GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
Semester-IV

Course Title: Soil Engineering
(Course Code: 4340602)

Diploma programme in which this course is offered	Semester in which offered
Civil Engineering	4th Semester

1. RATIONALE

After learning Mechanics of deformable bodies and Hydraulics in 3rd semester, this subject "Soil Engineering" is introduced in 4th semester, as it deals with the natural material "Soil" whose behavior is somewhat intermediate between solids and fluids. Soil Engineering involves study of Soil, its behavior and application as an engineering material. Design of foundation of building, dams, towers, embankments, roads, railways, retaining wall, bridges is mainly governed by characteristics and behavior of Soil, hence this subject is very important for civil engineering students.

2. COMPETENCY

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

- **Evaluate and interpret test results for selection of proper Soil as a construction material and as a strata for foundation.**

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with the identified competency are to be developed in the student for the achievement of the following COs:

a) Identify types of Soil according to mode of deposition and mode of transportation.
b) Determine the physical and index properties of soil to estimate behaviour and other important engineering properties for given construction activities.
c) Classify coarse grained and fine grained soil by IS method
d) Determine Coefficient of permeability and shear parameters of soil and apply results in foundation analysis and other construction activities.
e) Determine O.M.C. and M.D.D. values of soil and select suitable method of soil stabilization.
f) Compute bearing capacity of soil and earth pressure and interpret results.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	0	2	4	30*	70	25	25	150

(*):Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment 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, **CA** - Continuous Assessment; **ESE** -End Semester Examination.*

5. SUGGESTED PRACTICAL EXERCISES

The following practical outcomes (PrOs) are the subcomponents of the COs. *Some of the **PrOs** marked **'*'** are compulsory, as they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'*.

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Determine moisture content of soil by oven drying method	I	02*
2	Determine field density and dry density of soil by Core cutter method	I	02*
3	Determine field density and dry density of soil by Sand replacement method	I	02*
4	Determine specific gravity of soil by pycnometer/density bottle	I	02*
5	Classification of soil by sieve analysis method	II	04*
6	Determine Liquid limit, Plastic limit and Shrinkage limit of soil	III,IV	04*
7	Determine Permeability of soil by constant head method	III,IV	02*
8	Determine Permeability of soil by falling head method	V	02*
9	Determine Shear parameters of soil by Direct Shear test	VI	04*
10	Determine OMC & MDD of soil by standard proctor test [Light compaction Test]	VII	04*
	Total hours		**28 Hrs.**

Note

i. *More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.*

ii. *The following are some **sample** 'Process' and 'Product' related skills(more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency.*

Sr. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Identify components	10
2	Prepare experimental setup.	20
3	Operate the equipment setup.	20
4	Follow safe practices .	10
5	Record observations correctly.	20
6	Interpret the result and conclude.	20
Total		**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

This major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to usher in uniformity of practicals in all institutions across the state.

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1	Assembly of Core cutter for In-situ density determination.	02
2	Assembly of Sand replacement for In-situ density determination.	03
3	Sieve set & sieve shaker for mechanical analysis of soil.	05
4	Standard Proctor test apparatus for OMC & MDD determination of soil.	10
5	Density bottles/ Pycnometer for specific gravity determination.	04
6	Direct shear test apparatus.	09
7	Permeability test apparatus for constant water head.	07
8	Permeability test apparatus for falling water head.	08
9	Casagrande apparatus for Liquid limit determination.	06
10	Shrinkage Limit test apparatus.	06
11	Hot air oven with temperature control	01 to 10
12	Electronic weighing balance.	01 to 10

7. AFFECTIVE DOMAIN OUTCOMES

The following ***sample*** Affective Domain Outcomes (ADOs) are embedded in many of the above mentioned COs and PrOs. More could be added to fulfill the development of this competency.

a) Work as a leader/a team member.
b) Follow safety practices while using equipment.
c) Realize importance of green energy. (Environment related)

The ADOs are best developed through the laboratory/field based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

i. 'Valuing Level' in 1st year

ii. 'Organization Level' in 2nd year.
iii. 'Characterization Level' in 3rd year.

