Palestine Polytechnic University

College of Engineering

Environmental Technology Engineering

Effect Of Organic And Inorganic Waste On Soil Properties Of Daily Covering Soil In Almynia Landfills

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Submitted to the college of engineering in partial fulfillment of the requirements for the bachelor degree in environmental technology engineering

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Dec,2017

الإهداء

إلى ينبوع العطاء الذي زرع في نفوسي الطموح والمثابرة ، والدي العزيز بشير

إلى الربيع الذي لا ينضب .. أمي الغالية نداء

لزوجي الحبيب محمد الذي خلق لي أجواء جيدة للقيام بهذا العمل و ساندي و كان عوني و مصدر ثقتي.

لامي الثانية التي لم تبخل علي بالعطاء و ام الغالي ،، ردينة.

إلى إخواتي وأخواتي الذين ساعدوني بالقيام بمسؤولياتي مجى ، دعاء ، صفاء ، ديمة ، صهيب ، احمد ، مؤمن .

لبناتي الرائعات حبيبة و ردينه .

إلى أرواح الشهداء الذين ضحوا بأرواحهم من أجل الأقصى.

لأولئك الذين ضحوا بحريتهم من أجل حرية الأخرين للسجناء والمعتقلين ،،

إلى كل عشاق العلم والمعرفة ،،

لأستاذي القدير الدكتور نبيل الجولاني أهدي هذا العمل.

شكر و تقدير

قال صلى الله عليه و سلم : (من لا يشكر الناس لا يشكر الله).

أتقدم بالشكر و الامتنان إلى مشرفي الدكتور نبيل الجولاني لدعمه و إرشاده الذي لم يتوقف ، والذي لولاه لما وصلت إلى وصلت إليه.

و اتقدم بالشكر الجزيل لصديقاتي الرائعات ،، اللواتي لم يتركنني في أي لحظة من لحظات دراستي و اخص بالذكر صديق الغالية هيا الجعبري.

كما اتقدم بالشكر الجزيل للجامعة و العامين فيها و أخص بالذكر الأساتذة في مختبر التربة لتقديمهم المساعدة و التسهيلات و خاصة الاستاذ جبريل الشويكي و المعلمة افنان الكركي.

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Abstract

This study investingate the possibility of using organic and inorganic materials with the sand clay soil for daily coverage in Almynia landfill in Palestine , different percentage of selected organic materials (wood chips , food waste) and inorganic materials (lime slurry waste , glass) were used was used with the sandy soil and several tests were conducted on the soil to investigate the effect.

The research variable were on :

1- one type of soil.

2- percentage of organic and inorganic (10% , 20% and 30%).

3- Tests (shear strength , permeability and compaction test)

The result of this revealed that organic materials continuously decreased shear strength , increase permeability and decrease maximum dry density with increase of moisture content.

The inorganic material increased shear strength , increased maximum dry density with decrease moisture content.

الملخص

بحثت هذه الدراسة في إمكانية استخدام المواد العضوية وغير العضوية مع التربة الطينية الرملية للتغطية اليومية في مكب الميتيا في فلسطين .و ذلك بخلط نسب مختلفة من المواد العضوية (فواكه و نجارة الخشب) و مواد غير عضوية (زجاج و ربو) مع التربة الرملية وأجريت عدة اختبارات على التربة للتحقق في تأثير.

كان متغير البحث على:

١- نوع واحد من التربة.

٢- نسبة العضوية وغير العضوية (١٠٪، ٢٠٪ و ٣٠٪).

٣- الاختبارات (قوة القص، نفاذية واختبار الضغط)

وأظهرت نتائج ذلك أن المواد العضوية انخفضت بشكل مستمر من قوة القص وزيادة النفاذية وتقليل كثافة الجفاف القصوى مع زيادة محتوى الرطوبة.

المواد غير العضوية زيادة قوة القص، وزيادة أقصى كثافة الجافة مع انخفاض محتوى الرطوبة.

Chapter one

Introduction

1.1 General

Every day produces a large amount of municipal solid waste , the term "waste " is defined as any material that is discarded , abandoned , or is not of any economical value. waste can be classified into solid or liquid with many other intermediate categories (for example semi solid , semi liquid). Solid waste is one of the most critical one from waste management point of view .the way to disposed solid waste is by collection then separation and send to the landfill , so that there is waste treatment and the landfill must cover all disposed waste at the end of each day to avoid unpleasant odors and possible fires that occur The US federal regulations requires at least 6 inches of soil cover every day. and the soil is obtained by either drilling test pits in the vicinity of the landfill or imported from abroad to protect the environment and human [1].

While cover consisting of six inches of soil is effective in protecting human health and the environment. costs of excavating, loading and hauling on-site soil; the cost of procuring off-site soil; and impeding the movement of landfill gas and leachate

Daily cover is an essential component of landfill operations and has several environmental functions , Types and quantities of material selected for daily cover must be suitable for each landfill to achieve the overall goal is to control the problems that may occur [1].

Operational waste dumps represent a dynamic work environment should be monitored and managed on an ongoing basis for long periods to achieve a comprehensive environmental control, and after the first deposition amount of waste in the last day are placed daily cover material to receive the new amounts of waste in the next day [2].

The residual waste left for longer periods of a week or so. is used as a daily cover material with a thickness greater than the previously used and is the called intermediate cover material, and a residue of these waste left for more than months, is used for the so-called temporary capping before the final stage [2].

Number of develop means waste can be useful .These means include improvement of the geotechnical properties of the waste bottom sediment by means of soil stabilization. The purpose of soil stabilization is to reduce permeability and improve compressibility, structural quality and workability of the municipal solid waste in order to reduce the problems of settlement to landfills reclamation[3].

The methodology that used in landfill is Compaction, which is a process to reduce voids and increase the density and shear strength of the material by using mechanical process [3].

This research will consists of mixing organic and inorganic materials with the soil used for daily coverage in Al Mynia landfill. The organic materials are selected from peel of fruits such as oranges, apples and bananas mixed with wood chips added to the soil at different percentages. The inorganic materials used consist of stone slurry waste that will be added to the soil as powder and test their effect on soil compaction, shear strength and permeability.

1.2 Problem Statement

The lack of quantities of daily covering soil in landfill operation is becoming a real threat. In many landfill the waste itself sometimes is mixed with covering soil and used as covering material, the development and innovation of new covering material for daily use in landfill may extend of the operation life of landfills and reduce the exploitation of clay soil which is important for agriculture and the environment .This research will investigate the effect of organic and inorganic materials on prosperities of daily covering soil.

1.3 Objectives

The main objective is to investigate the effect of organic and inorganic waste on shear strength , compaction and permeability properties of landfill covering soil .

Research variables

1. One type of soil(AL Mynia covering soil)
2. Organic waste (10 , 20 & 30 weight percentages).
3. Inorganic waste (10 , 20 & 30 weight percentages).

The main tests to be carries out are :

a) Shear strength test (Direct shear).
b) Compaction test.
c) Permeability test (Constant head).

1.4 Research Methodology

1- Al Mynia Landfill has been Visited, and an observe of the process of daily covering took place.

2- Quantities of the soil used for daily covering was collected.

3- The soil was tested to establish its main properties, such as specific gravity, gradation sieve analysis, compaction shear, strength, and permeability.

4- The soil was tested by adding organic waste with different weight percentages (e.g. food waste and woodchips).

5- The soil was tested by adding inorganic waste (e.g. stone slurry waste and glass). With different weight percents.

6- The test results of the soil was compared before and after adding the different types of waste.

7- The necessary analysis, comparison, and discussion of result was made.

8-The necessary conclusions and recommendation was made.

1.5 Limitation

Note that the properties of soil that result from this research is only for AlMyina landfill soil and it may be different if other type of soil is used for daily covering of waste.

1.6 Action Plan

This work in this research will be implemented in two stages over two semesters . The action plans with different tasks for the two stages are illustrated in Table (1.1) and Table (1.2).

Table (1.1) Action plan for the first semester 2016.

TASKS	September				October				November				December			
	W 1	W 2	W 3	W 4	W 1	W 2	W 3	W 4	W 1	W 2	W 3	W 4	W 1	W 2	W 3	W 4
Identification the project idea																
Visit almynia landfill																
collecting samples of soil from the landfill																
Literature review																
Testing of soil																
Analysis of result																
Writing the report and submission																

Table (1.2) Action plan for the second semester 2017.

TASKS	February				March				April				May			
	W 1	W 2	W 3	W 4	W 1	W 2	W 3	W 4	W 1	W 2	W 3	W 4	W 1	W 2	W 3	W 4
Literature Review																
Testing the soil by adding organic waste																
Testing the soil by adding inorganic waste																
Analysis of test results and discussion																
Writing the project report and submission																

Chapter Two

Literature Review

2.1 Introduction

Solid waste management is one of the basic essential services that must provided by municipal authorities in the country ,to keep urban areas clean. However, it is among the most bad provided services in the basket the systems applied are unscientific, old and inefficient, cover ratio of the people is low, and the poor are marginalized. Waste is littered all over resulting in insanitary living conditions[4].

one of the ways that the municipals take to dispose the wastes is the landfills , In the past, a lot of problems related to landfills occurred as a result of non engineered facilities and bad management. It is essential that issues outlined in landfill manuals are considered in the design and the development of the landfill[5].

There are many possible environmental problems are associated with the landfilling of waste. These problems may be long-term and include possible contamination of the surface and groundwater water systems, the out control of migration of landfill gas and the generation of odors, noise and visual nuisances [5].

2.2 Landfill

The landfill is a site used for disposal of solid material by burial in the ground that is licensed as a landfill under the Environmental Protection Act 1986[6].

Landfill has been widely used especially in developing countries for municipal solid waste to dispose wastes all .if adequate land is available it will be dependable and cost effective method. However, severe environmental impacts such as groundwater pollution and nuisance odor will created if a wrong management and operation of landfill happened ,example Almynia landfill as shown in Figure (2.1) [2].

minimize the exposure to human and environment and store or contain the wastes are the main aims of traditional landfill design[2].

Figure(2.1) : Almynia landfill.

2.2.1 Landfill site design

A good design for a landfill site will reduce or prevent the negative effects on the environment and human health which arising from the landfill of waste[5].

In the design of the landfill, it must taken into account that to be away from the surface and underground water sources in order to avoid leakage of leachate.

The main objectives of the design of landfill that need to be taken into account in the design of a landfill. *Management systems for the control of leachate, gas, groundwater* , surface water and the design of engineering works taken the lining and capping systems into account.

Good Site design includes estimates of boundaries for the active fill area and the buffer zones, digging requirements in the active fill area, and final contours for the completed landfill. Various site improvements are required, may it will include access roads onto the site, and extending required utilities to the site [7].

The components of landfill are :

1-Surface/ Protection Layer.

2-Drainage Layer.

3- Composite Barrier.

4-Gas Collection Layer.

5-Foundation Layer.

6-Waste.

2.2.2 The most important aspects to be considered in landfill design as the following:

1- Nature and quantities of waste

The type of waste in the landfill and quantity determines the actions needed to deal with the waste, and the failure of hazardous waste and non-hazardous in terms of the different measures and the nature of the landfill to accept the waste.

2- Water control

It is to control the amount of leachate generated and to prevent leakage into the groundwater and surface water sources, and polluted water bundled must be processed before being discharged.

3- Protection of soil and water

The layer mode to protect the soil from leakage and groundwater and surface water, as appropriate to the desired thickness and permeability, The layer system may consist of a natural or artificially established mineral layer combined with a geo-synthetic liner.

4- leachate management

Pipes are placed in the base of the landfill to collect the leachate and not released into the soil, you must make sure from pipes efficiency .The leachate pipe linked to a tube assembly with a pipeline to transport and treatment [5].

Factor affecting leachate quality:

leachate quality depends on varies parameter such as waste age , moisture, oxygen content , and depth of waste ,as shown in Table (2.1) each parameter and it's percentage .

Table (2.1) : landfill leachate parameter [8].

Parameter	Landfill leachate
pH	7.14
Electrical conductivity (E.C) (ds/m)	15.74
Na^{+} (mg/l)	800
Ca^{+2} (mg/l)	1800
Mg^{+2} (mg/l)	39
K^{+} (mg/l)	185
Cl^{-} (mg/l)	3400
$SO4^{-2}$ (mg/l)	150
$NO3^{-}$ (mg/l)	39
Cu (mg/l)	10
Zn (mg/l)	120
Pb (mg/l)	5
Cd (mg/l)	0.9
Ni (mg/l)	1
Hg (mg/l)	0.7
TDS (mg/L)	17065

5- Gas Control

Landfill gas is composed of a mixture of hundreds of different gases. By volume, landfill gas typically contains 45% to 60% methane and 40% to 60% carbon dioxide. Landfill gas also includes small amounts of nitrogen, oxygen, ammonia, sulfides, hydrogen, carbon monoxide, and non-methane organic compounds such as trichloroethylene, benzene, and vinyl chloride [9].

Approximately 1.87 m3 of landfill gas is produced per one kilogram of degraded organic carbon (with a content of 50 percent CH_4)[10].

landfill gas produce

There are three sources of gases production in landfill as follows :

1- bacterial decomposition

The most of methane gas produced from the decomposition of organic waste , which is presented in the waste and soil on the cover , by bacteria in four phases , the decomposition and the gases produced during each phase .

the organic waster include food, street sweepings, garden waste, wood and textiles and paper products.

2- Volatilization it released gases

when the organic wastes changes from liquid or solid to vapor state. It may released Non-methane organic compounds .

3- Chemical reactions

Like Non-methane organic compounds which created by the reactions between some chemicals in waste. For example a harmful gas is produced when there is a reaction between chlorine bleach and ammonia in the landfill .

The quantities of gas production in landfill affected by characteristics of the waste (e.g., composition and age of the waste) and a number of environmental factors (e.g., the Availability of oxygen in the landfill, moisture content, and the temperature),such as:

1- Waste composition

Increasing amount of organic waste lead to release more landfill gases by bacteria during decomposition, volatilization and chemical reactions.

2-Presence of oxygen

Methane will be produced only when oxygen is not available in the landfill.

3-Moisture content

Gas production will increases if the moisture content increase in a landfill because it promote bacterial decomposition and chemical reactions which produce gases.

4- **Temperature** the gas production increase when the landfill's temperature increase , Because the bacterial activity and the rates of volatilization and chemical reactions increases with temperature [11].

2.3 Landfill cover

Applying a cover to a landfill surface is a part of a complex ranges of overlapping environmental control processes that must be occur on the landfill sites. Covers have a potential to solve some environmental problems. the selection of an appropriate cover material will need consider the characteristics of the cover material, the type of waste and the objectives of applying a cover.

The objectives of applying a landfill cover as the following :

1. To prevent windblown litter.
2. To prevent odors.
3. To avoid attracting birds to the site and prevent the air space above it.
4. To prevent vermin from being attracted the site.
5. To prevent flies from infesting the site.
6. To minimize the risk of fire on or within the site.
7. To ensure the visual appearance of the site[12].

2.3.1 Types of landfill cover

There are different types of covering during landfill operation according the stage of operation

1-Daily Cover : will explained in another section , and it is showing in Figure (2.2).

Figure (2.2) : Daily covering[11].

2- Intermediate Cover

Refers to put a suitable, adequate and suitable material (at the minimum 300 mm if soil is used) over deposited waste for a period of time before temporary capping or before of dispose a further wastes and it is shown in Figure (2.3) .

Figure (2.3) : Intermediate cover [11].

3- Temporary Cover

Refers to the providing of a temporary capping system, (at the minimum 0.5 m thickness), including a gas barrier membrane, to allow for settlement prior to the stallation of the final capping system. A sacrificial gas barrier membrane should also be laid on the interfaces between the cell being covered and the future cells.

4- Final Cover

Refers to provision of a permanent capping system across the top of the deposited waste to act as barrier and restoration layer between the external environment and the body of waste.

The fallowing figure (2.4) shows the stages of waste covering in landfill .

