SOIL MECHANICS

Subject code: **CE603PC**
Regulations: R16-JNTUH
Class: III Year B. Tech CE II Sem

DEPARTMENT OF CIVIL ENGINEERING
BHARAT INSTITUTE OF ENGINEERING AND TECHNOLOGY
Ibrahimpatnam - 501 510, Hyderabad

SOIL MECHANICS (CE603PC)
COURSE PLANNER

I. COURSE OVERVIEW:

Civil Engineers are required to construct structures on the soil. The loads coming onto these structures, along with the self-weight, have to be safely transmitted to the soil beneath it. A geotechnical engineer must be able to design a footing in such a way that soil below it will not fail there will not be any excessive settlements in the soil. This foundational course in civil engineering is intended to introduce to concepts of types of soils present in nature, properties of soil on which the load carrying capacity of the soil depends For this, the concept of (a) types of soil present in nature and their properties which in turn effect the load carrying capacity of soil, (b) shear strength of the soils, (c) settlement reduction by compaction and consolidation are covered in depth. The important calculations of stresses due to self weight and externally applied loads and the consequent theory of failures for prediction of the strength of the soils are also discussed. Through this course content engineers can design the foundation for safety and serviceability.

II. PREREQUISITE(S):

Level	Credits	Periods	Prerequisite
UG	4	4	Engineering Mechanics

III. COURSE OBJECTIVES:

The course should enable the students to:

I.	**Identify** the type of soil based on index properties of soils, soil formation & its structure
II.	**Recognize** the importance of permeability for calculating the seepage through soils. Find out the coefficient of permeability using various laboratory & field tests.
III.	**Analyze** the stress at any point below the ground surface due to self weight and externally applied load. Interpret the importance of consolidation and compaction on the settlement of footing.
IV.	**Recognise** the importance of shear strength in load carrying capacity of soil. Calculate the shear strength of soil using various laboratory tests.

IV. COURSE OUTCOMES:

Students, who complete the course, will have demonstrated the ability to do the following:

Course Outcomes	Description	Bloom's Taxonomy Levels	Program Outcomes, Program Specific Outcomes
CO1	Understand the mechanism Behaviour of Soil for different loads.	L3: Applying	PO1,PO2,PO3,PSO1, PSO3
CO2	and from Soil Condition will be able to determine properties of soil.	L2:Understand, L4: Analyzing	PO2,PO3,PO4,PO6, PSO1.

V. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program outcomes		Level	Proficiency assessed by
PO1	**Engineering knowledge**: To Apply the knowledge of mathematics, science, engineeringfundamentals/principals, and civil engineering to the solution of complex engineering problems encountered in modern engineering practice.	1	Assignments
PO2	**Problem analysis**: Ability to Identify, formulate, review research literature, and analyze complexengineering problems related to Civil Engineering andreaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2.5	Exercise, Exams
PO3	**Design/development of solutions**: Design solutions for complex engineering problems related to Civil Engineering anddesign system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	3	Exercise
PO4	**Conduct investigations of complex problems**: Use research-based knowledge and researchmethods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	Discussion, Seminars
PO5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modernengineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	-	Discussion, Seminars
PO6	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assesssocietal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the Civil Engineering professional engineering practice.	1	Discussions
PO7	**Environment and sustainability**: Understand the impact of the Civil Engineeringprofessional engineering solutionsin societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	-	------
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms ofthe engineering practice.	-	------
PO9	**Individual and team work**: Function effectively as an individual, and as a member or leader indiverse teams, and in multidisciplinary settings.	-	------
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineeringcommunity and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	-	------
PO11	**Project management and finance**: Demonstrate knowledge and understanding of theengineering and management principles and	-	-----

	apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.		
PO12	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage inindependent and life-long learning in the broadest context of technological change.	-	Prototype, Discussions

VI. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program outcomes		Level	Proficiency assessed by
PSO 1	**ENGINEERING KNOWLEDGE:**Graduates will be able to apply technical knowledge in drawing, analysis, design, laboratory investigations and construction aspects of civil engineering infrastructure, along with good basics in mathematics, basic sciences and technical communication.	2.5	Lectures and Assignments
PSO 2	**BROADNESS AND DIVERSITY:**Graduates will be able to summarize and can demonstrate about societal, economical, environmental, health and safety factors involved in infrastructural development, and shall work within multidisciplinary teams with competence in modern tool usage.	-	Tutorials
PSO 3	**SELF-LEARNING AND SERVICE:**Graduates will be able to pursue lifelong learning and professional development to face the challenging and emerging needs of our society, ethically and responsibly.	1	Seminars and Projects

0 - None **2 - Supportive** **3 – Highly Related**

VII. SYLLABUS:

UNIT – I

Introduction: Soil formation and structure – moisture content – Mass- volume relationship – Relative density.

Index Properties Of Soils: Grain size analysis – Sieve–

UNIT – II

Permeability: Soil water – capillary rise – flow of water through soils – Darcy's lawpermeability – Factors affecting permeability – laboratory determination of coefficient of permeability –Permeability of layered soils – In-situ permeability tests (Pumping in &Pumping out test).

Effective Stress & Seepage Through Soils: Total, neutral and effective stress – principle of effective stress – quick sand condition – Seepage through soils – Flownets: Characteristics and Uses.

UNIT – III

Stress Distribution In Soils: Boussinesq's and Westergaard's theories for point load, uniformly loaded circular and rectangular areas, pressure bulb, variation of vertical stress

under point load along the vertical and horizontal plane, and Newmark's influence chart for irregular areas.

Compaction: Mechanism of compaction – factors affecting compaction effects of compaction on soil properties – Field compaction Equipment – compaction quality control.

UNIT – IV

Consolidation: Types of compressibility – Immediate Settlement, primary consolidation and secondary consolidation - stress history of clay; e-p and e-log(p) curves – normally consolidated soil, over consolidated soil and under consolidated soil – preconsolidation pressure and its determination - Terzaghi's 1-D consolidation theory – coefficient of consolidation: square root time and logarithm of time fitting methods - computation of total settlement and time rate of settlement.

UNIT - V

Shear Strength Of Soils: Importance of shear strength – Mohr's– Coulomb Failure theories – Types of laboratory tests for strength parameters – strength tests based on drainage conditions – strength envelops – Shear strength of sands - dilatancy – critical void ratio.