8. UNDERPINNING THEORY

The major underpinning theory is given below based on the higher level UOs of *Revised Bloom's taxonomy* that are formulated for development of the COs and competency. If required, more such higher level UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
Unit – I Overview of Soil Engineering	1a. Identify the types of soil according to mode of deposition and mode of transportation 1b. Identify structures where soil is used as construction material 1c. Identify structures where soil is used as a strata/foundation to safely bear loads. 1d. Locate the major soil deposits in India.	1.1 Definition of Soil, Soil Mechanics, Soil Engineering, Importance of Soil engineering 1.2 History of Soil Engineering 1.3 Soil formation in Geological cycle 1.4 List of Structures where soil is used as construction material 1.5 Types of Soil according to mode of Transportation 1.6 Major Soil deposits of India
Unit – II Physical and Index properties of Soil	2a. Identify physical and index properties of soil and their relevance with important engineering properties. 2b. Interpret two and three phase of soil from given conditions. 2c. Derive interrelationships among different properties of soil from phase diagrams. 2d. Perform tests for determining properties of soil using relevant IS Code and interpret test results 2e. Calculate physical properties of soil from given data using interrelationships	2.1. Soil as a three phase system, assumptions for drawing two phase & three phase diagrams, 2.2. Fundamental definitions of physical properties- Water content, Bulk density, Dry density, Saturated density, Submerged density, Density of solids, Specific gravity-Absolute & Mass specific gravity, void ratio, porosity, Degree of saturation, Air content, Percentage air voids, Relative density 2.3. Derivation of following relations from phase diagrams and numericals on each : 2.3.1 e= n/n-1, n=e/1+e 2.3.2 w×G =e×sr 2.3.3 Ɣd=Ɣb/1+w 2.3.4 Ɣd=Ɣb/1+w 2.3.5 Ɣsat= (G+e)Ɣw/(1+e) 2.3.6 Ɣsub=(G-1)Ɣw/(1+e) 2.3.7 Ɣd= G Ɣw/1+e 2.4. Methods to determine moisture content of soil. 2.5. Determination of Bulk & Dry density

