Ref No:

SRI KRISHNA INSTITUTE OF TECHNOLOGY , BANGALORE-90

LABORATORY PLAN

Academic Year 2019-20

Program:	B E – Civil Engineering
Semester :	5
Course Code:	17CVL57
Course Title:	Geotechnical engineering laboratory
Credit / L-T-P:	02/ 0-0-3
Total Contact Hours:	42
Course Plan Author:	SHIVAPRASAD D G/SHIVASHANKAR R

Academic Evaluation and Monitoring Cell

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INSTRUCTIONS TO TEACHERS

- Classroom / Lab activity shall be started after taking attendance.
- Attendance shall only be signed in the classroom by students.
- Three hours attendance should be given to each Lab.
- Use only Blue or Black Pen to fill the attendance.
- Attendance shall be updated on-line & status discussed in DUGC.
- No attendance should be added to late comers.
- Modification of any attendance, over writings, etc is strictly prohibited.
- Updated register is to be brought to every academic review meeting as per the COE.

Table of Contents

Note : Remove "Table of Content" before including in CP Book
Each Laboratory Plan shall be printed and made into a book with cover page
Blooms Level in all sections match with A.2, only if you plan to teach / learn at higher levels

A. LABORATORY INFORMATION

1. Laboratory Overview

Degree:	B.E	*Program:*	CV
Year / Semester :	2 / 5	*Academic Year:*	2018-19
Course Title:	Geotechnical engineering laboratory	*Course Code:*	17CVL57
Credit / L-T-P:	2 / 0-0-3	*SEE Duration:*	180 Minutes
Total Contact Hours:	42 Hrs	*SEE Marks:*	80 Marks
CIA Marks:	20	*Assignment*	5/1 Experiment
Course Plan Author:	SHIVAPRASAD D G/SHIVASHANKAR R	*Sign*	Dt : 14-04-2019
Checked By:	Mohan K T	*Sign*	Dt : 16-04-2019

2. Laboratory Content

Expt.	Title of the Experiments	Lab Hours	Concept	Blooms Level
1	Visual soil classification.	06	Index properties	L3 Apply
2	Grain size analysis	03	Soil classification	L3 Apply
3	In-situ density tests	03	Analysis of Field Density	L3 Apply
4	Consistency limits	03	Consistency Limits	L3 Apply
5	compaction test	03	Analysis of Density and Moisture content	L3 Apply
6	Co-efficient of permeability test	03	Permeability Analysis	L3 Apply
7	Shear strength tests	09	Shear Strength of Soils	L3 Apply
8	Consolidation test	03	Consolidation Index	L3 Apply
9	Laboratory vane shear test	03	Shear Strength of Soils	L3 Apply
10	Demonstration of Swell pressure test, Standard penetration test and boring equipment	06	Demonstration	L2 Understand

3. Laboratory Material

Books & other material as recommended by university (A, B) and additional resources used by Laboratory teacher (C).

Expt.	Details	Expt. in book	Availability
A	**Text books (Title, Authors, Edition, Publisher, Year.)**	-	-
1-10	Punmia B C, Soil Mechanics and Foundation Engineering, Laxmi Publications co., New Delhi.	1-10	In Lib
B	**Reference books (Title, Authors, Edition, Publisher, Year.)**	-	
C	**Concept Videos or Simulation for Understanding**	-	-
C1	https://www.youtube.com/watch?v=5D99H8pGPhQ		
C2	https://www.youtube.com/watch?v=CAezS3mPzOc		
C3	https://www.youtube.com/watch?v=C10dklH12W0		

C4	https://www.youtube.com/watch?v=OsqmmBlm_9c		
C5	https://www.youtube.com/watch?v=c4i_y6u-tsE		
C6	https://www.youtube.com/watch?v=mfAj5zSWGzM		
C7	https://www.youtube.com/watch?v=GN8V7UGQwb8&list=PLSNhedsleX11ijsL3SDSg1lgklLrn9lW_		
C8	https://www.youtube.com/watch?v=XRlFvjG_6AY		
C9	https://www.youtube.com/watch?v=fhub_nMvfBE		
C10	https://www.youtube.com/watch?v=Mnfw5kEkA1Y		
D	**Software Tools for Design**	**-**	**-**
E	**Recent Developments for Research**	**-**	**-**
F	**Others (Web, Video, Simulation, Notes etc.)**	**-**	**-**

4. Laboratory Prerequisites:

Refer to GL01. If prerequisites are not taught earlier, GAP in curriculum needs to be addressed. Include in Remarks and implement in B.5.

Students must have learnt the following Courses / Topics with described Content . . .

Expt.	Lab. Code	Lab. Name	Topic / Description	Sem	Remarks	Blooms Level
1	15cv45	Basic Geotechnical Engineering	Fundamentals of Soil Mechanics, Index and Engineering Properties etc.	4		Understand L2
2						
3						
5						
-						
-						

5. Content for Placement, Profession, HE and GATE

The content is not included in this course, but required to meet industry & profession requirements and help students for Placement, GATE, Higher Education, Entrepreneurship, etc. Identifying Area / Content requires experts consultation in the area.

Topics included are like, a. Advanced Topics, b. Recent Developments, c. Certificate Courses, d. Course Projects, e. New Software Tools, f. GATE Topics, g. NPTEL Videos, h. Swayam videos etc.

Expt.	Topic / Description	Area	Remarks	Blooms Level
1				
3				
3				
5				
-				

B. Laboratory Instructions

1. General Instructions

SNo	Instructions	Remarks
1	Observation book and Lab record are compulsory.	
2	Students should report to the concerned lab as per the time table.	
3	After completion of the program, certification of the concerned staff in-charge in the observation book is necessary.	

4	Student should bring a notebook of 100 pages and should enter the readings /observations into the notebook while performing the experiment.	
5	The record of observations along with the detailed experimental procedure of the experiment in the Immediate last session should be submitted and certified staff member in-charge.	
6	Should attempt all problems / assignments given in the list session wise.	
7	When the experiment is completed,should return all the components/instruments taken for the purpose.	
8	Any damage of the equipment or burn-out components will be viewed seriously either by putting penalty or by dismissing the total group of students from the lab for the semester/year	
9	Completed lab assignments should be submitted in the form of a Lab Record in which you have to write the algorithm, program code along with comments and output for various inputs given	

2. Laboratory Specific Instructions

SNo	Specific Instructions	Remarks
1	Before conducting any test, students shall come prepared with theoretical background of the corresponding test (indicated under the section'theory' in each test).	
2	Students shall make sure to have the knowledge of using weighing balance ,oven.	
3	Students shall give importance to accuracy and precision while conducting the test and interpreting the results	
4	Students shall acquaint themselves with the safe and correct usage of instruments / equipments under the guidance of teaching / supporting staff of the laboratory	

C. OBE PARAMETERS

1. Laboratory Outcomes

Expt.	Lab Code #	COs / Experiment Outcome	Teach. Hours	Concept	Instr Method	Assessment Method	Blooms' Level
-	-	**At the end of the experiment, the student should be able to . . .**	-	-	-	-	-
1	17CVL57.1	compute the index properties of soil by different laboratory experiments.	1	Evaluate physical and index properties of the soil	CO1	L3	L3 Apply
2	17CVL57.2	draw the particle size distribution curve of different types of soils and classify the soils as per the result	2	Ability to classify the soil	CO2	L3	L3 Apply
3	17CVL57.3	determine field density using sand replacement and core cutter methods, and compare the results.	3	Ability to find dry density of given soil	CO3	L3	L3 Apply
4	17CVL57.4	find the consistency limits of soil	4	Determination of plasticity index of soil	CO4	L3	L3 Apply
5	17CVL57.5	calculate the optimum moisture content and maximum dry density using Standard Proctor Test	5	Find OMC and MDD, plan and asses field compaction program	CO5	L3	L3 Apply
6	17CVL57.6	compute the co-efficient of	6	Design of	CO6	L3	L3

		permeability through different types of soils by constant head and falling head methods		earth dams			Apply
7	17CVL57.7	calculate the shear strength of soil, and shear parameters from different laboratory tests Direct shear test ,Unconfined compression testand triaxial test..	7	Ability to find Shear strength parameters to assess strength and deformation characteristics of soil	CO7	L3	L3 Apply
8	17CVL57.8	calculate co-efficients related to compressibilty and consolidation by different methods	8	Ability to find consolidation strength parameters to assess strength and deformation characteristics of soil	CO8	L3	L3 Apply
9	17CVL57.9	calculate the shear strength of soil, and shear parameters from laboratory Vane shear test	9	Ability to find Shear strength parameters to assess strength and deformation characteristics of soil	CO9	L3	L3 Apply
10	17CVL57.10	understand the demonstration of the tests.	10	Understand In situ shear strength characteristicts	CO10	L2	L2 Undestand
		Total	**50**	**-**	**-**	**-**	**-**

Note: Identify a max of 2 Concepts per unit. Write 1 CO per concept.

2. Laboratory Applications

Expt.	Application Area	CO	Level
1	Evaluate physical and index properties of the soil	CO1	L3
2	Ability to classify the soil	CO2	L3
3	Ability to find dry density of given soil	CO3	L3
4	Determination of plasticity index of soil	CO4	L3
5	Find OMC and MDD, plan and asses field compaction program	CO5	L3
6	Design of earth dams	CO6	L3
7	Ability to find Shear strength parameters to assess strength and deformation characteristics of soil	CO7	L3
8	Ability to find consolidation strength parameters to assess strength and deformation characteristics of soil	CO8	L3
9	Ability to find Shear strength parameters to assess strength and deformation characteristics of soil	CO9	L3
10	Understand In situ shear strength characteristicts	CO10	L2

Note: Write 1 or 2 applications per CO.

3. Mapping And Justification

CO – PO Mapping with mapping Level along with justification for each CO-PO pair.

To attain competency required (as defined in POs) in a specified area and the knowledge & ability required to accomplish it.

Expt.	Mapping		Mapping Level	Justification for each CO-PO pair	Level
-	CO	PO	-	**'Area': 'Competency' and 'Knowledge' for specified 'Accomplishment'**	-
1	CO1	PO1	L3	Application of the fundamentals of Soil Mechanics will help the students to compute the Index Properties of soil	L2
1	CO1	PO4	L3	Computation of Index Properties of soil plays the major role in determination of Engineering Properties and Subsoil Investigation.	L3
2	CO2	PO1	L3	Application of the fundamentals of Soil Mechanics will help the students to classify various soils according to its particle size	L6
2	CO2	PO4	L3	Classification of soil according to the grain size is essential for the field identification of soil as well as selection of test procedures, boring procedures, modifications and improvements etc	L2
3	CO3	PO1	L3	Application of the fundamentals of Soil Mechanics will help the students to calculate the field density of soils	L3
3	CO3	PO4	L3	Determination of field density is an essential for the compaction control procedure, estimation of bearing capacity, calculation of stresses on soil mass, determination of active and passive earth pressure etc.	L6
4	CO4	PO1	L3	Application of the fundamentals of Soil Mechanics will help the students to calculate liquid limit plastic limit and shrinkage limit. And consisstency indices	L2
4	CO4	PO4	L3	Determination of plasticity index is an essential for knowing compressibility of soil.	L3
5	CO5	PO1	L3	Application of the fundamentals of Soil Compaction will help the students to calculate the requirements of field compaction	L6
5	CO5	PO4	L3	Determination of optimum moisture content and maximum dry density is essential for the conduct of field compaction	L2
6	CO6	PO1	L3	Application of the fundamentals of Soil Water & Permeability will help the students to analyze the flow of water through the soil mass	L3
7	CO7	PO1	L3	Application of the fundamentals of Soil Mechanics will help the students to compute the shear strength of various soils	L6
7	CO7	PO2	L3	Computation of shear strength is unavoidable for the analysis of geohazards, foundation failures, problems in slope stability etc	L2
7	CO7	PO4	L3	Determination of shear strength is extremely important for subsoil investigations, slope stability, construction of structures on weak soil etc.	L3
8	CO8	PO2	L3	Essential for the determination of differential/total settlement in soft/problematic soil conditions	L6
8	CO8	PO4	L3	Settlement determination is unavoidable before the construction in soft/problematic soil conditions	L2
9	CO9	PO1	L3	Application of the fundamentals of Soil Mechanics will help the students to compute the shear strength of various soils	L3
10	CO10	PO1	L2	Students have engineering knowledge on swelling of soil, and boring	L2

4. Articulation Matrix

CO – PO Mapping with mapping level for each CO-PO pair, with course average attainment.

