VAISHNO COLLEGE OF ENGINEERING

Affliated to HPTU, Hamirpur and approved by AICTE

Engineering Geology And Rock

Lab Manual

CE-611(CBCS Syllabus)

Department of Civil Engineering

VillThapkour, PO Bhardoya, Tehsil Indora,Distt. Kangra (HP)-176403

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Vision of Institute

To emerge as an institute of eminence in the fields of engineering, technology and management in serving the industry and the nation by empowering students with a high degree of technical managerial and practical competence.

Mission of Institute

M1 To strengthen the theoretical, practical and ethical dimensions of the learning process by fostering a cultural of research and innovation among faculty members and students.

M2 To encourage long term interaction between academia and industry through the involvement of industry for hands on implementation of the curriculum.

M3 To strengthen and molding students in professional ethical, social and environmental dimensions by encouraging participation in co-curricular extracurricular and CSR activities.

Vision of the Department

To produce engineers having professional and leadership qualities with capacity to take up professional and research assignments in Civil Engineering and allied fields with focus on inter-disciplinary and innovative approach and to compete at the global level.

Mission of the department

1. To impart quality and real time education to contribute to the field of Civil Engineering.

2. To impart soft skills, leadership qualities and professional ethics among the graduates to

handle projects independently.

3. To develop graduates to compete at the global level.

Program Educational Objectives (PEOs) of the department

PE01:- To impart quality education and knowledge in contemporary science and technology to
meet the challenges in the field of Civil Engineering and to serve the society.

PEO2:- To impart the knowledge of analysis and design using the codes of practice and
software packages.

PEO3:-To inculcate the sense of ethics, morality, creativity, leadership, professionalism, self confidence and independent thinking.

PEO4:- To motivate the students to take up higher studies and innovative research projects.

PROGRAM OUTCOMES

PO1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO 12: Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcome (PSOs)

PSO 1: The graduates of this program will be able to meet the needs of public in the design
and execution of quality construction work considering principles of mechanics, mathematics
and physics to construct sustainable buildings that will ensure safety and durability till the
service period.

PSO 2: The graduates will calculate the loads and the stresses acting on the building, analysis for
the loads and design sections of structures to sustain the loads using building analysis software
packages.

PSO 3: The graduates will be able to work effectively as an individual or in a team having
acquired leadership skills and manage projects in multidisciplinary environments.

<u>Lab Syllabus & List of Experiments</u>

Teaching Scheme			Credits	Marks			Duration of End Semester Examination
L	T	P/ D	C	Sessional	End Semester Exam	Total	
0	0	2	1	30	20	50	2 hrs

Course Objectives:

To introduce students to different types of rocks and to find out the characteristics, suitability and engineering properties of various types of rocks. At the end of the course, the students will be able to conduct the various tests on the given specimen of the rock.

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LIST OF EXPERIMENTS:

To conduct following tests on the given rock specimens:-

1. Void index test
2. Permeability test.
3. Uniaxial compressive strength test.
4. Point load test.
5. Brazilian Tensile strength test
6. Bending test.
7. Slake durability test.
8. Shear strength test.
9. Punching shear test.
10. Shear testing for discontinuities.
11. Rock toughness measurement.
12. Rock bolt pull out test.

Evaluation Scheme

Internal Assessment: 30 marks (pass marks:12)

Distribution of marks for internal assessment:

- Written/presentation/Demonstration: 05
- Viva-voice: 05
- Teacher assessment: Lab Work performance/Report/File Work:15
- Attendance: 05

External Assessment: 20 marks (pass marks: 08)

Total marks 30+20=50, Pass marks = 20

Note: Student has to pass internal & external assessment separately.

GENERAL GUIDELINES AND SAFETY INSTRUCTIONS

1. Sign in the log register as soon as you enter the lab and strictly observe your lab timings.

2. Strictly follow the written and verbal instructions given by the teacher / Lab Instructor. If you do not understand the instructions, the handouts and the procedures, ask the instructor or teacher.

3. Never work alone! You should be accompanied by your laboratory partner and / or the instructors / teaching assistants all the time.

4. It is mandatory to come to lab in uniform and wear your ID cards.

5. Do not wear loose-fitting clothing or jewellery in the lab. Rings and necklaces are usual excellent conductors of electricity.

6. Mobile phones should be switched off in the lab.

7. Keep the labs clean at all times, no food and drinks allowed inside the lab.

8. Intentional misconduct will lead to expulsion from the lab.

9. Do not handle any equipment without reading the safety instructions. Read the handout and procedures in the Lab Manual before starting the experiments.

10. Do your wiring, setup, and a careful circuit checkout before applying power. Do not make circuit changes or perform any wiring when power is on.

11. Avoid contact with energized electrical circuits.

12. Do not insert connectors forcefully into the sockets.

13. Never try to experiment with the power from the wall plug.

14. Immediately report dangerous or exceptional conditions to the Lab instructor / teacher: Equipment that is not working as expected, wires or connectors are broken, the equipment that smells or “smokes”. If you are not sure what the problem is or what's going on, switch off the Emergency shutdown.

