SRM VALLIAMMAI NGINEERING COLLEGE

(An Autonomous Institution)
SRMNagar,Kattankulathur- 603203.

DepartmentofCivilEngineering

CE 3468 -Soil Mechanics Laboratory Manual
(Fourth Semester)
Regulations 2023
AcademicYear2024 – 2025 (Even Semester)




Preface

This instruction manual has been prepared by the Department of Civil Engineeringto facilitate instruction during practical classes and further to be used as a reference manual by the civil engineering students of this college. This manual covers explanation of experiments included in the latest syllabus of Regulations 2023 of SRM Valliammai Engineering College for under graduate degreecourse in civil engineering. Any suggestions for the improvement of the manual will be gratefully received.

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REGULATION2023

CE 3468 **SOILMECHANICSLABORATORY** **LT P C**

0042

COURSEOBJECTIVES:

- Tostudytheparticlesizedistributionofdifferentsoil.
- Toenhancetheknowledgeonvariousindexpropertiesof soil.
- Togainknowledgeaboutthecompactioncharacteristicsofsoil.
- Tolearnabouttheshearingpropertiesofsoil.
- Tostudyaboutthebearingcapacityofsoil.

COURSEOUTCOME:

Onthecompletionofthecourse,thestudentswillbeableto:

1. StudentsareabletoclassifythesoilbasedonISCode
2. Studentsareabletoconducteststodeterminebboththeindexproperties
3. Studentsareabletoconducttestsonengineeringpropertiesof soils
4. Studentsareabletoconducttestsoncharacterizationofthesoilbasedon their properties.
5. Studentsareabletoconductfieldtestson soil.

TOTAL:45PERIODS

Listof Experiments

1. **DETERMINATIONOFINDEXPROPERTIES**
   a. Specificgravityofsoil solids
   b. Grainsizedistributionofcohesionlesssoil–Sieveanalysis
   c. Grainsizedistributionofcohesivesoil-Hydrometeranalysis
   d. LiquidlimitandPlasticlimittests oncohesivesoil
   e. ShrinkagelimitandDifferentialfreeswelltestsforcohesive soil

2. **DETERMINATIONOFINSITUDENSITYANDCOMPACTIONCHARACTERISTICS**
   a. FielddensityTest(Sandreplacementmethod)
   b. Determinationofmoisture–densityrelationshipusing standardProctor compaction test.
   c. Determinationofrelativedensityforthegivensample

3. **DETERMINATIONOFENGINEERINGPROPERTIES**
   a. ConstantHeadPermeabilitydeterminationforgivensample.
   b. FallingHeadPermeabilitydeterminationforgivensample.
   c. Onedimensionalconsolidationtest(Demonstrationonly)
   d. Directsheartestincohesionless soil
   e. Unconfinedcompressiontestincohesivesoil
   f. Laboratoryvanesheartestincohesivesoil
   g. Tri-axialcompressiontestincohesionlesssoil(Demonstrationonly)
   h. CaliforniaBearingRatioTestforthegivensoil

LABORATORYSAFETYPROCEDURES

Do's

- Knowthepotentialhazardsofthematerialsusedinthelaboratory.
- Wearpersonalprotectiveapparelwhenworking.
- Washskinpromptlyifcontactedbyany chemical.
- HandleHeavyEquipmentwithutmostcare.
- Becautiouswhenworkingwith electricity.
- Shoes must cover the entire foot. Open toed shoes and sandals are inappropriate footwear in laboratories.
- Restrain and confine long hair and loose clothing. Pony tails and scarves used to control hair must not present a loose tail that could get caught in moving parts of machinery.
- Cleanalltheapparatusbeforeand aftertheexperiment.
- Washyourhandsthoroughlyonceyoucompletetheexperiments.

Don't

- Don'tEat,drink,chewgum,orapplycosmeticsinlaboratory.
- Don'thandleheavyweightscarelessly.
- Don'tuseGoldenOrnamentsWhileHandlingMercury.

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Ex. No: 1 **Date:**

DeterminationofSpecificgravityofsoilsolids

AIM

Todeterminethespecificgravityofsoil solids.

THEORY

Specificgravityofsoilsolidsistheratioofweight,inairofagivenvolume;ofdrysoil solidstotheweightofequalvolumeofwaterat4ºC.Specificgravityofsoilgrainsgives the property of the formation of soil mass and is independent of particle size. Specific gravityof soilgrainsisused incalculating void ratio,porosityand degree of saturation, by knowing moisture content and density. The value of specific gravity helps in identifying and classifying the soil type.

APPARATUSREQUIRED

1. Pycnometer
2. 450mmsieve
3. Weighingbalance
4. Oven
5. Glassrod
6. Distilledwater

PROCEDURE

1. Drythepycnometerandweighitwithitscap. (W_1)
2. Takeabout200 gm ofovendriedsoilpassingthrough4.75 mmsieveintothe pycnometer and weigh again (W_2).
3. Addsufficientde-airedwatertocoverthesoilandscrewonthecap.
4. Shakethepycnometerwellandremoveentrappedairifany.
5. Aftertheairhasbeenremoved,fillthepycnometerwithwater completely.
6. Thoroughlydrythepycnometerfromoutsideandweighit (W_3).
7. Cleanthepycnometerbywashingthoroughly.
8. Fill the cleaned pycnometer completely with water up to its top with cap screw on.
9. Weighthepycnometerafterdryingitontheoutsidethoroughly (W_4).
10. Repeattheprocedureforthreesamplesandobtaintheaveragevalueofspecific gravity.

RESULT

AveragespecificgravityofsoilsolidsG=

OBSERVATIONSANDCALCULATIONS

Determinethespecificgravityofsoilgrains(G)usingthefollowingequation $G = (W_2 – W_1) /\{(W_2 – W_1) - (W_3 – W_4)\}$

Where

W_1 =Emptyweightof pycnometer.

W_2 =Weightofpycnometer+ovendrysoil

W_3 =Weightofpycnometer+ovendrysoil+water

W_4 = Weight of pycnometer + water

OBSERVATIONFORSPECIFICGRAVITYDETERMINATION			
	TRIAL1	**TRIAL2**	**TRIAL3**
Emptyweightof pycnometer. **W_1ingms**			
Weight of pycnometer + oven drysoil **W_2ingms**			
Weight of pycnometer + oven drysoil+ water **W_3ingms**			
Weightofpycnometer+ water **W_4ingms**			
SpecificGravity, G (NoUnit)			

SpecificGravityandMoistureContentofsoilsolids

1. WhatismeantbySpecificGravity?

   Theratioofunitweightof Soilsolidstotheunitweightofthewateriscalledspecific gravity of soil solids.

2. Whatarethedifferenttypesofspecificgravity?

   Specific Gravity of Soil Solids

   ApparentSpecificGravity

3. WhatismeantbyApparentspecific gravity?

   TheratioofBulkunitweightofsoiltotheunitweightofthewateriscalledApparent gravity of soil solids

4. WhataretheDifferentmethodstofindSpecificGravity?

   Pycnometer Method

   DensityBottleMethod

5. DifferentnameofSpecificGravityofSoilSolids? True

   specific Gravity

6. DifferentnameofBulkSpecificGravity?

   Apparent Specific Gravity

7. RangeofSpecificGravityofSoilSolids It

   range from 2.65 to 2.70 for soil

8. RangeofSpecificGravityofSoilSolids It

   range from 1.25 to 1.50 for soil.

9. Whatismeantbycapillary water?

   The water which move up / down due to the surface tension is called as capillary water.

10. WhatismeantbyHygroscopicwater?

    Thewaterwhichbind/heldaroundthesoilparticleisknownasHygroscopicwater.

11. WhatismeantbyWater Content?

    TheratioofMassofwatertothemassofsoilsolidiscalledWater content

12. Whatarethedifferentmethodstofindwatercontent? Calcium

    Carbide Method

    TorsionBalanceMethod

    Sand Bath Method

    HotAirOven Method

13. HowthewatercontentmeasuredfromOven Method?

    The wet soil is kept in oven at the temperature on 105 degree for 24 hours. The weight of water and the weight of dry weightobserved. With that water content to be found.

14. ExplainCalciumCarbideMethod?

    In this method, the wet sample is kept in the flask with calcium carbide chemical. The closed flask to be shake and the carbon dioxide will form and the pressure due to formed gas is measured with pressure gauge attached with flask.

15. ExplainCalciumCarbideMethod?

    In this method, the wet soil if weighed and fried in the hot pan. After few minutes the dry weight to be found. With this water content to be found

16. Whatarethedifferenttypesofsoilwater? Free

    water

    Structural Water Capillary

    Water Hygroscopicwater

17. Whatismeantbyfreewater?

    Thewaterwhichflowundergravitybetweenthevoidsiscalledfreewater.

18. Whatisstructuralwater?

    Thewaterpresentinsidethestructureofthesoilwhichcan'tdrywithoveniscalled structural water

19. Whatismeantbycapillarywater?

    The water which move up / down due to the surface tension is called as capillary water.

Ex. No: 2 **Date:**

DeterminationofGrainSizeDistribution(SieveAnalysis)

AIM

Toconductsieveanalysisofsoiltoclassifythegivencoarsegrainedsoil.

THEORY

Grainsizeanalysisisusedintheengineeringclassificationofsoils.Particularlycoarse grainedsoils. Partof suitabilitycriteria of soilsforroad, airfield,levee, damandother embankment construction is based on the grain size analysis. Information obtained from the grain size analysis can be used to predict soil water movement. Soils are broadlyclassifiedascoarsegrainedsoilsandfinegrainedsoils.Furtherclassification ofcoarsegrainedsoilsdependsmainlyongrainsizedistributionandthefinegrained soils are further classified based on their plasticity properties. The grain size distribution of coarse grained soil is studied by conducting sieve analysis.

APPARATUSREQUIRED

1. AsetofSieves4.75mm,2.36mm,1.18mm,0.60mm, 0.425mm,0.30 mm 0.15 mm 0.075mm including lid and pan.
2. Tray
3. WeighingBalance
4. Sieve Shaker
5. Brush

PROCEDURE

1. Weigh500 gmsofsoilsample,ofwhichgrainsizedistributionhastobestudied.
2. Cleanthesievesetsothatnosoilparticleswerestruckinthem.
3. Arrange the sieves in order such that coarse sieve is kept at the top and the fine sieve is at the bottom. Place the closed pan below the finest sieve.
4. Takethesoilobtainedintothetopsieveandkeepthelidtoclosethetopsieve.
5. Position the sieve set in the sieve shaker and sieve the sample for a period of 10 minutes.
6. Separate the sieves and weigh carefully the amount of soil retained on each sieve, this is usually doneby transferring thesoilretained on eachsieve ona separate sieve of paper and weighing the soil with the paper.

7. EntertheobservationsintheTableandcalculatethecumulativepercentageof soil retained on each sieve
8. Draw the grain size distribution curve between grain size on log scale on the abscissa and the percentage finer on the ordinate.

RESULT

Percentageofgravel(>4.75mm)=

Percentage of coarse sand (4.75mm – 2.00 mm) =

Percentageofmediumsand(2.00mm–0.425mm)= Percentage of fine sand (0.425mm – 0.0.075 mm) =

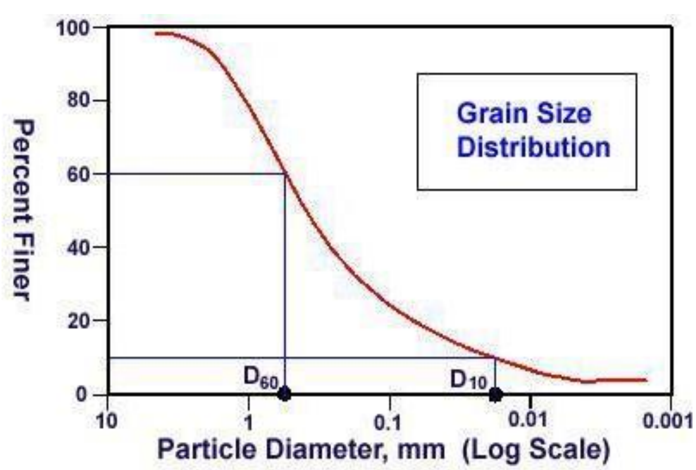
Percentage of fines (<0.075 mm) =

Uniformity Coefficient C_u=

CoefficientofCurvatureC_c=

OBSERVATIONS &CALCULATIONS					
Weightofthesoiltakenfortesting(W)=					
Sl. No.	Aperturesizeof sieve in mm	Weight of soilretained (gm)	%Weight Retained	Cumulative Percentage Retained	Percentage Finer
1	4.75 mm				
2	2.36 mm				
3	1.18 mm				
4	0.600 mm				
5	0.425 mm				
6	0.300 mm				
7	0.150mm				
8	0.075mm				

Plotthegraphbetweenpercentagefinerandlogarithmicgrainsize(mm). Fromthe graph,obtain the percentage of coarse, medium and fine sands.



