Teaching and Examination Schemes with Syllabus

of

Master of Technology (Civil)

in

Geotechnical Engineering

As per NEP

(Approved by 62nd meeting of Senate dated August 6, 2024)

Department of Civil Engineering

Sardar Vallabhbhai National Institute of Technology, Surat

Vision and Mission of the Institute

Vision

To be one of the leading Technical Institutes disseminating globally acceptable education, effective industrial training and relevant research output

Mission

To be a globally accepted centre of excellence in technical education catalyzing absorption, innovation, diffusion and transfer of high technologies resulting in enhanced quality for all the stake holders

Vision and Mission of the Department

Vision

To be a global centre of excellence for creating competent professionals in Civil Engineering

Mission

- To provide excellent education producing technically competent, globally employable civil engineers who will be leaders in the chosen field
- To undertake research in conventional and advanced technologies fulfilling the needs and challenges of modern society
- To provide consultancy services and develop partnerships with society, industry and public organizations.
- To organize seminar, conferences, symposia and continuing education programmes for academic and field community.

Foreword

The SVNIT, Surat was established in the year 1961 and the Geotechnical Engineering Section is part of the institute since 1973. The section consists of dedicated team of 7 faculty members. The section has 6 well equipped laboratories and all faculties acquired their Doctorate from renowned universities in the field of Geotechnical Engineering like IITs, NITs etc. Beside high-quality teaching and instruction at UG and PG, the section is actively involved in basic and applied research and consultancy services. The section is providing quality technical and advisory support through consultancy to various private construction agencies, State Government, Central Government projects. Alumni from Geotechnical Engineering Section are serving at various International as well as National Level Organizations and some have been successful entrepreneurs in the fields of Geotechnical Engineering. The Geotechnical Engineering Section presents a picture of a small but fully dedicated and developed faculty contributing to all round growth of students, Institute, Industries and Society.The M. Tech. programme in Geotechnical Engineering is one of the oldest PG programmes of the institute.

The curriculum of the programme is regularly revised taking inputs from industry and alumni.The syllabus includes core courses, electives, practicals, summer training and dissertation. Through course work spread in the first two semesters, the students are exposed to various techniques and theory of geotechnical engineering. Through quizzes and assignments students' performance is continuously evaluated. Experiments are regularly updated with latest equipment and software. Dissertation spread over two semesters help students to comprehend a problem, analyse it and develop a detailed methodology to derive valid conclusions through a number of field, laboratory or simulated experiments

Programme Educational Objectives (PEOs)

The graduates of the M.Tech. Geotechnical Engineering Programme will:

- Excel in professional career and horn research skills in the field of Geotechnical Engineering
- Exhibit professionalism through lifelong learning and able to work in teams for sustainable infrastructure growth and development of the nation.
- Graduates will communicate effectively in their team, adapt to emerging technologies for sustained growth and exhibit social responsibility with professional ethics.

Programme Outcomes (POs)

The outcomes of the Master of Technology programme in Geotechnical Engineering are:

- An ability to independently carry out research /investigation and development work to solve practical problems.
- An ability to write and present a substantial technical report/document.
- Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate Master program.

Programme Specific Outcomes (PSOs)

- Students will acquire the knowledge to characterize the geotechnical site, evaluate the properties of geo-materials and design the geotechnical structures for static and dynamic loadings.
- Students will be able to address the geotechnical challenges related to excavation, geo-environmental issues, ground improvement, earth retaining structures and pavement geotechnics, using advanced tools, techniques and software with due consideration of sustainability.
- Students will be able to contribute towards multidisciplinary scientific research in the field of geotechnical engineering for infrastructure growth and development of the nation.

Teaching Scheme
M.Tech. in (Civil) Geotechnical Engineering

Sr. No.	Subject	Code	Scheme L-T-P	Exam Scheme			Credits (Min.)	Notional hours of Learning (Approx.)
				Th. Marks	T Marks	P Marks		
	First Semester							
1	Advanced Foundation Engineering	CEGT101	3-1-0	100	25	-	4	65
2	Slope stability and Retaining structures	CEGT102	3-1-0	100	25	-	4	65
3	Advanced Soil mechanics	CEGT103	3-1-0	100	25	-	4	65
4	**Core Elective - 1**	##	3-0-0	100	-	-	3	50
5	**Core Elective - 2**	##	3-0-0	100	-	-	3	50
6	Geotechnical Engineering laboratory	CEGT104	0-0-4	-	-	50	2	62
						Total	**20**	**357**
7	Vocational Training / Professional Experience (optional) (Mandatory for Exit)	##	0-0-10				5	200 (20 x 10)
	Second Semester							
1	Ground Improvement Techniques	CEGT201	3-1-0	100	25	-	4	65
2	Soil Dynamics & Earthquake Geotechnics	CEGT202	3-1-0	100	25	-	4	65
3	Core Elective - 3	##	3-1-0	100	25	-	4	65
4	Core Elective - 4	##	3-0-0	100	-	-	3	50
5	Institute (Open) Elective	##	3-0-0	100	-	-	3	50
6	Numerical Modelling in Geomechanics	CEGT204	0-0-4	-	-	100 40+60 * **	2	62
						Total	**20**	**357**
7	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	##	0-0-10				5	200 (20 x 10)

Sr. No.	Subject	Code	Exam Scheme			Credits (Min.)	Notional hours of Learning (Approx.)
			Th.	T	P		
			Marks	Marks	Marks		
	Third Semester						
1	MOOC course-I*	#	#	#	#	3/4	70/80
2	MOOC cousse-II*	#	#	#	#	3/4	70/80
3	Dissertation Preliminaries	CEGT303	-	-	350$	14	560
			Total			**20-22**	**700-720**
	Fourth Semester						
1	Dissertation	CEGT403	-	-	600$	20	800

$ **Internal**: 40% and **External**: 60%
*Swayam/NPTEL

Core Elective - 1
1. CEGT110 Geosynthetics & Reinforced Soil Structure
2. CEGT111 Soil Structure Interaction
3. CETP116 Research Analytical Methods
4. CEST112 Theory of Elasticity & Plasticity

Core Elective 2
1. CEGT120 Rock Mechanics
2. CEGT121 Constitutive Modelling in Geomechanics
3. CECT111 Low Cost Construction
4. CETP117 Pavement Analysis and Design

Core Elective - 3
1. CEGT210 Finite Element Method in Geotechnical Engineering
2. CEGT211 Structural Geology

Core Elective - 4:
1. CEGT220Environmental Geotechnology
2. CEGT221 Tunnelling and Underground Structures
3. CEST213Foundation Design of Structures & Soil-structure Interaction

Institute (Open) Elective:
1 CEST230 Soil Exploration and Field Tests

2 CEEC730AI/ML Based Applications in Civil Engineering

Allotment of elective

The choice of the elective courses is primarily based on the interest of the students. Facultiesoffering the respective elective subject interact with all students and brief out the content with relevance of the subject in field or in research. On the basis of merit, students are given thefreedom to select the elective of their choice. Emphasize is made to offer maximum numberof electives in each semester, however, at least 6 students need to opt a certain elective to runit.

Assessment of Performance

Assessment of Theory Courses

The evaluation pattern for the theory courses, *as of now*, shall be as under:

Mid-semester examination: 30 marks

Assignment/Quizzes: 20 marks

Tutorials (if applicable): 25 marks

End-semester exam: 50 marks

The mid- and end-semester examinations are of 1.5 hours and 3 hours, respectively.

Assessment of Dissertation/Projects

Internal assessment of 40% weightage by guide(s) Final assessment of 60% weightage by a panel of examiners

For more details please refer to the institute website

https://www.svnit.ac.in/Data/Notice/AcademicRegulations2013-2014.pdf

Course-wise Detailed Syllabus

Semester I

CEGT101Advanced Foundation Engineering

L	T	P	C
3	1	0	4

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Interpret laboratory and field-testing results for foundation design
CO2	Comprehend soil investigation reports and suggest the suitable type of foundation
CO3	Design the suitable shallow and deep foundation for structures
CO4	Evaluate bearing capacity and settlement of shallow and deep foundations using various approaches
CO5	Apply the acquired knowledge for the design of special foundation

2. Syllabus

- **SOIL PROPERTIES & INTERPRETATIONS (06 Hours)**

  Soil properties and its applications, Interpretation of the soil parameters for foundation design, Interpretation of the soil investigation report.

- **SHALLOW FOUNDATIONS (11 Hours)**

  Stress distribution of soil, Different types of shallow foundation, Modes of failure in soil beneath foundation, Flexible and rigid foundation, Bearing Capacity of Soil, Settlement of Foundations, Shallow foundations design criteria, Case studies.

- **DEEP FOUNDATIONS (13Hours)**

  Types of pile foundation, factors affecting choice of types of piles, Load carrying capacity of single and group of piles, Group efficiency, Uplift and Lateral resistance of piles, settlement of single and group of piles, Negative skin friction, Geotechnical aspects for pile design, Secant pile, Contiguous pile, Pile load test (vertical, lateral and pull out), Deep Foundation: barrette pile, belled pile, rock socketed pile, well foundation, micro pile, batter/rake pile, fender pile, under-ream pile, large diameter pile, different materials of pile, Construction of pile foundation, Pile driving analysis, Non-destructive test on piles.

- **FOUNDATIONS ON WEAK DEPOSITS** **(04 Hours)**

  Identification of weak soils, Problems associated with weak deposits, Foundations for expansive soil, Collapsible soils.

- **SPECIAL FOUNDATIONS** **(11 Hours)**

  Foundation on layered soil, Foundations on slope, foundations on rocks, Compensated foundation, Raft foundation, Pile Raft foundation, Annular foundation for circular structures, Concept of offshore foundations, Techno legal consideration in geotechnical engineering.

(Total Lectures: 45 hours. Tutorial: 15 hours)

3. References

1. Bowles J E "Foundation Analysis & Design" McGraw Hills Inc. New York, 5th edition 2012.
2. Nayak N V "Foundation Design Manual" Dhanpatrai & Sons, New Delhi, 2016.
3. Das B M 'Principles of Foundation Engineering' PWS Publishing Co., Boston, 2011.
4. Srinivasulu P., Vaidyanathan C.V., "Handbook of Machine Foundation", McGraw Hills Inc, 2002
5. Tomlinson, M., & Woodward, J. (2007). *Pile Design and Construction Practice*. CRC press.
6. IS 1892 (1979): Code of practice for subsurface investigations for foundations.
7. IS 6403 (1981): Code of practice for determination of bearing capacity of shallow foundations.
8. IS 1904 (1986): Code of practice for design and construction of foundations in soils: General requirements.
9. IS 8009-1 (1976): Code of practice for calculation of settlements of foundations, Part 1: Shallow foundations subjected to symmetrical static vertical loads.
10. IS 8009-2 (1980): Code of practice for calculation of settlement of foundations, Part 2: Deep foundations subjected to symmetrical static vertical loading.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	3	1	3
CO2	3	3	3	3	3	3
CO3	2	1	2	3	3	2
CO4	3	2	3	3	2	3
CO5	3	2	3	3	3	3

1-Low 2-Moderate 3-High

CEGT102Slope Stability and Retaining Structures

L	T	P	C
3	1	0	4

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Illustrate the basic concepts of earth pressure theory
CO2	Identify and select the suitable retention system for excavation projects
CO3	Analyse the arching in soil and its benefits in geotechnical design
CO4	Evaluate the stability of embankment slope, open cuts and natural slopes.
CO5	Applying the earth pressure theory, theory of arching and slope stability methods to analyse and design the geotechnical system involving retaining systems

2. Syllabus

- **LATERAL EARTH PRESSURE** **(06 Hours)**

  Lateral Earth Pressure at Rest, Rankine Active and Passive Earth Pressure, Coulomb's Active and Passive Earth Pressure, Lateral Earth Pressure Due to Surcharge, Inclined backfill, Circular retaining wall, and Earthquake loading.