15. Never use damaged instruments, wires or connectors. Hand over these parts to the Lab instructor/Teacher.

16. Be sure of location of fire extinguishers and first aid kits in the laboratory.

17. After completion of Experiment, return the bread board, trainer kits, wires, CRO probes and other components to lab staff. Do not take any item from the lab without permission.

18. Observation book and lab record should be carried to each lab. Readings of current lab experiment are to be entered in Observation book and previous lab experiment should be written in Lab record book. Both the books should be corrected by the faculty in each lab.

20**. Special Precautions during soldering practice**

a. Hold the soldering iron away from your body. Don't point the iron towards you.

b. Don't use a spread solder on the board as it may cause short circuit.

c. Do not overheat the components as excess heat may damage the components/board.

d. In case of burn or injury seek first aid available in the lab or at the college dispensary.

Experiment No: 1

AIM: To determine the uniaxial compressive strength of a given rock specimen and to **calculate the Young's Modulus.**

Scope: The procedure used in the determination of compressive strength involves the use of a cylindrical specimen of rock loaded axially between platens in a testing machine. The stress value at failure is defined as the compressive strength of the specimen and is given by the relationship-

$$(UCS) = P / A$$

Where, a_c = compressive strength of the specimen

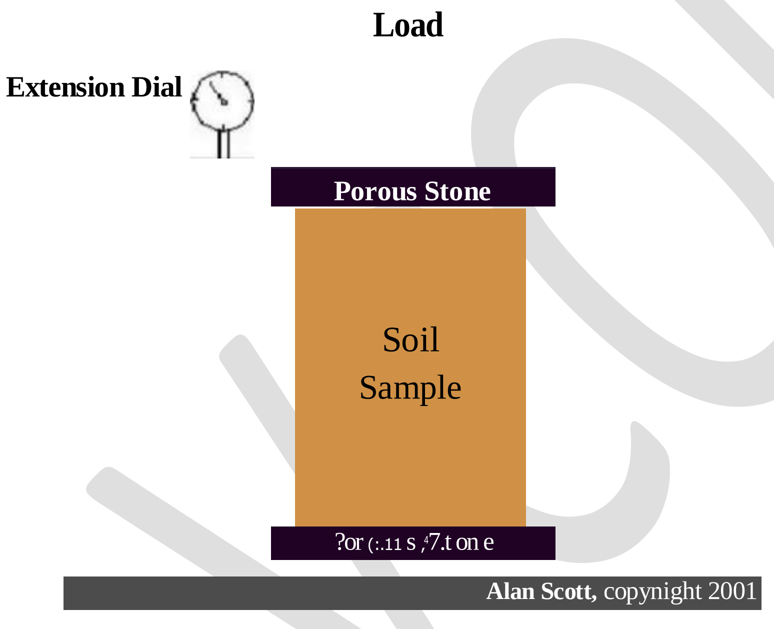
P = applied load at failure (Kg.)
A = cross-sectional area (sq.cm.)

Specimen Specification:

1. Specimen is straight, circular cylinder having a length to diameter ratio of 2.5-3.0 and diameter preferably not less than NX Core size (i.e. approx. 54 mm). **The** diameter of specimen is related to the size of the largest grain in rock by the ratio of at least **10:1.**
2. The ends of the specimen are cut parallel to each other and at right angle to the longitudinal axis.
3. The ends of the specimen are flat to 0.02 mm.
4. **The ends of** the specimen are perpendicular to the axis of the specimen within 0.001 radian or 0.05 mm in 50 mm.
5. **The** sides of the specimen are smooth and free of abrupt irregularities and straight to within 0.3 mm over the full length of the specimen.
6. Samples are stored for no longer than 30 days in such a way as to preserve the natural water content as far as possible until the time of specimen preparation. The specimen is stored prior to testing for 5 to 6 days in an environment of $20^{\circ}C + 2^{\circ}C$ and 50% ± 5% humidity.

Apparatus Required: MTS, Vernier Caliper and rock specimen.

1. Measure the length of the specimen at two places at right angle to each other and diameter of the specimen to the nearest 0.1 mm by averaging two diameters measured at right angles to each other at about the upper height, mid height, and the lower height of the specimen. Use average diameter for calculating the cross-sectional area.
2. Load the specimen under Servo Controlled Stiff Testing Machine (MTS) in such a way that the stress rate is within the limits of 0.5-1.0 MPa/sec.
3. Obtain the stress strain curve or load vs displacement curve from the MTS.
4. Select a straight line of the curve in the elastic limit and calculate stress and strain from load versus displacement curve. Divide stress by strain to get young's modulus of the specimen.



Calculation :

It is calculated by dividing the maximum load at failure by cross-sectional area of the specimen.

$$= P / A$$

Where, P is load at failure (Kg.)

A is cross-sectional area (sq.cm.)

