DELHI TECHNOLOGICAL UNIVERSITY

Department of Civil Engineering

Syllabi for Master of Technology

Geotechnical Engineering

M. Tech. Geotechnical Engineering				
Course code: Course Title	**Course Structure.**			**Pre-Requisite**
	L	**T**	**P**	
GTE501: Advanced Soil Mechanics	3	0	2	Nil

Course Objective: Introduction to the concept of soil mechanics and knowledge of various properties of soils. Students will be able to develop concepts like clay mineral structure and the engineering behaviour of soil.

S. No	Course Outcomes (CO)
CO1	Acquire a comprehensive understanding of clay minerals, the structure of soil particles and special soils
CO2	Analyse effective stress, pore pressure, hydraulic conductivity, and Seepage of soil
CO3	Develop a comprehensive understanding of issues related to compressibility and consolidation
CO4	Analyse shear behaviour and settlement of soils
CO5	Understand in situ undrained shear strength, stress history, and modulus values

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	1	2	1
CO4	3	3	2
CO5	1	3	3

S. No	Contents	Contact hours
UNIT 1	Clay mineralogy, clay-water electrolyte system, soil structure and fabric, Special soils: collapsible & sensitive clays, loessic, bouldery, and expansive soils	8
UNIT 2	Effective stress, pore pressure, hydraulic conductivity and its directional variation, electro osmosis, Seepage behaviour of soil-flow net constructions by various techniques, seepage in layered soils, filter design, seepage through dam body.	8
UNIT 3	Consolidation: one-dimensional and generalized consolidation theories, primary and secondary consolidation, determination of Cv by various methods, viscoelastic models, sand drains, effect of smear, numerical solutions, and consolidation settlements.	10

UNIT 4	Shear behaviour of soils, pore pressure parameters, UU, CU & CD tests, stress path method for settlement analysis.	8
UNIT 5	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.	8
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Soil Mechanics: Principle and Practice: GE Barnes, (2000) (ISBN 9-03-088753-7).	2000
2	Advanced Soil Mechanics: BM Das (1997), (ISBN 0-77-04915-8).	1997
3	Soil Mechanics: TW Lambe and RV Whitman (1987), (ISBN 0-71-6059714-1).	1987
4	Fundamentals of Soil Behaviour: James K. Mitchell (1993), (ISBN 7-83-4697512-6).	1993

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

PO1: An ability to independently carry out research/investigation, and development work to solve practical problems.
PO2: An ability to write and present a substantial technical report/ document.
PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialisation of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor's program.

M. Tech. Geotechnical Engineering					
Course code: Course Title		**Course Structure**			**Pre-Requisite**
GTE502: Geotechnical Exploration		**L**	**T**	**P**	
		3	0	2	
Course Objective: The objective of this course is to provide students with a comprehensive understanding of surface and sub-surface exploration methods, including aerial and remote sensing techniques, geophysical methods, and rock drilling procedures. Students will learn about various sampling techniques, sampling disturbance mitigation strategies, and methods for storage, labelling, and transportation of samples.					
-	-	-	-	-	- -
S. No	**Course Outcomes (CO)**				
CO1	Understanding of Exploration Methods				
CO2	Proficiency in Drilling, Sampling, and Lodging Techniques				
CO3	Comprehensive knowledge of Stress and Deformation in Rocks				
CO4	Expertise in Strength and Permeability Testing				
CO5	Data Processing and Site Monitoring Skills				

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No.	Contents	Contact hours
UNIT 1	Surface and subsurface exploration methods: Aerial and remote sensing techniques, Geophysical methods, electrical resistivity, seismic refraction.	8
UNIT 2	Drilling Sampling and Lodging Techniques: Rock drilling, Sampling techniques, Logging stratigraphic profile.	8
UNIT 3	Stress and Deformation in Rocks: Stresses in rocks, Stress anisotropy, and stress ratio. Stress relief and compensation techniques, USBM, door stopper cells, flat	10

	jack, hydro fracture, strain rosette, and dilatometers. Deformability, pressure tunnel, and borehole tests.	
UNIT 4	Strength and Permeability testing: Strength tests, in situ 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 - Relevant standards and codes.	8
UNIT 5	Field and Laboratory Testing, Data processing and Interpretation: 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.	8
	TOTAL	**42**

REFERENCES

S. No.	Name of Books/Authors/Publishers	Year of Publication / Reprint
1	Bowles, J.E., Foundation Analysis and Design, McGraw-Hill International Edition.	1997
2	Schnaid, F., "In Situ Testing in Geomechanics, Taylor and Francis".	2008
3	Burt G. Look, "Handbook of Geotechnical Investigation and Design Tables, CRC press"	2014
4	Roy E. Hunt, "Geotechnical Engineering Investigation Handbook, Taylor and Francis.	2005

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

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

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

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

M. Tech. Geotechnical Engineering					
Course code: Course Title		**Course Structure.**			**Pre-Requisite**
GTE503: Rock Mechanics		**L**	**T**	**P**	Nil
		3	0	2	
Course Objective: To make the students understand engineering properties of rock and classification of rocks, laboratory testing, in-situ testing of rocks by various methods, tunnelling in rocks, underground construction, foundations on rock, bearing capacity, and various techniques to improve in-situ strength of rocks.					
-	-	-	-	-	- -

S. No	Course Outcomes (CO)
CO1	Understand the concept of rock mechanics and various classifications of rocks.
CO2	Understand laboratory testing of rocks and assess the in-situ properties by various methods.
CO3	Analyze various theories for evaluating pressure around openings in the rock mass and underground excavation
CO4	Analyse the bearing capacity of intact and jointed rocks and design a foundation on rock.
CO5	Analyse real-life problems of tunnels with rock mass and underground openings.