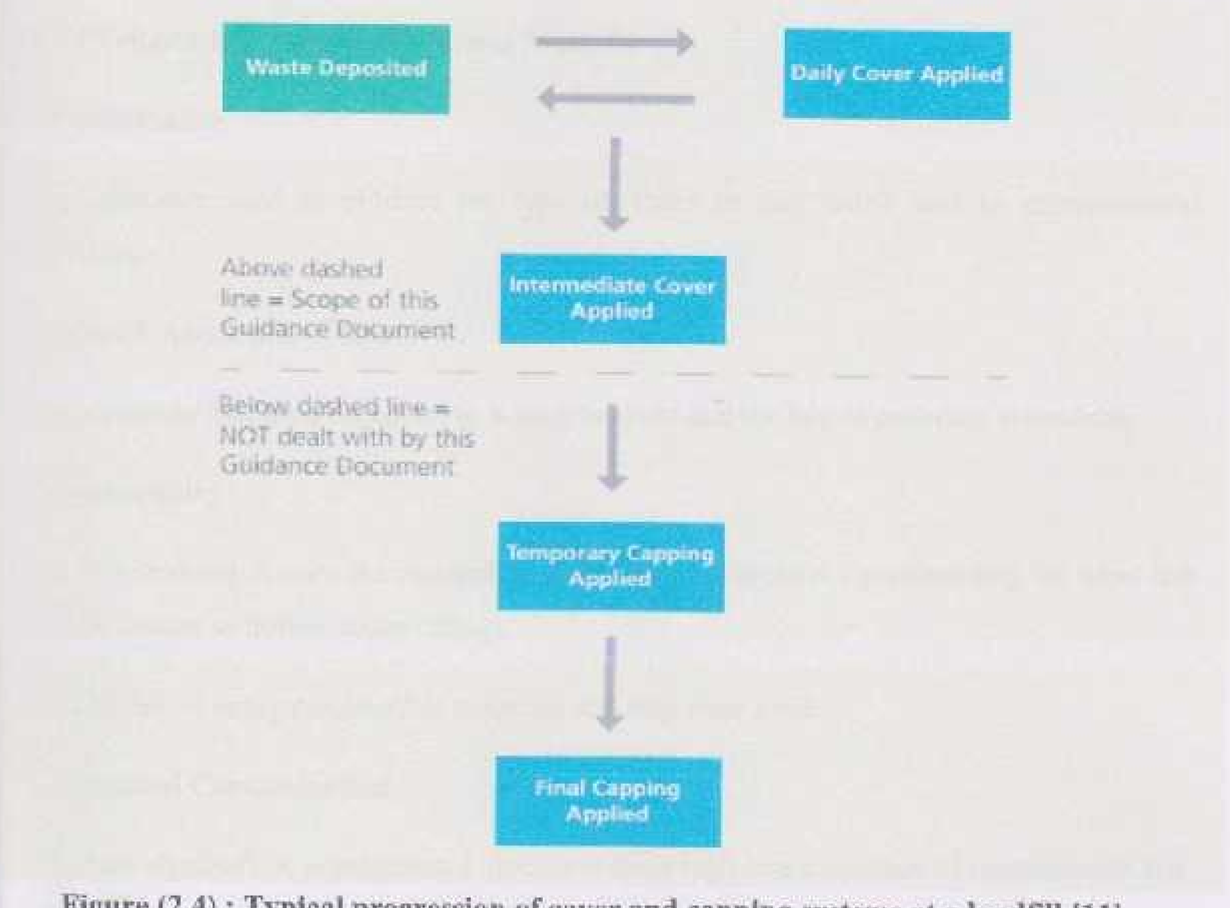


Figure (2.4) : Typical progression of cover and capping systems at a landfill [11].

2.3.2 Daily covering

Is a term used to describe material (about 150 mm if soil cover is used) spread over deposited waste at the end of each working day. Appropriate synthetic materials may also be used.

The main purposes of daily cover as the following :

1-To reduce Litter.
2-To reduce Odors.
3-To reduce Dust.
4-To reduce Flies.
5-To reduce Birds [7].

2.3.3 Criteria For Selection Of Cover Material

1-Performance

The substance used to produce the type of waste or dust didn't lead to environmental problems.

2-Ease Of Application / Removal.

The substance that used for covering is easy to apply and the buy of materials is available.

3-Permeability

The free draining is even the perched leachate does not become a problem (e.g. on areas that will be subject to further waste filling).

Availability of easily combustible materials and may pose a risk.

4- Chemical Contamination

Materials shouldn't be contaminated ,doesn't contain high concentrations of contaminants and there is no cross-contaminated materials and hazardous toxic Can it be replaced.

5-Traction Needs Of Vehicles

If there is material support to transport vehicles

6-limitations

some materials need special attention to the preservation and storage and there is materials affected by conditions lead to damage such as high winds.

7-Cost

some materials need a high cost in the procurement of materials and transported to the site.

8-Compliance With Legislation

their is some substance of the proposed cap in line with legislation and other didn't [11].

2.4 Soil in landfill

Soils are the traditional materials for Municipal Solid Waste landfill daily covers, but their performance is debatable, particularly in consumption of the valuable landfill space The use of waste materials, which should be disposed of to landfills, as landfill daily covers encourages the practice of waste recycling and thereby prolongs the life of existing landfills. In addition, it also provides a practical solution to places where suitable soils are not readily available [13].

In general, the main objectives of a landfill cover soil is to prevent of greenhouse gas emissions and minimizing the leachate production. The cover soil properties like the bulk density, air capacity and soil thickness, which will minimize the leachate production may conflict with the physical properties which is necessary to drain greenhouse gases emissions. The landfills which have good gas exchangeable properties may will not minimize percolation. If the soil has low gas exchangeable in order to reduce percolation, so a separate ventilation method should be provided [14].

2.4.1 Soil definition

is an important part of the biosphere and reflect an intermediary in the transfer of chemicals and substances in the atmosphere, hydrosphere and the living beings and the most important part of it is the productivity ,to maintain the survival of agricultural and environmental functions[15].

There are two basic soil groups

1- Cohesive soil : Are small soil particles and grains crystallized coherent. The size of particle less than 0.002mm , it is used in embankment fills [14]. The cohesive soil has low permeability.

2- Granular: particle size range from 0.003 to 0.08mm (sand) and 0.8 to 1.0mm (fine to medium gravel) .And the soil is known to drain the water[14]. In the case of sand and gravel can get maximum density in the dry state and saturated, testing curves are relatively flat so density can be obtained regardless of water content[16].

2.4.2 Soil profile

Is a vertical cross-section, and upon detection of soil layers become clear .Each layer to be different from other physical or chemical methods and variations are developed based on the various interactions of the components , slope, native vegetation, weathering, and climate, When examining the layers are at a depth of 3-5 feet [15]

Soil horizon:

There are three primary layers of the soil is called the main layers of the soil which A, B, C These are part of a system for naming soil horizons in which each layer is identified by a code: O, A, E, B, C, and R.

The O horizon is an organic layer made up by the decay of the remains of plants and animals

The A horizon Usually called topsoil and is the top layer where the accumulation of organic material, With the passage of time lose these soil characteristics, including metal and because of leachate.

The E horizon the color of the E horizon is very light. This horizon usually occurs in sandy forest soils with high amounts of rainfall.

The B horizon it is the layer found is in the ground and it's also called accumulation layer, the organic matter accumulated due to the leachate chemical material .

The B horizon has less organic matter and more clay than the A horizon. Together, the A, E, and B horizons are known as the slum. This is where most of the plant roots grow.

The C horizon is called the substratum, It is usually absorbs a layer properties ,A and b ,it is the parent layer of the soil.

The R horizon is the underlying bedrock, such as limestone, sandstone, or granite. It is found beneath the C horizon , the layer is shown in Figure 2.5.

Figure (2.5): Primary soil profile[15].

2.4.3 Soil compaction

It is used to control the behavior of the soil in order to improve the qualities and characteristics by adjusting the mechanical or chemical properties.

Mechanical modification is a way to increase the density and shear strength and reduce settlements [14].

Why compact?

There are five principle reasons to compact soil as :

1- Increases load-bearing capacity.

2- Prevents soil settlement and frost damage.

3-Provides stability.

4- Reduces water seepage, swelling and contraction.

5- Reduces settling of soil , as shown in Figure (2.6) [16].

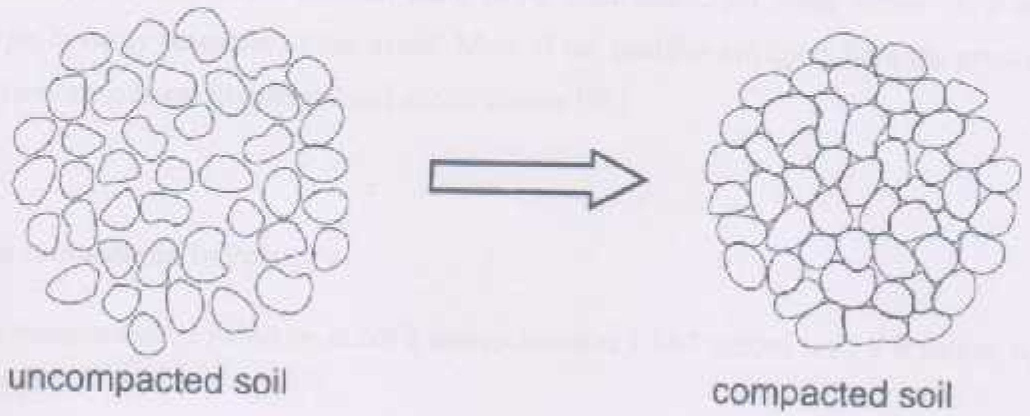


Figure (2.6) : Compacted soil via un-compacted[23].

Types of compaction

There are four types of compaction effort on soil:

1-Vibration.

2- Impact.

3- Kneading.

4- Static pressure [16].

2.5 Solid waste

Solid waste is a byproduct of human activities which tends to increase with rapid urbanization, improved living standards and changing consumption patterns. The waste is generated during industrial processing, institutional and developmental activities. There are two components of solid waste i.e. Biodegradable and Non-Biodegradable. The decomposable *organic matter, such as vegetables, fruits; food materials, etc are the Biodegradable waste*[13].The *dry* materials like glass, metal, leather, textile, paper packing material, house hold wastes are Non-Biodegradable waste. Generally, the higher the economic development and rate of urbanization, the greater the amount of solid waste produced [17] .For many decades, land filling has been favored as a method of waste disposal for a number of reasons, often because it is probably the cheapest available method and also as a result of the availability of holes in the ground. Land filing with Municipal Solid Waste is a common practice in many countries of the world. Most of the landfills are open dumping grounds, and they pose serious environmental and social threats [18].

Waste composition in Palestine

Waste composition in Palestine in 2012 was estimate at 1.387 million ton , it is shown in Figure (2.7) .

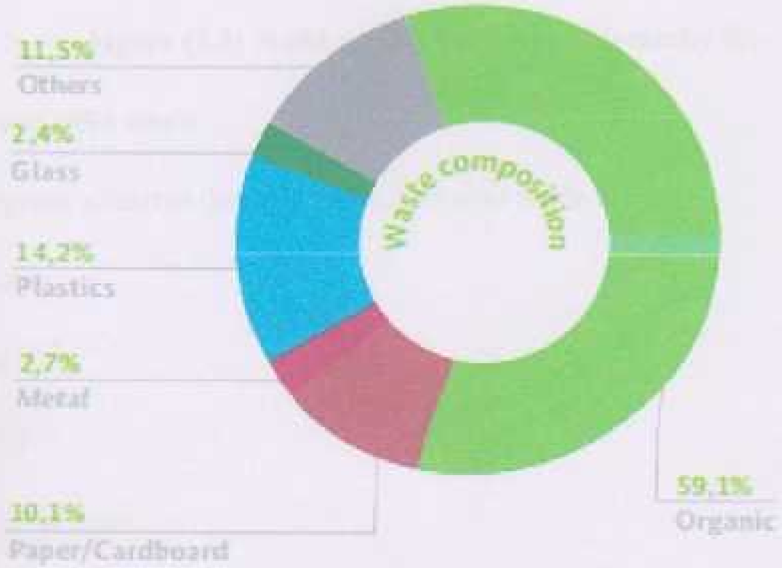


Figure (2.7) : Waste composition in Palestine[18].

2.5.1 Solid Wastes and its Management in Palestine

Palestine is not like other countries; it has its special situation because of the Israeli occupation. The closure and segregation of the main roads of the Palestinian, leading to complicate the solid waste management problem and resulted in the usage of alternative uncontrolled dumping sites which may be polluted the soil and the ground water, solid waste management hierarchy show in Figure (2.8) [6].

Figure (2.8) :Solid waste mangemant hierarchy [6].

2.5.2 Sources of solid waste

In most emergency situation the main sources of solid waste are:

1-medical center

2-food stories

3-feeding center

4-food distribution point

5-wearhouses

6-markets[19].

Types of solid waste

Solid waste can be divided by source into four categories which are municipal solid waste, industrial solid waste, sewage sludge, agricultural wastes, and mining waste [6].

1. **Household wastes :** the wastes that generated from houses, restaurants and hotels.
2. **Agricultural wastes:** including plant and organic wastes.
3. **Industrial wastes.**
4. **Wastes of construction activities and various installations.**

Other types of wastes:

1- Hazardous Wastes : It is from the chemical industries such as the chemical compounds, mineral and water solutions, mercury compounds, electronic industries and paper industry.

2- Medical Wastes : These are the garbage of hospitals, medical laboratories, private clinics . The waste containers used syringes, tubes, and containers.

3- Biological Pesticides : These are used to protect humans, animals and plants from the harmful effects that result from some insects, rodents, noxious herbs, fungi, and bacteria. The biological pesticides are very important because it increase the agricultural production; Gaza Strip alone uses 100 tons of pesticides [6].

Table (2.2) shows the percentage of waste collection and final destination in Palestine.

Table(2.2) : Municipal solid waste percentages [18].

Municipal Solid Waste Collection Coverage	
- Rural areas	88%
- Urban areas	93%
Municipal Solid Waste Final Destination	
-Composted	less than 0.5%
- Recycled	less than 0.5%
- Land filled	33%(42%WB, 22% GS)
- Openly dumped	67%
-Number of Dumpsites:	163
-Number of Controlled Landfills:	-
-Number of Sanitary Landfills:	-
- Planned	2
- Under construction	1 (GS)
- Constructed	1
- Operational	3 (2 WB, 1 GS)

2.5.3 Municipal solid waste composition

Waste composition is one of the main factors influencing emissions from solid waste treatment, as different waste types contain different amount of degradable organic carbon and fossil carbon. Waste compositions in Municipal Solid Waste vary widely in different regions and countries [5].

Composition of Organic Municipal Solid Waste

MUNICIPAL SOLID WASTE stream is diverse and contains a variety of organic and inorganic materials. Usually organic parts include food waste, leaf and yard waste.

Food Waste

Food waste represents a large part of organic material found in residential waste. primarily It is generated by the residential and Industrial, commercial, and institutional sectors, and can be either post-consumer, originating from residential and commercial kitchens (i.e., restaurants and hospitals), or pre-consumer, coming from distribution and retail agents (i.e., transporters and supermarkets). Food waste has a high moisture content, which can lead to the generation of leachate and odors during handling and processing[20].

2.5.4 Solid waste leachate

Leachate may be defined as any liquid percolating through the deposited waste and emitted from or contained within a landfill. This leachate picks up suspended and soluble materials that originate from or are products of the degradation of the waste. If this leachate is allowed to migrate from the site it may pose a severe threat to the surrounding environment and in particular to the groundwater and surface water regimes and in Figure (2.9) can show Leachate pond.

Effective environmental protection requires an understanding of the composition and volumes of leachate being generated and the implementation of control measures. The composition of leachate within a landfill is unique as the characteristics of the leachate will vary depending on the wastes deposited [8].

The main factors that influence the generation of leachate include:

1-meteorological conditions at the site

2-waste composition

3-waste density

4-waste age

5- depth of landfill

6-moisture content

7- rate of water movement[8].

Figure (2.9): leachate pond.

2.5.5 Almynia landfill

The central waste dump of Hebron and Bethlehem governorates in the Minya area south of Bethlehem. The landfill consists of 8 cells for landfill and the area of each cell is about 25000 m, Witch Benefit over 800,000 people in the southern West Bank.

The land fill Consisting of four cells and a special pool to collect the leatchate.

The daily waste weights to more than 600 tons of waste are produced in Hebron and Bethlehem governorates[24].

Figure (2.10): Almynia landfill position.

Chapter Three

Materials and Testing

3.1 Materials

3.1.1 soil

The soil used in this research is collected from Almynia landfill area, and it is used for daily covering in the landfill. Different types of tests carried out on the soil to establish its prosperities , as will be shown later in this chapter.