TEXT BOOKS:

1. Principals of Geotechnical Engineering by Braja M. Das, Cengage Learning Publishers, 8th Edition, (2014).

2. Geotechnical Engineering Principles and Practices by Cuduto, PHI International

3. Basic and Applied SoilMechanics by Gopal Ranjan & ASR Rao, New age International Pvt. Ltd.

REFERENCES:

1. Geotechnical Engineering by Manoj Dutta & Gulati S.K – Tata McGraw Hill Publishers New Delhi.

2. Soil Mechanics and Foundation Engineering by VNS Murthy, CBS Publishers and Distributors.

3. Geotechnical Engineering by C. Venkataramiah, New age International Pvt. Ltd, (2002).

MOOC'S- SWAYAM/ NPTEL:

https://nptel.ac.in/courses/105103097/

https://nptel.ac.in/courses/105103097//#

GATE SYLLABUS:

- Soil Mechanics: Origin of soils, soil classification, three-phase system, fundamental definitions, relationship and interrelationships, permeability &seepage, effective stress principle, consolidation, compaction, shear strength.
- Foundation Engineering: Sub-surface investigations- scope, drilling bore holes, sampling, penetration tests, plate load test. Earth pressure theories, effect of water table, layered soils. Stability of slopes-infinite slopes, finite slopes. Foundation types-foundation design requirements. Shallow foundations-bearing capacity, effect of shape, water table and other factors, stress distribution, settlement analysis in sands & clays. Deep foundations–pile types, dynamic &static formulae, load capacity of piles in sands &clays, negative skin friction

IES SYLLABUS:

- Soil Mechanics: Properties of soils, classification and interrelationship; Compaction behaviour, methods of compaction and their choice; Permeability and seepage, flow nets, Inverted filters; Compressibility and consolidation; Shearing resistance, stresses and failure; soil testing in laboratory and in-situ; Stress path and applications; Earth pressure theories, stress distribution in soil; soil exploration, samplers, load tests, penetration tests.
- Foundation Engineering: Types of foundations, Selection criteria, bearing capacity, settlement, laboratory and field tests; Types of piles and their design and layout, Foundations on expansive soils, swelling and its prevention, foundation on swelling soils.

VIII. COURSE PLAN:

Lecture No.	Week	Unit	Learning Objective	Topics to be covered	Teaching Methodology	References
1.	1	1	Understand how the properties of soil formation	**To Understand:** Introduction to geotechnical engineering, properties of soils	PPT,Talk & Chalk, Discussion	T1:1.1
	1	1				
2.	1	1	Learn how the soil structures are formed	**To Understand:** Formation of soil and soil structures	PPT,Talk & Chalk, Discussion	T1:1.4
3.	1	1	Understand how the clayey soils are formed	**To Understand:** Clay mineralogy and adsorbed water	PPT,Talk & Chalk, Discussion	T:6.6
	2	1				
4.	2	1				
	2	1	Learn how the relative density is formed	**To Understand:** Relative density	PPT,Talk & Chalk, Discussion	T3:3.15
5.	2	1	Understand the	**To Understand:**	PPT,Talk &	T1:3.3

			properties of soil	INDEX PROPERTIES OF SOILS: grain sizes analysis	Chalk, Discussion	
	3	1				
6.	3	1	Understand the hydrometer method was used	**To Understand:** Sieve and hydrometer method of analysis	PPT,Talk & Chalk, Discussion	T1:3.8
	3	1				
7.	3	1	Analyse the limits of soil	**To Understand:** Consistency limit and indices of soil	PPT,Talk & Chalk, Discussion	T1:3.9
	4	1				
8.	4	1	Understand how the I.S classification of soils is done	**To Learn:** I.S classification of soils	PPT,Talk & Chalk, Discussion	T1:4.3
9.	4	2	Understand what is permeability	**To Learn:** PERMEABILITY - soil water –capillary rise	PPT,Talk & Chalk, Discussion	T1:5.9
	4	2				
10.	5	2	Understand how the water flows through soil	**To Learn:** Flow of water through soil	PPT,Talk &Chalk, Discussion	T1:5.4
	5	2				
11.	5	2	Understand Darcy‟s law	**To Understand:** Darcy‟s law	PPT,Talk & Chalk, Discussion	T1:5.4.1
12.	5	2	Understand how permeability of soil is determined	**To Understand:** Permeability and factors effecting laboratory determination of coefficient of permeability	PPT,Talk & Chalk, Discussion	T1:5.6
13.	6	2	Identify how the layers are formed in permeability	**To Understand:** Permeability of layered systems	PPT,Talk & Chalk, Discussion	T1:5.8
14.	6	2	Undersatand the concept of seepage through	**To Understand:** SEEPAGE THROUGH SOILS –	PPT,Talk & Chalk, Discussion	T1:6.9 to 6.10

			soils	total, neutral and effective stresses quick sand conditions		
15.	6	2	Understand the seepage through soils	**To Understand:** Seepage through soils	PPT,Talk & Chalk, Discussion	T1:6.5
16.	6	2	Understand the effect of flow nets and uses	**To Understand:** Flow nets, characteristics and uses	PPT,Talk & Chalk, Discussion	T1:6.3 to6.3
17.	7 7	3 3	Understand the concept of Boussinesq‟s theory for different Shapes of area	**To Understand:** STRESS DISTRIBUTION IN SOILS – Boussinesq‟s theory for point loads and areas of different shapes	PPT,Talk & Chalk, Discussion	T1:10.2.1
18.	7 7	3 3	Understand the concept of Westergaard‟s theory of different shapes	**To Learn:** Westergaard‟s theory for point loads and area of different shapes	PPT,Talk & Chalk, Discussion	T1:10.2.4
19.	8 8	3 3	Develop Newmark‟s influence chart	**To Learn:** Newmark‟s influences chart	PPT,Talk & Chalk, Discussion	T1:10.7
20.	8	3	Understand what is mechanism	**To Understand:** COMPACTION-mechanism of compaction	PPT,Talk & Chalk, Discussion	T1:7.22
21.	8 9	3 3	Discover various factors of compaction of soils	**To Understand:** Factors effecting compaction of soils properties	PPT,Talk & Chalk, Discussion	T1:7.22
22.	9	3	Discuss the factors affecting the compaction of soil	**To Learn:** Effect of compaction on soil properties	PPT,Talk & Chalk, Discussion	T1:12.3.2
23.	9	3				
24.	9	3	Understand field compaction test	**To Learn:** Field compaction equipment	PPT,Talk & Chalk, Discussion	T1:12.6.1

