Programme Name/s : Civil Engineering/ Civil & Rural Engineering/ Construction Technology/ Civil & Environmental Engineering/

Programme Code : CE/ CR/ CS/ LE

Semester : Fourth

Course Title : GEOTECHNICAL ENGINEERING

Course Code : 314315

I. RATIONALE

The stability of any structure depends upon behavior of soil and bearing capacity of soil to carry loads under different loading conditions. Thus, the geotechnical engineering enables the decision maker to predict the behavior of soil under different loading conditions and also to determine the probable settlement arising from the construction activities. This course therefore will develop the basic understanding among the students to ensure the safety, stability, and long-term quality in the wide range of civil engineering projects such as buildings, dams, towers, embankments, roads, railways, retaining walls, bridges, underground tank and underwater structures.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

Evaluate various soil properties required for design of foundation.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Apply the basic knowledge of Geology and Geotechnical Engineering in given situation
- CO2 - Measure the physical properties of given soil sample
- CO3 - Determine the shear strength of given soil sample
- CO4 - Use the relevant method of compaction to determine parameters of given soil sample
- CO5 - Undertake the relevant soil investigation techniques to determine the bearing capacity of the given soil strata

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/ s	Learning Scheme					Credits	Assessment Scheme										
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical					
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
314315	GEOTECHNICAL ENGINEERING	GTE	DSC	3	-	2	3	8	4	3	30	70	100	40	25	10	25#	10	25	10	175

Total IKS Hrs for Sem. : 1 Hrs

Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination

Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Elaborate the importance of geology in civil engineering field. TLO 1.2 Classify the given type of rocks based on their genesis. TLO 1.3 Signify the importance of soil as a construction material. TLO 1.4 Justify the importance of Geo-technical Engineering in civil Engineering.	**Unit - I Overview of geology and geotechnical engineering** 1.1 Introduction to Geology: Branches, importance of geology, composition of earth. 1.2 Petrology: Definition of a rock, classification based on their genesis (mode of origin), formation, classification and engineering uses of igneous, sedimentary and metamorphic rocks. (IKS*: Sun temple of Konark made up of Chlorite, Laterite, Khondalite stones) 1.3 IS definition of soil, Importance of soil in Civil Engineering as construction material for foundation bed of structures. 1.4 Field applications of geotechnical engineering for foundation design, pavement design, design of earth retaining structures, design of earthen dam.	Lecture Using Chalk-Board Presentations Demonstration Site/Industry Visit Case Study
2	TLO 2.1 Elaborate the physical properties of soil. TLO 2.2 Determine the Index properties of given soil sample using the relevant method. TLO 2.3 Draw the particle size distribution curve for the given sample with its interpretation. TLO 2.4 Interpret the computed values of Atterberg's limits of Consistency for the given soil specimen data.	**Unit - II Physical and Index Properties of Soil** 2.1 Physical Properties: Soil as a three phase system, water content, void ratio, porosity and degree of saturation, density index, unit weight of soil mass; bulk unit weight, dry unit weight, unit weight of solids, saturated unit weight, submerged unit weight, specific gravity 2.2 Determination of Index Properties of Soil: determination of water content by oven drying method as per IS code, determination of bulk unit weight and dry unit weight by core cutter method and sand replacement method as per IS code, determination of specific gravity by pycnometer. 2.3 Particle size distribution, mechanical sieve analysis as per IS code, particle size distribution curve, effective diameter of soil, Uniformity coefficient and coefficient of curvature, well graded and uniformly graded soils, particle size. classification of soils, I.S. classification of soil. 2.4 Consistency of soil: Stages of consistency, Atterberg's limits of consistency viz. Liquid limit, plastic limit and shrinkage limit, plasticity index, determination of liquid limit, plastic limit	Lecture Using Chalk-Board Presentations Demonstration Hands-on Site/Industry Visit