-	-	Experiment Outcomes	Program Outcomes															-
Expt.	CO.#	**At the end of the experiment student should be able to . . .**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	Level
1	17CVL57.1	Students are able to compute the index properties of soil by different laboratory experiments.	2	-	-	3	-	-	-	-	-	-	-	-	-	-	-	L3
2	17CVL57.2	Students are able to to draw the particle size distribution curve of different types of soils and classify the soils as per the result	2	-	-	3	-	-	-	-	-	-	-	-	-	-	-	L3
3	17CVL57.3	Students are able to determine field density using sand	2	-	-	3	-	-	-	-	-	-	-	-	-	-	-	L3

		replacement and core cutter methods, and compare the results.																
4	17CVL57.4	Students are able to find the consistency limits of soil	3	-	-	3	-	-	-	-	-	-	-	-	-	-	-	L3
5	17CVL57.5	Students are able calculate the optimum moisture content and maximum dry density using Standard Proctor Test	2	-	-	3	-	-	-	-	-	-	-	-	-	-	-	L3
6	17CVL57.6	Students are able to compute the co-efficient of permeability through different types of soils by constant head and falling head methods	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	L3
7	17CVL57.7	Students are able to calculate the shear strength of soil, and shear parameters from different laboratory tests Direct shear test ,Unconfined compression testand triaxial test..	2	3	-	3	-	-	-	-	-	-	-	-	-	-	-	L3
8	17CVL57.8	Students are able to calculate co-efficients related to compressibilty and consolidation by different methods	-	3	-	3	-	-	-	-	-	-	-	-	-	-	-	L3
9	17CVL57.9	Students are able to calculate the shear strength of soil, and shear parameters from laboratory Vane shear test	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	L3
10	17CVL57.10	Students are able to understand the demonstration of the tests.	3	-	-	-	-	-	-	-	-	-	-	-		-	-	L2
		Average	**2.1**	**0.6**	**-**	**1.8**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	-	-	L6
-	*PO, PSO*	*1.Engineering Knowledge; 2.Problem Analysis; 3.Design / Development of Solutions; 4.Conduct Investigations of Complex Problems; 5.Modern Tool Usage; 6.The Engineer and Society; 7.Environment and Sustainability; 8.Ethics; 9.Individual and Teamwork; 10.Communication; 11.Project Management and Finance; 12.Life-long Learning; S1.Software Engineering; S2.Data Base Management; S3.Web Design*																

5. Curricular Gap and Experiments

Topics & contents not covered (from A.4), but essential for the course to address POs and PSOs.

Expt	Gap Topic	Actions Planned	Schedule Planned	Resources Person	PO Mapping
1					
2					
3					
4					
5					

Note: Write Gap topics from A.4 and add others also.

6. Experiments Beyond Syllabus

Topics & contents required (from A.5) not addressed, but help students for Placement, GATE, Higher Education, Entrepreneurship, etc.

Expt	Gap Topic	Actions Planned	Schedule Planned	Resources Person	PO Mapping
1					
2					
3					
4					

5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					

D. COURSE ASSESSMENT

1. Laboratory Coverage

Assessment of learning outcomes for Internal and end semester evaluation. Distinct assignment for each student. 1 Assignment per chapter per student. 1 seminar per test per student.

Unit	Title	Teaching Hours	No. of question in Exam							CO	Levels
			CIA-1	CIA-2	CIA-3	Asg-1	Asg-2	Asg-3	SEE		
1	Visual soil classification.	06	1	-	-	-	-	-	1	CO1	L3
2	Grain size analysis	03	1	-	-	-	-	-	1	CO2	L3
3	In-situ density tests	03	1	-	-	-	-	-	1	CO3	L3
4	Consistency limits	03	-	1	-	-	-	-	1	CO4	L3
5	Standard compaction test	03	-	1	-	-	-	-	1	CO5	L3
6	Co-efficient of permeability test	03	-	1	-	-	-	-	1	CO6	L3
7	Shear strength tests	09	-	-	1	-	-	-	1	CO7	L3
8	Consolidation test	03	-	-	1	-	-	-	1	CO8	L3
9	Laboratory vane shear test	03	-	-	1	-	-	-	1	CO9	L3
10	Demonstration of Swell pressure test, Standard penetration test and boring equipment	06	-	-	-	-	-	-	1	CO10	L2
-	**Total**	**42**	**3**	**3**	**3**	**-**	**-**	**-**	**10**	**-**	**-**

2. Continuous Internal Assessment (CIA)

Assessment of learning outcomes for Internal exams. Blooms Level in last column shall match with A.2.

Evaluation	Weightage in Marks	CO	Levels
CIA Exam – 1	15	CO1, CO2, CO3	L3,L3,L3
CIA Exam – 2	15	CO4 ,CO5, CO6	L3,L3,L3
CIA Exam – 3	15	CO7 ,CO8, CO9	L3,L3,L3
Assignment - 1	05	CO1, CO2, CO3	L3,L3,L3
Assignment - 2	05	CO4 ,CO5, CO6	L3,L3,L3
Assignment - 3	05	CO7 ,CO8, CO9	L3,L3,L3
Seminar - 1	-		
Seminar - 2	-		
Seminar - 3	-		
	-		
Other Activities – define – Slip test		CO1 to Co9	L2, L3, L4 . ..
Final CIA Marks	**20**	**-**	**-**

-

SNo	**Description**	**Marks**

1	Observation and Weekly Laboratory Activities	04 Marks
2	Record Writing	08 Marks for each Expt
3	Internal Exam Assessment	08 Marks
4	Internal Assessment	20 Marks
5	SEE	80 Marks
-	**Total**	**100 Marks**

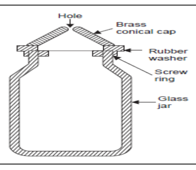
E. EXPERIMENTS

Experiment 01 : Visual soil classification.

-	**Experiment No.:**	1	**Marks**		**Date Planned**		**Date Conducted**	
1	Title	Visual soil classification.						
2	Course Outcomes	Students are able to compute the index properties of soil by different laboratory experiments.						
3	Aim	To determine the Water content by oven drying method and infrared moisture method						
4	Material / Equipment Required	• Lab manual • Oven • containers • Balance • soil sample.						
5	Theory, Formula, Principle, Concept							
6	Procedure	• Clean the water content and find the weight with lid W1 • Put the required quantity of soil sample in the container and replace the lid take the weight W2. • Keep the container in the oven with the lid removed and maintain temperature of the oven between 105° C to 110° C for about 24 hours. • Takeout the container, replace the lid and find the weight W3 of the container with lid and dry soil sample. • Determine the water content in the wet soil using formula.						
7	Diagram							
8	Observation Table							

Sl.No	1	2	3	4	5
Container No.					
Weight of the container W1 gm					
Weight of container and wet soil W2 gm					
Weight of container and dry soil W3 gm					
Weight of dry soil (W3-W1) gm					

		Weight of wet soil (W2-W1) gm					
		Water content ={(W2-W3)/(W3-W1)}*100					
		Average content of the soil					
9	Sample Calculations						
10	Graphs, Outputs	• - • -					
11	Results & Analysis	• - • -					
12	Application Areas	Evaluate physical and index properties of the soil					
13	Remarks						
14	Faculty Signature with Date						

-	**Experiment No.:**	1	**Marks**		**Date Planned**		**Date Conducted**	
1	Title	Visual soil classification.						
2	Course Outcomes	Students are able to compute the index properties of soil by different laboratory experiments.						
3	Aim	To determine the specific gravity of by pycnometer and density bottle method						
4	Material / Equipment Required	• Lab Manual • Pycnometer with a conical cap screwed at its top • Balance, sensitive to 0.2 g • Wash bottle with desired, distilled water • Glass rod, about 150 mm and 3 mm diameter • Thermostatically controlled oven.						
5	Theory, Formula, Principle, Concept	Specific gravity -true specific gravity, apparent specific gravity; significance and uses • $G_T = \{(M_2 - M_1) - (M_3 - M_4)\}/(M_2 - M_1)$ • Average specific gravity at 27°C = $G_{27} = G_T * \{(G)_{water\ T}/(G)_{water\ 27}\}$						
6	Procedure	• Clean the Pycnometer or density bottle, and dry it. Find the mass of the Pycnometer with its cap and washer, accurate to 1.0 g (Ml). • Introduce about 400 g of oven dried coarse grained soil in to the Pycnometer. Record the mass of the Pycnometer with its cap and washer along with the soil (M2). • Fill the Pycnometer with distilled water to half its height, and mix it thoroughly with the soil using the glass rod. Keep the entire system aside for about 4 hrs. At the end of this period, fill the Pycnometer with water up to the top of the conical cap. Dry the Pycnometer from outside and record its mass (M3). • Clean the Pycnometer thoroughly. Fill it with distilled water up to the top of conical cap. Dry the Pycnometer from outside and record its mass to the nearest 0.2 g (M4). • Repeat the steps (2) and (3) thrice. • Calculate the specific gravity of the soil at the room temperature as well as at 27°C.						
7	Diagram							

8	Observation Table	(see observation table below)
9	Sample Calculations	
10	Graphs, Outputs	• - • -
11	Results & Analysis	• - • -
12	Application Areas	Evaluate physical and index properties of the soil
13	Remarks	
14	Faculty Signature with Date	

Observation Table (item 8):

Determination No.	1	2	3
Pycnometer No.			
Mass of Pycnometer (M1) g			
Mass of (Pycnometer or Density bottle + soil) (M2) g			
Mass of (Pycnometer or Density bottle + soil + water) (M3) g			
Mass of (Pycnometer or Density bottle + water) (M4) g			
Specific gravity			
Average specific gravity at lab temperature (GT)			
Average specific gravity at 27°C (G27)			

Experiment 02 : Grain size analysis

-	Experiment No.:	2	Marks		Date Planned		Date Conducted	
1	Title	Grain size analysis						
2	Course Outcomes	Students are able to to draw the particle size distribution curve of different types of soils and classify the soils as per the result						
3	Aim	To determine the grain size distribution of the given soil by dry sieving.						
4	Material / Equipment Required	• Lab Manual • Set of IS sieves: 4.75mm, 2.36mm, 1.18mm, 600 micron, 425 micron, 300 micron, 212 micron, 150 micron, 75 micron. • Brushes to clean the sieves • Mechanical sieve shaker • Balance • Trays • Thermostatically controlled hot air oven						
5	Theory, Formula, Principle, Concept	Particle size classification of soils: IS system, MIT system, Differentiation: clay size fraction and clays; particle size distribution curves, characteristic sizes, well graded and poorly graded soils; gradation characteristics						
6	Procedure,	• Arrange the sieves one above the other such that 4.75 mm sieve is at the top and 75 micron sieve is at the bottom. Place a cover at the top and receiver at the bottom. • Fix the set of sieves to the mechanical sieve shaker. Operate the sieve shaker for a minimum of 10 minutes.						

		• Carefully collect and record the mass of the soil fraction retained on each sieve and also in the pan. • Calculate the cumulative mass of soil fraction retained on each sieve. Calculate the percentage finer. • Plot a graph of percentage finer (along y-axis) V/S equivalent particle diameter in mm (along x-axis in log scale). Draw a smooth curve encompassing the plotted points. • Record the values of percentage sand, percentage silt and percentage clay size fractions from the graph. • Record D10, D30 and D60 from the graph. • Calculate coefficient of curvature (C_C) and coefficient of uniformity (C_U). • Classify the soil based on gradation.
7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph	
8	Observation Table,	Total mass of soil taken for analysis = M = -------------------------- g.

