CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project. That the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein has not been undertaken or done by unspecified sources of person

LEONG BAN SAN

ABSTRACT

Development of a percolating sand trap for urban drainage was attempted in this project. Sand traps in University Teknologi Petronas campus were chosen for the initial observation. From the observation, most of the sand traps were trapping sand and water. Some become mosquito breeding ground. Larvae were found in the water retained by sand traps. Several tests were conducted in this project on soils particle size, laboratory permeability test, percolation test on field and percolation test with different water table. The result of the experiment indicated that the mining sand has 0.02 cm/s hydraulic conductivity. Loamy sand from Seri Iskandar area has 0.000158cm/s hydraulic conductivity and sandy loam from UTP new academic building area has 0.000103 cm/s hydraulic conductivity. A prototype sand trap used for field percolation test for each location was able to percolate retained water within three days. From the results, different sizes of opening from the trap do not affect much to the percolation rate. The percolation rate was affected by soil moisture content and level of water table. Water of recharge or rainfall percolate through opening below prototype was cause to the underground soil moisture content and water table increase. This percolation reduces with lower hydraulic gradient during water table increased. An improvement in design of the percolating sand trap has to modify to fulfill the site condition of high water table area. It is necessary to determine site water table level and hydraulic conductivity before application of percolating sand trap. The procedure appears promising for field use following prototype using appropriate boundary and initial conditions and field testing.

ACKNOWLEDGEMENTS

First of all, I would like to thank the ALMIGHTY for finishing the Final year project successfully and for all the experiences and the knowledge that I have gained during my two semester project period.

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CHAPTER 1: INTRODUCTION

1.1 Background of Study

Prior to the late 1970s, a number of sedimentation basins were constructed in Australia using primary gabions or masonry walls to create unlined sedimentation ponds. Difficulties were experienced in de-watering and de-silting the sedimentation trap.

Refer to chapter thirty four of "Urban Stormwater Management Manual". Sand traps are also named as sediment traps. Sedimentation traps function as providing an enlarged waterway area and/or reduced hydraulic gradient to reduce flow velocities and allow bedload sediment to be trapped and suspended sediments to settle out of suspension.

A sand trap is used to separate and retain particles of grit from a body of flowing water. A sand trap can take one of the two basic forms:

i) A pit below the invert level of a surface water drain or sewer, formed at a place where it can be conveniently pumped or dug out. This form of trap is also known as catch pit (Figure 1.1).

ii) An enlargement in a channel or pipe, to slow the flow in order to allow granular material transported to be deposited.

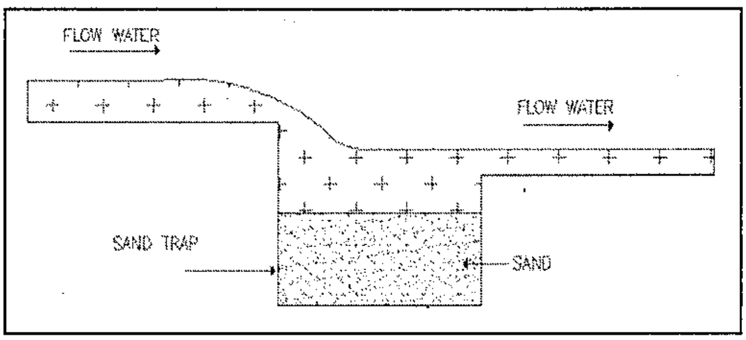

Figure 1.1 – Water flowing sand trap

1.2 Problem Statement

The sand traps not only retain particles of grit but also retain water. The water retained in the sand trap for more than five days may give opportunity for mosquito breeding in the water, where the mosquito egg in the water will transform to aquatic larva, aquatic pupa and finally to adult mosquito within five days. The increasing population of mosquito may consequently increase the number of dengue cases in urban area.

According to the "the Star" newspaper report on 5th February 2007, the Health Ministry called on the public to report on their neighbors who harbor mosquitoes as 16 people had died due to dengue this year. Total of 6,458 suspected dengue cases were recorded nationwide during the first five weeks of the year, adding that about 50% of the cases were in Selangor and Kuala Lumpur.

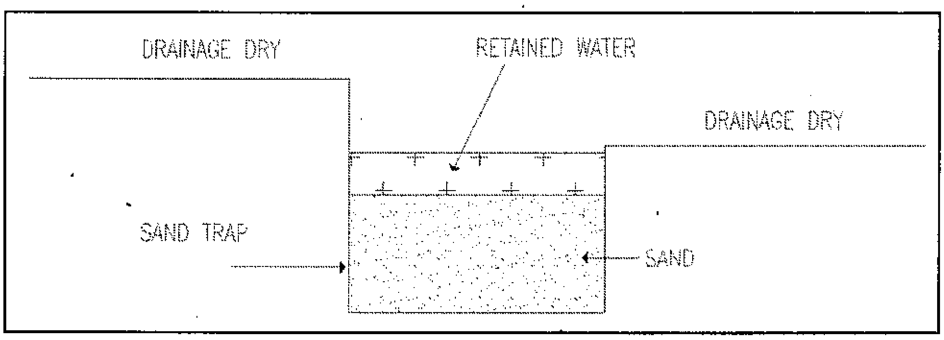

Figure 1.2 – Sand trap with retained water

Observations were made in the campus of the Universiti Teknologi Petronas (UTP). The sand traps in the UTP campus retained water and some of it with appearance of mosquito larvae. Figures 1.2 - 1.4 shows the sand trap retaining water and mosquito larvae (located at the passageway from new Village Five to pocket C).

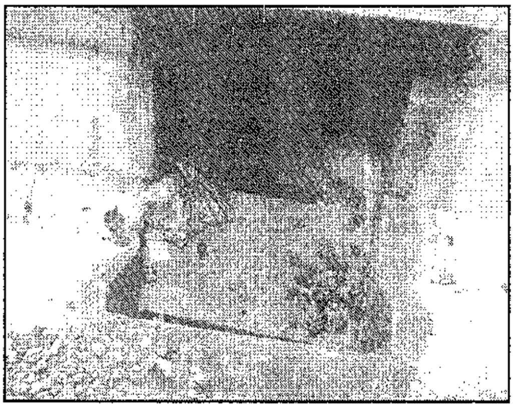

Figure 1.3 – Sand trap retaining water, sand and rubbish

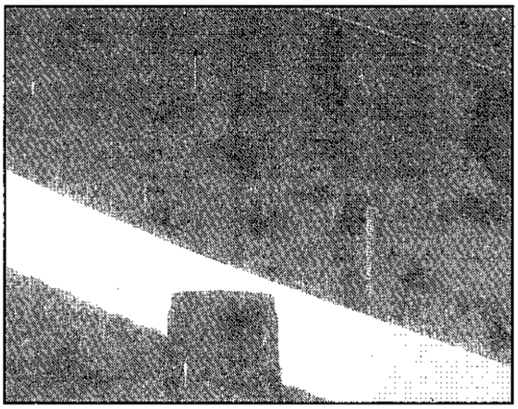

Figure 1.4 – Larvae retained in sand trap

1.3 Objectives and Scope of Study

The objective of the study was to develop a percolating sand trap was so as to percolate the retained water in the standard sand trap within three days. The percolate sand trap can also be in urban utilities like communication conduit boxes and electrical power conduit boxes. So, the percolating sand trap have to designed as a free of water/dry sand trap with percolate the retained water to the sub-soil and infiltrate to the ground water table.

The scope of the study will involve study of mosquito breeding, the study of best management practice for storm water management, designation of percolating opening in sand trap and hydraulic permeability of various soil types at the bottom of the sand trap.

CHAPTER 2: LITERATURE REVIEW

2.1 Urban Drainage

Drainage is defined as the removal of excess. For designing a drainage system for a particular area, certain criteria must be used to determine water accessibility. A number of surveys must be undertaken before the water balance of the area can be made, resulting in adequate hydrogeological, hydropedological and topographic maps.

The most common techniques used to drain excess water are:

- Surface drainage
- Subsurface drainage

2.1.1 Surface Drainage

Surface drainage is the removal of excess runoff from rainfall, irrigation, seeps, or springs by water flowing on the soil surface. Surface drainage allows for removal of much larger volumes of water in a shorter time span than subsurface drainage. Two approaches can be followed when working with surface drainage. The first is to divert water away using turf lined channels before it can collect in low spots. The channel should lead to a natural outlet such as a road ditch where the excess water can be handled properly. The second, less desirable, approach is to provide a channel to drain water from the low spot after it collects.

Random drains are commonly used to drain scattered low spots that are not removed during construction. Drainage channels are used to link these low spots and then the water is channeled to an outlet. The drainage channels should follow the natural slope of the land.

2.1.2 Subsurface Drainage

Subsurface drainage is the removal of water from the root zone. It is accomplished by deep open drains or buried pipe drains.

a) Deep Open Drains

The excess water from the root zone flows into the open drains. The disadvantage of this type of subsurface drainage is that it makes the use of machinery difficult.

b) Pipe Drains

Pipe drains are buried pipes with openings through which the soil water can enter. The pipes convey the water to a collector drain.

Drain pipes are made of clay, concrete or plastic. They are usually placed in trenches by machines. In clay and concrete pipes (usually 30 cm long and 5 - 10 cm in diameter), drainage water enters the pipes through the joints. Flexible plastic drains are much longer (up to 200 m) and the water enters through perforations distributed over the entire length of the pipe.

c) Deep Open Drains Versus Pipe Drains

Open drains use land that otherwise could be used for crops. They restrict the use of machines. They also require a large number of bridges and culverts for road crossings and access to the fields. Open drains require frequent maintenance (weed control, repairs, etc.).

2.2 Sump

A sump is a pit or small chamber used for collecting liquids. they may be associated with pumps where they have the function of providing temporary storage of wastewater or stormwater prior to being discharged. They may also be used to settle and retain solids, leaves and other pollutants held.

Design depends upon which of the above have been utilized. The trap may behave as a settling tank in which case the surface loading rate 'SLR", given by the flow Q divided by the plan area (A) should be equivalent to the particle settling velocity for the particles to be settled. When the trap conforms with case to above, it will be necessary to utilize sediment transport formulae to determine the suspended and bed load transport rates and the required cross section as well as plan area to obtain sand deposition and retention.

2.2.1 Design Considerations

- Sufficiently large to prevent overflows.
- Enable screening of solids and grits.
- Provision for emptying solids and grits.
- Covered to prevent ingress of rainwater.

2.2.2 Maintenance Requirement

Removal of trapped solids and grits after every washing or hosing down operation.

2.3 Soil Classification

Soil classification systems have been developed to provide scientists and resource managers with generalized information about the nature of a soil found in a particular location. In general, environments that share comparable soil forming factors produce similar types of soils. This phenomenon makes classification possible. Numerous classification systems are in use worldwide. We will examine the systems commonly used in the United States and Canada.

The soils classification of this project will use United States system for identification of soils. To identify the soils, several tests have to conducted in laboratory. There are sieve analysis and hydrometer. Both are used to indentify soil particle. Sieve analysis is used to indentify the percentage of gravel, sand and silt. Hydrometer is used to identify the percentage of silt and clay. After identification of soil, a soil texture triangle (Figure 2.1) it used to determine the type of soil.

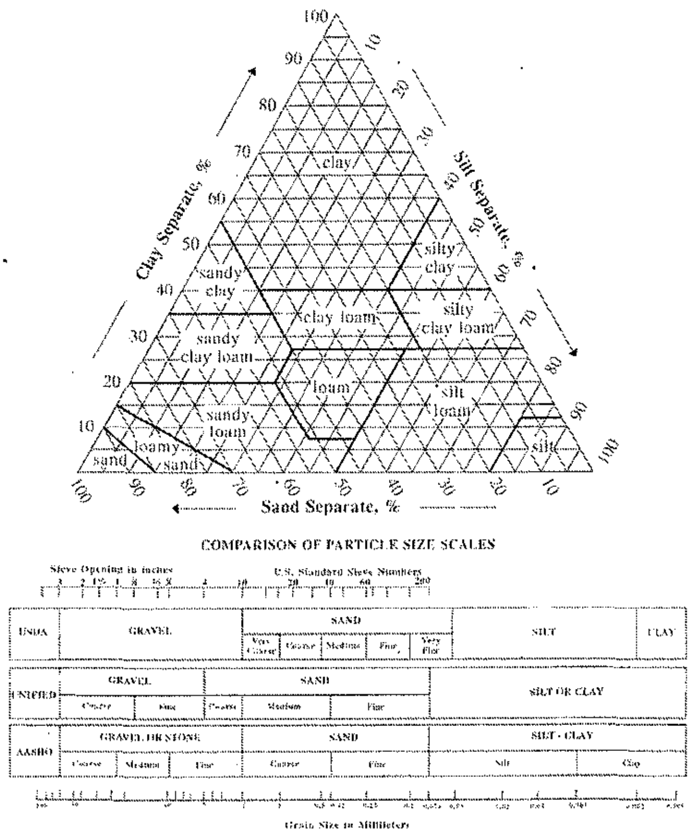

Figure 2.1 – Soils texture triangle

2.4 Ground.Water and Water Table

Groundwater is the body of water found in soil saturated with water in the pores. The locus of point in the groundwater where the water pressure is equal to atmospheric pressure is defined as water table, which is also called as the free water surface or the phreatic surface.

2.4.1 Water Table

Rain that falls on the surface seeps down through the soil and into a zone called the zone of aeration or unsaturated zone where most of the pore spaces are filled with air (Figure 2.2). As it penetrates deeper, it eventually enters a zone where all pore spaces and fractures are filled with water. This zone is called the saturated zone. The surface below which all openings in the rock are filled with water (the top of the saturated zone) is called the water table. Below the water table, soil is assumed to be fully saturated although it is likely that, due to the presence of small volumes of entrapped air, the degree of saturation will be marginally below 100%.