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Introduction, problems of rock mechanics, classifications of rock masses	8
UNIT 2	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.	8

UNIT 3	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.	10
UNIT 4	Foundation on rocks; bearing capacity of intact and jointed rocks; rock slopes; slope stability, rock bolt anchors & grouting	8
UNIT 5	Underground openings, pillars, tunnels, methods of construction, problems associated with tunnels, tunnelling in various subsoil conditions and rocks.	8
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Rock Mechanics Design in Mining and Tunnelling, by Z.T. Bieniawski, (1984), Pub: A.A. Balkema	1984
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)	2008

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

PO1: An ability to independently carry out research/investigation, and development work to solve practical problems.
PO2: An ability to write and present a substantial technical report/ document.
PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialisation of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor's program.

M. Tech. Geotechnical Engineering				
Course code: Course Title	**Course Structure.**			**Pre-Requisite**
GTE504: Soil Structure Interaction	**L**	**T**	**P**	Nil
	3	1	0	

Course Objective: The objective of this course is to provide students with a comprehensive understanding of soil-structure interaction problems, particularly focusing on shallow foundations and beams on elastic foundations. Students will learn about contact pressures, sub-grade modulus concepts, and the analysis of foundations of finite rigidity.

S. No	Course Outcomes (CO)
CO1	Understanding of Soil-Structure Interaction (SSI) for Shallow Foundations
CO2	Proficiency in Analytical Methods for Beams on Winkler Foundation
CO3	Competence in Analyzing Beams on Elastic Half Space
CO4	Expertise in Dynamic Soil-Structure Interaction
CO5	Advanced Knowledge of Wave Propagation and SSI Applications

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Soil - Structure Interaction for Shallow Foundations: 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.	8
UNIT 2	Analytical Methods of Analysis of Finite Beams on Winkler 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,	8

	analysis of frames on wrinkle foundation, analysis of rigid piles with horizontal and vertical loads.	
UNIT 3	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.	10
UNIT 4	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.	8
UNIT 5	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	8
	TOTAL	**42**

-	-	-	-	-	- -

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Tsudik, E. (2012)"Analysis of Structures on Elastic Foundations"- J. Ross Publishing	2012
2	Wolf, J. P. (1985)"Dynamic soil-structure interaction"- Prentice Hall int..	1985
3	Wolf, J. P., & Song, C. (1996). "Finite-element modelling of unbounded media"- Chichester: Wiley.	1996
4	"Structure Soil Interaction" - State of the Art Report, Institution of Structural Engineers. (1978)	1978
5	"Structure Soil Interaction" - State of the Art Report, Institution of Structural Engineers. (1978)	1996

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

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

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

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

M. Tech. Geotechnical Engineering					
Course code: Course Title		**Course Structure.**			**Pre-Requisite**
GTE505: Advanced Foundation Engineering		**L**	**T**	**P**	Nil
		3	0	2	
Course Objective: The objective of this course is to understand the soil exploration planning for different projects, depth, location, bearing capacity, and settlement criteria for the design of shallow foundations, action and load capacity of a single pile, and piles in a group, design of well foundation, lateral stability and, construction of well foundations, design of foundations on expansive soils and expansive soil.					
-	-	-	-	-	- -
S. No	**Course Outcomes (CO)**				
CO1	Analyse the given soil condition to decide the suitability of a particular foundation.				
CO2	Design shallow foundations for structures.				
CO3	Design deep foundations for structures.				
CO4	Design and construct well foundations and understand methods to rectify the tilts and shifts of wells.				
CO5	Design foundations on problematic soils.				

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Planning of soil exploration for different projects, methods of subsurface exploration, methods of borings along with various penetration tests.	8
UNIT 2	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.	8

UNIT 3	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 behaviour of piles, proportioning of pile foundations, the lateral and uplift capacity of piles.	10
UNIT 4	Well foundation, IS and IRC codal provisions, elastic theory and ultimate resistance methods, Coffer dams, various types, analysis, and design.	8
UNIT 5	Foundations under uplifting loads. Foundations on problematic soils: Foundations for collapsible and expansive soil.	8
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Bowles. J.E., (1997),"Foundation Analysis and Design, Tata McGraw-Hill International Edition"	1997
2	Das B.M., (1999), "Shallow Foundations: Bearing capacity and settlement, CRC Press,"	1999
3	Tomlinson M.J.,(1994)," Pile design and construction Practice, Chapman and Hall Publication,".	1994
4	Poulos, H. G. and Davis, F. H., (1980) "Pile Foundation Analysis and Design", Wiley and Son	1980

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

PO1: An ability to independently carry out research/investigation, and development work to solve practical problems.
PO2: An ability to write and present a substantial technical report/ document.
PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialisation of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor's program.

M. Tech. Geotechnical Engineering					
Course code: Course Title		**Course Structure.**			**Pre-Requisite**
GTE507: Soil Dynamics and Machine Foundations		**L**	**T**	**P**	Nil
		3	0	2	
Course Objective: The objective of this course is to understand various types of vibrations of a single degree of freedom system, methods of evaluation of design parameters, application of principles for the design of machine foundations, and various vibration isolation techniques.					
-	-	-	-	-	-
S. No	**Course Outcomes (CO)**				
CO1	Understand the basic knowledge about the theory of vibration and the dynamic behaviour of soil.				
CO2	Analyse wave propagation into soil and vibration measuring instruments.				
CO3	Analyse and design the suitable foundation system for different structures subjected to different types of dynamic loading.				
CO4	Analyse and design foundations for hammers, dynamic stiffness of piles, and reciprocating engines.				
CO5	Analyse different types of vibration isolation systems, deformation problems, and dynamic instrumentation.				