IS Sieve	Particle size D, mm	Mass retained (g)	Cumulative mass reatained (g)	% cumulative retained	% finer
4.75 mm	4.75 mm				
2.36 mm	2.36 mm				
1.18 mm	1.18 mm				
600 micron	0.6 mm				
425 micron	0.425 mm				
300 micron	0.3 mm				
150 micron	0.15 mm				
75 micron	0.075 mm				
Pan	-				

9	Sample Calculations	• The given soil is ___________________ grained. • (i) % sand = (ii) % silt = (iii) % clay size = • (i) D_{10} = (ii) D_{30} = (iii) D_{60} = • (i) Coefficient of uniformity = $C_U = D_{60} / D_{10}$ = ____________________ • (ii) Coefficient of curvature = $C_C = (D_{30})^2 / (D_{60} x D_{10})$ = ____________________ • Particle size and gradation classification of the given soil: ____________________
10	Graphs, Outputs	
11	Results & Analysis	
12	Application Areas	Ability to classify the soil
13	Remarks	
14	Faculty Signature with Date	

-	**Experiment No.:**	2	**Marks**		**Date Planned**		**Date Conducted**	
1	Title	Grain size analysis						
2	Course Outcomes	Students are able to determine the grain size distribution of soil						

3	Aim	To determine the grain size distribution of the given soil by Hydrometer analysis
4	Material / Equipment Required	• Lab Manual • Three 1000 ml capacity measuring jars • Hydrometer • Mechanical stirrer • Balance • Dispersion agents- Sodium hexa meta phosphate and sodium carbonate • Thermostatically controlled hot air oven • Stop watch
5	Theory, Formula, Principle, Concept	Sedimentation analysis: Principle and assumptions made; Hydrometer analysis; Calibration of hydrometer, corrections to hydrometer readings.
6	Procedure	• Calibrate the hydrometer to be used in the test. • Determine the meniscus correction. • Take about 50 g of oven dried soil sample passing 75 μ IS sieve. • Subject the soil to pre-treatment to remove soluble salts or organic matter or calcium compounds, if necessary. • Dissolve 3.3 g of sodium hexa meta phosphate and 0.7 g of sodium carbonate in 100 ml distilled water. Transfer the solution to 1000 ml capacity jar and add distilled water to make the volume of the solution to 1000 ml (This dispersion agent solution is required for getting the composite correction). • Take the measured quantity of soil in a beaker. Add 100 ml of solution prepared by dissolving 3.3 g of sodium hexa meta phosphate and 0.7 g of sodium carbonate in distilled water to the beaker. • Warm the soil suspension gently for about 10 minutes. • Transfer the soil suspension to the cup of a mechanical stirrer using about 100 ml of distilled water. Stir the suspension for about 15 minutes. • Transfer the stirred soil suspension to another 1000 ml capacity measuring jar. • Add distilled water to the suspension to make its volume to 1000 ml. • Place suitable covers on the top of the two 1000 ml measuring jars – one containing the dispersion agent solution and the other containing the soil suspension. Shake the contents in the two jars vigorously and place them slowly on a level platform. Start a stop watch immediately. • Insert the hydrometer in to the jar containing the soil suspension slowly and allow it to float freely. • Note down the hydrometer readings corresponding to upper meniscus after suitable time intervals or note down the time intervals corresponding to well defined hydrometer readings. • After 4 minutes reading, take out the hydrometer from the jar, rinse it with distilled water and allow it to stand in another 1000 ml jar containing distilled water. • Insert the hydrometer in to the jar containing soil suspension from time to time and note down the hydrometer readings and corresponding time intervals. After removing the hydrometer from the jar each time, rinse it with distilled water and store it in the jar containing distilled water. • Record the temperature of the soil suspension and the composite correction in the beginning of the test and also after each time the hydrometer reading is taken beyond 15 minutes period. • Calculate the equivalent diameter of the soil particles corresponding to the noted time intervals (D) and also the corresponding values of percentage finer based on the dry mass of the soil sample taken for the test (N') and based on the total mass of the dry soil sample taken for the grain size analysis(N). • Carry out the test till the equivalent diameter of the particles is less than 2 μm. • Using the values of equivalent diameter of the particles (D) and the values of corresponding percentage finer (N), plot the grain size distribution curve. From the plotted curve, note down the percentage of

		silt size and clay size fractions present in the soil.
7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph	
8	Observation Table	• Soil: • Mass of total dry soil taken for the analysis (M) = -------------------------g • Mass of the dry soil fraction passing 75 μ sieve (M') =-------------------- g • Mass of the dry soil sample taken for the test (Md) = -------------------- g • Specific gravity of soil solids passing 75 μ sieve (G) = --------------------- • Hydrometer No.: • Meniscus correction (Cm)

Date	Time	Elapsed time (t)	Hydrometer reading (Rh')	Temperature	Composite correction (C)	Rh = Rh' + Cm	Effective depth (HR)	D	R = Rh'+C	% finer based on M'	% finer based on M

9	Sample Calculations	
10	Graphs, Outputs	
11	Results & Analysis	
12	Application Areas	Ability to classify the soil
13	Remarks	
14	Faculty Signature with Date	

Experiment 03 : In-situ density tests

-	Experiment No.:	3	Marks		Date Planned		Date Conducted	
1	Title	In-situ density tests						
2	Course Outcomes	Students are able to determine field density using sand replacement and core cutter methods, and compare the results.						
3	Aim	To determine the dry density of the soil *in-situ* by sand replacement method:						
4	Material / Equipment Required	• Lab Manual • Sand pouring cylinder with a pouring cone at its bottom separated from it by a shutter. • Cylindrical calibrating container, 100 mm internal diameter and 150 mm internal depth, with a flange. • Glass plate, about 45cm square and 1cm thick. • Metal tray with a central circular hole of diameter equal to the diameter of the sand pouring cone at its outlet. • Tools for excavating the hole. • Balance accurate to 1g. • Containers for water content determination. • Thermostatically controlled hot air oven. • Clean, uniformly graded natural sand passing the 600 micron IS sieve and retained on the 300 micron IS sieve.						
5	Theory, Formula,	Sand replacement method of determining *in situ* dry density - practical						

	Principle, Concept	significance.
6	Procedure	(a) Determination of the Bulk density of the sand: • Fill the sand in the sand pouring cylinder up to a height 1cm below the top. • Determine the total initial mass of the cylinder with the sand (M1), which is to be maintained constant throughout the test. • Keep the cylinder on a glass plate. Open the shutter and allow the sand to run out. Close the shutter when no movement of sand is observed. Remove the cylinder and record the mass of the sand collected on the glass plate (M2). This represents the mass of the sand filling the cone portion of the sand pouring cylinder. Place the sand back into the cylinder to maintain the constant mass M1. • Measure the inner diameter and height of the calibrating container and hence, determine the volume of the calibrating container. • Place the cylinder with sand concentrically on the top of the container. Open the shutter, and allow the sand to the run into the container. Close the shutter when no further movement of sand is observed. Remove the cylinder and record its mass along with the remaining sand (M3). Put the sand back into the container to maintain the constant mass M1. • Calculate the density of sand in the cylinder. (b) Determination of the dry density of the soil in-situ: • Level the surface where the in-situ density of the soil is required to be determined. • Keep the metal tray on the level surface and excavate a circular hole of about 15 cm deep. Collect the excavated soil in the tray. Immediately record the mass of the excavated soil (M), and keep some soil for moisture content determination. • Remove the tray and place the cylinder with sand on the excavated hole. Open the shutter, and allow the sand to run into the hole. When the no further movement of the sand is seen, close the shutter. Determine the mass of the cylinder with the remaining sand in it (M4). • Determine the bulk density, field water content and field dry density of the soil.
7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph	
8	Observation Table	**Observations and Calculations** **(a) Determination of the bulk density of sand:** 1. Inside diameter of the calibrating container (d) cm = 2. Inside height of the calibrating container (h) cm = 3. Volume of the calibrating container (Vc) cm3 = 4. Mass of the (sand + cylinder) before pouring (M1) g. = 5. Mass of the sand in the cone (M2) g. = 6. Mass of the (sand + cylinder), after pouring into the calibrating container (M3) g. = 7. Mass of the sand, filling the calibrating container (Msand) = (M1 – M3 – M2) g. = 8. Bulk density of the sand (✕s) = (Msand / Vc) g/cm3 = **(b) Determination of the bulk density of the soil in-situ:** 1. Mass of the wet soil excavated from the hole (M) g. = 2. Mass of (sand + cylinder) after pouring into the hole (M4) g. = 3. Mass of sand in the hole (Mh) = (M1- M4 - M2) g. = 4. Volume of the hole (V) cm3 = 5. Bulk density of the soil in-situ (✕b
9	Sample Calculations	
10	Graphs, Outputs	

11	Results & Analysis	Average insitu field dry density: = --------------
12	Application Areas	Ability to find dry density of given soil
13	Remarks	
14	Faculty Signature with Date	

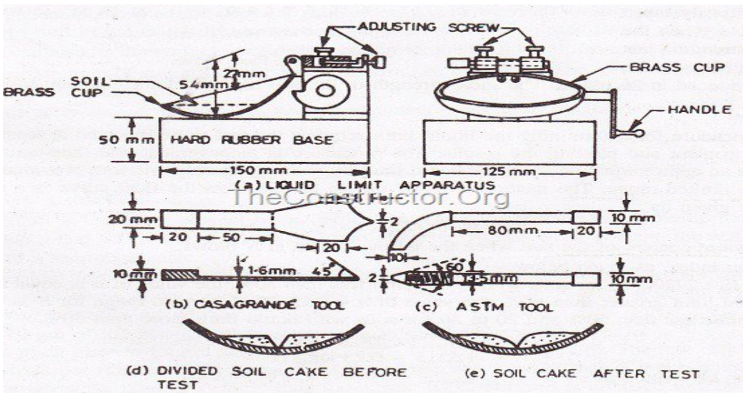
-	**Experiment No.:**	3	**Marks**		**Date Planned**		**Date Conducted**	
1	Title	In-situ density tests						
2	Course Outcomes	Students are able to determine field density using sand replacement and core cutter methods, and compare the results.						
3	Aim	To determine the dry density of the soil *in-situ* by core cutter method:						
4	Material / Equipment Required	a) 1. Cylindrical core cutter of steel, 127.4 mm long and 100 mm internal diameter with awall thickness of 3 mm, bevelled at one end. b) 2. Steel dolly, 25 mm high and 100 mm internal diameter with a wall thickness of 7.5 mm, with a lip to enable it to be fitted on the top of the core-cutter. c) 3. Steel rammer d) 4. Knife e) 5. Grafting tool or pickaxe or spade f) 6. Straight edge g) 7. Balance accurate to 1g h) 8. Containers for water content determination. i) 9. Thermostatically controlled hot air oven.						
5	Theory, Formula, Principle, Concept	Field density is defined as weight per unit volume of soil mass in the field at insitu conditions. Equations are; $\rho d = \rho t/(1+w)$ gm/cm^3 OR $\gamma d = \gamma t/(1+w)$ kN/m^3 Where, ρd = dry density, γd = dry unit weight, ρt= field moist density, γt =field moist unit weight, w =water content, γw = unit weight of water = 9.81 kN/m^3						
6	Procedure, Program, Activity, Algorithm, Pseudo Code	a) Determine the internal volume of the core-cutter Vc in cm^3. And weigh the cutter accurate to 1 gm. b) Select the area in the field where the density is required to be found out and level it. c) Place the cutter over the ground with the dolly and drive the cutter with the hammer until top of the cutter is just below the ground level. d) Remove the soil outside the cutter by digging up to the bottom level of the cutter. Take out the cutter with remove the dolly and trim both sides of the cutter with knife and straight edge. e) Determine mass of the cutter with the soil (M2). f) Take a small sample of soil from the site of water content determination and seal it properly. g) The field test may be repeated at other places if required. The water content of sample collected is determined in the laboratory as per the procedure explained earlier. Use the above equation for determining γd OR ρd.						
7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph							
8	Observation Table, Look-up Table, Output	Length of core cutter l=-----------------cm Diameter of core cutter d=--------------cm Volume of core cutter=Vc=------------cm						

SI.No.	Particulars	Test nos. 1	2	3
1	Mass of empty cutter (M1), gms			
2	Mass of cutter + wet soil (M2), gms			
3	Volume of core cutter (Vc) cm^3			
4	Mass of empty container (M3), gms			
5	Mass of container + wet soil (M4), gms			
6	Mass of container + dry soil (M5), gms			
7	Water content (w)=(M4-M5)/(M5-M3)			
8	Field moist density ρt (kN/m^3)			
9	Dry density ρd (kN/m^3)			

9	Sample Calculations	
10	Graphs, Outputs	
11	Results & Analysis	Average insitu field dry density: = --------------
12	Application Areas	Ability to find dry density of given soil
13	Remarks	
14	Faculty Signature with Date	