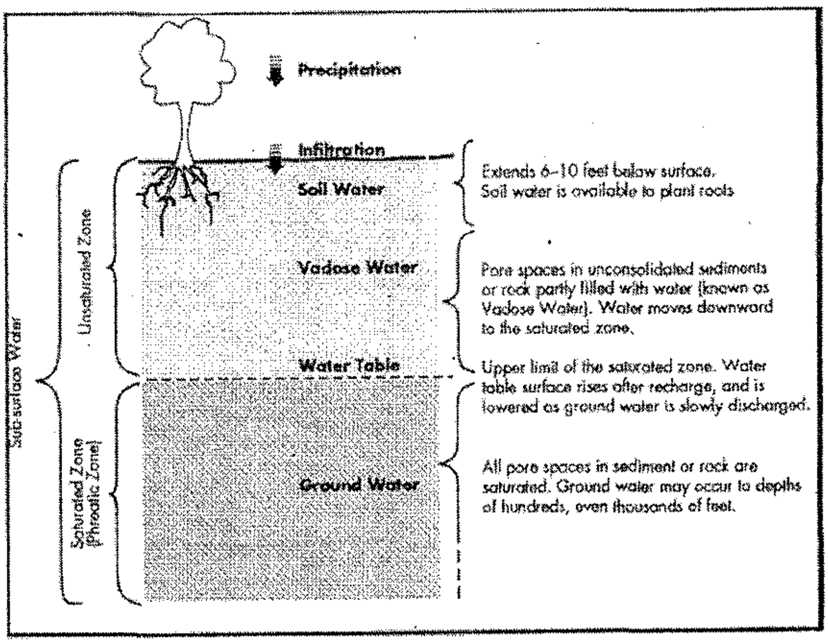

Figure 2.2 – Zoning of Water table

The water table occurs everywhere beneath the Earth's surface. In desert regions it is always present, but rarely intersects the surface. In more humid regions it reaches the surface at streams and lakes, and generally tends to follow surface topography. The depth of the water table may change as the amount of water flowing into and out of the saturated zone changes. During dry seasons, the depth to the water table increases. During wet seasons, the depth to the water table decreases.

2.4.2 Movement of Groundwater

Groundwater generally moves very slowly because it must travel through the pore spaces of rock and soil. Average groundwater velocities are a few cm/day. Groundwater is replenished (recharged) through both natural processes and artificial methods. The rate of groundwater flow is controlled by two properties of the rock: porosity and permeability

a) Porosity

Porosity is the percentage of void space in a material, and determines the amount of water a rock can hold. Void space can be from fractures, vesicles, dissolution channels, or pore spaces between elastic grains. Porosity depends on the size, shape and arrangement of the material composing the rock. In general, porosity of less than 5% is low, 5-15% is moderate, and porosity over 15% is considered high

b) Permeability

Permeability is the ability of a material to transmit water (a measure of the connectivity of the pore spaces). Clay may have a high porosity, but has low permeability because the pore spaces are isolated. The term aquifer is applied to materials that have good porosity and permeability and serve as water sources in sufficient quality for drinking. Aquicludes are materials that have low permeability and restrict the movement of water

2.5 Darcy's Law

In 1856, Darcy published a simple equation for the discharge velocity of water through saturated soils, which may express as:

$$Q = Aki \quad \text{or} \quad v = Q/A = ki \tag{2.1}$$

Where, v = discharge velocity, which is the quantity of water (Q) flowing in unit time through a unit gross cross-section area of soil (A) at right angles to the direction of flow

k = hydraulic conductivity (also known as coefficient of permeability)

i = hydraulic gradient

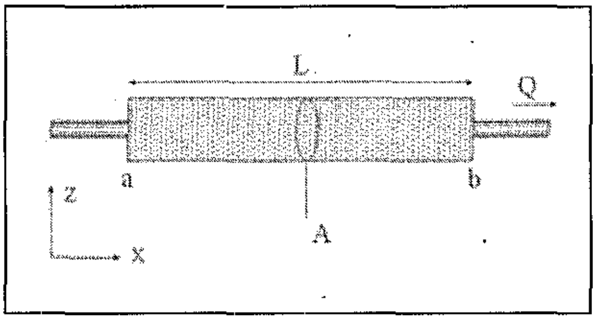

Figure 2.3 – Diagram showing definitions and directions for Darcy's law.

2.5.1 Hydraulic Gradient

The percolate rate as groundwater moves through the saturated zone depends on the permeability of the rock and the hydraulic gradient. The hydraulic gradient is defined as the difference in elevation divided by the distance between two points on the water table.

2.5.2 Hydraulic Conductivity

The hydraulic conductivity depends primarily on the average size of the pores which, in turn is related to the distribution of particles size, particle shape and soil structure. In general, the smaller the particle the smaller is the average size of the pores and lower is the hydraulic conductivity.

Table 2.1 – Typical Values of Hydraulic Conductivity of Various Type of Soils

K (cm/s)	10^{2}	10^{1}	$10^{0}=1$	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}	10^{-8}	10^{-9}	10^{-10}
K (ft/day)	10^{5}	10,000	1,000	100	10	1	0.1	0.01	0.001	0.0001	10^{-5}	10^{-6}	10^{-7}
Relative Permeability	Pervious				Semi-Pervious				Impervious				
Aquifer	Good					Poor				None			
Unconsolidated Sand & Gravel	Well Sorted Gravel		Well Sorted Sand or Sand & Gravel			Very Fine Sand, Silt, Loess, Loam							
Unconsolidated Clay & Organic					Peat		Layered Clay			Fat / Unweathered Clay			
Consolidated Rocks	Highly Fractured Rocks				Oil Reservoir Rocks			Fresh Sandstone		Fresh Limestone, Dolomite		Fresh Granite	

2.6 Geotextile

Geotextiles are permeable fabrics which, when used in association with soil, have the ability to separate, filter, reinforce, protect, or drain. As the use of geotextile fabrics has expanded, there has been the introduction of geotextile composites and the development of products such as geogrids and meshes. Overall, these materials are referred to as geosynthetics and each configuration of geonets, geogrids and others.

CHAPTER 3: METHODOLOGY/PROJECT WORK

3.1 Procedure Identification

Three main stages towards the completion of this project are percolating sand trap prototype design, laboratory test and field test.

3.1.1 Percolating Sand Trap Prototype Design

The sand trap design and specifications are given in the Urban Stormwater Management Manual for Malaysia (1997). Sand traps are gross pollutant traps and there are various devices for entrapment of gross solids from stormwater, such as floating debris traps, in-pit devices, trash racks and litter control devices, sediment traps, "SBTR" traps and proprietary devices. From a study of each type of devices (Table 3.1), sediment traps was the device chosen for this project.

Table 3.1 – Overall Classification of Gross Pollutant Traps

Group	Description and Function	Catchment Area
Floating Debris Traps	Litter capture on permanent water bodies.	> 200 ha
In-pit devices	Litter and sediment capture in existing pits	0.1 – 1 ha
Trash Racks & Litter Control devices	Hard or soft litter capture devices on drains	2 – 400 ha
Sediment Traps	Sediment removal only, on drains	> 200 ha
"SBTR" Traps	Sediment and litter capture for drain or pipes	5 – 2000 ha
Proprietary devices	Range of devices, mainly for pipes	2 – 40 ha

Sedimentation traps function by providing an enlarged waterway area and reduced hydraulic gradient to reduce flow velocities and allow bedload sediment to be trapped and suspended sediments to settle out of suspension. For litter problem, it does not provide litter removal on the device.

For design of gross pollutant trap, data required are, catchment area, hydrology on inflows, soils type and estimates of sediment loads. Refer to MBI (Masjid Bandaraya Ipoh) drainage and irrigation department. The specification size of sand traps must be in ratio 1:2 to the drain size and the depth of main sand trap with drain within 6 inches.

In developing a percolating sand trap, an opening at the bottom of the sand trap is provided to allow the retained water to percolate through the soil below. A layer of geotextile is put on the top of the percolating opening and a layer of aggregate to fill in the cylinder of percolating opening. The geotectile layer would function as a filter to trap for particle. So that, clogging would be minimized. Figure 3.1 shows the percolating sand trap.

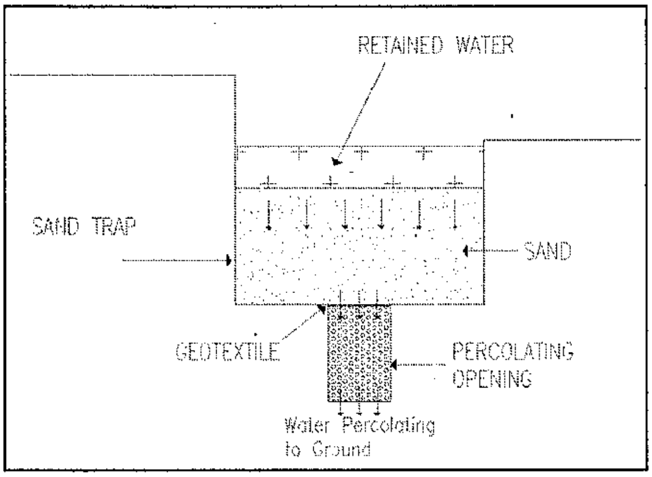

Figure 3.1 – Percolating sand trap

The size of percolating sand trap prototype was based on the actual sand trap available at the passageway from new Village Five to pocket C (Figure 3.2). The design model was based on two components, box of sand trap and opening cylinder of sand trap. The specification of percolating sand trap box prototype was 15-inch length, 15-inch width and 16-inch height. There were three diameter of percolate opening cylinder: 3 inches, 4 inches and 5 inches for the opening of percolate with 8-inch height (Figure 3.3).

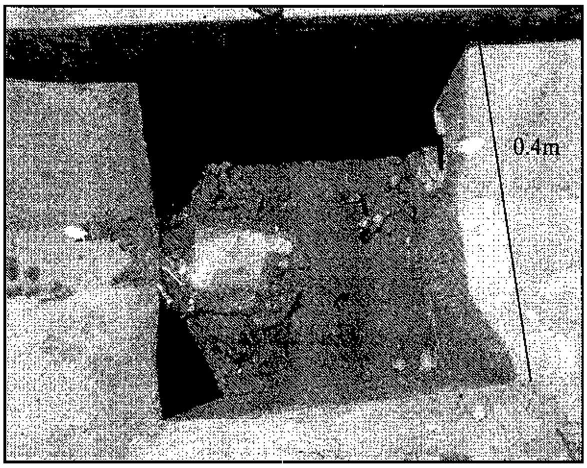

Figure 3.2 – 0.4 m-length square sand trap

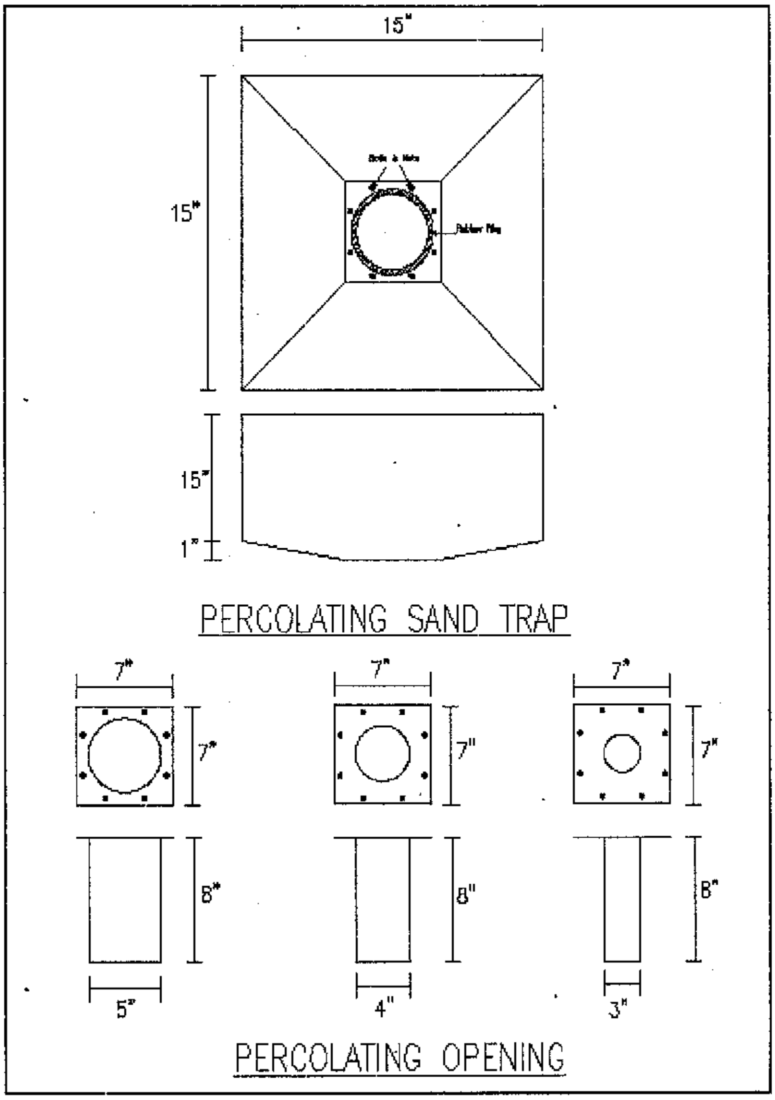

Figure 3.3 – Design and specification of percolating sand trap prototype

Test model was fabricated by using rust-free galvanized iron (G.I.) sheet. The percolating testing model is shown in Figures 3.4 to 3.7:-

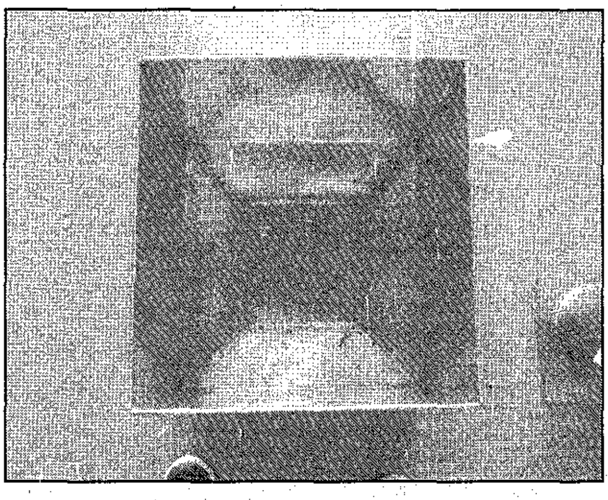

Figure 3.4 – Top view of 15" (W) x 15" (L) x 16" (H) percolating sand trap prototype

