AL-BAHA UNIVERSITY
FACULTY OF ENGINEERING
CIVIL ENGINEEING DEPARTMENT

SOIL MECHANICS LABORATORY MANUAL

CIVIL ENGINEERING DEPARTMENT
2024

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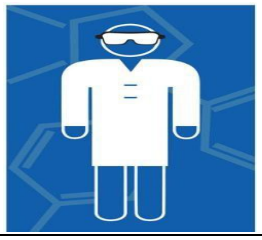
General Safety Guidelines:

Rule	Guideline/Prohibition	Rationale
1	No Eating, Drinking, or Chewing Gum	To maintain a sterile and safe environment. 
2	No Smoking in the Laboratory Area	To safeguard the laboratory and its occupants. 
3	Dress Appropriately	Appropriate attire for personal safety and experiment integrity. 
4	Conduct Yourself Responsibly	Maintain a focused and serious atmosphere. 
5	Hazard Symbols Awareness	Identify potential dangers in the laboratory. 
6	Equipment Shutdown	Conserve energy and prevent equipment damage. 
7	Equipment Cleaning	Promote equipment longevity and prevent cross-contamination. 
8	Maintain Cleanliness	Ensure a safe, efficient, and well-maintained laboratory. 

SAFETY FIRST

(General Administration of Safety and Risks)

الإدارة العامة للسلامة والمخاطر

Phone: 0177257700 - 15424

Email: safety@bu.edu.sa

(Important Phone Number)

ارقام مهمة

الجهة	رقم التلفون	الجهة	رقم التلفون
الشرطة Police	999	طوارئ الكهرباء Electricity Emergency	933
الدفاع المدني Fire Department	998	طوارئ المياه Water Emergency	939
الاسعاف Red Crescent	997	استشارة طبية Medical advice	937
امن الطرق Roads Security	996	الدوريات الأمنية Emergency Number	911
المرور Traffic	993	مكافحة الفساد Corruption (Nazaha)	980

Soil Mechanics Laboratory

- **Introduction**

Soil is the material which supports the foundation of all structures. It is also used as a construction material for civil engineering works. Knowledge of physical and mechanical properties of soil is very important. Laboratory soil engineering courses represent an integral part of the theoretical study.

- **Objectives**

1. Develop an understanding of the physical and mechanical properties of soil. This includes learning how to classify soil, measure its water content and density, and determine its strength and stress-strain characteristics.
2. Gain practical experience in conducting soil tests. This involves learning how to use a variety of soil testing equipment, such as hydrometers, pycnometers, and direct shear devices.
3. Apply theoretical concepts of soil mechanics to real-world problems. This may involve designing foundations, analyzing slopes, or evaluating the suitability of soil for a particular construction project.
4. Develop critical thinking and problem-solving skills. Students will need to be able to analyze their test results, draw conclusions, and make recommendations based on their findings.

- **Report Writing**

To ensure proper documentation and individual understanding, each student will prepare and submit a personal report for every completed soil mechanics lab test. A high-quality A4 paper is mandatory for report submission. Use the report template provided in Appendix (A) as a guide when structuring your reports. This ensures consistency and adherence to key elements expected in your work.

- **Lab. Instruments:**

The soil lab allows the students to perform soil experiments. The table below indicates the soil tests.

No.	TEST	Instruments
1	Sieve analysis test	Sieves, oven, balance, and mechanical vibration machine
2	Natural water content	Drying oven set at 105°C.
3	Unconfined Compression	Unconfined compression machine
4	Constant Head Permeability	head perimeter
5	Falling Head Permeability	Constant head permeameter Graduated flask
6	Liquid limit	Casagrande device
7	Consolidation	Consolidation (Odometer)
8	Plastic limit	Glass plate, oven, and balance
9	Pocket penetrometer	Pocket device

MORE DETAILS IN APPENDIX (B)

Appendixes

A.Writing lab Report Template

Albaha University

Faculty of Engineering

Civil Engineering Department

Course # (……..)