Experiment 04 : Consistency limits

-	Experiment No.:	4	Marks		Date Planned		Date Conducted	
1	Title	Consistency limits						
2	Course Outcomes	Students are able to find the consistency limits of soil						
3	Aim	Determination of the liquid limit by Casagrande's method						
4	Material / Equipment Required	a) A mechanical liquid limit apparatus (casagrande type) with grooving tools. b) Evaporating dishes, wash bottle etc. c) Balance accurate to 0.01 g. d) Airtight container to determine water content. e) Oven to maintain temperature at 105 °C to 110 °C. f) desiccator and other accessories.						
5	Theory, Formula, Principle, Concept	Consistency of fine-grained soils may be defined as the relative ease with which a soil can be remolded. Consistency limits may be categorized into three limits called Atterberg limits. They are 1) Liquid limit 2) Plastic limit and 3) Shrinkage limit The liquid limit is the moisture content at which the groove, formed by a standard tool into the sample of soil taken in the standard cup, closes for 10 mm on being given 25 blows in a standard manner. This is the limiting moisture content at which the cohesive soil passes from liquid state to plastic state. Flow index If=(w1-w2)/log (N2/N1)=---------						
6	Procedure, Program, Activity,	1.A representative sample of mass of about 120 gm passing through 425 μ IS sieve is taken for the test. Mix the soil in an evaporating dish with distilled water						

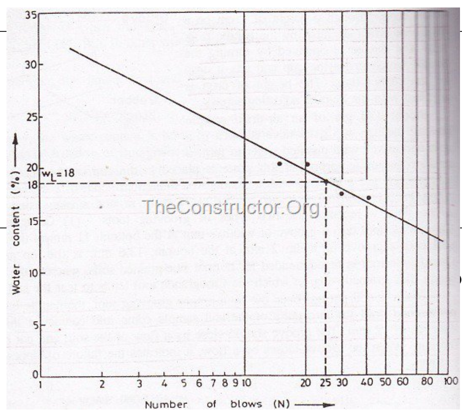
	Algorithm, Pseudo Code	to form a uniform paste. 2. Adjust the cup of the device so that the fall of the cup on to the hard rubber base is 10 mm. 3. Transfer the portion of the paste to the cup of liquid limit device. Allow some time for the soil to have uniform distribution of water. 4.Level the soil topsoil so that the maximum depth of soil is 12 mm. A channel of 11 mm wide at the top, 2 mm at the bottom and 8 mm deep is cut by the grooving tool. The grooving tool is held normal to the cup and the groove is cut through the sample along the symmetrical axis of the top. 5.The handle of the device is turned at a rate of about 2 revolutions per second and the number of blows necessary to close the groove along the bottom distance of 12 mm is counted. A sample of soil which closes the groove is collected vi.The soil in the cup is re-mixed thoroughly (adding some more soil if required) some quantity of water which changes the consistency of soil, repeat the process. At least 4 tests should be conducted by adjusting the water contents of the soil in the cup in such a way that the number of blows required to close the groove may fall within the range of 5 to 40 blows. A plot of water content against the log of blows is made as shown in figure. The water content at 25 blows gives the liquid limit.
7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph	

8 Observation Table, Look-up Table, Output

Trail No	1	2	3	4
No of blows (N)				
Weight of Container (W1)				
Weight of Container+Wet soil (W2)				
Weight of Container+dry soil (W3)				
Water content w=(W2-W3)/(W3-W1)				

9 Sample Calculations

10 Graphs, Outputs



Draw a flow curve between log N and w.
Liquid limit (for N=25) =

11	Results & Analysis	Flow index If= Liquid Limit=----------%
12	Application Areas	Determination of plasticity index of soil
13	Remarks	
14	Faculty Signature with Date	

-	**Experiment No.:**	4	**Marks**		**Date Planned**		**Date Conducted**	
1	Title	Consistency limits						
2	Course Outcomes	Students are able to find the consistency limits of soil						
3	Aim	Determination of the Liquid Limit by Cone Penetration method						
4	Material / Equipment Required	a) Cone Penetrometer b) Spatula.						
5	Theory, Formula, Principle, Concept	The liquid limit is determined based on penetration resistance of soil.						
6	Procedure, Program, Activity, Algorithm, Pseudo Code	a) About 120 gm. of air dried soil from thoroughly mixed portion of material passing 425 micron IS sieve is obtained. b) Distilled water is mixed to the soil thus obtained in a mixing disc to form a uniform paste. c) Then the wet soil paste is transferred to the cylindrical cup of cone penetrometer apparatus, ensuring that no air is trapped in this process. d) Finally the wet soil is leveled up to the top of the cup and placed on the base of the cone penetrometer apparatus. e) The penetrometer is so adjusted that the cone point just touches the surface of the soil paste in the cup and the initial ready is to be taken. f) The vertical clamp is then released allowing the cone to penetrate into soil paste under its own weight for 5 seconds. After 5 seconds the penetration of the cone is noted to the nearest millimeter. g) The test is repeated at least to have four sets of values of penetration in the range of 14 to 28 mm. h) The exact moisture content of each trial is determined i) Draw a graph representing water content, (ω) on y-axis and cone penetration on x-axis. j) The water content corresponding to a cone penetration of 20 mm is taken as liquid limit.						

7 Block, Circuit, Model Diagram, Reaction Equation, Expected Graph

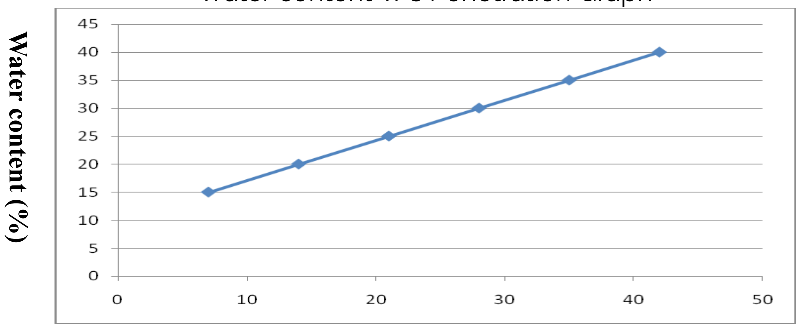
8 Observation Table, Look-up Table, Output

Sl. No.	Cup No.	Weight of cup (w_1)	Weight of cup + Wet soil (w_2)	Weight of cup + Dry soil (w_3)	Water Content $\omega = \frac{(w_2 -}{(w_3 -}$	Penetration (mm)
1						
2						
3						
4						
5						
6						
7						
8						

9 Sample Calculations

10 Graphs, Outputs

Water content V/s Penetration Graph



Penetration (mm)

11 Results & Analysis — Liquid limit of soil = W_L = ____________%

12 Application Areas — Determination of plasticity index of soil

13 Remarks

14 Faculty Signature with Date

-	Experiment No.:	4	Marks		Date Planned		Date Conducted	

1	Title	Consistency limits
2	Course Outcomes	Students are able to find the consistency limits of soil
3	Aim	Determination of Plastic Limit of the soil
4	Material / Equipment Required	a) Porcelain evaporating dish. b) Flat glass plate. c) Balance accurate to 0.01 g. d) Apparatus for water content distribution.
5	Theory, Formula, Principle, Concept	The Plastic limit of soil may be defined as that water content at which soil starts crumbling when rolled into threads of 3mm diameter. Plasticity Index(Ip) = (LL – PL)
6	Procedure, Program, Activity, Algorithm, Pseudo Code	a) Select a representative sample of fine-grained soil of about 20 gms passing through 420 μ IS sieve. Mix it with distilled water thoroughly on a glass plate such that the palm of the soil can be rolled into a thread of 3 mm diameter. Allow some time for the proper distribution mixed with water. b) Take about 10 gm of this wet sail and roll it into a thread on a glass plate with the palm of the sand rolling must be such that it forms a uniform thread of 3 mm diameter. If the thread cracks before attaining 3 mm diameter, and a little more water, knead it and roll again. If the rolling can be done to diameter less than 3 mm, mix the soil, knead it to remove same extra moisture in the soil. This process has to continue till the sample crumbles just at about 3 mm diameter. Collect the crumbled soil and determine its water content. c) Repeat the process to get at least three water content determination. d) The water content so obtained is the plastic limit of the soil
7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph	
8	Observation Table, Look-up Table, Output	(see observation table below)
9	Sample Calculations	
10	Graphs, Outputs	
11	Results & Analysis	The Plastic limit of soil is = $W_{P=}$ -----------------------% Plasticity Index (Ip)=-----------
12	Application Areas	Determination of plasticity index of soil
13	Remarks	
14	Faculty Signature with Date	

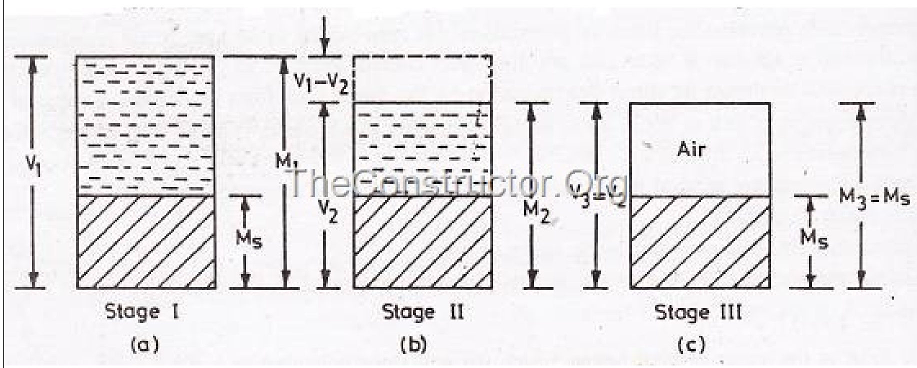
Trail No	1	2	3	4
Weight of Container (W1)				
Weight of Container+Wet soil (W2)				
Weight of Container+dry soil (W3)				
Water content w=(W2-W3)/(W3-W1)				

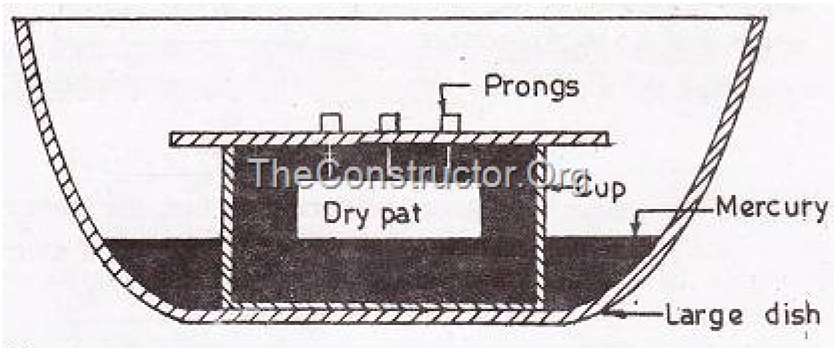
-	**Experiment No.:**	4	**Marks**		**Date Planned**		**Date Conducted**	
1	Title	Consistency limits						
2	Course Outcomes	Students are able to find the consistency limits of soil						
3	Aim	Determination of Shrinkage Limit of soil sample						
4	Material /	a) 2 nos of porcelain evaporating dish, about 12 cm in diameter within a flat						

	Equipment Required	bottom. b) 3 nos of shrinkage dish made of non-corroding metal, having a flat bottom, 45 mm diameter and 15 mm high. c) A glass cup of about 50 mm diameter and 25 mm high. d) Two numbers glass plates of size 75×75 mm, one plate of plane glass and the other with three metal prongs. e) Spatula balance accurate to 0.01 g, oven etc. f) Mercury. g) Desiccator and other accessories.
5	Theory, Formula, Principle, Concept	The shrinkage limit of soil is the minimum water content at which a soil can be completely saturated or it is the water content at which the reduction in water content will not result in change in volume of soil sample. Shrinkage limit=, $w_s = \frac{(M_1 - M_s) - (V_1 - V_2)\rho_w}{M_s} \times 100$ Shrinkage ratio, $SR = \frac{M_s}{V_2 \rho_w}$ Volumetric shrinkage $V_s = \frac{V_1 - V_2}{V_2} \times 100$
6	Procedure, Program, Activity, Algorithm, Pseudo Code	a) Determine the mass of the clean, empty shrinkage dish. Fill the shrinkage dish to overflowing with mercury. Remove the excess by pressing the plain glass plate firmly over the top of the dish. Record the mass of the mercury in the shrinkage dish. This mass when divided by the unit mass of mercury gives the volume of the dish which itself represents the volume of the wet soil mass to be placed in the shrinkage dish. b) Take about 100 gm of soil sample passing 425 micron IS sieve. c) Place about 30 g of soil in evaporating dish and mix it thoroughly with distilled water such that all the soil voids are completely filled and the soil becomes pasty enough to be readily worked into the shrinkage dish without entrapping air bubbles. The water content of the soil paste shall be approximately equal to the liquid limit of the soil. d) Coat the inside surface of the shrinkage dish with a thin layer of silicon grease to prevent the adhesion of the soil to the dish. Fill the shrinkage dish by well mixed soil paste to one third its volume and tap it on a firm cushioned surface. Place some more soil and repeat this process until the paste is thoroughly compacted and all included air has been removed. When the dish is completely filled up, strike off the excess soil paste with a straight edge and wipe off all the soil paste adhering to the outside surface of the shrinkage dish. e) Record the mass of the shrinkage dish with the wet soil mass in it. Allow the soil pat to dry in air until the colour of the pat turns from dark to light, which may take one day to about a week depending upon the type of soil. Then, dry the pat in an oven to constant mass. Cool it in a desiccator and record the mass of the shrinkage dish with the dry soil pat immediately. f) Fill the glass cup to overflowing with mercury and remove the excess by pressing the glass with three prongs. Place the cup with mercury in the evaporating dish without spilling any mercury from the cup. Place the oven dried soil pat on the surface of the mercury in the cup. Then, carefully force the pat into the mercury by means of glas plate with prongs. Collect the displaced mercury and record its mass. Determine its volume, which itself represents the volume of the dry soil pat. g) Conduct three trials for each soil and report the average value of the

shrinkage limit. If any individual value varies from the average by ± 2 %, discarded the test results and repeat the test.