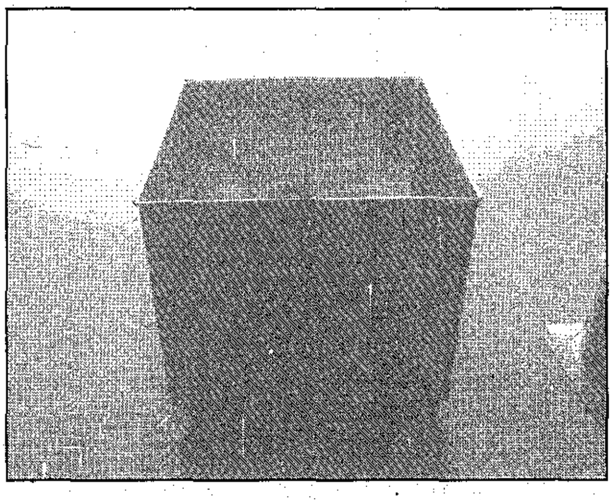

Figure 3.5 – Side view of 15" (W) x 15" (L) x 16" (H) percolating sand trap prototype

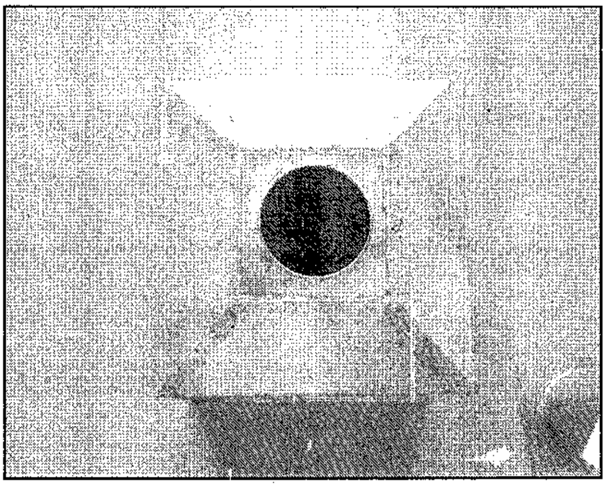

Figure 3.6 – Bottom view of 15" (W) x 15" (L) x 16" (H) percolating sand trap prototype

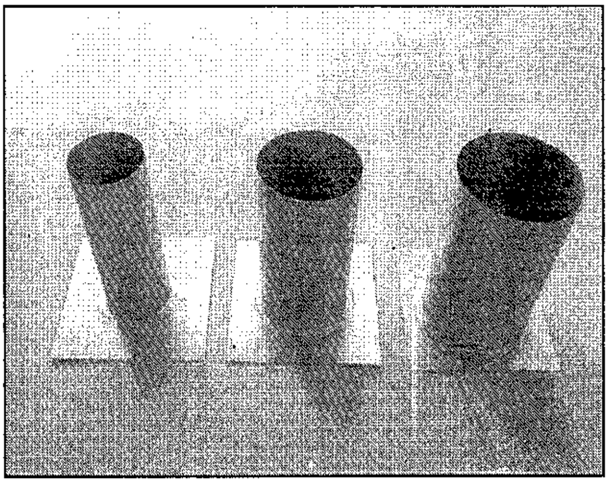

Figure 3.7 – 3", 4" & 5" diameter of percolating opening

3.1.2 Laboratory Test

Several laboratory tests were conducted, sieve analysis test, hydrometer test, constant head permeability test and falling head permeability test. All the soil specimens were disturbed samples as they were taken from soils pits by auger. The disturbed sample was used to analyze the particle size distribution with sieve analysis test and hydrometer test (for clay soils). It also was used for permeability test with two methods to test the permeability, constant head permeability test and falling head permeability test. Refer to BS 8110: Part 5: Method 5 Determination of permeability by the constant head method for soils containing less than 10% by mass of material passing the 63 μm sieve. BS8110: Part 6: Method 4 – Determination of permeability in a hydraulic consolidation cell for soils containing more than 10% by mass of material passing the 63 μm sieve. The flow of test method is shown in Figure 3.9.

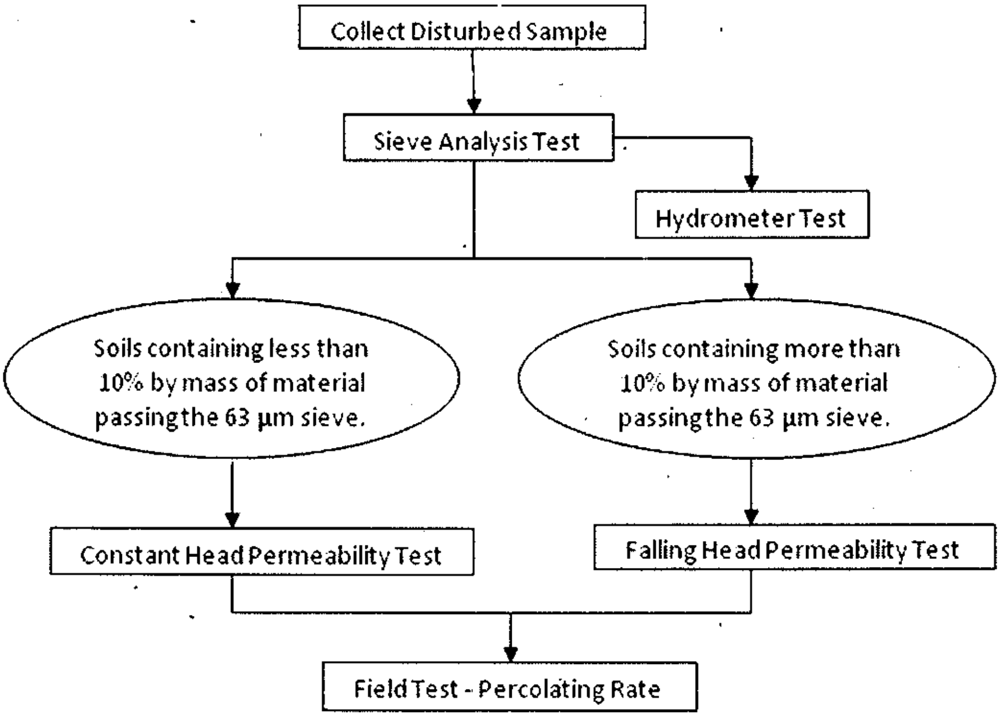

Figure 3.8 – Flowchart of Laboratory Test

3.1.3 Field Test

Field test location was depending on the soil sample collected for laboratory test. Three primary locations were chosen to study the permeability of soils: sandy loam soils at UTP campus, sandy soils at Ipoh-Lumut Highway and silty soils at Seri Iskandar.

The percolation test is a field procedure conducted in the soil horizons selected for installation of the proposed subsurface soil absorption system for the purpose of observing the rate that clean water will percolate through the soil under saturated conditions. The test provides a method for approximating the actual movement of water through the soil which will occur during operation of the subsurface soil absorption system.

3.2 Testing Method

3.2.1 Sieve Analysis

The equipment for sieve analysis was sieves and pan with 20 cm diameter, sieve brush, balance with capacity 1000 g and sensitivity 0.1 g, drying oven, sieve shaker, rubber-tipped pestle and evaporation dish.

The test procedure was simple. First, sieves were clean and weigh thoroughly 0.1 g. Approximately 500 g samples was selected and weigh, then beak the soil in to individual particle with either the fingers or a rubber-tipped pestle. Dry and remove the soil sample in drying oven after 16-24 hours drying. Record the sample weight into data sheet. Second step, to pass the sample through the stack of sieves by used of the following sieve sizes, 2mm, 1.18mm, 600μm, 425μm, 300μm, 212μm, 150μm, 63μm and appropriate receiver.

After 10 minutes of shake, weighed each sieve and recorded the gross weight of the sieve plus soil. The amount of the total sample retained on each sieve as a 100 percent determined by sum the weight of the residue collected on each sieve and compare this to the sample weight recorded. Repeat the test if discrepancy of more than 2% by weight is considered unsatisfactory. After that, compute the percentage passing each sieve by starting with 100% and subtracting the percent retained on each sieve as a cumulative procedure. Finally, a grain-size distribution curve plotted on a semi-logarithmic graph to result analysis. The test completed if the total sample passes the 63μm sieve less than 10%, if more than 10% passes then continue with a particle size distribution method.

The analysis have to compute the coefficient of uniformity (Cu = D60/D10) from the curve grain-size distribution; where D refers to the effective diameter of the soil particles and the subscripts (10 and 60) denote the percent which is smaller. An indication of the spread or range of grain sizes is given by Cu, with a large Cu value indicating that the D60 and Dl0 sizes differ appreciably.

3.2.2 Hydrometer

The equipment for hydrometer test was hydrometer graduated 0.995 to 1.030 g/ml, two 1 L graduated glass measuring cylinders with ground glass stoppers marked at 1 L volume, a thermometer to cover the temperature range 0 to 50°C, readable to 0.5°C, balance readable to 0.01g, stop clock or stopwatch readable to 1s, desiccators containing anhydrous silica gel, wide-mouth conical flask of 1 L capacity, two measuring cylinders of capacity 100 ml and 500 ml, wash bottle containing distilled water, constant temperature bath and sodium hexametaphosphate solution.

For preparation and assembly the equipment and chemical, 50g of the test sample weighed to 0.01g and obtain its initial dry mass, m_o. Test sample placed in the wide-mouth conical flask. 100ml of the sodium hexametaphosphate solution added to the soil in the conical flask. Mixtures shake thoroughly until all the soil is in suspension. Suspension transferred from the flask to the 63μm test sieve placed on the receiver, and washes the soil in the sieve using a jet of distilled water from the wash bottle. The amount of water used during this operation shall not exceed 500ml. The suspension that has passed through the sieve transferred to the 1 L measuring cylinder and make up to the 1 L graduation mark with distllled water. Analyses the suspension for the sedimentation analysis. The material retained on the 63μm test sieve transferred to an evaporating dish and dries in the oven maintained at 105°C to 110°C. After that material received on the sieves down to 63μm size after cooled. The material retained on each sieve to approximately 0.01g weighed. Any material passing the 63μm test sieve added to the measuring cylinder.

For sedimentation of soil specimen, rubber bung inserted into the cylinder containing the soil suspension, shakes it and placed it in the constant-temperature bath so that it immersed in water at least up to the 1 L graduation mark. 100ml of the sodium hexametaphosphate solution added to the second 1 L sedimentation cylinder and diluted with distilled water to exactly 1 L. Rubber bung inserted to the cylinder in the constant temperature bath alongside the first. Cylinder containing the dispersion solution took out for shake thoroughly and placed it in the bath after at least one hour. After that, the cylinder containing the soil suspension took out and shake vigorously end-over-end about 60 times in 2 min and then immediately replace it in the bath. Start the timer at the instant of the cylinder with the soil suspension replaced upright in the bath. The rubber bungs removed carefully from the cylinders.

Hydrometer in the suspension immersed to a depth slightly below its floating position and allows it to float freely. Hydrometer readings took at the upper rim of the meniscus after periods of 0.5 min, 1 min, 2 min and 4 min. Hydrometer removed slowly, rinse in distilled water and place it in the cylinder of distilled water with dispersion at the same temperature as the soil suspension. The top of the meniscus reading, R_0. observed and recorded into data sheet

Hydrometer reinserted in the soil suspension and readings recorded after periods of 8 min, 30 min, 2 h, 8 h, and 24 h from the start of sedimentation. The exact time period was recorded precise times are not critical time provided. The hydrometer inserted slowly about 15s before a reading is due. The hydrometer inserted and withdraws before and after taking each reading very carefully to avoid disturbing the suspension unnecessarily. 10 second allowed for each operation and avoids vibration of the sample.

The temperature of the suspension observed and recorded during the first 15 min and then after every subsequent reading. Read the temperature to an accuracy of ±0.5°C.

3.2.3 Constants Head Permeability Test

The equipment for constants head permeability test was permeameter mould of non-corrodible material and the mould shall be fitted with a detachable base plate and removable extension counter, drainage bade, drainage cap, constant head tank, graduated glass cylinder, stop watch and meter scale..

2.5 kg of disturbed soils specimen took for testing from a thoroughly mixed air dried or oven dried material. Get the desired moisture content required quantity of water and thoroughly mix the soil. Between the compaction base plate and extension collar clamped, then assembly on a solid base and sample with filled and compacted. Excess soils removed after completion of a compaction the collar and properly saturated the mould with sample in the permeameter.

Test procedure connected the specimen through the top inlet to the constant head reservoir with open of the bottom outlet. After that, steady flow of water established to perform constant head established. Finally, quantity of flow collected for a convenient time interval. For the same interval repeated three times to get accuracy of the testing specimen.

3.2.4 Falling Head Permeability Test

The equipment for falling head permeability test was a non-corrodible permeameter, mould with a detachable base plate and a removable exterior collar, compacting equipment, porous disc for drainage base and cap, container tank with an overflow valve and stand pipe on a board

The preparation of disturbed soil specimen 2.5 kg sample for testing took from a thoroughly mixed air dried or oven dried material. Get the desired moisture content required quantity of water and thoroughly mix the soil. Between the compaction base plate and extension collar clamped, then assembly on a solid base and sample with filled and compacted. Excess soils removed after completion of a compaction the collar and properly saturated the mould with sample in the permeameter.

Specified test procedure prepared to the soil specimen (soils particle with passing more than 10% of 63μm sieve). Then, soil specimen saturated with desired water. Permeameter assembled in the bottom tank and fill the tank with water. Stand pipe to inlet nozzle connected of the mould. Some water to flow until steady flow obtained. Finally, time interval noted for a fall of head in the stand pipe. For the same interval test repeated three times to get accuracy of the testing specimen.