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Introduction, fundamentals of vibrations, vibration of elementary spring, mass, dashpot systems, degrees of freedom	8
UNIT 2	Dynamic properties of geo-materials, wave propagation; Laboratory and field tests for evaluation of dynamic soil properties; vibration sensors.	8
UNIT 3	Vibration of foundations on elastic half space; design procedures for foundations with dynamic loads	10

UNIT 4	Dynamic stiffness of single pile and pile groups; Lumped parameter solutions, analysis and design of foundations for hammers, reciprocating engines and turbo generators	8
UNIT 5	Vibration isolation, retaining walls, small and large deformation problems, dynamic instrumentation	8
	TOTAL	**42**

-	-	-	-	-	- -

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Das, B.M. (1983) “Fundamentals of Soil Dynamics”, Elsevier	1983
2	Steven Kramer (2008), “Geotechnical Earthquake Engineering”, Pearson	2008
3	Prakash, S. (1981), Soil Dynamics, McGraw-Hill,	1981
4	Kameswara Rao, N.S.V. (1998), “Vibration analysis and foundation dynamics,	1998

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

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

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

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

M. Tech. Geotechnical Engineering					
Course code: Course Title		**Course Structure.**			**Pre-Requisite**
GTE511: Geo-environmental Engineering		**L**	**T**	**P**	Nil
		3	0	2	
Course Objective: The objective of this course is to provide students with a comprehensive understanding of soil-environment interaction, soil mineralogy, soil-water interaction, Soil-water-contaminant interaction, contaminant analysis, design of various landfill components, and stabilization of contaminated soils and risk assessment approaches.					
-	-	-	-	-	- -
S. No	**Course Outcomes (CO)**				
CO1	Understand the properties of water in relation to the porous media.				
CO2	Understand the mechanisms of soil-water interaction.				
CO3	Analyse soil-waste interaction.				
CO4	Apply containment principles to detect the level of contamination.				
CO5	Design an appropriate barrier to control contamination				

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Soil as a multiphase system; Soil-environment interaction; Properties of water in relation to the porous media; Water cycle with special reference to the soil medium.	8
UNIT 2	Soil mineralogy; significance of mineralogy in determining soil behaviour; Mineralogical characterization. Mechanisms of soil-water interaction: Diffuse double layer models; Force of attraction and repulsion;	8
UNIT 3	Soil-water-contaminant interaction; Theories of ion exchange; Influence of organic and inorganic chemical interaction. Concepts of waste containment;	10

	Sources, production, and classification of wastes, Environmental laws and regulations.	
UNIT 4	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.	8
UNIT 5	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.	8
	TOTAL	**42**

-	-	-	-	-	- -

REFERENCES

S. No.	Name of Books/Authors/Publishers	Year of Publication / Reprint
1	Mitchell, J.K., and Soga, K. (2005). Fundamentals of Soil Behaviour, John Wiley and Sons Inc.	2005
2	Fang, H-Y. (1997). “ Introduction to Environmental Geotechnology, CRC Press”	1997
3	Daniel, D.E. (1993) “Geotechnical Practice for Waste Disposal, Chapman and Hall.”	1993
4	Rowe, R.K., Quigley, R.M. and Booker, J.R.,(1995) “ Clay Barrier Systems for Waste Disposal Facilities, E & FN Spon,”	1995
5	Reddi, L.N. and Inyang, H.F. (2000) “Geo-environmental Engineering - Principles and Applications, Marcel	2000

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

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

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

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

M. Tech. Geotechnical Engineering					
Course code: Course Title		Course Structure.			Pre-Requisite
GTE513: Application of Remote Sensing and GIS in Geotechnical Engineering		L 3	T 0	P 2	Nil
Course Objective: The objective of this course is to provide students with a comprehensive understanding of the principles of Remote Sensing and GIS techniques and the application of GIS in various natural resources mapping and monitoring					
-	-	-	-	-	- -
S. No	**Course Outcomes (CO)**				
CO1	An ability to acquire knowledge of the basic principles of GIS and Image Processing				
CO2	An ability to utilize GIS packages and their salient features for data acquisition for geotechnical applications				
CO3	Understand spatial analysis and data pre-processing				
CO4	Apply georeferencing, interpolation of data, GPS, and network systems.				
CO5	Develop statistical models and apply GIS to various natural resources mapping and monitoring.				

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Introduction, Geographical concepts and Terminology, Difference between Image Processing system and GIS, Utility of GIS	8
UNIT 2	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	8
UNIT 3	Remote Sensing Data in GIS, Topology and Spatial Relationships, Data storage verification and editing of Data pre-processing	10

UNIT 4	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	8
UNIT 5	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	8
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Burrough, P.A. and McDonnel, R.A., (2000) "Principles of Geographic Information Systems", Oxford University Press.	2000
2	Chrisman, Nicholas R. (2002). "Exploring Geographic Information Systems." John Wiley.	2002
3	Demers, Michael N., (2008)"Fundamentals of Geographic Information Systems", 2nd Ed. Wiley.	2008
4	Ghosh, S.K. and Chandra, A.M., (2008) "Remote Sensing and GIS", Narosa Publishing House.	2008
5	Lo, C.P. and Young, A.K.W., (2002) "Concepts and Techniques of Geographical Information Systems", Prentice Hall India.	2002

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

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

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

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

M. Tech. Geotechnical Engineering				
Course code: Course Title	**Course Structure.**			**Pre-Requisite**
GTE515: Tunnel Engineering	**L**	**T**	**P**	Nil
	3	0	2	

Course Objective: To impart advanced theoretical and practical knowledge in the planning, design, construction, and maintenance of tunnels. To develop proficiency in tunnel behavior modeling and numerical simulation techniques. To evaluate complex tunnel-ground interactions, advanced support systems, and monitoring strategies. To expose students to global tunnel projects and innovations through critical case studies and research review.