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
3	TLO 3.1 Apply the Darcyâ€™s law of permeability in given situation to determine the coefficient of permeability for a given soil sample. TLO 3.2 Apply the concept of flow net in the given situation. TLO 3.3 Draw the Mohr-coulomb failure envelope for the given type of soil sample. TLO 3.4 Use the relevant method to determine shear strength of given soil sample.	**Unit - III Permeability and Shear Strength of Soil** 3.1 Definition of permeability, Darcyâ€™s law of permeability, coefficient of permeability, factors affecting permeability, determination of coefficient of permeability by constant head and falling head permeability tests, simple problems to determine coefficient of permeability. 3.2 Seepage through earthen structures, seepage velocity, seepage pressure, phreatic line, flow lines, application of flow net, (No numerical problems.) 3.3 Shear failure of soil, field situation of shear failure, concept of shear strength of soil, components of shearing resistance of soil â€“ cohesion, internal friction. Mohr-coulomb failure theory, Strength envelope, strength Equation for purely cohesive and cohesion less soils. 3.4 Laboratory methods: Direct shear test, vane shear test (Numerical on direct shear test only)	Lecture Using Chalk-Board Presentations Demonstration Hands-on Site/Industry Visit
4	TLO 4.1 Undertake the compaction of given sample using relevant method of compaction. TLO 4.2 Use the relevant method of soil stabilization for the given situation as per IS code. TLO 4.3 Determine the CBR value of given soil sample as per IS code. TLO 4.4 Explain the lateral earth pressure theory with labelled sketch for given situation.	**Unit - IV Compaction and Stabilization of soil** 4.1 Concept of compaction, purpose of compaction, field situations where compaction is required, Standard proctor test â€“ test procedure as per IS code, Compaction curve, optimum moisture content, maximum dry density, Zero air voids line, Modified proctor test, factors affecting compaction, field methods of compaction : rolling, ramming and vibration, concept of consolidation, difference between compaction and consolidation. 4.2 Concept of soil stabilization, necessity of soil stabilization 4.3 California bearing ratio, C.B.R. test, interpretation of C.B.R. values. 4.4 Definition of earth pressure, lateral earth pressure at rest, active earth pressure and passive earth pressure with no surcharge condition, coefficient of earth pressure, Rankineâ€™s theory and its assumptions.	Lecture Using Chalk-Board Presentations Video Demonstrations Hands-on Site/Industry Visit
5	TLO 5.1 Undertake relevant Exploration Technique for evaluating soil strata. TLO 5.2 Determine the bearing capacity of soil using the relevant data for the given soil sample. TLO 5.3 Justify the need of field test in determining the bearing capacity of the soil for the given strata	**Unit - V Site Investigation and Bearing Capacity of Soil** 5.1 Site Investigation: Necessity of site investigation and sub-soil exploration, types of exploration, criteria for deciding the location and number of test pits and bores. Field identification of soil: dry strength test, dilatancy test and toughness test, Determination of free swell index. 5.2 Bearing capacity: Definition of bearing capacity, ultimate bearing capacity, safe bearing capacity and allowable bearing pressure, Introduction to Terzaghiâ€™s analysis and its assumptions (No Numerical). Types of failures in soil: general, local and punching shear failure, effect of water table on bearing capacity. 5.3 Field methods for determination of bearing capacity â€“ Plate load test and standard penetration test. Test procedures as Per IS: 1888 & IS:2131	Lecture Using Chalk-Board Presentations Video Demonstrations Collaborative learning Site/Industry Visit

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Identify the type of given rock specimen.	1	*Identification of rocks from the given specimen	2	CO1
LLO 2.1 Use oven drying method to determine the percentage of moisture content in given soil specimen.	2	*Determination of moisture content of given soil sample by oven drying method as per I.S. 2720 part- II	2	CO2
LLO 3.1 Use pycnometer method for determining specific gravity of given soil sample to classify its type.	3	*Determination of specific gravity of soil by pycnometer method as per I.S. 2720 part- III.	2	CO2
LLO 4.1 Undertake the core cutter method to find bulk and dry unit weight of given soil sample in field.	4	*Determination of Bulk and dry unit weight of soil in field by core cutter method as per I.S. 2720 (Part- XXIX).	2	CO2
LLO 5.1 Undertake the sand replacement method to find bulk and dry unit weight of coarse-grained soils.	5	Determination of bulk and dry unit weight of soil in field by sand replacement method as per I.S. 2720 (Part- XXVIII).	2	CO2
LLO 6.1 Classify type of soil based on grain size distribution.	6	*Determination of grain size distribution of given soil sample by mechanical sieve analysis as per I.S. 2720 (Part- IV).	2	CO2