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
		of soil by Core Cutter method and Sand Replacement method. 2.6. Determination of Specific Gravity of soil by pycnometer.
Unit– III **Classification of Soil**	3a. Use different methods of Classification. 3b. Interpret the particle size distribution curve for given soil samples. 3c. Analyse fine grained Soil based on Consistency Limits. 3d. Classify given soil samples by IS method.	3.1 Classification of soil as per grain size by IS method. Basic criteria of classification of soils. 3.2 Difference between coarse grained and fine grained soil on the basis of their size and engineering properties. Mechanical Analysis of coarse grained soil. Sedimentation analysis of fine grained soil. 3.3 Particle size distribution curve. Nature of various grading Curves. Coefficients of uniformity and curvature. 3.4 Classification of soil on the basis of plasticity. Atterberg's limits of consistency: Liquid limit, plastic limit and shrinkage limit. Plasticity index, Liquidity Index and Consistency Index. 3.5 Determination of Liquid limit, Plastic limit and Shrinkage limit as per IS.
Unit– IV Permeability and Seepage	4a. Identify the factors affecting the permeability for a given type of soil sample. 4b. Compute coefficient of Permeability for given type of soil sample. 4c. Interpret the concept of seepage pressure.	4.1 Definition of permeability, permeable and impermeable soil, Darcy's law of permeability. 4.2 Factors affecting the permeability of soil. Coefficient of permeability, Difference between flow through pipe and flow through soil. 4.3 Laboratory Methods to determine Coefficient of Permeability- Constant Head Method and Falling Head method. 4.4 Field methods to determine Coefficient of Permeability: Pumping-out tests and Pumping-in tests. 4.5 Definition of Seepage and seepage pressure. Quick sand condition. Types of flow net. Characteristics and application of flow net.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
Unit– V Compaction and Stabilization of Soil	5a. Apply the principle of Compaction and choose the method of compaction for different soils. 5b. Differentiate phenomenon of compaction from consolidation of soil. 5c. Determine optimum moisture content and maximum dry density of soil in the laboratory. 5d. Suggest suitable method of Soil stabilization for ground improvement in a given situation.	5.1 Concept of compaction and its effect on various soil properties like density, permeability, shear strength & bearing capacity. 5.2 Factors affecting compaction like water content, types of soil, nature of soil, method of compaction, admixtures. 5.3 Optimum moisture content (O.M.C) and maximum dry density (M.D.D.) by IS standard compaction test- Light and Heavy compaction test(Proctor Test). Standard compaction curves. 5.4 Method of field compaction. Various compaction equipment, role of O.M.C. in field. 5.5 Concept and requirements of soil stabilization. Different methods of soil stabilization–Mechanical soil stabilization and Chemical soil stabilization (Use of cement, lime, fly ash, bitumen). Use of Geo-Synthetic as a stabilizing material. 5.6 Necessity of site investigation and sub soil exploration. Types and purpose of exploration. Basic field identification test of soil.
Unit– VI Shear Strength of Soil	6a. Interpret various shear parameters of soil. 6b. Compute shear strength of soil for given condition. 6c. Identify shear failure of soil in various situations.	6.1 Cohesion, Angle of internal friction, shear strength. 6.2 Coulomb's law for shear strength. 6.3 Different methods to find shear strength of soil in the laboratory. Procedure to find shear strength using Box shear test. 6.4 Types of soil- C-soil, ø-soil and C-ø soil. Mohr's circle method to find shear envelope and shear strength parameters.
Unit– VII Bearing capacity of Soil and Earth Pressure	7a Identify the factors affecting Bearing Capacity of soil. 7b Determine bearing capacity of different soils. 7c Suggest type of foundation for the given situation of soil. 7d Calculate earth pressure by Rankine's formula.	7.1 Concept of bearing capacity. Types of Bearing capacity- Ultimate bearing capacity, Safe bearing capacity, Net bearing capacity and Allowable bearing pressure. Influence of water table on bearing capacity. 7.2 I.S. method to determine bearing capacity of soils. Different theoretical

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
		methods to determine bearing capacity of soils. Introduction to Terzaghi's analysis. Assumptions and limitations of Terzaghi's theory. Different field methods for determination of bearing capacity – Plate load Test and Standard Penetration Test. 7.3 Different types of footings. Types of shear failure of footings. Methods to improve bearing capacity of soils. 7.4 Define Earth Pressure. Active and passive earth pressure for no surcharge condition. Rankine's formula to determine coefficient of earth pressure. 7.5 Liquefaction: Definition, Causes, Effect and Remedy of Liquefaction.

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	**Over view of soil engineering**	**02**	**02**	**02**	**00**	**04**
II	**Physical and Index properties of soil**	**08**	**02**	**04**	**06**	**12**
III	**Classification of Soil**	**06**	**02**	**02**	**06**	**10**
IV	**Permeability and Seepage**	**06**	**02**	**02**	**06**	**10**
V	**Compaction and Stabilization of Soil**	**08**	**02**	**04**	**08**	**14**
VI	**Shear Strength of Soil**	**06**	**02**	**02**	**06**	**10**
VII	**Bearing Capacity ofSoil and Earth Pressure**	**06**	**02**	**02**	**06**	**10**
Total		**42**	**14**	**20**	**36**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*

Note*: This specification table provides general guidelines to assist student for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions to assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may slightly 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) Collect different photographs of a nearby soil deposit by natural formation.
b) Collect the photographs of different types of footings/foundations being constructed nearby with their primary details.
c) Collect different photographs of structural members where compaction of soil is being done before construction.
d) Collect the photographs of five different types of soil wrt classification of soil.
e) Collect the information with photographs of structural failure due to issue of soil stability.
f) Collect the information with photographs of soil improvement by different methods available in field.
g) Collect the information with photographs of structural members having excessive settlement of soil nearby.
h) Collect the information with photographs of failure of soil due to liquefaction.
i) Collect the information with photographs of different geo-synthetics.

