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ताळगांव पठार,
गोंय - ४०३ २०६
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(Accredited by NAAC with Grade A+)

GU/Acad –PG/BoS -NEP Engg. /2025-26/550 Date: 14.11.2025

CIRCULAR

Ref. No.: GU/Acad –PG/BoS -NEP Engg. /2024-25/784 dated 27.01.2025

In supersession to the above referred Circular, the Syllabus of Semester III & IV of the **Master of Engineering (Geotechnical Engineering)** Programme approved by the Standing Committee of the Academic Council in its meeting held on 24th & 25th July 2025 is attached. The syllabus of Semester II approved earlier by the Academic Council in its meeting held on 06th December 2024 and the syllabus of Semester I approved by the Academic Council in its meeting held on 22nd August 2024 is also attached.

The Dean, Faculty of Engineering and Principals of affiliated Colleges offering the **Master of Engineering (Geotechnical Engineering)** Programme are requested to take note of the above and bring the contents of the Circular to the notice of all concerned.

ASHWIN VYAS LAWANDE
Digitally signed by ASHWIN VYAS LAWANDE
Date: 2025.11.14 16:48:33 +05'30'

(Ashwin V. Lawande)
Deputy Registrar – Academic

To,

1. The Dean, Faculty of Engineering, Goa University.
2. The Principals of affiliated Engineering Colleges.

Copy to,

1. The Director, Directorate of Technical Education, Govt. of Goa
2. The Chairperson, BoS in Civil Engineering.
3. The Controller of Examinations, Goa University.
4. The Assistant Registrar Examinations (Prof.), Goa University.
5. Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.

MASTER OF ENGINEERING (GEOTECHNICAL ENGINEERING)
RC 2024-25

TWO YEAR PROGRAMME STRUCTURE						
SEMESTER – I						
Sr No.	**Course Code**	**Title of the Course**	**L**	**T**	**P**	**Credits**
Programme Specific Core (PSC) Courses						
1	GTE-500	Advanced Soil Mechanics	3	0	0	3
2	GTE-501	Advances in Ground Improvement Techniques	3	0	0	3
3	GTE-502	Shallow Foundations	3	1	0	4
4	GTE-503	Geotechnical Engineering Lab - 1	0	0	1	1
5	GTE-504	Geotechnical Engineering Lab - 2	0	0	1	1
Programme Specific Elective (PSE) Courses						
6	GTE-531	Stability Analysis of Slopes and Landslides	3	1	0	4
OR						
7	GTE-532	Design of Foundations on Rock	3	1	0	4
Research Specific Elective (RSE) Courses						
8	REC-561	Engineering Research & Publications	3	1	0	4
OR						
9	REC-562	Literature Review & Technical Writing for Engineers	3	1	0	4
		TOTAL	**15**	**3**	**2**	**20**
Semester II						
Sr. No.	**Course Code**	**Title of the Course**	**L**	**T**	**P**	**Credits**
Programme Specific Core (PSC) Courses						
1	GTE-505	Deep Foundations	3	0	0	3
2	GTE-506	Geotechnical Engineering Lab - 3	0	0	1	1
3	GTE-507	Offshore Geotechnics	3	0	0	3
4	GTE-508	Soil Dynamics and Machine Foundations	3	0	0	3
5	GTE-509	Geotechnical Engineering Lab - 4	0	0	2	2
Programme Specific Elective (PSE) Courses						
6	GTE-533	FEM in Geotechnical Engineering	3	0	0	3
7	GTE-534	FEM Lab	0	0	1	1
OR						
8	GTE-535	Environmental Geotechnics	3	0	0	3
9	GTE-536	Environmental Geotechnics Lab	0	0	1	1
Research Specific Elective (RSE) Courses						
10	REC-563	Statistics and Data Analysis for Engineering Research	2	0	0	2
11	REC-564	Statistics and Data Analysis Lab	0	0	2	2
OR						
12	REC-565	Statistical Techniques for Engineering Research	2	0	0	2
13	REC-566	Probability and Statistical analysis lab	0	0	2	2
		TOTAL	**14**	**0**	**6**	**20**

Semester III						
Sr. No.	**Course Code**	**Title of the Course**	**L**	**T**	**P**	**Credits**
Programme Specific Core (PSC) Courses						
1	GTE-600	Design of Foundations	3	0	0	3
2	GTE-601	Geotechnical Engineering Lab - 5	0	0	1	1
3	GTE-602	Reinforced Earth and Geosynthetics	3	0	0	3
4	GTE-603	Geotechnical Engineering Lab - 6	0	0	1	1
Programme Specific Elective (PSE) Courses						
5	GTE-631	Geotechnical Earthquake Engineering	3	0	0	3
6	GTE-632	Geotechnical Earthquake Engineering Lab	0	0	1	1
OR						
7	GTE-633	Advanced Methods of Analysis	3	0	0	3
8	GTE-634	Advanced Methods of Analysis Lab	0	0	1	1
Research Specific Elective (RSE) Courses						
9	GTE-661	Forensic Geotechnical Engineering	2	0	0	2
10	GTE-662	Forensic Geotechnical Engineering Lab	0	0	2	2
OR						
11	GTE-663	Probabilistic methods in Geotechnical Engineering	2	0	0	2
12	GTE-664	Probabilistic methods in Geotechnical Engineering Lab	0	0	2	2
General Elective (GE) Courses						
13	GEC-681	Sustainability - Principles & Practices	3	0	0	3
14	GEC-682	Sustainability - Principles & Practices Lab	0	0	1	1
OR						
15	GEC-683	Project Management	3	0	0	3
16	GEC-684	Project Management Lab	0	0	1	1
		TOTAL	**14**	**0**	**6**	**20**
Semester IV						
Sr. No.	**Course Code**	**Title of the Course**	**L**	**T**	**P**	**Credits**
General Elective (GE) Courses						
1	GEC-685	Financial Management	4	0	0	**4**
OR						
2	GEC-686	Entrepreneurship	4	0	0	**4**
Program Specific Dissertation/Internship						
3	**GTE-698**	Dissertation	0	0	0	**16**
OR						
4	**GTE-699**	Internship	0	0	0	**16**
		TOTAL	**4**	**0**	**0**	**20**

THREE YEAR PROGRAMME STRUCTURE						
SEMESTER – I						
Sr No.	**Course Code**	**Title of the Course**	**L**	**T**	**P**	**Credits**
Programme Specific Core (PSC) Courses						
1	GTE-500	Advanced Soil Mechanics	3	0	0	3
2	GTE-503	Geotechnical Engineering Lab - 1	0	0	1	1
Programme Specific Elective (PSE) Courses						
3	GTE-531	Stability Analysis of Slopes and Landslides	3	1	0	4
OR						
4	GTE-532	Design of Foundations on Rock	3	1	0	4
Research Specific Elective (RSE) Courses						
5	REC-561	Engineering Research & Publications	3	1	0	4
OR						
6	REC-562	Literature Review & Technical Writing for Engineers	3	1	0	4
		TOTAL	**9**	**2**	**1**	**12**

SEMESTER I

Programme Specific Core (PSC) Courses

Name of the Programme : Master of Engineering (Geotechnical Engineering)
Course Code : GTE-500
Title of the Course : Advanced Soil Mechanics
Number of Credits : 03 (3L)
Effective from AY : 2024-25

Pre-requisites for the Course:	Knowledge of Soil Mechanics and Strength of Materials	
Course Objectives:	The course will enable the students to: 1. Understand the fundamental principles governing flow in soils, elastic and plastic behaviour of soil, stress distributions and contact pressure. 2. Apply numerical methods for solving the governing differential equations for various flow and stress problems. 3. Analyse the stress paths of soils under different conditions and yield criteria. 4. Design solutions for real-world geotechnical problems	
Content:		**No. of hours**
Unit - 1	**Idealised Concept of Soil:** Darcy's law, Steady state 3-D flow in an isotropic soil, continuity equation, equation of state, governing differential equation, solution by numerical methods, matrix method, FEM, Methods for reducing flow. 3-D flow through anisotropic soil of compressible fluid, through partly saturated soil, Terzaghi-Rendulic and Biot's equations, solution by numerical methods. Sand drains.	**12**
Unit - 2	**Strength behaviour of soils**: Mohr Circle of Stress; UU, CU, CD tests, drained and undrained behaviour of sand and clay, significance of pore pressure parameters; determination of shear strength of soil; Interpretation of triaxial test results, large direct shear test. Stress path: Drained and undrained stress path; Stress path with respect to different initial state of the soil; Stress path for different practical situations.	**11**
Unit - 3	**Stress Distribution in Soil:** Application of theory of elasticity, Boussinesq, Mindlin, Westergaards theories, Newmarks chart, Osterberg chart. **Contact Pressure**: Factors affecting, effect of rigidity of footing and/ or superstructure, simplified elastic-plastic analysis, thin plate theory, numerical methods, use of FEM, and rafts on consolidating soil layer.	**11**
Unit - 4	**Elastic and plastic deformations:** elastic wall; 3-D stress representation. Octahedral stresses, stress invariants. Introduction to yielding and hardening; yield curve and yield	**11**

	surface, associated and non-associated flow rule. **Yield Criteria**: Failure envelopes for soils, 3-D representation.	
Pedagogy:	Constructive, Collaborative and Inquiry based learning	
References/ Readings:	1. Atkinson J.H, "An introduction to the Mechanics of soils and Foundation", McGraw- Hill Co., 1993, ISBN-13: 978-0077077323 2. Craig, R.F., Soil Mechanics, Van Norstrand Reinhold Co. Ltd., 1997, ISBN-13: 978-0412374403 3. Das, B.M., "Advanced Soil Mechanics", Taylor and Francis, 1997, 2nd Edition. ISBN-13: 978-1560325611 4. Lambe, T.W. and Whitman, R.V., Soil Mechanics, John Wiley & Sons, 1969, ISBN-13: 978-0471511922 5. Terzaghi, K., Peck, R.B. and Mesri, G., Soil Mechanics in Engineering Practice, John Wiley & Sons, 1996, ISBN-13: 978-0471086581	
Course Outcomes:	After taking this course, student will be able to: CO1 Understand the fundamental principles governing flow in soils, elastic and plastic behaviour of soil, stress distributions and contact pressure. CO2 Apply numerical methods for solving the governing differential equations for various flow and stress problems. CO3 Analyse the stress paths of soils under different conditions and yield criteria. CO4 Design solutions for real-world geotechnical problems	

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Name of the Programme : **Master Of Engineering (Geotechnical Engineering)**
Course Code : **GTE-501**
Title of the Course : **Advances In Ground Improvement Techniques**
Number of Credits : **03 (3L)**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Knowledge of Soil Mechanics	
Course Objectives:	The course will enable the students to: 1. Understand the necessity for ground improvement and identify various methods used in the field including the newest trends and monitoring systems. 2. Explain the mechanics behind the various ground improvement methods 3. Apply the various ground improvement techniques for improvement of sandy and clayey soils 4. Analyse various soil stabilization techniques with case studies.	
Content:		**No. of hours**
Unit - 1	**Introduction:** Necessity of improving soils. Methods of Ground improvement: Mechanical, Hydraulic, Physico-chemical, Electrical, Thermal methods etc. and their applications. General Principles of Compaction and Consolidation. **Ground water in excavations and methods of ground water control:** ground water under artisan conditions beneath excavations, selection of appropriate method, special type of equipments employed in foundation investigations and construction.	**11**
Unit - 2	**Ground Improvement for Cohesionless Soils:** Mechanical compaction by Vibroflotation, compaction pile, Vibro-compaction piles, Dynamic compaction, Blasting, etc. Effectiveness of the various methods.	**11**
Unit - 3	**Ground Improvement for Cohesive Soils:** Improvement in soft clay deposits: Preloading, Sand drains; PVDs, Stone Columns, drainage and monitoring, Design and Installation. **Soil Stabilization:** Lime stabilization-Base exchange mechanism, Pozzolanic reaction, lime-soil interaction, Cement stabilization: Mechanism, amount, age and curing. Fly-ash - Lime Stabilization, Soil Bitumen Stabilization, Dewatering, heating/freezing, electro-osmosis.	**12**
Unit - 4	**Soil Reinforcement:** Introduction to reinforced earth, Soil nails, lime columns, ground anchors, geosynthetics, micro piles, mini piles. **Ground Improvement by Grouting:** Grouting in soil, types of grout, desirable characteristics, grouting pressure, grouting methods.	**11**

	Recent trends in ground improvement: MICP, bio-enzymes, nano-materials, Monitoring system for ground improvement and real time ground monitoring systems.	
Pedagogy:	Constructive, Collaborative and Inquiry based learning	
References/ Readings:	1. Bell. F.G. " Foundation Engineering In Difficult Ground", Butterworths. ISBN-13: 978-1483108667 2. Purushotham Raj, P., "Ground Improvement Techniques", Tata McGraw Hill, New Delhi, 1999, ISBN-13: 978-00746316583. 3. Chattopadhyay, B. C. and Maity, J., "Ground Control and Improvement Techniques", 2017, PEEDOT, Howrah. ISBN: 9788120353206 4. Koerner, R. M., "Designing with Geosynthetics", Prentice Hall, New Jersey, 2005, ISBN-13: 978-0131454156 5. Hausmann, M.R., Engineering Principles of Ground Modification, McGraw-Hill International Editions, 1999, ISBN-13: 978-0070277980	
Course Outcomes:	After taking this course, student will be able to: CO1 Understand the necessity for ground improvement and identify various methods used in the field including the newest trends and monitoring systems. CO2 Explain the mechanics behind the various ground improvement methods CO3 Apply the various ground improvement techniques for improvement of sandy and clayey soils CO4 Analyse various soil stabilization techniques with real time monitoring system	

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Name of the Programme : **Master Of Engineering (Geotechnical Engineering)**
Course Code : **GTE-502**
Title of the Course : **Shallow Foundations**
Number of Credits : **04 (3L+1T)**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Knowledge of Soil Mechanics and Foundation Engineering	
Course Objectives:	The course will enable the students to: 1. Understand the fundamentals of soil investigation, bearing capacity and settlement of shallow foundations and identify various types of shallow footings and their applications 2. Analyse the bearing capacity and settlement of various foundations and perform slope stability analysis using subsurface investigation data 3. Design spread footings, combined footing, retaining walls ensuring stability and suitability for specific site conditions. 4. Formulate the design of complex shallow foundations in difficult site conditions.	
Content:		**No. of hours**
Unit - 1	**Sub–surface Investigation and Sampling:** Planning of soil exploration for different projects; methods of subsurface exploration; Methods of Boring; Field tests, Laboratory tests; Plate load test; Penetrometer tests; Geophysical methods.	**15**
Unit - 2	**Bearing Capacity of Shallow Foundations:** Modes of failure, theories, effects of inclination, eccentricity of load, base tilt, sloping ground, shape, roughness of base, ground water, adjacent footings and non-homogeneous soil conditions. **Settlement of Shallow Foundations:** Types, calculation of initial distortion settlements, consolidation settlement, secondary compression settlement, permissible settlements	**15**
Unit - 3	**Spread Footings:** Location, proportioning for equal settlement, contact pressure, design principles. **Combined Footings:** Types, design principles of rectangular, trapezoidal, strap footings, modulus of subgrade reaction, continuous footings on elastic foundation, special footings, construction practices. **Mat Foundations:** Types, stability and settlement, design principles, elements of design and construction of shell foundation. **Floating Foundations:** Concept, types, problems to be considered in design, design principles.	**15**
Unit - 4	**Retaining Walls:** Influence of soil properties, earth and foundation Pressures, stability, design principles. **Slope Stability analysis:** Mechanism, movements associated, causes and consequences, classification, monitoring. **Shallow foundation:** footings on sloping ground, raft	**15**

	foundation, settlements of rafts; shallow footings for framed buildings.	
Pedagogy:	Constructive, Collaborative and Inquiry based learning.	
References/ Readings:	1. Arora, K. R., "Soil Mechanics and Foundation Engineering", 7th ed., Standard Publishers and Distributors, Delhi, 2004, ISBN-13: 978-8180141129 2. Bowles. J. E., "Foundation Analysis and Design", Tata McGraw-Hill International Edition,1995, ISBN-13: 978-0071188445 3. Das B.M., Shallow Foundations: Bearing capacity and settlement, CRC Press, 1999, ISBN-13: 978-0849319183 4. Katzenbach, R., Leppala, S. and Choudhury, D., Foundation systems for high rise structures, CRC Press,2012, ISBN-13: 978-0415584731 5. Murthy, V.N.S, "A text book of Soil Mechanics and Foundation Engineering", UBS Publishers & Distributors Pvt. Ltd., New Delhi, 2007, ISBN-13: 978-8174766351	
Course Outcomes:	After taking this course, student will be able to: CO1 Understand the fundamentals of soil investigation, bearing capacity and settlement of shallow foundations and identify various types of shallow footings and their applications CO2 Analyse the bearing capacity and settlement of various foundations and perform slope stability analysis using subsurface investigation data CO3 Design spread footings, combined footing, retaining walls ensuring stability and suitability for specific site conditions. CO4 Formulate the design of complex shallow foundations in difficult site conditions	