Uniformity coefficient C_u= D_{60}/ D_{10}

CoefficientofCurvatureC_c=$(D_{30})^2/D_{60} x D_{10}$

Ex. No: 3 **Date:**

DeterminationofGrainSizeDistribution(HydrometerAnalysis)

AIM

Todeterminethegrainsizedistributionofsoilsamplecontainingappreciableamount of fines by hydrometer analysis test.

THEORY

Fordeterminingthegrainsizedistributionofsoilsample,usuallymechanicalanalysis (sieve analysis)is carriedoutinwhichthefinersieveusedis 63micron orthenearer opening. If a soil contains appreciable quantities of fine fractions in (less than 63 micron) wet analysis is done. One form of the analysis is hydrometer analysis. It is verymuchhelpfultoclassifythesoilasperISIclassification.Thepropertiesofthesoil are very much influenced by the amount of clay and other fractions.

APPARATUSREQUIRED

1. Hydrometer
2. Glassmeasuringcylinder-Twoof1000mlcapacitywithgroundglassorrubber stoppers about 7 cm diameter and 33 cm high marked at 1000 ml volume. Thermometer- To cover the range 0 to 50º C with an accuracy of 0.5 º C.
3. Waterbath.
4. Stirringapparatus.
5. I.Ssievesapparatus.
6. Balance-accurateto0.01 gm.
7. Oven-105ºto110º.
8. Stop watch.
9. Desiccators
10. Centimeter scale.
11. Porcelainevaporatingdish.
12. Widemouthconicalflaskorconicalbeakerof1000ml capacity.
13. Thickfunnel-about10cmindiameter.
14. Filterflask-totakethefunnel.
15. Measuringcylinder-100mlcapacity.
16. Washbottle-containingdistilledwater.

17. Filterpapers.
18. Glassrod-about15to20cmlongand4to5mmindiameter.
19. Hydrogenperoxide-20volumesolution.
20. Hydrochloric acid N solution-89 ml of concentrated hydrochloric acid.(specific gravity 1.18) diluted with distilled water one litre of solution.
21. Sodium hexametaphosphate solution-dissolve 33 g of sodium hexametaphosphate and 7 gms of sodium carbonate in distilled water to make one litre of solution.

PROCEDURE

Volume

Volumeofwaterdisplaced: Approximately800 mlof watershallbepoured in the 1000 ml measuring cylinder. The reading of the water level shall be observed and recorded.

Thehydrometershallbeimmersedinthewaterandthelevelshallagainbeobserved and recorded as the volume of the hydrometer bulb in ml plus volume of that part of the stem that is submerged. For practical purposes the error to the inclusion of this stem volume may be neglected.

From the weight of the hydrometer: The hydrometer shall be weighed to the nearest 0.1 gm. The weight in gm shall be recorded as the volume of the bulb plus the volume of the stem below the 1000 ml graduation mark. For practical purposes the error due to the inclusion of this stem may be neglected.

Calibration

(a) The sectional area of the 1000 ml measuring cylinder in which the hydrometer is to used shall be determined by measuring the distance between the graduations. The sectional area is equal to the volume include between the two graduations divided by the measured distance between them.

1. The distance from the lowest reading to the center of the bulb is (R_h) shall be recorded (R_h=H_L+ L/2).
2. Thedistance fromthehighest hydrometerreadingtothe centerofthebulb shall be measured and recorded.
3. Drawagraphhydrometerreadingsvs$H_H$andR_H.Astraightlineisobtained. This calibration curve is used to calibrate the hydrometer readings which are taken with in 2 minutes.

4. From 4 minutes onwards the readings are to be taken by immersing the hydrometereachtime.Thismakesthesoilsolutiontorise,therebyrisingdistanceof free fall of the particle. So correction is applied to the hydrometer readings.

5. Correction applied to the $R_h$and H_H V_h=

Volume of hydrometer bulb in ml.

A=Area of measuring cylinder in cm^2.

Fromthesetwocorrectedreadingsdrawgraph(straightline)

RESULT

GrainsizedistributionofsoilisdonebyHydrometerAnalysis.

Calculation

Totalweightofdrysoiltaken,W= Specific

Gravity of soil, G =

Wt.ofsoilgoneintosolution, Ws=

Meniscus correction, Cn = Dispersion

agent correction = Reading in water

RW = Temperature correction =

%finerforwt.OfsoilWsgoneintosolutionN=[(100G)/{Wsx(G)}]xR

OBSERVATIONS &CALCULATIONS

ElapsedTimein Sec	Hydrometer readingupper Meniscus Rh1000	Correctedhydrometer Reading (1-lowermeniscusCm)	N (%finerForsoil)

GrainSizeDistribution:

1. Whatis meantbyCc?

   CcifdefinedasCoefficientofCurvature.ItdependsonD$_{10}$,D$_{30}$&D$_{60}$valuefrom the grain size distribution Curve

2. WhatismeantbyCu?

   Cc if defined as Coefficient of Uniformity. It depends on D10& D60 value from the grain size distribution Curve

3. WhatismeantbyGrainSizeDistributioncurve?

   The curvedrawnin semi logsheetbetweenthesizeofparticlesinXAxisandthe %FinerintheYAxisiscalledasgrainsizedistributioncurve.

4. WhatarethetesttobedonefordrawingGSD? Sieve

   Analysis

   SedimentationAnalysis

5. Whataretheclassificationinsieveanalysis? Coarse

   Soil Fraction

   FineSoil Fraction

6. WhatarethecorrectiontobecarriedoutinSedimentationAnalysis? Correction

   due to Meniscus, Chemicals and Temperature

7. WhattojudgefromCc??

   IfthevalueofCcbetween1to3means,thesoilis"WellGradedSoil"Else"Poorly Graded Soil"

8. WhattojudgefromCu?

   If the value of Cu > 4 means, the soil is "Well Graded Sand" & Cu > 6 means, the soil is "Well Graded Gravel". Else "Poorly Graded Soil"

Ex. No: 4 **Date:**

DeterminationofLiquidLimitandPlasticLimit AIM

Todeterminetheliquidlimitandplasticlimitofthegivensoil sample

THEORYANDAPPLICATION

Liquid limit is significant to know the stress history and general properties of the soil met with construction. From the results of liquid limit the compression indexmay be estimated. The compression index value will help us in settlement analysis. If the natural moisture content of soil is closer to liquid limit, the soil can be considered as soft if the moisture content is lesser than liquids limit, the soil can be considered as softifthemoisturecontentislesserthanliquidlimit.Thesoilisbrittleandstiffer.The liquidlimitisthemoisturecontentatwhichthegroove,formedbyastandardtoolinto the sample of soil taken in the standard cup, closes for 10 mm on being given 25 blows in a standard manner. At this limit the soil possess low shear strength.

The moisture content expressed in percentage at which the soil has the smallest plasticity is called the plastic limit. Just after plastic limit the soil displays the propertiesofasemisolid.Fordeterminationpurposestheplasticlimititisdefinedas the water content at which a soil just begins to crumble when rolled into a thread of 3mm in diameter. The values of liquid limit and plastic limit are directly used for classifying the finegrained soils. Once the soilis classified it helps inunderstanding the behaviour of soils and selecting the suitable method of design construction and maintenance of the structures made-up or and resting on soils.

APPARATUSREQUIRED:

1. Measuringbalance
2. Liquidlimitdevice (Casagrandes)
3. Groovingtool
4. 425micron sieve
5. Glassplate
6. Spatula

7. Mixingbowl
8. Washbottle
9. Mositurecontent bins
10. Dryingoven

Procedureforliquidlimit:

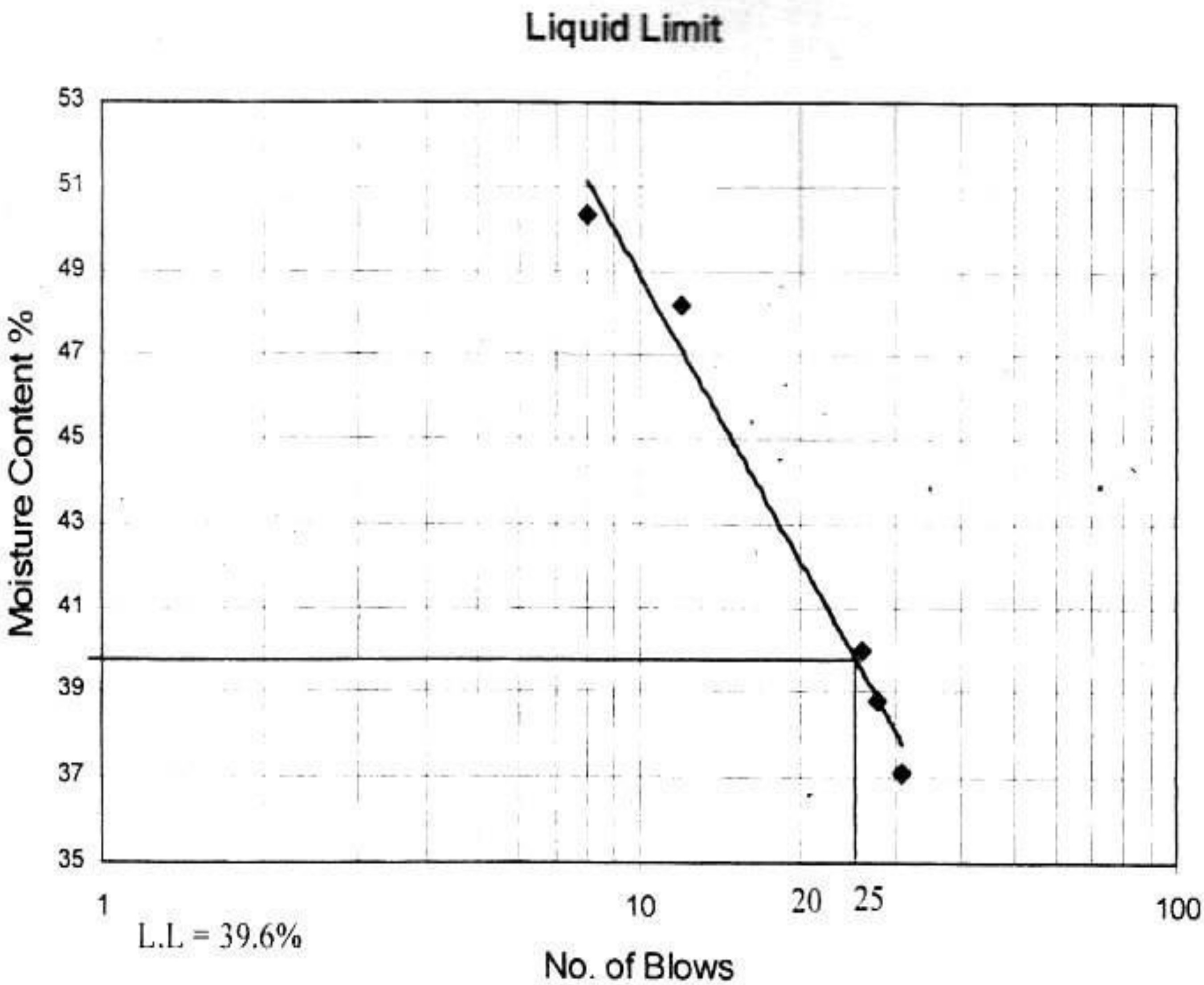
- About 120 gm of air dried soil from thoroughly mixed portion of material passing 425 micron I.S sieve is to be obtained.
- Distilled water is mixed to the soil thus obtained in a mixing disc toform uniform paste. The paste shall have a consistency that would require 30 to 35 drops of cup to cause closer of standard groove for sufficient length.
- A portion of the paste is placed in the cup of LIQUID LIMIT device and spread into portion with few strokes of spatula.
- Trimittoadepthof1cmatthepointofmaximumthicknessandreturnexcessof soil to the dish.
- The soil in the cup shall be divided by the firm strokes of the grooving tool along thediameterthrough the centrelineofthefollowerso thatclean sharpgrooveof proper dimension is formed
- Lift and drop the cup by turning crank at the rate of two revolutions per second until the two halves of soil cake come in contact with each other for a length of about 1 cm by flow only.
- The number of blows required to cause the groove close forabout 1 cm shallbe recorded.
- A representative portion (15gm) of soil is taken from the cup for water content determination by oven drying.
- Repeatthetestwithdifferentmoisturecontentsatleastthreemoretimesforblows between 10 and 40.