Observation Table :

S. No.	Length of the Specimen (cm.)			Diameter of the Specimen (cm.)						Cross-sectional Area (sq.cm.) A	Load at Failure (kg.) P	**a, =** P / A
	L_I	1,2	4,.	D_i	**D2**	**D3**	**D4**	**135**	**Dt,**	D.		
1												
2												
3												
4												
5												
Average												

Result:

1. **No. of specimen tested**
2. **Uniaxial Compressive** Strength
3. **Mode of failure**
4. **Lithological description of the rock** specimen
5. **Source of sample : Chunar Sandstone**
6. **Date of testing**
7. **Type of testing machine**

S. Water **content & degree of saturation at the time of test**

Experiment No: 2

Aim: To determine the Point Load Strentli Index of a 2.iven rock specimen to calculate

uniaxial compressive strength.

Theory: Point had index is a simple technique for measuring the strength of rock specimen in the field by using portable equipment. The specimens may be rock core or irregular lump. The strength index is calculated from the following equation

$$I, = P/D^2$$

where,

= point load strength index

P = load at fracture

D = Distance between two conical platens

Approximate conversion of Point Load Strength Index to Uniaxial Compressive Strength can be made by

U.C.S. = (24) I,

It varies from 12 to 24 depending upon the nature/type of specimen

The International Society of Rock Mechanics has given three methods for determining the point load strength index

1. **Diametral Test**
2. **Axial test**
3. **Irregular lump test.**

Apparatus Required: Point load machine, distance measuring system to indicate the distance between two conical platens, specimen, Vernier Calipers.

Procedure:

1. **Diametral Test: Take Core specimens with length to diameter ratio greater than 1.4 for diametral testing. Insert the specimen in the testing machine and bring the platens into the contact along the core diameter, ensuring that the distance L between the contact point and the nearest free end is at least 0.7d, where d is core diameter. Increase the load till the specimen breaks. Now, record the distance between conical platens (D) and failure load P. Repeat the procedure on at least ten specimens for each sample.**

2. **Axial Test: Take core specimens with length** to diameter ratio of **1.1 — 0.05 for axial test. Insert the specimen in the testing machine and bring the platens into the contact along** the axis **if the specimen (i.e. length of the specimen). Now, load the specimen to failure and record the distance between conical platens (D) and failure load P. Repeat the procedure on at least ten specimens for each sample.**

3. **Irregular Lump Test & Block Test: Take rock lumps with typical diameter approximately 50 mm and with a ratio of longest to shortest diameter between 1.0 to 1.4. Trim it using any convenient technique. Load each specimen up to the failure and the value of D and P are recorded. At least, test 20 lumps for each sample.**

Block Test:

P P

De' 4 Al rr 4 WDIff

I_S =

Where W = smallest width to loading direction.

Irregular lump test:

P *P*

4WDIn- **W_1 W_2**

2

4 2 -=)D/7r

I,= **where W**

I_s(50) for both these tests is given by:

(i) l,(50) = K/50 where, Pio can be obtained from a log-log plot between P and De

V 4 A

7T

(ii) 1,(50) = (De/50)" x l,, where De =

Observation Table :

1. Axial Test

S.N.	Length of Specimen (cm)			Diameter of Specimen fern)			Load at failure (KN)	Point Load Strength Index (Mpa)
	L_1	L2	L,,	D,				
I								
3								
4								
5								
							Average	

2. Diametral Test :

S.N.	Length of Specimen (cm)			Diameter of Specimen (cm)			Load at failure (KN)	Point Load Strength Index
	L_1	L2	1-,,	D_1	D2	D,,		
I								
I								
3								

4								
5								
							Average	

Result

(i) **Average Point Load Strength Index for**

(A) Axial test :

(B)Diametral test :

(C) Irregular Lump Test :

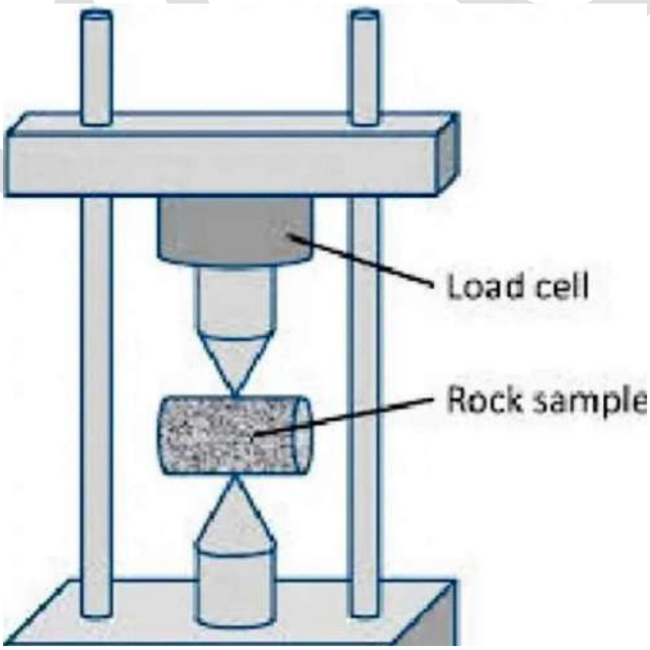
(ii) Uniaxial Compressive Strength :