3.2.5 Field Percolation Test

A square hole excavated to suit the percolate sand trap size and a circular hole excavated at the middle of the square hole with the percolate opening. It's ensured that the sizes of percolate opening fit with the excavated circular hole and avoid disturbing the surrounding soil. After hole drilled, the percolate sand trap and percolate opening assembled with screws and nuts. The assembled percolate sand trap placed to the hole and backfill the void area and all loose material and smeared clay removed from the sides and bottom of excavation. The circle hole covered with graded aggregate passing 5mm sieve. During backfill, the soil compacted with hoe and spray water on top of backfilled soils to conduct a natural compaction of soil during water permeable into the soils. Finally, the percolations tested with fill the prototype with water to 15cm depth and the time determined for the water to seep away each 1cm (The level of water referred to the indicator attached inside the prototype). During the previous water level seeped away to empty level, water refilled to 15cm level. The reading took until a stable rate of drop reached. Once a stable rate reached, the average drop of the last three readings in computing the percolation time by drop of each 1cm water level divide to average time of last 3 readings was took.

3.2.6 Percolation Test with Water Table

A 80 gallon of water tank was used to contain the soil collected from site. Three water outlets were designed to control or determine of water tank's water table. Before backfilling the soil into the water tank, soil bulk density was to be determined. To determine the soil bulk density, a measured diameter of steel cone used. The cone pressed into the original soil at least two quarter length of cone. After that, pulled the cone uplift and the soil will uplift together with the cone. Soil removed from the cone and its length and density measured. Bulk density calculated with formula weight over volume and total weight of soil had filled up the water tank. During filling the soil into water tank, every estimated 20 kg of soil have to be compacted manually. After soil filled as calculated weight, water flowed in to the prototype until it estimated saturated. To avoid air void trapped in soil, a slow water flow used to recharge in soil. Water level can be controlled or determined with the water outlet beside the water tank. Finally, the percolate rate test similar ran with the field percolation test method with different water table.

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Sieve Analysis and Hydrometer Results

The objective of this test was to determine the particle size distribution by the hydrometer method. This test was carried out according to BS 1377: Part 2: 1990: 9.5 Hydrometer analysis is based on the principle of sedimentation of soil grains in water and when a soil specimen is dispersed in water, the particles settle at different velocities, depending on their shape, size, and weight, and the viscosity of the water (Das, 2002). Sodium hexametaphosphate used as the dispersing agent in the test.

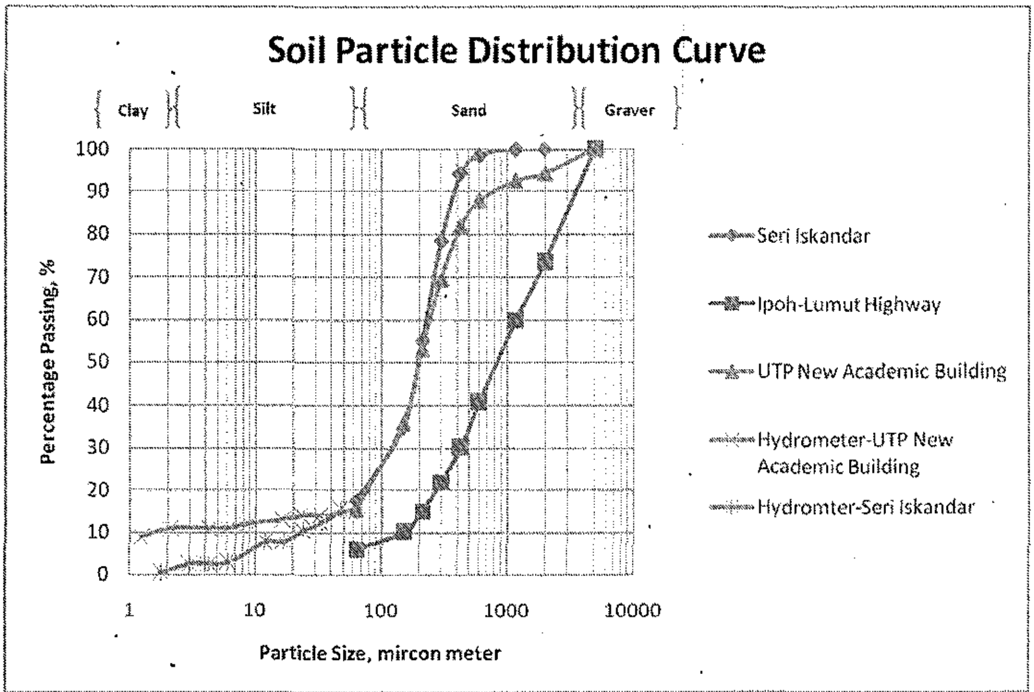

Figure 4.1 – Soil Particle Distribution Curve

Sieve analysis was carried out before conducting the hydrometer analysis was conducted. The results of sieve analysis and hydrometer analysis are combined on one graph, such as the one shown in Figure 4.1. According to Das (2002) "when these results are combined, a discontinuity generally occurs in the range where they overlap. This discontinuity occurs because soil particles are generally irregular in shape. Sieve analysis gives intermediate dimensions of a particle; hydrometer analysis gives the diameter of an equivalent sphere that would settle at the same rate as the soil particle". Adjustment was done to make the graph continuous as shown in Figure 4.1. Refer to photo in appendix for the photo taken during the test.

From the above graph in Figure 4.1, the characteristic of different type of soil located at each location can be determined. Soil in Ipoh-Lumut Highway consists of 93% coarse material and 7% fines. The coefficient of uniformity, Cu is 8.43 and the coefficient of curvature is 1.09. It is classified as well graded sandy soil. Soil in UTP new academic building consists of 85% coarse material and 15% fines. The coefficient of uniformity, Cu is 119 and the coefficient of curvature is 32. It is classified as loam soil. Finally, soil in Seri Iskandar consists of 83% coarse material and 17% fines. The coefficient of uniformity, Cu is 10 and the coefficient of curvature is 2.9. It is classified as sandy silt soil.

The particle-size distribution curve shows not only the range of particle sizes present in a soil, but also the type of distribution of various size particles. Curve of soil in Ipoh-Lumut Highway are distributed over a wide range, termed well graded. A well graded soil has a uniformity coefficient greater than about 4 for gravels and 6 for sand, and coefficient of gradation between 1 and 3 (for gravels and sands). Curve of soil in UTP New Academic Building and Seri Iskandar are represents a type of soil in which most of the soil grains are of the same size. This is called poorly graded soil.

Soil types of each sample collected were referred to Figure 2.1 the soils texture triangle. The results are shown in Table 4.1.

Table 4.1 – Soil type of each sample collected

Location	**% sand**	**% silt**	**% clay**	**Type**
Seri Iskandar	85	15	0	Loamy Sand
UTP New Academic Building	83	5	10	Sandy Loam
Ipoh-Lumut Highway	95	5	0	Sand

4.2 Laboratory Permeability Results

The objective of this test was to determine the soil permeability by the constant head permeability method or falling head permeability method. This test was carried out according to BS 1377: Part 5: 1990: 5 & Part 6: 1990: 4, The coefficient of permeability depend primarily on the average size of the pores, which in turn is related to the distribution of particle sizes, particle shape and soil structure. (R.F.Craig,1997).

Table 4.2 – Hydraulic Conductivity Comparison (Theoretical and Measured)

Location	Soil Type	Hydraulic Conductivity (Theoretical)	Hydraulic Conductivity (Measured)
Ipoh-Lumut Highway	Sandy	0.01 cm/s – 100 cm/s	0.02 cm/s
UTP New Academic Building	Loamy sand	0.000001 cm/s – 0.01 cm/s	0.000103cm/s
Seri Iskandar	Loamy Sand	0.000001 cm/s – 0.01 cm/s	0.000158 cm/s

The permeability test results of various soils are shown in Table 4.2. The measured hydraulic conductivity were in the range of theoretical of hydraulic conductivity.

Table 4.3 – Estimated calculate percolate duration with 15 liters of water.

Location	Soil Type	Percolate Duration		
		3 inch	4 inch	5 inch
Ipoh-Lumut Highway	Sandy	2 hours 11 minutes	1 hour 13 minutes	47 minutes
UTP New Academic Building	Sandy Laom	23 days	13 days	8 days
Seri Iskandar	Loamy Sand	23 days	13 days	8 days

The estimated percolate duration with consideration of laboratory permeability test result and percolate opening size to percolate 15 liters of water was shown in Table 4.3. The process of this calculation was estimated quarter of prototype storage with 15 liters of water to percolate under consideration of hydraulic conductivity found at various locations. From the calculation, different designed percolate opening size will have several of rates of percolate duration. It was due to the surface areas that allow water percolate through the different size of designed percolate opening.

Estimated calculation from Table 4.3, it shown soil from Ipoh-Lumut Highway was achieved objective of project within three days. The percolating rate was less than a day for each type of percolate opening it was due to the hydraulic conductivity of sandy soil achieved 0.02 cm/s. The objective didn't achieve for loam soil from UTP New Academic Building and Seri Iskandar to percolate estimated 15 liter of water within three days. From the hydraulic conductivity test conducted at laboratory, the hydraulic conductivity for soil from UTP New Academic Building and Seri Iskandar were around 0.0001 cm/s and it was in range of loam hydraulic conductivity. The hydraulic conductivity was the reason to cause to both soils from UTP New Academic Building and Seri Iskandar took longer period twenty three days to percolate estimated 15 liters of water.

Darcy's Law (1856) published the discharge velocity of water through saturated soils was depend on the hydraulic conductivity and area of soil specimen. The size of designed percolate opening was affected the percolate duration for various soil types, where larger percolate opening was percolate faster.

The estimate calculation of Table 4.3 was based on the horizontal one way flow of water, where the percolate on field was triaxial flow. So, the percolate duration on site was assumed that lower than the estimated percolate duration based on one way horizontal flow.

4.3 Field Percolate Rate Results

The objective of this test was to determine the percolating rate on site. This test was carried out similar to the infiltromter method, to infiltrate water continuously into unsaturated soil. After a certain time it was observed that the soil around and below the area became almost saturated and that the wetting front was rather a sharp boundary between wet and dry soil.