Sl. No.	Description	Test1	Test2	Test3
1	Noofblows(N)			
2	Containernumber			
3	Weightof thecontainer+wetsoil			
4	Weightofthecontainer+drysoil			
5	Weightofthewater(3–4)			
6	Weightofthe container			
7	Weightofthedrysoil(4–6)			
8	Moisturecontent(%),W={(5/7)*100}			

Sl. No.	PERCENTAGEOFWATERCONTENT	No.OF BLOW
1		
2		
3		
4		
5		

Usetheabovetableforrecordingnumberofblowsandcalculatingthemoisturecontent

- Use semi-log graph paper. Take number of blows on log scale (X –Axis) and water content on nominal scale (Y – axis). Plot all the points. (Flow curve)
- Readthewatercontentat25 blowswhichisthevalueofliquidlimit.



From graph,

FlowIndex,IF=$(W_2–W_1)/\log_{10}(N_2–N_1)$=

Liquid Limit (LL) =

Procedureforplasticlimit:

- Take about 20gm of thoroughly mixed portion of the material passing through 425 micron I.S. sieve obtained in accordance with I.S. 2720 (part 1).
- Mixitthoroughlywithdistilledwaterintheevaporatingdishtillthesoilmassbecomes plastic enough to be easily molded with fingers.
- Allowittoseasonforsufficienttime(for24hrs)toallowwatertopermeate throughout the soil mass
- Takeabout10gmsofthisplasticsoilmassandrollitbetweenfingersandglassplate with just sufficient pressure to roll the mass into a threaded of uniform diameter throughout its length. The rate of rolling shall be between 60 and 90 strokes per minute.
- Continuerollingtillyougetathreadedof3mmdiameter.
- Kneedthesoiltogethertoauniformmassand reroll.
- Continuetheprocessuntilthethreadcrumbleswhenthediameteris3mm.
- Collect the pieces of the crumbled thread in air tight container for moisture content determination.
- Repeat the test to at least 3 times and take the average of the results calculated to the nearest whole number.
- Note: Compare the diameter of thread at intervals with the rod. When the diameter reduces to 3 mm, note the surface of the thread for cracks.

Results:

Liquid Limit =

Plastic Limit=

Flow Index =

Plasticity Index =

ToughnessIndex=

Sl. No.	Description	Test1	Test2	Test3
1	Containernumber			
2	Wt.container+Lid,W1			
3	Wt.container+Lid+Wetsample,W2			
4	Wt.container+Lid+Dry sample,W3			
5	Wt.ofdrysample=W3–W1			
6	Wt.ofwaterinthesoil=W3–W2			
7	Watercontent(%) =[(W3 –W2)/(W3–W1)]*100			

CalculationsforPlasticLimit:

- Collectthepiecesofthecrumbledthreadinairtightcontainerformoisture content determination and record the result as the plastic limit.

  PlasticLimit(PL)=

  PlasticityIndex(IP)=(LL–PL)=

  Toughness Index = (I_P/ I_F)

Ex. No: 5 **Date:**

DeterminationofShrinkageLimitandDifferentialFreeSwellIndex AIM:

Todeterminetheshrinkagelimit,shrinkageratioandvolumetricshrinkageforthegiven soil

THEORY:

As the soil loses moisture, either in its natural environment, or by artificial means in laboratoryitchangesfromliquidstatetoplasticstate,fromplasticstatetosemisolidstate and then to solid state. Volume changes also occur with changes in water content. But there is particular limit at which any moisture change does not cause soil any volume change.

APPARATUSREQUIRED:

1. EvaporatingDish(Porcelain,about12 cmdiameterwithflatbottom).
2. Spatula
3. ShrinkageDish(Circular,porcelainornon-corrodingmetaldishhavingaflatbottom and 45mm in diameter and 15 mm in height internally).
4. StraightEdge(Steel,15cmin length).
5. Glass cup(50 to 55 mmin diameter and 25 mm in height, the top rimof whichis ground smooth and level).
6. Glassplates(Two,each75mmoneplateshallbeofplainglassandtheothershall have prongs).
7. Sieves(2mmand425micronISsieves).
8. Oventhermostaticallycontrolled.
9. Graduate Glass (having a capacity of 25 ml andgraduated to0.2 mland 100cc one mark flask).
10. Balance(Sensitiveto0.01gminimum).
11. Mercury(Clean,sufficienttofilltheglasscuptooverflowing)
12. Washbottlecontainingdistilledwater.

Procedure:

Preparationofsoil paste

- Take about 100 gm of soil sample from a thoroughly mixed portion of the material passing through 425micron I.S. sieve.
- Place about 30 gm the above soil sample in the evaporating dish and thoroughlymixed with distilled water and make a creamy paste.
- Usewatercontentsomewherearoundtheliquidlimit

Fillingtheshrinkagedish

- Coattheinsideoftheshrinkagedishwithathinlayerofvaselinetopreventthesoil sticking to the dish.
- Fillthedishinthreelayersbyplacingapproximately 1/3rdoftheamountofwetsoil with the help of spatula. Tap the dish gently on a firm base until the soil flows over the edges and no

apparent air bubbles exist. Repeat this process for 2nd and 3rd layers also till the dish is completely filled with the wet soil.

- Strike off the excess soil and make the top of the dish smooth. Wipe off all the soil adhering to the outside of the dish.
- Weighimmediately,thedishwithwetsoilandrecordtheweight.
- Air-dry the wet soil cake for 6 to 8hrs, until the colour of the pat turns from dark to light.Thenovendrythemtoconstantweightat1050Cto1100Csayabout12to16 hrs.
- Removethedrieddiskofthesoilfromoven.Coolitinadesiccator.Thenobtainthe weight of the dish with dry sample.
- Determinetheweightoftheemptydishandrecord.
- Determine the volume of shrinkage dish which is evidently equal to volume of the wet soil as follows.
- Place the shrinkage dish in an evaporating dish and fill the dish with mercury till it overflows slightly.
- Press it with plain glass plate firmly on its top to remove excess mercury. Pour the mercury from the shrinkage dish into a measuring jar and find the volume of the shrinkage dish directly. Record this volume as the volume of the wet soil pat.
- VolumeoftheDrySoilPat
- Determine the volume of dry soil pat by removing the pat from the shrinkage dish and immersing it in the glass cup full of mercury in the following manner.
- Placetheglasscupinalargeroneandfilltheglasscuptooverflowingwithmercury. Remove the excess mercury by covering the cup with glass plate with prongs and pressingit.Seethatnoairbubblesareentrapped.Wipeouttheoutsideoftheglass cuptoremovetheadheringmercury.Then,place itinanotherlargerdish,whichis, clean and empty carefully.
- Place the dry soil pat on the mercury. It floats submerge it with the pronged glass platewhichisagainmadeflushwithtopofthecup.Themercuryspillsoverintothe largerplate.Pourthemercurythatisdisplayedbythesoilpatintothemeasuringjar and find the volume of the soil pat directly.
- Caution:Donottouchthemercurywithgoldrings.

Results:

Shrinkagelimit =

Shrinkageratio =

Volumetricshrinkage =

OBSERVATION

WeightofContainer,gms	
Wt.ofwetsample+Container,gms	
Wt.ofdrysample+Container,gms	
Wt.of Water	
Wt.ofwetsoilpat	
Wt.ofdrysoilpat	
Watercontent, in%	
Wt.ofmercurycontainer,gms	
Wt.ofmercurydisplaced,gms	
Volumeofdisplacedmercury=Volume of dry soil pat, V_d cm^3	
Volumeofcontainer,Vcm^3	
ShrinkageLimit	
ShrinkageRatio	

ATTERBERG'SLimit:

1. WhatismeantbyLL?

   The water content at the boundary limit between the plastic state and the liquidstate is called Liquid limit

2. WhatismeantbyPL?

   Thewatercontentattheboundarylimitbetweenthe Semisolidstateandthe plastic state is called plastic limit

3. Whatis meantbySL?

   Thewatercontentattheboundarylimitbetweenthesolidstateandthesemisolid state is called shrinkage limit

4. What are the methods to find Liquid Limit?

   CasagrandeLiquidLimitTest,OnePointMethod

5. HowtofindShrinkage LimitinLab?

   It isfoundbyusing Mercury DisplacementMethod.Because, SL can't be findby directly.

6. Whatarethecharacteristicsof Degreeofsaturationatdifferentstates?

   DegreeofSaturationis0to100%atinSolidState.Afterthat,Degreeofsaturation is 100%. At LL, PL & SL, Degree of saturation is 100%

7. Howtofindtheconsolidationofclayinsoil

   ConsolidationofclayisfoundusingtheCcvalue,InitialVoidratio,Effective Vertical Stress over the soil

8. HowtoJudgethesoilbasedonA Line.

   If soil falls above A Line, it is Inorganic Clay and the Soil falls below A line, soil is Organic Clay.

9. WhatisthepurposeoffindingLL,Pl&SL?

   To classify the fine Grained Soil based on BIS classification. If LL<35%, Soil is Low Compressibility. If LL is between 35 to 50%, soil Medium Compressibility. If the LL > 50%, Soil is High Compressibility.

10. WhatismeantbyA Line?

    InconsistencyChart,toclassifythesoilALineisneeded.ALineequationis $I_p = 0.73 (LL – 20)$

Ex.No:6 **Date:**

DeterminationofFieldDensity
(Sand Replacement Method)

AIM:

To determine the field density of soil at a given location by sand replacement method.

THEORY:

In core cutter method the unit weight of soil obtained from direct measurement of weight and volume ofsoil obtained from field. Particularly forsandysoils the core cutter method is not possible. In such situations the sand replacement method is employed to determine the unit weight. In sand replacement method a small cylindrical pit is excavated and the weight of the soil excavated from the pit is measured. Sand, whose density is known, is filled into the pit. By measuring the weightofsandrequiredtofillthepitandknowingthedensityofsoil,volumeofthe pitiscalculated.Knowingtheweightofsoilexcavatedfromthepitandthevolume of pit the density of soil is calculated. Therefore in this experiment there are two stages (1) Calibration of sand density and (2) Measurement of soil density.

APPARATUS

1. Moisturecontent cups
2. Sandpouring Cylinder
3. Calibratingcan
4. Metaltraywithacentralhole
5. Drysand(Passingthrough600micronsieve)
6. Balance
7. Metaltray
8. Scrapertool
9. Glass plate

PROCEDURE

CALIBRATIONOFSANDDENSITY

- Measuretheinternaldimensionsdiameter(d)andheight(h)ofthecalibratingcanand compute its internal volume V.
- Fill the sand pouring cylinder (SPC) with sand with 1 cm top clearance to avoid any spillover during operation and find its weight (W1)

- Place the SPC on a glass plate, open the slit above the cone by operating the valve and allow the sand to run down. The sand will freely run down till it fills the conical portion. When there is no further downward movement of sand in the SPC, close the slit.
- FindtheweightoftheSPCalongwiththesandremainingafterfillingthecone(W2)
- Place the SPC concentrically on top of the calibrating can. Open the slit to allow the sandtorundownuntilthesandflowstopsbyitself.Thisoperationwillfillthecalibrating can and the conical portion of the SPC. Now close thes lit and find the weight of the SPC with the remaining sand(W3)

MEASUREMENTOFSOILDENSITY

- Cleanandleveltheground surfacewherethefielddensityistobedetermined.
- Placethetraywithacentralholeovertheportionofthesoiltobetested.
- Excavateapitintotheground,throughtheholeintheplate,approximately12cmdeep (Closetheheightofthecalibratingcan)Theholeinthetraywillguidethediameterof the pit to be made in the ground.
- Collecttheexcavatedsoilintothetrayandweighthesoil(W)
- Determinethemoisturecontentoftheexcavatedsoil.
- PlacetheSPC,withsandhavingthelatestweightofW3,overthepitsothatthebase of the cylinder covers the pit concentrically.
- Open the slit of the SPC and allow the sand to run into the pit freely, till there is nodownward movement of sand level in the SPC and then close the slit.
- FindtheweightoftheSPCwiththeremainingsandW4.