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Name of the Programme : **Master Of Engineering (Geotechnical Engineering)**
Course Code : **GTE-503**
Title of the Course : **Geotechnical Engineering Lab - 1**
Number of Credits : **1**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Knowledge of Soil Mechanics and Foundation Engineering	
Course Objectives:	The course will enable the students to: 1. Understand fundamental principles and procedures of routine soil testing 2. Analyse the strength properties of soil through various tests 3. Design a comprehensive soil investigation plan tailored to the specific site condition. 4. Explore the use of advanced instrumentation techniques in geotechnical engineering	
Content:		**No. of hours**
	Students shall carry out tests on the soil samples collected from trial pits at the site after planning suitable soil investigation plan for the site: (i) Routine tests on soils: moisture content, unit weight, Atterberg limits, particle size distribution (ii) Strength properties of soil - Direct shear test, large direct shear test, triaxial test, Vane Shear test, UCS test, Cyclic Triaxial test (iii) Permeability tests, consolidation test, compaction test, CBR test.	**30**
Pedagogy:	Inquiry based learning, Integrative, Reflective Learning, Constructive learning and Collaborative learning.	
References/ Readings:	1. Das, B.M. "Soil Mechanics Laboratory Manual" Oxford University Press, 2014, ISBN-13: 978-0190209667 2. Germaine, J.T. and Germaine A.V. "Geotechnical Laboratory Measurements for Engineers" Wiley publication, 2009, ISBN-13: 978-0470900710. 3. Head, K.H. “Manual of Soil Laboratory Testing", CRC Press, 1998, ISBN-13: 978-0419141503. 4. Kalinski, M.E. “Advanced Soil Mechanics Laboratory Manual”, Wiley publication, 2006, ISBN-13: 978-0470134993 5. Lambe, T. “Soil Testing for Engineers" Wiley publication, 1951, ISBN-13: 978-0471511854	
Course Outcomes:	After taking this course, student will be able to: CO1 Understand fundamental principles and procedures of routine soil testing CO2 Analyse the strength properties of soil through various tests CO3 Design a comprehensive soil investigation plan tailored to the specific site condition.	

	CO4 Explore the use of advanced instrumentation techniques in geotechnical engineering

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Name of the Programme : **Master of Engineering (Geotechnical Engineering)**
Course Code : **GTE-504**
Title of the Course : **Geotechnical Engineering Lab – 2**
Number of Credits : **1**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Knowledge of Soil Mechanics and Foundation Engineering	
Course Objectives:	The course will enable the students to: 1. Understand fundamental principles and procedures of soil tests for ground modification. 2. Estimate bearing capacity and suitable ground improvement techniques. 3. Design a comprehensive ground improvement solution tailored to the specific site condition 4. Explore the use of advanced techniques in geotechnical engineering	
Content:		**No. of hours**
	Students shall perform following experiments: 1. Shear strength parameters under various drainage conditions by using Direct shear test and Triaxial test. 2. Relative density test on modified soil samples 3. Compaction level test 4. Borehole and SPT 5. Study of Plate load test, Cone Penetration test (CPT), Field CBR test, Field Vane shear test. 6. Study experiments on Geosynthetics, Instrumentation and Geophysical test.	**30**
Pedagogy:	Inquiry based learning, Integrative, Reflective Learning, Constructive learning and Collaborative learning.	
References/ Readings:	1. Das, B.M. "Soil Mechanics Laboratory Manual" Oxford University Press, 2014, ISBN-13: 978-0190209667 2. Germaine, J.T. and Germaine A.V. "Geotechnical Laboratory Measurements for Engineers" Wiley publication, 2009, ISBN-13: 978-0470900710. 3. Head, K.H. “Manual of Soil Laboratory Testing", CRC Press, 1998, ISBN-13: 978-0419141503. 4. Kalinski, M.E. “Advanced Soil Mechanics Laboratory Manual”, Wiley publication, 2006, ISBN-13: 978-0470134993 5. Lambe, T. “Soil Testing for Engineers" Wiley publication, 1951, ISBN-13: 978-0471511854	
Course Outcomes:	After taking this course, student will be able to: CO1 Understand fundamental principles and procedures of soil tests for ground modification. CO2 Estimate bearing capacity and suitable ground improvement techniques.	

	CO3 Design a comprehensive ground improvement solution tailored to the specific site condition CO4 Explore the use of advanced techniques in geotechnical engineering

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Programme Specific Elective (PSE) Courses

Name of the Programme : Master of Engineering (Geotechnical Engineering)
Course Code : GTE-531
Title of the Course : Stability Analysis of Slopes and Landslides
Number of Credits : 4 (3L+1T)
Effective from AY : 2024-25

Pre-requisites for the Course:	Knowledge of Soil Mechanics and Foundation Engineering	
Course Objectives:	The course will enable the students to: 1. Understand the types and causes of slope failures, the mechanics behind slope instability, and the role of geological, topographic, and hydrological factors in landslide occurrence and classification. 2. Apply various investigative techniques to assess slope stability, and to implement monitoring systems for slope movements and hydro-meteorological variables. 3. Analyse slope stability using advanced methods such as infinite and finite slope analysis. 4. Design effective slope stabilization and strengthening measures, as well as to develop and implement landslide risk mitigation strategies, considering both structural and non-structural approaches, with attention to climate change impacts.	
Content:		**No. of hours**
Unit - 1	**Slopes:** Types and causes of slope failures, mechanics of slope failure, failure modes. Slopes system and its geological topographic and hydrological setting; landslide classification, controls and triggers; landslide risk. **Landslide investigations:** photo-interpretation and field mapping, monitoring, site investigations (topographic, borehole, geophysical).	**15**
Unit - 2	**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. **Slope instability processes:** stress distributions and paths in a slope; role of water in slope instability; total stress and effective stress analyses; short- vs. long-term slope stability; weakening, softening, and progressive failure; first-time rupture vs. reactivation.	**15**
Unit - 3	**Large rock slope instabilities:** morpho-structural features, lithological and structural controls, triggering. rainfall-induced shallow landslides: characterization, regional-scale prediction; rheology of water-sediment mixtures, onset and propagation processes, field evidence and dynamic modelling.	**15**

Unit - 4	**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. Monitoring: ground-based and remote surface displacements monitoring techniques; underground deformation monitoring; monitoring of hydro-meteorological variables and pore pressures; monitoring network architecture. **Landslide risk mitigation:** active vs. passive approaches; slope stabilization techniques; active and passive structural protection; non-structural protection and Early Warning, LiDAR, GIS. Climate change considerations. Case studies.	**15**
Pedagogy:	Constructive, Collaborative and Inquiry based learning.	
References/ Readings:	1. Abramson L, Lee, T, Sharma, Boyce, G. "Slope Stability and Stabilization Methods", Wiley Publications,2002, ISBN-13: 978-0471384939 2. Atkinson, J. H., "An introduction to the Mechanics of soils and Foundation", McGraw- Hill Co, 1993, ISBN-13: 978-0077077323 3. Chowdhary, R. and Chowdhary, I. , "Geotechnical Slope Analysis", CRC Press, 2009, ISBN-13: 978-0849374434 4. Countryman, C., "Principles of Slope Stability", Wiley publication, 1977, ISBN-13: 978-0471010302 5. Harr, M. E., "Ground Water and Seepage", McGraw Hill, 1962, ISBN-13: 978-0070260111	
Course Outcomes:	After taking this course, student will be able to: CO1 Understand the types and causes of slope failures, the mechanics behind slope instability, and the role of geological, topographic, and hydrological factors in landslide occurrence and classification. CO2 Apply various investigative techniques to assess slope stability, and to implement monitoring systems for slope movements and hydro-meteorological variables. CO3 Analyse slope stability using advanced methods such as infinite and finite slope analysis. CO4 Design effective slope stabilization and strengthening measures, as well as to develop and implement landslide risk mitigation strategies, considering both structural and non-structural approaches, with attention to climate change impacts.	

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Name of the Programme : Master of Engineering (Geotechnical Engineering)
Course Code : GTE-532
Title of the Course : Design of Foundations on Rock
Number of Credits : 4 (3L+1T)
Effective from AY : 2024-25

Pre-requisites for the Course:	Knowledge of Rock Mechanics and Foundation Engineering	
Course Objectives:	The course will enable the students to 1. Understand the formation, physical properties, and classification of rocks and rock masses, as well as the engineering properties of weak rocks, and the application of rock in various engineering contexts. 2. Apply laboratory and in-situ testing methods for assessing the properties of rocks and rock masses, and to utilize these methods in evaluating the stability and suitability of rocks for foundation and other engineering applications. 3. Analyze the modes of failure in rock foundations and the bearing capacity of foundations and rock-socketed piles 4. Design effective solutions for rock slope stabilization, develop design strategies for tunnels, foundations for bridges and dams.	
Content:		**No. of hours**
Unit - 1	**Rock:** Formation of rocks, Physical properties, identification of rock- procedure, Engineering properties of weak rocks, Classification of rocks and rock masses, Elastic constants of rock; In-situ stresses in rock, applications of rock and rock masses. Discontinuities and factors affecting discontinuities.	**15**
Unit - 2	**Rock Testing:** Laboratory tests, in-situ tests and applications of rocks and rock masses, RQD, RMR, Q System and GIS. Failure criteria for rock masses. **Modes of failure of foundation** – plane, circular, wedge, toppling; Rock slope stabilization by grouting, bolting, rock anchors.	**15**
Unit – 3	**Bearing capacity of foundation**, monotonic and cyclic plate load tests, Design considerations for bridges and dams-settlement control, lateral stability, seepage, erosion, etc. **Rock socketed Piles** – Bearing capacity and settlement of piles. Case study of foundations on rock.	**15**
Unit – 4	**Tunneling in soft and hard rock**, stabilisation, tunnel lining, grouting, rock bolting.	**15**
Pedagogy:	Constructive, Collaborative and Inquiry based learning.	
References/ Readings:	1. Goodman, R.E., "Introduction to Rock Mechanics", John Wiley & Sons, 1989, ISBN-13: 978-0471812005 2. Hudson, J.A., Harrison J.P., "Engineering Rock Mechanics: An Introduction to the Principles",Wiley and Sons, 1997, ISBN-13: 978-0080419121 3. Jaegar, Cook, Zimmerman, "Fundamentals of Rock Mechanics", Wiley	

	and Blackman, 2002, ISBN-13: 978-0632057597 4. Ramamurthy, T., "Engineering in Rocks", PHI Learning Pvt. Ltd, 2010, ISBN-13: 978-8120347083 5. Wyllie, D.C., "Foundations on Rock", E & FN Spon, 1999, ISBN-13: 978-0415280015
Course Outcomes:	After taking this course, student will be able to: CO1 Understand the formation, physical properties, and classification of rocks and rock masses, as well as the engineering properties of weak rocks, and the application of rock in various engineering contexts. CO2 Apply laboratory and in-situ testing methods for assessing the properties of rocks and rock masses, and to utilize these methods in evaluating the stability and suitability of rocks for foundation and other engineering applications. CO3 Analyse the modes of failure in rock foundations and the bearing capacity of foundations and rock-socketed piles. CO4 Design effective solutions for rock slope stabilization, develop design strategies for tunnels, foundations for bridges and dams.

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Research Specific Elective (RSE) Courses
Name of the Programme : Master of Engineering (Geotechnical Engineering)
Course Code : REC-561
Title of the Course : Engineering Research & Publication
Number of Credits : 4 (3L+1T)
Effective from AY : 2024-25

Pre-requisites for the Course:	Nil	
Course Objectives:	The course will enable the students to 1. Understand the importance of literature review, defining the research objectives. 2. Explain qualitative and quantitative methods of data analyses and its importance. 3. Classify research publications, select appropriate journals based on research areas. 4. Practice ethics in publication and academic integrity	
Content:		**No of Hours**
Unit -1	**Overview of scientific research in engineering**, foundational and fundamental concepts like types of research and considerations for research in specific domains, motivation to do research, critical thinking, assumptions and hypotheses, basic and applied research, importance of formulation of broad research objectives	**11 + 4T**
Unit -2	**Purpose and Methodology of Literature Search and Review** of the scientific and engineering publications. Sources such as scholarly databases, public domain, open access, current literature, review articles, critical review and gap analysis, defining research objectives	**11 + 4T**
Unit -3	**Quantitative and qualitative Data –** importance of data in research, types of data, data collection techniques, Quantitative methods for analysis of data – statistical tools, mathematical modeling, simulation, experimental data, optimization methods; Qualitative data collection, preparing questioners, rating scale, conducting survey, validation of models.	**12 + 4T**
Unit- 4	**Preparation of Publications-** Elements of research publications, types of publications, writing for journal publications, basic requirements for publication, selection of journals, journal quality indicators, peer review, reply to comments and responses, publication ethics, references, citations, authorship, plagiarism, academic integrity	**11 + 3T**
Pedagogy:	Inquiry based learning, Integrative, Reflective Learning, Constructive learning and Collaborative learning	
References/ Readings:	1. Herman Tang, 'Engineering Research-Design, Methods and Publications', John Wiley and Sons, 2021, ISBN:9781119624486.	

	2. Meikang Qiu, Han Qiu, Yi Zeng, 'Research & Technical Writing for Science and Engineering', Taylor & Francis Publications, 2022, ISBN:9781003139058 3. Michael Jay Katz, 'From Research to Manuscript', Springer Publication, 2009, ISBN:9781402094668. 4. Rob Dekkers, Lindsey Casey, Peter Langhorne, 'Making Literature Review Work', Springer Publications, 2022, ISBN:9783030900243
Course Outcomes:	After taking this course, student will be able to: CO 1. Understand the importance of literature review, defining the research objectives. CO 2. Explain qualitative and quantitative methods of data analyses and its importance. CO 3. Classify research publications, select appropriate journals based on research areas. CO 4. Practice ethics in publication and academic integrity

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Name of the Programme : Master of Engineering (Geotechnical Engineering)
Course Code : REC-562
Title of the Course : Literature Review & Technical Writing
Number of Credits : 4 (3L+1T)
Effective from AY : 2024-25

Pre-requisites for the Course:	Nil	
Course Objectives:	The course will enable the students to 1. Understand the importance of literature review and writing a review paper. 2. Explain the method to be followed to write a review paper. 3. Classify data for qualitative and quantitative analysis 4. Demonstrate technical writing for conference.	
Content:		**No of Hours**
Unit -1	**Overview on Literature Review**, difference between objectives of literature review and research objectives; types of literature review, qualitative and quantitative reviews, search strategies, primary and secondary sources, database search strategies, field search, root search, complimentary search, meta-analysis	**12 + 4T**
Unit -2	**Database management of literature reviews**, bibliometric analysis, importance of writing a review paper, reply to comments and responses, publication ethics, references, citations, authorship, plagiarism, academic integrity; public domain, open access, current literature.	**11 + 4T**
Unit -3	**Technical writing on a specific research topic**, structure of the paper, abstract, introduction, experimental, simulation, analysis, discussion, inferences, title, acknowledgment, referencing, presentation of tables, figures, graphs, equations; comparison between technical writing for conference papers and journal paper	**11 + 4T**
Unit- 4	**Importance of data in research**, types of data, data collection techniques, Quantitative methods for analysis of data – statistical tools, mathematical modeling, simulation, experimental data, optimization methods; Qualitative data collection, preparing questioners, rating scale, conducting survey, validation of models.	**11 + 3T**
Pedagogy:	Inquiry based learning, Integrative, Reflective Learning, Constructive learning and Collaborative learning	
References/ Readings:	1. Herman Tang, 'Engineering Research-Design, Methods and Publications', John Wiley and Sons, 2021, ISBN:9781119624486. 2. Meikang Qiu, Han Qiu, Yi Zeng, 'Research & Technical Writing for Science and Engineering', Taylor & Francis Publications, 2022, ISBN:9781003139058.	