Course Title: ……

Semester: (……)

Instructor: ……

Group ….

Experiment No. …….

Title of Experiment: ……

Names	ID.s
1.	

Date of Experiment: ……

Time of Experiment……

Table of contents

Team meeting (Optional)

Introduction

Experimental design

Data

Calculations

Figures & Graphs

Results & Discussion

References

(Optional)

Meeting Minutes

Meeting#... of Report#...

Time: …….

Date: …….

Venue: ……

Attendants:

1) ……
2) ……
3) ……
4) ……

Agenda

Writing tasks that are taken before and during the meeting.

Discussion Taken

Writing down all objectives you will discuss in the meeting.

Actions Person Responsible

Writing the distribution of tasks between team members.

Introduction:

Usually, the Introduction is one paragraph that **explains the objectives or purpose of the lab**. In one sentence, state the hypothesis. Sometimes an introduction may contain background information, briefly **summarize how the experiment was performed**, state the findings of the experiment, and list the conclusions of the investigation. Even if you don't write a whole introduction, you need to state the purpose of the experiment, or why you did it. This would be where you state your hypothesis.

Experimental design

a) Materials

List everything needed to complete your experiment.

b) Equipment:

List everything needed to complete your experiment.

c) Methods

Describe the steps you took during your investigation. This is your procedure. Be sufficiently detailed that anyone could read this section and duplicate your experiment. Write it as if you were giving directions for someone else to do the lab. It may be helpful to provide a Figure to diagram your experimental setup.

Data:

Numerical data obtained from your procedure usually is presented as a table. Data encompasses what you recorded when you conducted the experiment. It's just the facts, not any interpretation of what they mean.

Calculations:

The Analysis section contains **any calculations you made based on those numbers**. This is where you interpret the data and determine whether a hypothesis was accepted.

Figures & Graphs

Graphs and figures must both be labeled with a descriptive title. Label the axes on a graph, being sure to include units of measurement.

Results & Discussion

Describe in words what the data means. Sometimes the Results section is combined with the Discussion (Results & Discussion).

Reference:

If your research was based on someone else's work or if you cited facts that require documentation, then you should list these references.

B. Experiments described as per Al-Baha University Curriculum for Soil laboratory.

1- Sieve Analysis Test:

Purpose: The standard grain size analysis test determines the relative proportions of different grain sizes as distributed among certain size ranges.

Equipment:

1) Balance (degree of accuracy is 1gm).
2) Set of sieves.
3) Cleaning brush.
4) Sieve shaker.
5) Mixer (blender).
6) Timing device.

Test procedure:

1- Record the weight of the given dry soil sample.

2- Make sure that all the sieves are clean and assemble them in the ascending order of sieve numbers (#4sieve at top and #200sieve at bottom). Place the pan below #200 sieve Carefully pour the soil sample into the top sieve and place the cap over it.

3- Place the sieve stack in the mechanical shaker and shake for 5 minutes.

4- Remove the stack from the shaker and carefully weigh and record the weight of each sieve with its retained soil. In addition, remember to weigh and record the weight of the bottom pan with its retained fine soil.

5- Obtain the mass of soil retained on each sieve by using the balance and record this mass as the weight retained on the data sheet. The sum of these retained masses should be approximately equals the initial mass of the soil sample. A loss of more than two percent is unsatisfactory.

6- Calculate the percent retained on each sieve by dividing the weight retained on each sieve by the original sample mass.

7- Calculate the percent passing (or percent finer) by starting with 100 percent and subtracting the percent retained on each sieve as a cumulative procedure.

8- Make a semi-logarithmic plot of grain size vs. percent finer.

9- Compute C_c and C_u for the soil.

The students are able to conclude the following:

1. Calculate the percent passing from sieve.
2. Make a semi-logarithmic plot of grain size vs. percent finer.
3. Compute Cc and Cu for the soil.

2- Constant Head Permeability Test:

Purpose: Determination of the Coefficient of Permeability (k) of coarse sand.