RESULT

1. **Dryunitweightofthesoil =**
2. **Wetunitweightofthesoil=**
3. **Voidratioofthesoil =**
4. **Porosityofthesoil=**
5. **Degreeofsaturation**

OBSERVATION–SANDREPLACEMENTMETHOD

Sl. No.	Description	Test1
	CALIBERATIONOFAPPARATUS	
1	Weightofsand + cylinderbeforepouring(W_1) (g)	
2	Meanweightofsandpouring cylinderwithremainingsandafterfillingincone(W_2)	
3	Volumeofcalibratingcontainer(V) cc	
4	Meanweightofsandpouring cylinderwithremainingsandafterfillinginconeand	
5	Weightofsandfillingcalibratingcontainers, W_a= (W_1–W_3–W_2) (g)	
6	CalibratedBulk densityof sand,ρ_S=(5/3)(g/cc)	
7	Weightof wet soilfrom thehole orWt. ofexcavated Soil(Ws or W_W) (g)	7
8	Weightofsand + cylinder afterpouring intheholeand cone(W_4) (g)	8
9	Weightof sand inthehole, Wh=(W1–W4 –W2) (g)	9
10	Bulkdensity of soil,ρ W/Wh)* ρS (g/cm^3)	10
11	Bulkunit weight of soil,γ 9.8 * ρ kN/m^3)	11
12	ContainerNumber	12
13	Weightof container +wet soil (g)	13
14	Weightof container +dry soil (g)	14
15	Weightofcontainer(g)	15
16	Weightofdrysoil(g)	16
17	Weightofwater(g)	17
18	Watercontent,W= (R17/R16)*100 (%)	18

Ex. No: 7 **Date:**

DeterminationofMoistureDensityRelationship (Proctor Compaction)

AIM:

TodetermineOptimumMoistureContentandMaximumdrydensityforasoilby Conductingstandardproctorcompactiontest

THEORY:

Compaction is the process of densification of soil mass, by reducing air voids under dynamic loading. On the other hand though consolidation is also a process of densification of soil mass but it is due to the expulsion of water under the action of continuously acting static load over a long period. The degree of compaction of a soil is measuredintermsofitsdrydensity.Thedegreeofcompactionmainlydependsuponits moisturecontentduringcompaction,compactionenergyandthetypeofsoil.Foragiven compaction energy, every soil attains the maximum dry density at a particular water contentwhichisknownasoptimummoisturecontent(OMC).Compactionofsoilincreases itsdrydensity,shearstrengthandbearingcapacity.Thecompactionofsoildecreasesits void ratio permeability and settlements. The results of this test are useful in studying the stabilityearthen structureslikeearthendams, embankmentsroadsandairfields.In such constructions the soils are compacted. The moisture content at which the soils are tobe compactedinthefieldisestimatedbythevalueofoptimummoisturecontentdetermined by the Proctor compaction test.

APPARATUSREQUIRED:

1. Proctormouldhavingacapacityof1000ccwithaninternaldiameterof100mmand a height of 127.3 mm. The mould shall have a detachable collar assembly and a detachable base plate.
2. Rammer:Amechanicaloperatedmetalrammerhavinga5.08cmdiameterfaceand a weightof2.5kg. Therammershallbeequipped witha suitable arrangementto control the height of drop to a free fall of 30 cm.
3. Sampleextruder.
4. Abalanceof15kgcapacity.
5. Sensitivebalance.
6. Straightedge.
7. Graduatedcylinder.

8. Mixingtoolssuchasmixingpan,spoon,towel,spatulaetc. and Moisturetins.

PROCEDURE:

- Takeabout3kgofairdried soil
- Sievethesoilthrough20mmsieve.Takethesoilthatpassesthroughthesievefor testing.
- Take2.5kgofthesoilandaddwatertotitobringitsmoisturecontenttoabout4% in coarse grained soils and 8% in case of fine grained soils.
- Clean, dryandgreasethemouldandbaseplate.Weighthemouldwithbaseplate. Fit the collar.
- Compactthewetsoilinthreeequallayersbytherammerwith25evenlydistributed blows in each layer.
- Removethecollarandtrimoffthesoilflushwiththetopofthemould.Inremoving the collar rotate it to break the bond between it and the soil before lifting it off the mould.
- Cleantheoutsideofthemouldandweighthemouldwithsoilandbaseplate.
- Removethesoilfromthemouldandobtainarepresentativesoilsamplefromthe bottom, middle and top for water content determination
- Repeattheaboveprocedurewith8, 12, 16and21%ofwatercontentsforcoarse grained soil and 14,18,22 and 26 % for fine grained soil samples approximately.
- The above moisture contents aregiven only for guidance. However, the moisture contents may be selected based on experience so that, the dry density of soil showstheincreaseinmoisturecontent. Eachtrialshouldbeperformedonafresh sample.

Results:

OptimumMoistureContent(OMC)% =

Maximumdrydensity(g/cc) =

OBSERVATION

Dia.ofthemould,D(cm)= Vol.ofthemould, V(cm^3)=

Ht.ofthemould,H(cm) = Wt.ofthemould, W1(g)=

Sl. No.	Description	Test1	Test2	Test3	Test4
(a)Density					
1	Weightofthemould+compactedsoil(W2) (g)				
2	Weightofmould(W1)(g)				
3	Weightofcompactedsoil,W(W2–W1)(g)				
4	Bulkdensity(g/cm^3)				
5	Drydensity(g/cm^3)				
6	Watercontent%,w				
	Zerovoidratio(Gsϒw)/(1+(wGs/100))				
	Voidratio,e=((Gsϒw)/(ϒd))-1				
(b)Watercontent					
	Containernumber				
7	Emptyweightofcontainer(g)				
8	Weightofcontainer+wetsoil(g)				
9	Weightofcontainer+drysoil(g)				
10	Weightofdrysoil(R8 –R7) (g)				
11	Weightofwetsoil(R9–R7) (g)				
12	Weightofwater(R8–R9)(g)				
13	Moisturecontent,W[(R12/R10)*100](%)				

FieldDensityTest

1. WhatismeantbyDensityofsoil?

   TheRatioofMassofthesoiltothevolumeofthesoiliscalledasdensityof soil.

2. WhatarethedifferentformsofDensityofsoil? Dry

   Density

   Wet / Bulk Density

   Saturated Density

   SubmergedDensity

3. WhatarethemethodstofindFieldDensityofSoil? Sand

   Replacement Method

   CoreCutterMethod

4. Whataretheimportancesoffindingfielddensity?

   Toconfirmtheachievementofcompactionduringsubgradepreparation.

5. WhatarethedifferentFieldMethodstocompactthesoil? Rollers,

   Tampers ,Vibrators ,Terra Probe method

6. WhataretheDisadvantagesofCoreCutterTest?

   While taking out the core cutter from the ground, the soil present at the bottomportion may get collapse and fall down

7. Whatarethedisadvantagesofsandreplacement test?

   Generally,itgivesgoodresults.Butifthecalibrationofcleansandgetserror,final finding also will be error

8. WhatistherangeofPermeabilityforCoursesand? More

   Than 10-3 mm/sec

9. How to classify the permeability of soil?

   High,Medium,Low,VeryLow&Impervious

10. WhatismeantbyPermeability?

    TheflowofwaterinsidethesoilporesiscalledasPermeability

Ex. No: 8 **Date:**

DeterminationofRelativeDensityofCohesionlessSoils (Demonstration)

AIM:

Todeterminetherelativedensityofcohesionless soil.

THEORY

Relativedensityisalsoknownasdensityindex.Itisdefinedastheratioofdifference between the void ratio of cohesion less soil in the loosest state and any given void ratiotothedifferencebetweenitsvoidratiosintheloosestandinthedensest states. The concept of density index gives a practically useful measure of compactness of such soils. The compactive characteristics of cohesion less soils and the related propertiesofsuchsoilsaredependentonfactorslikegrainsizedistributionandshape ofindividualparticles.Thecompactivecharacteristicsofcohesionlesssoilssandthe related properties of such soils are dependent on factors like grain size distribution andshapeofindividualparticles.Relativedensityisalsoeffectedbythesefactorsand servesasaparametertocorrelatepropertiesofsoils.Varioussoilpropertiessuchas penetration resistance, compressibility, compaction , friction angle , permeability and CBR has been found to have simple relationships with relative density.

APPARATUSREQUIRED

1. Vibratorytable:Asteeltablewithcushionedsteelvibratingdeckabout75x75cm. The vibrator should have a net weight of over 45 kg. The vibrator should have frequency of 3600 vibrations per minute, a vibrator amplitude variable between 0.05 and 0.65 mm under a115 kg load.
2. Moulds: Cylindrical metal density moulds of 3000cc 150mm dia and 169.77 mm high.
3. Oneguidesleeve:Withclampassemblyshouldbeprovidedwithlocknuts.
4. Surchargebaseplate:10mmthickwithhandleforeachmould.
5. Onedialgaugeholder
6. Dialgauge:Adialgaugewith50mmtraveland0.02mmleast count.
7. Pouringdevices: Consistingoffunnels12mmand25mmindiameterand150mm long with cylindricalspotsandlippedbrimsforattachingto 150mmand300mmhigh metal cans.
8. Mixingpans:Twomixingpans

`

PROCEDURE

The test procedure to determine the relative density of soil involves the measurementofdensityofsoilinitsloosestpossiblestate()anddensestpossible state ( ) .Knowing the specific gravity of soil solids (G) the void ratios of the soil in itsloosest(emax)anddenseststate(emin)arecomputed.Thedensityofsoilinthe field () (natural state) is used to compute void ratio (e) in the field. After obtaining the three void ratios the relative density is computed. For 4.75mm size particles 3000ccmouldisused.Mouldsarefirstcalibrated,Thenthedensitiesofthesoilare obtained.

CALIBRATIONOFMOULDS

Tocalibratethemouldshouldbefilledwithwaterandaglass plateshouldbeslide carefully over the top surface of the mould in such a manner as to ensure that the mouldiscompletelyfilledwithwater.Thevolumeofthemouldshouldbecalculated in cc by dividing the weight of water in the mould by the unit weight of water.

PREPARATIONOFSOILSAMPLE

Arepresentativesampleofsoilshouldbeselected.Theweightofsoilsampletobe taken depends upon the maximum size of particles in the soil .The soil sample should be dried in an oven at a temperature of 105ºc to 110ºc .The soil sample should be pulverized without breaking the individual soil particles and sieved through the required sieve.

PROCEDUREFORTHEDETERMINATIONOFMINIMUMDENSITY

1. Thepouringdeviceandmouldshouldbeselectedaccordingtothemaximumsize of particle. The mould should be weighed and weight recorded. Oven dry soil should be used.
2. Soil containing particles smaller than 10mm should be placed as loosely as possible in the mould by pouring the soil through the spout in a steady stream. The spoutshouldbeadjustedsothattheheightoffreefallofthesoilsalways25mm.While pouringthesoilthepouringdeviceshouldbemovedinaspiralmotionfromtheoutside towards the centre to form a soil layer of uniform thickness without segregation. The mouldshouldbefilledapproximately25 mmabovethetopandleveledwiththetopby making one continuous pass with steel straight edge. If all excess material is not removedanadditionalcontinuouspassshouldbemade.Greatcareshallbeexercised to avoid jarring during the entire pouring and trimming operation.
3. Themouldandthesoilshouldbeweighedandtheweight recorded.
4. Soil containing particles larger than 10mm should be placed by means of a large

scoopheldascloseaspossibletoandjustabovethesoilsurfacetocausethematerial tosliderattherthanfallintothepreviouslyplacedsoil.Ifnecessarylargeparticlesmay be held by hand to prevent them from rolling offs the scoop.

5. Themould shouldbefilled tooverflowingbutnotmore than25mmabovethe top. The surface of the soil should be leveled with the top of the mould using the steel straightedgeinsuchawaythatanyslightprojectionsofthelargerparticlesabovethe topofthemould shallapproximatelybalancethe large voids in thesurfacebelowthe top of the mould.
6. Themouldandthesoilshouldbeweighedandtheweightrecorded.

OBSERVATION:

Weigh of the mould =

Volumeofthemould =

Sl. No.	Description	Trial1	Trial 2	Trial 3
1	Weightofthemould,gms			
2	Weightofthesoil+mouldgms			
3	WeightofthesoilW gms			
4	CalibratedvolumeofmouldV$_c$			
5	Minimumdensity			

RESULT

Minimumdensity=

Ex. No: 9 **Date:**

DeterminationofPermeabilityofSoil
(Constant Head Method)

AIM:

Todeterminethecoefficientofpermeabilityofthesoilbyconductingconstanthead method.