- **RETAINING SYSTEM** **(09Hours)**

  Types of retaining systems. **Retaining wall**: Types of Retaining Walls, Application of Lateral Earth Pressure Theories to Design and Stability of Retaining Walls, Construction Joints and Drainage from Backfill, Retaining wall with relieving shelf. **Sheet-Pile Walls**: Cantilever Sheet-Pile Walls in sand, clay and layered soil, Anchored Sheet-Pile Walls, Free Earth Support Method for Penetration of Sandy and Clayey Soil, Holding Capacity of Anchor Plates in Sand and Clay.

- **OPEN CUTS AND DEEP EXCAVATIONS** (**08 Hours)**

  Open cuts, sheeting and bracing systems in shallow and deep open cuts in different soil types, lateral earth pressure distribution on braced-cuts, stability of braced-cuts in saturated clay, piping failures in sand cuts, Diaphragm walls, Secant Pile, Touch Pile, Contiguous Pile for deep excavations.

- **COMPONENTS OF EXCAVATIONS (06 Hours)**

  Dewatering: Ditches and sumps, well points, deep-well pumps, sand drains. Pre-stressed Ground Anchors, Modern Retaining Systems, Coffer dams: various types, analysis and design. Instrumentations for deep excavations.

- **ARCHING IN SOILS (06 Hours)**

  Theory of Arching in Soils and its Applications in design of tunnels & conduits,pressure computations around tunnels, benefits of arching, arching for other geotechnical systems.

- **SLOPE STABILITY (10 Hours)**

  Introduction, Factor of Safety, Stability of Infinite Slopes, Finite Slopes, Analysis of Finite Slopes with Plane Failure Surfaces and with Circular Failure Surfaces, Bishop's Simplified Method of Slices, Morgenstern's Method of Slices, Determination of Factor of Safety of Slopes made of Clay and Embankment on Saturated Clay, Slope protection and stabilization. Earth Dams and Embankments: choice of material, Design of filters and drains. Stability in rapid drawdown. Use of different draining conditions (CD, CU, UU) in soil for evaluating the stability of slope.

(Total Lecture Hours 45, Tutorial: 15 hours)

3. References

1. Clayton, C. R., Woods, R. I., & Milititsky, J. (2014). Earth Pressure and Earth-Retaining Structures. CRC press.
2. Budhu, M. (2008). Foundations and Earth Retaining Structures. John Wiley & Sons Incorporated.
3. Ou, C. Y. (2014). Deep Excavation: Theory and Practice. CRC Press.
4. Duncan, J. M., Wright, S. G., & Brandon, T. L. (2014). Soil Strength and Slope Stability. John Wiley & Sons.
5. Abramson, L. W., Lee, T. S., Sharma, S., & Boyce, G. M. (2001). Slope Stability and Stabilization Methods. John Wiley & Sons.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	1	1	1	1	1
CO2	2	1	2	1	1	1
CO3	1	1	1	1	1	1
CO4	3	2	2	2	2	2
CO5	3	3	3	2	2	3

1-Low 2-Moderate 3-High

CEGT103 Advanced Soil Mechanics

L	T	P	C
3	1	0	4

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Illustrate the types of soil structure and clay minerals and their characteristics.
CO2	Comprehend the effective stress, permeability and seepage in soil under different hydraulic conditions
CO3	Analyze the consolidation behavior of soil to calculate corresponding settlement
CO4	Appraise the shear strength characteristics of soil and the governing factors
CO5	Evaluate the geotechnical parameters for the design of geotechnical structures

2. Syllabus

- **CLAY MINERALOGY** **(05 Hours)** Types of Soil Structure, Clay Minerals, Characteristics and Construction of Mineral groups, Soil water.

- **PRINCIPLE OF EFFECTIVE STRESS** **(06 Hours)**
  Concept of effective stress and its necessity, Capillarity in soils; Steady state flow in soils. Effect of flow on effective stress

- **PERMEABILITY AND SEEPAGE** **(09 Hours)**
  Determination of coefficient of permeability by laboratory methods, field methods and indirect methods; Factors affecting permeability; Permeability of unsaturated soil; Seepage forces; quick sand and piping; Flow nets; Design of filters; Flow net for anisotropic and non- homogeneous soils.

- **CONSOLIDATION** **(10 Hours)**
  Mechanics of consolidation; phenomenon of consolidation; Primary & secondary consolidation settlements; one dimensional, three dimensional and radial

consolidation. Various consolidation tests and determination of parameters; Field consolidation curve; Sand drains; Smear zone

- **SHEAR STRENGTH** **(15 Hours)**

  Shear resistance; stress -strain relationship in soils; failure criteria: Mohr Coulomb's failure; Triaxial and direct shear tests; UU, CU, CD tests; shear parameters under different drainage conditions; Pore-pressure parameters; Factors affecting shear behavior of fine grained soils and coarse grained soils; Total and effective stress-strength parameters; Total and effective stress-paths; Concept of unsaturated soil mechanics and critical state soil mechanics.

(Total Lecture Hours 45, Tutorial: 15 hours)

3. References

1. Budhu, M. "Soil Mechanics Fundamentals", John Wiley & Sons Inc., New York, USA. 2015.
2. Kaniraj S R, "Design Aids in Soil Mechanics & Foundation Engineering", Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1988
3. Ranjan, G. and Rao, A.S.R., "Basic and Applied Soil Mechanics", New Age International Publishers, New Delhi, India.2008
4. Das, B.M. and Khaled S., "Principles of Geotechnical Engineering", Cengage Learning, Stamford, USA.2014.
5. Bowles, J. E, "Foundation Analysis and Design", McGraw-Hill, New York, 5th edition, 2012.
6. Lambe T.W, Whitman R.V.," Soil Mechanics", John Wiley & Sons, 1969.
7. Holtz, Robert D., William D. Kovacs, and Thomas C. Sheahan. "An Introduction to Geotechnical Engineering". Vol. 733. Englewood Cliffs: Prentice-Hall, 1981.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	1	3	3	3	1
CO2	3	1	3	3	3	1
CO3	3	1	3	3	3	1
CO4	3	1	3	3	3	2
CO5	3	2	3	3	2	3

1-Low 2-Moderate 3-High

CEGT110 Geosynthetics and Reinforced Soil Structures

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Comprehend the basic principles of reinforced soil for its applications in geotechnical engineering
CO2	Identify the different types of Geosynthetics and its functions
CO3	Evaluate the different engineering properties of Geosyntheticfor its applications in civil engineering
CO4	Appraise different codal provisions for reinforced geotechnical structures
CO5	Design suitable ground improvement and reinforced soil structures using Geosynthetics

2. Syllabus

- **INTRODUCTION** **(03 Hours)**

  Historical background of reinforced soil, Principles of reinforced soil through Mohr circle analysis.

- **DIFFERENT TYPES OF GEOSYNTHETICS** **(04 Hours)**

  Types of geosynthetics like geotextiles, geogrids, geonets, geocells, geo-composites, their manufacturing methods

- **TESTING METHODS FOR GEOSYNTHETICS** (**06 Hours)**

  Techniques for testing of different index properties, strength properties, Apparent Opening Size, In-plane and cross-plane permeability tests, assessment of construction induced damage and extrapolation of long term strength properties from short term tests.

- **REINFORCED SOIL RETAINING WALLS (12Hours)**

  Different types of walls like wrap-around walls, full-height panel walls, discrete-facing panel walls, modular block walls. Design methods as per BS-8006 and FHWA methods Construction methods for reinforced soil retaining walls.

- **REINFORCED SOIL SLOPES (07 Hours)**

  Basal reinforcement for construction on soft clay soils, construction of steep slopes with reinforcement layers on comptenet soils, Different slope stability analysis methods like planar wedge method, bi-linear wedge method and circular slip methods. Erosion control on slopes using geosynthetics.

- **APPLICATIONS IN FOUNDATIONS (05 Hours)**

  Binquet and Lee's approach for analysis of foundations with reinforcement layers.

- **DRAINAGE AND FILTRATION APPLICATIONS OF GEOSYNTHETICS (03 Hours)**

  Different filtration requirements, filtration in different types of soils and criteria for selection of geotextiles, estimation of flow of water in retaining walls, pavements, etc. and selection of geosynthetics.

- **PAVEMENT APPLICATION (05 Hours)**

  Pavement application: 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 raiway lines.

(Total Lecture Hours 45)

3. References

1. Koerner, R.M. "Designing with Geosynthetics", Prentice Hall, New Jersey, USA, 5th edition, 2005.
2. Jewell, R.A., "Soil Reinforcement with Geotextiles", Special Publication No. 123, CIRIA, Thomas Telford. London, UK, 1996.
3. Geosynthetics - New Horizons, Eds. G.V. Rao, PK Banerjee, J.T. Shahu, G.V. Ramana, Asian Books Private Ltd., New Delhi, 2004.
4. Shukla,S. K.. "Geosynthetics and its applications" Thomas Telford, London, 2002.
5. Shukla, S. K.. "Fundamentals of Geosynthetic Engineering". CRC Press. 2006.
6. Additional Reading: Design guidelines from IRC, FHWA, BS, IS and other codal organizations.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	1	1	2	2	2
CO2	1	1	1	2	1	2
CO3	2	1	1	2	2	2
CO4	3	3	2	3	3	3
CO5	3	3	3	3	3	3

1-Low 2-Moderate 3-High

CEGT111 Soil Structure Interaction

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Illustrate a basic background of stress and displacement of soil, Scope of soil-foundation interaction analysis.
CO2	Identify situation where soil-structure interaction is likely to occur ,elastic analysis of pile and pile group for different loading condition with SSI
CO3	Evaluate behaviour of pile single pile and pile group by different spring concepts, boussinsq's method ,line load and strip load consideration.
CO4	Analyse and predict the behaviour piled raft foundation for static and dynamic loading condition
CO5	Apply the concepts of wrinker's approach and elastic continuum approach in problems associated with SSI for buildings for different foundation input motion.