	3. Michael Jay Katz, 'From Research to Manuscript', Springer Publication, 2009, ISBN:9781402094668 4. Rob Dekkers, Lindsey Casey, Peter Langhorne, 'Making Literature Review Work – Multidisciplinary Guide to Systematic Approaches', Springer Publications, 2022, ISBN:9783030900243.
Course Outcomes:	After taking this course, student will be able to: CO 1. Understand the importance of literature review and writing a review paper. CO 2. Explain the method to be followed to write a review paper. CO 3. Classify data for qualitative and quantitative analysis CO 4. Demonstrate technical writing for conference.

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Semester II

Programme Specific Core (PSC) Courses

Name of the Programme : Master of Engineering (Geotechnical Engineering)
Course Code : GTE-505
Title of the Course : Deep Foundations
Number of Credits : 3 (3L)
Effective from AY : 2024-25

Pre-requisites for the Course:	Knowledge of Soil Mechanics and Foundation Engineering	
Course Objectives:	The course will enable the students to: 1. Understand the classification, construction practices, and machinery involved in pile foundations, as well as the effects of pile installation on different soil types. 2. Apply knowledge of load capacity assessment methods for single piles, pile groups and to implement pile load testing methods. 3. Analyse settlement behavior of single piles and pile groups, as well as to assess the lateral resistance of piles and the effectiveness of different approaches to enhance lateral resistance. 4. Design different types of deep foundations as per code and in problematic conditions.	
Content:		**No. of hours**
Unit - 1	**Pile foundations –** Classification, construction practices - Brief description of machinery in use, Characteristics and use of drilling mud. Effects of pile driving in clays and sands, effects of installing bored piles. Pile Integrity test **Load Capacity of Piles -** Single piles, pile groups, piles to rock, SPT and static cone penetrometer, uplift resistance, negative friction, special types of piles, pile driving formulas, dynamic loads on piles, influence of earthquake forces.	**11**
Unit - 2	**Pile Load Tests -** Maintained loading test, constant rate of penetration test, method of equilibrium, I.S. approach, errors in measurements, lateral load test **Settlement Analysis of Single Piles -** Methods of analysis, solutions for settler-lent and load distribution, simplified method to constructing load settlement curve, determination of soil parameters, validity of methods. **Settlement Analysis of Pile Groups -** Analysis of group settlement, solutions for free standing groups, design charts, validity of methods.	**11**
Unit - 3	**Laterally Loaded Piles -** Lateral resistance of single piles, conventional statical approach, Brom's and Brinch Hansen's methods, I.S. approach, socketed piles, battered piles, pile groups, methods of increasing lateral resistance, load deflection	**12**

	behaviour, modulus of subgrade reaction approach, pile groups, I.S. approach. Introduction to sheet piles, and diaphragm walls. **Special Piles -** Piles in swelling and shrinking soils, lateritic soils, piles in soils undergoing lateral movement, micro piles, simple design and construction practices.	
Unit - 4	**Box caissons –** types, analysis, construction. **Well Foundations:** IS and IRC Codal provisions, Types, components, construction methods, design methods (Terzaghi, IS and IRC approaches), check for stability, base pressure, side pressure and deflection. **Pneumatics caissons -** analysis, construction. Foundations on problematic soils: Foundations for collapsible and expansive soil. **Cofferdams:** Types, analysis and design. Latest advances in deep foundations, Foundations for uplift loads.	**11**
Pedagogy:	Constructive, Collaborative and Inquiry based learning.	
References/ Readings:	**Text Books:** 1. Arora, K. R. "Soil Mechanics and Foundation Engineering", 7th ed., Standard Publishers andDistributors, Delhi,2004, ISBN-13: 978-818-014-1129 2. Bowles. J.E., "Foundation Analysis and Design", Tata McGraw-Hill International Edition, 1995, ISBN-13: 978-007-118-8445 3. Katzenbach, R., Leppala, S. and Choudhury, D., "Foundation Systems for High Rise Structures, CRC Press, 2012, ISBN-13: 978-041-558-4731 4. Poulos, H. G. and Davis, E. H., "Pile Foundation Analysis and Design", John Wiley and Sons, 1980, ISBN-13: 978-047 102 0844 5. Tomlinson M. and Woodward J. "Pile design and construction Practice", CRC Press, 2014, ISBN-13: 978-146-659-2636.	
Course Outcomes:	After taking this course, student will be able to: CO 1. Understand the classification, construction practices, and machinery involved in pile foundations, as well as the effects of pile installation on different soil types. CO 2. Apply knowledge of load capacity assessment methods for single piles, pile groups and to implement pile load testing methods. CO 3. Analyse settlement behaviour of single piles and pile groups, as well as to assess the lateral resistance of piles and the effectiveness of different approaches to enhance lateral resistance. CO 4. Design different types of deep foundations as per code and in problematic conditions.	

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Name of the Programme : Master of Engineering (Geotechnical Engineering)
Course Code : GTE-506
Title of the Course : Geotechnical Engineering Lab - 3
Number of Credits : 1 P
Effective from AY : 2024-25

Pre-requisites for the Course:	Knowledge of Soil Mechanics and Foundation Engineering	
Course Objectives:	**The course will enable the students to:** 1. Understand the processes and techniques involved in in-situ testing of piles. 2. Apply concepts in selecting suitable test and loading arrangement. 3. Analyse the data collected from field tests and prepare report 4. Design the capacity of pile and well foundation	
Content:		**No. of hours**
	Student shall complete at least five from the list below: A) Visit to sites, collection and analysis of data and preparation of report for: 1. Static pile load tests 2. Dynamic pile load analysis 3. Lateral load test 4. Pile Integrity test 5. Bi-directional load test B) Develop EXCEL sheets/ MATLAB/ SCiLAB/ Python programme for: 1. p-y curves 2. Extrapolation of pile load test data 3. t-z curves 4. Soil design of micro-piles 5. Soil design of well foundation C) Model studies on: 1. Piles	**30**
Pedagogy:	Inquiry based learning, Integrative, Reflective Learning, Constructive learning and Collaborative learning.	
References/ Readings:	1. Day R.W. "Foundation Engineering Handbook: Design and Construction with the 2009 International Building Code", McGraw-Hill, 2010, ISBN-13: 978-007-174-0094 2. Hunt R.E., “Geotechnical Engineering Investigation Handbook”, CRC Press, 2006, ISBN-13: 978-084-931-8582 3. Nayak, N. V., “Foundation Design Manual”, Dhanpat Rai and Sons, 1988, ISBN-13: 978-817-700-0322. 4. Schnaid F. “In-Situ Testing in Geomechanics: The Main Tests”, Taylor & Francis, 2009, ISBN-13: 978-041-540-9091. 5. Tomlinson M. and Woodward, J., “Pile Design and Construction Practice”, CRC Press, 2014, ISBN-13: 978-146-659-2636.	

Course Outcomes:	After taking this course, student will be able to: CO 1. Understand the processes and techniques involved in in-situ testing of piles. CO 2. Apply concepts in selecting suitable test and loading arrangements CO 3. Analyse the data collected from field tests and prepare report CO 4. Design the capacity of pile and well foundation

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Name of the Programme : Master of Engineering (Geotechnical Engineering)
Course Code : GTE-507
Title of the Course : Offshore Geotechnics
Number of Credits : 3 (3L)
Effective from AY : 2024-25

Pre-requisites for the Course:	Knowledge of Soil Mechanics and Foundation Engineering	
Course Objectives:	The course will enable the students to: 1. Understand the ocean environment, the nature, origin, and formation of marine deposits, as well as the fundamental principles governing site investigation techniques and the stress-strain behaviour of marine soils. 2. Apply shallow and deep penetration sampling techniques, submersible drilling, in-situ soil testing, and laboratory testing methods to investigate marine deposits, and to interpret the results for engineering applications. 3. Analyse the engineering properties of marine deposits, and to evaluate the stability of on-shore structures under the influence of wave action and other marine forces. 4. Design foundations for off-shore foundation structures with an emphasis on ensuring the stability and reliability of these structures in the marine environment.	
Content:		**No. of hours**
Unit - 1	**Marine Deposits -** Ocean environment, nature, origin, formation of marine deposits, classification, carbonate sediments, coral reef deposits, oil wells, hydrates and other minerals. **Site Investigation Techniques** -Shallow and deep penetration sampling techniques, submersible drilling and sampling techniques, sample disturbances, in-situ testing of soils, laboratory testing techniques, interpretation problems and applications, stress-strain behaviour of soils.	**11**
Unit - 2	**Engineering Properties of Marine Deposits** - Strength and deformation behaviour, influence of cementation and crushing on engineering behaviour; liquefaction of soils. **Foundations For On-Shore Structures -** Wave action on breakwaters and piles, stability of rock-mound and vertical wall breakwaters, on-shore piles design principles, anchored bulkhead, types, methods of analysis, design principles**,** anchorages, construction practices.	**13**
Unit - 3	**Off-Shore Structures -** Introduction, classification, forces acting, submarine pipe lines, stability, installation techniques, ocean bed anchors, geotechnical considerations, sulphate action on concrete piles in marine environment. Jacket Type Structures - Types, forces acting, dynamic stresses, axial capacity, wave equation.	**11**

	Smith's idealization, basic equations, soil parameters, effect of set up, solutions from wave equation analysis, reliability, lateral capacity, p-y curves construction practices.	
Unit - 4	**Gravity Structures -** Types, installation techniques, forces acting, design principles, bearing capacity, sliding, overturning, settlement –long term due to dynamic loading, liquefaction and scour. Anchorages and stability aspects of semi-submersibles, tension leg platforms and spars.	**10**
Pedagogy:	Constructive, Collaborative and Inquiry based learning.	
References/ Readings:	1. Poulos, H. G., "Marine Geotechnics", Unwin Hyman Ltd, London, UK, 1988, ISBN-13: 978-004-624-0051 2. Reddy, D. V., Arocksamy, M., Offshore Structures, Vol. 1", R.E.Kreiger Pub. & Co, 1991, ISBN-13: 978-089-874-7666 3. Randolph, M., Gourvenec, S., "Offshore Geotechnical Engineering", CRC Press, 2011, ISBN-13: 978-041-547-7446 4. Swami Saran, "Analysis and Design of Substructures", Oxford & IBH Publishing Company Private Ltd., Delhi, 1996, ISBN-13: 978-8120417175. 5. Thomson, D., Beasley, D. J., "Handbook of Marine Geotechnical Engineering", US Navy., 2012, ISBN-13: 978-146-792-8823	
Course Outcomes:	After taking this course, student will be able to: CO 1. Understand the ocean environment, the nature, origin, and formation of marine deposits, as well as the fundamental principles governing site investigation techniques and the stress-strain behaviour of marine soils. CO 2. Apply shallow and deep penetration sampling techniques, submersible drilling, in-situ soil testing, and laboratory testing methods to investigate marine deposits, and to interpret the results for engineering applications. CO 3. Analyse the engineering properties of marine deposits, and to evaluate the stability of on-shore structures under the influence of wave action and other marine forces. CO 4. Design foundations for off-shore foundation structures with an emphasis on ensuring the stability and reliability of these structures in the marine environment.	

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Name of the Programme : **Master of Engineering (Geotechnical Engineering)**
Course Code : **GTE-508**
Title of the Course : **Soil Dynamics and Machine Foundations**
Number of Credits : **3 (3L)**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Knowledge of Soil Mechanics and Foundation Engineering	
Course Objectives:	The course will enable the students to: 1. Understand the fundamentals of vibrations, the principles of vibration isolation, and vibration measuring instruments, the basic concepts of wave propagation and the behaviour of soils under dynamic loading. 2. Apply methods for determining dynamic elastic constants of soils and to use these methods to assess the dynamic behaviour of soils in various engineering contexts. 3. Analyse the mechanisms of soil liquefaction and to evaluate the bearing capacity of dynamically loaded foundations. 4. Design machine foundations and to ensure the stability and performance of foundations under dynamic loads.	
Content:		**No. of hours**
Unit - 1	**Fundamentals of vibrations:** Dynamic loads due to machines, Earthquake loading, single, two and multiple degree of freedom systems, vibration isolation, vibration absorbers, vibration measuring instruments, **Wave propagation:** Longitudinal and torsional vibrations in finite and infinite medium, Wave propagation in elastic half space. Elastic continuum medium, semi-infinite elastic continuum medium, soil behaviour under dynamic loading,	**12**
Unit - 3	**Dynamic elastic constants of soil:** determination of dynamic elastic constants, various methods including block resonance tests, cyclic plate load tests, wave propagation tests, oscillatory shear box test. **Liquefaction of soils:** liquefaction mechanism, factors affecting liquefaction, studies by dynamic triaxial testing, oscillatory shear box, shake table and blast tests, assessment of liquefaction potential.	**11**
Unit - 4	**Machine foundations:** Design criteria for machine foundations; Elastic homogeneous half space and lumped parameter solutions, analysis and design of foundations for reciprocating and impact type machines, turbines, effect of machine foundation on adjoining structures.	**12**
Unit - 5	**Bearing capacity of foundations:** Introduction to bearing capacity of dynamically loaded foundations, such as those of water towers, chimneys and high rise buildings, response of pile foundations.	**10**

Pedagogy:	Constructive, Collaborative and Inquiry based learning.
References/ Readings:	1. Das, B.M., Ramana, G. V., "Fundamentals of Soil Dynamics", Elsevier,2008, ISBN-13: 978-012-088-7815 2. Kramer, S., "Geotechnical Earthquake Engineering", Pearson, 1996, ISBN-13: 978-013-374-9434. 3. Kameswara Rao, N.S.V., "Vibration Analysis and Foundation Dynamics", Wheeler Publication Ltd, 1998, ISBN-13: 978-818-581-4165. 4. Prakash, S., "Soil Dynamics", McGraw Hill, 1981, ISBN-13: 978-007-050-0705. 5. Swami Saran, "Soil Dynamics and Machine Foundations" 3rd Edn. Galgotia Publishers, 2010, ISBN-13: 978-817-013-2082.
Course Outcomes:	After taking this course, student will be able to: CO 1. Understand the fundamentals of vibrations, the principles of vibration isolation, and vibration measuring instruments, the basic concepts of wave propagation and the behaviour of soils under dynamic loading. CO 2. Apply methods for determining dynamic elastic constants of soils and to use these methods to assess the dynamic behaviour of soils in various engineering contexts. CO 3. Analyse the mechanisms of soil liquefaction and to evaluate the bearing capacity of dynamically loaded foundations. CO 4. Design machine foundations and to ensure the stability and performance of foundations under dynamic loads.

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Name of the Programme : Master of Engineering (Geotechnical Engineering)
Course Code : GTE-509
Title of the Course : Geotechnical Engineering Lab - 4
Number of Credits : 2 P
Effective from AY : 2024-25

Pre-requisites for the Course:	Knowledge of Soil Mechanics and Foundation Engineering	
Course Objectives:	The course will enable the students to: 1. Understand the processes and techniques involved in soil investigation. 2. Apply laboratory testing methods to analyze soil and rock samples collected from investigation sites. 3. Analyse the data collected from boreholes and laboratory tests to prepare a detailed soil investigation report. 4. Design and interpret load-settlement curves by collecting load-settlement data from testing sites	
Content:		**No. of hours**
	Students shall visit at least two soil investigation sites (at least one site on exploratory boring and one site on plate load test), collect and analyse the data as listed below: 1. Borehole log, type of soil, colour of wash water, presence of ground water table, core recovery, RQD for rock samples, SPT, undisturbed sample collection. 2. Conduct lab tests on the soil samples collected: index properties, unit weight, direct shear test, density and compression test on rock specimen and evaluate SBC of soil/rock. 3. Prepare detailed soil investigation report indicating number of boreholes, depth of bore holes, borehole log, soil/rock properties, calculation of SBC and foundation recommendation. 4. Visit a testing site and collect load-settlement data, plot load settlement curve and estimate SBC and settlement of foundation.	**60**
Pedagogy:	Inquiry based learning, Integrative, Reflective Learning, Constructive learning and Collaborative learning.	
References/ Readings:	1. Day R.W. "Foundation Engineering Handbook: Design and Construction with the 2009 International Building Code", McGraw-Hill, 2010, ISBN-13: 978-007-174-0094 2. Hunt R.E., “Geotechnical Engineering Investigation Handbook”, CRC Press, 2006, ISBN-13: 978-084-931-8582 3. Nayak, N. V., “Foundation Design Manual”, Dhanpat Rai and Sons, 1988, ISBN-13: 978-817-700-0322. 4. Schnaid F. “In-Situ Testing in Geomechanics: The Main Tests”, Taylor & Francis, 2009, ISBN-13: 978-041-540-9091.	