Lithological Description of Specimen :

(iv) Source of sample :

(v) No. of specimen tested

(vi) Specimen diameter and thickness:



Experiment No: 3

AIM : To determine the Slake Durability Index of Rocks. Scope :

One good test of durability of rocks is the slake durability test proposed by Franklin and Chandra **(1972) modified by Gamble and later recommended by ISRM. The apparatus consists of a** drum **of 140 mm diameter and 100 mm length with sieve mesh (2 mm opening) forming** the **cylindrical walls. About 500 gm of rock is broken into 10 lumps and loaded inside the drum, which is turned at 20 rpm in a water bath. After ten minutes of this slow rotation. the percentage of rock retained inside the drum (on a dry weight basis) reported as the Slake Durability Index.**

This test is intended to assess the resistance offered by a rock sample to weakening and disintegration when subjected to two standard cycles of drying and wetting.

Appatarus :

The apparatus consists essentially of the following :

(a) **A test drum** comprising a **2.00 mm standard mesh cylinder of unobstructed length 100 mm and diameter 140 mm with solid fixed base. The drum must withstand a temperature of 105"c. The drum has a solid removable lid. The drum** must **be sufficiently strong to retain its shape during use, but neither the exterior of the** mesh nor the interior of **the drum should be obstructed, for example by reinforcing members.**

(b) **A trough to contain the test drum supported with axis horizontal in a manner allowing free rotation, capable of being filled with a slaking fluid such as water to a level 20 mm below the** drum axis. The drum **is mounted to allow 40 mm unobstructed clearance between the trough** and the **base of the mesh.**

(c) **A motor drive capable of rotating the drum at a speed of 20 rpm. The speed to be held constant to within 5% for a period of 10 min.**

(d) An oven **capable of** maintaining a **temperature** of 105'c **to within 3°c for a period of at least** 12 hours.

(e) A balance capable of weighing the **drum plus sample to an accuracy of 0.5 gm.**

Procedure :

(a) Select a representative sample comprising the rock lumps. each with a mass **of 40-60 g , to give a total sample mass of 450-550g. The maximum grain size of** the **rock is not more than 3 mm. Lumps are roughly spherical in shape and corners are rounded.**

(b) Place the sample in a clean drum and **dry to a constant mass at a temperature of 105"c, usually requiring from 2 to** 6 hr in **the oven. Record the mass "A" of the drum plus sample. Test the sample after cooling.**

(c) Replace the lid, mount the drum in the trough and coupled to the motor.

(d) Fill the trough with slaking fluid, usually tap water at 20"c, to a level 20 mm below the drum axis, and rotate the drum for 200 revolutions during a period of 10 min to an accuracy of 0.5 min.

(e) Remove the drum from the trough and the lid from the drum. Dry the drum plus retained portion of the sample to constant mass at 105`)c. Record the mass "B" of the drum plus retained portion of the **sample after cooling.**

(f) Repeat the steps from (c) - (e) and record the mass "C" of the drum plus retained portion of the sample.

(g) Brush the drum to clean and record its mass "D".

Calculation :

The Slake-durability index (second cycle) is calculated as the percentage ratio of final to initial dry sample masses as follows:

Slake-durability index $I_{d2} = ((C - D)/(A - D)) \times 100\%$

Mass **of 'A' :** Mass

of 'B' : Mass of 'C'

: Mass of 'D' : Slake

Durability Index

Results :

(a) The Slake-durability index :

(b) The nature and temperature of the slaking fluid :

(c) The appearance of fragments retained in the drum :

(d)The appearance of material passing through the dnim :

Note : The second cycle slake durability index, tested with tap water at 20°c, is proposed for use in rock classification. However, samples with second cycle from 0 to 10% should be further characterized by their first cycle slake durability indexes as follows-

Slake-durability index I_{dl} = ((B_ D) / (A —D)) x 100 %

Indexes taken after three or more cycles of slaking and drying may be useful when evaluating rocks of higher durability. Rocks giving low slake durability, results should be subjected to soils classification tests, such as determination of Atterberg limits or sedimentation size analysis

Experiment No: 4

Aim: To determine the tensile strength of a given rock specimen.

Scope : The specimen tested for compressive strength often fails due to the development of tensile stresses. Tensile failure is an important phenomenon in the mechanical winning of minerals, drilling and blasting of rocks, failure of roof and floor etc.. particularly because rocks are very much weaker in tension than in compression.