3.1.2 Organic waste

The organic waste used in this research is selected from food waste, woodchips. A brief description of each of the selected waste is presented below:

A. food waste

Dumping food waste in a landfill causes odors as it decomposes, attracts flies and vermin, and has the potential to add biological oxygen demand to the leachate. removing the organic wastes away from the landfills disposal is preferred [17].

In this experiments, It has been used fruit waste as an example of food waste , in our Experimental tests the follows were used : Oranges, Bananas and Apples. Drying the organic waste and cutting it into small pieces and dried it on the oven.

B. woodchips

The enormous amount of waste woods dumped into landfills every year which come from the houses, markets and the highest quantity is from wood cutting.

The wood chips was brought from carpentry, it is a small pieces of wood, it was used as an example of paper trees and garden wastes, it has been dried also on the oven .

The organic mixed by 50 percent food waste and 50 percent woodchips.

3.1.3 Inorganic waste

The inorganic waste used in this research consist of two types as follows:

A. Stone slurry waste (lime stone)

The stone slurry waste is the most abundant type of waste available in Palestine. The stone slurry waste cause a tremendous environmental pollution and cause threat to human, animals and plants.

In this research we get the stone slurry waste from the Quarries , and dried on the oven, then grinding it to make easy when it used.

B. Glass

Glass makes up a large component of household and industrial waste due to its weight and density. The glass component in municipal waste is usually made up of bottles, broken glassware, light bulbs and other items [21].

In this research glass grinded by Los Angeles machine into a powder before mixing with covering soil.

The inorganic mixed by 50 percent glass and 50 percent stone slurry.

3.2 Testing of soil only .

In this study we will study some prosperities of soil ,then the same tests will be carried out by mixing the soil with organic and inorganic materials. All tests carried out on the soil are according to the standard [22].

3.2.1 Specific gravity

The specific gravity of a given material is defined as the ratio of the weight of a given volume of the material to the weight of an equal volume of distilled water. In soil mechanics, the specific gravity of soil solids (which is often referred to as the specific gravity of soil) is an important parameter for calculation of the weight-volume relationship. Thus specific gravity, G" is defined as equation (1) or (2) .

$$G_s = \frac{\text{unit weight (or density) of soil solids only}}{\text{unit weight (or density) or water}} \qquad (1)$$

Or

$$Gs = \frac{Ws/Vs}{\rho 2} = \frac{Ws}{Vs*\rho s} \quad (2)$$

Where, Ws = mass of soil solids (g) .

Vs = volume of soil solids (cm3).

ρw = density of water (g/cm3).

The general ranges of the values of Gs for various soils are given in Table(3 .1).

Table (3.1) : General Ranges of Gs for Various Soils [22].

Soil type	Range of G_s
Sand	2.63-2.67
Silts	2.65-2.7
Clay and silty clay	2.67-2.9
Organic soil	Less than 2

purpose of the test

Determine the specific gravity of soil which is important in calculating void ratio, porosity, unit weight, degree of saturation.

Procedure

1. Clean the volumetric flask well and dry it.

2. Carefully fill the flask with de-aired, distilled water up to the 500 ml mark (bottom of the meniscus should be at the 500 ml mark).

3. Determine the mass of the flask and the water filled to the 500 ml mark (W1) .

4. Insert the thermometer into the flask with the water and determine the temperature of the water .

5. Put approximately 100 grams of air dry soil into an evaporating dish.

6. If the soil is cohesive, add water (de-aired and distilled) to the soil and mix it to the form of a smooth paste. Keep it soaked for about one-half to one hour in the evaporating dish. (Note: This step is not necessary for granular, i.e., non-cohesive, soils.) .

7. Transfer the soil (if granular) or the soil paste (if cohesive) into the volumetric flask.

8. Add distilled water to the volumetric flask containing the soil (or the soil paste) to make it about two-thirds full.

9. Remove the air from the soil-water mixture. This can be done by:

a. Gently boiling the flask containing the soil-water mixture for about 15 to 20 minutes. Accompany the boiling with continuous agitation of the flask. (If too much heat is applied, the soil may boil over.)

Or

b. Apply vacuum by a vacuum pump or aspirator until all of the entrapped air is out. This is an extremely important step. Most of the errors in the results of this test are due to entrapped air which is not removed.

10. Bring the temperature of the soil-water mixture in the volumetric flask down to room temperature, i.e., T1 -see Step 4. (This temperature of the water is at room temperature.)

11. Add de-aired, distilled water to the volumetric flask until the bottom of the meniscus touches the 500 ml mark.

12. dry the outside of the flask and the inside of the neck above. the meniscus Determine the combined mass of the bottle plus soil plus water (W2).

13. Just as a precaution, check the temperature of the soil and water in the flask to see if it is or not.

14. Pour the soil and water into an evaporating dish. Use a plastic squeeze bottle and wash the inside of the flask. Make sure that no soil is left inside.

15. Put the evaporating dish in a oven to dry to a constant weight.

16. Determine the mass of the dry soil in the evaporating dish (Ws).

Calculation

1. Calculate the specific gravity by equation (3)

$$G_s = \frac{\text{mass of soil, WS}}{\text{mass of equal volume of soil}} \quad (3)$$

Where,

mass of soil = Ws

mass of equal volume of water, Ww = (W1 + Ws) - W2 (4)

So,

$$G_{sT} = \frac{Ws}{Ww} \quad (5)$$

Specific gravity is generally reported on the value of the density of water at 20°C. if the temperature is different than 20°C, a correction for G_s must be applied by multiplied with A, according to Table (3.2) .

Table (3.2) : Values of A[22].

Tempreature	A	Temperature (T_1 °C)	A
16	1.0007	24	0.9991
17	1.0006	25	0.9988
18	1.0004	26	0.9986
19	1.0002	27	0.9983
20	1	28	0.9977
21	0.9998	29	0.9974
22	0.9996	30	
23	0.9993		

At least three specific gravity tests should be conducted. For correct results, these values should not vary by more than 2 to 3%. A sample calculation for specific gravity is shown in Table (3.3).

Table (3.3) : Specific Gravity of Soil sample.

Temperature	23
Mass of flask + water filled to mark, W1 (g)	640.3
Mass of flask + soil + water filled to mark, W2 (g)	702
Mass of dry soil, Ws (g)	100
Mass of equal volume of water as the soil solids, Ww (g) = (W1+ Ws) - W2	38.3
$Gs@T°c = \frac{Ws}{Ww}$	2.611
$Gs_{20°c} = Gs_{T°c}$ X A	2.609

3.2.2 Sieve analysis

In order to classify a: soil for engineering purposes, one needs to know the distribution of the size of grains in a given soil mass. Sieve analysis is a method used to deter mine the grain size distribution of soils. Sieves are made of woven wires with square openings. Note that, as the sieve number increases the size of the openings decreases. Table (3.4) gives a list of the U.S. standard sieve numbers with their corresponding size of openings in mm. For all practical purposes, the No. 200 sieve is the sieve with the smallest opening that should be used for the test.

Table (3.4) : The set of standard seives with opening in mm [22].

sieve NO.	opening (mm)	sieve NO.	opening (mm)
4	4.75	35	0.5
5	4	40	0.425
6	3.35	45	0.355
7	2.8	50	0.3
8	2.36	60	0.25
10	2	70	0.212
12	1.7	80	0.18
14	1.4	100	0.15
16	1.18	120	0.125
18	1	140	0.106
20	0.85	200	0.075
25	0.71	270	0.053
30	0.6	400	0.038

Every soil type behaves differently with respect to maximum density and optimum moisture. Therefore, each soil type has its own unique requirements and controls both in the field and for testing purposes. Soil types are commonly classified by grain size, determined by passing the soil through a series of sieves to screen or separate the different grain sizes shown Figure (3.1).

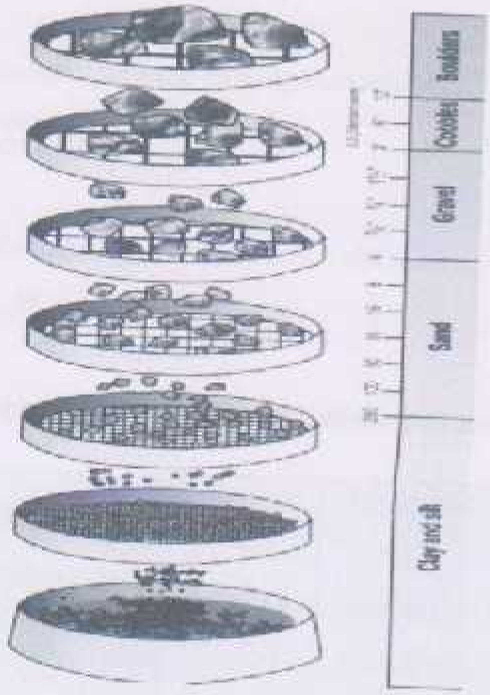


Figure (3.1) : Sieve analysis test [14].

Procedure

1. Collect a representative oven dry soil sample.
2. Determine the mass of the sample accurately.
3. Prepare a stack of sieves. A sieve with larger openings is placed above a sieve with smaller openings. The sieve at the bottom should be No. 200. A bottom pan should be placed under sieve No. 200. the sieves that are generally used in a stack are Nos. 4, 10,20,40,60, 140, and 200; however, more sieves can be placed in between.
4. Pour the soil prepared in Step 2 into the stack of sieves from the top
5. Place the cover on the top of the stack of sieves.
6. Run the stack of sieves through a sieve shaker for about 10 to 15 minutes.
7. Stop the sieve shaker and remove the stack of sieves.
8. Weigh the amount of soil retained on each sieve and the bottom pan.

Calculation

1. Calculate the percent of soil retained on the nth sieve (counting from the top)

$$\frac{\text{mass retained}, W_n}{\text{total mass}, W\ (\text{Step 2})} * 100 = R_n \qquad (8)$$

2. Calculate the cumulative percent of soil retained on the nth sieve n^{th} sieve

$\sum_{i=1}^{i=n} Rn$

3. Calculate the cumulative percent passing through the n^{th} sieve (9)

percent finer = $100 - \sum_{i=1}^{i=n} Rn$

(10)

A sample calculation of sieve analysis is shown in Table (3.5).

Mass of oven dry sample, W = 3000 g.

Table (3.5) : sieve analysis of the soil sample.

Sieve No.	Sieve opining (mm)	Mass of soil returned on each sieve, Wn (g)	Corrected of mass returned on each sieve	Percent of mass returned on each sieve, Rn	Cumulative percent returned, ∑Rn	Percent finer, 100-∑Rn
1.5	37.5	322.6	322.772	10.759	10.759	89.24
314	19	586.3	586.612	19.553	30.312	69.687
318	9.5	496.7	496.965	16.5655	46.87834	53.121
4.75	4.75	285.7	285.852	9.528	56.406	43.593
2	2	331.8	331.977	11.0659	67.472	32.527
850	0.85	332.2	332.377	11.079	78.551	21.448
425	0.425	254.8	254.935	8.497	87.049	12.95
140	0.106	263.9	264.04	8.801	95.851	4.148
200	0.075	56.9	56.93	1.897	97.748	2.251
pan	0	67.5	67.536	2.251	100	0
sum		W1=2998.4	3000	100		

Mass loss during sieve analysis = $\frac{W-W1}{W}$ x 100 = $\frac{3000-2998.4}{3000}$ x100= .0533 (OK, if less than 2%) , So we make correction of mass returned on each sieve.

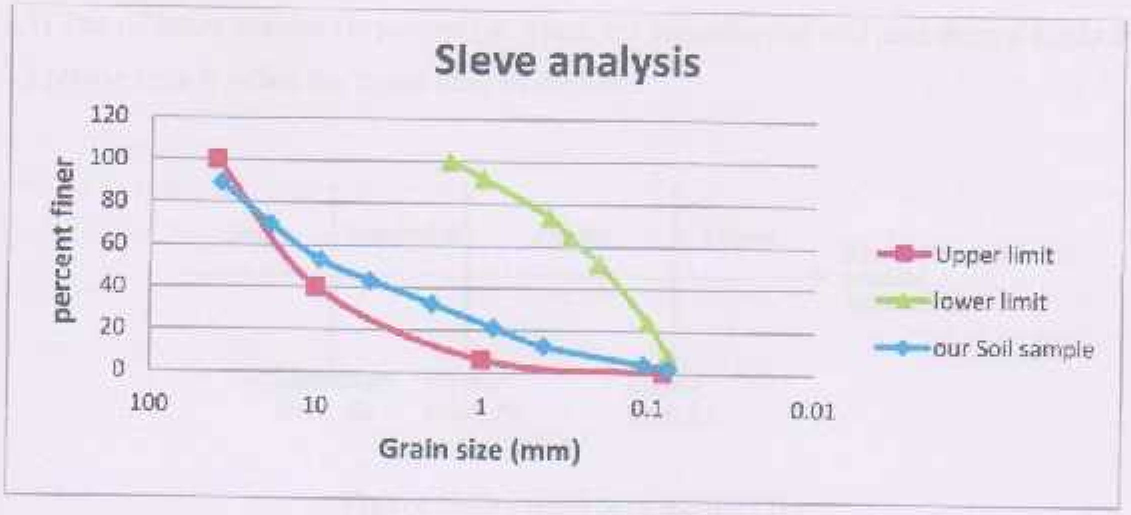


Figure (3.2) : Plot of percent finer vs. grain size for soil sample.

ther Calculations

. Determine D_{10}, D_{30}, and D_{60} from Figure. (3.2) , which are, respectively, the diameters corresponding to percents finer of 10%, 30%, and 60%

D_{10}= 0.3

D_{30}= 1.8

D_{60}= 14

alculate the uniformity coefficient (Cu) and the coefficient of gradation (Cc) using the following equations:

= 46.67 (11) $Cu = \frac{D60}{D10}$

$Cc = \frac{D30^2}{D60 \times D10}$ =0.77 (12)

3.2.3 Liquid Limit

When a cohesive soil is mixed with an excessive amount of water, it will be in a somewhat liquid state and flow like a viscous liquid. However, when this viscous liquid is gradually dried, with the loss of moisture it will pass into a plastic state. With further reduction of moisture, the soil will pass into a semisolid and then into a solid state. This is shown in Figure

(3.3) The moisture content (in percent) at which the cohesive soil will pass from a liquid state to a plastic state is called the liquid limit of the soil.

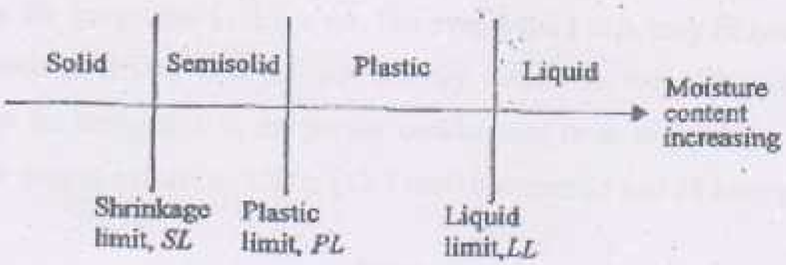


Figure (3.3) : Atterberg limits[22]

Procedure

1. Determine the mass of three moisture cans (W1).

2. Put about 250 g of air-dry soil, passed through No. 40 sieve, into an evaporating dish. Add water from the plastic squeeze bottle and mix the soil to the form of a uniform paste.

3. Place a portion of the paste in the brass cup of the liquid limit device. Using the spatula, smooth the surface of the soil in the cup such that the maximum depth of the soil is about 8 mm.

4. Using the grooving tool, cut a groove along the center line of the soil pat in the cup (Figure (3.4) a).

5. Turn the crank of the liquid limit device at the rate of about 2 revolutions per second. By this, the liquid limit cup will rise and drop through a vertical distance of 10 mm once for each revolution. The soil from two sides of the cup will begin to flow toward the center. Count the number of blows, N, for the groove in the soil to close through a distance of 1/2 in. (12.7 mm) as shown in Figure (3.4) b.