7 Block, Circuit, Model Diagram, Reaction Equation, Expected Graph





8 Observation Table, Look-up Table, Output

Sl.no	Particulars	1	2
1	Mass of empty mercury dish		
2	Mass of mercury dish, with mercury equal to volume of the shrinkage dish		
3	Mass of mercury = (2) – (1)		
4	Volume of shrinkage dish V_1= (3)/13.6		
5	Mass of shrinkage dish		
6	Mass of shrinkage dish + wet soil		

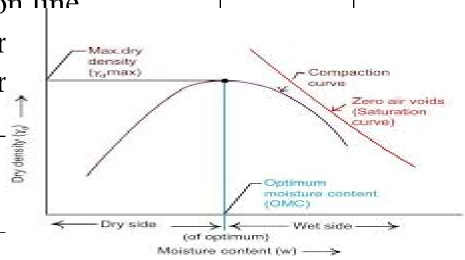
		7	Mass of wet soil M_1= (6) – (5)		
		8	Mass of shrinkage dish + dry soil		
		9	Mass of dry soil M_s= (8) – (5)		
		10	Mass of mercury dish + mercury equal to in volume of dry pat		
		11	Mass of mercury displaced by dry pat =(10) – (1)		
		12	Volume of dry pat V_2= (11)/13.6		
9	Sample Calculations				
10	Graphs, Outputs				
11	Results & Analysis	Ws=-----% S.R=----- V.S=-----			
12	Application Areas	Determination of plasticity index of soil			
13	Remarks				
14	Faculty Signature with Date				

Experiment 05 : compaction test

-	Experiment No.:	5	Marks		Date Planned		Date Conducted	
1	Title	compaction test						
2	Course Outcomes	Students are able calculate the optimum moisture content and maximum dry density using Standard Proctor Test						
3	Aim	Moisture content –Dry density relationship by Standard Proctor compaction test						
4	Material / Equipment Required	1. A cylindrical metal mould of capacity 1000 cm 3 , with an internal diameter of 100 mm and an internal affective height of 127.3 mm. The mould is fitted with a detachable base plate and a removable extension collar approximately 60 mm high. 2. A metal rammer of 50 mm diameter with a circular face and mass 2.6 kg with a free fall of 310 mm. 3. A steel straight edge about 30 cm in length and with one beveled edge. 4. 4.75 mm I.S. sieve 5. Balance – (a) with a capacity of 10 kg and accuracy of 1 g (b) with a capacity of 200 g and accuracy of 0.01 g						

		6. Thermostatically controlled hot air oven. 7. Airtight and non-corrodible containers for water content determination 8. Mixing tools like tray, trowel and spatula.
5	Theory, Formula, Principle, Concept	Bulk density $\rho t = (M2-M1)/V$ Dry density $\rho d = \rho t/(1 + w)$ Dry density ρd for zero air voids line. $\rho d = GPw/(1 + (wG/S))$
6	Procedure, Program, Activity, Algorithm, Pseudo Code	1. Measure the inner diameter and inner height of the cylindrical mould and hence, calculate the volume of the mould. Compare them with standard values. 2. Take about 3 kg of air dried soil passing 4.75mm IS sieve and mix it with a suitable amount of water depending on the soil type (For sandy and gravelly soils, an initial moisture content of 4 to 6% and for cohesive soils, an initial moisture content of (w p -10)% to (w p -8)% would be suitable, where w p is the plastic limit of the soil). Keep the soil in a sealed container for saturation for a minimum period of about 16 hrs. 3. Clean the mould with the base plate and record its mass. Attach the collar to the mould. Place it on a solid base such as concrete floor. 4. Remix the soil thoroughly. Compact the moist soil in to the mould, with the collar attached, in three equal layers, each layer being given 25 blows from a 2.6 kg rammer dropped from a height to 310mm above the soil surface. The blows should be uniformly distributed over the surface of each layer. The surface of each layer of the compacted soil shall be roughened with a spatula before laying the next layers. The final layer shall project not more than 6 mm above the top of the mould after the collar is removed. 5. Remove the collar and level off the compacted soil surface to the top of the mould carefully. Then, record the mass of the mould with the base plate and compacted soil. 6. Remove the compacted soil specimen from the mould and place it on the mixing tray. Keep a representative soil sample of the specimen for water content determination. 7. Mix the remaining soil with the reminder of the originally mixed soil in the tray. Add water in suitable increments to the soil sample and mix the soil thoroughly and repeat the above procedure. 8. Conduct a minimum of 5 determinations such that the optimum moisture content lies within this range. 9. Plot the Indian Standard light compaction curve (w % along x-axis and ✕ d along y- axis). Obtain OMC and ✕ d max from the plotted curve. Plot also the ZAV line.
7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph	
8	Observation Table, Look-up Table, Output	Diameter of the mould (D) =-- cm Height of the mould (H) =-- cm Volume of the mould (V) =-- cm^3 Mass of the rammer=2.6 kg Free fall of the rammer=310 mm

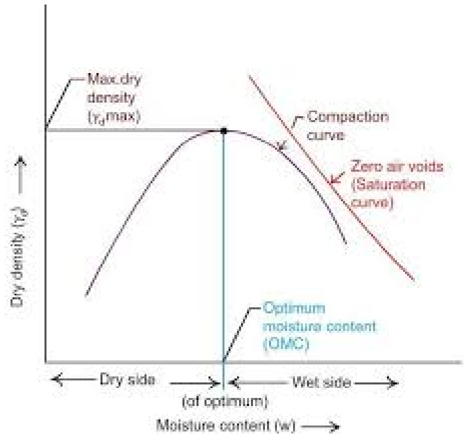
Test No.	1	2	3	4
Mass of empty mould M_1 gm Volume of mould, cm^3				

		Mass of mould + sample,M_2,gm Mass of wet soil, M,gm Wet density, ρ_t g/cm^3 Water content, w% Dry density, ρ_d, gm/cm^3 W1 for calculation % of saturation line ρ_d, gm/cm^{3}for ρ_d, gm/cm^{3}for 
9	Sample Calculations	
10	Graphs, Outputs	
11	Results & Analysis	Maximum dry density ρd = ____ g/cm3 Optimum moisture content, w = ___ %
12	Application Areas	Find OMC and MDD, plan and asses field compaction program
13	Remarks	
14	Faculty Signature with Date	

-	Experiment No.:	5	Marks		Date Planned		Date Conducted	
1	Title	compaction test						
2	Course Outcomes	Students are able calculate the optimum moisture content and maximum dry density using Standard Proctor Test						
3	Aim	Moisture content –Dry density relationship by Modified Proctor compaction test						
4	Material / Equipment Required	1. A cylindrical metal mould of capacity 1000 cm 3 , with an internal diameter of 150 mm and an internal affective height of 127.3 mm. The mould is fitted with a detachable base plate and a removable extension collar approximately 60 mm high. 2. A metal rammer of 50 mm diameter with a circular face and mass 4.9 kg with a free fall of 450 mm. 3. A steel straight edge about 30 cm in length and with one beveled edge. 4. 4.75 mm I.S. sieve 5. Balance – (a) with a capacity of 10 kg and accuracy of 1 g (b) with a capacity of 200 g and accuracy of 0.01 g 6. Thermostatically controlled hot air oven.						

		7. Airtight and non-corrodible containers for water content determination 8. Mixing tools like tray, trowel and spatula.
5	Theory, Formula, Principle, Concept	Bulk density $\rho t = (M2-M1)/V$ Dry density $\rho d = \rho t/(1 + w)$ Dry density ρd for zero air voids line. $\rho d = GPw/(1 + (wG/S))$
6	Procedure, Program, Activity, Algorithm, Pseudo Code	Measure the inner diameter and inner height of the cylindrical mould and hence, calculate the volume of the mould. Compare them with standard values. 2. Take about 5 kg of air dried soil passing 4.75mm IS sieve and mix it with a suitable amount of water depending on the soil type (For sandy and gravelly soils, an initial moisture content of 4 to 6% and for cohesive soils, an initial moisture content of (w p -10)% to (w p -8)% would be suitable, where w p is the plastic limit of the soil). Keep the soil in a sealed container for saturation for a minimum period of about 16 hrs. 3. Clean the mould with the base plate and record its mass. Attach the collar to the mould. Place it on a solid base such as concrete floor. 4. Remix the soil thoroughly. Compact the moist soil in to the mould, with the collar attached, in five equal layers, each layer being given 25 blows from a 4.9 kg rammer dropped from a height to 4500mm above the soil surface. The blows should be uniformly distributed over the surface of each layer. The surface of each layer of the compacted soil shall be roughened with a spatula before laying the next layers. The final layer shall project not more than 6 mm above the top of the mould after the collar is removed. 5. Remove the collar and level off the compacted soil surface to the top of the mould carefully. Then, record the mass of the mould with the base plate and compacted soil. 6. Remove the compacted soil specimen from the mould and place it on the mixing tray. Keep a representative soil sample of the specimen for water content determination. 7. Mix the remaining soil with the reminder of the originally mixed soil in the tray. Add water in suitable increments to the soil sample and mix the soil thoroughly and repeat the above procedure. 8. Conduct a minimum of 5 determinations such that the optimum moisture content lies within this range. 9. Plot the Indian Standard light compaction curve (w % along x-axis and ✕ d along y- axis). Obtain OMC and ✕ d max from the plotted curve. Plot also the ZAV line.
7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph	
8	Observation Table, Look-up Table, Output	Diameter of the mould (D) =-- cm Height of the mould (H) =-- cm Volume of the mould (V) =-- cm^3 Mass of the rammer=4.9 kg Free fall of the rammer=450 mm

Test No.	1	2	3	4
Mass of empty mould M_1 gm Volume of mould, cm^3 Mass of mould + sample,M_2,gm Mass of wet soil, M,gm				

		Wet density, ρ_t g/cm^3 Water content, w% Dry density, ρ_d, gm/cm^3 W1 for calculation of saturation line % ρ_d, gm/cm^3 for S=100% ρ_d, gm/cm^3 for S=80%
9	Sample Calculations	
10	Graphs, Outputs	
11	Results & Analysis	Maximum dry density ρd = ____ g/cm3 Optimum moisture content, w = ___ %
12	Application Areas	Find OMC and MDD, plan and asses field compaction program
13	Remarks	
14	Faculty Signature with Date	