2. Syllabus

- **SOIL-FOUNDATION INTERACTION** **(04 Hours)**

  Introduction to soil – stresses and displacement in soils, Soil behaviour, Foundation behaviour, Interface behaviour, Scope of soil-foundation interaction analysis

- **ELASTIC ANALYSIS OF PILE** **(07 Hours)**

  Elastic analysis of single pile, Theoretical solutions for settlement and load distribution, Analysis of pile group, axial loaded single pile and pile group, pile cap – pile-soil interactions.

- **PILE LOAD DEFLECTION** **(06 Hours)**

  Prediction for laterally loaded piles, subgrade reaction and elastic analysis, static interaction analysis of shallow and deep foundation.

- **SOIL RESPONSE MODELS (08 Hours)**Winkler model, Elastic continuum, P-Y curves, Q-Z curves and T-Z springs concepts, Elastic plastic behavior of soil, Time dependent behavior, boussinsq's method, line load, strip load consideration

- **BEAM ON ELASTIC FOUNDATION (07 Hours)**
  Pile on wrinkler's foundation, vertically loaded pile, rigid pile, evaluation of spring stiffness, non-homogeneous soil, laterally loaded pile in layered soil, piles in elastic continuum, vertically and laterally loaded pilein elastic continuum,

- **DYNAMIC SOIL-STRUCTURE INTERACTION (07 Hours)**
  Soil structure interaction of piled raft foundation for static loading and dynamic loading for homogeneous soil and for layered soil

- **ENGINEERING APPLICATION OF SOIL-STRUCTURE INTERACTION (06 Hours)**
  Foundation input motion, seismic soil structure interaction analysis based on time period for buildings, examples and case studies

(Total Lecture Hours 45)

3. References

1. Hemsley, J.A, Elastic Analysis of Raft Foundations, Thomas Telford, 1998.
2. McCarthy, D.F. Essentials of Soil Mechanics and Foundations, basic geotechnics (7th Edition), Prentice Hall, 2014.
3. Selvadurai, A.P.S., Elastic Analysis of Soil Foundation Interaction, Elsevier, 2013.
4. Poulos, H.G., and Davis, E.H., Pile Foundation Analysis and Design, John Wiley, 1990.
5. Scott, R.F. Foundation Analysis, Prentice Hall, 1981.
6. Structure Soil Interaction - State of Art Report, Institution of structural Engineers, 1978. ACI 336, Suggested Analysis and Design Procedures for Combined Footings and Mats, American Concrete Institute, Dehit, 1988.
7. Bowels, J.E., "Analytical and Computer methods in Foundation" McGraw Hill Book Co., New York

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PO3
CO1	3	3	1	2	2	1
CO2	2	2	2	2	3	3
CO3	2	2	3	3	2	2
CO4	3	1	2	2	2	2
CO5	3	3	2	3	3	2

1-Low 2-Moderate 3-High

CETP116RESEARCH ANALYTICAL METHOD

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

CO1	Perform statistical analysis of the sample data collected using different sampling techniques towards insightful inferences
CO2	Analyse different continuous and discrete probability distributions
CO3	Develop correlations by analysing univariate and multivariate data
CO4	Apply hypothesis testing techniques using different sampling distributions/tests
CO5	Solve the real-world problem with appropriate optimization tool

2. Syllabus

- **SOCIAL RESEARCH FORMULATION** **(09 Hours)**
  Design of research - Scaling techniques - Sampling design - Design of questionnaire - Data collection and statistical processing, variables, types of variables, scaling of variables, coding of variables in software tools

- **STATISTICS & PROBABILITY CONCEPTS** **(09 Hours)**
  Various probability distributions & their applications - Parameter estimation - Hypothesis testing - Random variables - Method of maximum likelihood - Hypothesis testing to compare multiple population - Statistical quality control

- **HYPOTHESIS TESTING** **(09 Hours)**
  Hypothesis testing, types of error in hypothesis, confidence interval, significance tests for comparing variances and means, tests with small and large samples, two-tail and one-tail student’s t-test, analysis of variance (ANOVA), non-parametric tests (Chi-square test and Kolmogorov–Smirnov test), central limit theorem, practice with transportation data.

- **REGRESSION ANALYSIS** **(09 Hours)**
  Simple linear regression, residuals and variances, Assumptions, multiple linear regression, two stage regression, forward, backward and step-wise regression, residual analysis, correlation analysis, type of correlations, coefficient of correlation, Karl-Pearson’s coefficient, multivariate data analysis, factor analysis, applications in transportation engineering, goodness-of-fit tests and curve fitting.

- **OPTIMIZATION TECHNIQUES** **(09 Hours)**

Linear programming - Simplex method - Transportation model - Concepts of non– linear programming - Decision theories – Rules - Decision under uncertainty, Applications in Transportation Engineering

(Total contact hours: 45)

3. Tutorial

1. Exercise for measuring central tendency, dispersion and shape of data, graphical representation, plots and pattern, interpretation of results, and histograms using MS office tools and other statistical packages
2. Sampling exercises, data storing, handling, cleaning, and descriptive analysis exercises by using statistical tools.
3. Exercise for fitting probabilistic distributions and hypothesis testing using statistical tools.
4. Exercise for correlation analysis, simple linear and multiple linear regressions, nonlinear regression, using statistical tools.
5. Exercise for parametric and non-parametric tests, test of significance, paired and unpaired sample tests and evaluation, using statistical tools.
6. Exercise for analysis of variance, univariate and multivariate analysis using statistical tools.
7. Exercise for solving optimization problems using solver and using statistical tools.
8. C++ /Java/python/R/MATLAB programming for statistical analysis and probability studies

4. REFERENCES:

1. Benjamin J. R., Cornell C. A., *Probability Statistics and Decision for Civil Engineers,* McGraw-Hill, 1970.
2. Kothari, C.R., *Research Methodology: Method and Techniques,* New Age International Publication, 2004.
3. Hines W. W., Montgomery D. C., *Probability and Statistics in Engineering and Management Science*, John Wiley and Sons, New York, 1990.
4. Sharma J.K., *Operation Research: Theory & Applications*, MacMillan India Ltd., 2000.
5. Bhandarkar P.L., Wilkinson T.S., *Methodology & Techniques of Social Research*, Himalaya Publishing House, 1991.
6. Simon P. Washington, Matthew G. Karlaftis, Fred, Mannering L., *Statistical and econometric methods for transportation data analysis*, CRC Press, Second Edition, 2010.
7. Washinton SP, Karlafits MG, Mannering F.L., *Statistical and econometric method for transportation data analysis*, 2nd addition, CRC Press, 2011.
8. Richard A. Johnson, Dean W. Wichern, *Applied Multivariate Statistical Analysis,* Prentice Hall, 1992.

9. Cooley, WW and Lohnes, RR, *Multivariate Data Analysis*, John Wiley, 1971.
10. Joseph F. Hair, Bill Black, Barry Babin, Rolph E. Anderson, Ronald L. Tatham, *Multivariate Data Analysis*, Prentice Hall; 2005.

5. CO-PO-PSO_Mapping

Course Objective	Program Specific Outcome			Program outcomes		
	PSO1	PSO2	PSO3	PO1	PO2	PO3
1	3	3	3	3	3	3
2	3	2	2	3	2	3
3	3	3	3	3	3	3
4	3	2	3	3	3	3
5	3	3	3	3	2	3

Note: 1: Slightly 2: Moderately 3: Substantially

CEST112: Theory of Elasticity & Plasticity

L	T	P	C
3	-	-	3

1. **Course Outcomes (COs):**

At the end of the course students will be able to:

CO1	Comprehend and apply principles of elasticity in sufficiently rigorous manner
CO2	Evaluate the response of the structure against three-dimensional stress state at a given point
CO3	Demonstrate the skill of problem formulations in elastic analysis
CO4	Analyzethe solutions of 2D and 3D elementary problems in elasticity
CO5	Implement the concept of plasticity in a plastic analysis of structural forms

2. **Syllabus:**

- **Basic Concepts and Material Properties: (09 Hours)**
  Force,Surfaces forces, Body forces, Statical and Kinematical indeterminacy, Macroscopic and microscopic properties, Isotropy, Homogeneity, Continuity, Uniaxial stress-strain relationship, Elasticity, Anelasticity, Work hardening, Ductility, Plasticity, Creep, Relaxation, Fatigue, Hysteresis, Bauschinger effect, Elastic, plastic and Viscous models.
- **Three-dimensional Elasticity: (11 Hours)**
  Stress-tensor, Components of stress tensor,Equations of equilibrium in 2D and 3D Cartesian coordinates, Stresses on inclined plane, Transformation of stresses, Octahedral shear stresses, Stress invariants, Cauchy’s stress quadric, Equilibrium equations in Polar coordinates, Strain-tensor, Components of strain tensor, Saint-Venant’s Compatibility equations, Plane stress problem, Plane strain problem.
- **Formulations of Problems in Elasticity: (09 Hours)**
  Stress-strain relation in 3D field, Generalised Hook’s law,Relation between elastic constants, Displacement formulation or Navier’s equations, Beltrami-Michell compatibility equations,
- **Application of Theory of Elasticity: (08 Hours)**
  Airy’s stress function, Solution of simply supported beams and cantilever beams subjected to different loadings by polynomials. Bending of prismatic bar, Saint-

Venant's theory of torsion, Prandtl's theory of torsion, Membrane analogy.

- **Plasticity: (08 Hours)**

  Principal stress state**,** Yield criteria and it's graphical representation,PlasticStress-strain relations and diagrams, Flow rules, Strain hardening criteria. Plastic analysis of structural forms.

[Total Theory Hours: 45]

3. References:

1. Timoshenko S. P; and Goodier J. N; "Theory of Elasticity", MC Graw Hill Book Co., Inc., New York, USA, (2016).
2. Volterra E; & Gaines J. H; "Advanced Strength of Materials", Prentice Hall Publication, New York, USA, (2012).
3. Venkatraman B; & Patel S. A; "Structural Mechanics with Introduction to Elasticity and Plasticity", MC Graw Hill Publication, New York, USA, (2014).
4. Filonenko M; "Theory of Elasticity" Borodich Dover Publication, New York, USA, (2013).
5. Wang C. T; "Applied Elasticity" Mc Graw Hill Publication, NY, USA, (2011).
6. Chakrabarty J; "Theory of Plasticity", Elsevier publications, New York, USA, (2016).
7. Budynas R.," Advanced Strength and Applied Stress Analysis", Prime Publication, New York, USA, (2016).
8. Boresi, A.P., & Sachmidt. R. J., "Advanced Mechanics of Materials", Wiley Publication, New York, USA, (2016).