Equipment:

1. Constant head permeameter
2. Graduated flask
1- Sensitive balance (degree of accuracy is 0.1 gm.).
2- Stopwatch
3- Porous stones.

Test Procedure:

1- The sand has been filled and the permeameter is all set prior to the class.
2- Allow water to flow through the funnel until the water level in the funnel is constant.
3- Open the bottom outlet, run water through the perimeter until the sand is saturated and no air bubbles appear to flow out of the discharge pipe (steady flow).
4- Measure the head of water (h), distance between the water surface in the funnel and the bottom outlet of the perimeter (fill in column 4 of the table).
5- Run the water with the bottom outlet open for some time to achieve steady state (no air bubbles flowing through the pipe) at that particular height.
6- Use graduated jar to collect the discharge water.
7- Start the stopwatch and collect the discharge water in the graduated jar for a particular period (say 3 minute), record the time of collection (column 3 of the table).
8- Record the volume of water from the graduated jar (column 2 of the table).
9- Repeat steps 4 to 10 three times and calculate the average k (cm/s)

The students are able to conclude the following:

1. Carry out the Permeability test.
2. Determination of the Coefficient of Permeability (k) of coarse sand.

3- Falling Head Permeability Test:

Purpose: To determine the Coefficient of Permeability (k) of the soil of low Permeability as fine soil (Silt and Clay).

Equipment:

1- head perimeter,
2- Graduated flask,
3- Sensitive balance (degree of accuracy is 0.1 gm.).
4- Stopwatch.
5- Porous plates.

Test Procedure:

1- Compact the sample in the lower chamber section of the perimeter, in layers approximately 1.5 cm deep, to within about 2 cm of the lower chamber rim. Use an appropriate tamping device to compact the sample to the desired density.
2- Remove the upper section of the chamber tie rods and place the upper porous stone on the specimen, securing the upper section of the chamber with spring to the unit.
3- Measure and record the length and the diameter of the specimen.
4- Use the clamp to attach the falling head burette to the support rod. Position the burette as high as is possible for practicality. Place the meter stick directly behind the burette, so the height of water in the burette above the chamber outflow port may be read.
5- Saturate the specimen, following the steps outlined above.
6- Measure the heights of the two levels from the outflow level.

The students are able to conclude the following:

1.Carry out the Permeability test.

2.Determine the Coefficient of Permeability (k) of Silt and Clay soil.

4- Liquid Limit Test:

Equipment:

1- Casagrande device,

2- Porcelain (evaporating) dish,

3- Flat grooving tool with gage,

4- Moisture cans,

5- Balance (accuracy 0.1 gm),

6- Spatula,

7- Wash bottle filled with distilled water,

8- Drying oven set at 105°C.

Test Procedure:

1- Use potion of soil passing sieve #40 (0.425 mm).

2- Mix soil with water to form a paste.

3- Place in cup using spatula.

4- Make a groove using a grooving tool.

5- Rotate the cam at approximately 2 revolutions per second.

6- Record the number of blows (N) required to close a gap of 13 mm at the bottom.

7- Take a sample from the soil and get it's water content (W.C)

8- A- If (N > 25) then W.C < L.

9- Plot the point on the semi log graph (W.C versus N) and draw the flow curve as the line of best fit.

10-Get (L.L) [water content corresponding to N=25 blows] from the graph.

The students are able to conclude the following:

1- Determine the Liquid limit of the soil, after which the soil start behaves as viscous fluid.

5- Plastic Limit Test:
Equipment:

1- Soil specimen.
2- Moisture cans.
3- Glass plate.
4- Spatula.
5- Oven.
6- Balance (accuracy 0.1 gm).

Procedure:

1- Use portion of soil passing from sieve # 40 (0.425 mm).
2- Take about 30 gm of soil and mix with water.
3- Take about 10 gm and form a ball.
4- Roll the fingers on a glass plate to a thread.
5- A- If the thread cracked at diameter > 3mm then W.C < P.L,
Mix the paste with some additional water and repeat steps 3 to 4.
B- If the thread cracked at diameter < 3mm then W.C > P.L,
Allow soil to dry in air and repeat steps 3 to 4.
6- Repeat the above steps until the thread cracks at diameter 3mm.
7- Get W.C of the soil that cracked to be the plastic limit.