	10	3				
25.	10	3	Understand the concept of compaction control	Compaction control	PPT,Talk & Chalk, Discussion	T1:12.6.2
26.	10	4	Understand the consolidation process	**To Understand:** CONSOLIDATION – Immediate Settlement, primary consolidation and secondary consolidation Stress history of clay		T1:12.6.2
	10	4			PPT,Talk & Chalk, Discussion	
27.	11	4	Understand how the e vs p & log-p curves	**To Understand:** e-p and e- log p curves	PPT,Talk & Chalk, Discussion	T1:12.6.2
	11	4				
28.	11	4	Recognise the magnitude of 1 - D consolidation	**To Learn:** Magnitude and rates of 1-D consolidation	PPT,Talk & Chalk, Discussion	T1:7.2.1
	11	4				
29.	12	4	Understand Terzaghi‟s theory	**To Understand:** Terzaghi‟s theory	PPT,Talk & Chalk, Discussion	T1:7.4
	12	4				
30.	12	4	Understand the consolidated	**To Learn:** normally consolidated soil, over consolidated soil and under consolidated soil – preconsolidation pressure and its determination	PPT,Talk & Chalk, Discussion	T1.2.1
31.	12	4	Understand the coefficient of consolidation	**To Understand:** coefficient of consolidation: square root time and logarithm of time fitting methods.-	PPT,Talk & Chalk, Discussion	T1:12.6.1
32.	13	4	Understand the settlement	**To Learn:** computation of total settlement and time	PPT,Talk & Chalk, Discussion	T1:12.6.1

				rate of settlement.		
33.	13	5	Discuss the shear strength of soils	**To Learn:** SHEAR STRENGTH OF SOILS –Mohr and coulomb failure theories	PPT,Talk & Chalk, Discussion	T1:8.4.2
34.	13	5	Discuss the shear strength of soils	**To Understand:** SHEAR STRENGTH OF SOILS –Mohr and coulomb failure theories	PPT,Talk & Chalk, Discussion	T1:8.4.2
35.	13	5	Understand the laboratory tests	Types of laboratory strength test	PPT,Talk & Chalk, Discussion	T1:8.8
	14	5				
36.	14	5	Discuss the drainage conditions based on strength test	**To Learn:** Strength test based on drainage conditions	PPT, Talk & Chalk, Discussion	T1:8.12.2
	14	5				
37.	14	5	Understand the shear strength of sands	**To Learn:** Shear strength of sands	PPT, Talk & Chalk, Discussion	T1:8.11.3
	15	5				
38.	15	5	Discuss Critical void ratio of clay	**To Understand:** Critical void ratio of clay	PPT, Talk & Chalk, Discussion	T1:8.11.2
39.	15	5				
	15	5	Discuss the liquefaction and shear strength of clay	**To Understand:** Liquefaction and shear strength of clay	PPT, Talk & Chalk, Discussion	T1:8.12
40.	16	5				
41.	16	5				
		Beyond Syllabus				
42.	16			*Practical applications of index and engineering properties		
43.	16			*How to change index and engineering properties with various methods		

IX. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Objectives	Program Outcomes												Program Specific Outcomes		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
I	2	3	3	-	-	-	-	-	-	-	-	-	2	--	2
II	-	2	3	2	-	2	-	-	-	-	-	-	3	-	-
Average	1	2.5	3	1	-	1	-	-	-	-	-	-	2.5	-	1

0=None **2=Supportive** **3=Highly related**

X. QUESTION BANK: (JNTUH)

DESCRIPTIVE QUESTIONS: (WITH BLOOMS PHRASES)

UNIT-I

SHORT ANSWER QUESTIONS-

S.NO	Question	Blooms Taxonomy Level	Programme Out come
1.	Name common clay minerals.	Remember	CACE006.01
2.	Define void ratio, porosity.	Remember	CACE006.01
3.	What are the various types of structures present in soil?	Remember	CACE006.01
4.	Define degree of saturation, % air voids.	Remember	CACE006.01
5.	Define water content and name the laboratory tests used for determining water content.	Remember	CACE006.01
6.	Define saturated unit weight, submerged unit weight, what is the relationship between saturated and submerged unit weight.	Remember	CACE006.01
7.	What is the relationship between void ratio, specific gravity and water content?	Remember	CACE006.01
8.	Define relative density & explain its significance.	Remember	CACE006.01
9.	Draw two phase & three phase diagram.	Remember	CACE006.01
10.	What is the principle of hydrometer & write its expression?	Remember	CACE006.01

LONG ANSWER QUESTIONS-

S.No	Question	Blooms Taxonomy Level	Programme Out come
1.	Explain the clay mineralogy in detail with their schematic representation?	Remember	CACE006.01
2.	Starting from three phase representation of soil	Understand	CACE006.01