THEORY

The property of the soil which permits water to percolate through its continuously connected voids is called its permeability. Water flowing through the soil exerts considerable seepage forces which has direct effect on the safety of hydraulic structures.Thequantityof waterescapingthrough andbeneathandearthendam depends on the permeability of the embankment and the foundation soil respectively. The rate of settlement of foundation depends on the permeability properties of the foundation soil.

APPARATUSREQUIRED

1. Permeabilityapparatuswithaccessories
2. Stop watch
3. Measuring jar

PROCEDURE–ConstantHeadMethod

1. Compact the soil into the mould at a given dry density and moisture content by a suitabledevice.Placethespecimencentrallyoverthebottomporousdiscandfilter paper.
2. Placeafilterpaper,porousstoneandwasherontopofthesoilsampleandfixthe top collar.
3. Connectthestandpipetotheinletofthetopplate.Fillthestandpipewithwater.
4. Connectthereservoirwithwatertotheoutletatthebottomofthemouldandallow the water to flow through and ensure complete saturation of the sample.
5. Open the air valve at the top and allow the water to flow out so that the air in the cylinder is removed.
6. When steady flow is reached, collect the water in a measuring flask for convenient time intervalsbykeepingtheheadconstant.Theconstantheadofflow is provided with the help of constant head reservoir
7. Repeat the for three more different time intervals.

RESULT:

Coefficientofpermeabilityofthegivensoilsampleby Constant Head Method =

OBSERVATIONS AND CALCULATIONS – Constant Head Method

Calculatethecoefficientofpermeabilityofsoilusingtheequation

$$K = QL/At$$

Where

K=Coefficientofpermeability

Q=Quantityofwatercollectedintimetsec(cc)

t = Time required (sec)

A=Crosssectionalareaofthesoilsample(sq.cm)

h = Constant hydraulic head (cm)

L=Lengthofsoilsample(cm)

DiaofSpecimen,D =

LengthofSpecimen=

Head =

Areaofspecimen=

Sl. No.	**Time,tsec**	**Quantityofdischarge,Q cm^3**	**$K_T$cm/sec**

Ex. No:10 **Date:**

DeterminationofPermeabilityofSoil (Variable Head Method)

AIM:

To determine the coefficient of permeability of the soil by conducting falling head method.

THEORY

The property of the soil which permits water to percolate through its continuously connected voids is called its permeability. Water flowing through the soil exerts considerable seepage forces which has direct effect on the safety of hydraulic structures.Thequantityof waterescapingthrough andbeneathandearthendam depends on the permeability of the embankment and the foundation soil respectively. The rate of settlement of foundation depends on the permeability properties of the foundation soil.

APPARATUSREQUIRED

1. Permeabilityapparatuswithaccessories
2. Stop watch
3. Measuring jar

PROCEDURE–FallingHeadMethod

1. Compact the soil into the mould at a given dry density and moisture content by a suitabledevice.Placethespecimencentrallyoverthebottomporousdiscandfilter paper.
2. Placeafilterpaper,porousstoneandwasherontopofthesoilsampleandfixthe top collar.
3. Connectthestandpipetotheinletofthetopplate.Fillthestandpipewithwater.
4. Connectthereservoirwithwatertotheoutletatthebottomofthemouldandallow the water to flow through and ensure complete saturation of the sample.
5. Open the air valve at the top and allow the water to flow out so that the air in the cylinder is removed.
6. Fixtheheighth$_1$andh$_2$onthepipefromthetopofwaterlevelinthe reservoir
7. Whenalltheairhasescaped,closetheairvalveandallowthewaterfromthepipe to flow through the soil and establish a steady flow.
8. Recordthetimerequiredforthewaterheadtofallfromh$_1$toh$_2$.
9. Changetheheighth$_1$andh$_2$andrecordthetimerequiredforthefallof head.

RESULT:

Coefficientofpermeabilityofthegivensoilsampleby Falling Head Method =

OBSERVATIONSANDCALCULATIONS–VariableHeadMethod

Calculatethecoefficientofpermeabilityofsoilusingtheequation.

$$K=2.303A*L/AtLog_{10}(h_1/h_2)$$

K=Coefficientofpermeability a=Areaofstandpipe(sq.cm)
t=Timerequiredfortheheadtofallfromh1toh2(sec)

A = Cross sectional area of the soil sample (sq.cm)

L=Lengthofsoilsample(cm)
h_1=Initialheadofwaterinthestandpipeabovethewaterlevelinthe reservoir (cm)
h_2 = final head of water in the stand pipe above the water level in the reservoir (cm)

1. Diameterofthestandpipe(cm)=
2. Crosssectionalareaofstandpipe(sq.cm)=
3. Lengthofsoilsample(cm)=
4. Areaofsoilsample(sq.cm)=

Sl. No.	**Time,tsec**	**Initialhead, $h_1$cm**	**Finalhead, $h_2$cm**	**$log_{10}h_1/h_2$**	**$K_T$cm/sec**

Co-efficientofPermeability:

1. WhatismeantbyPermeability?

   Theflowofwaterinsidethesoilporesiscalledas Permeability.

2. WhatarethemethodstofindPermeability? Direct

   Method

   ConstantHeadPermeabilityTestMethod Falling

   Head Permeability Test Method Pumping Out Test

   PumpingInTest

   Indirect Method

   FoundusingSoilParticleSize

3. WhichmethodissuitableforSandySoil?

   ForSandysoil,theConstantHeadpermeabilityTesttobeadopted

4. WhichmethodissuitableforClayeySoil?

   ForClayeysoil,theVariableHeadpermeabilityTesttobeadopted

5. WhatistherangeofPermeabilityforClay? Less

   Than 10^{-9}mm/sec.

6. WhatistherangeofPermeabilityforSilt?

   10^{-7}mm/sec to 10^{-9}mm/sec

7. WhatistherangeofPermeabilityforFineClay?

   10^{-5} mm/sec to 10^{-7}mm/sec

8. WhatistherangeofPermeabilityforCleanSand?

   10-^{3}mm/sec to 10^{-5}mm/sec

9. WhatistherangeofPermeabilityforCoursesand? More

   Than 10^{-3}mm/sec

10. How to classify the permeability of soil?

    High,Medium,Low,VeryLow&Impervious

Ex. No: 11 **Date:**

DeterminationofCoefficientofConsolidation

AIM

Todeterminethecoefficientofconsolidationofagivenclaysoil.

THEORY

When a load is applied on a saturated soil, the load will initially be transferred to the waterinporesofthesoil. Thisresultsindevelopmentofpressureinporewaterwhich results in the escape of water from voids and brings the soil particles together. The process of escape of water under applied load, leads to reduction in volume of voids and hence the volume of soil. The process of reduction of volume of voids due to expulsion of water under sustained static load is known as consolidation. The magnitude of consolidation depends on the amount of voids or void ratio of the soil. The rate of consolidation depends on the permeability properties of soil. The two important consolidation properties of soil are (i) co-efficient of consolidation (C_v) and (ii)Compression index(C_c).The coefficientof consolidation reflectsthe behaviourof soilwithrespecttotimeunderagivenloadintensity.Compressionindexexplainsthe behaviour of soils under increased loads.

APPARATUSREQUIRED

1. Consolidometerconsistingofspecimenring.
2. Guidering
3. Porousstones
4. Dialgauges
5. Stop watch

PROCEDURE

Preparationofspecimen

Sufficient thickness of the soil specimen is cut from undisturbed sample. The consolidation ring is gradually inserted into the sample. The consolidation ring is gradually inserted into the sample by pressing and carefully removing the material around it. The specimen shouldbe trimmed smoothandflushtothe endsof the ring. Anyvoidsinthespecimencausedduetoremovalofgravelorlimestonepiecesshould be filled back by pressing completely the loose soil in the voids. The ring should be wipedcleanandweighedagainwiththesoil.Placewetfilterpaperontopandbottom faces of the sample and two porous stones covering it should be in place. Place this whole assembly in the loading frame. Over the porous stone a perforated plate with loading ball is placed.

The sample is put for saturation both from top and bottom. After allowing time for saturation the load is applied through the loading frame. The settlement in sample is measured using a dial gauge. The stepwise procedure for observing reading is as follows:

1. Applytherequiredloadintensity(stress)atwhichCvistobedetermined.
2. Astheloadingisapplied,thestopwatchshouldbe started.
3. Takethereadingsofthedialgaugeatdifferenttimeintervalfromthetimeof loading and record them in the table.

OBSERVATIONANDCALCULATIONS

(a) Squarerootmethod

1. Recordthedialgaugereadingsatdifferenttimeintervalfromthepointofloadingin Table.
2. Plotagraphbetween√tonXaxisanddialgaugereadingonYaxis. Wheretistime in minutes.
3. The curvedrawn reflects three components ofsettlement (i)Immediate settlement orelasticcompression.Thiswillbereflectedintheformofsteepsettlementsinasmall time interval and a nearly vertical line at the initial portion of the curve represents it. This is followed by (ii) Primary consolidation curve, which will be nearly a straight line with a reduced sloe. The majority of consolidation will be in this zone. After primary consolidation(iii)Secondaryconsolidationtakesplacethatismarkedbyacurvenearly parallel to time axis.
4. Draw a straight linethrough a primary consolidation zone. Identification of primary consolidationzonedependsonexperienceandeyejudgement.Extentthestraightline to meet Y-axis at O_c. O_c is the corrected zero.
5. Draw another straight line through Oc, with a slope equal to 1.15 times the slope of the earlier straight line.
6. The Straight line so drawn (with 1.15 times the slope of primary consolidation line will intersect the originally plotted curve at a point. The X coordinate of this point will give $\sqrt{t_{90}}$. Where t_{90} is the time required for 90% consolidation (in minutes)
7. Thecoefficientofconsolidationiscalculatedasfollows

$$Cv=0.848H_2/(t_{90}\times 60)cm^2/sec.$$

WhereH=lengthofdrainagepath(cm)

H=halfthicknessofsoilsamplefordoubledrainageand

H=thicknessofsoilsample for single drainage

t_{90}=timerequiredfor90%consolidationinminutes.

(b) Log-method

1. The compression dial readings should be plotted against the log of time and a smooth curve drawn to pass through the points.
2. The two straight portions of the curve should be extended to intersect at a point, the ordinate of which gives d_{100} corresponding to 100% primary compression.
3. The corrected zero point ds shall be located by the laying of above point in the neighbourhood of 0.1 minute a distance equal to the vertical distance between this point and one at a time which is four times this value
4. The50%compressionpointwhichishalfwaybetweenthecorrectedzeropointand the 100% compression point, shall be marked on the curve and the readings on the time axis corresponding to this point t_{50}, time to 50% primary compression, shall be noted. The readings on the dial gauge reading axis, corresponding to 100% compression gives d100.
5. Coefficientofconsolidationiscalculatedasfollows

$$C_v=0.197H_2/t_{50}.$$

RESULT

CoefficientofConsolidationofthegivensoilsampleCv=

TABULATION

Dimensions of sample: Diameter = Thickness=

Unit weight of soil =

Elapsed time Inminutes,t	√t	Dialgauge reading
0		
0.25		
2.25		
4.00		
6.25		
9.00		
12.25		
16.00		
20.25		
25.00		
36.00		
49.00		
64.00		
81.00		
100.00		
121.00		
144.00		
169.00		
225.00		
256.00		

Ex. No: 12 Date:

Directsheartestincohesion-lesssoil

AIM:

Todeterminetheshearingstrengthofthesoilusingthedirectshearapparatus.

THEORY:

Shearstrengthofa soil is its maximum resistanceto shearing stresses. Itis equal to the shear stress at failure on the failure plane. Shear strength is composed of (i) internal frictions,whichistheresistanceduetothefrictionbetweentheindividualparticlesattheir contact points and inter locking of particles. (ii) cohesion which is the resistance due to interparticleforceswhichtendtoholdtheparticlestogetherinasoilmass.Coulombhas represented the shear strength of the soil by the equation:

APPARATUSREQUIRED:

1) Directshearbox apparatus
2) Loadingframe(motorattached).
3) Dialgauge.
4) Provingring.
5) Tamper.
6) Straightedge.
7) Balancetoweighupto200mg.
8) Aluminumcontainer.
9) Spatula.

PROCEDURE:

- Checktheinnerdimensionofthesoilcontainer.
- Putthepartsofthesoilcontainertogether.
- Calculatethevolumeofthecontainer.Weighthe container.
- Place the soilin smooth layers(approximately 10 mm thick). If a dense sample is desired tamp the soil.
- Weighthesoilcontainer,thedifferenceofthesetwoistheweightofthesoil. Calculate the density of the soil.
- Makethesurfaceofthesoilplane.