There are two methods to determine the tensile strength-

1. Direct Method. 2. Indirect Method.

The greatest difficulty in the direct test for determination of tensile strength of rocks is the gripping of specimen. To get uniform tensile stress distribution and for easy gripping, specially prepared specimens are required and they are difficult to make. As a result, indirect methods have been developed for determining the tensile strength t)I it)ck

Brazilian Test : The Brazilian Test, as the name suggests. originated from South America. The test makes use of a circular solid disc which is compressed to failure across a diameter. However, the test is valid only when the failure of disc initiates with a vertical crack originating from the centre of the disc and proceeding upward and downward along the loading diameter.

Apparatus Required

1. Brazilian cage - Two steel loading jaws designed so as to contact a disc shaped rock specimen at diametrically opposed surfaces over an area of contact of approximately 10° at failure. The critical dimension of apparatus is the radius of curvature of jaws and length of guide pins coupling the two curved jaws and the width of the jaws. The radius of jaws is 1.5 x specimen radius, guide pin permit rotation of one jaw relative to the other by 4×10^{-3} radians out of plane of the apparatus (25 mm penetration of guide pin). Width of the jaw is 1.1 x

specimen thickness. The upper jaw contains a spherical seating formed by a 25 mm diameter half ball bearing.

A suitable machine for applying and measuring compressive load to the specimen.

3. Vernier Caliper.

4. Rock Specimen.

Procedure

1. Take the cylindrical specimen **whose surfaces** are free from any **tool marks and irregularities.** The end **faces are flat to within 0.25 mm and parallel to within 0.25°.**
2. **The specimen diameter is not less than NX (apparatus 54 mm) core size. Thickness of specimen is equal to specimen radius.**
3. **3. Apply the load on the specimen continuously at a constant rate such that failure in the weakest rock occurs within 15-30 sec. A loading** rate **of 200 N/s is recommended.**

Calculation : The Brazilian tensile strength which is defined as the load resisting ability of rock under diametral loading, can be calculated by the expression **-**

o-, ={2P/(7-rDt)}or {1³/(7rrt)}

where, a, = tensile strength, (MPa) P = load at failure, (N)

D = diameter of specimen, (mm) t = thickness of specimen, (mm) r = radius of specimen, (mm)

Observation **Table :**

S.N.	Diameter (D. mm)			Thickness (t. mm)			**Load at Failure (Kg. P)**	**Tensile Strength (MPa)**
	D_i	**D2**	**$D_{ay,}$**	**ll**	t_2	$t_{a,,}$		
1								
I								
3								
4								

5								
							Average	

Results:

(1) lithological description of the specimen

(2) Source of sample :

(3) Number of specimen :

(4) **Specimen diameter and** thickness :

(5) Water content and **degree of** saturation **at the time of test :**

Test duration :

Date of testing and type of testing machine :

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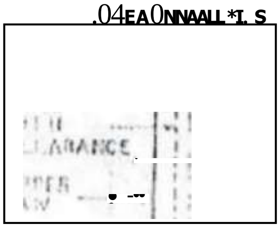

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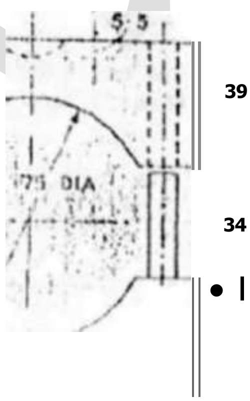
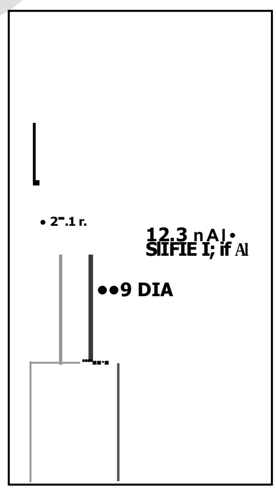
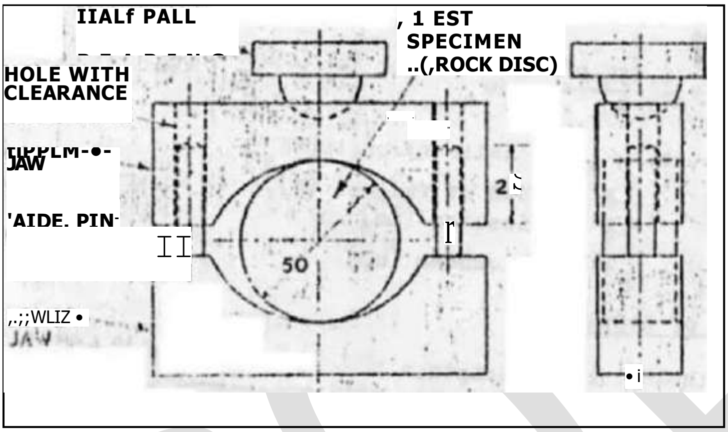
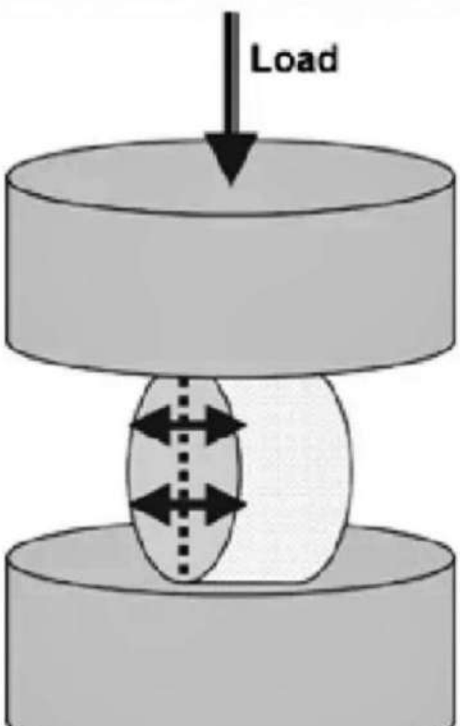






