater bearing formations, classification of aquifers, flow and storage characteristics of aquifers, Darcy's law, anisotropy and heterogeneity. Wells and Well Hydraulics: Different types of wells, construction of wells, steady and unsteady state solutions for confined, unconfined and leaky aquifers, effect of boundaries, Multiple Well Systems, Partially Penetrating Wells, Well for special Conditions, Characteristics Well Losses, Specific Capacity Surface investigation of Ground water: Geologic methods, Remote sensing, geophysical exploration, Electric resistivity Method, Seismic Refraction Method, Gravity and Magnetic Methods, Water Witching. Concept of Artificial Recharge of Ground water, recharge methods, research on water spreading, Wastewater recharge for reuse, Recharge Mounds. Artificial Recharge on long Island, New York, Include Recharge, artificial Recharge for Energy purposes. Groundwater Flow Modelling: Porous media models, Analog models, Electric Analog Models and Digital computer models.

Suggested Books:

1. Todd, D.K., "Groundwater Hydrology", John Wiley. 1959
2. Bear, J., "Hydraulics of Groundwater", McGraw. 1979
3. Bouwer, H., "Groundwater Hydrology", McGraw Hill. 1978
4. Walton, W.C., "Groundwater Resources Evaluation", McGraw Hill. 1970
5. Freeze and Cherry, "Groundwater", Prentice Hall. 1979

GTE5204 Physical Modelling in Geomechanics

Introduction to modelling, empirical models, theoretical models, numerical modelling, constitutive modelling, physical models, geological model, classification model Physical modelling, dimensional analysis, scaling laws, Gravity modelling Introduction to constitutive modelling, theoretical modelling and centrifuge modelling

Suggested Books:

1. David wood, Geotechnical Modelling, CRC press (1999).
2. M. B. C. Ulker and M. Safiur Rahman, Modeling and Computing for Geotechnical Engineering: An Introduction, CRC press, (2018).

GTE5206 Numerical and Analytical Method in Geomechanics

Solution of Non-linear Equations: Bisection, False Position, Newton-Raphson, Successive approximation method, Iterative methods, Solution of Linear Equations: Jacobi's method, Gauss Seidal method, Successive over relaxation method. Finite Difference Method: Two point Boundary value problems – Disichlet conditions, Neumann conditions; ordinary and partial differential equations. Finite Element Method: Fundamentals, Constitutive finite element models for soils. Correlation and Regression Analysis: Correlation - Scatter diagram, Karl Pearson coefficient of correlation, Limits of correlation coefficient; Regression –Lines of regression, Regression curves, Regression coefficient, Differences between correlation and regression analysis. One-dimensional Consolidation - Theory of consolidation, Analytical procedures, Finite difference solution

procedure for multi layered systems, Finite element formulation, Flow Through Porous Media - Geotechnical aspects, Numerical methods, Applications and Design analysis, Flow in jointed media.

Suggested Books:

1.S. Chandrakant., Desai and John T. Christian, "Numerical Methods in Geotechnical Engineering", Mc. Graw Hill Book Company, (1977)
2.M.K. Jain, S.R.K. Iyengar and R.K. Jain, "Numerical Methods for Scientific and Engineering computations", Third edition, New Age International (P) Ltd. Publishers, New Delhi. (2008)
3.D.J. Naylor and G.N. Pande, "Finite Elements in Geotechnical Engineering", Pineridge Press Ltd., UK. (1981)

GTE5208 Waste to Energy

Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications. Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation. Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors. Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

Suggested Books:

1. Desai, A. V. (1990) " Non Conventional Energy" - Wiley Eastern Ltd.
2. Khandelwal, K. C. and Mahdi, S. S. (1983) "Biogas Technology - A Practical Hand Book" (Vol. I & II) - Tata McGraw Hill Publishing Co. Ltd.
3. Challal, D. S. (1991) "Food, Feed and Fuel from Biomass" - IBH Publishing Co. Pvt. Ltd.
4. WereKo-Brobby, C.Y. and Hagan, E. B. (1996) "Biomass Conversion and Technology"- John Wiley & Sons.