	5. Tomlinson M. and Woodward, J., "Pile Design and Construction Practice", CRC Press, 2014, ISBN-13: 978-146-659-2636.
Course Outcomes:	After taking this course, student will be able to: CO 1. Understand the processes and techniques involved in soil investigation. CO 2. Apply laboratory testing methods to analyze soil and rock samples collected from investigation sites. CO 3. Analyse the data collected from boreholes and laboratory tests to prepare a detailed soil investigation report. CO 4. Design and interpret load-settlement curves by collecting load-settlement data from testing sites

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Programme Specific Elective (PSE) Courses
Name of the Programme : Master of Engineering (Geotechnical Engineering)
Course Code : GTE-533
Title of the Course : FEM in Geotechnical Engineering
Number of Credits : 3 (3L)
Effective from AY : 2024-25

Pre-requisites for the Course:	Knowledge of Soil Mechanics and Foundation Engineering	
Course Objectives:	The course will enable the students to: 1. Understand basic stress-strain relationship for soil and develop Stress deformation analysis. 2. Apply FEM formulations to various problems. 3. Compute various parameters required for FEM formulation. 4. Develop finite element formulation for different geotechnical problems including shallow foundation, seepage and consolidation problems.	
Content:		**No. of hours**
Unit - 1	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	**11**
Unit - 2	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.	**11**
Unit - 3	Displacement formulation for rectangular, triangular and isoparametric elements for two dimensional and axisymmetric stress analysis.	**11**
Unit - 4	Settlement Analysis: 2-D elastic solutions for homogeneous, isotropic medium, Steady Seepage Analysis: Finite element solutions of Laplace's equation, Consolidation Analysis: Terzaghi consolidation problem, Choice of Soil Properties for Finite Element Analysis.	**12**
Pedagogy:	Constructive, Collaborative and Inquiry based learning.	
References/ Readings:	1. Bathe, K.J. "Finite Element Procedures", PHI Ltd, 2006, **ISBN-13:** 978-8120328587 2. Chandraputla, T. R., Belgundu, A. D., "Introduction to Finite Elements in Engineering"; Prentice Hall, 2001, **ISBN-13:** 978-013-216-2746 3. G. Ramamurthy, "Applied Finite Element Analysis", I.K.International Publishing House Pvt Ltd., 2010, **ISBN-13:** 978-93-80578-45-3. 4. Potts David, M., Zdravkovic, L., "Finite Element Analysis in Geotechnical Engineering Theory and Application", Thomas Telford. 2001, **ISBN-13:** 978-072-772-7831 5. Zienkiewicz, O.C., Taylor, R.L., "Finite Element Methods Vol I & Vol II",	

	McGraw Hill, 2005, **ISBN-13 (Vol I):** 978-0750663205, **ISBN-13 (Vol II):** 978-075-066-3212
Course Outcomes:	After taking this course, student will be able to: CO 1. Understand basic stress-strain relationship for soil and develop Stress deformation analysis. CO 2. Apply FEM formulations to various problems. CO 3. Compute various parameters required for FEM formulation CO 4. Design and interpret load-settlement curves by collecting load- Develop finite element formulation for different geotechnical problems including shallow foundation, seepage and consolidation problems.

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Name of the Programme : **Master of Engineering (Geotechnical Engineering)**
Course Code : **GTE-534**
Title of the Course : **FEM Lab**
Number of Credits : **1 P**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Knowledge of Soil Mechanics, Foundation Engineering and FEM	
Course Objectives:	The course will enable the students to: 1. Understand the basic principles of FEM and methodology of FEM modelling 2. Apply concepts in selecting suitable model parameters and boundary conditions. 3. Analyse the model for various loading conditions. 4. Intrepret analysis results and create a report	
Content:		**No. of hours**
	Student shall complete at least 08 FEM lab modelling exercises from the list below: 1. Model of an isolated footing on cohesive, sandy, c-ϕ soil and layered strata by using any Industry standard FEM software 2. Model of a combined footing on cohesive, sandy, c-ϕ soil and layered strata by using any Industry standard FEM software 3. Model of a Raft foundation on cohesive, sandy, c-ϕ soil and layered strata by using any Industry standard FEM software 4. Model of a pile group 5. Model of a combined pile -raft foundation 6. Model of a finite slope with horizontal and inclined surface with and without surface loading 7. Model of a finite slope with surface loads and seepage pressures 8. Model of a deep excavation 9. Model of an underground cavity 10. Model of a tunnel 11. Model of a basic soil structure interaction problem 12. Model of a seismic ground response analysis problem 13. Model of a structure with sinking support	**30**
Pedagogy:	Inquiry based learning, Integrative, Reflective Learning, Constructive learning and Collaborative learning.	
References/ Readings:	1. Bathe, K.J. "Finite Element Procedures", PHI Ltd, 2006, **ISBN-13:** 978-8120328587 2. Chandraputla, T. R., Belgundu, A. D., "Introduction to Finite Elements in Engineering"; Prentice Hall, 2001, **ISBN-13:** 978-013-216-2746 3. G. Ramamurthy, "Applied Finite Element Analysis", I.K.International Publishing House Pvt Ltd., 2010, **ISBN-13:** 978-93-80578-45-3. 4. Potts David, M., Zdravkovic, L., "Finite Element Analysis in Geotechnical	

	Engineering Theory and Application", Thomas Telford. 2001, **ISBN-13:** 978-072-772-7831 5. Zienkiewicz, O.C., Taylor, R.L., "Finite Element Methods Vol I & Vol II", McGraw Hill, 2005, **ISBN-13 (Vol I):** 978-0750663205, **ISBN-13 (Vol II):** 978-075-066-3212
Course Outcomes:	After taking this course, student will be able to: CO 1. Understand the basic principles of FEM and methodology of FEM modelling CO 2. Apply concepts in selecting suitable model parameters and boundary conditions CO 3. Analyse the model for various loading conditions. CO 4. Intrepret analysis results and create a report

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Name of the Programme : Master of Engineering (Geotechnical Engineering)
Course Code : GTE-535
Title of the Course : Environmental Geotechnics
Number of Credits : 3 (3L)
Effective from AY : 2024-25

Pre-requisites for the Course:	Knowledge of Soil Mechanics and Foundation Engineering	
Course Objectives:	The course will enable the students to: 1. Understand the soil mineralogy and soil-water interaction. 2. Apply concepts to study soil-water-contaminant interaction. 3. Classify wastes and study waste containment. 4. Design methods to remediate the contaminated sites.	
Content:		**No. of hours**
Unit - 1	Soil as a multiphase system; Soil-environment interaction; Properties of water in relation to the porous med; Water cycle with special reference to soil medium.Soil mineralogy; significance of mineralogy in determining soil behavior; Mineralogical characterization.	**11**
Unit - 2	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.	**11**
Unit - 3	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.	**12**
Unit - 4	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.	**11**
Pedagogy:	Constructive, Collaborative and Inquiry based learning.	
References/ Readings:	1. Daniel, D.E, "Geotechnical Practice for Waste Disposal", Chapman and Hall, 1993, ISBN: 978-041-235-1709. 2. Mitchell, J. K. and Soga, K., "Fundamentals of Soil Behavior", John Wiley and Sons Inc.2005, ISBN **:** 978-047-146-3023. 3. Rowe, R.K, "Geotechnical and Geoenvironmental Engineering	

	Handbook", Kluwer Academic Publishers, 2004, ISBN: 978-030-645-3540. 4. Reddi, L.N. and Inyang, H.F, "Geoenvironmental Engineering - Principles and Applications", Marcel Dekker Inc, 2000, ISBN: 978-082-470-3463 5. Sharma, H.D. and Lewis, S.P, "Waste Containment Systems, Waste Stabilization and Landfills: Design and Evaluation", John Wiley & Sons Inc, 1994, ISBN: 978-047-157-5368.
Course Outcomes:	After taking this course, student will be able to: CO 1. Understand the soil mineralogy and soil-water interaction. CO 2. Apply concepts to study soil-water-contaminant interaction. CO 3. Classify wastes and study waste containment. CO 4. Design methods to remediate the contaminated sites.

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Name of the Programme : **Master of Engineering (Geotechnical Engineering)**
Course Code : **GTE-536**
Title of the Course : **Environmental Geotechnics Lab**
Number of Credits : **1 P**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Knowledge of Soil Mechanics and Foundation Engineering	
Course Objectives:	The course will enable the students to: 1. Understand the processes and techniques involved in testing of soil for its chemical constituents. 2. Apply suitable tests for identification and quantification of chemical constituents. 3. Analyse the data for chemical constituents of soils 4. Assess the potential of soil for chemical migration	
		No. of hours
Content:	Student shall complete at least 08 from the list below: 1. Determination of Hydraulic conductivity of Soils 2. Determination of coefficient of consolidation of medium swelling clays. 3. Determination of coefficient of consolidation of highly swelling clays. 4. Determination of Shear Strength of Clayey soils by triaxial test (UU). 5. Determination of Shear Strength of Clayey soils by triaxial test (CU & CD). 6. Determination of total soluble solids, Organic matter 7. Determination of calcium carbonate, PH, soluble sulphates in soil. 8. Chemical tests for determination of cation exchange capacity 9. Chemical tests for leachate analysis, Iron, Manganese, chloride 10. Determination of Thermal Properties of Geomaterials 11. Determination of Electrical Properties of Geomaterials	**30**
Pedagogy:	Inquiry based learning, Integrative, Reflective Learning, Constructive learning and Collaborative learning.	
References/ Readings:	1. Day R.W. "Foundation Engineering Handbook: Design and Construction with the 2009 International Building Code", McGraw-Hill, 2010, ISBN-13: 978-007-174-0094. 2. Hunt R.E., "Geotechnical Engineering Investigation Handbook", CRC Press, 2006, ISBN-13: 978-084-931-8582. 3. IS 2720: "Method of Test for Soil (relevant parts)" 4. Sarsby, Robert W. "Environmental Geotechnics in Practice", ICE Publishing, ISBN-13: 978-072-776-3631 5. Schnaid F. "In-Situ Testing in Geomechanics: The Main Tests", Taylor &	

	Francis, 2009, ISBN-13: 978-041-540-9091.
Course Outcomes:	After taking this course, student will be able to: CO 1. To understand the processes and techniques involved in testing of soil for its chemical constituents CO 2. To apply suitable tests for identification and quantification of chemical constituents CO 3. To analyse the data for chemical constituents of soils CO 4. To assess the potential of soil for chemical migration

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Research Specific Elective (RSE) Courses
Name of the Programme : Master of Engineering (Geotechnical Engineering)
Course Code : REC-563
Title of the Course : Statistics and Data Analysis for Engineering Research
Number of Credits : 2
Effective from AY : 2024-25

Pre-requisites for the Course:	Basic Knowledge of Statistics	
Course Objectives:	The course will enable the students to 1. Explain the different types of data and parameter estimations 2. Explain standard probability distributions 3. Select the appropriate parameter estimation & distribution method 4. Co-relate different Hypotheses	
Content:		**No of Hours**
Unit -1	**Data Analysis:** Types of data, data collection techniques, Quantitative methods for analysis of data – statistical tools, experimental data, Qualitative data collection, questioners, rating scale, conducting survey. Statistical Modeling and Graphical Diagnostics - Scatter Plot, Stem-and-Leaf Plot, Histogram, Box Plot **Correlation and Regression Modeling:** Basic concept and numericals.	**9**
Unit -2	**Probability distributions and Sampling distributions:** Basic introduction to Bernoulli, Binomial and Normal distribution. Basic introduction to Sampling distributions- Normal, t-distribution, Chi-square and F- distributions.	**7**
Unit -3	**Parameter estimation:** Point Estimation – Concept, unbiased estimator, method of maximum likelihood. Parameter estimation of standard distributions- Binomial and Normal. Confidence Interval Estimation - Concept, Confidence interval on mean of single normal population with variance known, Confidence interval on the ratio of variances of two normal distributions	**7**
Unit- 4	**Tests of Hypotheses:** Introduction, Type I and type II errors, significance level and power of the test, Test of hypotheses - on mean of single normal population with variance known, on variance of single normal population.	**7**
Pedagogy:	Inquiry based learning, Integrative, Reflective Learning, Constructive learning and Collaborative learning	
References/ Readings:	1. D. V Thiel, 'Research Methods for Engineers', Cambridge Press, 2014, ISBN:978-110-70-3-488 2. T. Mustafy, T. U Rahman, 'Statistics & Data Analysis for Engineers and Scientists', Springer, 2024, ISBN:9789819946600. 3. D. C. Montgomery, C. G. Runger, 'Applied Statistics and Probability for Engineers', 6th Edition, Wiley India, 2016, ISBN 0-471-20454-4	

	4. R. E. Walpole, R. H. Myers, S. L. Myers, K. E. Ye; Probability and Statistics for Engineers and Scientists ,9th Edition, Pearson Education India, 2013, ISBN 978-0-321-62911-1 5. J. Schmuller, Statistical Analysis with Excel for Dummies, 5th Edition, John Wiley & Sons, 2022.
Course Outcomes:	After taking this course, student will be able to: CO 1. Explain the different types of data and probability distributions. CO 2. Select the appropriate parameter estimation & distribution method CO 3. Apply estimators for the given situations. CO 4. Evaluate Hypotheses based on the statistical considerations.

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Name of the Programme : Master of Engineering (Geotechnical Engineering)
Course Code : REC-564
Title of the Course : Statistics and Data Analysis Lab
Number of Credits : 2
Effective from AY : 2024-25

Pre-requisites for the Course:	Basic Knowledge of Statistics	
Course Objectives:	The course will enable the students to 1. Apply the different types of data and parameter estimations 2. Analyze standard probability distributions 3. Demonstrate parameter estimation & distribution methods 4. Co-relate different Hypotheses	
Content:		**No of Hours**
	Using open-source software like libreoffice or any proprietary software perform following experiments: 1. Obtain measures of central tendency and dispersion. 2. Obtain Quartiles, Percentiles and prepare Box-and-Whisker Diagram 3. Develop Pie chart, Bar Chart, Histogram and Stem-and-Leaf Plot, 4. Develop_correlation using Pearson's Correlation Coefficient and showing Scatter Diagrams and Trendlines 5. Develop Linear and Nonlinear Regression Models 6. Obtain probability values involving probability distributions – Binomial and Normal 7. Obtain values of Normal, t-distribution, Chi-square and F-statistic. 8. Develop confidence interval for single population and two populations with variance known. 9. Develop confidence interval on the ratio of variances of two normal distributions. 10. Perform test of hypotheses on mean/variance of single/ two population(s).	**60**
Pedagogy:	Inquiry based learning, Integrative, Reflective Learning, Constructive learning and Collaborative learning	
References/ Readings:	1. D. V Thiel, 'Research Methods for Engineers', Cambridge Press, 2014, ISBN:978-110-70-3-488 2. T. Mustafy, T. U Rahman, 'Statistics & Data Analysis for Engineers and Scientists', Springer, 2024, ISBN:9789819946600. 3. D. C. Montgomery, C. G. Runger, 'Applied Statistics and Probability for Engineers', 6th Edition, Wiley India, 2016, ISBN 0-471-20454-4 4. R. E. Walpole, R. H. Myers, S. L. Myers, K. E. Ye; Probability and Statistics for Engineers and Scientists ,9th Edition, Pearson Education India, 2013, ISBN 978-0-321-62911-1 5. J. Schmuller, Statistical Analysis with Excel for Dummies, 5th Edition,	

	John Wiley & Sons, 2022.
Course Outcomes:	After taking this course, student will be able to: CO 1. Apply the different types of data and parameter estimations CO 2. Analyze standard probability distributions CO 3. Demonstrate parameter estimation & distribution methods CO 4. Co-relate different Hypotheses

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Name of the Programme : Master of Engineering (Geotechnical Engineering)
Course Code : REC-565
Title of the Course : Statistical Techniques for Engineering Research
Number of Credits : 2
Effective from AY : 2024-25