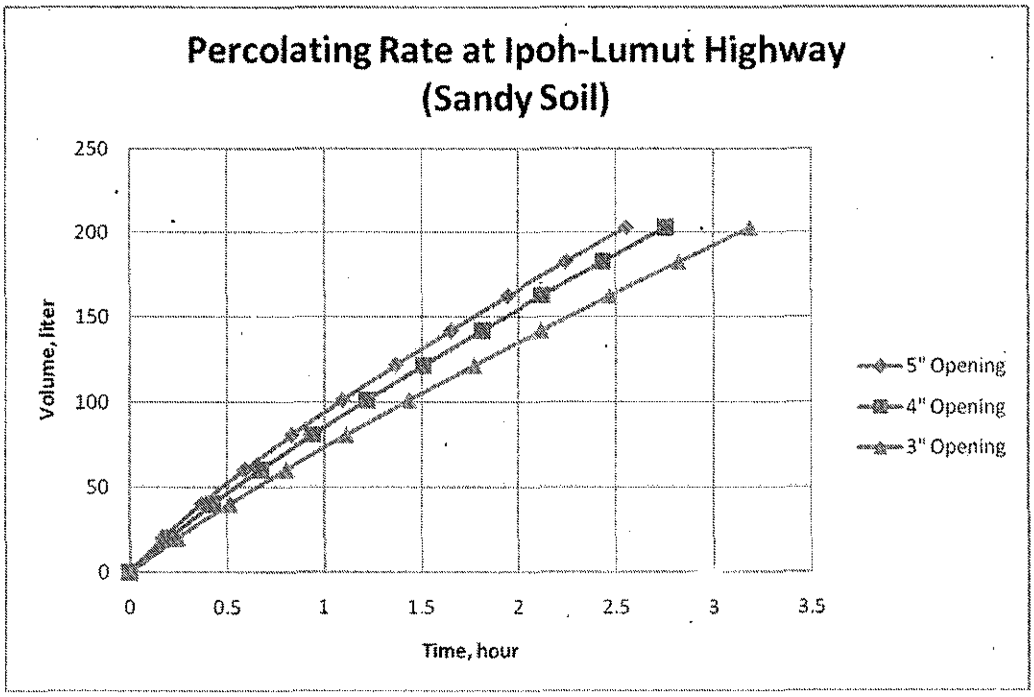

Figure 4.2 – Percolating rate at Ipoh-Lumut Highway

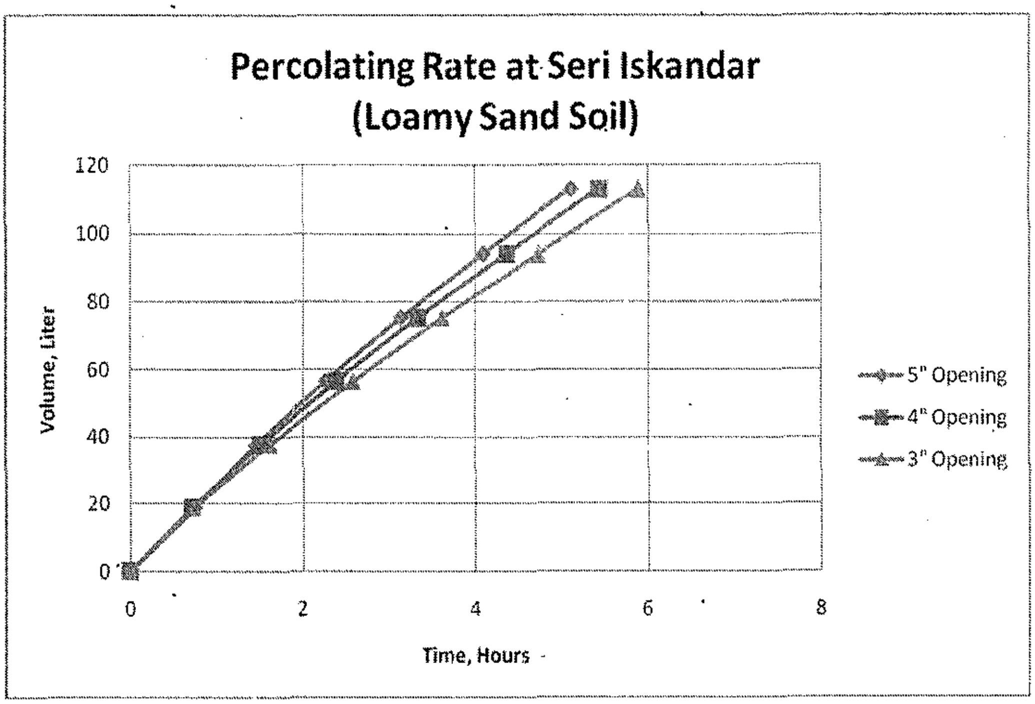

Figure 4.3 – Percolating rate at Seri Iskandar

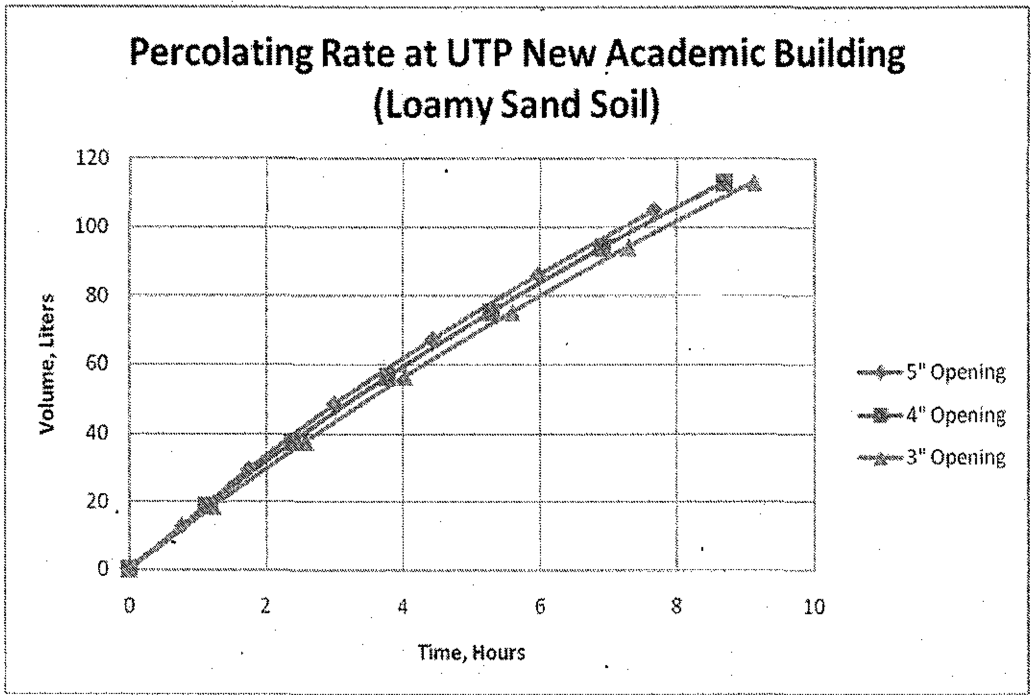

Figure 4.4 - Percolating rate at UTP New Academic Building

From Figure 4.2 – 4.4, it is seem that the percolate rate was higher during the beginning of percolation test. It was due to the water permeable from the prototype above to the backfill soil during construction of prototype on site where it was less compaction compared to the original soil condition and the air void of soil element in natural state and backfilled state. The percolation rate was lower with time while keep refilled water into prototype; it was due to the soil below getting saturated which affected the percolation rate. From the percolation test with different size of percolate opening will have different rate of percolation, where the smaller size of percolate opening consume more time to percolate volume of retained water on prototype.

Table 4.4 – Percolation rate of each location and size of opening

Location	Percolate Rate (liter/hour)		
	5"	4"	3"
Ipoh-Lumut Highway	67.86	64.62	63.16
Seri Iskandar	19.86	18.55	17.10
UTP New Academic Building	12.11	11.50	11.12

The data of Table 4.4, percolation rate of each location and size of opening was based on the test conducted. The reading was taken until a stable rate of drop reached. Once a stable rate reached, the average drop of the last three readings in computing the consumed percolation time by drop of each volume of storage tested divide to average time of last three readings was took.

The field percolation test was the most time consuming test. The field percolation tests were conducted under normal weather condition, where the soil was not fully saturated. Its was like reason for the percolate rate on site were 67 liter per hour for Ipoh-Lumut Expressway's site area, 19 liter per hour for Seri Iskandar site area and 12 liter per hour for UTP New Academic Building site area.

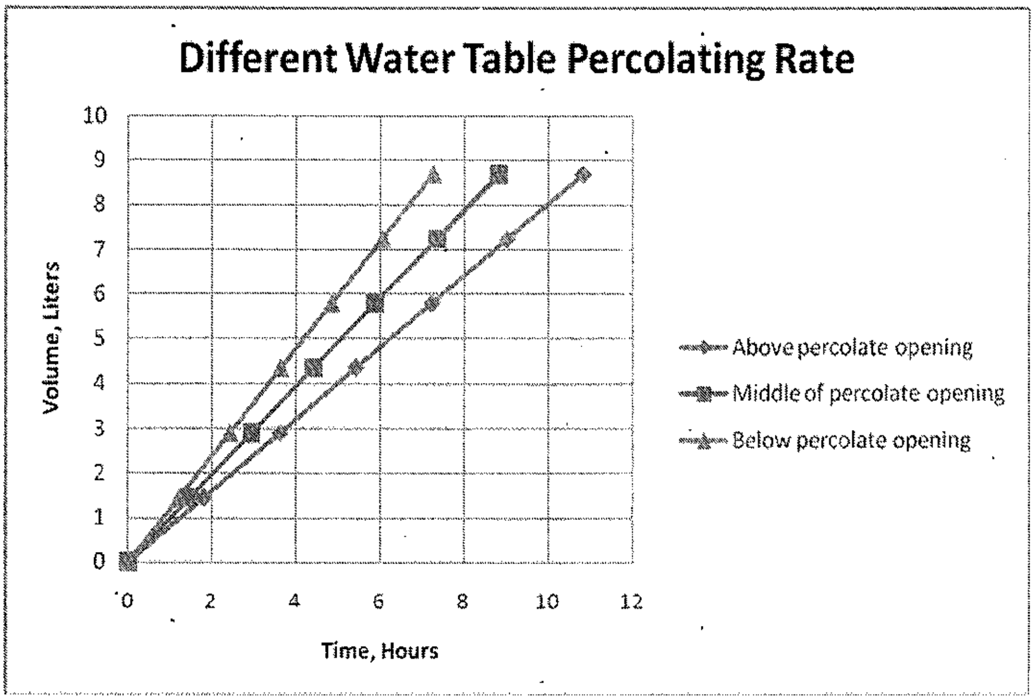

Figure 4.5 – Different water table percolating rate

The percolation test was also conducted under different soil water level condition to determine the effect of water table on the percolate rate. In this percolation test, water table was controlled with the water outlet beside the water tank. The results of different soil water table percolation test are shown in Figure 4.5,

Table 4.5 – Percolate rate with different water table

Water Table	Percolate Rate (liter/hour)
Above Percolate Opening	0.802
Middle of Percolate Opening	0.983
Below percolate Opening	1.199

According to the Craig (1997), water seeping through soil particles follows a very tortuous path between the soil particles, but macroscopically the flow path can be considered as a smooth line. The percolation rate at which the water flows through the soil pores was higher for field percolation test in which there were more soil pores and less moisture. The percolation rate was lower for percolation test under consideration of close water table to the percolate opening. It was due to the soil pores already filled with water and the hydraulic gradient, when the water filled in pores water level was increased and it was reduce the hydraulic gradient. Equation 2.1 of Darcy (1856) was shown the discharge (percolate rate) of water through saturated soil was affected by gross-section area of soil, hydraulic conductivity and hydraulic gradient. Lower hydraulic gradient was lower the rate of percolation.

From the results under different water table percolation test, the percolate rates for water table above percolate opening was 0.8 liter per hour, middle of percolate opening was 0.9 liter per hour and below percolate opening was 1.1 liter per hour (Table 4.5). As mentioned above, it was due to the hydraulic gradient between the prototype water level and water table. During long period of water recharge in drainage, the soil below percolating sand trap will get saturated and increase the level of water table. This faction will reduce the field capacity by the incoming moisture content.

CHAPTER 5: CONCLUSIONS

5.1 Conclusions from the Literature Review

Designing a percolating sand trap is a complex task where the student needs to develop a realistic prototype for testing and analysis with different types of soil and different diameter of percolate opening. The whole project requires a thorough knowledge of urban storm water management, drainage principle and application, soil mechanics and hydraulics. Thus, completing the project is a challenge to the designer using it knowledge on the lesson gained throughout the whole studies in civil engineering.

According to the research conducted by Stenitzer and Gassner (2005), on condition that good measurements or estimated of the capillary conductivity function of the soil layer at the lower boundary of a soil profile are available, deep percolation may be assessed by continuous measurement of water level and suction gradient at this depth, which should be situated well below the deepest roots. Where groundwater fluctuations may be influenced by water extraction and do not reflect natural conditions. The results of analyzing low water discharge will not be representative to the area of test conducted within the prototype storage basin. So, several series of test have to be conduct at the area of interest in long period of monitoring.

According to the drainage department of local authority (Masjid Bandaraya Ipoh), there is no conventional design for the sand trap or sump on urban drainage. The sand trap size depended to the suspended solid flow in runoff water and the size of drainage. Nowadays, to maintenance of sediment trapped on drainage easily and manpower cost saving, so engineers try to avoid sump at urban area and design a gross pollutant trap at the end of drainage collector for each designed community. It was due to easy maintenance of sediment trapped on drainage. Its mean that the percolating sand trap was useful to upgrade the existing drainage sand traps.

For the particle size distribution experiment, the accuracy of the results can be increase be testing more soil sample conducted by sieve analysis test and hydrometer test.

However, the experiment of three different location soil still succeeded by shown that the soil that being use in this study are sandy, loamy sand and sandy loam.

For the laboratory permeability test, the objective of the experiment which to find soil saturated permeability. After analyzing, the permeability of each soil sample was still in the range of theories of hydraulic conductivity. Hydraulic conductivity of sandy soils from Ipoh-Lumut Expressway was 0.02 cm/s, sandy loam soils from UTP New Academic Building was 0.000103 cm/s and sandy loam soils from Seri Iskandar was 0.000158 cm/s. From the result of permeability test, estimation can be done to actual infiltration rate on site.

The estimated percolated rates for each type of soils were based on the hydraulic conductivity result from laboratory. The soils condition for permeability test were fully saturated and by one-way infiltrate, where it were different to actual site condition, which soils are not fully saturated and with tri-axial infiltrate. So the estimated field hydraulic conductivity was higher than laboratory results.

The field percolation test was the most time consumable test, it need researcher have full time on site to monitor the permeability rate. The difficulty of field percolation test were supply of water and time consuming on monitor the permeable rate. It may need help from other to supply water and monitor.

5.2 Conclusion from Test Results

The results of field percolation rate could achieved the objective of this project namely to percolate retain water within three days but it was not possible under effect of saturated soil and water table below the percolating sand trap. Water percolates downward to the water table at the point of projection to the water-bearing bed, and then moves down dip beneath the overlying impermeable bed. In actual condition it is a dilemma of long period of rainfall or irrigation to the drainage system. The water recharge will percolate though the percolating opening to the soil below, it will increase the moisture content and water table level. The increase of soil moisture content and water table will decrease the performance percolation during long period of rainfall or irrigation to the drainage. Also, it cause to the percolating sand trap was not suitable for high water table area especially for the silty clay soil with hydraulic conductivity less than 0.001 cm/s.

A high water table which under pores water pressure will discharge groundwater through percolate opening to the percolating sand trap. The hydrostatic pressure of the ground water is due to the weight of water at higher levels in the water-bearing bed, or aquifer (percolate opening) as it is usually called. The pressure head of water at a given point in an aquifer is its hydrostatic pressure expressed as the height of a column of water that can be supported by the pressure. The pressure head is the height that a column of water raises in a tightly cased well that has no discharge. If the pressure in the aquifer is sufficient to lift the water above the top of the aquifer, artesian conditions are said to exist. The difference in height between the point of percolate opening and the point of discharge must be sufficient to develop a pressure equal to the weight of the column of water in the well plus the loss of head by friction in the aquifer before a well will flow at the percolate opening.