If N = about 25 to 35, collect a moisture sample from the soil in the cup in a moisture can. Close the cover of the can, and determine the mass of the can plus the moist soil (W2). Remove the rest of the soil paste from the cup to the evaporating dish. Use paper towels to thoroughly clean the cup. If the soil is too dry, N will be more than about 35. In that case, remove the soil with the spatula to the evaporating dish. Clean the liquid limit cup thoroughly with paper towels. Mix the soil in the evaporating dish with more water, and try again. If the soil is too wet, N will be less than about 25. In that case, remove the soil in the cup to the evaporating dish. ,Clean the liquid limit cup carefully with paper towels. Stir the soil paste with the spatula for some time to dry it up. The evaporating dish may be placed in the oven for a few minutes for drying also. Do not add dry soil to the wet-soil paste to reduce the moisture content for bringing it to the proper consistency. Now try again in the liquid limit device to get the groove closure of 1/2 in. (12.7 mm) between 25 and 35 blows.

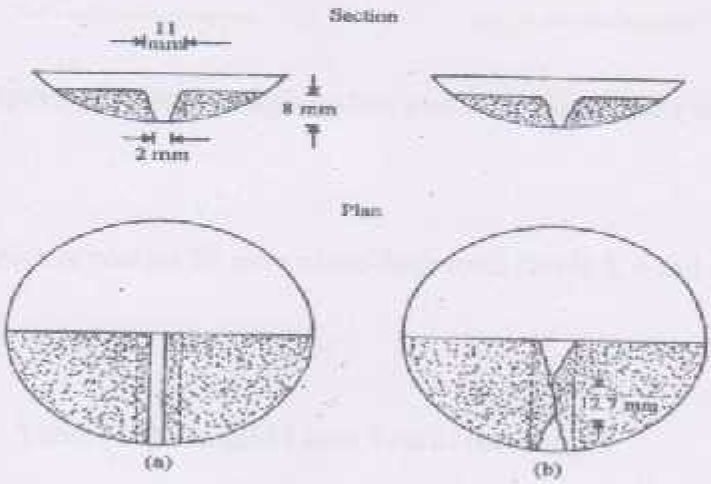


Figure (3.4) : Schematic diagram of soil pat in the cup of the liquid limit device at (a) beginning of test, (b) end of test [22].

6. Add more water to the soil paste in the evaporating dish and mix thoroughly. Repeat Steps 3, 4 and 5 to get a groove closure of 1/2 in. (12.7 mm) in the liquid limit device at a blow count N = 20 to 25. Take a moisture sample from the cup. Remove the rest of the soil paste to the. evaporating dish. Clean the cup with paper towels.

7. Add more water to the soil paste in the evaporating dish and mix well. Repeat Steps . 3, 4 and 5 to get a blow count N between 15 and 20 for a groove closure of 1/2 in. (12.7 mm) in the liquid limit device. Take a moisture sample from the cup.

8. Put the three moisture cans in the oven to dry to constant masses (W3). (The caps of the moisture cans should be removed from the top and placed at the bottom of the respective cans in the oven.)

Soil sample before dropping

soil sample after dropping

Figure (3.5) : soil sample before and after liquid limit test.

Calculation

Determine the moisture content for each of the three trials (Steps 5, 6 and 7) as

$$w\% = \frac{w2-w3}{w3-w1} \square\ 100 \qquad (13)$$

Table (3.6) : Liquid Limit Test of the sample.

Can Name	mass of can, W1	Mass of can + moist soil, W2	Mass of can + dry soil, W3	Moisture content,	Number of blows, N
5	30.6	65.6	56.7	34.099	8
CB	32	72.5	62.4	33.223	17
E17	32	65.2	57.3	31.225	25
AA	31.8	68.5	60.7	26.989	29

Liquid limit equal the average of moisture contents, for soil sample test it is equal 31.385.

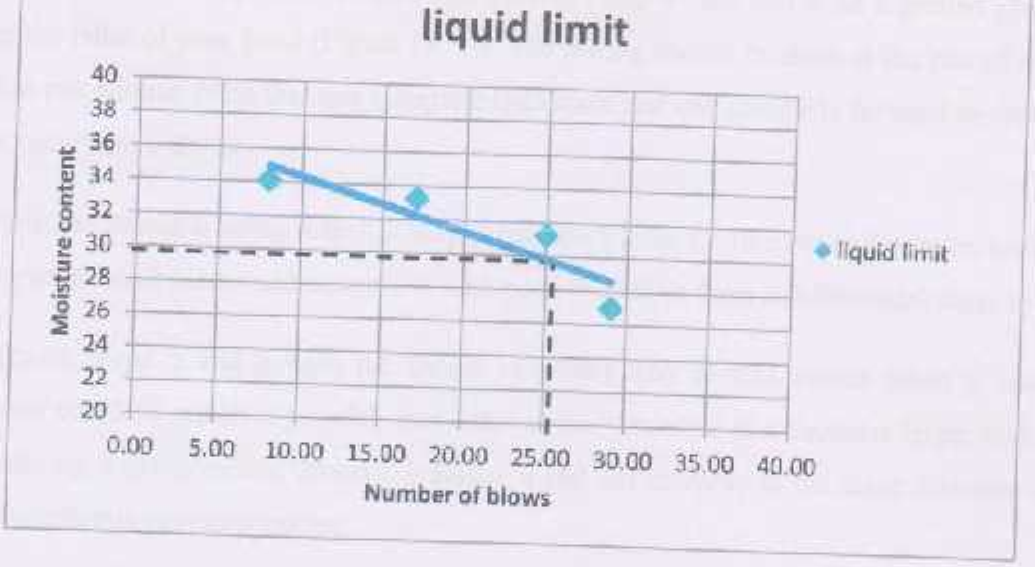


Figure (3.6) : Plot of moisture content (%) vs. number of blows for the liquid limit test results.

At N25 the moisture content is

3.2.4 Plastic limit

Plastic limit is defined as the moisture content, in percent, at which a cohesive soil will change from a plastic state to a semisolid state. In the laboratory, the plastic limit is defined as the moisture content (%) at which a thread of soil will just crumble when rolled to a diameter of%-in. (3.18 mm). This test might be seen as somewhat arbitrary and, to some extent, the result may depend on the person performing the test. With practice, however, fairly consistent results may be obtained.

Procedure

1. Put approximately 20 grams of a representative, air-dry soil sample, passed through No. 40 sieve, into a porcelain evaporating dish.

2. Add water from the plastic squeeze bottle to the soil and mix thoroughly.

3. Determine the mass of a moisture can in grams and record it on the data sheet (W1)

4. From the moist soil prepared in Step 2, prepare several ellipsoidal-shaped soil masses by squeezing the soil with your fingers.

5. Take one of the ellipsoidal-shaped soil masses (Step 4) and roll it on a ground glass plate using the palm of your hand (Figure (3. 7)). The rolling should be done at the rate of about 80 strokes per minute. Note that one complete backward and one complete forward motion of the palm constitute a stroke.

6. When the thread is being rolled in Step 5 reaches Via-in. (3.18 mm) in diameter, break it up into several small pieces and squeeze it with your fingers to form an ellipsoidal mass again.

7. Repeat Steps 5 and 6 until the thread crumbles into several pieces when it reaches a diameter of. (3.18 mm)It is possible that a thread may crumble at a diameter larger than (3.18 mm) during a given rolling process, whereas it did not crumble at the same diameter during the immediately previous rolling.

8. Collect the small crumbled pieces in the moisture can put the cover on the can.

9. Take the other ellipsoidal soil masses formed in Step 4 and repeat Steps 5 through 8.

10. Determine the mass of the moisture can plus the wet soil (W2) in grams. Remove the cap from the top of the can and place the can in the oven (with the cap at the bottom of the can).

11. After about 24 hours, remove the can from the oven and determine the mass of the can plus the dry soil (W3) in grams.

Figure (3.7) : soil sample during plastic test.

Calculations

Plastic limit $= \frac{\text{mass of moisture}}{\text{mass of dry soil}} = \frac{W2-W3}{W3-W1} * 100$ (14)

The results may be presented in a tabular form as shown in Table (3.7). If the liquid limit of the soil is known, calculate the plasticity index, PI, as :

PI=LL – PL (15)

Table (3.7): plastic limit test of the sample .

Mass of can, W1 (g)	30.9
Mass of can + moist soil, W2 (g)	78.7
Mass of can + dry soil, W3 (g)	70.5
PL = (W2-W3)/(W3-W1) X 100	20.707

Using equation 14 :

Plasticity index, PI = LL- PL

= 29.795 – 20.707 = 9.088

3.2.5 Constant Head permeability

The rate of flow of water through a soil sample of gross cross-sectional area, A, can be expressed as

Q=kIA (16)

where Q = flow in unit time.

k = coefficient of permeability .

I = hydraulic gradient.

For coarse sands, the value of the coefficient of permeability may vary from 1 to 0.01 cm/s and, for fine sand, it may be in the range of 0.01 to 0.001 cm/s. Several empirical relations between k and the void ratio, e, for sandy clay soils have been proposed such as :

$$K \alpha \frac{e^3}{1+e} \tag{17}$$

Procedure

1. Determine the mass of the plastic sample tube, the porous stones, the spring, and the two rubber stoppers (W1).

2. Slip the bottom porous stone into the sample tube, and then fix the bottom rubber stopper to the sample tube.

3. Collect oven-dry sandy clay soil in a container. Use a spoon, pour the sand into the sample tube in small layers, and compact it by vibration and/or other compacting means. Note: By changing the degree of compaction, a number of test samples having different void ratios can be prepared.

4. When the length of the sample tube is about two-third the length of the tube, slip the top porous stone into the tube to rest firmly on the sample.

5. Place a spring on the top porous stone, if necessary.

6. Fix a rubber stopper to the top of the sample tube. Note: The spring in the assembled position will not allow any expansion of the sample volume, and thus the void ratio, during the test.

7. Determine the mass of the assembly (Step 6 - W2).

8. Measure the length (L) of the compacted sample in the tube.

9. Assemble the permeability meter near a sink .

10. Run water into the top of the large funnel fixed to the stand through a plastic tube from the water inlet. The water will flow through the sample to the constant head chamber. After some time, the water will flow into the sink through the outlet in the constant head chamber.

11. Adjust the supply of water to the funnel so that the water level in the funnel remains constant. At the same time, allow the flow to continue for about 10 minutes in order to saturate the sample. Note: Some air bubbles may appear in the plastic tube connecting the funnel to the sample tube. Remove the air bubbles:

12. After a steady flow is established (that is, once the head difference h is constant), collect the water flowing out of the constant head chamber (Q) in a graduated cylinder. Record the collection time (t) with a stop watch.

13. Repeat Step 12 three times. Keep the collection time (t) the same and determine Q. Then find the average value of Q.

14. Change the head difference, h, and repeat Steps 11, 12 and 13 about three times.

15. Record the temperature, T, of the water to the nearest degree. Note: This value is sufficiently accurate for this type of test.

Calculation

1. Calculate the void ratio of the compacted sample as follows: Dry density, Υd of the soil sample as

$$\Upsilon d = \frac{W2-W1}{\frac{\Pi D^2 * L}{4}} \quad (18)$$

Thus

$$e = \frac{Gs * \Upsilon w}{\Upsilon d} - 1 \quad (19)$$

where ,Gs = specific gravity of soil solids

Υw = density of water.

D = diameter of the sample.

L = length of the sample.

H = head of water.

Calculate k as

$$K = \frac{QL}{Aht} \quad (20)$$

where A = area of sample $= \frac{\Pi}{4} D^2$

2. The value k is usually given for a test temperature of water at 20°C. So calculate k_{20} as

$k_{20°c} = k_{T°c} \frac{\eta_{T°c}}{\eta_{20°c}}$ (21)

Where $\eta_{T°c}$ and $\eta_{20°c}$ are viscosities of water at T'C and 20°C, respectively.

Table (3.8) gives the values of $\eta_{T°c}$ for various values of T (in °C).

Tables (3.9) and (3.10) give data and test result of the permeability test.

Table (3.8) : Variation of $\eta_{T°c}/\eta_{20°c}$ [22]

Temprature	$\eta_{T°c}/\eta_{20°c}$	Temprature	$\eta_{T°c}/\eta_{20°c}$
15	1.135	23	0.931
15	q.q06	24	0.91
17	1.077	25	0.889
18	1.051	26	0.869
19	1.025	27	0.85
20	1	28	0.832
21	0.976	29	0.814
22	0.953	30	0.797

Table (3.9) : Constant head permeability test data.

Length of sample, L = 20.5 cm   Diameter of sample, D = 7.6 cm

T=25 C

Volume of sample, $V = \Pi \frac{D^2 L}{4}$ (cm³)	929.503
Mass of sample tube with fittings, W1(g)	2454.8
Mass of tube with fittings and sample, W2 (g)	3761
Dry density of sample, $\gamma d = \frac{W2-W1}{V}$ (g/cm³)	1.405
Void ratio from equation (19) e =	0.86

Table (3.10) : Constant Head Permeability Test.

Test No.	1	2	3	4
Average flow, Q (cm3)	39.6	21.6	23.7	23.6
Time of collection, t (s)	600	300	300	300
Temperature of water, T (°C)	25	25	25	25
Head difference, h (cm)	118.5	118.5	124.5	124.5
Diameter of sample, D (cm)	7.6	7.6	7.6	7.6
Length of sample, L (cm)	20.5	20.5	20.5	20.5
Area of sample, $A = \frac{\Pi D^2}{4}$ (cm^2)	45.3416	45.3416	45.3416	45.3416
K (cm/s)	0.000252	0.000275	0 .00028689	0.000286
Average k = .00027477 cm/s				
$k_{20°C} = 2.44 * 10^{-4}$ cm/s				

3.2.6 Compaction Test

For construction of highways, airports, and other structures, it is often necessary to compact soil to improve its strength. Proctor (1933) developed a laboratory compaction test procedure to determine the maximum dry unit weight of compaction of soils which can be used for specification of field compaction. This test is referred to as the' standard Proctor compaction test and is based on the compaction of the soil fraction passing No, 4 U.S. sieve.

Procedure

1. Obtain about 4.5 kg of air-dry soil on which the compaction test is to be conducted. Break all the soil lumps.

2. Sieve the soil on a No.4 U.S. sieve. Collect all of the minus-4 material in a large pan. This should be about 2.7 kg or more. .

3. Add enough water to the minus-4 material and mix it in thoroughly to bring the moisture content up to about 5%.

4. Determine the weight of the Proctor mold + base plate (not the extension), W1 .

5. Now attach the extension to the top of the mold.

6. Pour the moist soil into the mold in three equal layers. Each layer should be compacted uniformly by the standard Proctor hammer 25 times before the next layer of loose soil is poured into the mold.

7. . Remove the top attachment from the mold. Be careful not to break off any of the compacted soil inside the mold while removing the top attachment.

8. Using a straight edge, trim the excess soil above the mold. Now the top of the compacted soil will be even with the top of the mold.

9. Determine the weight of the mold + base plate +- compacted moist soil in the mold, W2 .

10. Remove the base plate from the mold. Using a jack, extrude the compacted soil cylinder from the mold.

11. Take a moisture can and determine its mass, W3 (g).

12. From the moist soil extruded in Step 10, collect a moisture sample in the moisture can (Step II) and determine the mass of the can + moist soil, W4 (g).

13. Place the moisture can with the moist soil in the oven to dry to a constant weight.

14. Break the rest of the compacted soil (to No.4 size) by hand and mix it with the leftover moist soil in the pan. Add more water and mix it to raise the moisture content by about 4% .

15. Repeat Steps 6 through 12. In this process, the weight of the mold + base plate + moist soil (W2) will first increase with the increase in moisture content and then decrease. Continue the test until at least two successive down readings are obtained.

16. The next day, determine the mass of the moisture cans + soil samples, W5 (g) (from Step 13).

Calculation

Dry Unit Weight and Moisture Content at Compaction.

1. *Weight of mold, W1 to be determined from test (Step 4).*

2. Weight of mold + moist compacted soil, W2, to be determined from test (Step 9).
3. Weight of moist compacted soil = W2 – W1.
4. Moist unit weight

$$\Upsilon_{wet} = \frac{\text{weight of compacted moist soil}}{\text{volume of mold}} = \frac{W2-W1\,(lb)}{\frac{1}{30}(ft)} \quad (23)$$

5. Mass of moisture can, W3, to be determined from test (Step 11).
6. Mass of moisture can + moist soil, W4, to be determined from test (Step 12).
7. Mass of moisture can + dry soil, Ws, to be determined from test (Step 16).
8. Compaction moisture content

$$w\,(\%) = \frac{W4-W5}{W5-W3} \times 100 \quad (24)$$

9. Dry unit weight

$$\Upsilon d = \frac{\Upsilon wet}{1+\frac{W(\%)}{100}} \quad (25)$$

Table (3.11) shows the calculations for ϒ zav for the soil tested.