- Puttheuppergratingonstoneandloadingblockontopofsoil.
- Measurethethicknessofsoil specimen.
- Applythedesirednormalload.
- Removetheshearpin.
- Attachthedialgaugewhichmeasuresthechangeofvolume.
- Recordtheinitialreadingofthedialgaugeandcalibrationvalues.
- Beforeproceedingtotestcheckalladjustmentstoseethatthereisnoconnection between two parts except sand/soil.
- Startthemotor.Takethereadingoftheshearforceandrecordthe reading.
- Takevolumechangereadingstillfailure.
- Add5kgnormalstress0.5kg/cm^{2}andcontinuetheexperimenttill failure.
- Recordcarefullyallthereadings.Setthedialgaugeszero,beforestartingthe experiment.

Table:ObservationforDirectSheartest(Table1:Normalstress0.5kg/cm^2)

Leastcountofthedial : Provingringconstant :

Horizontal Gauge reading (1)	Vertical dial gauge reading (2)	Proving ring reading (3)	Hor. Dial gauge reading Initial reading div. Gauge (4)	Shear deformation col. (4) X Least countofdial (5)	Vertical gauge reading Initial reading (6)	Vertical deformation = div. In col. (6) XL.Cof dial gauge (7)	Proving reading Initial reading (8)	Shear stress =div.Col. (8) X Proving ringconstant area of the specimen (kg/cm^2) (9)
0								
25								
50								
75								
100								
125								
150								
175								
200								
250								
300								
400								
500								
600								
700								
800								
900								

Table:ObservationforDirectSheartest(Table1:Normalstress1kg/cm^2)

Leastcountofthedial : Provingringconstant :

Horizontal Gauge reading (1)	Vertical dial gauge reading (2)	Proving ring reading (3)	Hor. Dial gauge reading Initial reading div. Gauge (4)	Shear deformation col. (4) XLeast countof dial (5)	Vertical gauge reading Initial reading (6)	Vertical deformation = div. In col. (6) XL.Cof dial gauge (7)	Proving reading Initial reading (8)	Shear stress =div.Col. (8)X Proving ringconstant area of the specimen (kg/cm^2) (9)
0								
25								
50								
75								
100								
125								
150								
175								
200								
250								
300								
400								
500								
600								
700								
800								
900								

Table:ObservationforDirectSheartest(Table1:Normalstress1.5kg/cm^2)

Leastcountofthedial : Provingringconstant :

Horizontal Gauge reading (1)	Vertical dial gauge reading (2)	Proving ring reading (3)	Hor. Dial gauge reading Initial reading div. Gauge (4)	Shear deformation col. (4) X Least countof dial (5)	Vertical gauge reading Initial reading (6)	Vertical deformation = div. In col. (6) X L.Cof dial gauge (7)	Proving reading Initial reading (8)	Shear stress =div.Col. (8)X Proving ringconstant area of the specimen (kg/cm^2) (9)
0								
25								
50								
75								
100								
125								
150								
175								
200								
250								
300								
400								
500								
600								
700								
800								
900								

Calculations:

SampleSize=

Area of sample, Ao =

Volumeofsample,V=

Weight of sample, w =

Density of sample =

Sl. No.	Provingring reading		Shear Force, P_n, kg	Applied load, kg	Normal Force,p_v	Normal stress	Shear stress, t= p_n/ a
	InitialDiv.	Final Div.					
1							
2							
3							

RESULT

Theshearstrengthparametersofthegivensoilsample,

τ=

Ex. No:13 **Date:**

DeterminationofUnconfinedCompressioninCohesiveSoil

AIM

Todeterminetheshearingstrengthofthecohesivesoil.

THEORY:

The unconfined compression test is a special case of tri axial compression test in which $\sigma_2,\sigma_3=0$.Thecellpressureinthetriaxialcellisalsocalledtheconfiningpressure.Due to the absence of such a confining pressure, the uniaxial test is called the unconfined compression test. The cylindrical specimen of soil is subjected to major principal stress σ1 till the specimen fails due to shearing along a critical plane of failure.

APPARATUSREQUIRED:

1) Loadingframeofcapacityof2t,withconstantrateofmovement.
2) Provingring.
3) Soil trimmer.
4) Frictionlessendplatesof75mmdiameter(Perspexplatewithsilicongrease coating).
5) Evaporatingdish(Aluminumcontainer).
6) Soilsampleof75mm length.
7) Dialgauge(0.01mmaccuracy).
8) Balanceofcapacity200gandsensitivitytoweigh0.01g.
9) Oven,thermostaticallycontrolledwithinteriorofnoncorrodingmaterialtomaintain the temperature at the desired level. What is the range of the temperature used for drying the soil.
10) Sampleextractorandsplit sampler.
11) Dialgauge(sensitivity0.01mm).
12) Verniercaliperstofindoutthediameterandlengthofthe specimen.

PROCEDURE:

In this test, a cylinder of soil without lateral support is tested to failure in simple compression,ataconstantrateofstrain.Thecompressiveloadperunitarearequiredto fail the specimen as called Unconfined compressive strength of the soil.

Preparationofspecimenfortesting

A. Undisturbedspecimen

- Notedownthesamplenumber,boreholenumberandthedepthatwhichthe sample was taken.
- Removetheprotectivecover(paraffinwax)fromthesamplingtube.
- Placethesamplingtubeextractorandpushtheplungertillasmalllengthofsample moves out.

- Trimtheprojectedsampleusingawiresaw.
- Againpushtheplungeroftheextractortilla75mmlongsamplecomesout.
- Cutoutthissamplecarefullyandholditonthesplitsamplersothatitdoesnotfall.
- Takeabout10to15gofsoilfromthetubeforwatercontent determination.
- Notethecontainernumberandtakethenetweightofthesampleandthe container.
- Measure the diameter at the top, middle, and the bottom of the sample and find the average and record the same.

B. Mouldedsample

- For the desired water content and the dry density, calculate the weight of the dry soil Ws required for preparing a specimen of 3.8 cm diameter and 7.5 cm long.
- AddrequiredquantityofwaterW$_w$tothissoil.
- $W_w = W_S * W/100$gm
- Mixthesoilthoroughlywithwater.
- Place the wet soil in a tight thick polythene bag in a humidity chamber and place thesoilinaconstantvolumemould,havinganinternalheightof7.5cmandinternal diameter of 3.8 cm.
- After 24 hours take the soil from the humidity chamber and place the soil in a constant volume mould, having an internalheight of 7.5 cm and internaldiameter of 3.8 cm.
- Placethelubricatedmouldedwithplungersinpositionintheloadframe.
- Applythecompressiveloadtillthespecimeniscompactedtoaheightof7.5cm.
- Ejectthespecimenfromtheconstantvolumemould.
- Recordthecorrectheight,weightanddiameterofthe specimen.

TESTPROCEDURE

- Taketwofrictionlessbearingplatesof75mmdiameter.
- Placethespecimenonthebaseplateoftheloadframe(sandwichedbetweenthe end plates).
- Placeahardenedsteelballonthebearingplate.
- Adjustthecenterlineofthespecimensuchthattheprovingringandthesteelball are in the same line.
- Fixadialgaugetomeasuretheverticalcompressionofthe specimen.
- Adjustthegearpositionontheloadframetogivesuitablevertical displacement.
- Startapplyingtheloadandrecordthereadingsoftheprovingringdialand compression dial for every 5 mm compression.
- Continueloadingtillfailureiscomplete.
- Drawthesketchofthefailurepatterninthe specimen.

RESULTS:

Unconfinedcompressionstrengthofthesoil,q_u=

Shear strength of the soil, q_u / 2 =

Sensitivity=($q_u$forundisturbedsample)/($q_u$forremouldedsample)=

Table:ObservationforUCCTest

Specificgravity,G : Bulkdensity(Initial):

Initial water content : Degree of saturation :

Initial diameter of the specimen (D_O) cm :

InitialLengthofthespecimen(L_O)mm :

Initialareaofcrosssection(A_O)cm^2 :

Sl. No.	**Elapsed time (min)**	**Axialload,P (kg)**	**Compression dial reading, ∆L(mm)**	**Strain,ϵ (%)**	**Area,A (cm^2)**	**Compressive stress, σ (kg/cm^2)**
1						
2						
3						
4						

Calculations:

Theaxialstrain,ϵisdeterminedby,ϵ∆/ O)*100

Theaveragec/sarea,Aatparticularstrainisdeterminedby,A=(AO/[1-ϵ])

Plotismadebetweenσandϵ.Themaximumstressfromthiscurvegivesthevalues of the unconfined compressive strength qu. Where no maximum occurs, the unconfined compressive strength is taken as the stress at 20% axial strain.

Ex. No:14 **Date:**

LaboratoryVaneShearTestinCohesiveSoil

AIM

Todeterminetheundrainedshearstrengthofthecohesivesoilusingvane shear.

THEORY:

Vane shear test is a quick test, used either in the laboratory or in the field, to determine theundrainedshearstrengthofcohesivesoil.Thevanesheartesterconsistsoffourthin steel plates, called vanes, welded orthogonally to a steel rod. A torque measuring arrangement, such as a calibrated torsion spring, is attached to the rod which is rotated byawormgearandwormwheelarrangement,afterpushingthevanesgentlyintothesoil, the torque rod is rotated at a uniform speed (usually at 10 per minute). The rotation of thevaneshearsthesoilalongacylindricalsurface.Therotationofthespringindegrees is indicated by a pointer moving on a graduated dial attached to the worm wheel shaft. The torque T is the calculated by multiplying the dial reading with the spring constant.

APPARATUSREQUIRED:

1) Vaneshearapparatus.
2) Specimen.
3) Specimencontainer.
4) Callipers.

PROCEDURE:

- Prepare two or three specimens of the soil sample of dimensions of at least 37.5 mm diameter and 75 mm length in specimen.(L/D ratio 2 or 3).
- Mount the specimen container with the specimen on the base of the vane shear apparatus. If the specimen container is closed at one end, it should be provided with a hole of about 1 mm diameter at the bottom.
- Gently lower the shear vanes into the specimen to their full length without disturbing the soil specimen.
- Thetopofthevanesshouldbeatleast10mmbelowthetopofthespecimen.Note the readings of the angle of twist.
- Rotate the vanes at a uniform rate say 0.10 /s by suitable operating the torque application handle until the specimen fails.
- Notethefinalreadingoftheangleoftwist.
- Findthevalueofbladeheightandwidthincm.

RESULT:

UndrainedShearstrengthofthegivencohesivesoilsampleis

OBSERVATION

Sl. No.	Initial reading (Deg)	Final reading (Deg)	Difference (Deg)	Spring constant (kg – cm)	T = (Spring constant /180) X Difference (kg–cm)	Shear strength ,τ_f (kg–cm^2)
1						
2						
3						
4						
5						

CALCULATIONS:

Theshearstrengthofthesoilsampleusingvaneapparatusisgivenbyformula,

Shear strength, $S = T / \pi(D^2 H / 2 + D^3)$

Where S = shear strength of soil in kg/cm2

T = torque in cm kg

D = overall diameter of vane in cm

T = spring constant / 180o x difference in degrees.

Ex. No:14 **Date:**

Tri-axialcompressiontestincohesion-lesssoil
(DemonstrationOnly)

AIM:

Todeterminetheundrainedshearstrengthofthecohesivesoilusingvaneshear.

THEORY:

The strength test more commonly used in a research laboratory today is the triaxial compression test, first introduced in the U.S.A. by A. Casagrande and Karl Terzaghi in 1936–37.Thesoilspecimen,cylindricalinshape,issubjectedtodirectstressesacting in three mututally perpendicular directions. In the common solid cylindrical specimen test, the major principal stress σ_1 is applied in the vertical direction, and the other two principalstresses$\sigma_2$and$\sigma_3$areappliedinthehorizontaldirectionbythefluid pressure round the specimen.

APPARATUSREQUIRED:

KNOWLEDGEOFEQUIPMENT

1) A constant rate of strain compression machine of which the following is a brief description of one is in common use.

a) A loading frame in which the load is applied by a yoke acting through an elastic dynamometer, more commonly called a proving ring which used to measure the load. The frame isoperatedata constantratebyageared screwjack.Itis preferableforthe machine to be motor driven, by a small electric motor.

b) Ahydraulicpressureapparatusincludinganaircompressorandwaterreservoirin whichairunderpressureactingonthewaterraisesittotherequiredpressure,together with the necessary control valves and pressure dials.