S. No	Course Outcomes (CO)
CO1	Integrate geological, geotechnical, and structural knowledge for advanced tunnel analysis.
CO2	Design tunnels under various geological and loading conditions using analytical and numerical methods, including NATM, SEM, and mechanized tunnelling techniques, effectively.
CO3	Evaluate the performance of tunnel linings and support systems through monitoring data.
CO4	Conduct risk assessments and apply mitigation strategies in complex tunnelling scenarios.
CO5	Review and critique contemporary research and innovations in tunnelling

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Advanced Geological Considerations: Complex geology in tunneling. Geological hazards: fault zones, squeezing, and swelling grounds. Hydrogeological impacts on tunnels. Tunnel-Ground Interaction and Design: Analytical approaches: Elastic, elasto-plastic methods, Convergence-Confinement method, Load Transfer models for support systems.	8

UNIT 2	Numerical Modeling and Simulation; Finite Element Method (FEM) and Finite Difference Method (FDM) for tunnels, Software tools: PLAXIS, FLAC3D, Phase2, Modeling construction stages and ground relaxation.	8
UNIT 3	Advanced Construction Techniques: Sequential Excavation Method (SEM), NATM applications and control, Mechanized tunneling: EPB, Slurry TBM, Hybrid machines. Lining Design and Segmental Tunnels: Design of precast segments and gaskets, Fiber-reinforced linings, Corrosion protection, and waterproofing systems.	10
UNIT 4	Instrumentation and Monitoring: Instrumentation techniques: extensometers, load cells, piezometers, Deformation and stress monitoring, Real-time data interpretation and decision support. Risk and Sustainability in Tunneling: Probabilistic risk assessment, Life-cycle analysis, Environmental and social considerations.	8
UNIT 5	Case Studies and Research Trends: In-depth analysis of recent tunnel projects (e.g., Brenner Base Tunnel, Gotthard Base Tunnel), Discussion on AI/ML in tunneling, digital twins, Review of current literature and international tunneling standards.	8
	TOTAL	**42**

REFERENCES		
S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Tunnelling in Rock, *Authors:* E.T. Brown. *Publisher:* CRC Press / Balkema.	2002
2	Mechanised Shield Tunnelling, *Authors:* Bernhard Maidl, Markus Thewes, Ulrich Maidl. *Publisher:* Ernst & Sohn / Wiley.	2012
3	Tunnel Engineering Handbook (2nd Edition). *Editors:* Thomas R. Kuesel, Elwyn H. King, John O. Bickel. *Publisher:* Springer.	1996
4	Design and Construction of Tunnels: Analysis of Controlled Deformations in Rock and Soils (ADECO-RS). *Author:* Pietro Lunardi. *Publisher:* Springer.	2015
5	Numerical Methods in Geotechnical Engineering. *Author:* Michael Smith *Publisher:* CRC Press / Taylor & Francis.	2008
6	Geotechnical Aspects of Underground Construction in Soft Ground, *Edited by:* C. Bakker, A. Bezuijen, W. Broere, E. Kwast. *Publisher:* CRC Press / Taylor & Francis.	2006

M. Tech. Geotechnical Engineering					
Course code: Course Title		**Course Structure.**			**Pre-Requisite**
GTE520: Theoretical Soil Mechanics		**L**	**T**	**P**	Nil
		3	0	2	
Course Objective: The objective of this course is to provide students with a comprehensive understanding of stress and strain analysis in soils. Students will learn about elastic equilibrium analysis for plane strain and three-dimensional cases, effective stress principles, constitutive relations, and the equilibrium and compatibility of stress and strain states.					
-	-	-	-	-	- -
S. No	**Course Outcomes (CO)**				
CO1	Comprehensive Understanding of Stress and Strain in Soils.				
CO2	Mastery of Soil Mechanics Theorems and Compatibility Conditions.				
CO3	Expertise in Plasticity and Failure Mechanisms.				
CO4	Understanding of Anisotropic Behaviour and Elastic-Plastic Theories.				
CO5	Proficiency in Advanced Soil Behaviour and Rheological Modelling.				

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Stress and Strain Analysis in Soils: Elastic Equilibrium Analysis for plane strain and three-dimensional cases. Effective stress, analysis of deformation and strain, state of stress and strain, and constitutive relations.	8
UNIT 2	Theorems and Compatibility in Soil Mechanics: equilibrium and compatibility, general theorem of equilibrium. Drained and undrained loading, state boundary surface.	8
UNIT 3	Plasticity and Failure in Soils: plastic flow, yield and hardening, failure theorems for soils. Failures and plastic flow at critical state, associative and non-associative flow, and residual strength.	10

UNIT 4	Anisotropy, Elasticity, and Plastic Collapse: anisotropic compressions; ideal elastic behaviour-two and three-dimensional systems; theorems of plastic collapse. Application to soil interaction, elasto-plastic theory of soil.	8
UNIT 5	Advanced Soil Behaviour and Rheological Models: rheological models; non-linear viscoelasticity; problems and solutions.	8
	TOTAL	**42**

-	-	-	-	-	- -

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Fundamentals of Theoretical Soil Mechanics: ME Harr (ISBN 978-0-070267411).	1996
2	Elastic Solutions for Soils and Rock Mechanics: HG Poulos and EH Davis, (ISBN 9780471695653).	1974
3	Theory of Elasticity & Plasticity: SP Timoshenko & JN Goodier , (ISBN 978-0-9791865-0-9).	1982
4	Critical State Soil Mechanics: AN Schofield & CP Wroth, (ISBN 978-0641940484).	1968

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

PO1: An ability to independently carry out research/investigation, and development work to solve practical problems.
PO2: An ability to write and present a substantial technical report/ document.
PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialisation of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor's program.

M. Tech. Geotechnical Engineering					
Course code: Course Title		**Course Structure.**			**Pre-Requisite**
GTE522: Critical State Soil Mechanics		**L**	**T**	**P**	Nil
		3	0	2	
Course Objective: The objective of this course is to provide students with a comprehensive understanding of soil behaviour, focusing on the state of stress and strain in soils, stress and strain paths, and the behaviour of soils under various laboratory experiments. Students will learn about critical state soil mechanics, including the critical state line and the Roscoe surface, and their application to undrained and drained tests.					
-	-	-	-	-	- -
S. No	**Course Outcomes (CO)**				
CO1	Understanding of Stress and Strain in Soils				
CO2	Mastery of Critical State and Roscoe Surface Concepts				
CO3	Expertise in Over-consolidated Soil Behaviour and Hvorslev Surface				
CO4	Proficiency in Sand Behaviour Analysis				
CO5	Competence in Soil Behaviour Before Failure and Plasticity Models				