4. CO-PO-PSO Mapping:

	PO1	**PO2**	**PO3**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	3	2	2	3
CO2	2	1	3	3	3	2
CO3	3	2	3	2	3	1
CO4	2	1	2	3	3	2
CO5	3	1	2	3	2	3

Note:- 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEGT120Rock Mechanics

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

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Comprehend the origin of rocks, engineering behaviour of rock and rockmass.
CO2	Evaluate the physico-mechanical properties of rock and rockmass.
CO3	Classify the rock and rockmass using different classification systems.
CO4	Predict the strength and elastic properties of rock and rockmass using different failure criteria and empirical relations.
CO5	Design the support systems and other improvement method for rockmass.

2. Syllabus

- **INTRODUCTION** **(07 Hours)**
  Origin, interior and composition of the earth, Rock cycle, Layered formations, Measurement of attitude of formations, Joints, Faults, Stereographic projection methods, Presentation of geological data and analysis, Applications, Rock material, Engineering properties of rocks, Index properties of rocks.

- **LABORATORY TESTING IN ROCK ENGINEERING** **(07 Hours)**
  Laboratory tests for various physical and mechanical properties. Stress-Strain relationship, Direct Shear test, triaxial test, Creep test, Hardness test, Permeability test, Deformability etc.

- **INSITU STRESS** **(07 Hours)**
  Insitu stress, various methods of stress measurement, Hydrofracturing technique, Flat jack technique, Overcoring technique, Plate Loading Test, Jacking Test, Cable Jacking Test, Pressure Chamber Test, Borehole Deformation Test, Permeability Test etc.

- **FAILURE CRITERIA FOR ROCK AND ROCK MASSES** **(07 Hours)**
  Coulomb, Mohr's, Griffiths criteria, Rheology and rheological models, Mohr-Coulomb Yield Criterion, Drucker-Prager Criterion, Hoek-Brown Criterion, Murrell criteria, Bieniawski criteria, etc.

- **JOINTED ROCKMASS** **(09 Hours)**

Strength and deformability of jointed rock mass, Shear strength of jointed rocks, roughness, peak and residual strengths, Strength criteria for rockmass, Intact and rockmass classifications, Terzaghi, RQD, RSR, RMR and Q classifications, Applications.

- **IMPORTANT TOPICS IN ROCK MECHANICS (08 Hours)**

  Brittle – ductile transition, In-situ determination of elastic properties of rocks by dynamic method, Weathered rocks, Creep behaviour, Post failure behaviour, Flow through fractured rockmass, Methods to improve rock mass responses, Grouting in Rocks, Rock bolting, Rock Anchors.

(Total Lecture Hours 45)

3. References

1. Stagg K G & Zienkiewicz O C, "Rock Mechanics in Engineering Practice", John Wiley & Sons, London, 1969.
2. Billings MP, "Structural geology. Englewood Cliffs," New Jersey: Prentice-Hall; 1972.
3. Goodman R E, "Introduction to Rock Mechanics", John Wiley & Sons, New York, 1989.
4. Ramamurthy T., "Engineering in Rocks for Slopes, Foundation and tunnels", Prentice Hall of India Pvt Ltd, New Delhi, 2010.
5. Hudson J A and Harrison J P., "Engineering Rock Mechanics – An Introduction to the Principles" Elsevier, Oxford, 2000.
6. Mogi K, "Experimental rock mechanics", CRC Press, Vol 3, 2006
7. Jaeger, Cook and Zimmerman, "Fundamentals of Rock Mechanics", Blackwell Publishing, Fourth Edition, 2007.
8. Ghosh SK, "Structural geology: fundamentals and modern developments", Elsevier; 2013
9. Jumikis R. Alfreds, " Rock Mechanics" Trans Tech Publications, 1979 Koerner, R.M. "Designing with Geosynthetics", Prentice Hall, New Jersey, USA, 5th edition, 2005.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	2	1	2	1	1
CO2	2	2	2	2	1	2
CO3	2	2	3	2	2	2
CO4	2	3	3	2	2	3
CO5	3	3	3	3	3	3

1-Low 2-Moderate 3-High

CEGT121Constitutive Modelling in Geomechanics

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Illustrate the basic concepts of continuum mechanics
CO2	Comprehend the failure theory and yielding criterion of geo-materials
CO3	Illustrate the concept of critical state mechanics for development of constitutive models
CO4	Identify and select the suitable constitutive models to represent the real soils based on problem and materials involved.
CO5	Applying the appropriate constitutive models in FE analysis of geotechnical structures

2. Syllabus

- **INTRODUCTION TO CONTINUUM MECHANICS (6 Hours)**
  Stresses and strains, elastic stress-strain relations, Two-dimensional plane stress, plane strain and axisymmetric problems, equilibrium equations, compatibility equations and constitutive relations for linear elastic materials.

- **BEHAVIOUR OF REAL SOIL (6 Hours)**
  Soil anisotropy, concept of effective stress, drained and undrained conditions, Concept of different modulus of elasticity of soil, stress path, triaxial test data of real soil, Determination of different moduli of elasticity.

- **FAILURE THEORIES (4 Hours)**
  Mohr-Coulomb, Drucker-Prager, Tresca, Von-mises Failure theory and Cap models. Difference between yielding and failure.

- **PLASTICITY (6 Hours)**
  Plasticity basics: Yield criteria, Associated and non-associated flow rules, Plastic potentials, Hardening/Softening, Yielding envelopes of real soils, Stress dilatancy

theory, Plastic potential functions, Tension cut-off in soils, Work hardening plasticity theory: formulations and implementations, Hypo elasticity-plasticity.

- **CRITICAL STATE SOIL MECHANICS (11 Hours)**
  Critical state concept, Critical state parameters, Stress History, Normal compression line, Unloading-reloading line, Critical state interpretations (p'-q, v-p' space), Ko-line, Total and Effective stress path, Determinations of Critical state parameters, Cam-clay models and simulations, Case study on use of Cam-clay models.

- **CONSTITUTIVE MODELS IN GEOMECHANICS (12 Hours)**
  Role of constitutive model in geotechnical FEA, Simple constitutive models, Elastic models (linear elasticity, non-linear elasticity and elastic anisotropy), Principles of elasto-plastic models, Mohr Coulomb model and its limitations, Other elastic-perfectly plastic models (von Mises, Tresca, Drucker-Prager), Linear Elastic and variable moduli models, No-tension models, Hyperbolic model: Hardening Soil model and Hardening soil model with small-strain stiffness, Soft soil model, Cam-Clay models. Selection of the soil model dependent on the problem and materials involved.

(Total Lecture Hours 45)

3. References

1. Ugural, A. C. and Fenster, S. K. (2012). Advanced Mechanics of Materials and Applied Elasticity, PrenticeHall, New Jersey. References
2. Mase, G. T. and Mase, G. E. (1999). Continuum Mechanics for Engineers, CRC Press, Boca Raton.
3. Puzrin, A. M. (2012). Constitutive Modelling in Geomechanics: Introduction, Springer-Verlag, Berlin.
4. Nakai, T. (2013). Constitutive Modeling of Geomaterials: Principles and Applications, CRC Press, Boca Raton.
5. Schofield, A. N., & Wroth, P. (1968). Critical State Soil Mechanics (Vol. 310). London: McGraw-hill.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	**1**	**1**	**1**	**-**	**1**	**1**
CO2	**1**	**1**	**2**	**1**	**1**	**2**
CO3	**1**	**1**	**2**	**1**	**2**	**2**
CO4	**2**	**1**	**3**	**2**	**2**	**3**
CO5	**3**	**2**	**3**	**2**	**3**	**3**

1-Low 2-Moderate 3-High

CECT111 LOW COST CONSTRUCTION

L	T	P	C
3	0	0	3

1. Course Outcomes:

At the end of the course, students will be able to

CO1	Comprehend the aspects of low cost and sustainable infrastructure development
CO2	Identify the cost effective materials for the infrastructure development projects
CO3	Illustrate the applicability of low cost techniques and equipment in construction projects
CO4	Apply the low-cost methods for wastewater disposal systems and sanitation in rural and urban areas
CO5	Evaluate the cost benefits of using low-cost methods in construction projects

2. Syllabus

- **Concepts of low cost materials**

  Soil, Fly ash, Ferro cement, Lime, Fibers, Stone Dust, Boulders and oversize metal, Bitumen etc.

- **Low cost building material products**

  Walls; Stabilized and sun dried, soil blocks & bricks, Hollow concrete blocks, stone masonry blocks, Ferro cement partitions. Roofs ; Precast R.C. Plank & Joists roof, Precast channel roof, Precast L-panel roof, Precast Funicular shells, Ferro cement shells, Filler Slab, Seasal Fiber roof, Improved country tiles, Thatch roof.

- Low cost construction Techniques and Equipment

  Techniques; Rat trap bond construction, Precast R.C. and Ferro cement technique, Mud Technology. Equipments ; Brick molding machine, Stabilized soil block making machine and plants for the manufacturing of concrete blocks, Low Cost Roads.

- **Low cost sanitation**

  Waste water disposal system, Low cost sanitation for rural and urban areas, Ferro cement Drains

- **Cost analysis and comparison**

  Low cost materials, Low cost techniques

3. References:

1. Lal, K (2011) Handbook of Low Cost Housing, 1st Edition. New Age International Publisher
2. NBO, Handbook of Housing Statistics, Government of India.

1. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	1	2	2	2	3
CO2	2	1	2	2	1	3
CO3	2	2	2	2	2	3
CO4	2	2	2	1	1	3
CO5	3	3	3	1	1	3

Note: 1: Slightly 2: Moderately 3: Substantially

CETP117PAVEMENT ANALYSIS AND DESIGN

L	T	P	C
3	0	0	3

2. Course Outcomes (COs)

CO1	Comprehend the behaviour of pavement based on material characteristics
CO2	Analyse the pavement by considering various input parameters appropriately.
CO3	Select the rational method of pavement design.
CO4	Identify the design criteria based on the major failure patterns of pavement.
CO5	Design the pavement with the guidelines given by IRC, AASHTO, and PCA.

3. Syllabus

- **PAVEMENT TYPES AND MATERIALS** **(03 Hours)**

  Types and component parts of pavements; highway and airport pavements, Basic characteristics of materials used in pavements

- **STRESSES IN FLEXIBLE PAVEMENTS** **(08 Hours)**

  Layered system concepts, Stress solution for one, two- and three-layered systems, Fundamental design concepts, Stress analysis in flexible pavements using KENLAYER; problems

- **STRESSES IN RIGID PAVEMENTS** **(06 Hours)**

  Westergaard's theory and assumptions, Stresses due to curling, stresses and deflections due to loading, frictional stresses, Stresses in dowel bars and tie bars, Stress analysis in rigid pavements using KENSLABS; problems.

- **FACTORS AFFECTING PAVEMENT DESIGN** **(06 Hours)**

  Variables considered in pavement design, Classification of axle types, standard and legal axle loads, tyre pressure, contact pressure, ESWL, EWLF and EAL concepts, Traffic analysis: ADT, AADT, truck factor, growth factor, lane distribution factor, directional distribution factor and vehicle damage factor

- **DESIGN OF FLEXIBLE PAVEMENT** **(09 Hours)**

  IRC method of flexible pavement design, Asphalt Institute's methods with HMA and other base combinations, MEPDG method of flexible pavement design, Design of flexible pavement shoulders; problems.