2) Atriaxialcelltotake3.8cmdiaand7.6cmlongsamples,inwhichthesamplecan be subjected to an all-round hydrostatic pressure, together with a vertical compression load acting through a piston. The vertical load from the piston acts on a pressure cap. Thecellisusuallydesignedwithanonferrousmetaltopandbaseconnectedbytension rods and with walls formed of perspex.

Apparatusforpreparationofthesample:

1) 3.8cm(1.5inch)internaldiameter12.5cm(5inches)longsampletubes.

2) Rubberring.

3) An open ended cylindrical section former, 3.8 cm inside dia, fitted with a small rubber tube in its side.

4) Stop clock.

5) Moisturecontenttestapparatus.

6) Abalanceof250gmcapacityandaccurateto0.01gm.

PROCEDURE:

- The sample is placed in the compression machine and a pressureplate isplaced on the top. Care must be taken to prevent any part of the machine or cell from jogging the sample while it is being setup, for example, by knocking against this bottom of the loadingpiston.Theprobablestrengthofthesampleisestimatedandasuitableproving ring selected and fitted to the machine.
- The cellmust be properly set up and uniformly clamped down to prevent leakage of pressure during the test, making sure first that the sample is properly sealed with its end caps and rings (rubber) in position and that the sealing rings for the cell are also correctly placed.
- When the sample is setup water is admitted and the cell is fitted under water escapesfromthebeedvalve,atthetop,whichisclosed.Ifthesampleistobetestedat zero lateral pressure water is not required.
- Theairpressureinthereservoiristhenincreasedtoraisethehydrostaticpressure in the required amount. The pressure gauge must be watched during the test and any necessary adjustments must be made to keep the pressure constant.
- The handle wheel of the screw jack is rotated until the underside of the hemispherical seating of the proving ring, through which the loading is applied, just touches the cell piston.
- Thepistonisthenremoveddownbyhandleuntilitisjustintouchwiththepressure plateonthetopofthesample,andtheprovingringseatingisagainbroughtintocontact for the begging of the test

RESULT:

Shearparameterofthegivensoilsampleis

TABLE:OBSERVATIONANDRECORDING

Themachineissetinmotion(orifhandoperatedthehandwheelisturnedataconstant rate) to give a rate of strain 2% perminute. The strain dial gauge reading is then taken and the corresponding proving ring reading is taken the corresponding proving ring chart. The load applied is known. The experiment is stopped at the strain dial gauge reading for 15% length of the sample or 15% strain.

Soilspecimenmeasurement:

Height: Area:

Volume: Diameter:

Initialmass: Initialwatercontent:

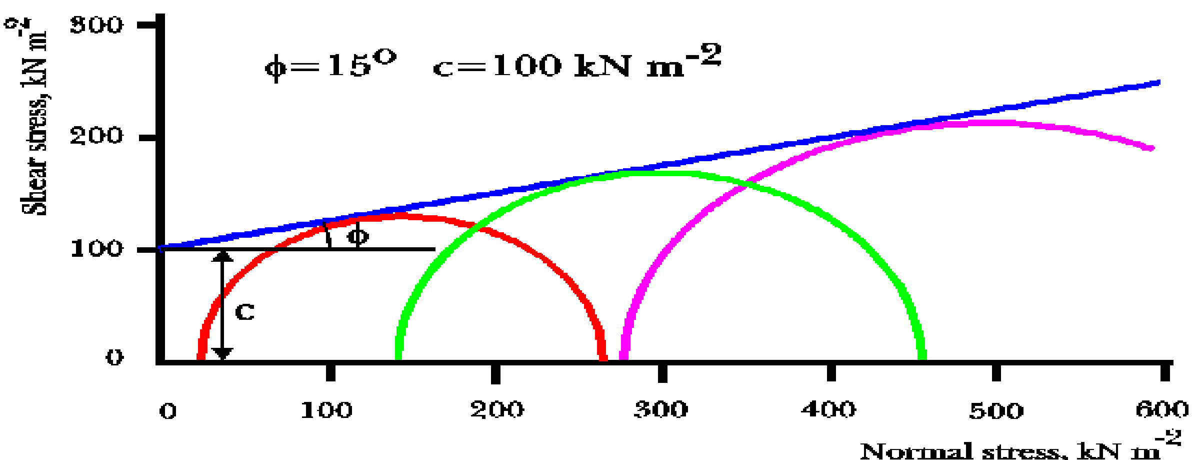
Finalmass: Finalwatercontent:

Cellpressureσ_3 kg/cm^2:

Load gauge reading 1	Strain 2	Proving ring reading 3	Loadon sample (kg) 4	Corrected area (cm^2) 5	Vertical stressσ_1) (R4/R5) 6	Deviator stress σ_d) (R6 – σ_3) 7

CALCULATIONS:

The shear parameters are obtained from a plot of Mohr circles for which purpose peak valueofprincipalstressdifferenceσ1–σ3orprincipalstress-ratioσ1/σ3ortheultimate value as desired may be used.



Results of triaxial tests

Ex. No:15 **Date:**

CaliforniaBearingRatioTest

AIM

TodeterminetheCaliforniabearingratiobyconductingaloadpenetrationtestinthe laboratory.

THEORY:

Thismethodwasoriginallydevisedby O.J. Porter,theoftheCaliforniaState Highway Department, but it has since been developed and modified by other authorities in U.S.A.,notablytheU.S.CorpsofEngineers.Themethodcombinesaloadpenetration test perfomedin the laboratoryorin-situ withtheempirical design charts todetermine thethicknessofpavementandofitsconstituentlayers.Thisisprobablythemostwidely used method for the design of flexible pavement. The thickness of the different elementscomprisingapavementisdeterminebyCBRvalues.TheCBRtestisasmall scalepenetrationtestinwhichacylindricalplungerof3in2c/sareaispenetratedinto asoilmassattherateof0.05in.perminute(1.25mm/min). TheCBRisdefinedasthe ratio of the test load to the standard load, expressed as percentage, for a given penetration of the plunger, CBR = (Test load/Standard load)*100

The test may be performed on undisturbed specimens and on remoulded specimens which may be compacted either statically or dynamically.

APPARATUSREQUIRED:

1) Cylindrical mould with inside dia 150 mm and height 175 mm, provided with a detachable extension collar 50 mm height and a detachable perforated base plate 10 mm thick.
2) Spacerdisc148mmindiaand47.7mminheightalongwith handle.
3) Metal rammers. Weight 2.6 kg with a drop of 310 mm (or) weight 4.89 kg a drop 450 mm.
4) Weights. One annular metal weight and several slotted weights weighing 2.5 kg each, 147 mm in dia, with a central hole 53 mm in diameter.
5) Loadingmachine.Withacapacityofatleast5000kgandequippedwithamovable head or base that travels at an uniform rate of 1.25 mm/min. Complete with Load indicating device.
6) Metalpenetrationpiston50mmdiaandminimumof100mminlength.
7) Twodialgaugesreadingto0.01 mm.
8) Sieves.4.75mmand20mmI.S.Sieves.
9) Miscellaneousapparatus,suchasamixing bowl,straightedge,scalessoakingor pan, drying oven, filter paper and containers.

PROCEDURE:

PREPARATIONOFTEST SPECIMEN

Undisturbedspecimen

Attachthe cutting edge to themould and push itgentlyinto theground. Remove the soil fromtheoutsideofthemould which ispushed in. When themouldis fullofsoil, remove it from weighing the soil with the mould or by any field method near the spot.

DeterminethedensityRemouldedspecimen

Preparethe remoulded specimenatProctor’s maximumdrydensity oranyotherdensity at which C.B.R is required. Maintain the specimen at optimum moisture content or the field moisture as required. The material usedshouldpass 20 mm I.S. sieve but it should be retained on 4.75mm I.S. sieve. Prepare the specimen eitherbydynamic compaction or by static compaction.

DynamicCompaction

- Takeabout4.5to5.5kgofsoilandmixthoroughlywiththerequiredwater.
- Fix the extension collar and the base plate to the mould. Insert the spacer disc over the base. Place the filter paper on the top of the spacer disc.
- Compact the mix soil in the mould using either light compaction or heavy compaction. For light compaction, compact the soil in 3 equal layers, each layer being given 55 blows by the 2.6 kg rammer.
- Forheavycompactioncompactthesoilin5layers,56blowstoeachlayerby the 4.89kg rammer.
- Removethecollarandtrimoffsoil.
- Turnthemouldupsidedownandremovethebaseplateandthedisplacerdisc.
- Weigh the mould with compacted soil and determine the bulk density and dry density.
- Put filter paper on the top of the compacted soil (collar side) and clamp the perforated base plate on to it.

Staticcompaction

- Calculatetheweightofthewetsoilattherequiredwatercontenttogivethedesired density when occupying the standard specimen volume in the mould from the expression.
- W =desireddrydensity* (1+w)* V
- WhereW =Weightofthewetsoilw=desiredwater content
- V =volumeofthe specimeninthemould=2250 cm3(asperthemouldavailable in laboratory)
- TaketheweightW(calculatedasabove)ofthemixsoilandplaceitinthemould.
- Placeafilterpaperandthedisplacerdisconthetopofsoil.
- Keep the mouldassembly in static loading frame and compact by pressing thedisplacer disc till the level of disc reaches the top of the mould.
- Keeptheloadforsometimeandthenreleasetheload.Removethedisplacerdisc.
- Thetestmaybeconductedforbothsoakedaswellasunsoaked conditions.

- Ifthesampleistobesoaked,inbothcasesofcompaction,putafilterpaperonthe topofthesoilandplacetheadjustablestemandperforatedplateonthetopoffilter paper.
- Put annular weights to produce a surcharge equal to weight of base material and pavement expected in actual construction. Each 2.5 kg weight is equivalent to 7 cm construction. A minimum of two weights should be put.
- Immerse the mould assembly and weights in a tank of water and soak it for 96 hours. Remove the mould from tank.
- Notetheconsolidationofthespecimen
- ProcedureforPenetrationTest
- Place the mould assembly with the surcharge weights on the penetration test machine.
- Seatthepenetrationpistonatthecenterofthespecimenwiththesmallestpossible load,butinnocaseinexcessof4kgsothatfullcontactofthepistononthesample is established.
- Set the stress and strain dial gauge to read zero. Apply the load on the piston so that the penetration rate is about 1.25 mm/min.
- Record the load readings at penetrations of 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 7.5, 10 and 12.5 mm. Note the maximum load and corresponding penetration if it occurs for a penetration less than 12.5 mm.
- Detach the mould from the loading equipment. Take about 20 to 50g of soil from the top 3 cm layer and determine the moisture content.

RESULT:

C.B.R.ofspecimenat2.5 mmpenetration=

C.B.R.ofspecimenat5.0 mmpenetration=

Observationand Recording

1. **Compactioncharacteristics:**

   (a) Dynamiccompaction:

   Optimumwatercontent(%):
   Weightofmould+compactedspecimen(g): Weight of empty mould (g):
   Weight of compacted specimen (g) :
   Volume of specimen (cm^3):
   Bulkdensity(g/cc):
   Drydensity (g/cc) :

   (b) Staticcompaction:

   Drydensity (g/cc) :
   Mouldingwatercontent(%):
   Wetweightofcompactedspecimen,W(g):

2. **Penetrationtest:**

   Surchargeweightused(g):
   Watercontentafter penetrationtest:

Penetrationdial		**Load dial**		**Correctedload (kg)**
Readings	Penetration(mm)	Readings	Load (kg)	
	0			
	0.5			
	1.0			
	1.5			
	2.0			
	2.5			
	3.0			
	4.0			
	5.0			
	7.5			
	10.0			
	12.5			

CALCULATIONS:

1. Expansionratio:

Theexpansionratiomaybecalculatedas follows,

Expansion ratio = $\{(d_f - d_i)/h\} * 100$

d_f = final dial gauge reading (mm)

d_i = initial gaugereading (mm)

h=initialheightofspecimen(mm)

2. Loadpenetration:

Plottheloadpenetratingcurve.Iftheinitialportionofthecurveisconcaveupwards,apply correction by drawing a tangent to the curve at the point of greatest slope and shift the origin. Find and record the correct load reading corresponding to each penetration.

CorrespondingtothepenetrationvalueatwhichtheC.B.R.isdesired,correctloadvalues are found from the curve and C.B.R. is calculated as follows;

C.B.R.=$(P_T/P_S)*100$

Where,

P_T = Corrected test load corresponding to the chosen penetration from the load penetration curve.