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	State of Stress and Strain in Soils: State of stress and strain in soils, Stress and strain paths and invariants, behaviour of soils under different laboratory experiments.	8
UNIT 2	Critical State Line and Roscoe Surface: 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.	8

UNIT 3	Behaviour of Over-consolidated Samples and Hvorslev Surface: 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.	10
UNIT 4	Behaviour of Sands: The critical state line for sands, Normalized plots, the effect of dilation, Consequences of Taylor's model	8
UNIT 5	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.	8
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	J. H. Atkinson and P. L. Bransby, (1978),"The mechanics of soils: An introduction to critical state soil mechanics", McGraw-Hill	1978
2	D. M. Wood, (1990) "Soil behaviour and critical state soil mechanics", Cambridge University Press	1990
3	B. M. Das, (2013)"Fundamentals of Geotechnical Engineering", Cengage Learning,	2013

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

PO1: An ability to independently carry out research/investigation, and development work to solve practical problems.
PO2: An ability to write and present a substantial technical report/ document.
PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialisation of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor's program.

M. Tech. Geotechnical Engineering				
Course code: Course Title	**Course Structure.**			**Pre-Requisite**
GTE524: Cost Management of Engineering Project	**L**	**T**	**P**	Nil
	3	0	2	

Course Objective: The objective of this course is to provide students with a comprehensive understanding of cost behaviour, profit planning, and various cost management techniques used in modern business environments. Students will learn about marginal costing and absorption costing methods, including their distinctions and applications in decision-making.

S. No	Course Outcomes (CO)
CO1	Comprehensive Understanding of Cost Behaviour and Profit Planning
CO2	Proficiency in Decision-Making and Variance Analysis
CO3	Expertise in Advanced Cost Management Approaches
CO4	Mastery of Activity-Based Cost Management and Strategic Tools
CO5	Competence in Budgetary Control and Quantitative Techniques

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Cost Behaviour and Profit Planning: Cost Behaviour and Profit Planning, Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis.	8
UNIT 2	Decision-Making and Cost Management Techniques: Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing.	8
UNIT 3	Costing in Different Sectors and Advanced Approaches: Costing of the service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management, and Theory of constraints.	10

UNIT 4	Activity-Based Cost Management and Strategic Tools: Activity-Based Cost Management, Bench Marking, Balanced Score Card and Value-Chain Analysis. Budgetary Control	8
UNIT 5	Budgetary Control and Quantitative Techniques: 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 Problems.	8
	TOTAL	**42**
-	- - - - - -	

REFERENCES		
S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting (2003)	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)	2015

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

PO1: An ability to independently carry out research/investigation, and development work to solve practical problems.
PO2: An ability to write and present a substantial technical report/ document.
PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialisation of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor's program.

M. Tech. Geotechnical Engineering				
Course code: Course Title	**Course Structure.**			**Pre-Requisite**
GTE530: Geotechnical Earthquake Engineering	**L**	**T**	**P**	Nil
	3	1	0	

Course Objective: The objective of this course is to provide students with a comprehensive understanding of engineering seismology, including the assessment of seismic risks and hazards, the dynamic response of soils and structures to earthquakes, and the design of earthquake-resistant structures. Students will learn to Analyse seismic data, determine site-specific characteristics, and apply engineering principles to mitigate the effects of seismic events on infrastructure.

S. No	Course Outcomes (CO)
CO1	Understanding of Seismic Risks and Earthquake Fundamentals
CO2	Proficiency in Site Characterization and Design Earthquake Determination
CO3	Expertise in Dynamic Soil Behaviour and Liquefaction Analysis
CO4	Competence in Seismic Analysis and Design of Infrastructure
CO5	Application of Mitigation Techniques and Analysis of Case Histories

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Fundamentals of Engineering Seismology: 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 characteristics.	8
UNIT 2	Site Characterization and Design Earthquake: Determination of site characteristics, local geology and soil condition, Determination of design earthquake, response spectra, and accelerograms.	8

UNIT 3	Site Response and Soil Dynamics: Site response to earthquake site investigation and soil test; dynamic behaviour of soils, liquefaction and cyclic mobility, analysis of pore pressure development. In-situ test for liquefaction.	10
UNIT 4	Seismic Analysis and Design: Analysis and design of slopes, embankments, seismic response of soil structure system, foundation Earth retaining structures for seismic loading.	8
UNIT 5	Case histories, mitigation techniques	8
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Steven Kramer, (2008) "Geotechnical Earthquake Engineering", Pearson	2008
2	Naeim, F. (2001). "The Seismic Design Handbook, Kluwer Academic Publication, 2nd Edition,"	2001
3	Ferrito, J.M (1997) "Seismic design criteria for soil liquefaction, Tech. Report of Naval Facilities Service Centre, Port Hueneme,"	1997

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

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

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

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

<table>
<tr><td colspan="6">M. Tech. Geotechnical Engineering</td></tr>
<tr><td colspan="2">Course code: Course Title</td><td colspan="3">Course Structure.</td><td>Pre-Requisite</td></tr>
<tr><td colspan="2" rowspan="2">GTE532: Stability Analysis of Slopes</td><td>L</td><td>T</td><td>P</td><td rowspan="2">Nil</td></tr>
<tr><td>3</td><td>1</td><td>0</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Course Objective: The objective of this course is to provide students with a comprehensive understanding of slope stability analysis and mitigation techniques. Students will learn to identify the types and causes of slope failures, Analyse slope stability using various methods, and implement appropriate measures to mitigate slope instability risks.</td></tr>
<tr><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-
-</td></tr>
<tr><td>S. No</td><td colspan="5">Course Outcomes (CO)</td></tr>
<tr><td>CO1</td><td colspan="5">Understanding of Slope Stability Principles</td></tr>
<tr><td>CO2</td><td colspan="5">Proficiency in Stability Analysis Methods</td></tr>
<tr><td>CO3</td><td colspan="5">Competence in Seepage Analysis and Control</td></tr>
<tr><td>CO4</td><td colspan="5">Expertise in Strengthening Measures and Mitigation Techniques</td></tr>
<tr><td>CO5</td><td colspan="5">Proficient in Slope Monitoring and Maintenance</td></tr>
</table>