	mass, derive the relationship between bulk unit weight, specific gravity, void ratio and degree of saturation.		
3.	With the help of three phase diagram, define the following: (i) Voids ratio (ii) Porosity (iii) Degree of saturation (iv) Water content (v) Absolute/true specific gravity (vi) Apparent specific gravity (vii) Air content (viii) Percentage of air voids and (ix) Relative density.	Understand	CACE006.01
4.	Explain in detail the procedure for Sieve analysis and discuss how you can plot grain size distribution curve from sieve analysis.	Remember	CACE006.03
5.	1m3 of wet soil weighs 20 kN. Its dry weight is 18 kN, specific gravity is 2.67. Determine the water content, porosity, void ratio, degree of saturation. Draw phase diagram.	Understand	CACE006.02
6.	An undisturbed sample of soil has a volume 100 cm3 & mass 200 g on oven drying for 24 hrs, the mass is reduced to 170 g. If G=2.68, determine void ratio, water content & degree of saturation.	Understand	CACE006.02
7.	A sample of fully saturated soil has a water content of 25% and a bulk unit weight of 20kN/m3. Determine the (i) dry unit weight (ii) void ratio (ii) specific gravity of the soil. What would be the bulk unit weight of the soil if the soil is compacted for the same void ratio but with a degree of saturation 90%.	Understand	CACE006.02
8.	A sample of soil compacted according to standard proctor test has a unit weight of 20.58 kN/m3 at 100% compaction and at optimum water content of 14%. What is the dry unit weight? What is the dry unit weight at zero air voids? If voids become filled with water what would be the saturated unit weight? Assume G=2.7.	Understand	CACE006.02
9.	An undisturbed saturated specimen of clay has a volume of 18.9 cm3 and a mass of 30.2g. On oven drying the mass reduces to 18 g. The volume of dry specimen as determined by displacement of mercury is 9.9 cm2. Determine the shrinkage limit, volumetric shrinkage, specific gravity, shrinkage ratio.	Understand	CACE006.02
10.	A soil has a liquid limit and plastic limit of 47% and 33% respectively. If the volumetric shrinkage at the liquid limit and plastic limit are 44% and 29%. Determine the shrinkage limit & shrinkage ratio.	Understand	CACE006.04

UNIT-2

SHORT ANSWER QUESTIONS-

S.NO	Question	Blooms Taxonomy Level	Programme Out come
1.	State Darcy's Law.	Remember	CACE006.05
2.	Define Permeability.	Remember	CACE006.05
3.	What are the factors affecting permeability of soil?	Remember	CACE006.05
4.	What is the range of coefficient of permeability for gravel, sand, silt and clayey soils?	Remember	CACE006.05
5.	Enumerate the laboratory tests for determining the coefficient of permeability?	Remember	CACE006.05
6.	Define total stress & neutral stress.	Remember	CACE006.05
7.	Write the expression for vertical coefficient of permeability in layered soils.	Remember	CACE006.05
8.	Define flow net & uses of flow net.	Remember	CACE006.05
9.	What are the characteristics of flow net.	Remember	CACE006.05

LONG ANSWER QUESTIONS-

S.NO	Question	Blooms Taxonomy Level	Programme Out come
1.	Explain the laboratory procedure for determining the coefficient of permeability for fine grained soils i.e., silts and clay?	Remember	CACE006.05
2.	Explain the laboratory procedure for determining the coefficient of permeability using constant head permeability test?	Remember	CACE006.05
3.	Explain in detail flow net with neat sketch? Discuss in detail properties and applications of flow net?	Remember	CACE006.05
4.	Explain about Darcy's law. Explain its validity in soil.	Remember	CACE006.05
5.	Discuss pumping-out method for the determination of the coefficient of permeability in the field.	Remember	CACE006.05
6.	Discuss pumping-in method for the determination of the coefficient of permeability in the field.	Remember	CACE006.05
7.	Differentiate between absorbed and capillary water in soils? Write the expression for determining height of capillary rise in small diameter pipe and in soils respectively.	Understand	CACE006.05
8.	A sand sample of 35 cm2 cross sectional area and 20 cm long was tested in a constant head permeameter. Under a head of 60 cm, the discharge was 120 ml in 6 min. The dry weight of	Understand	CACE006.05

	sand used for the test was 1120 g, and Gs = 2.68. Determine (a) the hydraulic conductivity in cm/sec, (b) the discharge velocity, and (c) the seepage velocity.		
9.	Determine the average coefficient of permeability in directions parallel and perpendicular to the planes of a stratified deposit of soil consisting of 3 layers of total thickness 3 m. The top and bottom layers are 0.5 m and 0.8 m thick. The values of K for top, middle, and bottom layers are 2×10-4 cm/s, 3×10-3 cm/s, 1×10-2 cm/s respectively.	Understand	CACE006.05
10.	The following data were recorded in a constant head permeability test. Internal diameter of Permeameter = 7.5 cm, head lost over a sample length of 18 cm = 24.7 cm, quantity of water collected in 60 s = 626 ml, porosity of the soil sample was 44%. Calculate the coefficient of permeability of the soil. Also determine the discharge velocity and the seepage velocity during the test. If the test was carried out at a temperature of 250 C, estimate the permeability of the soil for a porosity of 39% and at 200 C.	Understand	CACE006.05

UNIT-3

SHORT ANSWER QUESTIONS-

S.NO	Question	Blooms Taxonomy Level	Programme Out come
1.	Define Pressure bulb & explain its significance.	Understand	CACE006.04
2.	State the Boussinesq's expression for the vertical stress distribution in case of point load.	Remember	CACE006.05
3.	Explain the approximate method of stress distribution in soils.	Remember	CACE006.04
4.	Sketch Newmark's Influence chart & innumerate its uses.	Remember	CACE006.05
5.	State Westergaard's equation for vertical stress at a point due to point load.	Remember	CACE006.04
6.	State Newmark's equation for vertical stress below the corner of a uniformly loaded rectangular area.	Remember	CACE006.05
7.	State Boussinesq's equation for vertical stress at a point due to	Remember	CACE006.05
8.	Define compaction & its use.	Remember	CACE006.05
9.	Innumerate the factors affecting compaction.	Remember	CACE006.05
10.	Differentiate between compaction and consolidation.	Understand	CACE006.05

LONG ANSWER QUESTIONS-

S.NO	Question	Blooms Taxonomy Level	Programme Out come
1.	What are the assumptions made by Boussinesq's in deriving the expression for vertical stress in soil due to point load? Explain its limitations?	Remember	CACE006.04
2.	Explain assumptions & limitations of Westergaard's theory. State the expression for vertical stress in soil due to point load.	Remember	CACE006.04
3.	List the field compaction equipment and explain them in detail.	Remember	CACE006.04
4.	Describe standard proctor test and modified proctor test.	Remember	CACE006.04
5.	Explain the laboratory procedure to determine maximum dry density and optimum moisture content by using standard compaction test.	Remember	CACE006.02
6.	A load 500kN acts as a point load at the surface of a soil mass. Estimate the vertical stress at a point 4 m below and 3m away from the point of load using Boussinesq's and Westergaard's theory.	Understand	CACE006.05
7.	During a compaction test, a soil attains a maximum dry density of 18 kN/m3 at a water content of 12%. Determine the degree of saturation and percent air voids at maximum dry density. Also find the theoretical maximum dry density corresponding to zero air voids at OMC. The specific gravity of soils 2.67.	Understand	CACE006.05
8.	The maximum dry density of a sample by the light compaction test is 1.78 g/cc at an optimum water content of 15%. Find the air voids and the degree of saturation. G =2.67 what would be the corresponding value of dry density on the zero air void line at O.W.C.	Understand	CACE006.05
9.	A sample of soil compacted according to the standard Proctor test has a density of 2.06g/cm3 at 100% compaction and at an optimum water content of 14%. What is the dry unit weight? What is the dry unit weight at zero air voids? If the voids become filled with water what would be the saturated unit weight? Assume G=2.67.	Understand	CACE006.05
10.	The records of a soil compaction in the past gave compaction water content of 15% and saturation 85%. What might be the dry density of soil?	Understand	CACE006.05