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APPENDIX I

Project Picture

Project Picture

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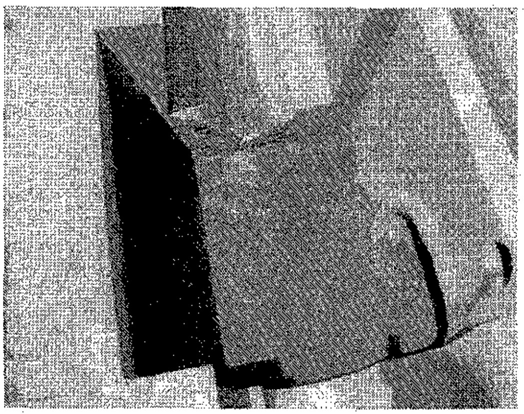
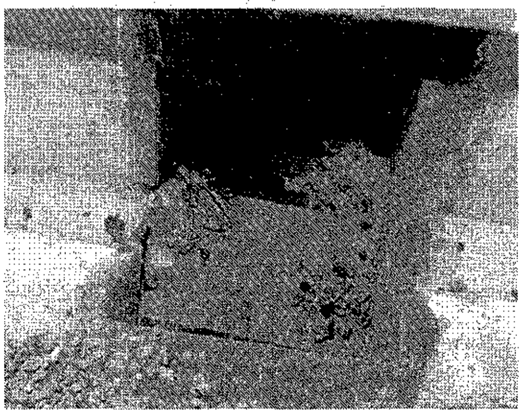
<tr><td></td><td></td></tr>
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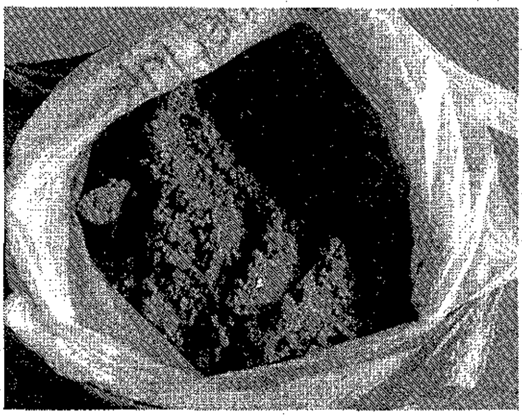
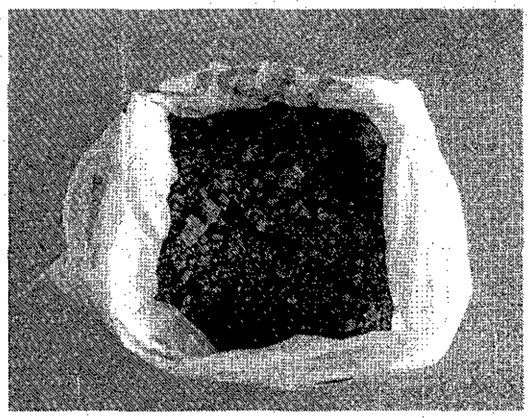
<tr><td></td><td></td></tr>
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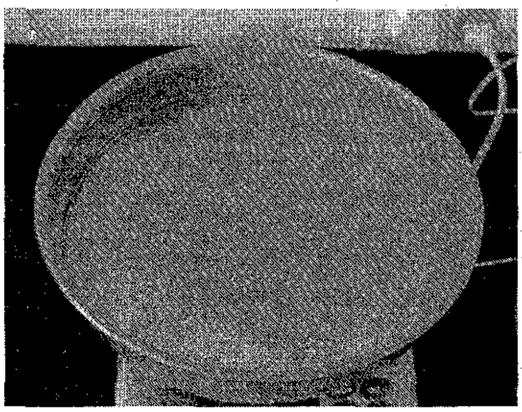
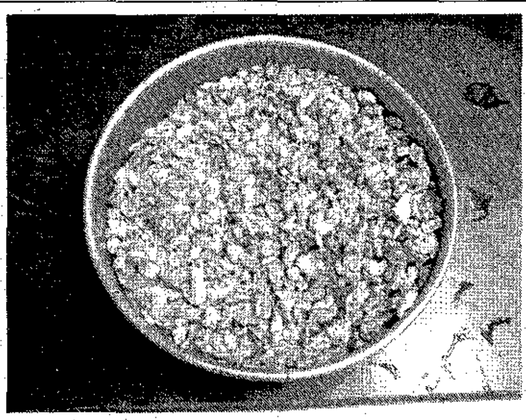
<tr><td></td><td></td></tr>
<tr><td>Weighting after sieve analysis test</td><td>Graded aggregate</td></tr>
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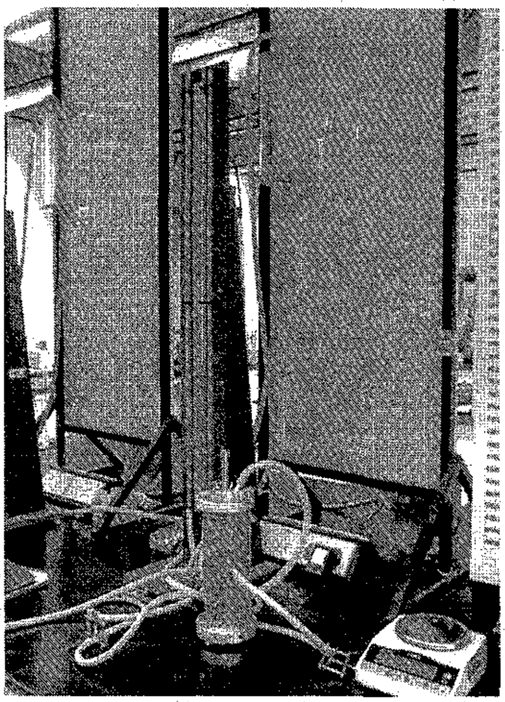
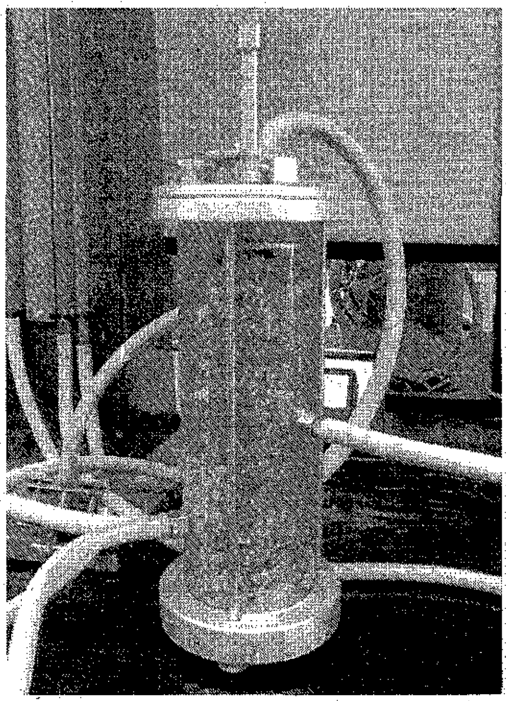
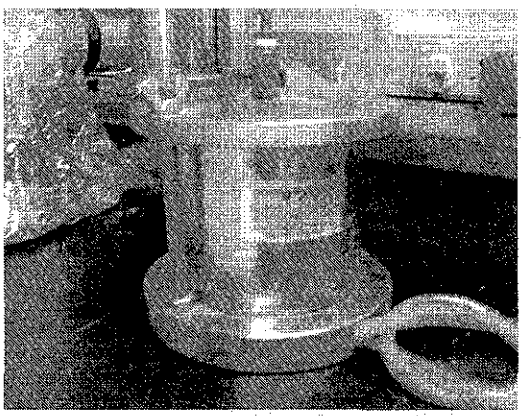
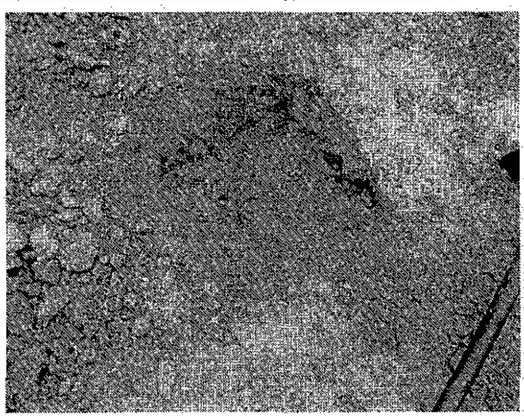
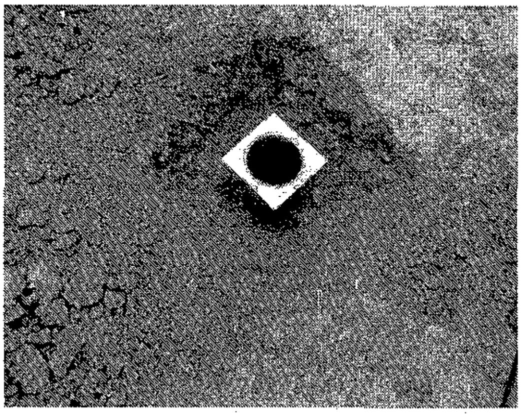
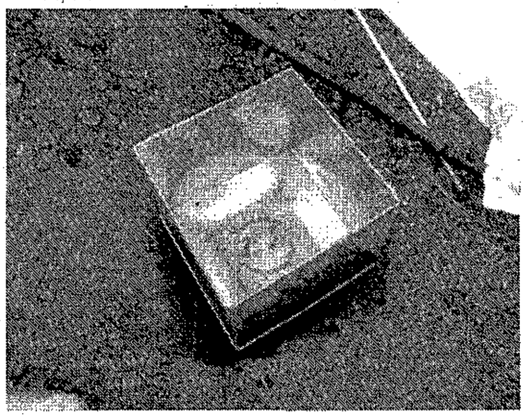
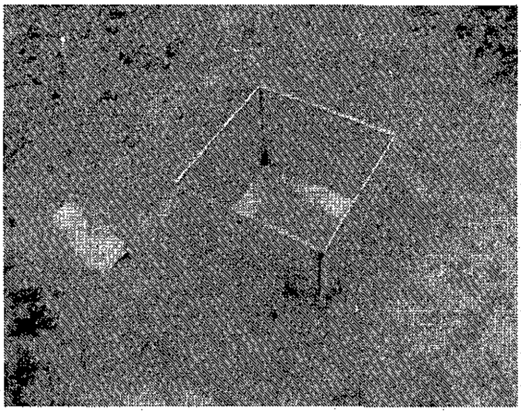
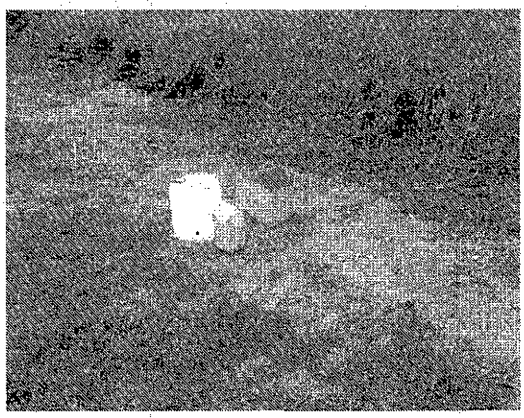
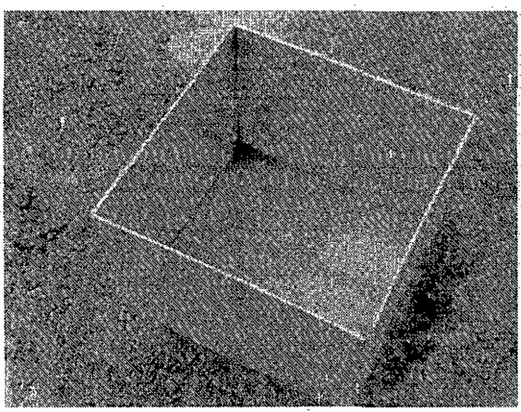
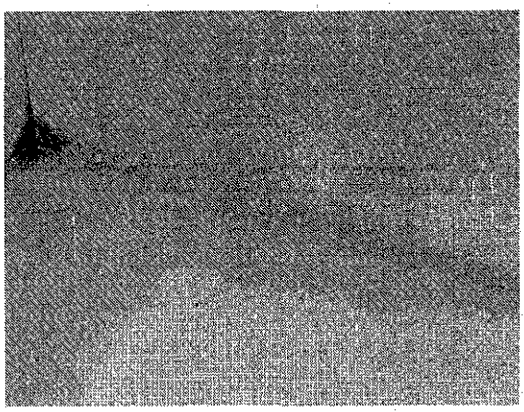
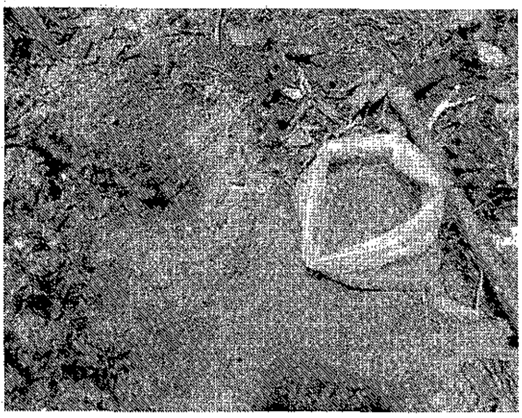
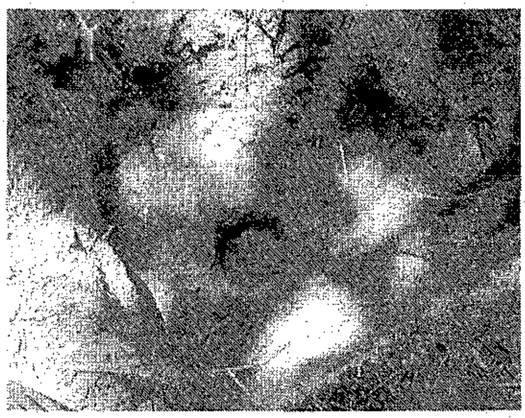
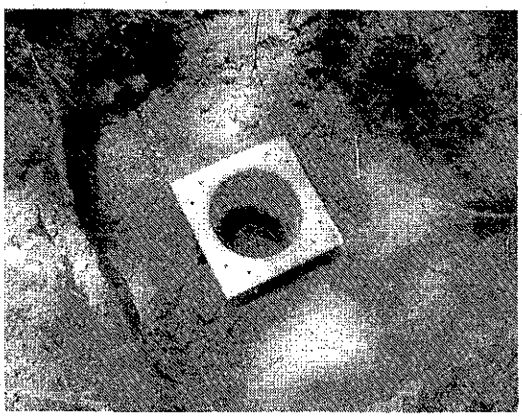
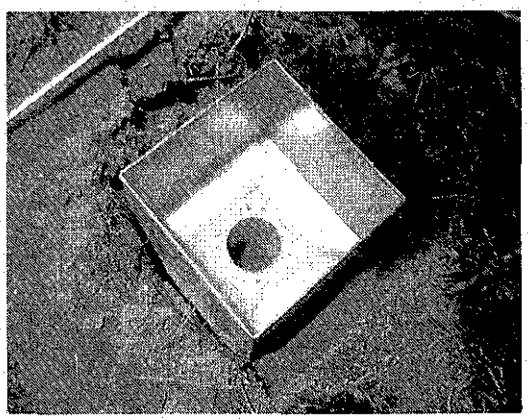
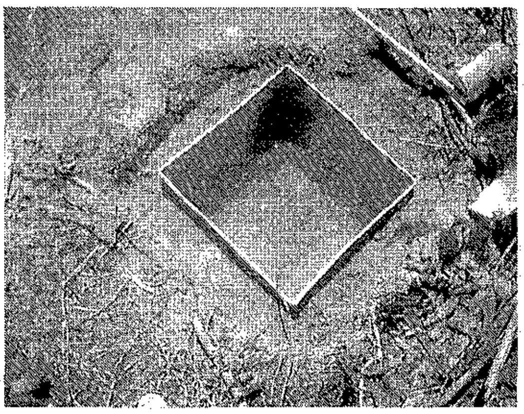
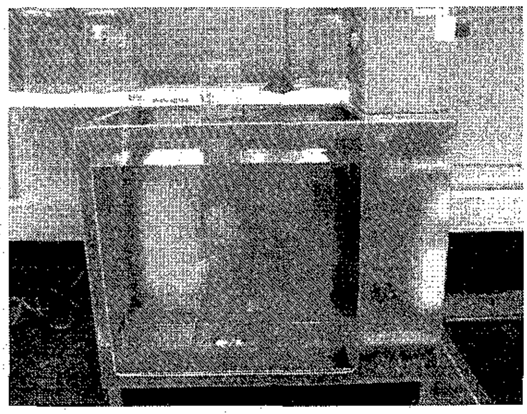
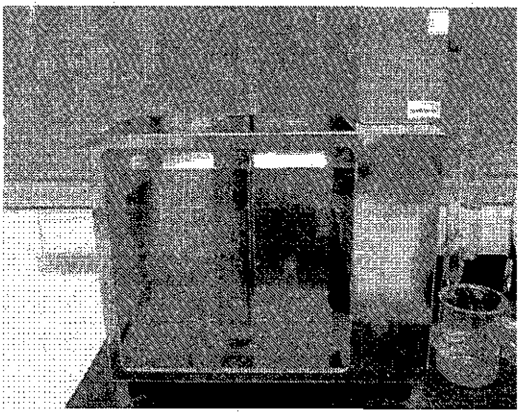
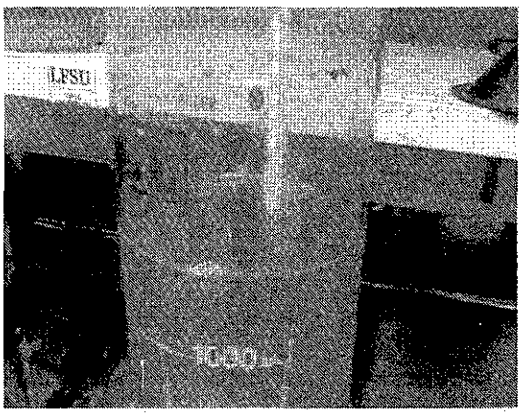
	