STEEL LOADING 'JAWS WITH A DISC SHAPED ROCK SPECIMEN FOR BRAZILIAN UST.


GCTS


Load

Experiment No: 5

AIM:

• **To determine the coefficient of permeability (k) for a given soil sample using falling head method.**

INTRODI ICTION

Permeability (or hydraulic conductivity) refers to the ease with which water can flow through a soil. This property is necessary for estimating the quantity of underground seepage under various hydraulic conditions, for investigating problems involving the pumping of water for underground construction, and for making stability analyses of earth dams and earth-retaining structures that are subject to seepage forces.

One of the major physical parameters of a soil that controls the rate of seepage through it is hydraulic conductivity, otherwise known as the coefficient of permeability.

There are two standard laboratory test methods to determine the hydraulic conductivity of soil:

1. **The constant head test method : used for permeable soils (k> I0-4 cm/s)**
2. **The falling head test method : used for less permeable soils (k<10-4 cm/s)**

THFORY

Falling head test method

The falling head permeability test is a common laboratory testing method used to determine the permeability of fine grained soils with intermediate and low permeability such as silts and clays. This testing method can be applied to an undisturbed sample.

Principal of the falling head method is based on Darcy's law which was proposed by Henry Darcy, a French scientist in 1856. It is a simple equation for the discharge velocity of water through **saturated soils.**

$$v = ki$$

where; v = Discharge velocity, which is the quantity of water flowing in unit time through a unit cross sectional area of soil at right angle to the direction of flow,

***k* = Coefficient of permeability**

***i* = Hydraulic** gradient

The rate of flow of the water through **the specimen at any time t can be given by,**

$$q = k\frac{h}{l}A = -a\frac{dh}{dt}$$

where; *q* = flow rate

a = cross-sectional area of the standpipe

***A* = cross-sectional area of the soil specimen**

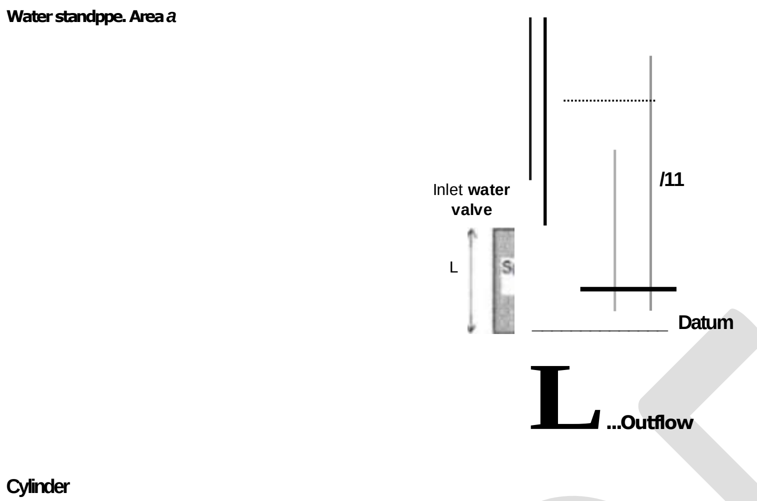


Figure 1: Diagram of the Falling-head Method

The equation used to calculate the coefficient of permeability is:

$$\underline{al}$$

$$InP^{h}$$

$$k= \underline{\quad al}$$

When the equation is arranged in the form of y = mx,

$$\text{In}(\tfrac{1}{?})=M_{al}(t_{r}$$

where;

a **= cross-sectional area of the standpipe**

A = **cross-sectional area of the soil specimen**

/ = length of the soil sample

***ti* — */0* = the time interval**

h_o = initial water level height from the bottom of the apparatus to the zero mark level of the stand pipe

hi **= height measured with time from the bottom of the apparatus to the water level**

The coefficient of permeability (k) can be determined using the gradient (m) of the graph

$\ln\left(\frac{h_i}{h_0}\right)$

$$m = \frac{kA}{al}$$

Therefore,

$$k = \frac{mal}{A}$$

against $(t_1 - t_0)$

Experiment No: 6

The coefficient of permeability is defined as the rate of flow of water under laminar flow conditions through a unit cross-sectional area of a porous medium under a unit hydraulic gradient and standard temperature conditions. The unit of k is m/s.