UNIT-4

SHORT ANSWER QUESTIONS-

S.NO	Question	Blooms Taxonomy Level	Programme Out come
1.	Define consolidation.	Remember	CACE006.05
2.	What are the different types of settlements in soil.	Remember	CACE006.04
3.	Define under consolidated clays.	Remember	CACE006.05
4.	Write the formula to determine the compression index in terms of liquid limit.	Remember	CACE006.05
5.	List the assumptions of Terzaghi's 1-D consolidation theory.	Remember	CACE006.05
6.	Define compression index.	Remember	CACE006.05
7.	Differentiate between primary consolidation and secondary consolidation.	Remember	CACE006.05
8.	Define primary consolidation & write the expression for calculating the consolidation settlement.	Remember	CACE006.05
9.	Define recompression index.	Remember	CACE006.05
10.	Discuss Terzaghi's theory of consolidation.	Remember	CACE006.05

LONG ANSWER QUESTIONS-

S.NO	Question	Blooms Taxonomy Level	Programme Out come
1.	Discuss Terzaghi's theory of consolidation, stating the various assumptions and their validity.	Remember	CACE006.04
2.	Write a brief procedure of consolidation test to determine the coefficient of consolidation by both logarithmic time fitting method.	Remember	CACE006.04
3.	Explain the procedure for determining pre consolidated pressure?	Remember	CACE006.05
4.	Explain how you will determine void ratio of the sample by change in void ratio method. Also explain how do you find coefficient volume change?	Remember	CACE006.04
5.	What are the different causes of pre consolidation of soils? What is the effect of pre consolidation on the settlement?	Remember	CACE006.04
6.	Differentiate between normally consolidated, under consolidated and over consolidated soils. How would you determine the over consolidation pressure.	Remember	CACE006.05
7.	What is over consolidation soil? Explain briefly with an example.	Remember	CACE006.04
8.	A soil sample 20 mm thick takes 20 minutes to reach	Understand	CACE006.05

	20% consolidation. Find the time taken for a clay layer 6 m thick to reach 40% consolidation. Assuming double drainage in both the cases.		
9.	A stratum of normally consolidated clay 7m thick is located at a depth 12m below ground level. The natural moisture content of the clay is 43% and its liquid limit is 48%. The specific gravity of the solid particles is 2.76. The water table is at a depth of 5m below ground surface. The soil is sand above the clay stratum. The submerged unit weight of the sand is 11kN/m3 and 18 kN/m3 above the water table. The average increase in pressure at the centre of the clay stratum is 120kN/m3 due to the weight of the building that will be constructed on the sand above the clay stratum. Estimate the expected settlement of the structure.	Understand	CACE006.04
10.	A clay layer of 6m thick is situated with sand on top and impervious rock at the bottom. In a consolidation test conducted in the laboratory on an undisturbed specimen of 20 mm thick clay sample, 90% settlement was reached in 3 hours. Estimate the time in years for the building on this deposit to reach 90% of its final settlement.	Understand	CACE006.05

UNIT-5

SHORT ANSWER QUESTIONS-

S.NO	Question	Blooms Taxonomy Level	Programme Out come
1.	Explain importance of shear strength of soils in foundation design.	Understand	CACE006.05
2.	Explain about determination of shear strength using vane shear test.	Remember	CACE006.05
3.	What are the names of shear tests based on drainage conditions?	Remember	CACE006.05
4.	What is the meaning of peak and residual shear strength of clay soils?	Understand	CACE006.05
5.	How can liquefaction in sands be prevented?	Remember	CACE006.05
6.	What are the merits and demerits of tri-axial test?	Remember	CACE006.05
7.	What are the merits and demerits of vane shear test.	Remember	CACE006.05
8.	What is unconfined compression test?	Remember	CACE006.05
9.	What is the difference between angle of repose and angle of internal friction	Remember	CACE006.05
10.	Define critical void ratio.	Remember	CACE006.05

LONG ANSWER QUESTIONS-

S.NO	Question	Blooms Taxonomy Level	Programme Out come
1.	When do you use the following shear tests and give reasons: (a) direct shear test; (b) vane shear test; (c) unconfined compression test.	Remember	CACE006.05
2.	Sketch stress strain diagrams for loose sand, dense sand, soft clay and stiff clay and comment.	Remember	CACE006.05
3.	Explain the merits and demerits of direct shear test when compared with the other laboratory tests to determine the shear strength of soil.	Remember	CACE006.05
4.	Classify the shear tests based on drainage conditions. Explain how the pore pressure variation and volume change take place during these tests. Enumerate the field conditions which necessitate each of these tests.	Understand	CACE006.05
5.	Discuss modified failure envelope. What are its advantages and disadvantages over the standard failure envelope.	Remember	CACE006.05
6.	Explain liquefaction of soils. Explain the conditions causing liquefaction of sand.	Remember	CACE006.05
7.	What is Coulomb's equation for shear strength of soil? Discuss the factors that affect the shear strength parameters of soil.	Remember	CACE006.05
8.	Determine the shear strength in terms of effective stress on a plane within saturated soil mass at a point where the total normal stress is 200 kN/m2 and the pore water pressure is 80 kN/m2. The effective stress shear strength parameters for the soil are c' = 16 kN/m2 and $_{\varphi}$'= 300 .	Understand	CACE006.05
9.	In an in-situ vane shear test on a saturated clay, a torque of 35 Nm was required to shear the soil. The diameter of the vane was 50 mm and length 100 mm. Calculate the undrained shear strength of clay. The vane was then rotated rapidly to cause remoulding of the soil. The torque required to shear the soil in the remoulded state was 5 Nm. Determine the sensitivity of the clay.	Understand	CACE006.04
10.	A direct shear test was performed on a 6cm x 6cm sample of dry sand the normal load was 360N. The failure occurred at a shear load of 180N.Plot the Mohr strength envelope and determine ∅ . Assume c=0 also determine principal stress at failure.	Understand	CACE006.04

XI. OBJECTIVE QUESTIONS:

UNIT-1

1. Secondary Consolidation is
   a) Caused by hydrodynamic loading. b) Caused by creep

   c) Large for the pressure below the pre consolidation pressure. d) Caused by temperature.