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) Guide student(s) in undertaking micro-projects.
c) ***'L' in section No. 4*** means different types of teaching methods that are to be employed by teachers to develop the outcomes.
d) About ***20% of the topics/sub-topics*** which are relatively simpler or descriptive in nature is to be given to the students for ***self-learning***, but to be assessed using different assessment methods.
e) With respect to ***section No.10***, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
f) Guide students on how to address issues on environment and sustainability.
g) Guide students for using data manuals.

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 semester, the micro-projects are group-based (group of 3 to 5). However, **in the fifth and sixth semesters**, the number of students in the group should ***not exceed three.***

The micro-project could be field application based, internet-based, workshop-based, laboratory-based or theory 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 duration of the micro-project should be about **14-16** ***(fourteen to sixteen) student engagement hours*** during the course. The students ought to submit micro-project by the end of the semester to develop the industry-oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

a) Determine void ratio of soil by performing necessary tests in the laboratory.
b) Compare specific gravity of fine grained soil, coarse grained soil and Aggregate.
c) Compare OMC and MDD values of two different types of soil available nearby.
d) Prepare spreadsheet or computer program to calculate the OMC and MDD of given soil sample by standard compaction method.
e) Prepare spreadsheet or computer program to determine type of soil using particle size distribution curve and mechanical sieve analysis.
f) Prepare spreadsheet or computer program to determine Liquid Limit and Plastic Limit of given soil sample.
g) Compare coefficient of permeability values of two different types of soil available nearby.
h) Classify the soil from one source by performing necessary tests in the laboratory.
i) Prepare spreadsheet or computer program to calculate shear parameters of soil by performing direct shear test in the laboratory.
j) Prepare a working model of liquefaction of soil.
k) Calculate Bearing Capacity of Soil performing necessary tests in the laboratory.
l) Prepare and Compare working models of embankment filling with and without geo-synthetics.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1	Soil Mechanics and Foundations	Dr. B.C.Punamia	Laxmi Publications Pvt. Ltd. NewDelhi ISBN: 81-700-808-19
2	Soil mechanics and Foundation Engineering	Dr. P.N.Modi	Standard Book House, New Delhi ISBN: 978-81-89401-30-6
3	Soil Mechanics and Foundation Engineering	S.K.Garg	Khanna Publishers, Delhi ISBN: 81-7409-104-1
4	Soil Mechanics and Foundation engineering	Dr. K.R. Arora	Standard Publishers ISBN-13: 978-8180141126
5	A Textbook of Soil Mechanics and Foundation Engineering	Murthy V.N.S.	CBS Publishers & Distributors Pvt. Ltd., New Delhi ISBN : 9788123913629

14. SOFTWARE/LEARNING WEBSITES

a) NPTEL Course :-Soil Mechanics by IIT, Guwahati
https://nptel.ac.in/courses/105103097

b) NCTEL Video series for Soil Mechanics laboratory Tests :
https://www.youtube.com/results?search_query=nctel+soil

c) Virtual Lab by Ministry of Education, Government of India www.vlab.co.in

15. PO-COMPETENCY-CO MAPPING

Semester III	Soil Engineering (Course Code: 4340602)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solutions	PO 4 Engineering Tools, Experimentation &Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning
Competency	Evaluate and interpret test results for selection of proper soil as a construction material and as a strata for foundation.						
Course Outcomes CO a) Identify types of Soil according to mode of deposition and mode of transportation.	3	-	-	-	2	-	2
CO b) Determine the physical and index properties of soil to estimate behaviour and other important engineering properties for given construction activities.	2	3	-	3	2	2	2
CO c) Classify coarse grained and fine grained soil by IS method	2	3	-	3	2	2	2
CO d) Determine Coefficient of permeability and shear parameters of soil and apply results in foundation analysis and other construction	2	3	-	3	2	2	2

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COe)Determine O.M.C. and M.D.D. values of soil and select suitable method of soil stabilization.	2	3	-	3	2	2	2
COf) Compute bearing capacity of soil and earth pressure and interpret results	2	3	-	-	2	2	2

*Legend: '**3**' for high, '**2**' for medium, '**1**' for low and '**-**' for no correlation of each CO with PO.*

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

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