P_S=Standardloadforthesamepenetrationtakenfromthetable below.

Penetrationofplunger(mm)	**Standardload(kg)**
2.5	1370
5.0	2055
7.5	2630
10.0	3180
12.5	3600

TheC.B.R.valuesareusuallycalculatedforpenetrationof2.5mmand5mm.Generally, the C.B.R. value at 2.5 mm will be greater that at 5 mm and in such a case/the former shallbetakenasC.B.R.fordesignpurpose.IfC.B.R.for5mmexceedsthatfor2.5mm, thetestshouldbe repeated. If identical resultsfollow,the C.B.R. correspondingto5mm penetration should be taken for design.

EngineeringPropertiesofSoil

1. WhatismeantUnconfinedinUCCTest?

   TherewillnoConfiningPressuregiventomakethesoiltofail.MinorPrincipal Stress is Zero.

2. WhatarethecalledShearstrengthparameters? Cohesion

   AngleofInternal Friction

3. Howtoclassifythesoilbasedonshearstrengthparameters? Purely

   Cohesive soil

   Cohesive soil

   CohesionlessSoil

4. Whatarethetestsavailabletofindshearstrengthparameters? Direct Shear

   Test

   Triaxial Compression Test

   UnconfinedCompressionTest Vane

   shear Test.

5. WhatarethedifferentDrainageConditiontobeconsiderinTriaxialTest? CD Test

   (consolideted drained Test)

   CU Test (consolideted Undrained Test)

   UUTest(UnconsolidetedUndrainedTest)

6. WhataretheadvantagesofUCCTest?

   Thistestismostapplicableforclayeysoil.Itwillgiveaccurateresultshearstrength

7. WhatismeantbyUnconfinedcohesion?

   ItisrepresentedbyCu.HalfoftheUnconfinedCompressionStrengthQuiscalled as Unconfined Cohesion

8. WhatisthedisadvantagesofUCStest?

   Soilmustbefreefromfissuresandthereshouldnotpresenceofsilt content

9. WhatismeantbyAngleoffailureplane?

   Angleoffailureplane(α)=45+Ø/2.Theanglemadebyfailureplanedependson angle of internal friction Ø.

10. WhatismeantbyPrincipalPlaneandprincipal stress?

    TheplaneatwhichshearstressisZeroiscalledasPrincipalPlaneandthestress acts on the principal plane is called as principal stress

11. WhatismeantbyDilation?

    Dilation Occurs in Dense sand, there will be volume change in soil under shear. Thephenomenonatwhichthevolumeinitiallydecreasesandthenincreasesafter the certain strain for dense soil is called Dilation.

12. What are the advantages of Direct Shear Test?

    TheTestisSimpleandConvenientforsandysoil

13. WhatarethedisadvantagesofTriaxialCompressionTest?

    TheTestisElabrate,TimeConsumingandSkilledpersontobetakecare.

14. HowtoarriveAngleofinternalfrictionfromtest?

    TheobservedvalueofShearloadforappliedNormalloadfordifferenttrialisdrawn in Graph. The angle ofthe line connecting allfailure pointsgives angle of internal friction.

15. WhatistheadvantagesofDirectSheartest?

    This test is suitable for all types of soil. Can measure the pore water pressure at any time. It gives most accurate results

16. WhatisthedisadvantagesofDirectSheartest?

    Failure plane is predefined as Horizontal. It will be suitable only for cohesionless soil

17. WhatismeantbyAngleoffailureplane? Angle

    of failure plane (α) = 45 + Ø/2.

    TheanglemadebyfailureplanedependsonangleofinternalfrictionØ.

18. WhatismeantbyPrincipalPlaneandprincipal stress?

    TheplaneatwhichshearstressisZeroiscalledasPrincipalPlaneandthestress acts on the principal plane is called as principal stress.

19. Whatarethe differenttypesof settlement?

    PrimarySettlement(ImmediateSettlement) Consolidation

    Settlement

    TertiarySettlement

20. Whatisthepurposeofconsolidation?

ToCalculatetheFuturesettlementoftheBuildingoranyotherstructure

21. WhatismeantbyDegreeofConsolidation?

Theratioofthesettlementatthetimetothefinalsettlementofsoiliscalled Degree of Consolidation.

22. Whatarethemethodstofindcoefficientofconsolidation? Log T Method

RootTMethod

23. WhatarethedisadvantagesofTriaxialCompression Test?

TheTestisElaborate,TimeConsumingandSkilledpersontobetakecare.

24. HowtoarriveAngleofinternalfrictionfromtest?

TheobservedvalueofMinorprincipalstressandMajorPrincipalstressfordifferent trial to be drawn as mohr circles. The angle of the common tangent line touching all mohr's circle.

25. WhatistheadvantagesofDirectSheartest?

This test is suitable for all types of soil. Can measure the pore water pressure at any time. It gives most accurate results

TOPICBEYONDSYLLABUS

Ex. No :16 **Date:**

DeterminationofMoistureContentofSoil

AIM

Todeterminethemoisturecontent(watercontent)ofagivensoilsample.

THEORY

A soil is an aggregate of soil particles having a porous structure. The pores may havewaterand/orair.Theporesarealsoknownasvoids.Ifvoidsarefullyfilledwithwater.Thesoil iscalledsaturated soil and if voids have only air, the soil is called dry.

Moisturecontentisdefinedastheratioofthemass/weightofwatertothemass/weightof soil solids

$$W = W_w / W_s$$

Where, W = water content

W_w=Weight/massofwater

W_s=Weight/massofsoilsolids(massofovendry soil)

Thetemperatureatwhichonlyporewaterisevaporated.Thistemperaturewas standardized105^0C to110^0C. Soils having gypsum are dried at 600ºC to 800ºC.

Thequantityofsoilsampleneededforthedeterminationofmoisturecontentdependson thegradationandthemaximumsizeofparticles.Followingquantitiesarerecommended.

Sl. No.	Soil	Max.quantityused(gm)
01	Coarsegravel	1000 to 2000
02	Fine gravel	300to500
03	Coarsesand	200
04	Mediumsand	50
05	Finesand	25
06	Siltand clays	10 to 25

The methods to determine moisture content in the laboratory are oven-drying, pycnometer, infrared lamp with torsion balance moisture meter. The approximate methods are alcohol burning method and calciumcarbide method.

APPARATUSREQUIRED

1. Containers
2. Balanceofsufficient sensitivity.
3. Hot Oven
4. Desiccators.

PROCEDURE

- Clean,dryandweighthecontainer withlid.
- Take the required quantity of the soil specimen in the container and weigh with lid.
- Maintainthetemperatureoftheovenbetween105ºCto110ºCfornormalsoilsand 600ºC to 800ºC for soils having loosely bound hydration water or/and Organic matter.
- Dry the sample in the oven till its mass becomes constant. In normal conditions the sample is kept in the oven for not more than24hours.
- After drying remove the container from the oven, replace the lid and cool in the desiccators.
- Weighthedrysoilinthecontainerwithlid.

RESULT:

Themoisturecontentofthegivensoil sample =

OBSERVATIONS

Sl. No.	DeterminationNo.	1	2	3
1	ContainerNo.			
2	Massofcontainerwithlid. W_1(gm)			
3	Massofcontainerwithlid+wetsoil, W_2(gm)			
4	Massofcontainer with lid + drysoil, W_3(gm)			
5	Massofwater, $W_w = W_2 - W_3$(gm)			
6	Massofdrysoil, $W_s = W_3 - W_1$(gm)			
7	Moisturecontent, $W = W_2 - W_3 / W_3 - W_1 \times 100$, (%)			

TOPICBEYONDSYLLABUS

Ex. No: 17 **Date:**

DeterminationofSpecificGravityUsingDensityBottle

AIM:

Determinethespecificgravityofsoilfractionpassing4.75mmI.Ssievebydensity bottle.

THEORY:

The knowledge of specific gravity is needed in calculation of soil properties like void ratio, degree of saturation etc. Specific gravity G is defined as the ratio of the weight of an equal volume of distilled water at that temperature both weights taken in air.

APPARATUSREQUIRED

1. Densitybottleof50mlwithstopperhavingcapillaryhole.
2. Balancetoweighthematerials(accuracy10gm).
3. Washbottlewithdistilledwater.
4. Alcoholandether.

PROCEDURE

- Cleananddrythedensitybottle
- washthebottlewithwaterandallowittodrain.
- Washitwithalcoholanddrainittoremovewater.
- Washitwithether,toremovealcoholanddrainether.
- Weightheemptybottlewithstopper(W_1)
- Takeabout10to20gmofovensoilsamplewhichiscooledinadesiccator. Transfer it to the bottle. Find the weight of the bottle and soil (W_2).
- Put 10mlofdistilled waterin the bottle to allowthe soilto soakcompletely.Leave it for about 2 hours.
- Again fill the bottle completely with distilled water put the stopper and keep thebottle under constant temperature water baths.
- Take thebottle outsideand wipe it cleananddrynote. Now determine the weight of the bottle and the contents (W_3).
- Nowemptythebottleandthoroughlycleanit.Fillthebottlewithonlydistilledwater and weigh it. Let it be W_4.
- Repeatthesameprocessfor2to3times,totaketheaveragereadingofit.

RESULT:

Specificgravityofsoil=

OBSERVATIONS

Sl. No.	ObservationNumber	1	2	3
1	Weightofdensitybottle(W1g)			
2	Weightofdensitybottle+drysoil(W2g)			
3	Weightofbottle+drysoil+water(W3g)			
4	Weightofbottle +water (W4g)			
5	SpecificGravity			

CALCULATIONS

$$Specific\ gravity\ of\ soil = \frac{\text{Density of water at 27 C}}{\text{Weight of water of equal volume}}$$

$$= \frac{(W_2 - W_1)}{(W_4 - W_1) - (W_3 - W_2)}$$

$$= \frac{(W_2 - W_1)}{(W_2 - W_1) - (W_3 - W_4)}$$

Unlessorotherwisespecifiedspecificgravityvaluesreportedshallbebasedonwaterat 27ºC. Thespecificgravityofthesoilparticlesliewithi ntherangeof2.65to2.85.Soils containingorganicmatterandporousparticlesmayhavespecificgravityvaluesbelow 2.0.Soilshavingheavysubstancesmayhavevaluesabove 3.0.

Ex. No:19 **Date:**

DeterminationofFieldDensity-CoreCutterMethod

AIM:

Todeterminethefielddensityofsoilatagivenlocationbycorecutter method

THEORY:

In core cutter method the unit weight of soil obtained from direct measurement of weight and volume ofsoil obtained from field. Particularly forsandysoils the core cutter method is not possible. In such situations the sand replacement method is employed to determine the unit weight. In sand replacement method a small cylindrical pit is excavated and the weight of the soil excavated from the pit is measured. Sand, whose density is known, is filled into the pit. By measuring the weightofsandrequiredtofillthepitandknowingthedensityofsoil,volumeofthe pitiscalculated. Knowingtheweightofsoilexcavatedfromthepitandthevolume of pit the density of soil is calculated. Therefore, in this experiment there are two stages (1) Calibration of sand density and (2) Measurement of soil density.

APPARATUS

1. Cylindricalcorecutter
2. Steel rammer
3. Steeldolly
4. Balance
5. Moisturecontent cups

PROCEDURE

CORECUTTER

- Measure the height (h) and internal diameter (d) of the core cutter and apply grease to the inside of the core cutter.
- Weightheemptycorecutter(W_1).
- Cleanandleveltheplacewheredensityistobedetermined.
- Drive the core cutter, with a steel dolly on itstop in to the soil to itsfull depth with the help of a steel rammer.
- Excavate the soil around the cutter with a crow bar and gently lift the cutter without disturbing the soil in it.
- Trim the top and bottom surfaces of the sample and clean the outside surface of the cutter.
- Weighthecorecutterwithsoil (W_2).
- Removethesoilfromthecorecutter,usingasampleejectorandtakearepresentative soil sample from it to determine the moisture content (w).

RESULT

1. **Dryunitweightofthesoil =**
2. **Wetunitweightofthesoil=**
3. **Voidratioofthesoil =**
4. **Porosityofthesoil=**
5. **Degreeofsaturation=**

OBSERVATIONS-CORECUTTERMETHOD

Internaldiameterofthecorecutter(d) Height

of the core cutter (h)

Volumeofthecorecutter(V)

Specific gravity of solids (G)