AIATFRIAI AND APPARATUS

1. Falling Head Permeability Apparatus
2. Permeameter with its accessories.
3. Standard soil specimen.
4. Stop watch.
5. Measuring jar.
6. Meter scale.
7. Container to collect excess water

A

A

Figure 2: Permeameter

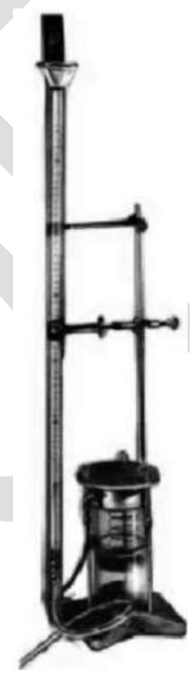


Figure 3: Falling Head Permeability Apparatus

Procedure

1. First, it has been checked whether the valve is closed and the tube connecting the permeameter and standpipe is tight, also a container has been place to collect the excess water falling from the valve.
2. Next, water has been filled in from the top of the glass standpipe up to the zero mark.
3. Soil specimen has been kept to get saturate for some time and when the water level dropped. again water has been filled up to the water zero mark level.
4. Then, h0 has been measured from the bottom of the apparatus to the zero mark level using the measuring tape.

5. The valve has been opened and water has been allowed to discharge through it for five minutes time interval.
6. After five minutes, the valve has been closed and hl (height of the new water level from the bottom of the apparatus) has been recorded.

Similarly record the height of water in the glass standpipe in every 5 minutes time interval for about 50 minutes.

7. Using the recorded readings the graph In ha

8. The coefficient of permeability, k has been found by the gradient of the graph. CATrIJI.ATIONS

Specimen Calculation

1. The cross-sectional area *(a)* of the standpipe, ^{2}

A= ^{ird}

4

0.02

4

A=i,

A=3.143 x $10^{-4}m^2$

2. The cross-sectional area *(A)* of the soil specimen,

A=-

4

$\pi \frac{0.1 (¿¿2)}{4}$

$A=¿$

A=7.857x $10^{-3}m^2$

3. The gradient (m) of the graph In r_2 against $(t_2—t_1)$ is, $\frac{h_,}{''}$ $=\frac{kA}{a}$

In= Y2—Y1

X2⁻X1

m— 0.888-0.121 135-5, *x* 60

$m = 4.26 \times 10^{-4}\ s^{-}$

4. The coefficient of permeability (k),

$$k = \frac{mal}{A}$$

$$k = \frac{4.26 \times 10^{-4} 1 (3.143 \times 10^{-4})(127.3 \times 10^{-3})}{7.857 \times 10^{-3}}$$

$k = 2.169 \times 10^{-6} ms^{-1}$

RESULTS

t (min)	h_a (cm)	h_1 (cm)	$\frac{h_0}{h_1}$	$\ln(\frac{h_0}{h_1})$
0	**140.2**	**140.2**	**1**	**0**
5	**140.2**	**124.2**	**1.29**	**0.121**
10	**140.2**	**110.2**	**1.272**	**0.241**
15	**140.2**	**97.3**	**1.441**	**0.365**
20	**140.2**	**85.7**	**1.636**	**0.492**
25	**140.2**	**75.3**	**1.862**	**0.622**
30	**140.2**	**65.9**	**2.127**	**0.755**
35	**140.2**	**57.7**	**2.430**	**0.888**
40	**140.2**	50.3	**2.787**	**1.025**
45	**140.2**	43.9	**3.194**	**1.161**
50	**140.2**	**-**	**-**	**-**

$m = 4.26 \text{x} \; 10^{-4} \; s^{-1}$

4. The coefficient of permeability (k),

$k = \frac{mal}{A}$

$k = \frac{4.26 \; x \; 10^{-4} 1(3.143 \; x 10^{-4})(127.3 \; x \; 10^{-3})}{7.857 \; x \; 10^{-3}}$

$k = 2.169 \; \text{x} \; 10^{-6} \text{ms}^{-1}$

RESULTS

t (min)	*hi)* (cm)	*hi* (cm)	h_o / $h_,$	in Hh, h_1
0	**140.2**	**140.2**	**1**	**0**
5	**140.2**	**124.2**	**1.29**	**0.121**
10	**140.2**	**110.2**	**1.272**	**0.241**
15	**140.2**	**97.3**	**1.441**	**0.365**
20	**140.2**	**85.7**	**1.636**	**0.492**
25	**140.2**	**75.3**	**1.862**	**0.622**
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40	**140.2**	**50.3**	**2.787**	**1.025**
45	**140.2**	**43.9**	**3.194**	**1.161**
50	**140.2**	**-**	**-**	

The calculated coefficient of permeability, k =2.169 x 10^{-} ms^{1}

Experiment **No. 7**

Name of Experiment: VANE SHEAR TEST

Aim

To determine the shear strength of soft saturated clay soil using vane shear apparatus.