SEMESTER III

Courses

GTE 651 Research Project

GTE 601 Major Project 1

GTE 6401 Plasticity & fracture Mechanics in Rock Structures

Introduction of plasticity, linear elasticity, nonlinear elasticity, hyper elasticity, hypo elasticity, hypo elasticity, Two and three dimensional stress analysis, stress invariants, octahedral stresses; small and large deformations, finite strains - Euler & Langragian approaches, Green's & Cauchy's strain tensors; Yield criteria: Von Mises, Tresca, Mohr-Coulomb, Drucker-Prager, Modified Mohr-Coloumb, Lade Duncan, Matsuoka Nakai model, Hoek & Brown yield criteria; Isotropic, Kinematic and mixed hardening, softening normality principle, plastic flow rule, plastic potential, Cam-clay, plastic stress-strain relations: stress path dependent behavior, generalised elasto-plastic stress-strain relations, insitu hardening and softening modulus. Crack phenomenon and mechanics of brittle fracture propagation, elementary theories of crack propagation, cracks in elasto-plastic media, Constitutive equations for rocks – Class I and Class-II materials, uniaxial and triaxial stress conditions in tension, Compression and shear, size effects, representative size of specimen;Continuum characterization of jointed rock mass, constitutive equations for discontinuities – Joint stiffnesses and shear strength, Application of fracture mechanics to underground opening, rock stabbing, bursting and hydraulic fracturing.

Suggested Books:

1. Miannay Dominique P, Fracture Mechanics, Publisher: Springer-Verlag New York Inc.
2. Brocks, Wolfgang, Plasticity and Fracture, Springer, (2018)
3. H. P. Rossmanith, Rock Fracture Mechanics, SPRINGER VERLAG GMBH, (2004).

GTE 6403 Theory of elasticity and plasticity in Geomechanics

Theory of Elasticity: Stress tensor, equations of equilibrium.. Kinematic relationships and equations of compatibility. Generalized Hooke's Law Boundary conditions. Plane stress, plane strain, Airy's stress function. Saint Venant's principle. Problems in rectangular and polar co-ordinates; inverse and semi-inverse methods; torsion of Prismatic bars members analogy; typical applications. Theory of plasticity; hydro-static and deviatoric components of stress tensor; invariant of stress tensors; Von Misses yield conditions; octahedral stresses. Analysis of Bending of bars of narrow rectangular cross section-formation of Plastic hinge, Torsion of prismatic bars-sand-heap analogy, Thick spherical shell-bursting pressure, Thick cylindrical tube.

Suggested Book:

1. Timoshenko, S. P., & Goodier, J. N. (1971),"Theory of Elasticity"- McGraw-Hill, New York
2. Shames, I. H.(1964), " Mechanics of deformable solids"- Prentice Hall
3. Srinath, L. S. (2003),"Advanced mechanics of solids"- Tata McGraw-Hill.
4. Chakrabarty, J.(2012), "Theory of plasticity" - Butterworth-Heinemann.
5. Popov, E. P., & Balan, T. A. (1968), " Mechanics of solids" - Pearson Education.

GTE 6405 Design of underground/ sub structures

Introduction : Substructure- Definition and purpose, role of foundation engineer Basic soil input parameters for foundation design: Foundation Deign: General Principles Type of foundations, selection of type of foundation Basic requirements, computation of loads, Limit state Design: Basic principles shallow foundations: type and their selection conventional method of design, Beams of elastic foundation and finite difference method of analysis, Structural design of footings and rafts, foundations subjected to eccentric- inclined loads, footing in seismic zones: pile foundations: type, construction techniques, proportioning of pile foundations: ;pads/ forces considered for structural design, structural design of deep/ pile foundations for a multistoried buildings subjected to dynamic loads: Bridges sub structure - forces on bridges foundation (IRC & IS specifications) design of piers, abatements & wing walls, well foundation components, stability analysis, designing of various components, materials for construction,, sinking of well Placing of curb, dredging and jetting: marine substructures: type, breakwaters, wharves, Sea walls, design and construction methods, foundations of transmission line towers, forces on tower foundation, general design criteria, choice & type of foundation, testing and design procedures. Tunnels, openings, design and construction methods, general design criteria, choice & type of tunnels and openings, testing and design procedures.