Pre-requisites for the Course:	Basic knowledge of Statistics and Probability	
Course Objectives:	The course will enable the students to 1. Understand the importance of statistical methods for research 2. Select the appropriate factorial design method for a given set of experimental plan. 3. Apply basic probability theorems and draw relevant inferences. 4. Analyze suitable probability model for given set of data	
Content:		**No of Hours**
Unit-1	**Overview on Statistical methods**, collection of data, one dimensional and two-dimensional statistical analysis, computation of central tendency and dispersion for grouped and ungrouped data, correlation preliminary, understanding variability in data.	**6**
Unit-2	**Design of Experiments**, Preparation of experimental plan, full factorial design, fractional factorial design, identification of parameters and levels, randomization, replication, blocking, interaction; numerical; Optimization methods for two parameters.	**9**
Unit-3	**Probability Preliminary**: Introduction to Probability, definition, Sample Space, Events, Conditional Probability, Theorem on total probability, Bayes' theorem. Random Variable: Introduction, Discrete and Continuous distribution, Characteristics- Mean, Variance and distribution function.	**8**
Unit-4	**Probability and Sampling Distribution**: Bernoulli, Binomial, Exponential, Normal, distribution. Mean, variance and distribution function, important properties, approximations and applications. Statistic and Sampling Distribution: Population and Sample. Statistic, Sampling distributions- Normal, t-distribution, Chi-square and F- distributions.	**7**
Pedagogy:	Inquiry based learning, Integrative, Reflective Learning, Constructive learning and Collaborative learning	
References/ Readings:	1. Tahvir Mustafy, Tauhid U Rahman, 'Statistics & Data Analysis for Engineers and Scientists', Springer, 2024, ISBN:9789819946600. 2. Jiju Antony, 'Design of Experiments for Engineers & Scientists', Elsevier, 2023, ISBN 978-044-315-1736 3. Douglas Montgomery, 'Design and Analysis of Experiments', Wiley India, Eighth Edition, 2013, 9788126540501 4. J. Ravichandran, Probability and Statistics for Engineers, Wiley India, 2010, ISBN: 9788126523504	

	5. R. Johnson, Probability and Statistics for engineers, Eighth Edition, Prentice Hall of India, New Delhi, 2015, ISBN 978-1-292-17601-7 6. J. Schmuller, Statistical Analysis with Excel for Dummies, 5th Edition, John Wiley & Sons, 2022.
Course Outcomes:	After taking this course, student will be able to: CO 1. Understand the importance of statistical methods for research CO 2. Select the appropriate factorial design method for a given set of experimental plans. CO 3. Apply basic probability theorems and draw relevant inferences. CO 4. Analyze suitable probability model for given set of data

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Name of the Programme : Master of Engineering (Geotechnical Engineering)
Course Code : REC-566
Title of the Course : Probability & Statistical Analysis Lab
Number of Credits : 2
Effective from AY : 2024-25

Pre-requisites for the Course:	Basic knowledge of Statistics and Probability	
Course Objectives:	The course will enable the students to 1. Apply basic probability theorems and draw relevant inferences. 2. Analyze suitable probability model for given set of data 3. Demonstrate factorial design methods 4. Synthesize fractional and full factorial experimental design data	
Content:		**No of Hours**
	Using open-source software like libreoffice or any proprietary software perform following experiments: 1. Obtain probability values involving discrete probability distributions - Bernoulli, Binomial. 2. Obtain probability values involving continuous probability distributions - Exponential and Normal distributions. 3. Obtain values of Normal, t-distribution, Chi-square and F-statistic. 4. Obtain values of Mean, Variance and distribution function of Bernoulli and Binomial distribution. 5. Obtain values of Mean, Variance and distribution function of Exponential and Normal distributions. 6. Obtain values of central tendency of grouped and ungrouped data. 7. Obtain values of dispersion of grouped and ungrouped data. 8. Analyse experimental output using full factorial design. 9. Analyse experimental output using fractional factorial design. 10. Analyse a full case study in involving full factorial design or fractional factorial design.	**60**
Pedagogy:	Inquiry based learning, Integrative, Reflective Learning, Constructive learning and Collaborative learning	
References/ Readings:	1. Tahvir Mustafy, Tauhid U Rahman, 'Statistics & Data Analysis for Engineers and Scientists', Springer, 2024, ISBN:9789819946600. 2. Jiju Antony, 'Design of Experiments for Engineers & Scientists', Elsevier, 2023, ISBN 978-044-315-1736 3. Douglas Montgomery, 'Design and Analysis of Experiments', Wiley India, Eighth Edition, 2013, 9788126540501 4. J. Ravichandran, Probability and Statistics for Engineers, Wiley India, 2010, ISBN: 9788126523504 5. R. Johnson, Probability and Statistics for engineers, Eighth Edition, Prentice Hall of India, New Delhi, 2015, ISBN 978-1-292-17601-7 6. J. Schmuller, Statistical Analysis with Excel for Dummies, 5th Edition,	

	John Wiley & Sons, 2022.
Course Outcomes:	After taking this course, student will be able to: CO 1. Apply basic probability theorems and draw relevant inferences. CO 2. Analyze suitable probability model for given set of data CO 3. Demonstrate factorial design methods CO 4. Synthesize fractional and full factorial experimental design data

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SEMESTER III

Programme Specific Core (PSC) Courses

Name of the Programme : Master of Engineering (Geotechnical Engineering)
Course Code : GTE-600
Title of the Course : Design of Foundations
Number of Credits : 3
Effective from AY : 2024-25

Pre-requisites for the Course:	Knowledge of Soil Mechanics and Foundation Engineering	
Course Objectives:	The course will enable the students to: 1. Understand the principles of structural design of shallow, deep foundations and retaining structures. 2. Analyse stability of shallow, deep foundations and retaining structures under various loading conditions. 3. Design footings, rafts, piles, wells and retaining structures for various loads and loading combinations 4. Formulate procedures for recommending suitable types of foundations and retaining structures.	
Content:		**No. of hours**
Unit - 1	Shallow Foundations: Limit state method of design of isolated footings, strip footing, combined footing, rigid and flexible mat, buoyancy raft, basement raft, Combined piled raft foundation.	**11**
Unit - 2	Pile Foundations: Estimation load carrying capacity of single and pile group under various loading conditions. Settlement of pile foundation, code provisions, design of single pile, pile groups and pile caps.	**11**
Unit - 3	Well Foundations: Types, components, construction methods, design methods (Terzaghi, IS and IRC approaches), check for stability, base pressure, side pressure and deflection.	**12**
Unit - 4	Retaining Walls: Analysis and design of flexible and rigid earth retention systems: counter fort, gravity, gabions, diaphragm walls, sheet pile walls, soldier piles and lagging. Support systems for flexible retaining walls (struts, anchoring), construction methods, stability calculations, design of flexible and rigid retaining walls, design of cantilever and anchored sheet pile walls.	**11**
Pedagogy:	Interactive learning, reflective thinking, critical analysis, and problem-solving.	
References/ Readings:	**<u>Text Books</u>** 1. Saran, S., "Analysis and Design of Sub-Structures – Limit State Design", CBS Publishers and Distributors, New Delhi, 2010, ISBN: 9788120417007.	

	2. Varghese, P. C., "Advanced Foundation Design", Prentice Hall India Learning Private Limited, New Delhi, 2009, ISBN: 9788120336155. **Reference Books** 3. Nayak, N. V., "Foundation Design Manual", 8th ed., Dhanpat Rai Publications, New Delhi, 2013, ISBN: 9789383182909. 4. Kurian, N. P., "Design of Foundation Systems: Principles and Practices", Narosa Publishing House, New Delhi, 2005, ISBN: 9788184877336. 5. Nilson, A. H., Darwin, D., and Dolan, C. W., "Design of Concrete Structures", 14th ed., McGraw-Hill Education, New York, 2009, ISBN: 9780073397948. 6. Indian Roads Congress (IRC) and Bureau of Indian Standards (BIS), Relevant Latest Codes and Standards, New Delhi, Latest editions..
Course Outcomes:	After going through this course, student will be able to: CO1. Apply the limit state method to design various shallow foundations such as isolated, combined, and mat footings, considering bearing capacity, settlement, and buoyancy effects CO2. Estimate load-carrying capacity and settlement of single piles and pile groups under axial and lateral loads, and design pile foundations and pile caps using IS code provisions CO3. Design footings, rafts , piles, wells, diaphragm walls for various loads and loading combinations CO4. Recommend suitable types of foundations and retaining structures.

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Name of the Programme: **: Master of Engineering (Geotechnical Engineering)**
Course Code: **: GTE-601**
Title of the Course: **: Geotechnical Engineering Lab - 5**
Number of Credits: **: 1**
Effective from AY: **: 2024-25**

Pre-requisites for the Course:	Knowledge of Soil Mechanics and Foundation Engineering	
Course Objectives:	The course will enable the students to: 1. Understand and Identify requirement of suitable type of foundation and retaining structure based on the actual site conditions. 2. Analyze the stability of foundations and retaining structures based on the site data, geotechnical properties and loading combinations. 3. Design the foundations and retaining structures based on the different loading combinations. 4. Formulate procedures for selecting appropriate foundations and retaining structures for given site conditions	
		No. of hours
Content:	Students shall create design spreadsheets for the following foundation systems (any five or more) by using MS-Excel, TK Solver or equivalent softwares : 1. Isolated Footings subjected to axial loads and biaxial moments 2. Combined Footings (rectangular or trapezoidal) 3. Raft Foundations (rigid and flexible types) 4. Pile Foundations 5. Pile Caps 6. Combined Piled Raft Foundations (CPRF) 7. Diaphragm Walls (design and stability under lateral earth pressure) 8. Well Foundations (including base pressure, side pressure, and stability checks) 9. Rigid Retaining Walls (any two types such as gravity, counterfort, or cantilever) 10. Flexible Retaining Walls (any two types such as sheet pile, anchored, or diaphragm walls)	**30**
Pedagogy:	Instructional learning, Inquiry based learning, Constructive learning, Collaborative learning and problem solving.	
References/ Readings:	**Text Books** 1. Saran, S., "Analysis and Design of Sub-Structures – Limit State Design", CBS Publishers and Distributors, New Delhi, 2010, ISBN: 9788120417007. 2. Varghese, P. C., "Advanced Foundation Design", Prentice Hall India Learning Private Limited, New Delhi, 2009, ISBN: 9788120336155. **Reference Books**	

	3. Nayak, N. V., "Foundation Design Manual", 8th ed., Dhanpat Rai Publications, New Delhi, 2013, ISBN: 9789383182909. 4. Kurian, N. P., "Design of Foundation Systems: Principles and Practices", Narosa Publishing House, New Delhi, 2005, ISBN: 9788184877336. 5. Nilson, A. H., Darwin, D., and Dolan, C. W., "Design of Concrete Structures", 14th ed., McGraw-Hill Education, New York, 2009, ISBN: 9780073397948. 6. Indian Roads Congress (IRC) and Bureau of Indian Standards (BIS), Relevant Latest Codes and Standards, New Delhi, Latest editions..
Course Outcomes:	After going through this course, student will be able to: CO1. Translate geotechnical design problems into spreadsheet models CO2. Apply code-based design principles using automated tools. CO3. Perform iterative and parametric analysis for optimized design. CO4. Validate and cross-check manual design results with software-aided computation.

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Name of the Programme : **Master of Engineering (Geotechnical Engineering)**
Course Code : **GTE-602**
Title of the Course : **Reinforced Earth and Geosynthetics**
Number of Credits : **3**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Knowledge of Soil Mechanics and Foundation Engineering	
Course Objectives:	The course will enable the students to: 1. Understand and Identify Geosynthetics based on their physical and strength properties and function. 2. Analyze the stability of slopes using geosynthetics. 3. Design retaining structures, walls and foundations using geosynthetics. 4. Formulate procedures for geosynthetic applications in civil engineering structures.	
Content:		**No. of hours**
Unit - 1	Introduction: Historical background of reinforced earth, Principles of reinforced soil through Mohr circle analysis, Materials and Failure modes. Different Types of Geosynthetics: Types of geosynthetics, Geotextiles, Geogrids, Geonets, Geocells, Geo-composites, Geojute and their manufacturing methods. Functions of geosynthetics, Properties; Physical, Chemical, Mechanical, Hydraulic. Testing Methods for Geosynthetics: Techniques for testing of different index properties, Strength properties, Apparent opening size, In-plane and Cross-plane permeability tests, Assessment of construction induced damage, Extrapolation of long term strength properties from short term tests. Manufacturing of geosynthetics, Functions, Properties.	**11**
Unit - 2	Reinforced Soil Retaining Walls: Different types of walls; Wrap-around walls, Full-height panel walls, Discrete-facing panel walls, and Modular block walls. Design methods as per BS-8006 and FHWA methods Construction methods for reinforced soil retaining walls, Design of reinforced soil walls and Design of Gabion wall. Reinforced Soil Slopes: Basal reinforcement for construction on soft clay soils, Construction of steep slopes with reinforcement layers on soils, Different slope stability analysis methods; Planar wedge method, Bi-linear wedge method, Circular slip methods. Erosion control on slopes using geosynthetics. Soil nailing techniques, Geosynthetic reinforced soil embankments.	**13**
Unit - 3	Applications in Foundations: Binquet and Lee's approach for analysis of foundations with reinforcement layers. Improvement of bearing capacity using reinforcements.	**11**

	Drainage and Filtration Applications of Geosynthetics: Different filtration requirements, Filtration in different types of soils and Criteria for selection of geotextiles. Estimation of flow of water in retaining walls, Pavements, Drains, Designing and Selection of geosynthetics for drainage and Filtration.	
Unit - 4	Applications in Roads and Railways: Geosynthetics for separation and Reinforcement in flexible pavements, Design by Giroud-Noiray approach, Reflection cracking and Control using geosynthetics. Use of geosynthetics for construction of heavy container yards and Railway lines. Applications in Landfills: Construction of Landfills using Geosynthetics: Different components of modern landfills, Collection techniques for leachate, Application of different geosynthetics like geonets, Geotextiles for drainage in landfills, Use of geomembranes and Geosynthetic Clay Liner (GCL) as barriers, EPA guidelines.	**10**
Pedagogy:	Interactive learning, reflective thinking, critical analysis, and problem-solving.	
References/ Readings:	**Text books** 1. Koerner, R. M., Designing with Geosynthetics, 5th ed., Prentice Hall, New Jersey, USA, 2005, ISBN-13: 978-0131454156 2. Saran, S., Reinforced Soil and Its Engineering Applications, 3rd ed., I.K. International Publishing House Pvt. Ltd., New Delhi, 2017, ISBN-13: 978-9385909726. **Reference Books** 3. Sivakumar Babu, G. L., An Introduction to Soil Reinforcement and Geosynthetics, Universities Press, Hyderabad, 2006, ISBN-13: 978-8173714818 4. Rao, G. V., Banerjee, P. K., Shahu, J. T., and Ramana, G. V. (Eds.), Geosynthetics: New Horizons, Asian Books Private Ltd., New Delhi, 2006, ISBN-13: 978-8188237272 5. Federal Highway Administration (FHWA), Design Guidelines and Manuals on Geosynthetics Applications, U.S. Department of Transportation, latest edition. Standards: (i) ASTM D4595 – Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method. (ii) ASTM D6638 – Standard Test Method for Determining Connection Strength between Geosynthetic Reinforcement and Segmental Concrete Units (Modular Concrete Block Retaining Wall Units). (iii) ASTM D4354 – Sampling of Geosynthetics and Rolled Erosion Control Products (RECPs) for Testing (iv) ASTM D6637 – Standard Test Method for Determining Tensile Properties of Geogrids by the Single or Multi-Rib Tensile Method (v) ASTM D6706 – Standard Test Method for Measuring Geosynthetic Pullout Resistance in Soil	

Course Outcomes:	**After going through this course, student will be able to:** CO1. Explain the principles of reinforced soil behavior using Mohr circle analysis and identify modes of failure in reinforced soil systems CO2. Classify different types of geosynthetics, explain their functions and properties, and interpret results from standard testing methods. CO3. Apply geosynthetics in real-world engineering problems such as drainage, filtration, pavement design, railway embankments, and landfill construction in accordance with industry standards CO4. Analyze and design reinforced soil retaining walls and slopes.