Constant head permeability tool	Soil sample in permeameter
	
Falling head permeability tool	Excavated hole for prototype

	
Determine the location of percolate opening	Assembled percolate opening and box
	
Backfilled	UTP campus site area
	
Percolation testing	Indicator reading

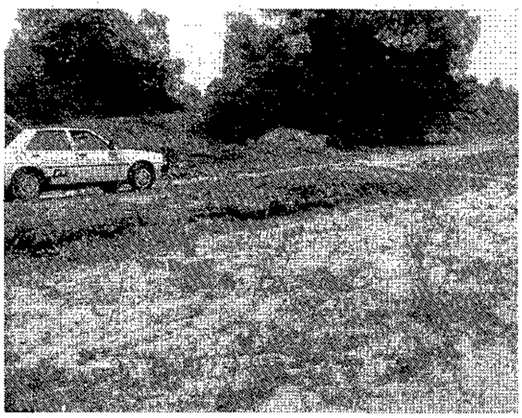
	
Seri Iskandar soil sample	Excavated hole for prototype
	
Install percolate opening	Installed whole prototype
	
Backfilled and percolation testing	Hydrometer for UTP campus soil sample



Hydrometer for Seri Iskandar soil sample

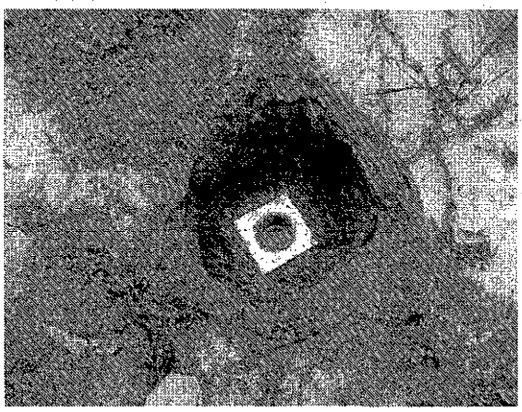


Hydrometer reading

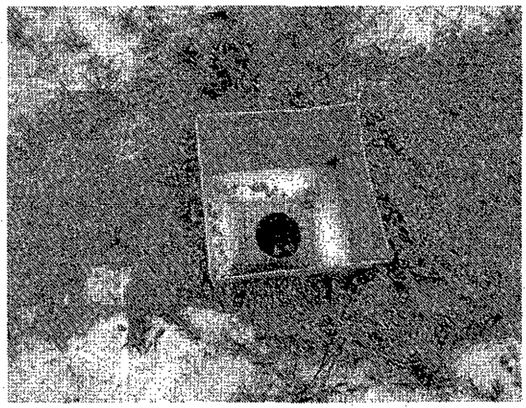


Ipoh-Lumut expressway site area

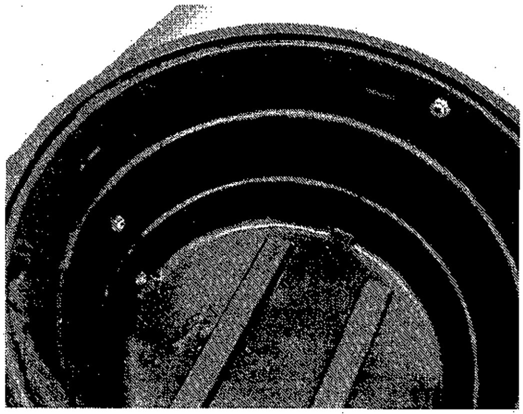
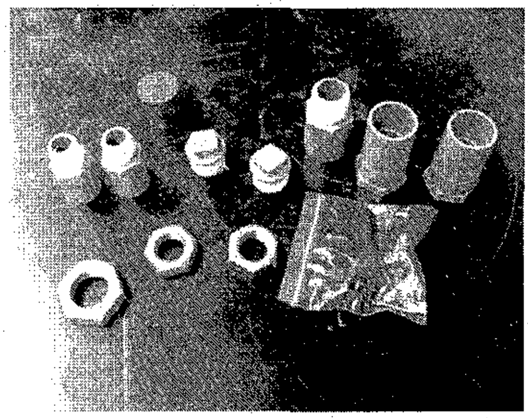
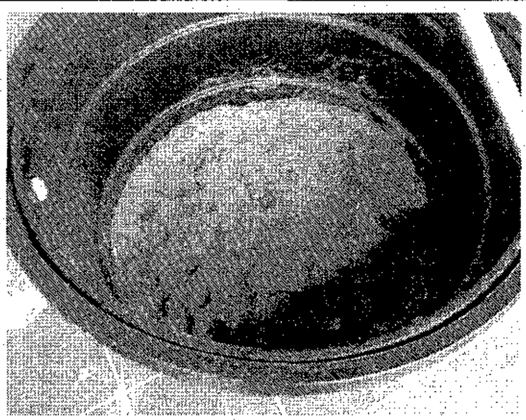
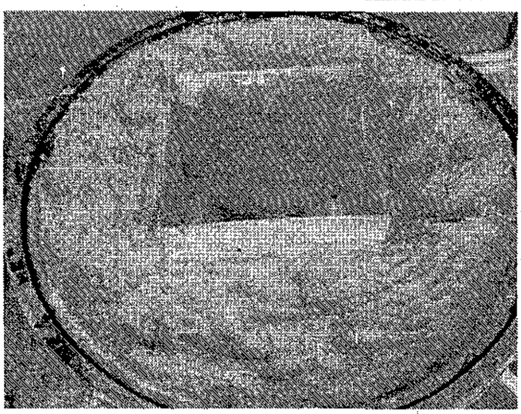
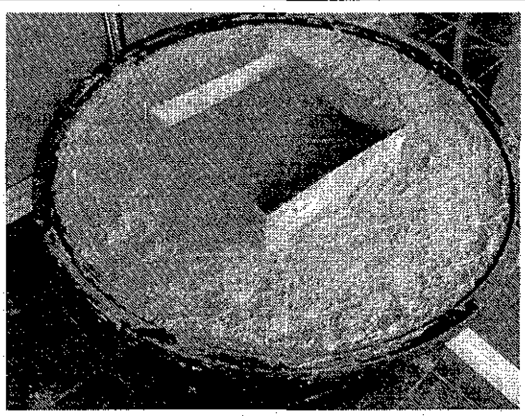
Excavated hole for prototype



Installed Percolate opening



Installed prototype

	
80 gallon water with 3 water outlet	Material used for water outlet
	
Weight soil for backfill	Compacted soil
	
Installed prototype on water tank	Percolation test

APPENDIX II

Data Sheet & Calculation

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	CIVIL ENGINEERING PROGRAMME
	FINAL YEAR PROJECT 1
	Topic : Developing of Percolating Sand Trap
	Supervised by : AP. Dr. Nasiman & Dr. Malay
	Prepared by : Leong Ban San

PARTICLE SIZE DISTRIBUTION TEST

Location :	UTP Main gates	Job Ref :	Lab/sieve/1
Soil Description :	sandy	Sample No	1
		Depth:	0.3 m
Test Method :	**BS 1377 : Part 2 : 1990**	Date :	3 april 2007
Initail dry mass			1000 g

Sieve Size		Mass retained, g	Percentage retained, %	Cumulative percentage passing, %
2	mm	235.9	23.59	76.41
1.18	mm	145.65	14.57	61.85
600	µm	165.6	16.56	45.29
425	µm	79.52	7.95	37.33
300	µm	103.86	10.39	26.95
212	µm	94.55	9.46	17.49
150	µm	79.7	7.97	9.52
63	µm	40.37	4.04	5.49
pan		54.74	5.47	0.00
Total		999.89		
Loss		0.11		
Percentage Loss, %		0.011		

Comments:

Refer to BS1377: part 5: 1990. The percentage passing through sieve size 63 was below 10%.

So, the soils specimen was suitable to test with permeability constant head testing

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	Supervised by : AP. Dr. Nasiman & Dr. Malay
	Prepared by : Leong Ban San

ARTICLE SIZE DISTRIBUTION TEST

ɔcation :	UTP New Academic Building	Job Ref :	Lab/sieve/13
oil Description :	Loam	Sample No	2
		Depth:	0.3 m
est Method :	**BS 1377 : Part 2 : 1990**	Date :	August 2007
ıitail dry mass			1000 g

Sieve Size		Mass retained, g	Percentage retained, %	Cumulative percentage passing, %
2	mm	56.12	5.61	94.39
1.18	mm	18.38	1.84	92.55
600	μm	46.04	4.60	87.95
425	μm	60.98	6.10	81.85
300	μm	122.34	12.23	69.61
212	μm	163.94	16.39	53.22
150	μm	172.97	17.30	35.92
63	μm	204.67	20.47	15.46
pan		154.39	15.44	5.63
otal		999.83		
oss		0.17		
ercentage Loss, %		0.017		

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CIVIL ENGINEERING PROGRAMME

FINAL YEAR PROJECT 1

Topic : Developing of Percolating Sand Trap

Supervised by : AP. Dr. Nasiman & Dr. Malay

Prepared by : Leong Ban San

ARTICLE SIZE DISTRIBUTION TEST

ocation :	Seri Iskandar	Job Ref :	Lab/sieve/12
oil Description :	sandy silt	Sample No	3
		Depth:	0.3 m
est Method :	**BS 1377 : Part 2 : 1990**	Date :	August 2007
iitail dry mass			1000 g

Sieve Size		Mass retained, g	Percentage retained, %	Cumulative percentage passing, %
2	mm	0	0.00	100.00
1.18	mm	0	0.00	100.00
600	μm	14.56	1.46	98.54
425	μm	44.25	4.43	94.12
300	μm	157.93	15.79	78.33
212	μm	233.9	23.39	54.94
150	μm	201.68	20.17	34.77
63	μm	172.36	17.24	17.53
pan		174.37	17.44	0.00
otal		999.05		
oss		0.95		
'ercentage Loss, %		0.095		

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	Supervised by : AP. Dr. Nasiman & Dr. Malay			
	Prepared by : Leong Ban San			
PARTICLE SIZE DISTRIBUTION TEST				
Location :	Pocket C - Parking Area		Job Ref :	Lab/sieve/2
Soil Description :	Mixed sand		Sample No	2
			Depth:	0.3 m
Test Method :	**BS 1377 : Part 2 : 1990**		Date :	3rd april 2007
Initail dry mass				1000 g
Sieve Size		Mass retained, g	Percentage retained, %	Cumulative percentage passing, %
2	mm	275.14	27.51	72.49
1.18	mm	213.58	21.36	51.13
600	μm	208.33	20.83	30.30
425	μm	94.22	9.42	20.87
300	μm	106.96	10.70	10.18
212	μm	61.33	6.13	4.04
150	μm	23.21	2.32	1.72
63	μm	11.29	1.13	0.59
pan		5.84	0.58	0.00
Total		999.9		
Loss		0.1		
Percentage Loss, %		0.01		

Comments:

Refer to BS1377: part 5: 1990. The percentage passing through sieve size 63 was below 10%.