The students were able to conclude the following:

1- Determine the plastic limit, it is the water content at which the soil begins to crumble when rolled into threads of diameter 3 mm.

6- Unconfined Compression Test:

Purpose: The primary purpose of this test is to determine the unconfined compressive strength
Equipment: Unconfined compression testing machine.

Test Procedure:

1. Extrude the undisturbed soil sample from the sampler (Shelby tube) then determine the type of soil, initial moisture content and the specific gravity of the soil.
2. Weigh the empty consolidation ring together with plate.
3. Place the sample on the consolidation ring and cut the sides of the sample to be approximately the same as the outside diameter of the ring as in figure 32. Rotate the ring and pare off the excess soil by means of the cutting tool so that the sample is reduced to the same inside diameter of the ring as in figure 33, make sure that there is no void space between the sample and the ring.
4. Measure the height (Hi) of the ring and it's inside diameter (d) and weigh the specimen plus ring plus plate.
5. Centre the porous stones on the top and bottom surfaces of the test specimen. Place the filter papers between porous stones and soil specimen. Press very lightly to make sure that the stones adhere to the sample. Lower the assembly carefully into the base of the water reservoir. Fill the water reservoir with water until the specimen is completely covered and saturated.
6. To prevent movement of the ring and porous stones, place the load plate centrally on the upper porous stone and adjust the loading device.
7. Adjust the dial gauge to a zero reading and record the consolidation dial readings with the times.
8. Use different pressures include load 5, 10, 20, 40, 80, 160, 320 and 640 Kg/m2 with reading time each 15 sec.

The students are able to conclude the following:

1- Determine the unconfined compressive strength (q_u).

7- Pocket Test:

Purpose: Used to determine the unconfined compression strength for undisturbed samples.

Equipment:

1- Smooth spatula,
2- Graduated device to measure the unconfined compression strength.

Test Procedure:

1- Put the graduated device perpendicular to the sample surface.
2- Press on a certain point on the surface to a certain sign on the graduated device.

The students are able to conclude the following:

1- Determine the unconfined compression strength.

8- Consolidation Test:

Equipment:

1- Consolidation (Odometer) cell: (ring, porous stones, water reservoir, and load plate),
2- Loading arm with base and weights.
3- Dial gauge to measure compression or swelling of the sample.

Test Procedure:

1- Extrude the undisturbed soil sample from the sampler (Shelby tube) then determine the type of soil, initial moisture content and the specific gravity of the soil.
2- Weigh the empty consolidation ring together with plate.
3- Place the sample on the consolidation ring and cut the sides of the sample to be approximately the same as the outside diameter of the ring as in figure 32. Rotate the ring and pare off the excess soil by means of the cutting tool so that the sample is reduced to the same inside diameter of the ring as in figure 33, make sure that there is no void space between the sample and the ring.
4- Measure the height (Hi) of the ring and it's inside diameter (d) and weigh the specimen plus ring plus plate.
5- Center the porous stones on the top and bottom surfaces of the test specimen. Place the filter papers between porous stones and soil specimen. Press very lightly to make sure that the stones adhere to the sample. Lower the assembly carefully into the base of the water reservoir.
6- Fill the water reservoir with water until the specimen is completely covered and saturated.
7- To prevent movement of the ring and porous stones, place the load plate centrally on the upper porous stone and adjust the loading device.
8- Adjust the dial gauge to a zero reading and record the consolidation dial readings with the times.
9- Use different pressures include load 5, 10, 20, 40, 80, 160, 320 and 640 Kg/m2 with reading time each 15 sec.

The students are able to conclude the following:

1- Determine the magnitude and rate of volume decrease of clayey soil**.**