- **DESIGN OF RIGID PAVEMENTS** **(09 Hours)**

  IRC method of plain jointed and continuously reinforced rigid pavement design , MEPDG method of rigid pavement design, Design of rigid pavement shoulders. Design of Joints; problems.

- **DESIGN OF PAVEMENT DRAINAGE** **(04 Hours)**

  Detrimental effects of water, methods for controlling water in pavements, Drainage materials: aggregates, geotextiles, pipes, Estimation of inflow, determination of drainage capacity, Drainage design for urban roads and rural roads as per IRC; problems

(Total contact hours: 45)

4. <u>REFERENCES</u>:

1. Asphalt Institute. Thickness Design – Asphalt Pavements for Highways and Streets Manual Series No. 1 (MS-1), Asphalt Institute, Kentucky, USA, 1999.
2. Das, A.Analysis of Pavement Structures, CRC Press, Taylor and Francis Group, Florida, USA, 2015.
3. Huang, Y.H. Pavement Analysis and Design, Second Edition, Dorling Kindersley (India) Pvt. Ltd., New Delhi, India, 2008.
4. IRC: 37-2012Guidelines for the Design of Flexible Pavements, The Indian Roads Congress, New Delhi, India, 2012.
5. IRC:58-2015Guidelines for the Design of Plain Jointed Rigid Pavements for Highways, The Indian Roads Congress, New Delhi, India, 2015.
6. Mallick, R.B. and T. El-KorchiPavement Engineering – Principles and Practice, CRC Press, Taylor and Francis Group, Florida, USA, 2009.
7. MEPDG-1.Mechanistic-Empirical Pavement Design Guide - A Manual of Practice, Interim Edition, American Association of State Highway and Transportation Officials, Washington, D.C., USA, 2008.

8. Papagiannakis, A.T. and E.A. MasadPavement Design and Materials, John Wiley and Sons, New Jersey, USA, 2008.
9. Yoder, E.J. and M.W. WitczakPrinciples of Pavement Design, Second Edition, John Wiley and Sons, New York, USA, 1975.

5. CO-PO-PSO_Mapping

	PSO1	**PSO2**	**PSO3**	**PO1**	**PO2**	**PO3**
1	2	3	3	3	1	3
2	2	3	1	3	2	3
3	3	3	2	3	2	3
4	3	3	1	1	2	2
5	3	2	1	3	3	3

Note: 1: Slightly 2: Moderately 3: Substantially

CEGT104 Geotechnical Engineering Laboratory

L	T	P	C
0	0	4	4

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Perform the laboratory tests for the determination of various geotechnical parameters
CO2	Perform field tests for the determination of various geotechnical parameters
CO3	Evaluate laboratory and field test results of different types of soil to identify the governing factors in geotechnical engineering

2. Practicals

1. Compaction tests - standard and modified Proctor tests
2. Permeability tests – constant head and falling head methods
3. Unsoaked and soaked CBR tests
4. Unconfined compression test
5. Vane shear and Direct shear test
6. Consolidation test
7. Triaxial compression test (UU, CU & CD)
8. Swell pressure test
9. Relative density test
10. Cyclic triaxial test
11. Field geotechnical investigations and field tests: Drilling of bore holes; undisturbed sampling and Standard Penetration Test
12. Dynamic Cone Penetration Test (large and small size)
13. Structural evaluation of road pavement using Falling Weight Deflectometer

14. The testing on rocks: Compression test, Point load test, Brazilian test, Slack durability test, and Creep test.

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3. References

1. Bowles, J. E., “Engineering Properties of Soils and their Measurement”. McGraw-Hill Book Company, Singapore.1992.
2. Lambe W., T., “Soil Testing for Engineers”, Wiley Eastern Limited, New Delhi.1993.
3. Head, K. H., “Manual of Soil Laboratory Testing” Volume 1-3, John Wiley and Sons, Singapore.1998.
4. SP-36., “Compendium of Indian Standards on Soil Engineering”, Part 1: Laboratory Testing of Soils for Civil Engineering Purposes, Bureau of Indian Standards, New Delhi.1987.
5. Bardet, J. P., “Experimental Soil Mechanics”, Prentice Hall, New Jersey .1997.
6. All relevant IS Codes.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	1	2	2	1	1
CO2	2	1	2	2	1	2
CO3	3	2	3	3	2	3

1-Low 2-Moderate 3-High

Semester II

CEGT210Finite Element Method in Geotechnical Engineering

L	T	P	C
3	1	0	4

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Illustrate the basic concepts of finite element (FE) analysis
CO2	Identify and select the suitable element and mesh configuration to obtain converged solution
CO3	Develop the element characteristic equation and generation of global equation
CO4	Create 1D, 2D and 3D FE models of practical problems
CO5	Applying the FE analysis on actual problem to determine induced displacements, forces, stresses and strains

2. Syllabus

- **INTRODUCTION (7 Hours)**

  Matrix algebra, Fundamentals of continuum mechanics, Stresses, displacements and strains in soils, solids and structures, Constitutive relations and models. Differential equations in solid and soil mechanics. Analytical and Numerical Solutions: Closed form solutions, Why study numerical analysis? Numerical methods - FDM, FEM and DEM. Introduction to FEM

- **FORMULATIONS IN FEM (5 Hours)**

  Matrix method, Potential energy method, Rayleigh-Ritz method, Weighted Residual method: Galerkin's Method. Errors in FEM.

- **ONE- AND TWO-DIMENSIONAL PROBLEMS (10 Hours)**

  Plane stress and strain, Interpolation functions, Shape functions (Lagrangian/Natural), Isoparametric elements – 1D and 2D, Numerical integration. Lagrangian elements, Infinite elements, Joint elements, Serendipity elements, Transition elements, Assembly and Solution techniques, Convergence requirements, Patch test, Examples.

- **AXISYMMETRIC PROBLEMS (5 Hours)**

  Formulation and Examples.

- **THREE-DIMENSIONAL PROBLEMS, CONSTITUTIVE MODELLING (8 Hours)**

  Formulation and Examples, Constitutive models in soils: Elastic, Elastic-plastic and No-tension models, Hyperbolic models, Introduction to Cam-Clay classes of mode.

- **FE ANALYSIS IN GEOTECHNICAL ENGINEERING(6 Hours)**

  Applications: In situ earth pressure, Construction and excavation sequences, Slope stability analysis (c-φ reduction), Seepage, Consolidation, Settlement analysis, Introduction to Dynamic consideration. Use of structural elements in Geotechnical systems.

- **TECHNIQUES FOR NONLINEAR ANALYSIS (4 Hours)**Iterative techniques: initial stress and strain methods, Tangent Stiffness methods, Stress correction method. Preprocessing and Post processing, Tutorials/Assignments.

(Total Lecture Hours 45, Tutorial: 15 hours)

3. <u>References</u>

1. Das B M, "Fundamental of Soil Dynamics", Elsevier Scientific Publishing Co., New York, 1983
2. Zienkiewicz OC, Taylor RL and Zhu JZ, The Finite Element Method Its Basis and Fundamentals, Elsevier, Amsterdam, 2014.
3. Logan DL, A First Course in the Finite Element Method, Cengage-Learning, New Delhi, 2007.
4. Reddy JN, An Introduction to the Finite Element Method, McGraw-Hill, New Delhi, 2005.
5. Cook, R. D., Malkus, D. S., Plesha, M. E. and Witt, R. J. (2002). Concepts and Applications of Finite Element Analysis, John Wiley and Sons, New York.

6. Nakai, T. (2013). Constitutive Modeling of Geomaterials: Principles and Applications, CRC Press, Boca Raton.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PO3
CO1	2	1	1	-	1	1
CO2	2	1	2	-	1	1
CO3	2	2	2	-	2	2
CO4	3	3	3	2	3	3
CO5	3	3	3	3	3	3

1-Low 2-Moderate 3-High

CEGT 211 Structural Geology

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Comprehend the fundamental principles and processes in geology
CO2	Classify different type of rocks, their formation and mineral composition
CO3	Analyze geological data using Stereographic projection methods and DIPS software
CO4	Predict the effect of different structural features on the design of civil engineering structures
CO5	Evaluate the geological condition for different geotechnical structures

2. Syllabus

- **INTRODUCTION** **(8 Hours)**
  General geology, Earth and Earth processes, Origin, Interior and age determination of Earth, Physical geology, Mineralogy, Petrology. Study of Igneous, Sedimentary, and Metamorphic rocks, Silicate structures, Symmetry elements, Mineral characteristics and Families of minerals.

- **PROCESSES IN GEOLOGY** **(8 Hours)**
  Igneous processes, Bowen's reaction principle, textures and structures of plutonic and volcanic rocks, Weathering processes, Sedimentary processes, Structures of sedimentary rocks, Effects of pressure and temperature, Metamorphic rocks and structures, Geological work of Rivers, Sea/Oceans, Glaciers, Wind and Deposits, Himalayan Geology

- **STRUCTURAL ELEMENTS** **(7 Hours)**
  Structural features, Beds, Folds, Joints, Faults and their Influence on Civil structures, Rockmass description, Plate tectonics and Sea floor spreading, Continental drift,

Mechanical behavior of soils and rocks, Principles of stratigraphy, Standard stratigraphic Time Scale, Indian stratigraphy, Distribution of various economic minerals, their composition and mode of occurrence.

- **MECHANICS OF FORMATION AND MEASUREMENT (11 Hours)**
  Layered formations, Attitude, true and apparent dips, topographic maps, outcrops. Measurement of attitude of formations. Folds, types of folds, classification, field study of folds, mechanics of folds, causes of folding. Joints, rock mass concept, Joint description and classification. Three point problems, Depth and thickness problems. Faults, mechanics of faulting, normal, reverse and thrusts, faults. Lineations. Foliations, Schistocity. Fault problems, Structural Associations.

- **FIELD STUDY AND GEOLOGICAL PROBLEMS (11 Hours)**
  Collection of geological data, Resistivity and Seismic Refraction methods, Scan line survey, Stereographic projection methods, Use of DIPS software, presentation of geological data and analysis, Applications, Earthquakes, Landslides, Subsidence, Erosion, Karst formations, Engineering properties of Rocks, Site selection for Slopes, Tunnels and Foundations, Rock as a construction material

(Total Lecture Hours 45, Tutorial: 15 hours)

3. References

1. Vallejo, L. G. DE.& Ferrer, M., Geological Engineering, CRC Press, Balkema, 2011.
2. Billings, B, F. G., Fundamentals of Engineering Geology, Butterworth-Heinemann, Oxford, 2016.
3. Gangopadhyay, A C Mclean, & Gribble, C D, Geology for Civil Engineers, 2nd Edition, E. & F. N. Spon, London, 1995.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	2	1	2	1	1
CO2	1	2	1	2	1	1
CO3	2	2	2	2	3	2
CO4	3	3	3	3	3	3
CO5	3	3	3	3	3	3

1-Low 2-Moderate 3-High

CEGT201Ground Improvement Techniques

L	T	P	C
3	1	0	4

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Identify the mineral composition responsible for the weak soil deposits and problems associated with it.
CO2	Understand general construction procedures and inspection items for ground improvement techniques.
CO3	Analyse various index/strength properties of soil and suggest suitable ground improvement method.
CO4	Ability to design the ground improvement methods as per site requirements using various national/international codal guidelines.
CO5	Ability to prepare numerical modelling for various ground improvement techniques.