Zero-Air-Void Unit Weight

The maximum theoretical dry unit weight of a compacted soil at a given moisture content will occur when there is no air left in the void spaces of the compacted soil. This can be given by

$$\Upsilon d(\text{theoritical}) = \Upsilon zav = \frac{\Upsilon w}{\frac{w(\%)}{100}+\frac{1}{Gs}} \quad (26)$$

where Υ_{zav} = zero-air-void unit weight.

Υ_w = unit weight of water.

w = moisture content.

Gs = specific gravity of soil solids.

Since the values of ϒw and Gs will be known, several values of w (%) can be assumed and ϒzav can be calculated. Table (3.11) shows the calculations for ϒ zav for the soil tested and reported in Table (3.12) .No. of layers =3, volume =994cm³,No. of blows 25

Table (3.11) : Standard Proctor Compaction Test Determination of Dry Unit Weight.

Water percent	5%	9%	12%	15%	18%	21%
Weight of mold, W1 (g)	3384.6	3384.6	3384.6	3384.6	3384.6	3384.6
Weight of mold + moist soil,W2 (g)	4949.5	5018	5135.9	5222	5261.5	5125
Weight of moist soil, W2- W1 (g)	1564.9	1633.4	1751.3	1837.4	1876.9	1740.4
Moist unit weight, Υ_{wet} (g/cm³)	1.65	1.73	1.85	1.94	1.98	1.84
Moisture can number	C18	B9	D4	22	C6	C15
Mass of can, W3 (g)	30.9	31.1	31.7	27.2	32	31.5
Mass of can+ moist soil,W4 (g)	257.2	210.4	168.7	199.2	246.2	174.2
Mass of can + dry soil, W5 (g)	243.3	192.9	151.8	173.7	209.6	147.9
Moisture content ,w (%)	6.54	10.82	14.07	17.4	20.61	22.59
Dry unit weight of compaction Υ_d (g/m³) =	1.55	1.56	1.62	1.65	1.64	1.5

Table (3.12) : Standard Proctor Compaction Test Zero Air-Void Unit Weight.

specific gravity of soil solids, Gs	Assumed moisture content, W (%)	unit weight of water , Υ_w (g/cm³)	Υ_{zav}, (g/cm³)
2.609	5	1.0	2.30
2.609	9	1.0	2.11
2.609	12	1.0	1.98
2.609	15	1.0	1.87
2.609	18	1.0	1.77
2.609	21	1.0	1.68

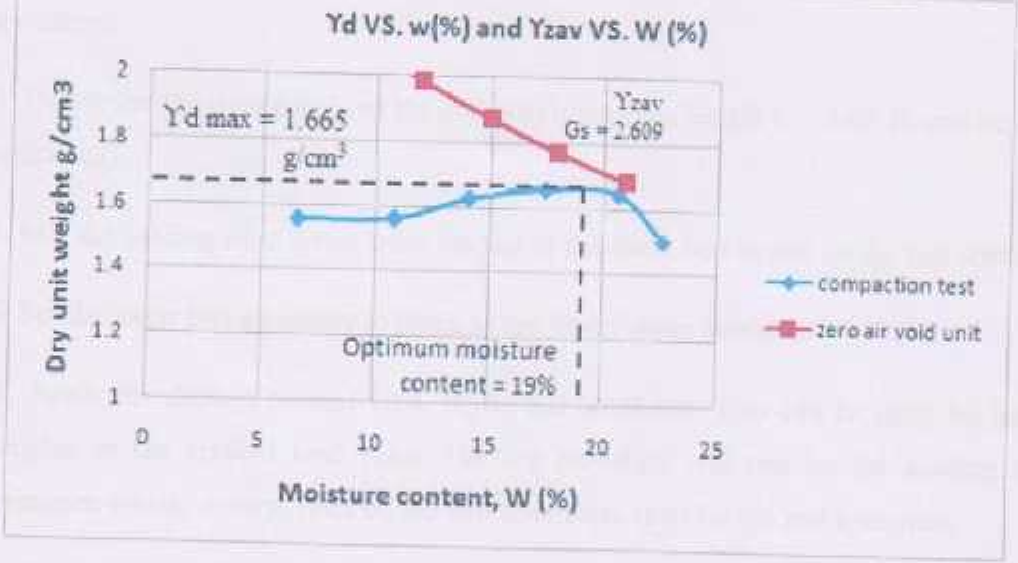


Figure (3.8) : Plot of Υ_d VS. w(%) and Υ_{zav} VS. W (%) for compaction test result.

3.2.7 Direct Shear Test

The shear strength, s, of a granular soil may be expressed by the equation

$$\tau = c + \sigma \tan\emptyset \qquad (25)$$

where σ' = effective normal stress.

Ø = angle of friction of soil.

C = cohesion (Kg/cm^2)

Procedure

1. Remove the shear box assembly. Back off the three vertical and two horizontal screws. Remove the loading head. Insert the two vertical pins to keep the two halves of the shear box together.

2. Weigh some dry sand in a large porcelain dish, W1 Fill the shear box with sand in small layers. A tamper may be used to compact the sand layers. The top of the compacted specimen

should be about 1/4 in. (6.4 mm) below the top of the shear box. Level the surface of the sand specimen.

3. Determine the dimensions of the soil specimen (i.e., length L, width B, and height H of the specimen).

4. Slip the loading head down from the top of the shear box to rest on the soil specimen.

5. Put the shear box assembly in place in the direct shear machine.

6. Apply the desired normal load, N, on the specimen. This can be done by hanging dead weights to the vertical load yoke. The top crossbars will rest on the loading head of the specimen which, in turn, rests on the soil specimen, rests on the soil specimen.

7. Remove the two vertical pines (which were inserted in Step 1 to keep the two halves of the shear box together).

8. Advance the three vertical screws that are located on the side walls of the top half of the shear box. This is done to separate the two halves of the box. The space between the two halves of the box should be slightly larger than the largest grain size of the soil specimen (by visual observation).

9. Set the loading head by tightening the two horizontal screws located at the top half of the shear box. Now back off the three vertical screws. After doing this, there will be no connection between the two halves of the shear box except the soil.

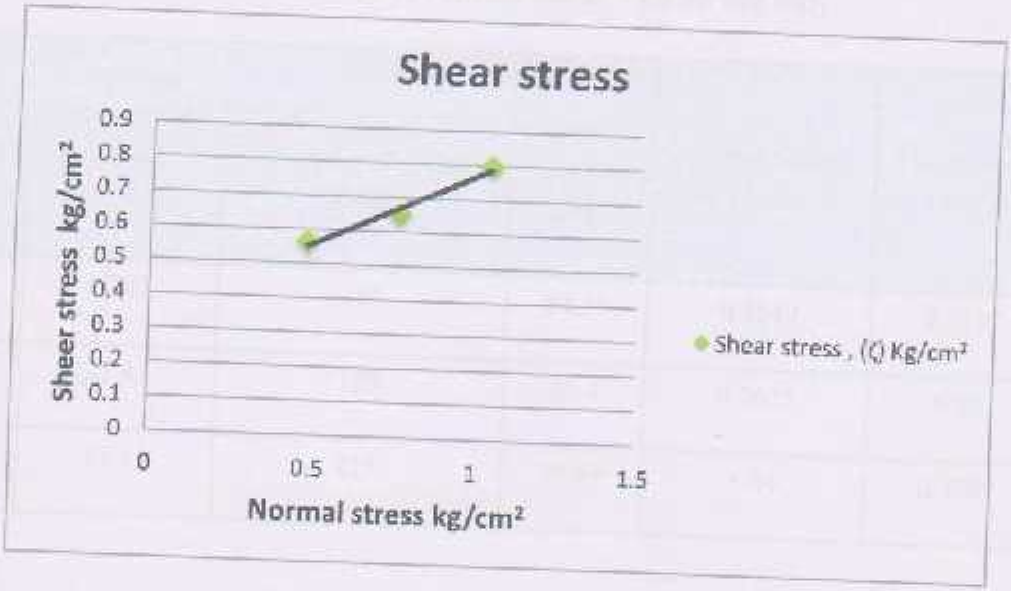
10. Attach the horizontal and vertical dial gauges (0.001 in. small div) to the shear box to measure the displacement during the test.

11. Apply horizontal load, S, to the top half of the shear box. The rate of shear displacement should be between 0.1 to 0.02 in.min (2.54 to 0.51 mm/min). For every tenth small division displacement in the horizontal dial gauge, record the readings of the vertical dial gauge and the proving ring gauge (which measures horizontal load, S). Continue this until after

(a) the proving ring dial gauge reading reaches a maximum and then falls, or (b) the proving ring dial gauge reading reaches a maximum and then remains constant.

Table (3.13) : Direct Shear Test on Sand Void Ratio Calculation.

No.	Vertical displacement (Kg)	No. of div. in proving ring dial gauge	Shear force (Kg)	Normal Stress, (σ) (Kg/cm²)	Shear stress (τ) Kg/cm²
1	17.45	155	20.15	0.4842	0.5597
2	27.45	180	23.4	0.7625	0.65
3	37.35	213	27.69	1.040	0.7961



Figure(3.9) : Shear strength of the soil used in this research.

Slope (y = 0.425x + 0.344)

$$\Phi = \tan^{-1}\left(\frac{\tau}{\sigma}\right) = 39^{\circ} \qquad (26)$$

C = 0.344 Kg/cm²

Chapter Four

Experimental results

4.1 Direct shear test on soil with percentages of organic and inorganic

The following Tables show the tests results of soil and soil with organic and inorganic percentages :

The results of Direct Shear Test on soil only is shown on Table (4.1).

Table (4.1) : Direct Shear Test on soil only.

No.	Vertical displacement (Kg)	No. of div. in proving ring dial gauge	Shear force (Kg)	Normal Stress, (σ) (Kg/cm²)	Shear stress (τ) Kg/cm²
1	17.45	155	20.15	0.4842	0.5597
2	27.45	180	23.4	0.7625	0.65
3	37.35	213	27.69	1.04	0.7961

Slope (y = 0.3788x + 0.3711)

$\Phi = \tan^{-1}(\frac{\tau}{\sigma}) = 20.75°$

C = 0.3711 Kg/cm² .

4.1.1 Effects of direct shear by adding percentages of organic material

The results of Direct Shear Test on organic only is shown on Table (4.2).

Table (4.2) : Direct Shear Test on organic only .

No.	Vertical displacement (Kg)	No. of div. in proving ring dial gauge	Shear force (Kg)	Normal Stress, (σ) (Kg/cm²)	Shear stress (τ) Kg/cm²
1	17.45	98	12.74	0.485	0.354
2	27.45	123	15.99	0.763	0.444
3	37.35	149	19.37	1.038	0.538

Slope (y = 0.3332x + 0.1917)

$\Phi = \tan^{-1}\left(\frac{\tau}{\sigma}\right) = 40.8°$

C = 0.1917 Kg/cm²

The results of Direct Shear Test on the organic only is shown on Figure (4.1) .

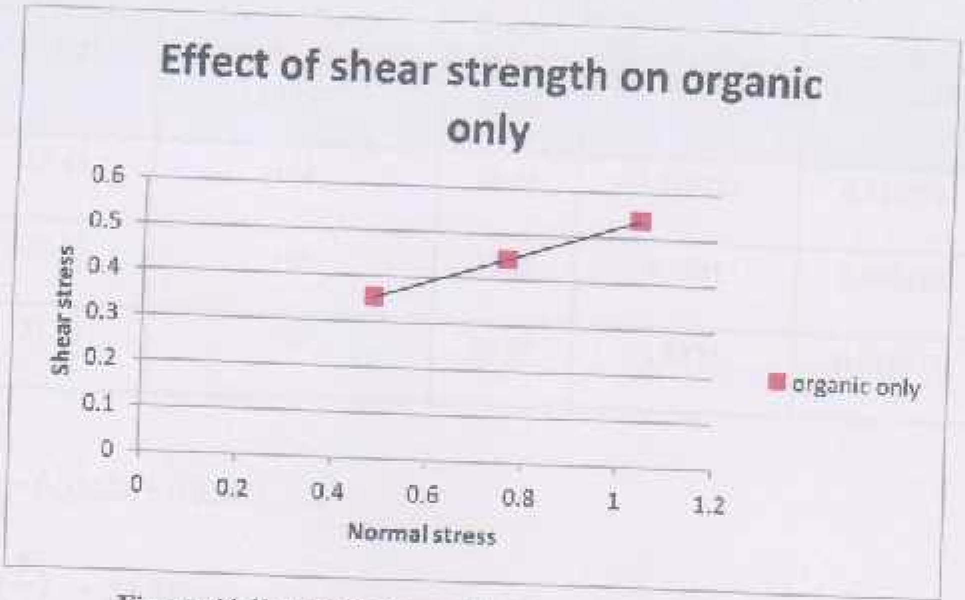


Figure (4.1) : shear strength of organic material only.

The results of Direct Shear Test on the soil with 10% organic is shown on Table (4.3).

Table (4.3) : Direct Shear Test on the soil with 10% organic with soil.

No.	Vertical displacement (Kg)	No. of div. in proving ring dial gauge	Shear force (Kg)	Normal Stress, (σ) (Kg/cm^2)	Shear stress (τ) Kg/cm^2
1	17.45	153	19.89	0.484722	0.5525
2	27.45	173	22.49	0.7625	0.624722
3	37.35	205	26.65	1.0375	0.740278

Slope (y = 0.3396x + 0.3706)

$\Phi = \tan^{-1}\left(\frac{\tau}{\sigma}\right) = 40°$

C = 0.3706 Kg/cm^2 .

The results of Direct Shear Test on the soil with 20% organic is shown on Table (4.4).

Table (4.4) : Direct Shear Test on the soil with 20% organic with soil .

No.	Vertical displacement (Kg)	No. of div. in proving ring dial gauge	Shear force (Kg)	Normal Stress, (σ) (Kg/cm^2)	Shear stress (τ) Kg/cm^2
1	17.45	142	18.46	0.484722	0.512778
2	27.45	164	21.32	0.7625	0.592222
3	37.35	199	25.87	1.0375	0.718611

Slope (y = 0.3322x + 0.3244)

$\Phi = \tan^{-1}\left(\frac{\tau}{\sigma}\right) = 38.32°$

C = . 0.3244 Kg/cm²

The results of Direct Shear Test on the soil with 30% organic is shown on Table (4.5).

Table (4.5) : Direct Shear Test on the soil with 30% organic with soil .

No.	Vertical displacement (Kg)	No. of div. in proving ring dial gauge	Shear force (Kg)	Normal Stress, (σ) (Kg/cm²)	Shear stress (τ) Kg/cm²
1	17.45	128	16.64	0.484722	0.462222
2	27.45	152	19.76	0.7625	0.548889
3	37.35	178	23.14	1.0375	0.642778

Slope (y = 0.3266x + 0.3026)

$\Phi = \tan^{-1}(\frac{\tau}{\sigma}) = 35.90\,°$

C = 0.3026 Kg/cm²

The results of Direct Shear Test on the soil with organic is shown on Figure (4.2) .

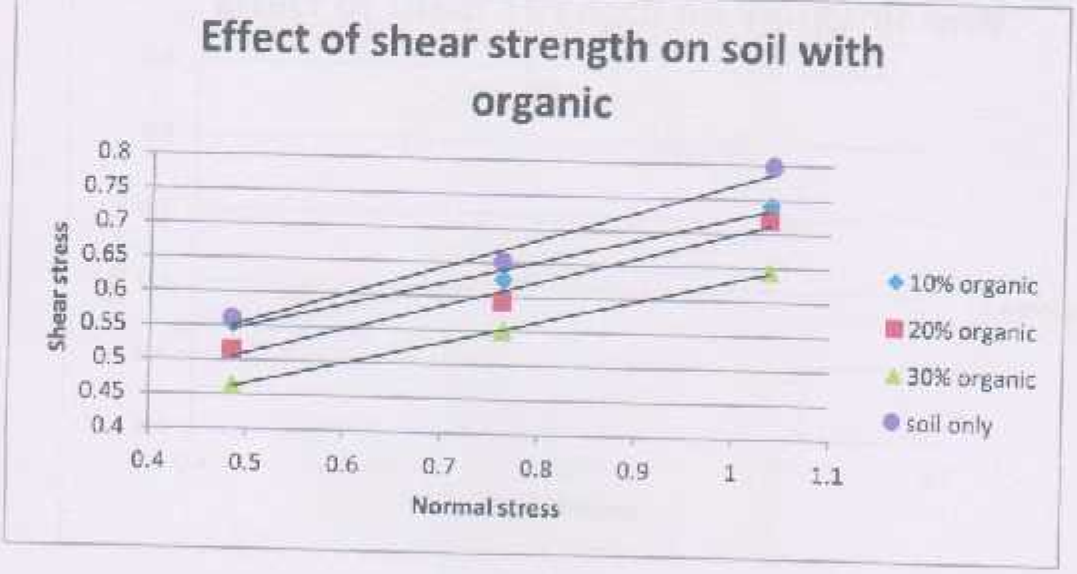


Figure (4.2) : Effect of organic material on shear strength of soil .