Experiment 06 : Co-efficient of permeability test

-	Experiment No.:	6	Marks		Date Planned		Date Conducted	
1	Title	Co-efficient of permeability test						
2	Course Outcomes	Students are able to compute the co-efficient of permeability through different types of soils by constant head and falling head methods						
3	Aim	Determination of Co-efficient of Permeablity of a soil sample by Constant Head method						
4	Material / Equipment Required	a) A constant head permeameter shown schematically in the figure. b) For a typical setup the following dimensions are used i. Internal diameter of the mould = 100 mm. ii. Effective height of the mould = 127.3 mm. iii. Detachable collar: 100 mm diameter and 60 mm height. iv. Drainage base, having a porous disc. c) Weighing balance, and other accessories.						
5	Theory, Formula, Principle, Concept	Permeability of soil can be determined from Darcy's Law. The equation to determine the permeability of soil using constant head permeability test is given by:						

		k = (Q⟨ST⟩L)/(A⟨ST⟩h⟨ST⟩t) Where, k = coefficient of permeability Q = volume of water collected in time t h = head causing flow A = cross sectional area of sample L = length of sample
6	Procedure, Program, Activity, Algorithm, Pseudo Code	A constant-head test assembly is as given in below figure. Select a representative soil mass of about 2.5 kg properly mixed. Fill the soil into the mould and compact it to the required dry density by making use of a suitable compacting device. Set the assembly as shown in figure after saturating the porous stones. The water supply is properly adjusted to maintain constant head. Open the valve and saturate the sample by allowing water to flow through for a sufficiently long time to remove all air-bubbles. When the whole setup is ready for the test, open the valve, allow the water to flow through the sample collect water in a graduated jar starting simultaneously a stopwatch. Note the time to collect a certain quantity of water Q. Repeat the test three times and determine the average of Q for the same time interval t. Measure the head h, length of sample L, and calculate the cross sectional area A of the sample. Calculate k by making use of equation
7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph	
8	Observation Table, Look-up Table, Output	Length of Soil sample L=---------cm Diameter of Soil sample D=-------cm Area of soil sample A=----------- Constant head h=-----------cm

		<table><tr><th>Sl.No</th><th>Quantity of water Q=------ml</th><th>Time t=-----sec</th><th>k=(QL)/(Ath) (cm/sec)</th></tr><tr><td>1</td><td></td><td></td><td></td></tr><tr><td>2</td><td></td><td></td><td></td></tr><tr><td>3</td><td></td><td></td><td></td></tr><tr><td>4</td><td></td><td></td><td></td></tr></table>
9	Sample Calculations	
10	Graphs, Outputs	
11	Results & Analysis	Coefficient of Permeability of soil k=----------------------cm/sec
12	Application Areas	Design of earth dams
13	Remarks	
14	Faculty Signature with Date	

-	**Experiment No.:**	6	**Marks**		**Date Planned**		**Date Conducted**	
1	Title	Co-efficient of permeability test						
2	Course Outcomes	Students are able to compute the co-efficient of permeability through different types of soils by constant head and falling head methods						
3	Aim	Determination of Co-efficient of Permeablity of a soil sample by Falling Head Permeability Test for fine grained soils.						
4	Material / Equipment Required	d) A falling-head permeameter shown schematically in the figure. e) For a typical setup the following dimensions are used i. Internal diameter of the mould = 100 mm. ii. Effective height of the mould = 127.3 mm. iii. Detachable collar: 100 mm diameter and 60 mm height. iv. Drainage base, having a porous disc. f) Weighing balance, and other accessories.						
5	Theory, Formula, Principle, Concept	Permeability of soil can be determined from Darcy's Law. The below equation can be used: $k = ((2.3 \times a \times L)/(A\times(t_2-t_1)))\times\log_{10}(h_1/h_2)$						
6	Procedure, Program, Activity, Algorithm, Pseudo Code	a) Open the valves in the standpipe and the bottom outlet. Ensure that the soil sample is fully saturated with out any entrapping of air bubble before starting the test. b) Fill the standpipe with water keeping the valves V1 and V2 open and allow the water to flow out through the outlet pipe for some time and then close the valves. c) Select in advance the heights h1 and h2 for the water to fall and determine the height $\sqrt{h_1h_2}$ and mark this height on the stand pipe. d) Open the valves and fill the standpipe with water up to height h1 and start the stopwatch. e) Record the time intervals for water to fall from height h1 to $\sqrt{h_1h_2}$ and from $\sqrt{h_1h_2}$ to h2. These two time intervals will be equal if a stead flow condition has been established. f) Repeat the step (e) at least after changing the heights h1 and h2. g) Stop the test and disconnect all the parts. h) Take a small quantity of the sample for water content determination.						
7	Block, Circuit,							

	Model Diagram, Reaction Equation, Expected Graph	
8	Observation Table, Look-up Table, Output	Length of Soil sample L=---------cm Diameter of Soil sample D=-------cm Area of soil sample A=----------- Area of stand pipe a=----------
9	Sample Calculations	
10	Graphs, Outputs	
11	Results & Analysis	Coefficient of Permeability of soil k=----------------------cm/sec
12	Application Areas	Design of earth dams
13	Remarks	
14	Faculty Signature with Date	

Sl.No	Initial Head (h1) cm	Final Head (h2) cm	Time t In seconds	k=((2.3 × a × L)/(A×t))×log10(h1/h2)

Experiment 07 : Shear strength tests

-	**Experiment No.:**	7	**Marks**		**Date Planned**		**Date Conducted**	
1	Title	Shear strength tests						
2	Course Outcomes	Students are able to calculate the shear strength of soil, and shear parameters from different laboratory tests Direct shear test ,Unconfined compression testand triaxial test..						
3	Aim	Determination of shear parameters C and Ø of the soil by Direct Shear test						
4	Material / Equipment Required	Shear box apparatus coonsisting of (a) Shear box 60 mm square and 50 mm deep, (b) Grid plates, porous stones, etc. (c) Loading device (d) Other accessories.						
5	Theory, Formula, Principle, Concept	Box shear tests can be used for the following tests. 1. Quick and consolidated quick tests on clay soil samples. 2. Slow test on any type of soil. Only using box shear test apparatus may carry the drained or slow shear tests on sand. As undisturbed samples of sand is not practicable to obtain, the box is filled with the sand obtained from the field and compacted to the required density and water content to stimulate field conditions as far as possible. So far clay soil is concerned the undisturbed samples may be obtained from the field. The sample is cut to the required size and thickness of box shear test apparatus and introduced into the apparatus. The end surfaces are properly trimmed and leveled. I9f tests on remolded soils of clay samples are required; they are compacted in the mould to the required density and moisture content. Coulombs equation is used for computing the shear parameters. For clay soils $S=c+\sigma\tan\Phi$						

For sand

$S = \sigma \tan\Phi$

Where, c=unit cohesion

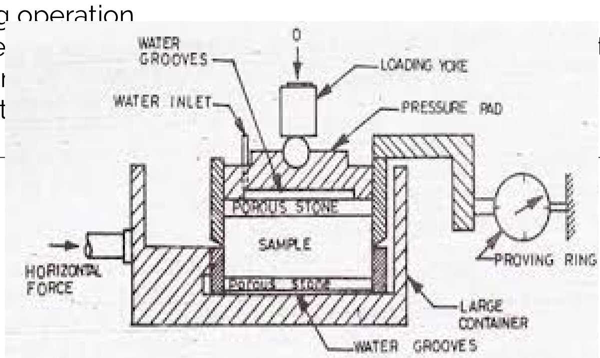
σ=normal load applied on the surface of the specimen.

Φ=angle of shearing resistance.

6 Procedure, Program, Activity, Algorithm, Pseudo Code

a) Place the sample of soil into the shear box, determine the water content and dry density of the soil compacted.
b) Make all the necessary adjustments for applying vertical load, for measuring vertical and lateral movements and measurement of shearing force, etc.
c) Apply a known load on the specimen and then keep it constant during the course of the test (for consolidation keep0 it for a long time without shearing, and quick tests apply the shearing without consolidation soon after placing the vertical load). Adjust the rate of strain as required of the specimen.
d) Shear the specimen till failure of the specimen is noticed or the shearing resistance decreases. Take the readings of the gauges during the shearing operation.
e) Remove … t, and determi…
f) Repeat t…

7 Block, Circuit, Model Diagram, Reaction Equation, Expected Graph



8 Observation Table, Look-up Table, Output

The test sample of cohesion less soil with a little cohesion is given in tabular form below.

(1) Soil density ρd = 1.62 g/cm³

Data sheet for sample 1: (for sample 2, 3, and 4 similar data sheets are to be prepared)

Initial area = Ao = 6×6 = 36 cm². Initial thickness = 2.4 cm. σ = 0.5 kg/cm²

Horizontal dial gauge reading	Horizontal displacement (mm)	Corrected area(cm²)*	Proving ring reading	Force (kg)	ζ (kg/cm²)	Vetical Dial reading	Vertical Dis(mm)	Ht(cm)
0	0	36	0	0				

* Corrected area in cm^2 is given by b (b-horizontal displacement)
b= width of shear box=6cm

From three samples the following results are obtained

Test No	Normal stress σ(kg/cm^2)	Shear stress at failure ζ(kg/cm^2)
1	0.5	
2	1.0	
3	1.5	

From the results a graph of Horizontal displacement VS Shear stress is drawn

Mohr's circles are also plotted.

From Mohr's circle the following details are obtained;

Major principal stress σ_1=-----------kg/cm^2

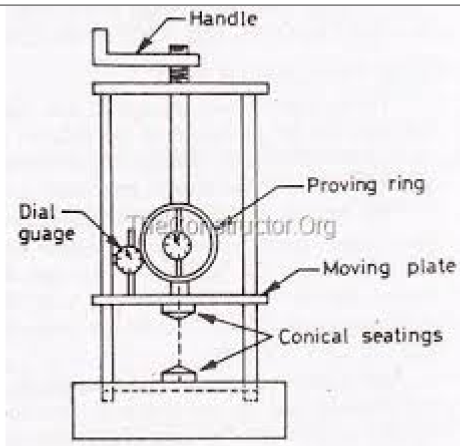
Minor principal stress σ_2=----------kg/cm^2

Inclination to major principal stress θ_1=---------degrees

Inclination to minor principal stress θ_2=---------degrees

9	Sample Calculations	
10	Graphs, Outputs	
11	Results & Analysis	Angle of internal friction Ǿ=------ Unit cohesion C=---------kg/cm^2
12	Application Areas	Ability to find Shear strength parameters to assess strength and deformation characteristics of soil
13	Remarks	
14	Faculty Signature with Date	

-	Experiment No.:	7	Marks		Date Planned		Date Conducted	
1	Title	Shear strength tests						
2	Course Outcomes	Students are able to calculate the shear strength of soil, and shear parameters from different laboratory tests Direct shear test ,Unconfined compression testand triaxial test..						
3	Aim	Determination of shear parameters C and Ǿ of the soil and unconfined compressive strength of soil by unconfined compression test.						
4	Material / Equipment	The unconfined compression test equipment may be used.						

<table>
<tr><td></td><td>Required</td><td></td></tr>
<tr><td>5</td><td>Theory, Formula, Principle, Concept</td><td>Determine the confined compressive strength of a given soil specimen. The tests may be carried out either on an undisturbed soil sample brought from the field or a remolded and compacted to the required density and moisture content. The only pressure that is applied in this case is the axial vertical pressure.</td></tr>
<tr><td>6</td><td>Procedure, Program, Activity, Algorithm, Pseudo Code</td><td>
a) The sample is prepared in the same way as for a triaxial test. Its natural water content and dry density are determined prior to the testing. The length (Lo) and diameter (do) are also measured.
b) Set the sample on the pedestal of the equipment and complete all the necessary adjustments for applying on axial loads.
c) Apply the axial load at a strain of about 0.5 to 2 % per minute and continue the load till the sample fails OR the deformation reaches 20 % of axial strain.
d) Sketch the failure pattern and measure the angle of failure if possible.
e) Take a small sample of soil from the failure zone for water content determination.
</td></tr>
<tr><td>7</td><td>Block, Circuit, Model Diagram, Reaction Equation, Expected Graph</td><td>


</td></tr>
<tr><td>8</td><td>Observation Table, Look-up Table, Output</td><td>
a) Do = cm, L = cm, Ao = cm²
b) Initial bulk density, ρt = gm/cm³
c) Initial water content, w = %
<table>
<tr><th>Strain dial reading</th><th>ΔL(mm)</th><th>Axial Strain %</th><th>Corrected area, A(cm²)</th><th>Proving ring reading (PR)</th><th>Axial Load P(kg)</th><th>Stress σ=P/A (kg/cm²)</th></tr>
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</table>
From the results so obtained a graph of Axial strain (%) Vs Axial stress is obtained
</td></tr>
<tr><td>9</td><td>Sample Calculations</td><td>
a) The axial strain, $\varepsilon\% = (\Delta L/Lo)\times 100$
Where, ΔL = change in length of specimen.
</td></tr>
</table>