CO-PO Articulation Metrices

Course Outcome	**PO1**	**PO2**	**PO3**
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	**Contents**	**Contact hours**
UNIT 1	Types and Causes of Slope Failures: Slopes: Types and causes of slope failures, mechanics of slope failure, failure modes.	8
UNIT 2	Stability Analysis Methods: 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.	8

UNIT 3	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 analysis of dam body during steady seepage.	10
UNIT 4	Strengthening Measures and Mitigation Techniques: stabilization of slopes by drainage methods, surface and subsurface drainage, use of synthetic filters, retaining walls, stabilization and strengthening of slopes, shot-creting, rock bolting, and rock anchoring.	8
UNIT 5	Instrumentation and Monitoring of Slopes: instrumentation and monitoring of slopes, slope movements, warning devices, and maintenance of slopes.	8
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Chowdhary R and Chowdhary I, "Geotechnical Slope Analysis", CRC Press. (2009)	2009
2	Harr M.E.," Ground Water and Seepage", McGraw-Hill. (1962)	1962

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

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

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

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

M. Tech. Geotechnical Engineering					
Course code: Course Title		Course Structure.			Pre-Requisite
GTE534: Pavement Analysis and Design		L	T	P	
		3	1	0	
-	-	-	-	-	-

Course Objective: The objective of this course is to provide students with a comprehensive understanding of pavement design principles and methodologies. Students will learn about the philosophy behind the design of flexible and rigid pavements, Analyse pavements using various analytical methods, and gain expertise in selecting design input parameters, material characterization, drainage considerations, and failure criteria.

-	-	-	-	-	-

S. No	Course Outcomes (CO)
CO1	Understanding of Pavement Design Philosophy and Analytical Methods
CO2	Proficiency in Selection of Design Input Parameters and Material Characterization
CO3	Expertise in Pavement Design Methods and Comparison of Approaches
CO4	Competence in Failure Criteria, Reliability, and Overlay Design
CO5	Proficient in Pavement Drainage and System Design

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Philosophy of design of flexible and rigid pavements, Analysis of pavements using different analytical methods	8
UNIT 2	Selection of pavement design input parameters – traffic loading and volume, Material characterization	8
UNIT 3	Pavement Design Methods: Design of flexible and rigid pavements using different methods, Comparison of different pavement design approaches.	10

UNIT 4	Failure Criteria, Reliability, and Overlays: Understanding factors contributing to pavement failure, Reliability in Pavement Design, Design of Overlays.	8
UNIT 5	Pavement Drainage and System Design: Importance of drainage in pavement design, designing effective drainage systems for pavements, Integrating overlay and drainage system design into pavement design strategies.	8
	TOTAL	**42**

-	-	-	-	-	- -

REFERENCES

S. No.	Name of Books/Authors/Publishers	Year of Publication / Reprint
1	Yang and H. Huang, (2004) “Pavement Analysis and Design, Pearson Prentice Hall”	2004
2	Yoder and Witzech (1982), “ Pavement Design, McGraw-Hill.”	1982

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

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

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

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

M. Tech. Geotechnical Engineering				
Course code: Course Title	**Course Structure.**			**Pre-Requisite**
GTE540: Computational Lab- Geotechnical Engineering	**L**	**T**	**P**	Nil
	0	0	8	

Course Objective: To familiarize students with computational techniques for geotechnical problem-solving.

- To apply finite element and finite difference methods in geotechnical engineering.
- To analyze geotechnical structures using commercial and open-source software.
- To enhance skills in data visualization, interpretation, and technical documentation

S. No	Course Outcomes (CO)
CO1	Model complex geotechnical problems using state-of-the-art software.
CO2	Validate computational results with theoretical and empirical data.
CO3	Prepare professional reports and interpret simulation outputs effectively.
CO4	Integrate GIS and CAD tools for geotechnical site investigations.

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	1	2	1
CO4	3	3	2

S. No	Contents	Contact hours
UNIT 1	**Numerical Modeling Fundamentals**: Numerical solution of 1D consolidation, Stress distribution (Boussinesq theory) in layered soils, Slope stability using limit equilibrium in Python.	8
UNIT 2	**Slope Stability Analysis**: Deterministic and probabilistic analysis of slopes, Bishop, Janbu, and Morgenstern-Price methods, FEM-based slope failure simulation in PLAXIS. **Seepage and Groundwater Flow**. Seepage modeling in	8

	earthen dams, Steady-state and transient flow simulations, Flow nets vs numerical solutions.	
UNIT 3	**Stress-Deformation & Consolidation Analysis**: Embankment loading and settlement behavior, 1D, 2D consolidation under staged loading, Ground improvement modeling. **Foundation System Modeling:** Pile and raft foundation analysis under axial and lateral loads, Soil-structure interaction modeling, Comparison with analytical solutions.	10
UNIT 4	**Dynamic & Earthquake Analysis**: Ground response analysis and liquefaction potential, Earthquake loading on slopes and retaining walls, Modeling wave propagation in soil. **Geotechnical Drawing & Visualization:** Borehole log interpretation and 2D soil profiling, Site layout and geotechnical cross-sections, GIS-based mapping of soil parameters.	8
UNIT 5	**Report Writing and Documentation**: Creating structured lab reports and technical papers, incorporating equations, tables, and figures, Reference and citation management.	8
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Several relevant software are: PLAXIS 2D/3D – Finite element analysis of soil and rock behavior. GeoStudio Suite (SLOPE/W, SEEP/W, SIGMA/W) – Slope stability, seepage, and stress-deformation analysis. FLAC (Fast Lagrangian Analysis of Continua) – Finite difference modeling for geotechnical applications. MIDAS GTS NX – Advanced geotechnical and tunneling simulations. AutoCAD / Civil 3D – Drafting and geotechnical drawing. MATLAB / GNU Octave – Numerical methods and scripting. Python (NumPy, SciPy, Matplotlib) – Custom geotechnical computation and visualization. QGIS – GIS-based subsurface modeling and site analysis.	Latest versions