Theory

In soil, shear strength is contributed by the two properties, viz, cohesion and angle of internal friction. In pure clays the shear resistance is due to internal friction is negligible. Hence complete shear strength in clays is due to cohesion.

Laboratory vane shear test is useful for cohesive soil of low shear strength (< 0.5 kg/cm') for which triaxial or unconfined compression tests can not be performed accurately.

Apparatus

The vane shear test apparatus consists of a torque head mounted on a bracket. Four shear vanes are fixed on a shaft and the shaft is fixed in the lower end of a circular disk graduated in degrees. A torsion spring is fixed between torque head and the circular disk. A maximum pointer is provided to facilitate reading the angle of torque. As the *strain indicating pointer* rotates when the torque is applied, it moves the *maximum pointer,* leaving it in position when the torque gets released at failure and the vane returns to its initial position. Turning the torque applicator handle effects the rotation of the vane.

Procedure:

1. Clean the apparatus thoroughly. Apply grease to the lead screw.
2. Fill up the sampling mould with remolded soil at required density and moisture content or the undisturbed soil sample. Level the surface of the sample with the mould.
3. Mount the sampling tube with sample under the base of the unit and clamp it in position.
4. Bring the *maximum pointer* into contact with *strain indicating pointer.* Note down the initial reading of these pointers on the circular graduated scale.
5. Lower the bracket until the shear vanes go into the soil sample to their full length.
6. Operate the *torque applicator handle* until the specimen fails, which is indicated by the return *of strain indicating pointer or* rotation of drum.
7. Note down the readings of *maximum pointer.*

K. The difference between the two readings (initial and final) gives the angle of torque.

9. Repeat steps 3 to 8, on a number of samples to obtain the average shear strength of the sample.

Observations and Calculations:

Diameter of Vane, d = Height of Vane, h = Spring Factor, K =

OBSERVATION TABLE

S.N	Initial Reading (1)1°)	Final Reading OM	Angle of Torque, U = (vi-v2)	Torque, T = uK/180 Kg cm	Shear Strength (Kg/cm·)	Average Shear Strength, τ (Kg/cm²)

T = 'UK/180

where

= difference of angle (angle of torque)

Vane Shear Test K = **spring factor**

T=;*a - (-h +- d*

)T

2 6

d = diameter of vane (cm) h = height of vane (cm)

t = **shear strength (kg/cm²) T = torque applied (kg-cm)**

Laboratory Experiment Evaluation Rubric

Category	Outstanding (Up to 100%)	Accomplished (Up to 75%)	Developing (Up to 50%)	Beginner (Up to 25%)
Written/Presentation/Demonstration	The write-up is clear, well-organized, and follows the prescribed format. All required sections (aim, apparatus, theory, procedure, diagram, etc.) are present and well-written. Demonstration is clear and thorough.	The report follows the specified format, but some sections (like the diagram or theory) are missing or incomplete. The demonstration is understandable but lacks depth.	The report includes most sections but lacks clarity, coherence, or completeness in some parts (e.g., diagram missing, unclear theoretical explanation). The demonstration is incomplete or unclear.	The report is poorly written and organized. Many sections are missing or incorrect (e.g., no diagram, incomplete procedure). The demonstration lacks clarity or is missing.
Viva-Voice	Demonstrates a deep understanding of the experiment, underlying principles, and outcomes. Answers questions confidently	Demonstrates a general understanding of the experiment and principles but struggles with some aspects. Provides correct answers to	Struggles with some fundamental concepts and principles. Answering questions requires additional prompts, with a few errors in	Lacks a basic understanding of the experiment. Unable to answer most questions accurately. Demonstrates significant gaps in knowledge.

Category	Outstanding (Up to 100%)	Accomplished (Up to 75%)	Developing (Up to 50%)	Beginner (Up to 25%)
	and accurately.	most questions.	understanding.	
Performance/Report/File Work	Performs the experiment accurately and efficiently. The report is thorough, with correct observations, calculations, and analysis. Data is recorded neatly and with appropriate units. All relevant calculations and interpretations are included.	Performs the experiment well with minor errors or delays. The report is complete but may contain some inaccuracies or missing components in calculations or observations.	Completes the experiment but with notable mistakes, either in the setup or the data. The report has several missing or inaccurate components, including incorrect or incomplete calculations.	Struggles to perform the experiment correctly. Significant errors in setup, data collection, and analysis. The report is poorly structured with major inaccuracies or missing sections.
Attendance	Consistently attends all lab sessions, actively participates, and engages with the experiment	Attends most lab sessions with occasional absences. Participation is generally good but lacks	Attends some lab sessions but has frequent absences or minimal participation.	Misses several lab sessions and shows minimal to no participation in class or

Category	Outstanding (Up to 100%)	Accomplished (Up to 75%)	Developing (Up to 50%)	Beginner (Up to 25%)
	and group discussions.	consistency or depth.		group activities.