2. The unit of co-efficient of consolidation is
   a) cm/sec b) cm^2/sec^2 c) cm^2/sec d) cm/sec^2.

3. The roller to be used for compaction of heart of earth dam is
   a) Smooth heavy roller b) Sheep foot roller c) Pneunatic roller d) Vibratory roller

4. The following soil has highest OMC.
   a) Gravel b) Sand c) Silt d) Clay

5. The 95% saturation line and 5% air voids line are
   a) Same b) Sometimes same and sometime different c) Different d) None.

6. During shearing the negative pore pressures are likely to develop in
   a) N.C clay and dense sand b) O.C clay and loose sand

   c) Loose and OC clay d) Dense sand and OC clay.

7. The max shear stress occurs on filament which makes angle with the horizontal plane equal to
   a) 90° b) 60° c) 45° d) 30°.

8. With usual notations the coulombs equation for shear under drained condition is
   a) $S=C+ \sigma \tan\theta$ b) $S= C' + (\sigma-U) \tan\theta$ c) $S= C' + U \tan\theta$ d) $S= C' \tan\theta + \sigma$

9. Assumption of Boussinesq theory
   a) Homogeneous, Isotrophic b) Weight less

   c) Semi infinite, elastic medium d) All the above.

10. For the stability analysis of an earth dam for steady seepage case, the most appropriate test Would be the

    a) UU test b) CU test c) CD test d) UD test

UNIT-2

1. The active earth pressure of a soil is proportional to (where φ is the angle of friction of the soil)
   A.$\tan(45° - \varphi)$ B.$\tan2(45° + \varphi/2)$ C.$\tan2(45° - \varphi/2)$ D.$\tan(45° + \varphi)$

2. The minimum water content at which the soil just begins to crumble when rolled into threads

3 mm in diameter, is known

A. liquid limit B. plastic limit C. shrinkage limit D. Permeability limit.

3. The lateral earth pressure on a retaining wall
A. is equal to mass of the soil retained B. proportional to the depth of the soil

C. proportional to the square of the depth of the soil

D. proportional to the internal friction of the soil E. none of these.

4. The internal molecular attraction of a soil, the cohesion
A. decreases as the moisture content increases

B. increases as the moisture content decreases

C. is more in well compacted clays

D. depends upon the external applied load.

5. The quantity of seepage of water through soils is proportional to
A. coefficient of permeability of soil B. total head loss through the soil

C. neither (a) nor (b) D. both (a) and (b).

6. When drainage is permitted under initially applied normal stress only and full primarily consolidation is allowed to take place, the test is known as
A. quick test B. drained test C. consolidated undrained test D. none of these.

7. The minimum water content at which the soil retains its liquid state and also possesses a small shearing strength against flowing, is known
A. liquid limit B. plastic limit C. shrinkage limit D. permeability limit.

8. Minimum size of the particles of silt soil, is
A.0.002 mm B.0.04 mm C.0.06 mm. D.0.08 mm E.1 mm

9. The active earth pressure of a soil is proportional to (where φ is the angle of friction of the soil)
A.tan (45° - φ) B.tan2 (45° + φ/2) C.tan2 (45° - φ/2) D.tan (45° + φ)

10. The minimum water content at which the soil just begins to crumble when rolled into threads 3 mm in diameter, is known

A. liquid limit B. plastic limit C. shrinkage limit D. Permeability limit.

UNIT-3

1. Under-reamed piles are generally
A. driven piles B. bored piles C. precast piles D. all the above.

2. Pick up the clay soil group which does not swell when wet from the following :
A. Kaolinite group B. Mite group C. Vermiculite group D. Montrorillonite group.

3. The ratio of the volume of voids to the volume of soil solids in a given soil mass, is known
A. porosity B. specific gravity C. void ratio D. water content.

4. A partially saturated sample of soil has a unit weight of 2.0 g/cm3 and specific gravity of soil particles is 2.6. If the moisture content in the soil is 20%, the degree of saturation is
A.20% B.77% C.92% D.none of these.

5. According to Coulomb's wedge theory, the active earth pressure slides the wedge
A. down and outwards on a slip surface B. up and inwards on a slip surface

C. horizontal upward and parallel to base D. horizontal inward and parallel to base.

6. The effective size of particles of soil is denoted by
A.D10 B.D20 C.D30 D.D60

7. Degree of saturation of a natural soil deposit having water content 15%, specific gravity 2.50 and void ratio 0.5, is
A.50% B.60% C.75% D.80%

8. The coefficient of compressibility of soil, is the ratio of
A. stress to strain B. strain to stress

C. stress to settlement D. rate of loading to that of settlement.

9. If the failure of a finite slope occurs through the toe, it is known as
A. slope failure B. face failure C. base failure D. toe failure.