4.1.2 Effects of direct shear on adding inorganic

The results of Direct Shear Test on the inorganic only is shown on Table (4.6) and Figure (4.3) .

Table (4.6) : Direct Shear Test on inorganic only .

No.	Vertical displacement (Kg)	No. of div. in proving ring dial gauge	Shear force (Kg)	Normal Stress, (σ) (Kg/cm^2)	Shear stress (τ) Kg/cm^2
1	17.45	151	19.63	0.485	0.54527778
2	27.45	170	22.1	0.763	0.61388889
3	37.35	189	24.57	1.038	0.6825

Slope (y = 0.2482x + 0.4248)

$\Phi = \tan^{-1}\left(\frac{\tau}{\sigma}\right) = 38.87°$

$C = 0.4248\ Kg/cm^2$

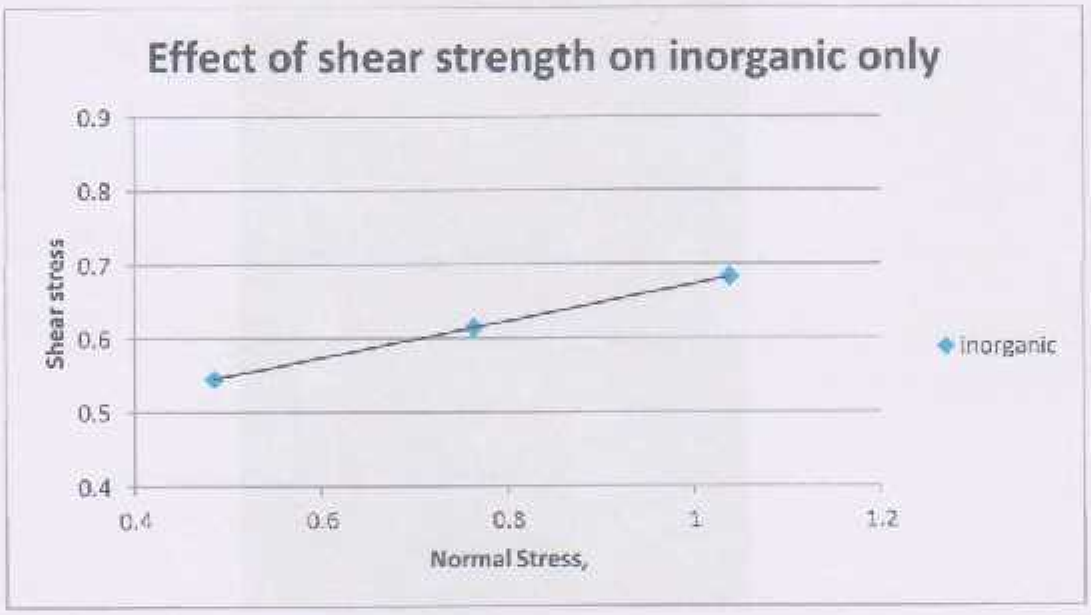


Figure (4.3) : Effect of shear strength on inorganic only .

The results of Direct Shear Test on the soil with 10% inorganic is shown on Table (4.7).

Table (4.7) : Direct Shear Test on the soil with 10% inorganic with soil .

No.	Vertical displacement (Kg)	No. of div. in proving ring dial gauge	Shear force (Kg)	Normal Stress, (σ) (Kg/cm^2)	Shear stress (τ) Kg/cm^2
1	17.45	164	21.32	0.484722	0.592222
2	27.45	189	24.57	0.7625	0.6825
3	37.35	224	29.12	1.0375	0.808889

Slope $(y = 0.3918x + 0.3961)$

$$\Phi = \tan^{-1}\left(\frac{\tau}{\sigma}\right) = 42.36$$

$C = 0.3961 Kg/cm^2$

Figure (4.4) shows the shear strength on soil with 10% inorganic.

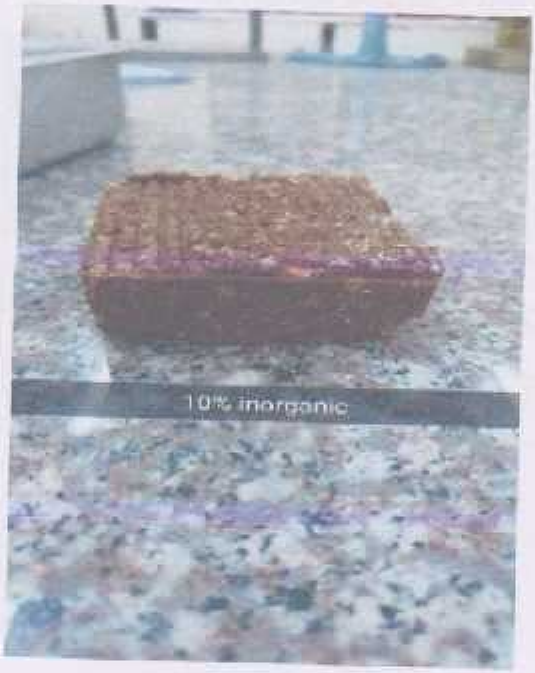


Figure (4.4) : shear strength on soil with 10% inorganic.

The results of Direct Shear Test on the soil with 20% inorganic is shown on Table (4.8).

Table (4.8) : Direct Shear Test on the soil with 20% inorganic with soil .

No.	Vertical displacement (Kg)	No. of div. in proving ring dial gauge	Shear force (Kg)	Normal Stress, (σ) (Kg/cm^2)	Shear stress (τ) Kg/cm^2
1	17.45	173	22.49	0.484722	0.624722
2	27.45	194	25.22	0.7625	0.700556
3	37.35	237	30.81	1.0375	0.855833

Slope (y = 0.4178x + 0.4088)

$\Phi = \tan^{-1}(\frac{\tau}{\sigma}) = 43.67$

C = 0.4088 Kg/cm^2

The results of Direct Shear Test on the soil with 30% inorganic is shown on Table (4.9).

Table (4.9) : Direct Shear Test on the soil with 30% inorganic with soil .

No.	Vertical displacement (Kg)	No. of div. in proving ring dial gauge	Shear force (Kg)	Normal Stress, (σ) (Kg/cm^2)	Shear stress (τ) Kg/cm^2
1	17.45	178	23.14	0.484722	0.642778
2	27.45	203	26.39	0.7625	0.733056
3	37.35	240	31.2	1.0375	0.866667

Slope (y = 0.4204 x + 0.4391)

$\Phi = \tan^{-1}(\frac{\tau}{\sigma}) = 44.47$

C = 0.4391 Kg/cm^2

Figure (4.5) shows the soil sample with 30 % inorganic after shear strength test was done.

Figure (4.5) : shear strength on soil with 30% inorganic

The results of Direct Shear Test on the soil with inorganic is shown on Figure (4.6) .

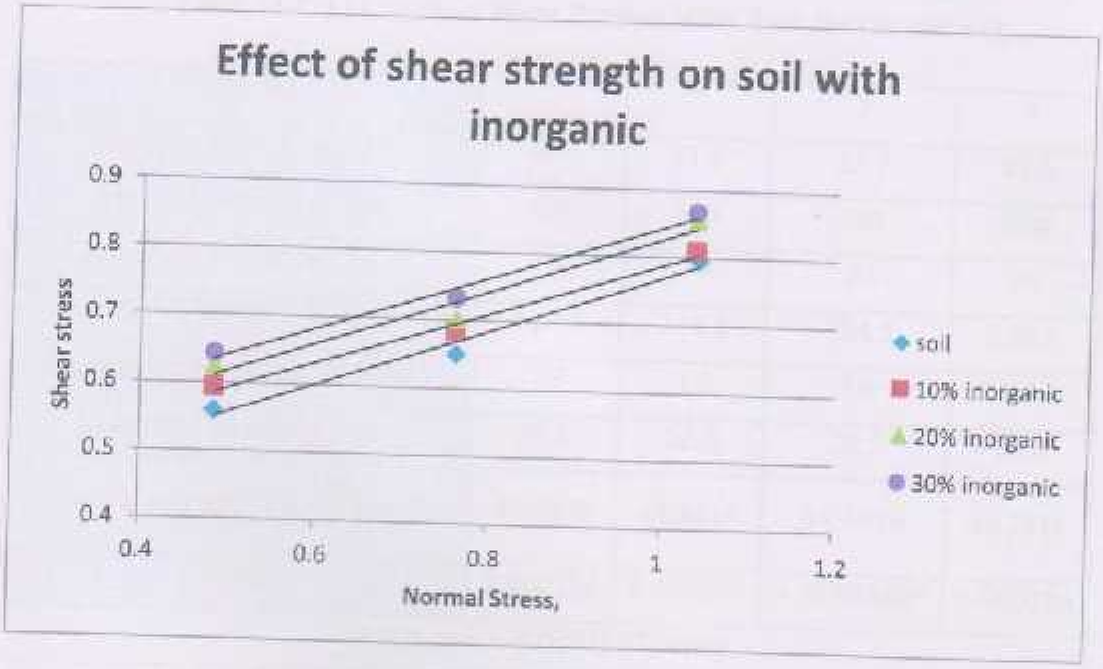


Figure (4.6) : Effect of shear strength on soil with inorganic.

4.2 permeability test on soil with percentages of organic and inorganic

4.2.1 Effects of permeability by adding organic

The following Tables (4.10) and (4.11) show the tests results of soil .

Table (4.10) : Constant head permeability test data for the soil only .

Length of sample, L = 20.5 cm   Diameter of sample, D = 7.6 cm

T=20 C

Volume of sample, $V = \Pi \frac{D^2 L}{4}$ (cm^3)	929.503
Mass of sample tube with fittings, W1(g)	2454.8
Mass of tube with fittings and sample, W2 (g)	3761
Dry density of sample, $\gamma d = \frac{W2-W1}{V}$ (g/cm^3)	1.405
Void ratio from equation (19) e =	0.86

Table (4.11) : Constant Head Permeability Test for the soil only.

Test No.	1	2	3	4
Average flow, Q (cm3)	39.6	21.6	23.7	23.6
Time of collection, t (s)	600	300	300	300
Temperature of water, T (°C)	20	20	20	20
Head difference, h (cm)	118.5	118.5	124.5	124.5
Diameter of sample, D (cm)	7.6	7.6	7.6	7.6
Length of sample, L (cm)	20.5	20.5	20.5	20.5
Area of sample, $A = \frac{\Pi D2}{4}$ (cm^2)	45.3416	45.3416	45.3416	45.3416
K (cm/s)	0.000252	0.000275	0 .00028689	0.000286
Average k = 0.00027477 cm/s				
$k_{20°c} = 2.44 * 10^{-4}$ cm/s				

The results of permeability Test on the soil with 10% organic is shown on Table (4.12).

Table (4.12) : permeability Test on the soil with 10% organic with soil .

Test No.	1	2	3	4	5	6
Average flow, Q (cm3)	8.8	8.5	7.6	6.9	5.4	5.3
Time of collection, t (s)	60	60	60	60	60	60
Temperature of water	25	25	25	25	25	25
Head difference, h (cm)	123.5	123.5	113.5	113.5	107.5	107.5
Diameter of sample,(cm)	7.6	7.6	7.6	7.6	7.6	7.6
Length of sample, (cm)	20.5	20.5	20.5	20.5	20.5	20.5
Area of sample, $A = \frac{\pi D2}{4}$	45.341	45.341	45.341	45.341	45.341	45.341
K (cm/s)	0.00054	0.00052	0.0005	0.00046	0.000379	0.000372
Average k = 0.000461cm/s						
$k_{20^\circ C}$ =4.61*10^{-4} cm/s						

The results of permeability Test on the soil with 20% organic is shown on Table (4.13).

Table (4.13) : permeability Test on the soil with 20% organic with soil .

Test No.	1	2	3	4	5	6
Average flow, Q (cm3)	10.9	10	9	8.5	7.2	6.6
Time of collection, t (s)	60	60	60	60	60	60
Head difference, h (cm)	123.5	123.5	113.5	113.5	107.5	107.5
Diameter of sample, D (cm)	7.6	7.6	7.6	7.6	7.6	7.6
Length of sample, L (cm)	20.5	20.5	20.5	20.5	20.5	20.5
Area of sample, $A = \frac{\pi D2}{4}$	45.341	45.341	45.341	45.341	45.341	45.341
K (cm/s)	0.00067	0.00061	0.0006	0.00056	0.000505	0.000463
Average k = 0.000567 cm/s						
$k_{20^\circ C}$ =5.67*10^{-4} cm/s						

The results of permeability Test on the soil with 30% organic is shown on Table (4.14).

Table (4.14) : permeability Test on the soil with 30% organic with soil .

Test No.	1	2	3	4	5	6
Average flow, Q (cm3)	12.3	12.9	13.9	15.09	17.45	18.3
Time of collection, t (s)	60	60	60	60	60	60
Head difference, h (cm)	109	109	115	115	120	120
Diameter of sample, D (cm)	7.6	7.6	7.6	7.6	7.6	7.6
Length of sample, L (cm)	20.5	20.5	20.5	20.5	20.5	20.5
Area of sample, $A = \frac{\pi D^2}{4}$ (cm^2)	45.341	45.341	45.341	45.341	45.341	45.341
K (cm/s)	0.00067	0.00061	0.0006	0.00056	0.000505	0.000463
Average k = 0.000981 cm/s						
$k_{20^\circ C} = 9.81*10^{-4}$ cm/s						

The relationship between k and the percentage of organic is shown on Figure (4.7) .

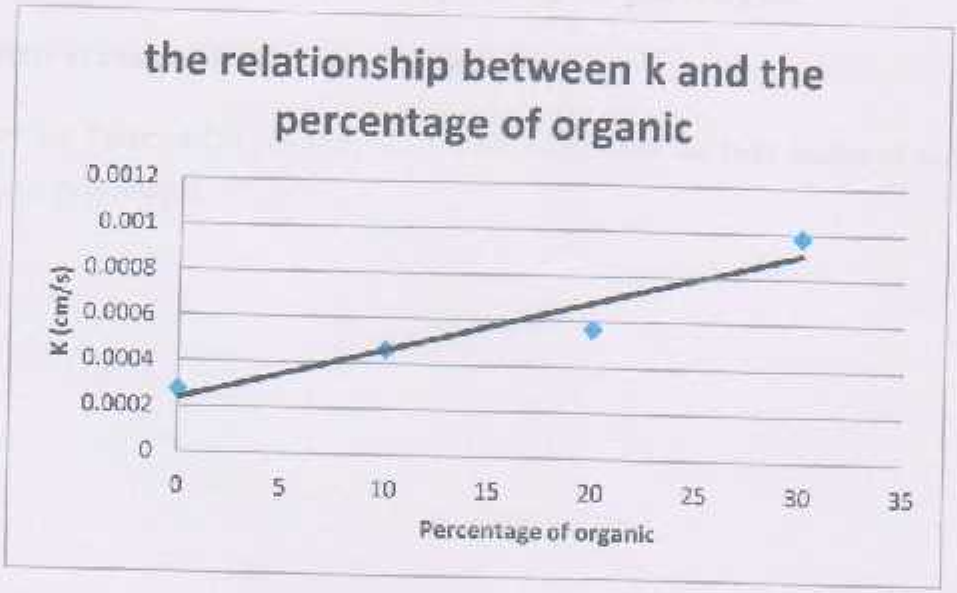


Figure (4.7) : The relationship between k and the percentage of organic.

