Program Name : **Civil Engineering Program Group**

Program Code : **CE/CR/CS**

Semester : **Fourth**

Course Title : **Geo-Technical Engineering**

Course Code : **22404**

1.RATIONALE

Geotechnical engineering is the important for every structure, since all structures rest on soil. The stability of these structures depends upon behavior of soil and bearing capacity of soil to carry loads under different loading conditions. Formation of soil and rocks, defects in rocks, soil behavior, and soil as an engineering material are essential parameter to an engineer. The design of foundation of buildings, dams, towers, embankments, roads, railways, retaining walls, bridges is mainly governed by these above stated parameters. The content of this subject are also useful in designing basement, underground tank and underwater structures. Knowledge of geology, soil characteristics, and stress distribution under loading on soil, bearing capacity of soil is also useful to every engineer in the design, execution and stability analysis of structures.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Evaluate soil properties for determining stability of foundation**.

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Identify types of rocks and sub soil strata of earth.
b. Interprete the physical properties of soil related to given construction activities.
c. Use the results of permeability and shear strength test for foundation analysis.
d. Interpret the soil bearing capacity results.
e. Compute optimum values for moisture content for maximum dry density of soil through various tests.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme													
				Theory							Practical						
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total		
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	
3	-	2	5	3	70	28	30*	00	100	40	25#	10	25	10	50	20	

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

Legends: ***L****-Lecture;* ***T*** *– Tutorial/Teacher Guided Theory Practice;* ***P*** *- Practical;* ***C*** *– Credit,* ***ESE*** *- End Semester Examination;* ***PA*** *- Progressive Assessment.*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