Suggested Books:

1. Swami Saran, Analysis and Design of Substructures: Limit State Design, Oxford & IBH Publishing Company Pvt. Limited, (2006)
2. Paul Andersen , Substructure analysis and design, Ronald Press; 2 nd edition (1958)
3. Wyllie Duncan C.," Foundations on Rock: Engineering Practice", E&FN Spon, Taylor and Francis.
4. Petros P. Xanthakos, Bridge Substructure and Foundation Design 1st Edition
5. Design and Construction of Tunnels by Pietro Lunardi Pub: Springer, (2008)

GTE 6407 Structural Geology

. Origin, interior and composition of the earth. Rock cycle, Igneous, Metamorphic and Sedimentary rocks. Rock structures. Plate tectonics, Continental drift and sea floor spreading. Geological time scale. Layered formations,

Attitude, true and apparent dips, topographic maps, outcrops. Measurement of attitude of formations. Folds, types of folds, classification, field study of folds, mechanics of folds, causes of folding. Joints, rock mass concept, Joint description and classification. Three-point problems, Depth and thickness problems. Faults, mechanics of faulting, normal, reverse and thrusts, faults. Lineation's. Foliations, Schistocity. Fault problems. Stereographic projection methods, Use of DIPS software, presentation of geological data and analysis, Applications, Scan line survey of rock joints in the visit

Suggested Books :

1. Marland P. Billings, Structural Geology, (2008)
2. Haakon Fossen , Structural Geology.(2016)
3. Donal M. Ragan , Structural Geology: An introduction to Geometrical Techniques.(2009)

GTE 6301 Geosynthetic

Introduction; Basic Description; Polymeric Materials; History and Manufacture of Geotextiles, Geogrids, Geonets, Geomembranes, Geofoam, Geosynthetic Clay Liners, and Overview of Geocomposits. Geotextiles: functions and mechanisms, properties and test methods, geotextile properties, use for separation, use for soil reinforcement, use for filtration, use for drainage, multiple functions, installation survivability. Geosynthetic Clay Liners (GCLs): properties and test methods, GCLs as single and composite liners, GCLs as covers, GCLs on slopes, construction methods. Geofoam: properties and test methods, various design applications, construction methods. Geogrids: properties and test methods, geogrid reinforcement for various purposes, construction methods. Geonets: properties and test methods, geonet applications, construction methods.Geocomposits: applications in separation, reinforcement, filtration, and drainage. Geogrids: properties and test methods, geogrid reinforcement for various purposes, construction methods. Geonets: properties and test methods, geonet applications, construction methods. Geomembranes: properties and test methods, use as liquid containment liners, use as covers for reservoirs and quasi-solids, use as canal liners, use as landfill liners, use as landfill covers and closures; applications in: underground storage tanks, dams, tunnels and cutoff walls; geomembrane seams

Suggested Books :

1. "Designing with Geosynthetics Vol. 1 & 2" by Robert M. Koerner, Xlibris Corporation.(2012)
2."An Introduction to Soil Reinforcement and Geosynthetics" by G. L. Sivakumar Babu, University Press (India) Private Limited (2006).

GTE 6303 Ground Improvement Techniques

Introduction: importance and history of ground improvement. Mechanical Modifications: properties of compacted soil, compaction control tests, field compaction, applications. Precompression: technique, procedure, and applications. Sand Drains: method, procedure and application Prefabricated vertical drains: method of installation and design. Soil Stabilisation: shallow stabilisation with additives like lime, fly ash, cement and other materials. Chemical modifications and Grouting. Hydraulic modification: dewatering systems, filtration, drainage and seepage control with geosynthetics.Vibroflotation technique, stone columns, sand compaction piles, dynamic compaction technique, ground freezing, and electro-osmosis.Ground modification by soil reinforcement: reinforcement techniques, use of flexible geosynthetic reinforcement in bearing capacity improvement, slope stability, erosion control, retaining walls and pavements.Difficult soils: collapsible soils, physical parameters and identification, collapse settlement, improvement techniques; expansive soils, general nature, swell test and swelling pressure tests, classification, improvement of expansive soils.