10. The water content of soil is defined as the ratio of
A. volume of water to volume of given soil B. volume of water to volume of voids in soil

C. weight of water to weight of air in voids

D. weight of water to weight of solids of given mass of soil.

UNIT -4

1. The liquid limit and plastic limit exist in
A. sandy soils B. silty soils C. gravel soilsD. clay soils.

2. Back fill with a sloping surface exerts a total active pressure Pa on the wall of height H and acts at
A. H/4 above the base parallel to base B. H/2 above the base parallel to base

C. H/3 above the base parallel to base D. H/5 above the base parallel to base.

3. The seepage force in a soil, is
   A. perpendicular to the equipotential lines B. proportional to the exit graident

C. proportional to the head loss D.all the above.

4. A soil has bulk density 2.30 g/cm3 and water content 15 per cent, the dry density of the sample, is
   A.1.0 g/cm2 B.1.5 g/cm3 C.2.0 g/cm3 D.2.5 g/cm3

5. The fluid generally used for grouting is
   A. cement and water mix B. clay suspension C. sodium silicate

   D. bitumen emulsion E. all the above.

6. A coarse-grained soil has a voids ratio 0.75, and specific gravity as 2.75. The critical gradient at which quick sand condition occurs, is
   A.0.25 B.0.50 C.0.75 D.1.00

7. Failure of the stability of slopes, generally occurs along
   A. slip plane B. a horizontal surface C. a curved surface D. all the surfaces.

8. The weight of a pycnometer containing 400 g sand and water full to the top is 2150 g. The weight of pycnometer full of clean water is 1950 g. If specific gravity of the soil is 2.5, the water content is
   A.5% B.10% C.15% D.20%

9. Which one of the following statements is true ?
   A. Clays are more porous than sands

   B. Pressure of organic matter in a soil decreases the bearing capacity of the soil

   C. Aluminous cement is used for foundations in soils with chemical deposits

   D. All the above.

10. A soil has bulk density 2.30 g/cm3 and water content 15 per cent, the dry density of the sample, is
    A.1.0 g/cm2 B.1.5 g/cm3 C.2.0 g/cm3 D.2.5 g/cm3

UNIT -5

1. The maximum shear stress occurs on the filament which makes an angle with the horizontal plane equal to
   A.30° B.45° C.60° D.90°

2. For determining the moisture content of a soil sample, the following data is available Weight of container = 260 g, Weight of soil sample and = 320 g container, Weight of soil sample (dried) and = 310 g container. The moisture content of the soil sample, is
   A.15% B.18% C.20% D.25%

3. Buoyant unit weight equals the saturated density
   A. multiplied by unit weight of water B. divided by unit weight of water

   C. plus unit weight of water D. minus unit weight of water.

4. Pick up the correct statement from the following:
   A. An unconfined compression test is a special case of triaxial compression test

   B. An unconfined compression test is a special case of direct shear test

   C. The confining pressure is maximum during an unconfined compression test

   D. The cylindrical specimen of a soil is subjected to major principal stress till it fails due to shearing along the plane of the failure.

5. A partially saturated soil is classified as
   A. one phase soil B. two phase soil C. three phase soil D. four phase soil.

6. The Westergaard analysis is used for
   A. sandy soils B. cohesive soils C. stratified soils D. clayey soils.

7. The critical exist gradient of seepage water in soils, is
   A. directly proportional to the voids ratio

   B. inversely proportional to the specific gravity

   C. directly proportional to the specific gravity

   D. inversely proportional to the voids ratio E. none of these.

8. Number of piles required to support a column, is
   A.1 B.2 C.3 D.4

9. The soil moisture driven off by heat, is called
   A. free water B. hydroscopic water C. gravity water D.none of these

10. The maximum load carried by a pile, when it continues to sink without further increase of load, is known as
    A. ultimate load carrying capacity B. ultimate bearing capacity

    C. ultimate bearing resistant D. all the above.

XII. GATE QUESTIONS:

1. Compaction of an embankment is carried out in 500 mm thick layers. The rammer used for compaction has a foot area of 0.05 sq. m and the energy imparted in every drop of rammer is 400 Nm. Assuming 50% more energy in each pass over the compacted area due to overlap, the number of passes required to develop compactive energy equivalent to Indian Standard light compaction for each layer would be

   (a) 10 (b) 16 (c) 20 (d) 26

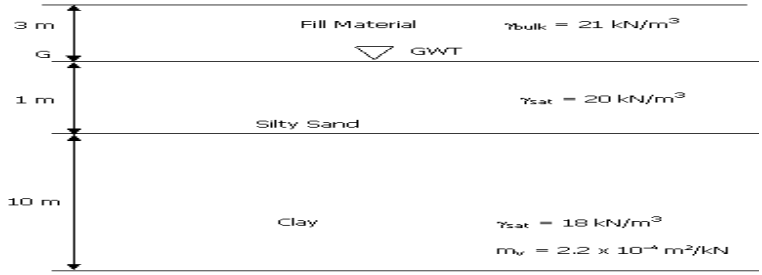
2. A braced cut, 5m wide and 7.5m deep is proposed in a cohesionless soil deposit having effective cohesion c'=0 and effective friction angle, □'=36^0. The first row of struts is to be installed at a depth of 0.5 m below ground surface and spacing between the struts should be 1.5m. If the horizontal spacing of struts is 3m and unit weight of the deposit is 20kN/m^3, the maximum strut load will be

   (a) 70.87 kN (b) 98.72 kN (c) 113.90 kN (d) 151.86kN

3. For the soil strata shown in figure,the water table is lowered by drainage by 2m and if the top 2m thick silty sand stratum remains saturated by capillary action even after lowering of water table, the increase in effective vertical pressure in kPa at mid-height of clay layer will be

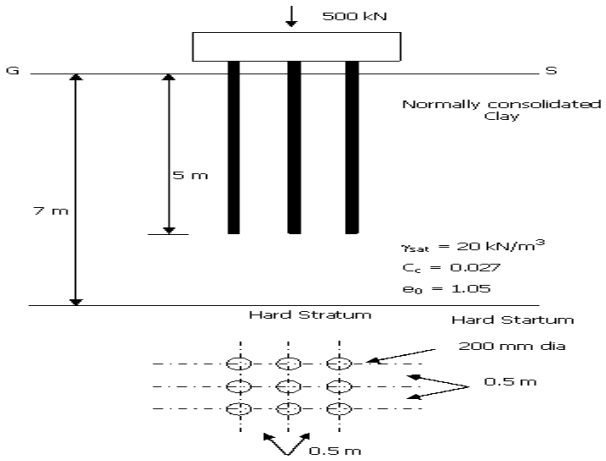
   (a) 0.2 (b) 2 (c) 20 (d) 200

4. At a reclamation site for which the soil strata is shown in figure, a 3m thick layer of a fill material is to be laid instantaneously on the top surface. If the coefficient of volume compressibility, m_v for clay is 2.2 x 10^{-4} m^2/kN, the consolidation settlement of the clay layer due to placing of fill material will be