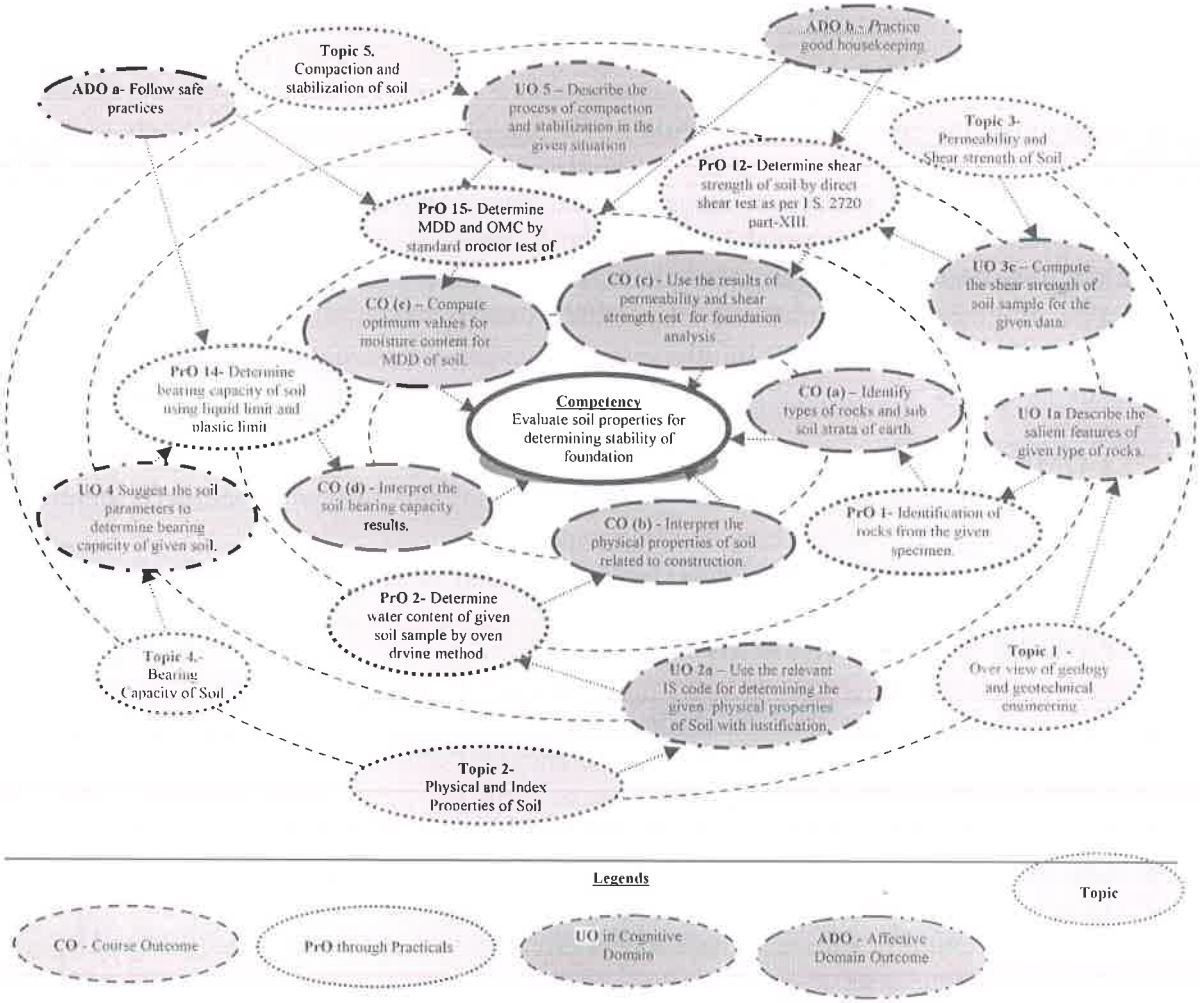

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Identification of rocks from the given specimen	I	02
2	Determine water content of given soil sample by oven drying method as per I.S. 2720 part- II	II	02*
3	Determine specific gravity of soil by pycnometer method as per I.S.	II	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	2720 part- III.		
4	Determine dry unit weight of soil in field by core cutter method as per I.S. 2720 (Part- XXIX).	II	02*
5	Determine dry unit weight of soil in field by sand replacement method as per I.S. 2720 (Part- XXVIII).	II	02
6	Determine Plastic Limit & Liquid Limit along with Plasticity Index of given soil sample as per I.S. 2720 I(Part- V).	II	02*
7	Determine Shrinkage limit of given soil sample as per I.S. 2720 (Part- V).	II	02
8	Determine grain size distribution of given soil sample by mechanical sieve analysis as per I.S. 2720 (Part- IV).	II	02*
9	Use different types of soil Identify and classify soil by conducting field tests-Through Visual inspection, Dry strength test, Dilatancy test and Toughness test .	II	02
10	Determine co efficient of permeability by constant head test as per I.S. 2720 (Part- XVII)	III	02
11	Determine co efficient of permeability by falling head test as per I.S. I.S. 2720 (Part- XVII)	III	02*
12	Determine shear strength of soil by direct shear test as per I.S. 2720 (Part-XIII)	III	02*
13	Determine shear strength of soil by vane shear test as per I.S. 2720 (Part-XXX)	III	02
14	Determine bearing capacity of soil using liquid limit and plastic limit	IV	02
15	Determine MDD and OMC by standard proctor test of given soil sample as per I.S. 2720 (Part- VII).	V	02*
16	Determination of CBR value on the field as IS.	IV	02
	Total		**32**

Note

i. *A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. *The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:*

S.No.	Performance Indicators	Weightage in %
1	Preparation of experimental set up	20
2	Setting and operation	20
3	Safety measures	10
4	Observations and Recording	10
5	Interpretation of result and Conclusion	20
6	Answer to sample questions	10
7	Submission of report in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
e. Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year.
- 'Organising Level' in 2nd year.
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Oven-thermostatically controlled to maintain temperature of 110° Cto 115° C	2
2	Pycnometer – consisting of 1 kg.honey /fruit jar with plastic cone, locking ring and rubber seal.	3
3	Core cutter apparatus- cylindrical core cutter of steel 100 mm dia x 127.3mm high with 3mm wall thickness beveled at 1mm.	4
4	Sand replacement apparatus- as per IS: 2720(Part-28)	5
5	Casagrande liquid limit apparatus- as per IS: 9259-1979	6
6	Shrinkage limit apperatus as per IS: 2720(Part- V)	7
7	Mechanical sieve shaker- carries up to 7 sieves of 15 cm to 20 cm dia (as per IS 2720-(Part 4)1985)	8
8	Constant head permeameter- as per IS:2720(Part-4)1986	10
9	Falling head permeameter -as per IS:2720(Part-4)1986	11
10	Direct shear test apparatus- as per IS: 2720(Part 13) 1986	12
11	Vane shear test apparatus- as per 2720 (Part -30)	13
12	Proctor compactometer for light compaction as per IS specification	15
13	Field CBR apperatus as per IS specification	16