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Name of the Programme : **Master of Engineering (Geotechnical Engineering)**
Course Code : **GTE-603**
Title of the Course : **Geotechnical Engineering Lab - 6**
Number of Credits : **01**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Knowledge of Soil Mechanics and Foundation Engineering	
Course Objectives:	The course will enable the students to: 1. Familiarize with the physical and mechanical properties of various geosynthetics, including geotextiles, geogrids, and geomembranes. 2. Conduct standard laboratory tests such as tensile strength, permeability, and puncture resistance on geosynthetic materials. 3. Analyze and interpret test results to evaluate the suitability of geosynthetics for different engineering applications. 4. Formulate procedures for geosynthetic applications in civil engineering structures.	
Content:		**No. of hours**
	List of experiments: 1. Determination of Physical properties like Mass per unit area, thickness, specific gravity, function of Geotextiles 2. Determination of Physical properties like Mass per unit area, thickness, specific gravity, function of Geogrids 3. Determination of Physical properties like Mass per unit area, thickness, specific gravity, function of Geomembranes 4. Determination of Tensile Strength of Properties: Determination of Grab, trapezoidal tear and wide width tensile strengths of geotextiles, Tensile strength of Geogrids and Geomembranes 5. Determination of Permeability Properties: Determination of in plane and cross plane permeability of geotextiles. 6. Determination of Puncture Resistance of geotextiles. 7. Design of a RE wall 8. Design of a subgrade system with geosynthetics 9. Design of a landfill with geosynthetics liner 10. Design of a PVD system	**30**
Pedagogy:	Instructional learning, Inquiry based learning, Constructive learning, Collaborative learning and problem solving.	
References/ Readings:	**<u>Text books</u>** 1. Koerner, R. M., Designing with Geosynthetics, 5th ed., Prentice Hall, New Jersey, USA, 2005, ISBN-13: 978-0131454156 2. Saran, S., Reinforced Soil and Its Engineering Applications, 3rd ed., I.K. International Publishing House Pvt. Ltd., New Delhi, 2017, ISBN-13: 978-9385909726. **<u>Reference Books</u>** 3. Sivakumar Babu, G. L., An Introduction to Soil Reinforcement and	

	Geosynthetics, Universities Press, Hyderabad, 2006, ISBN-13: 978-8173714818 4. Rao, G. V., Banerjee, P. K., Shahu, J. T., and Ramana, G. V. (Eds.), Geosynthetics: New Horizons, Asian Books Private Ltd., New Delhi, 2006, ISBN-13: 978-8188237272 5. Federal Highway Administration (FHWA), Design Guidelines and Manuals on Geosynthetics Applications, U.S. Department of Transportation, latest edition. Standards: (i) ASTM D4595 – Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method. (ii) ASTM D6638 – Standard Test Method for Determining Connection Strength between Geosynthetic Reinforcement and Segmental Concrete Units (Modular Concrete Block Retaining Wall Units). (iii) ASTM D4354 – Sampling of Geosynthetics and Rolled Erosion Control Products (RECPs) for Testing (iv) ASTM D6637 – Standard Test Method for Determining Tensile Properties of Geogrids by the Single or Multi-Rib Tensile Method (v) ASTM D6706 – Standard Test Method for Measuring Geosynthetic Pullout Resistance in Soil
Course Outcomes:	After going through this course, student will be able to: CO1. Demonstrate the ability to measure and evaluate physical properties like mass per unit area, thickness, and specific gravity of geosynthetics. CO2. Perform tensile strength and puncture resistance tests on geotextiles, geogrids, and geomembranes according to standard procedures CO3. Assess permeability characteristics of geotextiles and interpret their implications for filtration and drainage applications. CO4. Interpret laboratory test data to determine the suitability of geosynthetics for reinforced soil and environmental engineering applications.

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Programme Specific Elective (PSE) Courses

Name of the Programme : Master of Engineering (Geotechnical Engineering)
Course Code : GTE-631
Title of the Course : Geotechnical Earthquake Engineering
Number of Credits : 3
Effective from AY : 2024-25

Pre-requisites for the Course:	Knowledge of Soil Mechanics, Foundation Engineering and Soil dynamics	
Course Objectives:	The course will enable the students to: 1. Understand basics of earthquake seismology and ground motion characteristics relevant to geotechnical engineering causes and effects of earthquakes 2. Perform seismic hazard assessment and ground response analysis using analytical and computational tools. 3. Assess whether site is safe against liquefaction. 4. Design foundations and retaining structures to resist earthquakes as per different seismic zones.	
Content:		**No. of hours**
Unit - 1	Earthquake seismology – Causes of earthquake, Plate tectonics, Earthquake fault sources, Seismic waves, Elastic rebound theory, Quantification of earthquake, Intensity and magnitudes, Earthquake source models. Earthquake ground motion – Seismograph, Characteristics of ground motion, Introduction to seismic hazard analysis – DSHA, PSHA, Effect of local site conditions on ground motions, Design earthquake, Design spectra, Development of site specification and code-based design.	**11**
Unit - 2	Ground response analysis – One-dimensional ground response analysis: Linear approaches, Equivalent linear approximation of non-linear approaches, Computer code "SHAKE".	**11**
Unit - 3	Liquefaction and lateral spreading –Liquefaction related, phenomena, Liquefaction susceptibility: Historical, Geological, Compositional and State criteria. Evaluation of liquefaction by cyclic stress and cyclic strain approaches, Lateral deformation and spreading, Criteria for mapping liquefaction hazard zones.	**11**
Unit - 4	Seismic design of foundations, Seismic slope stability analysis: Internal stability and weakening instability and Seismic design of retaining walls.	**12**
Pedagogy:	Interactive learning, reflective thinking, critical analysis, and problem-solving.	
References/ Readings:	**<u>Text Books</u>** 1. Kramer, S., *"Geotechnical Earthquake Engineering"*, 1st Edition, Pearson, New Jersey, USA, 1996, ISBN-13: 978-0133749434. 2. Towhata, I., *"Geotechnical Earthquake Engineering"*, Springer Series in	

	Geomechanics and Geoengineering, Springer, Tokyo, Japan, 2008., ISBN-13: 978-4431700765 **Reference Books** 3. Seco e Pinto, P. (Ed.), *"Seismic Behaviour of Ground and Geotechnical Structures: Special Volume of TC 4"*, CRC Press, Leiden, Netherlands, 1997, ISBN-13: 978-9054108870 2 4. Naeim, F., *"The Seismic Design Handbook"*, Kluwer Academic Publishers, Boston, USA, 1999, ISBN-13: 978-0792391694 5. Ferrito, J. M**.,** *"Seismic Design Criteria for Soil Liquefaction"*, Technical Report, Naval Facilities Engineering Service Center, Port Hueneme, USA, 1994. 6. Day, R. W., *"Geotechnical Earthquake Engineering Handbook"*, 2nd Edition, McGraw-Hill Education, New York, USA, 2012, ISBN-13: 978-0071792387
Course Outcomes:	After going through this course, student will be able to: CO1. Explain the causes and mechanics of earthquakes, including faulting, seismic waves, and quantification through magnitude and intensity scales. CO2. Analyze earthquake ground motions and perform seismic hazard analysis and ground response analysis. CO3. Evaluate liquefaction potential and lateral spreading using cyclic stress and strain approaches and apply these methods to hazard mapping CO4. Design geotechnical elements such as foundations, slopes, and retaining walls to ensure seismic stability and performance under earthquake loading

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Name of the Programme : **Master of Engineering (Geotechnical Engineering)**
Course Code : **GTE-632**
Title of the Course : **Geotechnical Earthquake Engineering Lab**
Number of Credits : **1**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Knowledge of Soil Mechanics, Foundation Engineering and Soil dynamics	
Course Objectives:	**The course will enable the students to:** 1. Familiarize students with experimental methods for evaluating dynamic soil properties and seismic site response. 2. Analyse seismic data analysis and interpretate ground motion parameters 3. Perform field and laboratory tests for liquefaction assessment and dynamic characterization of soils. 4. Perform structural and geotechnical assessment by using professional tools and simulation software.	
Content:		**No. of hours**
	List of Experiments 1. Resonant Column Test – Determination of shear modulus and damping ratio. 2. Cyclic Triaxial Test – Plotting stress–strain curves for soil under cyclic loading. 3. Shake Table Test – Model study to simulate seismic effects. 4. Bender Element Test – Measurement of shear wave velocity in soil specimens. 5. Seismic Refraction or MASW Test – Determination of shear wave velocity profile of ground. 6. Cyclic Simple Shear Test – Evaluation of liquefaction resistance of soils. 7. Historical Earthquake Data Analysis – Collect data for 5 significant earthquakes and plot acceleration, velocity, and displacement time histories. 8. Recent Earthquake Data Analysis – Collect and plot time histories of 5 recent earthquakes. 9. Ground Motion Parameter Analysis – Determine amplitude, frequency, and duration from earthquake records using Soil DynmSeismosoft or equivalent software. 10. Ground Response Analysis – Perform site-specific response analysis using DEEPSOIL/SHAKE or equivalent software. 11. Liquefaction Analysis – Determine liquefaction potential and identify hazard zones for a typical site. 12. Ground Response Modeling – Model ground response using MIDAS GTS or equivalent geotechnical software. 13. Seismic Structural Analysis – Analyze a building frame under	**30**

	seismic loads using ETABS/STAAD.Pro or equivalent.	
Pedagogy:	Instructional learning, Inquiry based learning, Constructive learning, Collaborative learning and problem solving	
References/ Readings:	**Text Books** 1. Kramer, S., *"Geotechnical Earthquake Engineering"*, 1st Edition, Pearson, New Jersey, USA, 1996, ISBN-13: 978-0133749434. 2. Towhata, I., *"Geotechnical Earthquake Engineering"*, Springer Series in Geomechanics and Geoengineering, Springer, Tokyo, Japan, 2008., ISBN-13: 978-4431700765 **Reference Books** 3. Seco e Pinto, P. (Ed.), *"Seismic Behaviour of Ground and Geotechnical Structures: Special Volume of TC 4"*, CRC Press, Leiden, Netherlands, 1997, ISBN-13: 978-9054108870 2 4. Naeim, F., *"The Seismic Design Handbook"*, Kluwer Academic Publishers, Boston, USA, 1999, ISBN-13: 978-0792391694 5. Ferrito, J. M**.,** *"Seismic Design Criteria for Soil Liquefaction"*, Technical Report, Naval Facilities Engineering Service Center, Port Hueneme, USA, 1994. 6. Day, R. W., *"Geotechnical Earthquake Engineering Handbook"*, 2nd Edition, McGraw-Hill Education, New York, USA, 2012, ISBN-13: 978-0071792387.	
Course Outcomes:	After going through this course, student will be able to: CO1 Perform laboratory and field tests to determine dynamic properties of soils such as shear modulus, damping ratio, and wave velocities CO2 Collect, interpret, and visualize seismic data (time histories) from past and recent earthquakes for ground motion analysis. CO3 Conduct liquefaction hazard assessments and ground response analyses using tools like SHAKE, DEEPSOIL, or MIDAS GTS. CO4 Analyze the seismic response of geotechnical and structural systems using advanced software such as Seismosoft, ETABS, or STAAD.Pro.	

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Name of the Programme : **Master of Engineering (Geotechnical Engineering)**
Course Code : **GTE-633**
Title of the Course : **Advanced Methods of Analysis**
Number of Credits : **03**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Knowledge of Soil Mechanics and Foundation Engineering	
Course Objectives:	The course will enable the students to: 1. Understand advanced soil behavior under various stress conditions using constitutive and critical state models. 2. Apply modern analysis techniques, including numerical and probabilistic methods, to slope stability and foundation systems. 3. Evaluate soil–structure interaction problems such as retaining structures and ground improvement systems using FEM/FDM. 4. Develop the ability to use geotechnical software for parametric analysis, design verification, and advanced modeling.	
Content:		**No. of hours**
Unit - 1	**Fundamentals of Soil Behavior and Analysis Methods:** Stress–strain behavior of soils: isotropic and anisotropic conditions; Elasticity and plasticity theory applied to soils, Critical state soil mechanics concepts; Constitutive models for soils: Mohr–Coulomb, Drucker–Prager, Cam–Clay **Advanced Slope Stability Analysis:** Limit equilibrium methods and their limitations; Stress–deformation approach; Finite element/finite difference analysis for slope stability; Shear strength reduction method; Probabilistic slope stability and risk assessment	**11**
Unit - 2	**Earth Pressure and Retaining Structures:** Advanced methods of earth pressure computation ; Seismic earth pressure theories (Mononobe–Okabe, Wood's Method); Numerical modeling of retaining walls using FEM; Soil–structure interaction effects	**11**
Unit - 3	**Ground Improvement and Reinforcement Analysis:** Analytical modeling of reinforced soil systems;Design and analysis of geosynthetic-reinforced walls and slopes; Ground improvement modeling: stone columns, preloading, vertical drains; Modeling soil improvement in soft ground **Numerical Modeling in Geotechnical Engineering:** Introduction to finite element method (FEM) and finite difference method (FDM); Discretization, boundary conditions, mesh generation; Use of software; Parametric studies	**12**
Unit - 4	**Pile and Shallow Foundation Analysis:** Load–settlement behavior of deep foundations; Axial and lateral load analysis using p–y and t–z curves; Group effect and pile–soil–pile interaction; 2D/3D FEM modeling of shallow and deep foundations	**11**

Pedagogy:	Interactive learning, reflective thinking, critical analysis, and problem-solving.
References/ Readings:	**Reference Books** 1. Budhu, M., "Soil Mechanics and Foundations", 4th edition, John Wiley & Sons, New York, 2021, ISBN-13: 978-1119693871. 2. Chen, W. F., and Saleeb, A. F., "Constitutive Equations for Engineering Materials", 1st edition, Elsevier, Amsterdam, 1994, ISBN-13: 978-0444896844. 3. Griffiths, D. V., and Lane, P. A., "Slope Stability Analysis by the Finite Element Method", 1st edition, Thomas Telford, London, 1999, ISBN-13: 978-0727727831. 4. Haldar, A., and Mahadevan, S., "Probability, Reliability, and Statistical Methods in Engineering Design", 1st edition, John Wiley & Sons, New York, 2000, ISBN-13: 978-0471331216. 5. Kramer, S. L., "Geotechnical Earthquake Engineering", 1st edition, Prentice Hall, Upper Saddle River, 1996, ISBN-13: 978-0133749432. 6. Phoon, K. K. (Ed.), "Reliability-Based Design in Geotechnical Engineering: Computations and Applications", 1st edition, Taylor & Francis, London, 2008, ISBN-13: 978-0415418706. 7. Potts, D. M., and Zdravkovic, L., "Finite Element Analysis in Geotechnical Engineering: Theory and Application", 1st edition, Thomas Telford, London, 1999, ISBN-13: 978-0727727831. 8. Smith, I. M., and Griffiths, D. V., "Programming the Finite Element Method", 5th edition, John Wiley & Sons, Chichester, 2013, ISBN-13: 978-0470673362.
Course Outcomes:	After going through this course, student will be able to: CO1. Explain the stress–strain behavior of soils using elasticity, plasticity, and critical state frameworks. CO2. Perform advanced slope stability and retaining wall analyses using both traditional and numerical methods. CO3. Analyze reinforced soil systems and ground improvement techniques with appropriate modeling approaches. CO4. Model and interpret complex geotechnical systems (e.g., foundations, walls, slopes) using FEM/FDM-based tools.