2. Syllabus

- **INTRODUCTION** **(06 Hours)**

  Ground Improvement: Definition, Objectives of soil improvement, Classification of ground improvement techniques, Factors to be considered in the selection of the best soil improvement technique. Weak Deposits – Identification – Problems associated with weak deposits – Mitchel chart of applicability of treatment methods – Principles – Suitable methods . Mechanical Modification, Principle of modification for various types of soils

- **DEEP GROUND IMPROVEMENT** **(10 Hours)**

  Insitu compaction of cohesion less soil – Dynamic compaction & blasting - Vibroflotation – stone column – Encased stone column, stone column design as per codal provisions – strengthening of sub soil by stone column installation. Lime piles.

- **HYDRAULIC MODIFICATION (06 Hours)**

  Definition, aim, principle, techniques. gravity drain, lowering of water table, multistage well point, vacuum dewatering. Discharge equations. Design of dewatering system including pipe line effects of dewatering, Preloading, vertical drains, sand drains. Assessment of ground condition for preloading, Electro kinetic dewatering.

- **GEOSYNTHETICS AND REINFORCED SOIL (07 Hours)**

  Types of geosynthetics like geotextiles, geogrids, geonets, geocells, geo-composites, their functions, applications and manufacturing methods. Index properties and Strength properties of Geosynthetics. Historical background of reinforced soil, Principles of reinforced soil. Concept of MSE wall and Reinforced Soil slopes.

- **GROUTING (06 Hours)**

  Types of Grouts, Desirable characteristics of Grout, Grouting methods- Permeation grouting, displacement-compaction grouting, displacement-soil fracture grouting, Jet or Replacment-displacement grouting. Grouting pressure, Grouting technology

- **SOIL STABILIZATION (05 Hours)**

  Soil stabilization with admixtures like lime, flyash, cement etc, Properties of chemical components, reactions and effects. Bitumen, tar or asphalt in stabilization

- **MISCELLANEOUS METHODS (05 Hours)**

  Micro piles, Soil nailing, Ground Anchors, ground freezing and heating methods.

(Total Lecture Hours 45, Tutorial: 15 hours)

3. References

1. Hausmann M.R. “Engineering Principles of Ground Modification” McGraw Hill Publishing Company, New York, 2013
2. Koerner, R.M. "Designing with Geosynthetics", Prentice Hall, New Jersey, USA, 6th edition, 2012.
3. Jie H., " Principles and Practice of Ground Improvement, Wiley India, 2018

4. Patra N. H., “Ground Improvement Techniques”, Vikas publishing house Pvt. Ltd., 2013.
5. Chu, Jian; Indraratna, B; Rujikiatkamjorn, C, " Ground improvement case histories: compaction, grouting, and geosynthetics", Butterworth Heinemann - Elsevier, 2015
6. Design guidelines from IS code, FHWA, BS and other codal organizations

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	**1**	**1**	**1**	**1**	**1**	**1**
CO2	**1**	**1**	**1**	**1**	**1**	**1**
CO3	**2**	**2**	**2**	**3**	**3**	**2**
CO4	**2**	**2**	**2**	**2**	**2**	**2**
CO5	**2**	**2**	**3**	**3**	**3**	**2**

1-Low 2-Moderate 3-High

CE202Soil Dynamics and Earthquake Geotechnics

L	T	P	C
3	1	0	4

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Illustrate a basic background on geotechnical earthquake engineering and to develop basic competence in assessing seismic hazard and in characterising earthquake actions.
CO2	Demonstrate knowledge of Free and Forced vibrations.
CO3	Investigate Dynamic Soil Properties and Stress-strain behaviour of soils under cyclic loading.
CO4	Evaluate different geotechnical structures and access the liquefaction potential of a given site.
CO5	Design various types of machine foundation and capable of selecting the types of vibration isolation materials and techniques.

2. Syllabus

- **INTRODUCTION** **(3 Hours)**

  Introduction to soil dynamics and geotechnical earthquake engineering, Scope and objective, Nature and types of earthquake loading, Importance of soil dynamics, Importance of Geotechnical Earthquake Engineering.

- **THEORY OF VIBRATIONS** **(5 Hours)**

  Basics of vibration theory, Concept of dynamic load, Earthquake load, Single degree of freedom system, Multiple degree of freedom system, Free and forced vibrations, Damped and undamped systems, Equation of Motion.

- **ENGINEERING SEISMOLOGY** **(4 Hours)**

  Basic Seismology, Earthquake, List of major earthquakes, Causes of earthquakes, Sources of earthquake data, Faults, Plate tectonics, Seismograph and Seismogram, deterministic and probabilistic seismic hazard analysis, local site effects, ground response analysis.

- **EARTHQUAKE MAGNITUDE AND INTENSITY** **(6 Hours)**

Strong Ground Motion, Size of Earthquake, Magnitude and Intensity of Earthquake, Modified Mercalli Intensity Scale, Measuring of Earthquake, Earthquake Magnitude Local (Richter) magnitude, Surface wave magnitude, Moment magnitude, Seismic energy, Correlations, Spectral Parameters: Peak Acceleration, Peak Velocity, Peak Displacement.

- **WAVE PROPAGATION (3 Hours)**
  Types of waves, Seismic Travel Time Curve, Method for locating an Earthquake's Epicentre**.**

- **DYNAMIC SOIL PROPERTIES (6 Hours)**
  Dynamic stress, deformation and strength of soils, Effect of transient and pulsating loads, Field and Laboratory evaluation of dynamic soil properties, Resonant column test, Field tests, Typical values of soil constants.
- **LIQUEFACTION OF SOIL (6 Hours)**
  Liquefaction of soils, Factors influencing liquefaction, Liquefaction potential, Liquefaction evaluation from standard penetration test, CPT and shear wave velocity of soil.

- **MACHINE FOUNDATIONS (5 Hours)**
  Types of machine foundation, General criteria, Soil dynamic parameters, Block type machine foundation (Checking of resonance and permissible amplitude), Vibration isolation techniques**.**

- **SEISMIC ANALYSIS AND DESIGN OF GEOTECHNICAL STRUCTURES (7 Hours)**
  Pseudo-static, pseudo-dynamic and time history analysis, dynamic earth pressure, response spectra, Seismic slope stability analysis, Seismic design of shallow foundation, pile foundation, and uplift ground anchors, Codal provisions.

(Total Lectures: 45 hours)

3. References

1. Prakash S., "Soil Dynamics", McGraw-Hill Book Company,1981.

2. Steven L.K.,“Geotechnical Earthquake Engineering”,Prentice Hall Inc,1996.
3. Robert W. D.,“Geotechnical Earthquake Engineering Handbook”, McGraw Hill, New York,2012.
4. TowhataI.,“Geotechnical Earthquake Engineering”,Springer-Verlag Heidelberg,2008.
5. Ishihara, K.,“Soil Behaviour in Earthquake Geotechnics”, Oxford University Press, USA,1996.
6. Srbulov,M., “Geotechnical Earthquake Engineering:Simplified Analyses with Case Studies and Examples”,Springer-Verlag,2008.
7. Barkan, D.D., “Dynamics of Bases and Foundations”, McGraw-Hill Book Company,1962.
8. IS 1893, Indian Standard Criteria for earthquake resistant Design of Structures.
9. Saran S., Soil Dynamics and Machine Foundations. Galgotia Publications, 1999.
10. IS 2974 (Part I)-1982, Code of Practice for Design and Construction of Machine Foundations, Part I- Foundation for reciprocating type machines.
11. IS 2974 (Part II)-1980, Code of Practice for Design and Construction of Machine Foundations, Part II- Foundation for Impact type Machines (Hammer Foundations).
12. IS 2974 (Part III)-1992, Design and Construction of Machine Foundations- Code of Practice, Part III- Foundation for Rotary type Machines (Medium and High Frequency).
13. IS 2974 (Part IV)-1979, Code of Practice for Design and Construction of Machine Foundations, Part IV- Foundation for Rotary type Machines of Low Frequency.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	3	1	3	2	1
CO2	3	2	2	2	3	3
CO3	2	2	3	3	3	2
CO4	3	1	2	2	2	2
CO5	3	3	2	3	3	2

CEGT220Environmental Geotechnology

L	T	P	C
3	0	0	3

1. **Course Outcomes (COs)**

At the end of the course the students will be able to:

CO1	Identify the subsurface contamination and describe contaminant transport through geo-media.
CO2	Comprehend the characteristics of municipal solid waste and industrial by-products for their reuse in civil engineering structures.
CO3	Illustrate the application of various geosynthetics materials in the construction of landfills.
CO4	Design the solid waste disposal system and its components.
CO5	Design the slurry waste containment system using various methods of raising.

2. **Syllabus**

- **SUBSURFACE CONTAMINATION AND CONTAMINANT TRANSPORT (06 Hours)**

  Sources of subsurface contamination, Detection of polluted zones, Control and Remediation, Transport of contaminants by advection, diffusion, dispersion phenomena; Chemical mass transfer processes through sorption & desorption, precipitation & dissolution.

- **COMPOSITION OF SOLID WASTES (05 Hours)**

  Composition and characterization of solid waste; Determination of moisture content and organic content of MSW; Material loss fraction; Factors affecting unit weight of MSW; In-situ large Direct Shear Test for MSW; Environmental laws, regulations and assessment. ISWM Techniques.

- **CONTAINMENT OF SOLID WASTE IN LANDFILLS (18 Hours)**

  Landfills – Types, shapes, sizes; Components of landfill with their functions and requirements; typical sections of liner and cover system for hazardous and non-hazardous landfills;

  Clay liner and Compatibility: Compacted clay liner (CCL); Liner specifications; Clay mineralogy and its role in hydraulic performance of CCL; Hydraulic conductivity estimation;

Geosynthetic Clay Liner (GCL): Introduction and basic properties; Swelling and hydraulic characteristics; Solute and gas migration; Installation of GCL; Role of GCL in composite liners; Equivalency of GCL and CCL.

Geomembrane Liner (GM): Physico-mechanical response of GM; Endurance properties of GM, Service life estimation by considering ageing of GM; Leakage through GM and Installation & seaming of GM.

Design of cover systems: Introduction; Common final cover systems; Infiltration theories; Calculating percolation through cover systems; Erosion assessment; Evaluation of drainage layer capacity; Cover slope stability analysis.