4.2.2 Effects of permeability by adding inorganic

when conducting soil permeability test with adding inorganic materials, the water doesn't flow through the sample, and picture (4.) shows a soil sample with adding 10% inorganic materials.

Figure (4.8): Constant head permeability of soil with 10% organic.

4.3 compaction test on soil with percentages of organic and inorganic

4.3.1 Effects of compaction by adding organic

The following Tables(4.15) , (4.16) , (4.17) and (4.18) show the tests results of soil and soil with organic percentages :

Table (4.15) : Standard Proctor Compaction Test Determination of soil only.

Water percent	5%	9%	12%	15%	18%	21%
Weight of mold, W1 (g)	3384.6	3384.6	3384.6	3384.6	3384.6	3384.6
Weight of mold + moist soil,W2 (g)	4949.5	5018	5135.9	5222	5261.5	5125
Weight of moist soil, W2-W1 (g)	1564.9	1633.4	1751.3	1837.4	1876.9	1740.4
Moist unit weight, Υ_{wet} (g/cm³)	1.66	1.73	1.86	1.95	1.99	1.84
Moisture can number	C18	B9	D4	22	C6	C15
Mass of can, W3 (g)	30.9	31.1	31.7	27.2	32	31.5
Mass of can+ moist soil,W4 (g)	257.2	210.4	168.7	199.2	246.2	174.2
Mass of can + dry soil, W5 (g)	243.3	192.9	151.8	173.7	209.6	147.9
Moisture content ,w (%)	6.54	10.82	14.08	17.41	20.60	22.59
Dry unit weight of compaction Υ_d (g/m³) –	1.56	1.56	1.63	1.66	1.65	1.50

Table (4.16) : Standard Proctor Compaction for the soil with 10% organic Test.

Water percent	5%	8%	15%	21%	23%	25%
Weight of mold, W1 (g)	3384.6	3384.6	3384.6	3384.6	3384.6	3384.6
Weight of mold + moist soil,W2 (g)	4576.8	4591.4	4704.4	4955.6	5054.6	4852.6
Weight of moist soil, W2- W1 (g)	1192.2	1206.8	1319.8	1571	1670	1468
Moist unit weight, Υ_{wet} (g/cm³)	1.26	1.28	1.4	1.66	1.77	1.56
Moisture can number	F4	E11	31	E19	F16	22
Mass of can, W3 (g)	30.2	13.8	33	30.8	30.9	32
Mass of can+ moist soil,W4 (g)	81.8	106.2	126	152.8	123.2	145
Mass of can + dry soil, W5 (g)	78	98.8	112.4	129.2	104.9	121.5
Moisture content ,w (%)	7.95	8.71	17.13	20.98	24.73	26.26
Dry unit weight of compaction Υ_d (g/m³)	1.17	1.18	1.19	1.24	1.25	1.16

The result of compaction test on the soil with 10% organic shown in Figure (4.9).

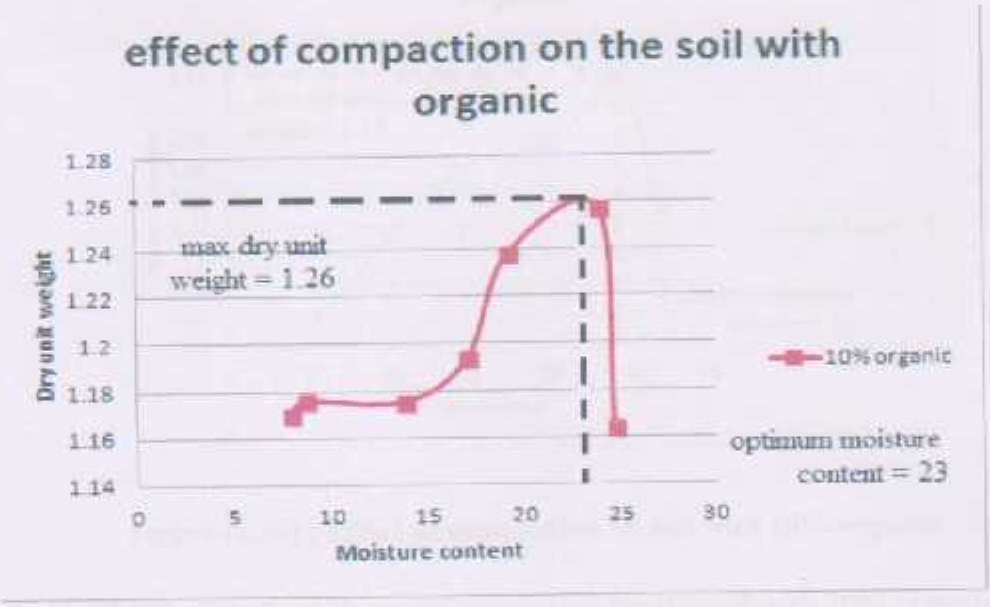


Figure (4.9) : Effect of compaction on soil with 10% organic.

Table (4.17) : Standard Proctor Compaction for the soil with 20% organic Test.

Water percent	5%	12%	18%	21%	23%	25%
Weight of mold, W1 (g)	3384.6	3384.6	3384.6	3384.6	3384.6	3384.6
Weight of mold + moist soil, W2 (g)	4341.4	4516.8	4589.4	4659.4	4698.2	4623.1
Weight of moist soil, W2- W1 (g)	956.8	1132.2	1204.8	1274.8	1313.6	1238.5
Moist unit weight, Υ_{wet} (g/cm³)	1.01	1.20	1.28	1.35	1.39	1.31
Moisture can number	154	A12	22	F16	17	F4
Mass of can, W3 (g)	18.6	41.8	32	31	43.2	30.3
Mass of can+ moist soil, W4 (g)	41.4	116.6	107.6	89.4	88.3	189.4
Mass of can + dry soil, W5 (g)	40.2	107.5	95.4	78.6	79.4	155.6
Moisture content ,w (%)	5.56	13.85	19.24	22.69	24.59	26.98
Dry unit weight of compaction Υ_d (g/m³)	0.96	1.05	1.07	1.10	1.12	1.03

The result of compaction test on the soil with 20% organic shown in Figure (4.10).

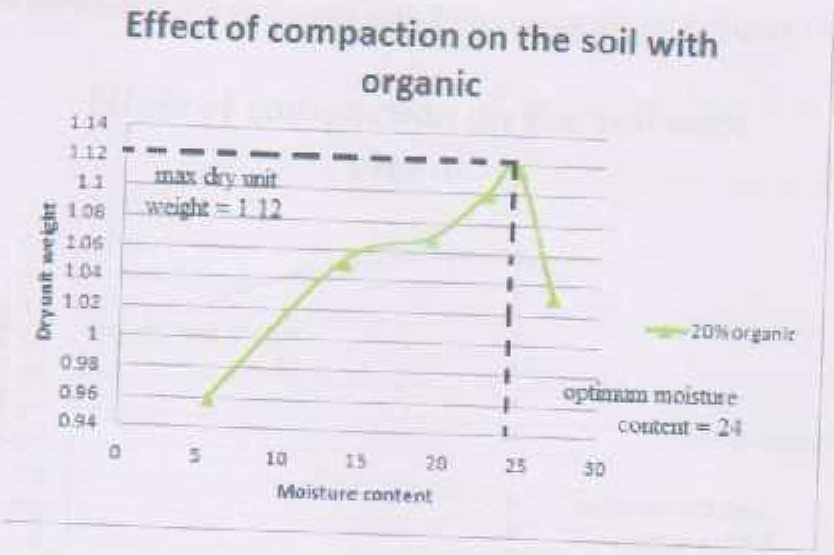


Figure (4.10) : Effect of compaction on soil with 20% organic.

Table (4.18) : Standard Proctor Compaction for the soil with 30% organic Test.

Water percent	5%	12%	21%	25%
Weight of mold, W1 (g)	3384.6	3384.6	3384.6	3384.6
Weight of mold + moist soil, W2 (g)	4106	4293.4	4432.5	4290.6
Weight of moist soil, W2- W1 (g)	721.4	908.8	1047.9	906
Moist unit weight, γ_{wet} (g/cm³)	0.76	0.96	1.11	0.96
Moisture can number	C18	C15	B9	154
Mass of can, W3 (g)	30.8	31.5	31.1	18.7
Mass of can+ moist soil, W4 (g)	163.3	187	94	183.5
Mass of can + dry soil, W5 (g)	155.2	168.8	82.2	148.6
Moisture content ,w (%)	6.51	13.26	23.09	26.87
Dry unit weight of compaction γ_d (g/m³)	0.72	0.85	0.90	0.76

The result of compaction test on the soil with 30% organic shown in Figure (4.10).

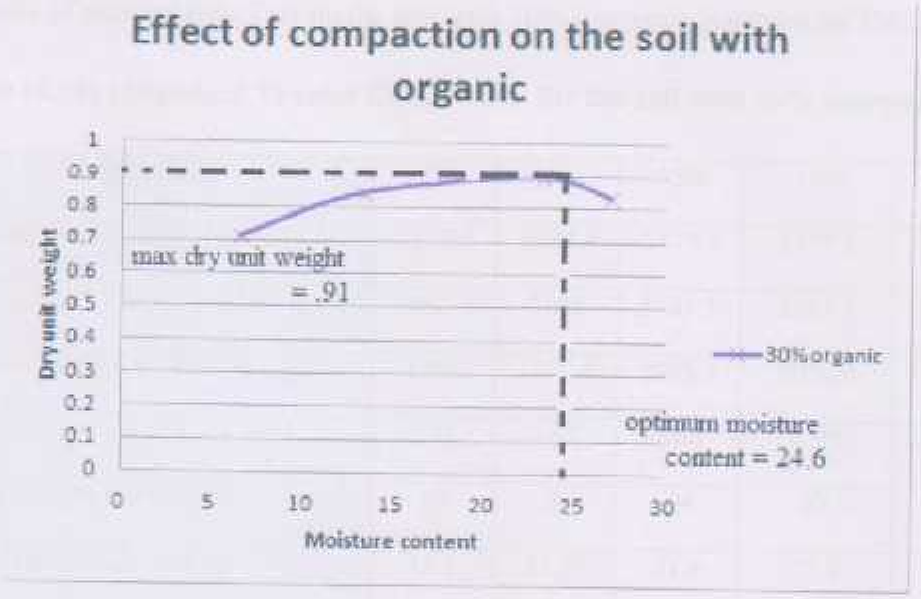


Figure (4.11) : Effect of compaction on soil with 30% organic.

The result of the soil and the soil with different percentage of organic shown in Figure (4.12).

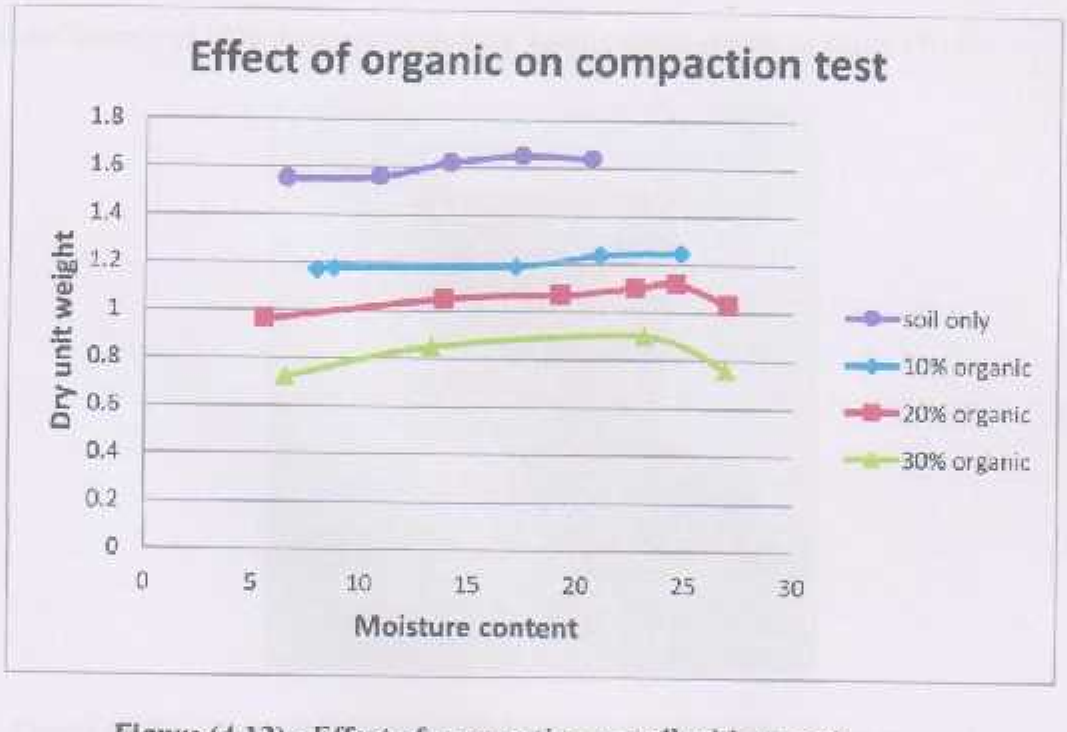


Figure (4.12) : Effect of compaction on soil with organic.

4.3.2 Effects of compaction by adding inorganic

The results of permeability Test on the soil with 10% inorganic is shown on Table (4.19).

Table (4.19) : Standard Proctor Compaction for the soil with 10% inorganic Test.

Water percent	5%	10%	12%	15%	18%
Weight of mold, W1 (g)	3377.4	3377.4	3377.4	3377.4	3377.4
Weight of mold + moist soil,W2 (g)	5083.4	5188	5342.5	5453.5	5354.4
Weight of moist soil, W2- W1 (g)	1706	1810.6	1965.1	2076.1	1977
Moist unit weight, Υ_{wet} (g/cm³)	1.81	1.92	2.08	2.20	2.09
Moisture can number	17	9	D4	22	C5
Mass of can, W3 (g)	43.2	31.12	31.6	27.2	31
Mass of can+ moist soil,W4 (g)	145	212.4	169.97	201.2	266.12
Mass of can + dry soil, W5 (g)	137	192.9	151.8	173.7	225.6
Moisture content ,w (%)	8.53	12.05	15.12	18.77	20.82
Dry unit weight of compaction Υ_d (g/m³)	1.67	1.71	1.81	1.85	1.73

The soil sample of 10% inorganic with 18% water content shown in figure (4.13).

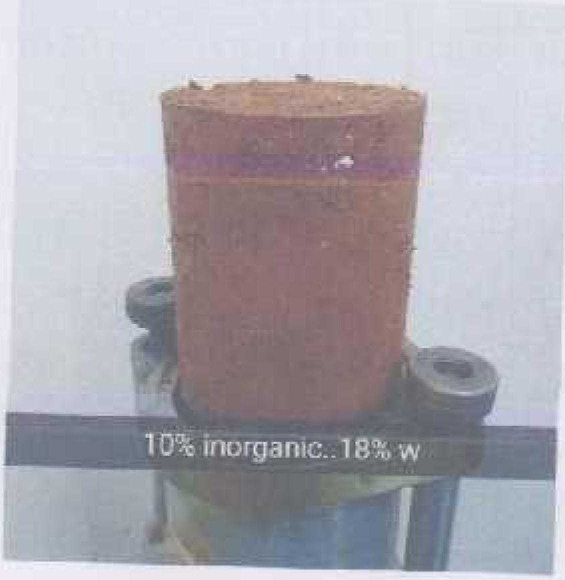


Figure (4.13) : The soil sample of 10% inorganic with 18% water content.

The result of the soil and the soil with 10% organic shown in Figure (4.14).