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Name of the Programme : **Master of Engineering (Geotechnical Engineering)**
Course Code : **GTE-634**
Title of the Course : **Advanced Methods of Analysis Lab**
Number of Credits : **01**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Knowledge of Soil Mechanics and Foundation Engineering	
Course Objectives:	The course will enable the students to: 1. Understand and analyze the stress–strain behavior of soils under various conditions and apply constitutive soil models such as Mohr–Coulomb, Drucker–Prager, and Cam–Clay. 2. Develop proficiency in slope stability analysis using limit equilibrium and numerical methods, including probabilistic approaches and risk assessment. 3. Analyze earth pressure problems and design retaining and reinforced soil structures using advanced computational tools and soil–structure interaction concepts. 4. Perform numerical modeling of geotechnical problems, including foundation behavior and ground improvement techniques using finite element and finite difference methods.	
		No. of hours
Content:	**<u>List of experiments</u>** 1. Determination of bearing capacity of footing including evaluation of bearing capacity factors of footing with different shapes and comparison with analytical solutions. 2. FE modeling of triaxial test with different constitutive models. 3. Evaluation of stability of slope using LEM based different methods and FEM based c - ϕ reduction method. 4. Determination of capacity of single pile, separation of end bearing and side friction of pile, and concept of pile-raft foundation. 5. FE Analysis of deep excavation using sheet pile wall and diaphragm wall with and without anchors, evaluation of ground deformation and wall deformations. 6. Stage construction of embankments and application of PVD drains. 7. Modeling of underground structures, retaining wall and reinforced earth wall using FEM and LEM based tools. 8. The construction of flow nets in earthen structure using FEM and graphical methods. 9. Modeling and analysis of typical soil structure interaction problems using software tools. 10. Modeling and analysis of typical dynamic soil structure interaction problems using software tools	**30**

Pedagogy:	Instructional learning, Inquiry based learning, Constructive learning, Collaborative learning and problem solving
References/ Readings:	**Reference Books** 1. Budhu, M., "Soil Mechanics and Foundations", 4th edition, John Wiley & Sons, New York, 2021, ISBN-13: 978-1119693871. 2. Chen, W. F., and Saleeb, A. F., "Constitutive Equations for Engineering Materials", 1st edition, Elsevier, Amsterdam, 1994, ISBN-13: 978-0444896844. 3. Griffiths, D. V., and Lane, P. A., "Slope Stability Analysis by the Finite Element Method", 1st edition, Thomas Telford, London, 1999, ISBN-13: 978-0727727831. 4. Haldar, A., and Mahadevan, S., "Probability, Reliability, and Statistical Methods in Engineering Design", 1st edition, John Wiley & Sons, New York, 2000, ISBN-13: 978-0471331216. 5. Kramer, S. L., "Geotechnical Earthquake Engineering", 1st edition, Prentice Hall, Upper Saddle River, 1996, ISBN-13: 978-0133749432. 6. Phoon, K. K. (Ed.), "Reliability-Based Design in Geotechnical Engineering: Computations and Applications", 1st edition, Taylor & Francis, London, 2008, ISBN-13: 978-0415418706. 7. Potts, D. M., and Zdravkovic, L., "Finite Element Analysis in Geotechnical Engineering: Theory and Application", 1st edition, Thomas Telford, London, 1999, ISBN-13: 978-0727727831. 8. Smith, I. M., and Griffiths, D. V., "Programming the Finite Element Method", 5th edition, John Wiley & Sons, Chichester, 2013, ISBN-13: 978-0470673362.
Course Outcomes:	After going through this course, student will be able to: CO1. Explain the fundamental soil behavior and constitutive models and apply them to analyze soil response under different loading conditions. CO2. Evaluate slope stability using both limit equilibrium methods and finite element strength reduction techniques, including probabilistic assessment. CO3. Analyze and design earth retaining systems and reinforced soil structures by considering soil-structure interaction and dynamic effects CO4. Create and interpret numerical models for foundation systems, ground improvement methods, and soil-structure interaction problems using industry-standard software.

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Research Specific Elective (RSE) Courses

Name of the Programme : Master of Engineering (Geotechnical Engineering)
Course Code : GTE-661
Title of the Course : Forensic Geotechnical Engineering
Number of Credits : 03
Effective from AY : 2024-25

Pre-requisites for the Course:	Knowledge of Soil Mechanics and Foundation Engineering	
Course Objectives:	The course will enable the students to: 1. Understand the causes and mechanisms of historical and modern geotechnical failures. 2. Apply methodology for conducting technical forensic investigations. 3. Explore legal, technical, and diagnostic aspects of geotechnical failure cases. 4. Analyze real-world case studies and draw lessons for improved design and construction practices.	
Content:		**No. of hours**
Unit - 1	Introduction: Historical failures of geotechnical structures such as finite and infinite slopes, high embankments such as earthen dams, tunnels, excavations/cuts, shallow and deep foundations, retaining structures, etc., characterization of failures, inadequacies in design, principles and advantages of Mobilized strength design. Technical forensic investigation: Collection of data, problem characterization, development of failure hypotheses, a realistic back analysis, field observations and performance monitoring, modelling of failure hypothesis and quality control of formal and technical aspects of the work.	**11**
Unit - 2	Guidelines for forensic investigation: types of distress, diagnostic tests, field and laboratory tests, analysis, legal issues such as facts, interpretations, opinions, negligence. Technical issues related to geotechnical failures: Primary shortcomings causing failures, shortcomings in design, inadequate site investigations, unforeseen occurrences and phenomena, shortcomings in construction; recommendations to limit future occurrence of failures.	**11**
Unit - 3	Case studies: Study of historic monuments, destruction due to environmental changes and survival of monuments, tall structure foundations, pre-historic caves in India etc., study of recent failures, consideration of geotechnical aspects such as settlement, shear strength, permeability, slope stability, etc., in construction of survived historic monuments as well as for the structures which have collapsed due to new adjacent constructions or disturbances due to human activities etc.	**12**

Unit - 4	Geotechnical engineering and legal system: Legal conflict of geotechnical failures, sanctions in the legal code of construction, geotechnical work for documentation of forensic cases; case studies of legal conflict of prominent structures such as landslides, deep excavations, unexpected settlements of oil tanks, distress in soil walls, failure due to slow creep of hills etc.	**11**
Pedagogy:	Interactive learning, reflective thinking, critical analysis, and problem-solving.	
References/ Readings:	**Text Books** 1. Rao, V. V. S. and Sivakumar Babu, G. L., "Forensic Geotechnical Engineering", 1st ed., Springer India, New Delhi, 2015, ISBN: 978-8132223764. 2. Day, R. W., "Forensic Geotechnical and Foundation Engineering", 2nd ed., McGraw Hill Education, New York, 2011, ISBN: 978-0071761338. **Reference Books** 3. Annamma, J., "Advanced Technology in Forensic Investigation – A Handbook with Case Studies", 1st ed., Cosmobooks, Kerala, 2013, ISBN: 978-9380538311. 4. Baldeva, S. and Agarwal, D., "Forensic Investigations and Fraud Reporting in India: Practical Insights to Predict, Prevent, Detect and Investigate Frauds", 1st ed., Bloomsbury Professional India, New Delhi, 2023, ISBN: 978-9356405950 5. Shen, E. C., Janardhanan, R., Natarajan, C. and Schmidt, R., "Indo-US Forensic Practices: Investigation Techniques and Technology", 1st ed., American Society of Civil Engineers, Reston, VA, 2006, ISBN: 978-0784408359.	
Course Outcomes:	After going through this course, student will be able to: CO1. Identify and categorize different types of geotechnical failures and understand their underlying mechanisms. CO2. Conduct a systematic forensic investigation including data collection, hypothesis development, and back analysis. CO3. Evaluate the role of design, site investigation, and construction practices in the occurrence of failures. CO4. Analyze legal aspects of geotechnical failures and prepare case documentation suitable for legal and engineering forums.	

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Name of the Programme : **Master of Engineering (Geotechnical Engineering)**
Course Code : **GTE-662**
Title of the Course : **Forensic Geotechnical Engineering Lab**
Number of Credits : **01**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Knowledge of Soil Mechanics and Foundation Engineering	
Course Objectives:	The course will enable the students to: 1. Understand the mechanisms and root causes of geotechnical failures through historical and contemporary case studies. 2. Learn and apply the methodology for technical forensic investigation, including data collection, analysis, and hypothesis development. 3. Identify and evaluate inadequacies in site investigation, design, and construction that lead to failure. 4. Analyze and report geotechnical failures with reference to technical and legal documentation requirements, and propose effective remedial measures.	
Content:		**No. of hours**
	Student shall complete experiments from the list below and submit detailed report which shall include the construction aspects, type of failure, site and soil investigations done before construction and after failure including field tests, instrumentation for monitoring, if any, drainage conditions, causes of failure and remedial measures, cost comparison, etc. 1. Foundation failure - structural 2. Settlement of structures, lateral movement, backfill settlements 3. Failure of structures in soils such as collapsible soil/ expansive soil/soluble soils, etc. 4. Slope Failures and landslides, debris flow, erosion failures, etc. 5. Collapse of trenches/excavation supports 6. Failures of retaining structures - soil reinforcement and geosynthetics.	**30**
Pedagogy:	Instructional learning, Inquiry based learning, Constructive learning, Collaborative learning and problem solving.	
References/ Readings:	**<u>Text Books</u>** 1. Rao, V. V. S. and Sivakumar Babu, G. L., "Forensic Geotechnical Engineering", 1st ed., Springer India, New Delhi, 2015, ISBN: 978-8132223764. 2. Day, R. W., "Forensic Geotechnical and Foundation Engineering", 2nd ed., McGraw Hill Education, New York, 2011, ISBN: 978-0071761338. **<u>Reference Books</u>** 3. Annamma, J., "Advanced Technology in Forensic Investigation – A	

	Handbook with Case Studies", 1st ed., Cosmobooks, Kerala, 2013, ISBN: 978-9380538311. 4. Baldeva, S. and Agarwal, D., "Forensic Investigations and Fraud Reporting in India: Practical Insights to Predict, Prevent, Detect and Investigate Frauds", 1st ed., Bloomsbury Professional India, New Delhi, 2023, ISBN: 978-9356405950. 5. Shen, E. C., Janardhanan, R., Natarajan, C. and Schmidt, R., "Indo-US Forensic Practices: Investigation Techniques and Technology", 1st ed., American Society of Civil Engineers, Reston, VA, 2006, ISBN: 978-0784408359.
Course Outcomes:	After going through this course, student will be able to: CO1. Identify and classify different types of geotechnical failures and their causes. CO2. Conduct technical forensic investigations and perform realistic back-analysis of failed geotechnical structures. CO3. Critically evaluate shortcomings in design, construction, and site investigation through failure case studies. CO4. Develop and present a comprehensive forensic report, including technical, legal, and economic aspects.

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Name of the Programme : **Master of Engineering (Geotechnical Engineering)**
Course Code : **GTE-663**
Title of the Course : **Probabilistic Methods in Geotechnical Engineering**
Number of Credits : **03**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Knowledge of Soil Mechanics and Foundation Engineering	
Course Objectives:	The course will enable the students to: 1. Understand the concepts of probability and statistical analysis methods 2. Identify and quantify the uncertainties in soil and rock properties 3. Analyze the stability of geotechnical structures considering uncertainties in soil and rock properties. 4. Design foundations, slopes, and other geotechnical structures, considering uncertainties in soil properties and loads.	
Content:		**No. of hours**
Unit - 1	Probability Theory: Fundamentals of probability, set theory, axioms of probability, conditional probability, Bayes' theorem, and different probability distributions commonly used in geotechnical engineering. Statistical Analysis: Data collection and analysis, sampling techniques, hypothesis testing, goodness-of-fit tests, and regression analysis as applied in geotechnical engineering	**11**
Unit - 2	Uncertainty Quantification: Identifying and quantifying uncertainties in soil properties, loads, and other parameters relevant to geotechnical engineering. Reliability Analysis: Methods for assessing the reliability of geotechnical structures and systems, including first-order reliability methods (FORM), second-order reliability methods (SORM), and Monte Carlo simulations.	**11**
Unit - 3	Risk Assessment: Evaluating the potential risks associated with geotechnical projects and developing strategies for mitigation. Probabilistic Models in Geotechnical Design: Applying probabilistic methods to design foundations, slopes, and other geotechnical structures, considering uncertainties in soil properties and loads.	**12**
Unit - 4	Software Tools: Hands-on experience with statistical software and programming languages (e.g., R) for performing probabilistic analysis. Case Studies: Real-world examples and case studies of how probabilistic methods are used in geotechnical engineering practice.	**11**

Pedagogy:	Interactive learning, reflective thinking, critical analysis, and problem-solving.
References/ Readings:	**Text Books** 1. Haldar, A. and Mahadevan, S., "Probability, Reliability, and Statistical Methods in Engineering Design", John Wiley and Sons, 1999, ISBN-13:978-0471331193. 2. Baecher, G. and Christian, J., "Reliability and Statistics in Geotechnical Engineering", John Wiely and Sons, Inc.,2005, ISBN:978-0470-87125-6. **Reference Books** 3. Hua-Sing Ang, A. and Tang, W.H., "Probability Concepts in Engineering Planning and Design: Basic Principles", Vol. I, John Wiely and Sons, Inc.,1975, ISBN-13:978-0471032007. 4. Melchers, R. E. and Beck, A. C., "Structural Reliability Analysis and Prediction", 3rd Edition, John Wiley and Sons, 2017, ISBN-13:978-1119265993. 5. 5. Erik, V., "Random Fields: Analysis and Synthesis", The MIT Press, Cambridge, Massachusetts, 2010, ISBN-13:978-9812563538.
Course Outcomes:	After going through this course, student will be able to: CO1. Understand and apply fundamental concepts of probability, statistics, and distributions to solve geotechnical engineering problems. CO2. Analyze uncertainty in soil parameters and loading conditions using statistical and probabilistic tools. CO3. Evaluate the reliability and risk of geotechnical systems using methods such as FORM, SORM, and Monte Carlo simulation. CO4. Apply probabilistic models in the design of geotechnical structures and use software tools for data-driven decision-making.

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Name of the Programme : **Master of Engineering (Geotechnical Engineering)**
Course Code : **GTE-664**
Title of the Course : **Probabilistic Methods in Geotechnical Engineering Lab**
Number of Credits : **01**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Knowledge of Soil Mechanics and Foundation Engineering	
Course Objectives:	The course will enable the students to: 1. Understand the concepts of probability and statistical analysis methods 1. Identify and quantify the uncertainties in soil and rock properties 2. Analyze the stability of geotechnical structures considering uncertainties in soil and rock properties. 3. Design foundations, slopes, and other geotechnical structures, considering uncertainties in soil properties and loads.	
Content:		**No. of hours**
	Student shall complete at least five assignments on applications of probabilistic methods from the list given below: 1. Slope stability analysis considering soil strength and pore pressure 1. Settlement of foundations under probabilistic loads and soil conditions. 2. Designing foundations that can accommodate the variability of soil properties and loading conditions 3. Analyzing stability of retaining walls 4. Analyzing stability of embankments 5. Analyzing stability of tunnels in soils and rock considering uncertainty in soil and rock properties 6. Analyzing stability of tunnels in soils and rock considering uncertainty in soil and rock properties 7. Analyzing stability of underground excavations considering uncertainty in soil and rock properties	**30**
Pedagogy:	Instructional learning, Inquiry based learning, Constructive learning, Collaborative learning and problem solving.	
References/ Readings:	**<u>Text Books</u>** 1. Haldar, A. and Mahadevan, S., "Probability, Reliability, and Statistical Methods in Engineering Design", John Wiley and Sons, 1999, ISBN-13:978-0471331193. 2. Baecher, G. and Christian, J., "Reliability and Statistics in Geotechnical Engineering", John Wiely and Sons, Inc.,2005, ISBN:978-0470-87125-6. **<u>Reference Books</u>** 3. Hua-Sing Ang, A. and Tang, W.H., "Probability Concepts in Engineering Planning and Design: Basic Principles", Vol. I, John Wiely and Sons, Inc.,1975, ISBN-13:978-0471032007.	

	4. Melchers, R. E. and Beck, A. C., "Structural Reliability Analysis and Prediction", 3rd Edition, John Wiley and Sons, 2017, ISBN-13:978-1119265993. 5. Erik, V., "Random Fields: Analysis and Synthesis", The MIT Press, Cambridge, Massachusetts, 2010, ISBN-13:978-9812563538.
Course Outcomes:	**After going through this course, student will be able to:** CO1. Apply probability and statistical methods to analyze soil behavior and variability in geotechnical problems. CO2. Quantify uncertainty in soil properties and loading conditions and evaluate its influence on the design and performance of geotechnical structures. CO3. Perform reliability analysis and risk assessment using methods such as FORM, SORM, and Monte Carlo simulations CO4. Use statistical software tools (e.g., R, Python) to conduct probabilistic design and decision-making in geotechnical engineering projects.