M. Tech. Geotechnical Engineering					
Course code: Course Title		**Course Structure.**			**Pre-Requisite**
GTE541: Introduction to AI Techniques in Geotechnical Engineering		**L**	**T**	**P**	**Nil**
		1	0	2	

Course Objective: The objective of this course is to introduce students to fundamental techniques and concepts in Artificial Intelligence (AI). The course will cover the basic principles of AI, machine learning, and deep learning, as well as their applications in various domains. Students will learn about different AI techniques, algorithms, and methodologies used for problem-solving and decision-making tasks. The course aims to provide a solid foundation in AI, enabling students to understand the capabilities and limitations of AI technologies and apply them effectively in practical scenarios. By the end of the course, students will be prepared to explore advanced topics in AI and pursue further studies or careers in AI-related fields.

S. No	Course Outcomes (CO)
CO1	Understand Fundamental AI Concepts.
CO2	Apply AI Techniques.
CO3	Evaluate AI Models.
CO4	Utilize AI Tools and Frameworks.
CO5	Discuss Ethical and Social Implications

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Expert Systems (ES): Basic concepts of ES, definition, and components of ES. Reasoning mechanisms, e.g., forward reasoning and backward reasoning.	5
UNIT 2	Concept of causable variable, knowledge representation methods, and development of the rule-based knowledge base, dealing with uncertainty, linear	4

	and nonlinear behaviour of variables, statistical concepts, and their applications to engineering and sciences.	
UNIT 3	Artificial Neural Networks (ANNs): background and history of ANNs, definitions and basic concepts of ANNs, biological and artificial neural networks, feed-forward and feed-back networks.	4
UNIT 4	Supervised and unsupervised learning methods–standard back-propagation (BP), concept of learning, learning rate and momentum concepts, self-organizing networks, etc., development of ANN models for specific problems, and selected case studies.	4
UNIT 5	Introduction to Genetic Algorithms (GAs): fundamentals and preliminary concepts of evolution and GA, preliminaries of optimization, genetic operators-selection, crossover, and mutation, binary and real-coded GAs, selected case studies involving GA applications to engineering.	5
	TOTAL	**22**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Russell & Norvig: Artificial Intelligence; A Modern Approach, 3rd edition.	2010
2	Qiangfu ZHAO and Tatsuo Higuchi, Artificial Intelligence: from fundamentals to intelligent searches, Kyoritsu.	2017

M. Tech. Geotechnical Engineering				
Course code: Course Title	**Course Structure.**			**Pre-Requisite**
GTE542: Modelling and Simulation in Geotechnical Engineering	**L**	**T**	**P**	Nil
	2	0	4	

Course Objective: To familiarize students with computational techniques for geotechnical problem-solving.

- To apply finite element and finite difference methods in geotechnical engineering.
- To analyze geotechnical structures using commercial and open-source software.
- To enhance skills in data visualization, interpretation, and technical documentation

S. No	Course Outcomes (CO)
CO1	Model complex geotechnical problems using state-of-the-art software.
CO2	Validate computational results with theoretical and empirical data.
CO3	Prepare professional reports and interpret simulation outputs effectively.
CO4	Integrate GIS and CAD tools for geotechnical site investigations.

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	1	2	1
CO4	3	3	2

S. No	Contents	Contact hours
UNIT 1	**Numerical Modeling Fundamentals**: Numerical solution of 1D consolidation, Stress distribution (Boussinesq theory) in layered soils, Slope stability using limit equilibrium in Python.	8
UNIT 2	**Slope Stability Analysis**: Deterministic and probabilistic analysis of slopes, Bishop, Janbu, and Morgenstern-Price methods, FEM-based slope failure simulation in PLAXIS. **Seepage and Groundwater Flow**. Seepage modeling in	8

	earthen dams, Steady-state and transient flow simulations, Flow nets vs numerical solutions.	
UNIT 3	**Stress-Deformation & Consolidation Analysis**: Embankment loading and settlement behavior, 1D, 2D consolidation under staged loading, Ground improvement modeling. **Foundation System Modeling:** Pile and raft foundation analysis under axial and lateral loads, Soil-structure interaction modeling, Comparison with analytical solutions.	10
UNIT 4	**Dynamic & Earthquake Analysis**: Ground response analysis and liquefaction potential, Earthquake loading on slopes and retaining walls, Modeling wave propagation in soil. **Geotechnical Drawing & Visualization:** Borehole log interpretation and 2D soil profiling, Site layout and geotechnical cross-sections, GIS-based mapping of soil parameters.	8
UNIT 5	**Report Writing and Documentation**: Creating structured lab reports and technical papers, incorporating equations, tables, and figures, Reference and citation management.	8
	TOTAL	**42**

REFERENCES

S. No.	Name of Books/Authors/Publishers	Year of Publication / Reprint
1	Several relevant software are: PLAXIS 2D/3D – Finite element analysis of soil and rock behavior. GeoStudio Suite (SLOPE/W, SEEP/W, SIGMA/W) – Slope stability, seepage, and stress-deformation analysis. FLAC (Fast Lagrangian Analysis of Continua) – Finite difference modeling for geotechnical applications. MIDAS GTS NX – Advanced geotechnical and tunneling simulations. AutoCAD / Civil 3D – Drafting and geotechnical drawing. MATLAB / GNU Octave – Numerical methods and scripting. Python (NumPy, SciPy, Matplotlib) – Custom geotechnical computation and visualization. QGIS – GIS-based subsurface modeling and site analysis.	Latest versions
2	Geotechnical Modelling, David Muir Wood. Routledge, Taylor & Francis Co.	2004

M. Tech. Geotechnical Engineering				
Course code: Course Title	**Course Structure.**			**Pre-Requisite**
GTE601: Earth Pressure and Earth Retaining Structures	**L**	**T**	**P**	GTE501: Advanced Soil Mechanics
	3	0	1	

Course Objective: To develop a deep understanding of earth pressure theories under static and dynamic conditions.