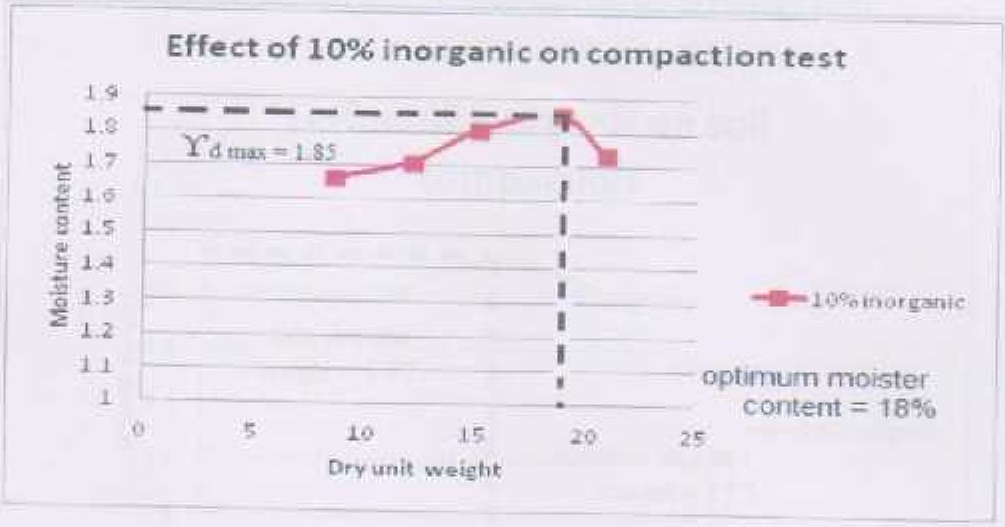


Figure (4.14) : Effect of compaction on soil with with 10% inorganic.

The results of permeability Test on the soil with 20% inorganic is shown on Table (4.20).

Table (4.20) : Standard Proctor Compaction for the soil with 20% inorganic Test.

Water percent	5%	10%	12%	15%	18%	21%
Weight of mold, W1 (g)	3377.4	3377.4	3377.4	3377.4	3377.4	3377.4
Weight of mold + moist soil, W2 (g)	5142.5	5255.6	5297	5499.6	5529.8	5479.2
Weight of moist soil, W2- W1 (g)	1765.1	1878.2	1919.6	2122.2	2152.4	2101.8
Moist unit weight, γ_{wet} (g/cm^3)	1.87	1.99	2.03	2.25	2.28	2.23
Moisture can number	E11	C5	5	17	22	C18
Mass of can, W3 (g)	31.6	31	30.6	43.3	31.4	30.8
Mass of can+ moist soil, W4 (g)	220	157	146.4	163	199.4	178.2
Mass of can + dry soil, W5 (g)	209.1	145	133.8	146	171.9	147.9
Moisture content ,w (%)	6.14	10.53	12.21	16.55	19.57	25.88
Dry unit weight of compaction γ_d (g/m^3)	1.76	1.80	1.81	1.93	1.91	1.77

The result of the soil and the soil with 20% organic shown in Figure (4.15).

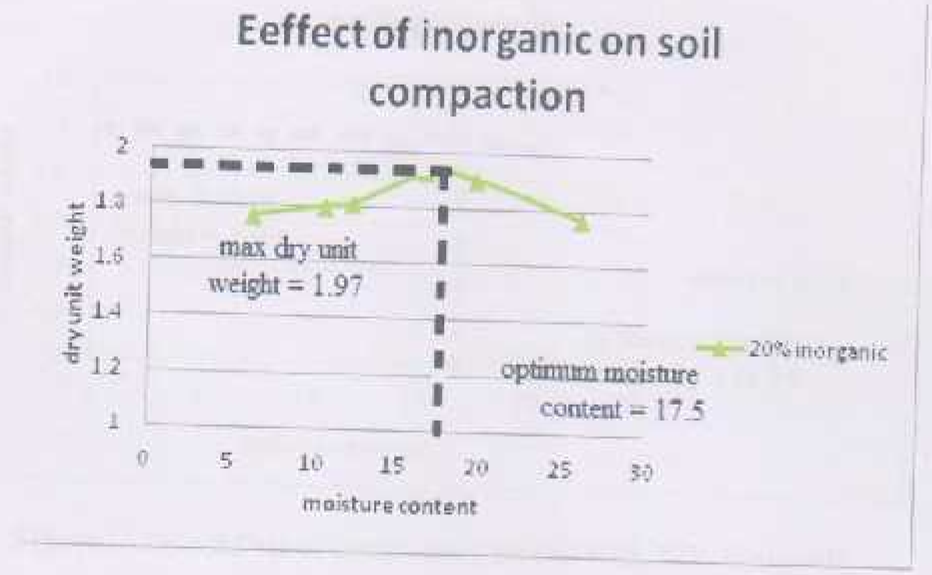


Figure (4.15) : Effect of compaction on soil with 20% inorganic

The results of permeability Test on the soil with 30% inorganic is shown on Table (4.21).

Table (4.21) : Standard Proctor Compaction for the soil with 30% inorganic Test.

Water percent	5%	10%	12%	15%	18%
Weight of mold, W1 (g)	3377.4	3377.4	3377.4	3377.4	3377.4
Weight of mold + moist soil, W2 (g)	5192.4	5378.3	5462.7	5556.6	5582.8
Weight of moist soil, W2- W1 (g)	1815	2000.9	2085.3	2179.2	2205.4
Moist unit weight, Υ_{wet} (g/cm³)	1.92	2.12	2.21	2.31	2.34
Moisture can number	154	A12	22	F16	17
Mass of can, W3 (g)	18.6	41.8	32	31	43.2
Mass of can+ moist soil, W4 (g)	120	149	126.4	137.63	139.4
Mass of can + dry soil, W5 (g)	114.1	137	114.8	122.3	122.9
Moisture content ,w (%)	6.18	12.61	14.01	16.79	20.70
Dry unit weight of compaction Υ_d (g/m³)	1.81	1.88	1.94	1.98	1.94

The result of the soil and the soil with 30% organic shown in Figure (4.16).

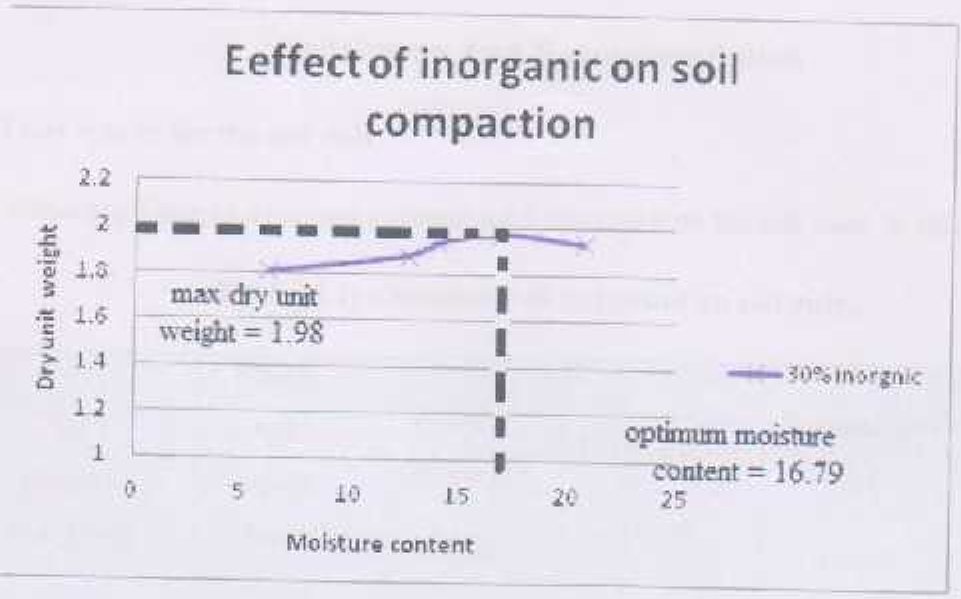


Figure (4.16) : Effect of compaction on soil with 30% inorganic.

The result of the soil and the soil with different percentage of organic shown in Figure (4.17).

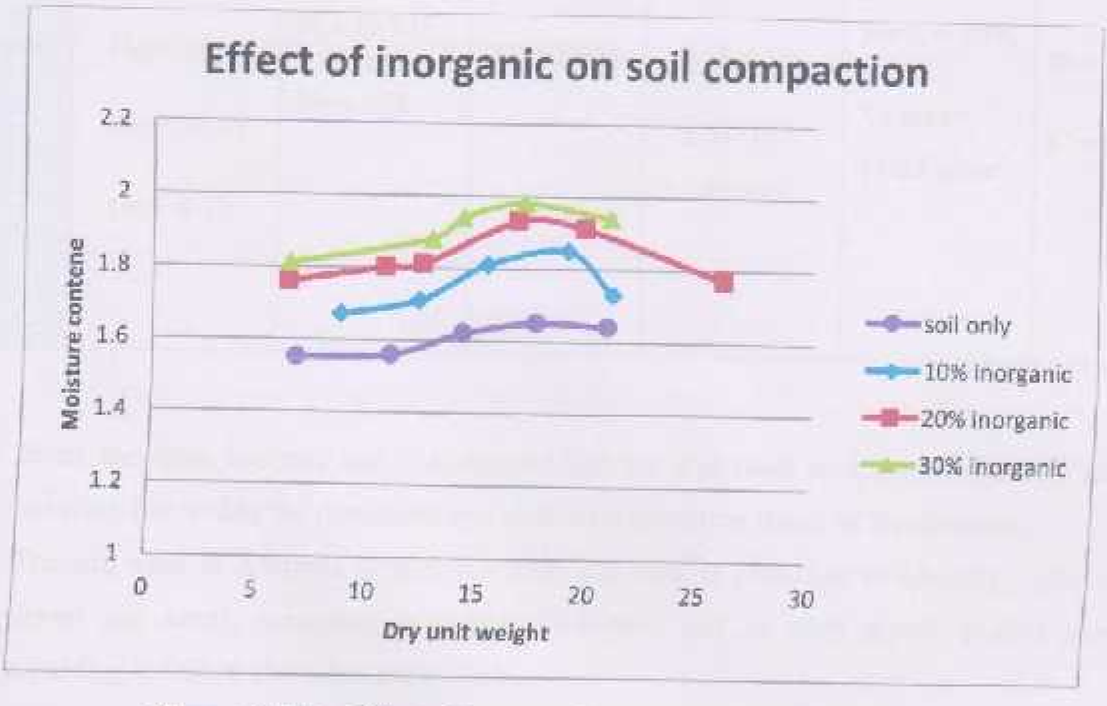


Figure (4.17) : Effect of compaction on soil with inorganic.

Chapter Five

Conclusion And Recommendation

5.1 Tests results for the soil only

The following Table (5.1) shows summary of Tests result on the soil used in this research :

Table (5.1) : Summary of test result on soil only.

Name of test	Sieve analysis test result	Plastic and liquid limit result	Specific gravity result	Permeability result	Compaction test result	Shear strength test result
Result	D_{10}= 0.3 D_{30}= 1.8 D_{60}= 14 Cu = 46.67 Cc = 0.77	LL=29.795 PL=20.707 PI=9.088	GS=2.611	K= $2.44*10^{-4}$ cm/sec	Optimum Wc% = 19% γ_d max= 1.665 g/cm^3	Φ = 20.75 C = 0.344

- From the sieve analysis test it is noticed that the soil used in ALMynia landfill for daily covering lies within the maximum and minimum gradation limits of the standard.
- The soil used in Almynia landfill for daily covering is classified as (A-2-7) (silty or clay gravel and sand), according to AASHTO system and as (GP) poorly graded gravel , according to united classification system .

5.2 test result with adding materials

From the experimental test conducted in this research, the following conclusions maybe with drawn :

1- direct shear:

Table (5.2) shows the summary of shear strength tests results.

Table (5.2) : Summary of shear strength tests results.

Sample	C	Φ
Soil only	0.32	40.8
Organic only	0.1917	30.303
10% organic	0.3706	40
20% organic	0.3244	38.32
30% organic	0.3026	35.90
Inorganic only	0.4248	38.87
10% inorganic	0.3961	42.36
20% inorganic	0.4088	43.67
30% inorganic	0.4391	44.47

A- Effect of organic on strength properties Φ , C :

The results have shown that the increase in organic percentage compared to the soil , the value of C will decrease , and Φ will decrease.

B- Effect of inorganic on strength properties Φ , C :

The results have shown that the increase in organic percentage compared to the soil , the value of C will increase , and Φ will increase.

2 - permeability test results:

Table (5.3) shows the summary of permeability tests results.

Table (5.3) : Summary of permeability test results.

Sample	K Value
Soil only	$2.7477*10^{-4}$ cm/s
10% organic	$4.61*10^{-4}$ cm/s
20% organic	$5.67*10^{-4}$ cm/s
30% organic	$9.81*10^{-4}$ cm/s
10% inorganic	undefined
20% inorganic	Undefined
30% inorganic	undefined

A- Effect of organic on permeability of the soil :

The results have shown that the increase in organic percentage compared to the soil , the value of K will increase, so the passing water will increase.

B- Effect of inorganic on permeability of the soil :

In this test there is no result received, but in the land fill the result will be different , because the powder stone slurry has been used , but in the landfills it will be in a larger size.

3 - Compaction test results:

Table (5.4) shows the summary of compaction test results.

Table (5.4) : Summary of compaction test results.

Sample	Optimum Wc%	γ_d max
Soil only	19	1.665
10% organic	23	1.26
20% organic	24	1.12
30% organic	24.6	.91
10% inorganic	18	1.85
20% inorganic	17.5	1.97
30% inorganic	16.79	1.98

A- Effect of organic on compaction of the soil :

The results have shown that the increase in organic percentage compared to the soil , the value of optimum moisture content will increase, and the maximum dry unit weight will decrease.

B- Effect of inorganic on compaction of the soil :

The results have shown that the increase in organic percentage compared to the soil , the value of optimum moisture content will increase, and the maximum dry unit weight will increase.

5.3 Recommendation

1. This study was done on Almynia landfill soil, and the results would be different using other soil,

2. Studies the optimum percent of materials must be worked on.

3. To find a good way to mix the soil with the materials on site.

4. To detect effects of the time on increasing the soil resistance after adding the materials, because the time of this study is not enough.

References

1. suman ghosh, s.E.h., sanitary landfill mission geoscience, Inc Irvine california 92612, U.S.A. 687: p. 10.

2. Victoria E., Siting, design, operation and rehabilitation of landfills. 2001, Melbourne.

3. Sundram, M.S., Basel Convention on Transboundary Movement of Hazardous Wastes: Total Ban Amendment Pace Int'l L. Rev 1997. 9: p. 1 .

4. Carey, P. and G. Carty, Landfill manuals: landfill site design. 2000: EPA.

5. Authority, E.P., Environmental guidelines solid waste landfill January 1996. 579: p. 63 .

6. Odeh, O., Strategies and Motivations in Translated Children's Literature: Defoe's Robinson Crusoe as a Case Study, 2010, an- Najah National University.

7. Parametrix, I., Solid Waste Landfill Design Manual June 1987: p632.

8. Dr. Brian Donlon, M.P.W., Mr. Dara Lynott& Mr. Gerry Carty. LANDFILL MANUALS LANDFILL MONITORING 2003: p. 90.

9. .https://www.atsdr.cdc.gov/hac/landfill/pdfsMandfill 2001 ch2mod.pdf.

10. Hurst, C., et al., Assessment of municipal waste compost as a daily cover material for odour control at landfill sites. Environmental pollution, 2005. 135(1): p. 171-177.

11. Agency, P., Guidance Note on Daily and Intermediate Cover at Landfills. 2014: p. 41 .

12. Ng, K. and I. Lo. Engineering properties of msw landfill daily covers using waste tire chips and paper sludge. in Proceedings Sardinia. 2007.

13. Kabata-Pendias, A., Trace elements in soils and plants. 2010: CRC press.

14. INC, M., Soil Compaction Handbook. 2011: p. 20.
15. http://www.senecahs.org/pages/uploaded_files/Explaining%20a%20soil%20Profile%20E%20Unit.pdf.

16. . Wong, W.w., Investigation of the geotechnical properties of municipal solid waste as function of placement conditions. 2009 .

17. Rose, J., Turning Food Waste Into Fuel Takes Gumpition And Trillion of Bacteria NPR 2014.

18. . Musleh, D.R., COUNTRY REPORT ON THE SOLID WASTE MANAGEMENT IN OCCUPIED PALESTINIAN TERRITORIES. April 2014. 92.

19. . Sharholy, M., et al., Municipal solid waste management in Indian cities-A review. Waste management, 2008. 2802): p. 459-467.

20. . themEnvironment, r.b.t.M.o., Technical Document on Municipal Solid Waste Organics Processing 2013: p. 208.

21. . Prakash, N., Empowering Women Using Environmentally Friendly Technology in Paper Recycling. Linking Environment, Democracy and Gender, 2012. 20: p. 125-136.

22. B.M., Soil mechanics laboratory manual. 2002: Oxford Das, University Press New York, USA.

23. http://www.geoengineer.org/gallery/main.php

24. http://www.hjsc-swm.com