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 7.1 Identify given soil based on plasticity chart.	7	*Determination of Plastic Limit & Liquid Limit along with Plasticity Index of given soil sample as per I.S. 2720 (Part- V).	2	CO2
LLO 8.1 Find co efficient of permeability of soil through coarse grained soils and fine grained soil.	8	*Determination of co efficient of permeability by constant head test as per I.S. 2720 (Part- XVII) or Determination of co efficient of permeability by falling head test as per I.S. I.S. 2720 (Part- XVII)	2	CO3
LLO 9.1 Determine the shear strength of soil sample using direct shear test.	9	Determination of shear strength of soil by direct shear test as per I.S. 2720 (Part-XIII)	2	CO3
LLO 10.1 Determine shear strength of soil in undisturbed as well as remoulded cohesive soil sample.	10	Determination of shear strength of soil by vane shear test as per I.S. 2720 (Part-XXX)	2	CO3
LLO 11.1 Perform standard proctor test to determine parameters such as OMC, MDD and amount of compaction	11	*Determination of OMC and MDD by standard proctor test of given soil sample as per I.S. 2720 (Part- VII).	2	CO4
LLO 12.1 Perform modified proctor test to determine parameters such as OMC, MDD and amount of compaction	12	Determination of OMC and MDD by Modified proctor test of given soil sample as per I.S. 2720 (Part- VIII).	2	CO4
LLO 13.1 Perform the CBR test on a given soil sample to evaluate thickness of pavement	13	Determination of CBR value as per IS 2720 (Part-16).	2	CO4
LLO 14.1 Classify given soil sample by conducting field tests Through Visual inspection, Dry strength test, Dilatancy test and Toughness test.	14	Use of field tests to idendify type of given soil sample.	2	CO5
LLO 15.1 Find degree of Expansiveness of given soil based on free swell index.	15	Determination of free Swell index of soil as per IS 2720 (Part 40)	2	CO5

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)/ASSIGNMENTS

- a. Collect the data of various rock specimen such as igneous, sedimentary, metamorphic and compare their properties with respect to geotechnical Engineering.
  b. Collect minimum three pictures rock mass showing Folds, Faults, Joints along with description.
  c. Observe open source videos for determination of Shrinkage limit of soil sample as per I.S. 2720 (Part- V) and write a procedure.
  d. Determine bearing capacity of soil using assumed value of liquid limit and plastic limit and show calculations (Workout bearing capacity of soil using established co relation.)
  e. Enlist minimum five compaction equipments along with their description

f. Enlist various soil stabilization techniques and write information of any three (including sketches).
g. Comment in the form of report on the effect of unconsolidated undrained, consolidated undrained and consolidated drained in shear test
h. Summarize the importance of Geosynthetic materials including their applications in civil Engineering
i. Summarize in the form report on the importance of piles including sketches and case studies
j. Write a report on role of Geophysical Exploration in civil Engineering.

Micro project

- a. Collect minimum five types of rock specimen in your area and compare their properties with respect to geotechnical Engineering aspect
  b. Visit nearby site having excavation pits and write short note about it strata by visual inspection.
  c. Collect minimum three samples of soil in your area and compare them for any three properties of soil
  d. Visit nearby reclamation land and study the stabilization method.
  e. Identity two different locations and suggest the appropriate stabilization methods (soil-cement, soil-lime, soil-flyash etc.) to improve its engineering properties.
  f. Study different free open sources software available for Geotechnical Engineering.
  g. Collect the photograph and information of anchors (stabilization of slopes) used to avoid over turning of structure.
  h. Collect the photographs and information on Causes, Effects and Types of Landslides.
  i. Collect information on foundations of ancient structures with Geotechnical Engineering aspect.
  j. Visit nearby two sites to classify soil based on field tests.

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Vane shear test apparatus- as per 2720 (Part -30)	10
2	Proctor compactometer for light compaction and heavy compaction as per IS specification	11,12
3	CBR apparatus as per IS specification IS 2720 (Part-16).	13
4	425 micron IS Seive and 100ml capacity graduated glass cylinder	15
5	Oven-thermostatically controlled to maintain temperature of 110 degree Celsius to 115 degree Celsius	2,3,4,7,11,12
6	Pycnometer â€“ consisting of 1 kg. honey /fruit jar with plastic cone, locking ring and rubber seal.	3
7	Core cutter apparatus- cylindrical core cutter of steel 100 mm dia x 127.3mm high with 3mm wall thickness beveled at 1mm.	4
8	Sand replacement apparatus- as per IS: 2720(Part-28)	5
9	Mechanical sieve shaker- carries up to 7 sieves of 15 cm to 20 cm dia (as per IS 2720-(Part 4)1985)	6
10	Casagrande liquid limit apparatus- as per IS: 9259-1979	7
11	Constant head permeameter- as per IS:2720(Part-4)1986	8
12	Falling head permeameter -as per IS:2720(Part-4)1986	8
13	Direct shear test apparatus- as per IS: 2720(Part 13) 1986	9