Design of liner systems: Geomembrane stability against Tensile stress under self-weight, Tensile Stress under waste down-drag during filling and Adequate anchorage; Stability of soil over Geomembrane; Settlement of land fill base on soft soil; Stability for moving vehicle on ramp; Selection of drainage layer material and thickness for leachate collection.

- **CONTAINMENT OF SLURRY WASTES (06 Hours)**

  Ponds or Impoundments; Operation; Embankment construction; Methods of raising in stages; Design aspects; Environmental impact and control. Design and maintenance of ash pond for fly ash disposal.

- **VERTICAL BARRIERS FOR CONTAINMENT (04 Hours)**

  Suitable types and requirements of vertical barriers; Soil-Bentonite slurry trench walls; Cement-Bentonite slurry trench walls.

- **GEOTECHNICAL REUSE OF WASTE MATERIAL (06 Hours)**

  Waste characteristics for soil replacement; Engineering Properties of waste and geotechnical reuse; sustainability; Waste material in embankments and fillsWeak Deposits- Identification-Problems associated with weak deposits- Mitchel chart of applicability of treatment methods.

(Total Lectures: 45 hours)

3. <u>References</u>

1. Rowe, R. K., Quigley, R. M., Brachman, R. W. I. and Booker, J. R. “Barrier Systems for Waste Disposal Facilities”, Taylor & Francis, London, UK. 2004.
2. Sharma, H. D. and Reddy, K. R. “Geoenvironmental Engineering: Site Remediation, Waste Containment and Emerging Waste Management Technologies”, John Wiley & Sons, New Jersey, USA. 2004.
3. Koerner, R. M., “Design with Geosynthetics”, Xlibris Corporation, USA. 2012.
4. Datta, M., Parida, B.P., Guha, B.K. and Sreekrishnan, T., “Industrial Solid Waste Management and Landfilling Practice”, Narosa Publishers, Delhi. 1999.
5. Gulhati, S. K. and Datta, M., Geotechnical engineering, Tata McGraw-Hill, New Delhi, 2005.
6. Regulations and guidelines developed by USEPA, http://www.epa.gov/
7. Regulations and guidelines proposed by CPCB, Ministry of Environment & Forest, GOI, http://www.cpcb.nic.in/
8. Qian, X., Koerner, R.M. Gray, D.H. “Geotechnical Aspects of Landfill Design and Construction”. Pearson, 2001.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	1	2	3	2	2
CO2	3	1	3	2	3	3
CO3	3	1	3	2	3	3
CO4	3	2	3	3	3	3
CO5	3	2	3	3	3	3

1-Low 2-Moderate 3-High

CEGT221Tunnelling and Underground Structures

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Comprehend the design aspects of various underground structures in soil and rockmass
CO2	Identify the excavation methods for construction of underground structures in different ground conditions
CO3	Analyze the underground structures in rock and soil using elastic and elastoplastic solutions
CO4	Appraise the underground structure using empirical, observational, analytical and numerical approaches
CO5	Design the support and safety system for underground structures

2. Syllabus

- **INTRODUCTION (6 Hours)**

  Introduction to underground space and tunnelling, History, Tunnelling challenges, Types and classification of underground opening, Factors affecting design, Design methodology, Functional aspects, Size and shapes, Support systems, Codal provisions

- **EXCAVATION METHOD AND MACHINERY (10 Hours)**

  Drilling and Blasting for Underground and Open Excavations, blast operation planning, Explosive products, Blast Design, controlled Blasting techniques, Blasting damage and control, safe practices with explosives and shots. Tunnel driving techniques, TBM techniques, Bottom up and bottom down method, Tunnelling in difficult ground condition, Underground supports, theory of arching, rock loads and loads on tunnel linings, Safety aspects, Case histories.

- **ANALYSIS AND DESIGN OF UNDERGROUND OPENINGS (12 Hours)**

  Analysis of Underground openings, stresses around different shapes, initial state of stresses, Closed form solutions, BEM, FEM, Design based on analytical methods, Empirical methods based on RSR, RMR, Q systems, Observational method- NATM, Convergence-confinement method, Design based on Wedge failure and key block analysis, Design of Shafts and hydraulic tunnels.

- **DESIGN OF SUPPORT SYSTEM (9 Hours)**
  Tunnel support systems, Different type of supports, Standup time, Ground Reaction Curve, Stability of excavation face and Tunnel portals, Surface settlement due to underground works, Ground subsidence study, Use of appropriate software packages, Shotcreting including some case histories, Underground instrumentation and monitoring

- **TUNNEL HEALTH AND SAFETY ISSUES (8 Hours)**
  Construction methods, Ventilation, De-watering, Control and monitoring system: services, operations and maintenance, Lighting: specifications, maintenance, emergency lighting, Power supply and distribution, Water supply and distribution, Safety provisions, Localized hazards, Fire hazards in highway tunnels, Rapid transit tunnels. Surveillance and control system for highway tunnels. Tunnel finish, Rehabilitation: Inspection methods, Repairs, Tunnel construction contracting.

(Total Lecture Hours 45)

3. References

1. Ramamurthy T., "Engineering in Rocks for Slopes, Foundation and tunnels", Prentice Hall of India Pvt Ltd, New Delhi, 2010.
2. Kolymbas, D., "Tunneling and tunnel mechanics: A rational approach to tunnelling", Springer Publications. 2008.
3. Goodman, R. E., "Introduction to Rock Mechanics", John Wiley & Sons, 1989.
4. Hoek, E. and Brown, E. T., "Underground excavations in rock", The Institute of mining and metallurgy. 2005.
5. Brady, B. H. G. and Brown, E. T., "Rock mechanics for underground mining", Springer Publication, 2006.
6. Obert, L. and Duvall, W.I., "Rock mechanics and the design of structures in rock", John Wiley and Sons, 1967.

7. Chapman D, Metje, N and Stark A, "Introduction to tunnel construction", Spon Press, Taylor and Francis, 2010.

4. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	2	2	2	1	2
CO2	2	2	3	2	2	3
CO3	2	3	3	2	3	3
CO4	3	3	3	2	3	3
CO5	3	3	3	3	3	3

1-Low 2-Moderate 3-High

CEST213: Foundation Design of Structures & Soil-Structure Interaction

L	T	P	C
3	0	0	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Interpret laboratory and field-testing results for foundation design.
CO2	Comprehend soil investigation reports and suggest the suitable type of foundation.
CO3	Design shallow and deep foundation, various machine foundations
CO4	Evaluate bearing capacity and settlement of shallow and deep foundations using various approaches
CO5	Apply the acquired knowledge for the design of special foundation.

2. Syllabus:

- **Soil Properties, Soil Exploration and Soil Improvement Techniques (09 Hours)**

  Soil properties and its applications, Laboratory testing, Soil exploration techniques – comparisons, Sounding tests, Geophysical methods, Sampling, Interpretation of Laboratory & field Testing, liquefaction, Quick Sand Condition, Introduction to Injection and grouting, Prefabricated vertical drain, Basic of vibroflotation, stone column.

- **Introduction to Shallow Foundation and Earth Retaining Structures (07 Hours)**

  Soil Investigation Reports study, Bearing capacity of soil, classification and designing of Shallow Foundation, Settlement of Foundations, Foundation on collapsible and expansive soil, Earth Reinforcement, RE wall, Gabion wall-concept, Rock Anchoring, Diaphragm technique, Diaphargm wall with anchor, Box Pushing, Cantilever

Retaining wall & Counterfort Retaining wall, Drainage for Retaining wall, Bridge Abutment wall.

- **Introduction Deep Foundation (03 Hours)**
  Caisson foundation, Cellular cofferdam, Braced-cut and Drainage

- **Machine Foundation (08 Hours)**
  Machine foundation – Types of machine foundation, General criteria, Theory of vibration, Single degree freedom system, Soil dynamic parameters, Block type machine foundation (Checking of resonance and permissible amplitude), vibration isolation techniques

- **Pile Foundation (08 Hours)**
  Pile foundation – Types of piles, Factors affecting choice of types of piles, Pile load test, Load carrying capacity of piles, Pile group, Group efficiency, Lateral resistance of piles, settlement of piles , Negative skin friction

- **Special Foundations (10 Hours)**
  Classification of Foundation, Special foundations, Raft foundation, types of rafts, Beams on elastic foundation, Footing subjected to moments, Footing subjected to tension, Geotextiles, various methods of foundation design, Technological consideration in Geotechnical Engineering. Idealization of soil-structure interaction. Concept of Non-linear Winkler foundation.

[Total Theory Hours: 45]

3. References

1. V N S Murthy “Advanced foundation Engineering” CBS publishers and distributors, 2007.
2. B.C.Punmia “Soil Mechanics and Foundation” Laxmi Publication, New Delhi, 2012.

3. P.Purushothama Raj “Ground Improvement Techniques” Laxmi Publication, New Delhi,2020.
4. Bowles J E “Foundation Analysis & Design” McGraw Hill Inc. New York, 1988.
5. Hugh Brooks “Basics of Retaining Wall Design” HBA Publication, Newport Beach, CA, USA, 2018.
6. Das B M “Principles of Foundation Engineering” PWS Publishing Co., Boston, 2011.

4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	3	1	3
CO2	3	3	3	3	3	3
CO3	3	2	3	3	2	3
CO4	3	2	2	3	3	2
CO5	3	1	3	3	3	3

Note:- 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEGT230Soil Exploration and Field Tests

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Comprehend the basics of site investigation methods and field tests and its extent for variety of structures including preliminary investigations.
CO2	Identify and suitable investigation method for soil exploration
CO3	Illustrate different specialized exploration methods based on condition and requirement
CO4	Appraise different codal provisions for field tests
CO5	Judge suitable instrumentation required for predicting the behavior of structure in soils and rocks

2. Syllabus

- **PRINCIPLES OF EXPLORATION (06 Hours)**

  Site investigation, objectives, Information required for soil investigation, Extent of Investigation for different types of structures (buildings, towers, industries, road, embankment, reservoir, Dams, retaining wall, etc.), Preliminary investigations.

- **BASICS OF EXPLORATION (07 Hours)**

Modern methods of boring and sampling; Preservation and transportation of samples; Sampling records. Investigations in marine condition. Different disturbance in soil sampling. Sample collection, data logging and handling.. Offshore investigation

- **EXPLORATION METHODS (08 Hours)**

  Electric resistivity test, , gravimetric survey, , Seismic surveys like seismic refraction test, reflection test, multi-channel analysis of surface wave test, etc., Trial pits, disturbed and undisturbed sampling, detailed bore hole investigations: types of borings and types of samplers.

- **FIELD TESTS (08 Hours)**

  Plate load test, pile load test, SPT test, CPT test, flat dilatometer test, DCPT test, Vane shear test, pressure meter test, field CBR test, core cutter, sand replacement test, nuclear probe method, block shear test.