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Over view of	1a. Describe the salient features of given type of	1.1 Introduction of geology, different branches of geology, importance of geology for civil

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
geology and geotechnical engineering	rocks. 1b. Identify the given type of rocks. 1c. Suggest the type of soil for the given situation. 1d. Describe the applications of Geo-technical Engineering for the construction of the given civil structure.	engineering structure and composition of earth. 1.2 Introduction of petrology, definition of a rock, classification based on their genesis (mode of origin), formation, classification and engineering uses of igneous, sedimentary and metamorphic rocks. 1.3 IS definition of soil, Importance of soil in Civil Engineering as construction material in Civil Engineering Structures, as foundation bed for structures 1.4 Field application of geotechnical engineering for foundation design,pavement design, design of earth retaining structures, design of earthen dam.
Unit –II Physical and Index Properties of Soil	2a. Use the relevant IS code for determining the given physical properties of Soil with justification . 2b. Calculate Atterberg's limits of Consistency for the given data. 2c. Interprete Atterberg's limits of Consistency for the given data.. 2d. Classify the given soil sample as per IS provision. 2e. Interpret the particle size distribution curve for the given data.	2.1 Soil as a three phase system, water content, determination of water content by oven drying method as per IS code, 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, determination of bulk unit weight and dry unit weight by core cutter method and sand replacement method as per IS code, specific gravity, determination of specific gravity by pycnometer. 2.2 Consistency of soil, stages of consistency, Atterberg's limits ofconsistency viz. Liquid limit, plastic limit and shrinkage limit,plasticity index, determination of liquid limit, plastic limit andshrinkage limit as per IS code. 2.3 Particle size distribution, mechanical sieve analysis as per IS codeparticle size distribution curve, effective diameter of soil, Uniformitycoefficient and coefficient of curvature, well graded and uniformlygraded soils, particle size. classification of soils, I.S. classification ofsoil.
Unit III Permeability and Shear Strength of Soil.	3a. Identify the factors affecting the permeability of given type of soil sample. 3b. Compute the coefficient of permeability for a given soil sample data.	3.1 Definition of permeability, Darcy'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.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	3c. Compute the shear strengh of soil sample for the given data. 3d. Interpret the shear failure of soil sample for the given data. 3e. Use the application of flow net in the given situation.	Seepage through earthen structures, seepage velocity, seepage pressure, phreatic line, flow lines, application of flow net,(No numerical problems.) 3.2 Shear failure of soil, field situation of shear failure, concept of shear strength of soil, components of shearing resistance of soil – cohesion,internal friction. Mohr-coulomb failure theory, Strength envelope, strength Equation for purely cohesive and cohesion less soils. Direct shear test and vane shear test –laboratory methods.
Unit IV Bearing Capacity of Soil	4a. Suggest the soil parameters to determine bearing capacity of given soil sample with justification. 4b. Suggest the method to determine bearing capacity of the soil for the given strata with justification. 4c. Choose the relevant type of foundation using Rankine formula for the given situation. 4d. Corelate the effect of water table on bearing capacity of soil for the given data.	4.1 Bearing capacity and theory of earth pressure: Concept of bearing capacity, ultimate bearing capacity, safe bearing capacity and allowable bearing pressure, Introduction to Terzaghi's analysis and assumptions made, effect of water table on bearing capacity. 4.2 Field methods for determination of bearing capacity – Plate load test and standard penetration test. Test procedures as Per IS: 1888 & IS:2131 4.3 Definition of earth pressure, active earth pressure and passive earth pressure for no surcharge condition, coefficient of earth pressure, Rankine's theory and assumptions made for non-cohesive Soils.
Unit V Compaction and stabilization of soil	5a. Describe the process of compaction and stabilization in the given situation. 5b. Suggest the relevant compacting equipment for the given type soil sample with justification. 5c. Choose the relevant method of soil stabilization for the given situation with justification. 5d. Compute the CBR value for given data of soil sample.	5.1 Concept of compaction, purpose of compaction, field situations where compaction is required, Standard proctor test test procedure as per IScode, 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 and Suitability of various compaction equipments-smooth wheel roller, sheep foot roller, pneumatic tyred roller, rammer and vibrator, difference between compaction and consolidation. 5.2 Concept of soil stabilization, necessity of soil stabilization, different methods of soil