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Overview of geology and geotechnical engineering	CO1	5	4	4	0	8
2	II	Physical and Index Properties of Soil	CO2	12	4	4	12	20
3	III	Permeability and Shear Strength of Soil	CO3	10	2	8	6	16
4	IV	Compaction and Stabilization of soil	CO4	10	4	4	6	14
5	V	Site Investigation and Bearing Capacity of Soil	CO5	8	0	8	4	12
Grand Total				**45**	**14**	**28**	**28**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two unit test of 30 marks will be conducted and average of two unit test is considered, Assessment of laboratory learning , Assignment, Microproject, Self learning (60% Weightage to process and 40% weightage to product), Question and Answer.

Summative Assessment (Assessment of Learning)

- Pen and Paper Test (Written Test), Practical Exam/ Oral Exam

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO- 1	PSO- 2	PSO- 3
CO1	3	-	-	2	1	-	2			
CO2	3	3	1	3	2	1	3			
CO3	2	2	1	2	1	2	2			
CO4	2	2	2	2	2	1	2			
CO5	2	2	2	2	2	1	2			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Punmia, B.C.	Soil Mechanics and Foundation Engineering	Laxmi Publication (P) ltd., New Delhi, ISBN 9788170087915
2	Murthy, V.N.S.	A text book of soil mechanics and foundation Engineering	CBS Publishers & Distributors Pvt. Ltd., New Delhi 2016 ISBN: 9788123913629
3	Ramamurthy, T.N. & Sitharam,T.G.	Geotechnical Engineering (Soil Mechanics)	S Chand and Company LTD., New Delhi, ISBN: 9788121924573
4	Braja M. Das	Principles of Geotechnical Engineering	Cengage Learning ISBN: 9789355738103
5	Parbin Singh	Engineering And General Geology	S K Kataria and Sons ISBN-13 978-8188458516

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://youtu.be/N2J-tvEeI4c?si=SgQPoICSbFAuOVLd	Determination of Water Content of Soil by Oven Drying Method
2	https://youtu.be/l6vk0EM4yPg?si=-M6WwrpxOlZYHy94	Determination of Specific Gravity of soil
3	https://youtu.be/5rDHjZ_RJq0?si=V714qwz1vE8f5pSP	Determination of Dry Density of Soil by Core Cutter Method
4	https://youtu.be/YejCi5SEOAU?si=n8w1uAauI7ZgaG9P	Determination of Dry Density of Soil by Sand Replacement Method
5	https://youtu.be/pM-w_cvk1nA?si=3evWNLPjtwFxtsP0	Determination of Liquid Limit and Plastic Limit of Soil
6	https://youtu.be/bmpn5oNDvOs?si=LxcoQUSe_lmL3QQ1	Direct Shear Test
7	https://youtu.be/CAezS3mPzOc?si=9-bIMPqTKy1MuPDG	Grain Size Analysis of Soil
8	https://youtu.be/c4i_y6u-tsE?si=BjcItf55LqNn2Ihn	Water Content Dry Density Relation Using Light Compaction OMC and MDD
9	https://youtu.be/fCmMW73rP64?si=mdAiq1WPkpc9n1Dl	California Bearing Ratio (CBR) value test
10	https://youtu.be/Lrml0egYtM4?si=ag1mezmk74UAuyCf	Determination of swelling properties (Free Swell Index of Soil)
11	https://smfe-iiith.vlabs.ac.in/List%20of%20experiments.html	Virtual laboratory practical for Soil Mechanics.
12	https://youtu.be/8Q8CZW9-jXE?si=8Yrf2NvS9b5v9kcF	A Soil Investigation Work (Borehole Drilling: SPT & Rock Coring)
13	https://www.ijsrp.org/research-paper-0121/ijsrp-p10935.pdf	The Architectural Study of Sun Temples in India: Based on Location, Construction Material and Spatial Analysis Study
14	https://youtu.be/QuE4tEK-5iY?si=t61uZOWhS_nd5z8H	Shallow Foundation: Plate Load Test
15	https://youtu.be/DjWDOqQjsyQ?si=k43rXl2I19YK9msV	How to conduct SPT / Standard Penetration Test/ Soil Exploration Technique/ Site Investigation

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students