- **INTERPRETATIONS AND CODAL PROVISIONS (08 Hours)**

  Soil profiling, interpretation of exploration data and report preparation, various standards for soil investigations.

- **INSTRUMENTATIONS (08 Hours)**

  Types of instruments used for Measurement of water table, pore pressure, LVDT, dial gauges, pressure gauges, non-contact based settlement measurements Dissertation preliminaries should clearly identify the goals & objectives and scope of the dissertation work taken up by the candidate. The focus is on proposed numericalmodelling/ experimental work/ field work. The study methodology and literature review on the dissertation topic is to be completed and a typed report is to be finalized in consultation with dissertation supervisor and submitted and presented for the assessment at the end of the semester.

(Total Lectures: 45 hours)

3. References

1. Clayton, C. R. I., Matthews, M. C. and Simons, N. E. (1995) Site Investigation (Second Edition). Oxford, Blackwell Sciences.
2. Hunt, R. E. (2005) Geotechnical Engineering Investigation Handbook (Second Edition), CRC Press Taylor & Francis Group.
3. Schnaid, F. (2009) In Situ Testing in Geomechanics : The Main Tests. Taylor & Francis.
4. Simons, N., Menzies, B. and Matthews, M. (2002) A Short Course in Geotechnical Site Investigation. Thomas Telford.
5. Dunnicliff, J. (1993) Geotechnical Instrumentation for Monitoring Field Performance. Wiley-Interscience Publication.

4. CO-PO-PSO_Mapping

	PO1	**PO2**	**PO3**	**PSO1**	**PSO2**	**PO3**
CO1	3	3	1	3	2	2
CO2	2	3	2	3	2	3
CO3	3	2	3	3	3	3
CO4	2	1	2	3	2	2
CO5	3	3	3	3	3	2

1-Low 2-Moderate 3-High

CECS230 AI/ML BASED APPLICATIONS IN CIVIL ENGINEERING

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Comprehend the basic principles of artificial intelligence (AI) and machine learning (ML) algorithms
CO2	Understanding Data collection & management tools & techniques for AI/ML application to Civil Engineering.
CO3	Derive the need and benefits of using AI/ML algorithms for developing applications in Civil Engineering using big-data analysis.
CO4	Solve the real-life problems in Civil Engineering using real-time data collection and big-data analysis involving AI/ML tools
CO5	Evaluate the performance of different AI/ML algorithms towards a given application in civil engineering.

2. Syllabus:

- **Machine Learning Basics: (8 hours)**

  Data Collection, Data Management, Big data, taxonomy of machine learning algorithms, Supervised Learning: Classification – Bayesian Classifier, K-nearest Neighbours, Regression- Linear Regression, Multivariate Regression, Logistic regression. Support Vector Machine (SVM) Algorithm. Unsupervised Learning: Clustering- K-means clustering algorithm and Hierarchical clustering algorithm. Reinforcement Learning: Q-Learning algorithm.

- **Data Collection Apparatuses (8 hours)**

  Type of data sources, Types of data, Types of sensors, Edge-devices, Introduction to microcontrollers, data communication protocols, Cloud storage and cloud computing, Local server setup, Cloud server setup, Introduction to Python, Introduction to Django server, Database setup.

- **Applications in Civil Engineering (15 hours)**

  Intelligent Transportation systems, smart mobility, shared mobility, Mobility as a

Service (MaaS), Real-time data monitoring, Structural health monitoring, Fire resistance evaluation of structures, automation in water resource management, Water quality monitoring, water distribution system monitoring, air and noise pollution monitoring, Rainfall-runoff modelling, Climate change monitoring, Soil liquefaction, Forecasting foundation related parameters, Building occupancy modelling, Building information modelling, Energy demand prediction, Predictive maintenance of equipment, roads and buildings

- **APPLICATION PART I: Data Collection and Management (7 hours)**
  Image processing for real time applications in Civil Engineering, Description of available database across specialisations, Selection of sensors and microcontroller, Integration of sensors with Edge-device, Programming of Edge-devices, Programming of server in Django framework, Collection of sensor data and storing to Database, Cloud computing
- **APPLICATION PART II: Big Data Analysis (7 hours)**
  Selecting the appropriate ML algorithm for analysis, Data Processing, Analysing the importance of each variable in decision making, and Analysis of processed data,

(Total Contact Hors: 45)

3. References:

1. Machine Learning using Python, by Manaranjan Pradhan, U Dinesh Kumar, Wiley.
2. A Primer on Machine Learning Applications in Civil Engineering, by Deka P C, Taylor & Francis.
3. Structural Health Monitoring: A Machine Learning Perspective, by Charles R. Farrar, Keith Worden, Wiley.
4. Building Blocks for IoT Analytics, By John Soldatos, Athens Information Technology, Greece, River Publishers.
5. Django - The Easy Way (2nd Edition), By Samuli Natri.
6. The Django Book (Release 2.0), By Adrian Holovaty, Jacob Kaplan-Moss, et al., 2013.
7. Benjamin J. R., Cornell C. A., Probability Statistics and Decision for Civil Engineers, McGraw-Hill, 1970.
8. Simon P. Washington, Matthew G. Karlaftis, Fred, Mannering L., Statistical and econometric methods for transportation data analysis, CRC Press, Second Edition, 2010.
9. Richard A. Johnson, Dean W. Wichern, Applied Multivariate Statistical Analysis, Prentice Hall, 1992.

10. *Arduino-ESP32 (Release 2.0.2)*, Espressif, 2022

4. <u>CO-PO-PSO_Mapping</u>

Course Objective	Program Specific Outcome			Program outcomes		
	PSO1	PSO2	PSO3	PO1	PO2	PO3
1	3	3	3	3	3	3
2	3	2	2	3	2	3
3	3	3	3	3	3	3
4	3	2	3	3	3	3
5	3	3	3	3	2	3

Note: 1: Slightly 2: Moderately 3: Substantially

CEGT204Numerical Modelling in Geomechanics

L	T	P	C
0	0	4	2

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Illustrate the application of spreadsheets, limit equilibrium, and finite element based computational geotechnics
CO2	Identify and select the appropriate models, elements and mesh configuration to obtain a converged geotechnical solution
CO3	Create finite element and limit equilibrium methods-based model of practical geotechnical engineering problems
CO4	Apply the FE analysis on actual geotechnical engineering problems to determine induced displacements, forces, stresses, and strains

2. Practicals

Excel programming for soil classification as per IS classification and determination of bearing capacity of footing.

- Evaluation of bearing capacity factors of footing with different shapes and comparison with analytical solutions.
- FE modeling of triaxial test with different constitutive models.
- Evaluation of stability of slope using LEM based different methods and FEM based c - ϕ reduction method.
- Determination of capacity of single pile, separation of end bearing and side friction of pile, and concept of pile-raft foundation.
- FE Analysis of deep excavation using sheet pile wall and diaphragm wall with and without anchors, evaluation of ground deformation and wall deformations.
- Stage construction of embankments and application of PVD drains.
- Modeling of underground structures, retaining wall and reinforced earth wall using FEM and LEM based tools.
- The construction of flow nets in earthen structure using FEM and graphical methods

(Total Practical Hours 56)

3. References

1. Potts, D. M. and Zdravkovic, L. (1999). Finite Element Analysis in Geotechnical Engineering: Theory, Thomas Telford, London.
2. Potts, D. M. and Zdravkovic, L. (2001).Finite Element Analysis in Geotechnical Engineering: Application, Thomas Telford, London.
3. Nakai, T. (2013). Constitutive Modeling of Geomaterials: Principles and Applications, CRC Press, Boca Raton.
4. Zaman, M., Gioda, G. and Booker, J. (2001). Modelling in Geomechanics, John Wiley and Sons, New York.
5. Naylor, D. J. and Pande, G. N. (1981). Finite Elements in Geotechnical Engineering, Pineridge Press, Swansea, UK.

4. CO-PO-PSO_Mapping

	PSO1	PSO2	PSO3	PO1	PO2	PO3
CO1	2	1	2	1	1	1
CO2	1	1	2	1	1	1
CO3	3	2	3	2	2	2
CO4	3	2	3	2	2	3

1-Low 2-Moderate 3-High

Semester III

1) MOOC course-I*
2) MOOC cousse-II* Internal: 40% and External: 60%
*Swayam/NPTEL

CEGT303Dissertation Preliminaries

L	T	P	C
		7	14

The work is assigned to the students immediately after the second semester examination. Thus, the candidate starts working on the given problem during the summer vacation prior to commencement of third semester.

The preliminary work involved is related to a state-of-art literature review, identification of the area and finalization of the specific problem, with clearly defined title. The presentation of the preliminary-Part 1 is addressed as the 1st stage seminar of the proposed dissertation work. The candidate is expected to present the plan of action and review of the published work related to the area.

The candidate should submit the report of their 1st Stage and a presentation about the same will be conducted thereafter in front of internal examiners.

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Compose a problem statement inadvancedareasof Geotechnical engineering based on review of relevant literature
CO2	Formulate objectives and scope based on identified research gap and need of the society
CO3	Develop comprehensive methodology and milestone for the research work
CO4	Design the numerical modeling/laboratory experiments/field experiments to meet the framed objectives of research
CO5	Prepare the detailed report and presentation so as to demonstrate writing and oral communication skills

2. CO-PO-PSO_Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	3	2	3	2	3
CO2	3	3	3	3	2	3
CO3	2	3	2	3	2	3
CO4	3	3	3	3	1	3
CO5	2	2	2	1	3	3

1-Low 2-Moderate 3-High

Semester IV

CEGT401Dissertation

L	T	P	C
		10	20

The preliminary dissertation work initiated in the third semester is further extended over fourth semester to undertake data collection through field studies / laboratory experiments / simulation experiments, data analysis, modeling to draw valid inferences.

The main objective of the dissertation work is to provide opportunity as well as motivation to the students to carryout original & independent research by developing the ability of using experimental and computational facilities.

Thesis is to be prepared by each student under the guidance of faculty supervisor and finally submitted in hard bound sets as per the specified schedule.

The assessment of the dissertation work will be carried out in two stages, first during the semester (continuous evaluation) for160 marks, and final viva-voce exam for 240 marks at the end of the semester.

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Demonstrate sound technical knowledge of selected problem as a dissertation work pertaining to Geotechnical Engineering domain
CO2	Assimilate the art of literature review and appropriate usage of modern tools and techniques relevant to selected problem
CO3	Develop the methodological framework and execute the experiments related to

	Field/Laboratory/Computational investigations leading to a valid conclusion
CO4	Acquire the skill of writing and presenting comprehensive technical report/document
CO5	Exhibit tendency of lifelong learning, professional ethics and function as a member or leader in a team

2. CO-PO-PSO_Mapping

AM840	PSO1	PSO2	PSO3	PO1	PO2	PO3
CO1	3	3	3	3	1	3
CO2	3	3	2	3	2	3
CO3	3	3	3	3	1	3
CO4	2	2	2	2	3	3
CO5						

1-Low 2-Moderate 3-High