   (a) 69.5 mm (b) 139 mm (c) 228 mm (d) 278 mm

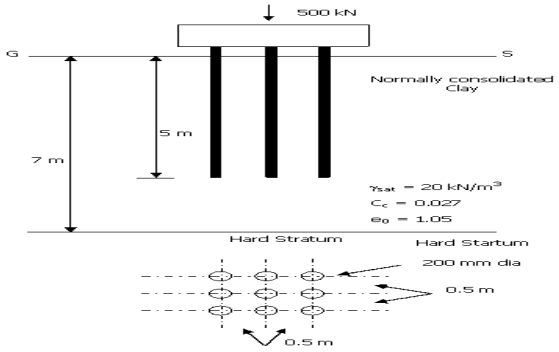
5. For the (3 × 3) pile group shown in the figure, the settlement of pile group, in a normally consolidated clay stratum having properties as shown in the figure, will be



(a) 69.5 mm (b) 139 mm (c) 228 mm (d) 278 mm

IES QUESTIONS:

1. For the (3 × 3) pile group shown in the figure, the settlement of pile group, in a normally consolidated clay stratum having properties as shown in the figure, will be



(a) 13.2 mm (b) 12.775 mm (c) 7.345 mm (d) none of these

2. Match the items of the two lists and select the correct answer.

List I (Boring Methods)

P Auger Boring

Q Wash Boring

R Percussion Drilling

S Rotary Drilling

List II (Field Conditions)

1. Below water table in all soil types except hard soils and rocks

2. Large diameter boreholes over 150 mm in size

3. Explorations for shallow foundations and highways

4. Bouldery and gravelly strata

Codes:

	P	Q	R	S
(a)	3	1	4	2
(b)	1	2	4	3
(c)	2	3	4	1
(d)	3	1	2	4

3. Match the items of List-I with List-II and select the correct answer.

List I

P Modulus of subgrade reaction

Q Relative density and strength

R Skin friction and point bearing reistance

S Elastic constants

List II

1. Cyclic pile load test

2. Pressure meter test

3. Plate load test

4. Standard penetration test

5. Dynamic cone penetration test

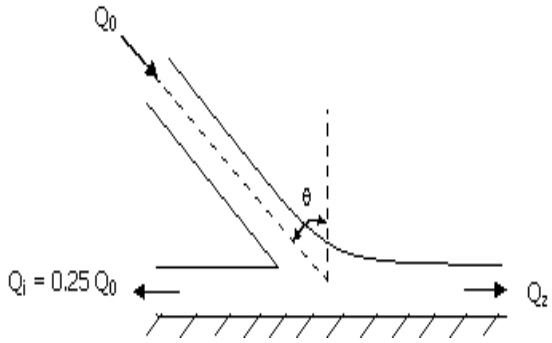
Codes:

	P	Q	R	S
(a)	1	3	2	5
(b)	1	2	4	3

(c) 2 5 1 3

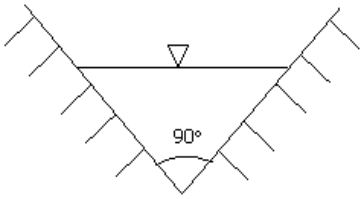
(d) 3 4 1 2

4. A horizontal jet strikes a frictionless vertical plate (the plan view is shown in the figure). It is then divided into two parts, as shown in the figure. If the impact loss can be neglected, what is the value of



(a) 15° (b) 30° (c) 45° (d) 60°

5. A hydraulic jump takes place in a triangular channel of vertex angle 90^0, as shown in figure. The discharge is $1 m^3/s$ and the pre-jump depth is 0.5 m. What will be the post-jump? (Take g = 9.81 m/s^2)



(a) 0.57 m (b) 0.91 m (c) 1.02 m (d) 1.57 m

6. Two pipelines, one carrying oil (mass density 900 kg/m^3) and the other water, are connected to a manometer as shown in the figure. By what amount the pressure in the water pipe should be increased so that the mercury levels in both the limbs of the manometer become equal? (Mass density of mercury = 13,550 kg/m^3 and g = 9.81 m/s^2)

(a) 24.7kPa (b) 26.5 kPa (c) 26.7 kPa (d) 28.9 kPa

XIII. WEBSITES:

1. **www.geoengineer.org**
2. www.geotechnicaldirectory.com
3. www.geotechnique.info
4. www. foundationengineering.info

XIV.EXPERT DETAILS:

1. Dr. Dharamveer Singh, Assistant Professor, IIT Bombay
2. Dr. Deepankar Choudhury, Associate Professor, IIT Bombay

XV. JOURNALS:(NATIONAL & INTERNATIONAL)

1. Editor in Chief, International Journal of Geotechnical Earthquake Engineering (IJGEE), Hershey, PA 17033, USA – 4 issues have been brought out
2. Editorial Advisory Panel, Geotechnique letters, ICE Publishers, London, UK.
3. Associate Editor, ASCE Journal of Materials in Civil Engineering, American Society of Civil Engineering (ASCE), USA for the period 2007-2009.
4. Editorial Advisory Board, Electronic Journal of Geotechnical Engineering (EJGE), USA (http://www.ejge.com/EdBoard.htm).
5. Guest Editor on "Earthquakes and Geotechnics", Special issue in Current Science Journal, by Indian Academy of sciences, Nov 2004.
6. Associate Editor, Journal of Earth System Science (JESS), by Indian Academy of Sciences and Springer online, special issue on Microzonation scheduled for September 2008.
7. Editorial Board Member, Indian Geotechnical Journal 1998-2000, 2010-2012

XVI. LIST OF TOPICS FOR STUDENT SEMINARS:

1. Compaction quality control measures
2. plasticity index of soil
3. over consolidation
4. Uncomplained shear test
5. estimating shear strength under different conditions

XVII. CASE STUDIES / SMALL PROJECTS:

Design and Execution of Soil Nail Wall System for Stabilisation of Railway Embankment for Constructing Underpass Using Box Pushing Under the Existing Railway Line Near Apsara Border, Dilshad Garden, Delhi