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Generic Elective (GE) Courses

Name of the Programme : Master of Engineering (Geotechnical Engineering)
Course Code : GEC-681
Title of the Course : Sustainability - Principles & Practices
Number of Credits : 03
Effective from AY : 2024-25

Pre-requisites for the Course:	Undergraduate level knowledge of any branch of engineering	
Course Objectives:	The course aims to provide the student with an: 1. Understanding of importance of Sustainability Practices 2. Explanation of Assessment, Planning and Implementation of Sustainability Principles 3. Description of the steps involved in implementing sustainable solutions 4. Apply the knowledge of sustainability practices to real life situations.	
Content:		**No. of Hours**
Unit-1	**Overview on Global Sustainability Goals (SDGs):** Industry-Innovation-Infrastructure, Health & Well Being, Clean Water & Sanitation, Education, Responsible Consumption and production, Climate Action, Quality Education, Economic growth, sustainable community living,	**10**
Unit-2	**Sustainability:** Requirements for Sustainability, Approaches towards Sustainable Engineering, Sustainability Challenges, Environmental Challenges; **Reasons for Un-sustainability** – Economics and Environment, Corporate View of Sustainability, Social Attitude, Approach, Cultural Narratives, Political Aspects, Ethics and Morals. Steps in life cycle impact assessment	**13**
Unit-3	**Sustainability Assessment:** Steps in assessing life cycle, data availability, process network analysis, Input-Output Analysis, Hybrid Models; Carbon footprint, Water footprint, Energy analysis of technologies, processes and its economics; Concept of Exergy and Emergy Analysis; Ecosystem Services in Sustainability Assessment; Case Studies	**10**
Unit-4	**Solutions for Sustainability:** Designing sustainable processes and products; Techno-Economic Analysis; Energy Ecosystem and its dynamic characteristics; Circular Economy; Nature based solutions, Green infrastructure, Techno-ecological synergy; Economic Policies, Societal Developments; Case Studies.	**12**
Pedagogy	Interactive learning, reflective thinking, critical analysis, and problem-	

	solving.
References/ Readings:	1. Raj Gaurang Tiwari, 'Sustainability Principles and Applications in Engineering Practices', Nova Science Publishers, 2024, ISBN:9798891136403 2. Bhavik R Bakshi, 'Sustainable Engineering', Cambridge University Press, 2019, ISBN:9781108420457 3. Margaret Robertson, 'Sustainability – Principles & Practices', Routledge Publishers, 2017, ISBN: 97811138650244
Course Outcomes:	After going through this course, student will be able to: CO 1. Understand the importance of sustainability practices CO 2. Assess, Plan and Suggest basic sustainability practices CO 3. Explain the steps involved in implementing sustainable solutions CO 4. Prepare a plan for sustainability practices to real life situations.

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Name of the Programme : **Master of Engineering (Geotechnical Engineering)**
Course Code : **GEC-682**
Title of the Course : **Sustainability - Principles & Practices Lab**
Number of Credits : **01**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Undergraduate level knowledge of any branch of engineering	
Course Objectives:	The course aims to provide the student with an: 1. Understanding of importance of Sustainability Development Goals (SDG) 2. Explanation on Assessment, Planning and Implementation of SDG 3. Description of the steps involved in order to achieve the SDG. 4. Apply the knowledge of sustainability practices to real life situations.	
Content:		**No. of Hours**
	The United Nations has promulgated Sustainable Development Goals (SDG)s. Every student has to prepare a detail report and presentation, based relevant literature, field visits and data collection, interaction with experts, on ANY TWO topics of SDG as applied to the local region or State of Goa. (1) No Poverty (2) Zero Hunger (3) Good Health & Well Being (4) Quality Education (5) Gender Equality (6) Clean Water & Sanitation (7) Affordable & Clean Energy (8) Decent Work and Economic Growth (9) Industry, Innovation and Infrastructure (10) Reduce Inequalities (11) Sustainable Cities & Communities (12) Responsible Consumption and Production (13) Climate Action (14) Life Below Water (15) Life on Land (16) Peace, Justice & Strong Institutions	**30**
Pedagogy	Instructional learning, Inquiry based learning, Constructive learning, Collaborative learning and problem solving	
References/ Readings:	1. Raj Gaurang Tiwari, 'Sustainability Principles and Applications in Engineering Practices', Nova Science Publishers, 2024, ISBN:9798891136403 2. Bhavik R Bakshi, 'Sustainable Engineering', Cambridge University Press, 2019, ISBN:9781108420457	

	3. Margaret Robertson, 'Sustainability – Principles & Practices', Routledge Publishers, 2017, ISBN: 97811138650244
Course Outcomes:	After going through this course, student will be able to: CO 1. Understand the importance of sustainability Development Goals (SDGs) CO 2. Assess, Plan and Suggest basic sustainability practices CO 3. Explain the steps involved in order to achieve the SDG CO 4. Prepare a plan for sustainability practices to real life situations.

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Name of the Programme : Master of Engineering (Geotechnical Engineering)
Course Code : GEC-683
Title of the Course : Project Management
Number of Credits : 03
Effective from AY : 2024-25

Pre-requisites for the Course:	Undergraduate level knowledge of any branch of engineering	
Course Objectives:	The course aims to provide the student with an: 1. Understanding of the various features of project management 2. Explanation of the relevance of human resource planning and management 3. Describes the importance of procurement planning, cost estimation, and quality management. 4. Detailed explanation on time and risk management.	
Content:		**No. of Hours**
Unit-1	**Overview on Project Management**: Need for Project Management, Project Life Cycle and its Phases, Scope of the project, requirements and scope, Organizational Influences, Project Management Plan, Integrated Change Control Plan, Agile Project Management and Lean Project Management, Project selection and portfolio management. **Economics & Cost Management**: Time Value of Money, Cost-Benefit Ratio, Cost estimation, methods of preparing estimates, budgeting, Cost monitoring and Control, cost on completion.	**10**
Unit-2	**Human Resource Management,** Planning Human Recourses, Acquiring human resources, developing and strategizing deployment of resources, leadership qualities, team management – motivation, monitoring and control, conflict management and interpersonal relationship management. Importance of Communication and communication management – tools and techniques; basic human fundamentals, ethics and professional conduct,	**12**
Unit-3	**Procurement Management**- Planning, Implementation – Monitoring and control of goods and services; Stakeholders Management, Contracts drafting, preparation, approval, implementation and closure. **Quality Management:** Introduction, quality planning tools and techniques, quality monitoring and control, tools and techniques,	**13**
Unit-4	**Time Management**: Purpose of Time Management, Time Planning, different methods of activity planning, milestones,	**10**

	resource assignment and time lines. Time monitoring and control - different types of charts; Path Planning – forward, backward, critical, lag and lead time lines. **Risk Management** – Risk Identification, Risk Qualitative Analysis, Risk Quantitative Analysis, Risk Response, Monitoring and Control	
Pedagogy	Interactive learning, reflective thinking, critical analysis, and problem-solving.	
References/ Readings:	1. J.Michael Bennet, Danny S.K.Ho, 'Project Management for Engineers', World Scientific Publishing, 2014, ISBN: 13-978-981444-7928. 2. J. M. Nicholas, Herman Steyn, 'Project Management for Engineering, Business and Technology, 6th Edn, Taylor & Francis Publications, 2021, ISBN: 978-0-367-277730-7 3. Neil G Siegel, Engineering Project Management, Wiley Publications, 2019, ISBN: 9781119525769. 4. Khanna.R.B., Project Management, PHI Publishing, 2011, ISBN: 978-81-203-4288.	
Course Outcomes:	After going through this course, student will be able to: CO 1. Explain the importance of Project Management CO 2. Describe the various components of Project Management CO 3. Analyze the importance of cost, human resource, procurement, quality, time and risk management CO 4. Apply project management knowledge in their professional life.	

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Name of the Programme : **Master of Engineering (Geotechnical Engineering)**
Course Code : **GEC-684**
Title of the Course : **Project Management Lab**
Number of Credits : **01**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Undergraduate level knowledge of any branch of engineering	
Course Objectives:	The course aims to provide the student with an: 1. Understanding of the various features of project management 2. Explanation of the relevance of applying project management knowledge to any one domain 3. Describes the advantages of applying project management tools & techniques to address specific problems 4. Ability to prepare reports and presentation on specific areas by applying knowledge of Project Management	
Content:		**No. of Hours**
	Project Management is applicable to all types of Human Activities. Every Student has to choose ANY TWO topics, prepare a detail report and presentation, based relevant literature, field visits and data collection, interaction with experts in the local region or State of Goa. The student shall apply project management knowledge to any ONE topics given below, the list is only indicative, students can choose topics from related / allied areas: (1) Large construction site (on-going projects) – residential, commercial, highways, ports, airports (2) Large Manufacturing Industry in any of the Industrial Areas in Goa, scaling up production, sales / marketing. (3) Waste Management; Water Management; (4) Application of Project Management to Law Enforcement (5) Project Management in Education – infrastructure, skill training (6) Project Management as applied to consumer goods / supplies (7) Manpower Management in the context of AI in software industry (8) Project Management – Global markets for local products using Digital Marketing platforms (9) Project management for Logistics and Transportation (10) Project management for Hospital & Health Management	**30**
Pedagogy	Instructional learning, Inquiry based learning, Constructive learning,	

	Collaborative learning and problem solving
References/ Readings:	1. J.Michael Bennet, Danny S.K.Ho, 'Project Management for Engineers', World Scientific Publishing, 2014, ISBN: 13-978-981444-7928. 2. J. M. Nicholas, Herman Steyn, 'Project Management for Engineering, Business and Technology, 6th Edn, Taylor & Francis Publications, 2021, ISBN: 978-0-367-277730-7 3. Neil G Siegel, Engineering Project Management, Wiley Publications, 2019, ISBN: 9781119525769. 4. Khanna.R.B., Project Management, PHI Publishing, 2011, ISBN: 978-81-203-4288.
Course Outcomes:	After going through this course, student will be able to: CO 1. Understanding of the various features of project management CO 2. Explanation of the relevance of applying project management knowledge to any one domain CO 3. Describes the advantages of applying project management tools & techniques to address specific problems CO 4. Ability to prepare reports and presentation on specific areas by applying knowledge of Project Management

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Semester IV

Generic Elective (GE) Courses

Name of the Programme : Master of Engineering (Geotechnical Engineering)
Course Code : GEC-685
Title of the Course : Financial Management
Number of Credits : 04
Effective from AY : 2024-25

Pre-requisites for the Course:	Basic knowledge of Finance, Economics	
Course Objectives:	The course aims to provide the student with an: 1. Understanding of Financial Systems and Its Management 2. Explanation of Financial Planning, Fund Flow and Cost Analysis 3. Analysis of Capital & Working Capital Management, Valuation, Long Term Financing 4. Description of product cost analysis, break even analysis and investment management.	
Content:		**No. of Hours**
Unit-1	**Financial Management: An Overview –** Types of Business organizations, Fundamental principle of finance. **The Financial System-** Functions, Financial Assets and Markets, **Financial Statements, Taxes, and Cash Flow**- Balance Sheet, Profit and loss Account, Profits Vs Cash Flow, Taxes; Financial decision making.	**15**
Unit-2	**Financial Statement Analysis**- Financial Ratios- Liquidity Ratios, Leverage & Profitability Ratios; **Fund Flow Analysis** - Fund Flow Statement; **Breakeven Analysis and Leverages**- Cost Volume Profit Analysis; **Financial Planning & Forecasting-** Financial Planning, Sales Forecast; **Cost Analysis-** Determination of product cost, overhead cost, volume and profits, planning and control on costs and decision making using costs.	**16**
Unit-3	**Fundamental Valuation Concepts -**The Time Value of Money, Risk and Return. **Capital Budgeting -**Techniques of Capital Budgeting – Capital Budgeting Process, project classification; cash flows, risk analysis, cost of capital; **Investment Criteria**- Net Present value, Benefit Cost Ratio, Internal Rate of return, Payback Period, Accounting rate of Return.	**15**

Unit-4	**Working Capital Management** -Working Capital Policy, Cash and Liquidity Management, Credit Management, Inventory Management, Working Capital Financing; **Corporate Valuation:** Debt analysis and management, Leasing, Hire Purchase, Valuation, Mergers, acquisitions and Restructuring; **Long Term Financing:** Sources of Long Term Finance, Raising Long Term Finance.	**14**
Pedagogy	Interactive learning, reflective thinking, critical analysis, and problem-solving.	
References/ Readings:	1. Prasanna Chandra "Financial Management: Theory and Practice" 11th Edition, McGraw Hill Education Publishers, 2023, ISBN: 978-9355-322-203 2. Pandey I.M., Finance- A Management Guide for Managing Company Funds and Profits, Prentice Hall India Publications, 1995, ISBN:978-8120-309-180 3. Van Horne, J.C, "Fundamentals of Financial Management", 13th Edition, Pearson Publications, 2015, ISBN:978-933-255-8670. 4. Khan, M.Y. and Jain, P.K., "Financial Management", 8th Edition, McGraw-Hill Education Publishers, 2018, ISBN:978-9353-1622-184	
Course Outcomes:	After going through this course, student will be able to: CO 1. Understand the Financial Systems and Its Management CO 2. Explain Financial Planning, Fund Flow and Cost Analysis CO 3. Analyze Capital & Working Capital Management, Valuation, Long Term Financing CO 4. Describe product cost analysis, break even analysis and investment management.	

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Name of the Programme : **Master of Engineering (Geotechnical Engineering)**
Course Code : **GEC-686**
Title of the Course : **Entrepreneurship**
Number of Credits : **04**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Basic knowledge of Creative Thinking, Innovation, Finance, Economics	
Course Objectives:	The course aims to provide the student with an: 1. Understanding of entrepreneurial skill sets and different types of entrepreneurship. 2. Explanation of Differences between New Enterprise, Social Enterprise and Family Business 3. Describes the process of preparing business plan, operational plans to start an enterprise 4. Apply the knowledge of market analysis, product planning, customer requirements, costing and finance	
Content:		**No. of Hours**
Unit-1	**Entrepreneurial Characteristics:** Overview on Entrepreneurship, Broad classification of entrepreneurs; Leadership, Goal Setting, Time and resource Planning, Communication, Networking, Knowledge & Skill Upgradation; Awareness of Social and Industrial Eco-system; Awareness of Government Policies and Schemes; Digital marketing and business promotion; Local and global market; Basic understanding of Legal and regulatory system, Intellectual Property Rights; Financial Literary; Decision making and risk taking abilities	**18**
Unit-2	**Creation of New Enterprise:** Creativity, Innovation, technology, wealth creation, social impact, Team building, Business Plan, project formulation and feasibility analysis; business simulation; designing and configuring business models and customers, Enterprise management tools and techniques; Launching and managing enterprises; Sales & Marketing Strategies; Human Resources; Incubation, Costing and Financial Plans, Case Studies	**14**
Unit-3	**Social Entrepreneurship:** Overview**,** project formulation and feasibility analysis; understanding customer needs, positioning the firm for social change and strategic advantage; social business model; participatory development; stakeholders; social impact assessment; networking; regional economic models; banking and loans; Women Entrepreneurship; Case Studies	**14**

Unit-4	**Family Business Management :** Small and Medium Business Enterprises; Growth plan formulation; Vision, Values and Strategies, Turn around strategies, cost management, finance and liquidity, family to corporate culture; Case Studies;	**14**
Pedagogy	Interactive learning, reflective thinking, critical analysis, and problem-solving.	
References/ Readings:	1. Nagasubba Rayudu, 'A Textbook on Entrepreneurship & Incubation', Mahi Publications, 2023, ISBN: 978811949282 2. Balasubramanya. M.H., 'Entrepreneurial Ecosystems for Tech Startup in India', Verlag Max Publications, 2021, 9783110679298. 3. Kenji Uchino, 'Entrepreneurship for Engineers', CRC Press, 2010, ISBN: 978143980063 4. Ryszard Praszkier, Andrzej Nowak, 'Social Entrepreneurship', Theory and Practice, Cambridge University Press, 2011, ISBN 9781139504331 5. Peter Leach, Tatwamasi Dixit, 'Indian Family Business Mantras', Rupa Publications, 2016, ISBN: 9788129136945 6. Bill Bolton, John Thompson, 'Entrepreneurs – Talent, Temperament, Opportunity', Elsevier Publications, 2004, ISBN:0750661283 7. John Bessant, Joe Tidd, 'Entrepreneurship', John Wiley Publications, 2015, ISBN: 9781118993095	
Course Outcomes:	After going through this course, student will be able to: CO 1. Understand entrepreneurial skill sets and different types of entrepreneurship. CO 2. Classify New Enterprise, Social Enterprise and Family Business CO 3. Explain process of preparing business plan, operational plans to start an enterprise CO 4. Apply the knowledge of market analysis, product planning, customer requirements, coting and finance	

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