GTE 6305 Excavation Technology

Introduction, planning of and exploration for various underground construction projects, stereographic projection method, principle and its application in underground excavation design Elastic stress distribution around tunnels, stress distribution for different shapes and under different in-situ stress conditions, Greenspan method, design principles, multiple openings, openings in laminated rocks, elasto-plastic analysis of tunnels, Daemen's theory Application of rock mass classification systems, ground conditions in tunneling, analysis of underground openings in squeezing and swelling ground, empirical methods, estimation of elastic modulus and modulus of deformation of rocks; uniaxial jacking / plate jacking tests, radial jacking and Goodman jacking tests, long term behaviour of tunnels and caverns, New Austrian Tunneling Method (NATM), Norwegian Tunneling Method (NTM), construction dewatering Rock mass-tunnel support interaction analysis, ground response and support reaction curves, Ladanyi'selasto-plastic analysis of tunnels, design of various support systems including concrete and shotcrete linings, steel sets, rock bolting and rock anchoring, combined support systems, estimation of load carrying capacity of rock bolts In-situ stress, flat jack, hydraulic fracturing and over coring techniques and USBM type drill hole deformation gauge, single and multi-point bore hole extensometers, load cells, pressure cells, etc. Instrumentation and monitoring of underground excavations, during and after construction, various case studies

Suggested Books :

1. Das, B. M. (2011) Principles of Foundation Engineering. Cengage Learning.

2. Koerner, R. M. (2012) Designing with Geosynthetics, Vol. 1 & 2. Xlibris Corporation.
3. Moseley, M. P., Kirsch, K (2004). Ground Improvement. Spon Press.

GTE 6307 Probability & Statistical Methods in Engineering

Preliminary data analysis: Graphical representation of data (stem and leaf plot, box plot, Q-Q Plots), frequency distribution, measure of central tendency-grouped and ungrouped data, measure of dispersion, measure of asymmetry, measure of peakedness, covariance, correlation coefficient. Random events: Sample space and events, Interpretation of probability, Probability axioms, Elementary theorems, conditional probability, Bayes' theorem. Random Variables: Definition of random variables - discrete and continuous; Probability definitions - PMF, PDF, CDF; Moments and expectations. Concept of risk and reliability. Probability Distributions: Discrete distributions - binomial distribution, Poisson's distribution; Continuous distributions – uniform distribution exponential distribution, gamma distribution, Weibull, Normal and lognormal distributions. Extreme value distributions, Multivariate distribution-Bivariate Normal distribution, other bivariate distribution, Transformations to Normal distribution. Model Estimation and Testing: Properties of estimators, sampling distributions-Chi square distribution, t-distribution, F distribution, Parameter estimation-Point estimation, confidence interval estimation, Hypothesis testing-Tests of hypotheses on the mean and variance, Goodness-of-fit tests, fitting theoretical distributions to observed frequency distributions and Tests of goodness-of-fit (chi-square test, Kolmogorov-Smirnov test). Curve fitting: method of least squares, simple linear regression, coefficient of correlation and the sample correlation, multiple linear regression. Principal component analysis. Case study of Monte Carlo simulation.