		Lo = Initial length of specimen. **b)** Corrected area A, $A = Ao/(1-\varepsilon)$ Where, Ao = initial sectional area op the specimen. **c)** Compressive stress, σ1, (which is the principal stress) is $\Delta\sigma 1= P/A$ where P = axial load. A plot of σ1versus ε gives the maximum stress, which is the unconfined compressive strength of the soil specimen. Observations and tabulation of the test results of a particular specimen:
10	Graphs, Outputs	
11	Results & Analysis	Average unconfined compressive stress qu=---------kg/cm^2 Angle of internal friction--------- Undrained cohesive strength-------------kg/cm^2
12	Application Areas	Ability to find Shear strength parameters to assess strength and deformation characteristics of soil
13	Remarks	
14	Faculty Signature with Date	

-	**Experiment No.:**	7	**Marks**		**Date Planned**		**Date Conducted**	
1	Title	Shear strength tests						
2	Course Outcomes	Students are able to calculate the shear strength of soil, and shear parameters from different laboratory tests Direct shear test ,Unconfined compression testand triaxial test..						
3	Aim	To determine the shear parameters of the soil sample C and Ǿ of the soil sample by triaxial shear test						
4	Material / Equipment Required	a) A triaxial cell to a capacity of 1000kN/m^2 b) Accessories such as rubber membrane, membrane stretcher, sample trimming device, split mould, knife, stopwatch etc.,						
5	Theory, Formula, Principle, Concept	The sample used for the tests in standard triaxial equipment is 38mm diameter and 76mm long. The tests may be carried out on any type of soil provided one makes a sample to simulate field conditions. The tests on c- Ǿ soil or on purely clay soil may be on a. Undisturbed samples b. Remolded samples The types of tests required are to be decided by taking into account the field conditions.						
6	Procedure, Program, Activity, Algorithm, Pseudo Code	a) Place the specimen on the pedestal, place the rubber membrane around it, set the loading cap and complete all the formalities required for conducting the test. b) For conducting an undrained test, close the drainage valve and for a drained test keep the valve open. c) For the sample to be consolidated under an all round pressure, keep the drainage outlet open. d) Apply the axial compressive force at a constant rate of strain. e) The failure of the sample may take place within a period of 5 to 15 minutes.						

f) After dismantling the set up, take out the specimen from the rubber membrane, weigh the sample and keep a small part of it for water content determination.

7 Block, Circuit, Model Diagram, Reaction Equation, Expected Graph

8 Observation Table, Look-up Table, Output

Initial length of the specimen L_0=---------cm
Initial diameter of the specimen d_0=-------cm
Initial area of the specimen A_0 =--------cm²
Cell pressure σ 3-----------kg/cm2

Strain dial reading	ΔL(mm)	Axial Strain % = $\Delta L/L_0$	Corrected area, A(cm²)	Proving ring reading (PR)	Deviator Load P(kg)	Deviator Stress σ=P/A (kg/cm²)	Vertical stress σ1= σ 3+deviator stress

The same tabular column is repeated for different samples under different cell pressures.

A graph of Strain vs Deviator stress is plotted

Mohr circles are drawn to plot Colomb's failure enevelope.

9 Sample Calculations

10 Graphs, Outputs

11 Results & Analysis — Angle of internal friction Ø=------

		Unit cohesion C=---------kg/cm²
12	Application Areas	Ability to find Shear strength parameters to assess strength and deformation characteristics of soil
13	Remarks	
14	Faculty Signature with Date	

Experiment 08 : Consolidation test

-	Experiment No.:	1	Marks		Date Planned		Date Conducted	
1	Title	Consolidation test						
2	Course Outcomes	Students are able to calculate co-efficients related to compressibilty and consolidation by different methods						
3	Aim	Determination of compression index and co-efficient of consolidation by consolidation test						
4	Material / Equipment Required	A fixed ring consolidometer as shown in the figure and other accessories						
5	Theory, Formula, Principle, Concept	The purpose of this test is to obtain the following information from the tests on undisturbed or disturbed samples of soil brought from the field. 1. Pressure-void ratio curves. 2. Compression index, Cc. 3. Coefficient of consolidation, cv. The following equations are necessary for the computation. a) E = (h-hs)/hs b) Hs = Ms/(G×A×ρw) c) Cc = δ e/(log (P/Po) d) Cv = 0.197×($h^2$50/ t 50) For the log of time fitting method Cv = 0.848×($h^2$90/ t 90) For the square root fitting method. Where, hs = height of solids in the ring. h = thickness of the sample at any stage of the best. E = void ratio of the sample at any stage of the test. Ms = dry mass of the solids in the ring. A = internal sectional area of the ring. The other information required in the analysis of the test results are α) The thickness of the ring and the area A of the ring. β) The specific gravity G of the solids.						
6	Procedure, Program, Activity, Algorithm, Pseudo Code	b) Determine mass of the consolidation ring (M1) c) Transfer the soil sample (disturbed or undisturbed) into the ring and level the surface with a straight edge. Use the standard practice for making a compact sample from disturbed soil. In all the cases the ring is pressed into the sample. Find the mass of wet sample with the ring (M2). A small sample of this soil is taken for water content determination. d) Place the ring in the consolidometer, set the loading device and arrange the dial gauge for taking readings. Before setting the ring, the porous stones should be saturated in advance. e) Apply a setting load of 5 kN/m² and take the initial reading. Allow the load to remain for 24 hours. f) Apply the load increment of 10 kN/m² and take dial gauge readings (DR) at elapsed times of ¼, ½,1,2,4,8,15,30,60,120,240,480,and 1140 minutes. Follow the same procedures for the next successive						

		loadings of 20,50,100,200,400 and 800 kN/m^2. g) After the completion of the final loading, unload the specimen in steps. First reduce to half of the final load and allow it to remain for 24 hours and take the DR. h) Dismantle the setup, remove the ring from its position and find its mass (M3) after removing the excess water remaining on the surface by blotting it. i) Dry the soil with the ring in an oven cool it finds its mass (M4).
7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph	
8	Observation Table, Look-up Table, Output	Empty mass of the ring (M1) area of the ring (A) Diameter of the ring (d) volume of the ring (VR) Thickness of the ring (hR) Sp.gr solids (G)

Load Intensity (kN/m²)	10	20	50	100	200	400
Elapsed time (min)	Dial Gauge readings					
0						
0.25						
0.50						
1						
2						
4						
8						
15						
60						
120						
240						
480						
1440						

From the consolidation test results the following information can be obtained.

Mass of dry soil gram = M4-M1

Height of solids, hs = Ms/(G × A × Pw)

Compression of sample under seating load = Δhi

		Initial thickness of sample under seatring load, ho = (hR - Δhi) Initial void ratio, eo = (ho/hs) – 1 Thickness of sample at any stage of loading, h = (ho - Δh) Where Δh = compression of sample obtained from DR Height of voids at any stage of loading, Δhe = (h – hs) Void ratio at any stage of loading, e = (Δhe/h) Now e-log p curve can be plotted by use of the load applied P and the void ratio compression index Cc can be obtained from the curve. Curves giving the relationships between the dial readings (DR) and log t or √t can be drawn and the coefficient of consolidation, Cv can be obtained from these curves.
9	Sample Calculations	
10	Graphs, Outputs	
11	Results & Analysis	
12	Application Areas	Ability to find consolidation strength parameters to assess strength and deformation characteristics of soil
13	Remarks	
14	Faculty Signature with Date	

Experiment 09 : Laboratory vane shear test

-	**Experiment No.:**	1	**Marks**		**Date Planned**		**Date Conducted**	
1	Title	Laboratory vane shear test						
2	Course Outcomes	Students are able to calculate the shear strength of soil, and shear parameters from laboratory Vane shear test						
3	Aim	To determine Cohesion or Shear Strength of Soil						
4	Material / Equipment Required	1. Vane shear test apparatus with accessories 2. The soil sample						
5	Theory, Formula, Principle, Concept	Vane shear test can be used as a reliable in-situ test for determining the shear strength of soft-sensitive clays. The vane may be regarded as a method to be used under the following conditions. 1. Where the clay is deep, normally consolidated and sensitive. 2. Where only the undrained shear strength is required. It has been found that the vane gives results similar to that as obtained from unconfined compression tests on undisturbed samples.						
6	Procedure, Program, Activity, Algorithm, Pseudo Code	1. A posthole borer is first employed to bore a hole up to a point just above the required depth 2. The rod is pushed or driven carefully until the vanes are embedded at the required depth. 3. At the other end of the rod just above the surface of the ground a torsion head is used to apply a horizontal torque and this is applied at a uniform speed of about 0.1 degree per second until the soil fails, thus generating a cylinder of soil 4. The area consists of the peripheral surface of the cylinder and the two round ends. 5. The first moment of these areas divided by the applied moment gives the unit shear value.						

7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph	
8	Observation Table, Look-up Table, Output	Force observed P=-------kg Eccentricity (lever arm) x=-------cm Turning moment Px=-----------kg-cm Length of the vane L=-------cm Radius of the vane blades r=-------cm
9	Sample Calculations	Undrained Shear strength of Clay Cu= (Px)/(2*.Π*r²(L+2/3*r))
10	Graphs, Outputs	
11	Results & Analysis	Undrained Shear strength of Clay Cu=-----------kg/cm²
12	Application Areas	Ability to find Shear strength parameters to assess strength and deformation characteristics of soil
13	Remarks	
14	Faculty Signature with Date	

Experiment 10 :Demonstration of Swell pressure test, Standard penetration test and boring equipment

-	**Experiment No.:**	10	**Marks**		**Date Planned**		**Date Conducted**	
1	Title	Demonstration of Swell pressure test, Standard penetration test and boring equipment						
2	Course Outcomes	Students are able to understand the demonstration of the tests.						
3	Aim	Demonstration of Swell pressure test						
4	Material / Equipment Required	a) Consolidometer b) Dial gauge c) reservoir d) Soil trimming tools, e) Water f) Oven g) Desiccator h) Balance and Containers						
5	Theory, Formula, Principle, Concept	The pressure which the expansive soil exerts, if the soil is not allowed to swell or the volume change of the soil is arrested is known as Swelling Pressure of Soil.. The main purpose of swelling pressure test is to determine the intrinsic swelling pressure of the expansive soil tested.						
6	Procedure, Program, Activity, Algorithm, Pseudo Code	A. Sample Preparation: 1. Reject at least 30mm (more if desired) sample from one end of the sample. 2. Clean the consolidation ring and gradually insert the consolidation ring in the sample by pressing with hands and carefully removing the soil around it. 3. The soil specimen cut shall project around 10mm on either side of the ring. 4. Trim, smooth and flush the specimen with both ends of the ring and fill all the voids if any. 5. The test may be conducted for both soaked as well as unsoaked conditions. If the sample is to be soaked, in both cases of compaction, put a filter paper on the top of the soil and place the adjustable stem and perforated plate on the top of filter paper. 6. Clean the ring from outside. 7. From disturbed sample compact the soil with desired field density and						

		moisture content and then repeat the above procedure. B. Test procedure: 1. Assembly of the Consolidometer Test is to be done as per Fig. 1. 2. The free swell reading under the seating shall be recorded at different time intervals till the equilibrium is reached. It takes around 6-7 days to reach equilibrium. (ReferTable 1) 3. Consolidate the swollen sample under different pressures record the compression dial readings till the sample reaches steady state for each load. (Refer Table 2) 4. Increase the consolidation loads until the specimen attains its original volume.
7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph	
8	Observation Table, Look-up Table, Output	(see table below)