- To analyze and design retaining walls, sheet pile walls, and reinforced soil structures.
- To understand construction methods, failure mechanisms, and stability aspects of earth retaining systems.
- To introduce modern approaches such as geosynthetics and soil nailing in earth retention.

S. No	Course Outcomes (CO)
CO1	Apply theoretical and empirical methods to compute earth pressures.
CO2	Design and analyse various retaining systems under different loading conditions.
CO3	Select appropriate construction methods based on site and design constraints.
CO4	Evaluate stability and serviceability aspects of earth retaining structures.

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2

S. No	Contents	Contact hours
UNIT 1	**Fundamentals of Earth Pressure**: Earth pressure types: active, passive, at-rest, Classical earth pressure theories (Rankine, Coulomb), Earth pressure on inclined and layered backfills, Influence of wall movement and wall friction. **Retaining Wall Design:** Types of retaining walls: gravity, cantilever, counterfort. Design	8

	for static and seismic conditions, Drainage and backfill requirements, Structural and stability checks (sliding, overturning, bearing capacity).	
UNIT 2	**Sheet Pile Walls and Braced Excavations:** Types of sheet pile walls: cantilever, anchored, Earth pressure distribution and analysis, Design of anchors and struts, Construction methods and dewatering.	8
UNIT 3	**Reinforced Soil Structures**: Concept of soil reinforcement, Design of reinforced earth walls (tie-back, geogrid-based), Construction and performance of mechanically stabilized earth (MSE) walls, Role of geosynthetics and facing elements.	10
UNIT 4	**Soil Nailing and Diaphragm Walls**: Soil nailing technique and design principles, Applications and construction methods, Diaphragm walls: types, construction, and design considerations.	8
UNIT 5	**Earth Pressure and Retaining Structures under Dynamic Loading**: Dynamic analysis of retaining walls, Pseudo-static and dynamic methods, Design and detailing under shock loading, thermal loading, and earthquakes.	8
	TOTAL	**42**

REFERENCES

S. No.	Name of Books/Authors/Publishers	Year of Publication / Reprint
1	Sabat, A.K. and Das, B.M. – *Earth Retaining Structures and Underground Excavations*, CRC Press, 1st Edition.	2003
2	Craig, R.F. – *Soil Mechanics*, CRC Press (Taylor & Francis), 8th Edition.	2012
3	Das, B.M. – *Principles of Foundation Engineering*, Cengage Learning, 9th Edition.	2022
4	Bowels, J.E. – *Foundation Analysis and Design*, McGraw-Hill Education, 5th Edition.	1996
5	Narasimha Rao, S. and Ramana, G.V. – *Analysis and Design of Retaining Structures*, PHI Learning Pvt. Ltd., 1st Edition.	2012

M. Tech. Geotechnical Engineering				
Course code: Course Title	**Course Structure.**			**Pre-Requisite**
GTE605: Ground Improvement Techniques	**L**	**T**	**P**	GTE501: Advanced Soil Mechanics
	3	1	0	

Course Objective: To understand the principles behind various ground improvement techniques.

- To develop the ability to select suitable methods based on soil conditions and project requirements.
- To analyze and design ground improvement systems for soft clays, loose sands, and expansive soils.
- To introduce construction methods, quality control, and field performance evaluation.

S. No	Course Outcomes (CO)
CO1	Identify and assess the need for ground improvement in geotechnical projects.
CO2	Select and design appropriate ground improvement techniques.
CO3	Apply theoretical principles to field practice through design exercises.
CO4	Evaluate the effectiveness of ground improvement through monitoring and case studies.
CO5	Identify and assess the need for ground improvement in geotechnical projects.

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	**Introduction to Ground Improvement**: Necessity and scope of ground improvement, Classification of methods, Selection criteria for techniques based on soil type and project needs. **Mechanical Modification:** Compaction (surface, deep, dynamic), Vibro-compaction and vibro-replacement, Preloading and surcharging with or without vertical drains.	8

UNIT 2	**Drainage and Dewatering Techniques:** Types of drains: sand drains, prefabricated vertical drains (PVDs), Electro-osmosis, Vacuum consolidation. **Grouting and Injection Techniques:** Types of grouts (chemical, cementitious, bituminous, etc.), Grouting methods: permeation, compaction, jet, fracture grouting, Applications and quality control.	8
UNIT 3	**Reinforcement Techniques**: Reinforced earth and geosynthetics (geotextiles, geogrids, geomembranes). Stone columns and sand compaction piles. Application in embankments and retaining structures.	10
UNIT 4	**Chemical and Thermal Methods:** Lime and cement stabilization, Fly ash and other industrial byproducts, Ground freezing and thermal stabilization techniques. **Soil Bio-Improvement (Emerging Techniques)**: Microbial-induced calcite precipitation (MICP), Enzyme-based soil stabilization, Research trends and case studies.	8
UNIT 5	**Field Implementation and Monitoring**: Construction techniques and quality control, Instrumentation for performance monitoring, Case studies of successful applications.	8
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Hausmann, M.R. – *Engineering Principles of Ground Modification*, McGraw-Hill Education.	1990
2	Sharma, S.K. and Sivapullaiah, P.V. – *Ground Improvement Techniques*, PHI Learning Pvt. Ltd., 1st Edition.	2012
3	Manfred Hausmann and Klaus Kirsch – *Ground Improvement by Deep Vibratory Methods*, CRC Press.	2009
4	IS 15284 Part 1 & 2 – *Design and Construction for Ground Improvement – Guidelines*, Bureau of Indian Standards. IS 13094 – *Guidelines for Ground Improvement by Preloading Method*, BIS.	Latest
5	Indraratna, B. and Chu, J. (Eds.) – *Ground Improvement: Case Histories*, Elsevier Geo-Engineering Book Series.	2005