Suggested Books :

1. Haldar, A., and Mahadevan, S. (2000) "Probability, reliability and statistical methods in engineering design." - John Wiley and Sons, New York.
2. Benjamin J. R and Cornell C .A , (1970) "Probability, statistics and decisions for civil engineers", - John Wiley, New York.
3. Papoulis A , (1991) "Probability, random variables and stochastic processes", 3rd Edition, - McGraw-Hill, New York.
4. Ross S.M , (2004) "Introduction to Probability and Statistics for Engineering and Scientist" - Academic Press, Elsevier

GTE 6201 Design of underground excavations

Introduction, planning of and exploration for various underground construction projects, stereographic projection

method, principle and its application in underground excavation design.Elastic stress distribution around tunnels, stress distribution for different shapes and under different in-situ stress conditions, Greenspan method, design principles, multiple openings, openings in laminated rocks, elasto-plastic analysis of tunnels, Daemen's theoryApplication of rock mass classification systems, ground conditions in tunneling, analysis of underground openings in squeezing and swelling ground, empirical methods, estimation of elastic modulus and modulus of deformation of rocks; uniaxial jacking / plate jacking tests, radial jacking and Goodman jacking tests, long term behaviour of tunnels an caverns, New Austrian Tunneling Method (NATM), Norwegian Tunneling Method (NTM), construction dewatering.Rock mass-tunnel support interaction analysis, ground response and support reaction curves, Ladanyi'selasto-plastic analysis of tunnels, design of various support systems including concrete and shotcrete linings, steel sets, rock bolting and rock anchoring, combined support systems, estimation of load carrying capacity of rock bolts In-situ stress, flat jack, hydraulic fracturing and over coring techniques and USBM type drill hole deformation gauge, single and multi-point bore hole extensometers, load cells, pressure cells, etc. Instrumentation and monitoring of underground excavations, during and after construction, various case studies

Suggested Books :

1. Hoek, E and and Brown, E. T.,(1980) " Underground Excavations in Rocks", Institute of Mining Engineering.
2. Obert, L. and Duvall, W.I., "Rock Mechanics and Design of Structures in Rocks", John Wiley (1967)
3. Singh, B. and Goel, R.K.,"Rock Mass Classification- A Practical Engineering Approach", Elsevier. (1999)
4. Singh, B. and Goel, R.K., "Tunnelling in Weak Rocks", Elsevier (2006)

GTE 6203 Foundation on Weak rocks

Requirements for satisfactory performance of foundations, bearing capacity of foundations on rocks and rock masses, allowable bearing pressure of rock foundations using a nonlinear failure criterion, monotonic and cyclic plate load tests, Pressure-settlement characteristics, effect of layering, anisotropy, heterogeneity and inelasticity Shallow foundations, shallow foundations on sloping ground, raft foundations, stilt foundations, foundations for suspension bridges, transmission line towers, framed buildings etc, treatment of foundations - open joints, solution cavities, weak seams Piles in weak rocks, bearing capacity and settlement of piles, piles in stratified rock masses, field load tests on piles in weak rocks, behaviour of bored / driven piles in soft / weathered rocks

Suggested Books :

1. Wyllie Duncan C.," Foundations on Rock: Engineering Practice", E&FN Spon, Taylor and Francis. (1999)
2. Hudson J.A. and J.P. Harrison. Engineering Rock Mechanics: an Introduction to the Principles, 1997. Elsevier,

Oxford
3. Singh, B. and Goel, R.K.,"Rock Mass Classification- A Practical Engineering Approach", Elsevier .(1997)
4. Ramamurthy, T., "Engineering in Rocks", PHI Learning Pvt. Ltd. (2014)

GTE 6205 Geotechnical Design Studio

Seepage analysis through an earth dam. Slope stability analysis of a dam. Settlement analysis of shallow and deep foundations; Analysis and design of retaining structures; Analysing the structural forces in a tunnel lining.

Suggested Books :

1. M.S.Rahman and M.B.Can Ulker Modeling and Computing for Geotechnical Engineering, (2018)
2. Donald P. Coduto , Foundation Design Principles and Practises, (1999)
3. Robert D. Haltz, WilliaM D kavacs and Thomas C. Shealen:An Introduction to Geotechnical Engineering (1981)

SEMESTER IV

Courses

GTE 652 Track 1 Research Project

GTE 602 Track 2 Project 2