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	5e. Interpret the value of CBR with reference to IS Provisions.	stabilization – echanical soil stabilization, lime stabilization, cement stabilization, bitumen stabilization, fly-ash stabilization. California bearing ratio, C.B.R. test, meaning of C.B.R. value. 5.3 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.

Note: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'.

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	General Geology and Over view of Geotechical Engineering	06	04	06	--	10
II	Physical properties of soil	12	04	04	08	16
III	Permeability and Shear strength of soil	12	04	04	08	16
IV	Bearing capacity of soil	06	04	04	04	12
V	Compaction and Stabilization of soil	12	04	04	08	16
Total		**48**	**20**	**22**	**28**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note*: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Visit to different site and identify the type of strata encounter and judge the bearing capacity of strata and correlate with actual value adopted as per IS provision.
b. Collection of soil sample of various types of soil.
c. Collection of photographs of machines used for stabilization and compaction.
d. Contribution of various scientists in geotechnical engineering.
e. Preparation of chart showing engineering properties of soil along with IS specification
f. Collection of data about soil deposites available in various region of India and showing it in the map of India.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects
f. Use Flash/Animations to explain various theorems in Geotechnical Engineering.
g. Demonstrate various concepts related to Geotechnical Engineering .
h. Encourage students to refer different websites to have deeper understanding of new concepts of Geotechnical Engineering.
i. Assign unit wise tutorials to group of 4 to 5 students for solving problems unit wise.
j. Assign micro projects to group of 4 to 5 students and let them prepare and present the project through PPT. Group shall submit a report which is limited to 5 pages.
k. Use of video animation films to explain concept, Facts and applications related to Geotechnical Engineering .
l. In respect of item 10 above teacher needs to ensure to create opportunity and provisions for such co curricular activities.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a. Write a report on role of a geotechnical engineer in civil engineering practice.
b. Taking the samples in field and test it in laboratory for different properties of soil.
c. Calculate the bearing capacity of soil from the Atterberg limit values.
d. Compute the plasticity index and toughness index for the given soil sample from given data.
e. Select a soil sample from given one which contains more clay particle, has greater saturated unit weight, has a greater dry unit weight, has a greater void reatio.

f. Derive the relation between discharge velocity and seepage velocity.
g. Compute the permeability of a given soil sample of stratified soil deposites.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Soil Mechanics and Foundation Engineering	Punmia, B.C.	Laxmi Publication (P) ltd., New Delhi, ISBN 9788170087915
2	A text book of soil mechanics and foundation Engineering	Murthy, V.N.S.	CBS Publishers & Distributors Pvt. Ltd., New Delhi 2016 ISBN: 9788123913629
3	Geotechnical Engineering(Soil Mechanics)	Ramamurthy, T.N. & Sitharam,T.G.	S Chand and Company LTD., New Delhi, ISBN: 9788121924573
4	Soil Mechanics and Foundation Engineering	Raj, P. Purushothama	Pearson India, New Delhi, 2014 ISBN: 9789332515123
5	Geltechnical Engineering	Kasamalkar, B. J.	Pune Vidyarthi Griha Prakashan, Pune

14. SOFTWARE/LEARNING WEBSITES

a. www.nptelvideos.in
b. www.youtube.com /geotechnical engineering
c. www.learnerstv.com (video lecture course – Engg Lectures-soil mechanics)
d. www.whatisgeotech.org