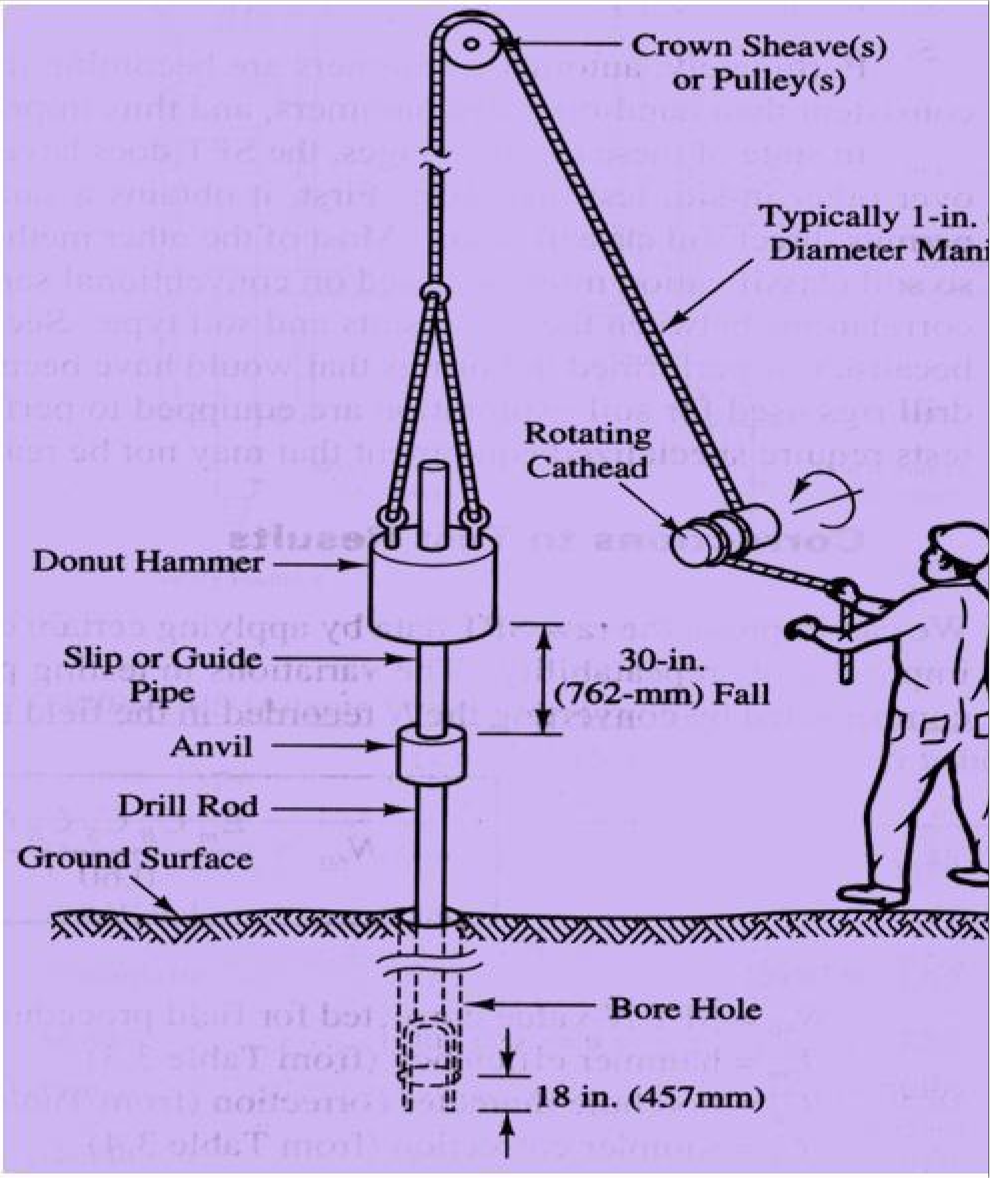
sl.no	Elapsed time (hours)	Swell dial readings (mm)
1	0	
2	1	
3	2	
4	4	
5	8	
6	12	
7	16	
8	20	
9	24	
10	28	
11	32	
12		
13		
14		
15		
16		

		sl.no	Applied pressure (kg/cm2)	Change in thickness of specimen (mm)
		1	0.05	
		2	01	
		3	0.25	
		4	0.5	
		5	1	
		6	2	
		7	4	
		8	8	
		9	16	
9	Sample Calculations			
10	Graphs, Outputs	1. Plot swelling dial reading (refer Table 1) with elapsed time as abscissa and swelling dial reading as ordinates on natural scale. If the curve so drawn becomes asymptotic with the abscissa, the swelling has reached its maximum and hence the swelling phase shall be stopped, and the consolidation phase shall be started. 2. The compression readings (refer Table 2) shall be plotted with change in thickness of expanded specimen as ordinates and consolidation pressure applied as abscissa in semi- logarithmic scale. The swelling pressure exerted by the soil specimen under zero swelling condition shall be obtained by interpolation.		
11	Results & Analysis			
12	Application Areas	Understand In situ shear strength characteristicts		
13	Remarks			
14	Faculty Signature with Date			

-	Experiment No.:	10	Marks		Date Planned		Date Conducted	
1	Title	Demonstration of Swell pressure test, Standard penetration test and boring equipment						
2	Course Outcomes	Students are able to understand the demonstration of the tests.						
3	Aim	Demonstration of Standard penetration test						
4	Material / Equipment Required	a) Tripod (to give a clear height of about 4 m; one of the legs of the tripod should have ladder to facilitate a person to reach tripod head.) b) Tripod head with hook c) Pulley d) Guide pipe assembly e) Standard split spoon sampler f) A drill rod for extending the test to deeper depths g) Heavy duty post hole auger (100 mm to 150 mm diameter) h) Heavy duty helical auger i) Heavy duty auger extension rods j) Sand bailer						

		k) Rope (about 15 m long & strong enough to lift 63.5 kg load repeatedly) l) A light duty rope to operate sand bailer m) Chain pulley block n) Casing pipes o) Casing clamps p) Casing couplings q) Measuring tapes r) A straight edge (50 cm) s) Tool box
5	Theory, Formula, Principle, Concept	
6	Procedure, Program, Activity, Algorithm, Pseudo Code	α) Identify the location of testing in the field β) Erect the tripod such that the top of the tripod head is centrally located over the testing spot. This can be reasonably ensured by passing a rope over the pulley connected to the tripod head and making the free end of the rope to come down and adjusting the tripod legs such that the rope end is at the testing spot. While erecting and adjusting the tripod legs, care should be taken to see that the load is uniformly distributed over the three legs. This can be achieved by ensuring the lines joining the tips of the tripod legs on the ground forms an equilateral triangle. Further, it should be ensured that the three legs of the tripod are firmly supported on the ground (i.e. the soil below the legs should not be loose and they should not be supported on a sloping rock surface or on a small boulder which may tilt during testing.) χ) Advance the bore hole, at the test location, using the auger. To start with advance the bore hole for a depth of 0.5 m and clear the loose soil from the bore hole. δ) Clean the split spoon sampler and apply a thin film of oil to the inside face of the sampler. Connect an A-drill extension rod to the split spoon sampler. ε) Slip the 63.6 kg weight on to the guide pipe assembly and connect the guide pipe assembly to the other end of the A-drill rod. ϕ) The chain connected to the driving weight is tied to the rope passing over the pulley at the tripod head. The other end of the rope is pulled down manually or with help of mechanical winch. By pulling the rope down, the drive weight, guide pipe assembly, A-drill rod and the split spoon sampler will get vertically erected. γ) A person should hold the guide pipe assembly split spoon sampler to be vertical with the falling weight lowered to the bottom of the guide assembly. η) Now place a straight edge across the bore touching the A-drill rod. Mark

		the straight edge level all round the A-drill rod with the help of a chalk or any other marker. From this mark, measure up along the A-drill rod and mark 15 cm, 30 cm and 45 cm above the straight edge level. Lift the driving weight to reach the top of the guide pipe assembly travel and allow it to fall freely. The fall of driving weight will transfer the impact load to the split spoon sampler, which drive the split spoon sampler into the ground. Again lift the drive weight to the top of travel and allow it to fall freely under its own weight from a height of 75 cm. as the number of blows are applied, the split spoon sampler will penetrate into the ground and the first mark (15 cm mark) on the drill rod approaches the straight edge. ι) Count the number of blows required for the first 15 cm, second 15 cm and the third 15 cm mark to cross down the straight edge. φ) The penetration of the first 15 cm is considered as the seating drive and the number of blows required for this penetration is noted but not accounted in computing penetration resistance value. The total number of blows required for the penetration of the split spoon sampler by 2^{nd} and 3^{rd} 15 cm is recorded as the penetration resistance or N-value. κ) After the completion of the split spoon sampler by 45 cm, pull out the whole assembly. Detach the split sampler from A-drill rod and open it out. Collect the soil sample from the split spoon sampler into a sampling bag. Store the sampling bag safely with an identification tag for laboratory investigation. λ) Advance the bore hole by another 1 m or till a change of soil strata which ever is early. μ) The test is repeated with advancement of bore hole till the required depth of exploration is reached or till a refusal condition is encountered. Refusal condition is said to exist if the number of blows required for the last 30 cm of penetration is more than 100. ν) The test will be repeated in number of bore holes covering the site depending on the building area, importance of the structure and the variation of the soil properties across the site. ο) The SPT values are presented either in the form of a table or in the form of bore log data.
7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph	

		
8	Observation Table, Look-up Table, Output	
9	Sample Calculations	
10	Graphs, Outputs	
11	Results & Analysis	
12	Application Areas	Understand In situ shear strength characteristicts
13	Remarks	
14	Faculty Signature with Date	

F. Content to Experiment Outcomes

1. TLPA Parameters

Table 1: TLPA

Expt-#	Course Content or Syllabus (Split module content into 2 parts which have similar concepts)	Content Teaching Hours	Blooms' Learning Levels for Content	Final Blooms' Level	Identified Action Verbs for Learning	Instruction Methods for Learning	Assessment Methods to Measure Learning
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*
1	Visual soil classification.	06	-L2 -L3	L3	Apply	Lecture	Assignment
2	Grain size analysis	03	-L2 -L3	L3	Apply	Lecture	Assignment
3	In-situ density tests	03	-L2 -L3	L3	Apply	Lecture	Assignment
4	Consistency limits	03	-L2 -L3	L3	Apply	Lecture	Assignment
5	compaction test	03	-L2 -L3	L3	Apply	Lecture	Assignment
6	Co-efficient of permeability test	03	-L2 -L3	L3	Apply	Lecture	Assignment
7	Shear strength tests	09	-L2 -L3	L3	Apply	Lecture	Assignment
8	Consolidation test	03	-L2 -L3	L3	Apply	Lecture	Assignment
9	Laboratory vane shear test	03	-L2 -L3	L3	Apply	Lecture	Assignment
10	Demonstration of Swell pressure test, Standard penetration test and boring equipment	06	-L2	L2	Understand	Lecture	Assignment

2. Concepts and Outcomes:

Table 2: Concept to Outcome – 15CV54

Expt - #	Learning or Outcome from study of the Content or Syllabus	Identified Concepts from Content	Final Concept	Concept Justification (What all Learning Happened from the study of Content / Syllabus. A short word for learning or outcome)	CO Components (1.Action Verb, 2.Knowledge, 3.Condition / Methodology, 4.Benchmark)	Course Outcome **Student Should be able to ...**
A	*I*	*J*	*K*	*L*	*M*	*N*
1	- -	Index properties	Index properties	Index properties of soil.	-Apply -Index properties of soil.	compute the index properties of soil by different laboratory experiments.
2	- -	Soil classification	Soil classification	Partial size distribution of soil.	-Apply -Soil Classification.	Draw the particle size distribution curve of different types of soils and classify the soils as per the result
3	- -	Analysis of Field Density	Analysis of Field Density	Field density of sand.	-Apply -Field Density.	determine field density using sand replacement and core cutter methods, and

						compare the results.
4	- -	Consistency Limits	Consistency Limits	Consistancy limit.	-Apply -Consistancy limits.	find the consistency limits of soil
5	- -	Analysis of Density and Moisture content	Analysis of Density and Moisture content	Standard proctor test.	Detailing -Moisture content.	calculate the optimum moisture content and maximum dry density using Standard Proctor Test
6	- -	Permeability Analysis	Permeability Analysis	Permeability test.	-Apply -Permisibility	compute the co-efficient of permeability through different types of soils by constant head and falling head methods
7	- -	Shear Strength of Soils	Shear Strength of Soils	Shear strength of soil by laboratory method.	-Apply -Soil strength.	calculate the shear strength of soil, and shear parameters from different laboratory tests Direct shear test ,Unconfined compression test and triaxial test..
8	- -	Consolidation Index	Consolidation Index	Compressibility and consolidation.	-Apply -Consolidation.	calculate co-efficients related to compressibilty and consolidation by different methods
9	- -	Shear Strength of Soils	Shear Strength of Soils	Shear strength of soil.	-Apply -Shear strength	calculate the shear strength of soil, and shear parameters from laboratory Vane shear test
10		Demonstration	Demonstration		-Understand	understand the demonstration of the tests.