So, the soils specimen was suitable to test with permeability constant head testing

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	Supervised by : AP. Dr. Nasiman & Dr. Malay
	Prepared by : Leong Ban San

PERMEABILITY TEST

Location :	UTP Main Gates			Job Ref :		Lab/permeability/2	
Soil Description :	Sandy			Sample No		1	
				Depth:		0.3 m	
Test Method :	**BS 1377 : Part 5 : 1990**			Date :		24th april 2007	
Sample diameter						76	mm
Sample Length						154	mm
Sample Area, A						4537.05	mm^2
Volume						698.71	cm^3
No of Test		**1**	**2**	**3**	**4**	**5**	**6**
Measured Flow, Q	mL	200	200	200	200	200	200
Time, t	s	35.25	35.98	36.44	35.28	35.94	36.45
Rate of Flow, q	mL/s	5.67	5.56	5.49	5.67	5.56	5.49
Height, h	m	0.615	0.61	0.605	0.615	0.61	0.605
Hydralic Geadient, i		4.489	4.453	4.416	4.489	4.453	4.416
Average Hydraulic Gradient		4.453					
Temperature, T (°C)	T (°C)	27	27	27	27	27	27
	Rt:	0.85	0.85	0.85	0.85	0.85	0.85
Velocity, (v = q/A)	cm/s	0.13	0.12	0.12	0.12	0.12	0.12
Avearage Velocity	cm/s	0.12					
Hydraulic Conductivity k = (v x Rt)/i	cm/s	0.02					

Comments:

From the result, the average velocity of trapped sand was 0.12 cm/s and the hydraulic conductivity was 0.02cm/s. Where its samiliar with coarse sand theory range 1.0cm/s - 0.01cm/s

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	Supervised by : AP. Dr. Nasiman & Dr. Malay
	Prepared by : Leong Ban San

Calculation

Location :	UTP Main Gates	Job Ref :	Lab/permeability/2
Soil Description :	Sandy	Sample No	1
		Depth:	0.3 m
Test Method :	**BS 1377 : Part 5 : 1990**	Date :	24th april 2007

<u>Volume of Cubic</u>		
Width of Model, a	381	mm
Length of Model, b	381	mm
Heigh of Model, d	381	mm
Total Volume of Cubic, (a x b x d)	55306.34	cm^3
<u>Volume of Trapezoid</u>		
Volume of Paramid (Heigh=46.36mm; Width=381mm; Length=381mm)	2242.98	cm^3
Volume of Paramid (Heigh=20.96mm; Width=177.8mm; Length=177.8mm)	220.82	cm^3
Total Volume of Trapeziod	2022.16	cm^3
Total Volume of Model	57328.50	cm^3
Quarter Total Volume of Model	14332.13	cm^3
Hydraulic Conductivity	0.04	cm/s

Diameter of Opening	mm	127	101.6	76.2
Area of Opening, A	cm^2	126.69	81.08	45.61
Flow Rate, q	cm^3/s	5.07	3.24	1.82
Time of Percolate, t	**s**	**2828.11**	**4418.93**	**7855.87**
	Hour	**0.79**	**1.23**	**2.18**
	Day	-	-	-

<u>Comments:</u>

From the calculation, all diameter of opening were suitable to use for percolate the retained water volume of 14332.12 cm^3 within 5 days.

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	FINAL YEAR PROJECT 1					
	Topic : Developing of Percolating Sand Trap					
	Supervised by : AP. Dr. Nasiman & Dr. Malay					
	Prepared by : Leong Ban San					
PERMEABILITY TEST						
Location :	UTP campus		Job Ref :		Lab/permeability/4	
Soil Description :	Silty		Sample No		4	
			Depth:		0.3 m	
Test Method :	**BS 1377 : Part 6 : 1990**		Date :		3rd May 2007	
Sample diameter					115	mm
Sample Length, l					105	mm
Sample Area, A					10388.24	mm^2
Volume					1090.76	cm^3
Standpipe Internal Diameter					5.00	mm
Standpipe Internal Area, à					19.64	cm^2
No of Test		**1**		**2**	**3**	
Water Level, h_0	cm	55		50	45	
Water Level, h_1	cm	50		45	40	
Time, t	s	196		202	212	
Hydraulic Conductivity, k k = 2.3(al/At)log(h0/h1)	cm/s	0.000096		0.000103	0.000110	
Temperature, T (°C)	T (°C)	27	27	27 27	27	27
	Rt:	0.85	0.85	0.85 0.85	0.85	0.85
Average Hydraulic Conductivity $k = 2.3(al/At)\log(h_0/h_1)$	cm/s	0.000103				

Comments:

From the result, the hydraulic conductivity was 1.03×10^{-4}cm/s. Where its samiliar with sandy clay theory range 0.01cm/s - 0.00001cm/s.

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	FINAL YEAR PROJECT 1			
	Topic : Developing of Percolating Sand Trap			
	Supervised by : AP. Dr. Nasiman & Dr. Malay			
	Prepared by : Leong Ban San			
Calculation				
Location :	Foot Ball Field (V4&V5)		Job Ref :	Lab/permeability/4
Soil Description :	Silty		Sample No	4
			Depth:	0.3 m
Test Method :	**BS 1377 : Part 6 : 1990**		Date :	3rd May 2007

Volume of Cubic		
Width of Model, a	381	mm
Length of Model, b	381	mm
Heigh of Model, d	381	mm
Total Volume of Cubic, (a x b x d)	55306.34	cm^3
Volume of Trapezoid		
Volume of Paramid (Heigh=46.36mm; Width=381mm; Length=381mm)	2242.98	cm^3
Volume of Paramid (Heigh=20.96mm; Width=177.8mm; Length=177.8mm)	220.82	cm^3
Total Volume of Trapeziod	2022.16	cm^3
Total Volume of Model	57328.50	cm^3
Quarter Total Volume of Model	14332.13	cm^3
Hydraulic Conductivity	0.000103	cm/s

Diameter of Opening	mm	127	101.6	76.2
Area of Opening, A	cm^2	126.69	81.08	45.61
Flow Rate, q	cm^3/s	0.01	0.01	0.00
Time of Percolate, t	**s**	**1098296.85**	**1716088.83**	**3050824.59**
	Hour	**305.08**	**476.69**	**847.45**
	Day	**12.71**	**19.86**	**35.31**

Comments:

From the calculation, all diameter of opening were not suitable to use for percolate the retained water volume of 14332.12 cm^3 within 5 days.

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	FINAL YEAR PROJECT 2
	Topic : Developing of Percolating Sand Trap
	Supervised by : AP. Dr. Nasiman & Dr. Malay
	Prepared by : Leong Ban San

'ERMEABILITY TEST

.ocation :	Seri Iskandar	Job Ref :	Lab/permeability/4
;oil Description :	Unknown	Sample No	4
		Depth(	0.3 m
'est Method :	**BS 1377 : Part 6 : 1990**	Date :	Aug 2007

;ample diameter	115	mm
;ample Length, l	105	mm
;ample Area, A	10388.24	mm^2
/olume	1090.76	cm^3
;tandpipe Internal Diameter	5.00	mm
;tandpipe Internal Area, a	19.64	cm^2

Jo of Test		**1**		**2**		**3**	
Vater Level, h_0	cm	80		80		80	
Vater Level, h_1	cm	50		50		50	
'ime, t	s	75		73		72	
Hydraulic Conductivity, k k = 2.3(al/At)log(h0/h1)	cm/s	0.001242		0.001277		0.001294	
'emperature, T (°C)	T (°C)	27	27	27	27	27	27
	Rt:	0.85	0.85	0.85	0.85	0.85	0.85
Average Hydraulic Conductivity $k = 2.3(al/At)\log(h_0/h_1)$	cm/s	0.001271					

;omments:

From the result, the hydraulic conductivity was 1.271×10^{-4}cm/s. Where its samiliar with sandy clay heory range 0.01cm/s - 0.00001cm/s.

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	FINAL YEAR PROJECT 1
	Topic : Developing of Percolating Sand Trap
	Supervised by : AP. Dr. Nasiman & Dr. Malay
	Prepared by : Leong Ban San

;alculation

.ocation :	Seri Iskandar	Job Ref :	Lab/permeability/4
;oil Description :	Silty	Sample No	4
		Depth:	0.3 m
⁻est Method :	**BS 1377 : Part 6 : 1990**	Date :	3rd May 2007

/olume of Cubic		
Nidth of Model, a	381	mm
.ength of Model, b	381	mm
⊣eigh of Model, d	381	mm
⌈otal Volume of Cubic, (a x b x d)	55306.34	cm^3
/olume of Trapezoid		
/olume of Paramid (Heigh=46.36mm; Width=381mm; Length=381mm)	2242.98	cm^3
/olume of Paramid (Heigh=20.96mm; Width=177.8mm; Length=177.8mm)	220.82	cm^3
⌈otal Volume of Trapeziod	2022.16	cm^3
⌈otal Volume of Model	57328.50	cm^3
⊋uarter Total Volume of Model	14332.13	cm^3
⊣ydraulic Conductivity	0.00127	cm/s

⊃iameter of Opening	mm	127	101.6	76.2
⊼rea of Opening, A	cm^2	126.69	81.08	45.61
⁼low Rate, q	cm^3/s	0.16	0.10	0:06
⌈ime of Percolate, t	**s**	**89074.47**	**139178.86**	**247429.08**
	Hour	**24.74**	**38.66**	**68.73**
	Day	**1.03**	**1.61**	**2.86**

⊃omments:

⁼rom the calculation, all diameter of opening were not suitable to use for percolate the retained water /olume of 14332.12 cm^3 within 5 days.

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CIVIL ENGINEERING PROGRAMME

FINAL YEAR PROJECT 1

Topic : Developing of Percolating Sand Trap

Supervised by : AP. Dr. Nasiman & Dr. Malay

Prepared by : Leong Ban San

PERMEABILITY TEST

Location :	Sand trap - Pocket C parking	Job Ref :	Lab/permeability/1
Soil Description :	Trapped Mix Sand	Sample No	2
		Depth:	0.3 m
Test Method :	**BS 1377 : Part 5 : 1990**	Date :	10 april 2007

Sample diameter	76	mm
Sample Length	150	mm
Sample Area, A	4537.05	mm^2
Volume	680.56	cm^3

No of Test		**1**	**2**	**3**	**4**	**5**	**6**
Measured Flow, Q	mL	200	200	200	200	200	200
Time, t	s	25.17	26.28	27.26	25.42	26.13	27.43
Rate of Flow, q	mL/s	7.95	7.61	7.34	7.87	7.65	7.29
Height, h	m	0.505	0.495	0.485	0.505	0.495	0.485
Hydralic Geadient, i		3.686	3.613	3.540	3.686	3.613	3.540
Average Hydraulic Gradient		3.613					
Temperature, T (°C)	T (°C)	27	27	27	27	27	27
	Rt:	0.85	0.85	0.85	0.85	0.85	0.85
Velocity, (v = q/A)	cm/s	0.18	0.17	0.16	0.17	0.17	0.16
Avearage Velocity	cm/s	0.17					
Hydraulic Conductivity k = (v x Rt)/i	cm/s	0.04					

Comments:

From the result, the average velocity of trapped sand was 0.17 cm/s and the hydraulic conductivity was 3c

was 0.04cm/s. Where its matched with coarse sand theory range 1.0cm/s - 0.01cm/s

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	Supervised by : AP. Dr. Nasiman & Dr. Malay
	Prepared by : Leong Ban San

Calculation

Location :	Sand trap - Pocket C parking	Job Ref :	Lab/permeability/1
Soil Description :	Trapped Mix Sand	Sample No	2
		Depth:	0.3 m
Test Method :	**BS 1377 : Part 5 : 1990**	Date :	10 april 2007

Volume of Cubic		
Width of Model, a	381	mm
Length of Model, b	381	mm
Heigh of Model, d	381	mm
Total Volume of Cubic, (a x b x d)	55306.34	cm^3
Volume of Trapezoid		
Volume of Paramid (Heigh=46.36mm; Width=381mm; Length=381mm)	2242.98	cm^3
Volume of Paramid (Heigh=20.96mm; Width=177.8mm; Length=177.8mm)	220.82	cm^3
Total Volume of Trapeziod	2022.16	cm^3
Total Volume of Model	57328.50	cm^3
Quarter Total Volume of Model	14332.13	cm^3
Hydraulic Conductivity	0.02	cm/s

Diameter of Opening	mm	127	101.6	76.2
Area of Opening, A	cm^2	126.69	81.08	45.61
Flow Rate, q	cm^3/s	2.53	1.62	0.91
Time of Percolate, t	**s**	**5656.23**	**8837.86**	**15711.75**
	Hour	**1.57**	**2.45**	**4.36**
	Day	-	-	-

Comments:

From the calculation, all diameter of opening were suitable to use for percolate the retained water volume of 14332.12 cm^3 within 5 days.

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31750 TRONOH
PERAK DARUL RIDZUAAN

TICLE SIZE DISTRIBUTION (HYDROMETER SEDIMENTION)

ation		Job ref :	
		Borehole/Pit no	
description		Sample no :	
		Depth :	m
method	BS 1377 : Part : 1990 : 9.6	Date :	
hod of preparation			

IBRATION AND SAMPLE DATA

rometer no.		1
iscus correction	cm	0.0005
ding in dispersant	R_o'	1.010
bration equation H_r = _____ - _____ R_h		
mass of soil	m	50 g
icle density easured/assumed*	ρ_s	2.65 g/m^3
osity of water at _____	η	0.798mPa·s

PRETREATMENT

Pretreated with		
Initial dry mass of sample	m_o	g
Dry mass after pretreatment	m	g
Pretreatment loss	$m_o - m$	g
		%

$D = 0.005531\sqrt{\frac{\eta H}{\ldots}}$ mm

$$K = \frac{100\rho_s}{m(\rho_s - 1)} \times R_d \ \%$$

DATA

	Time	Elapsed Time t min	Temperature T °C	Reading R_h'	$R_h' + C_m = R_h$	Effective depth H_r mm	Particle diameter D mm	$R_h' - R_o' = R_d$	Percentage finer than D K %
	30s	30s	30.4	1.023		137.68	0.06638	0.017	5.457
	1m	1m		1.020			0.04694	0.016	5.136
		2m		1.016			0.03319	0.015	4.815
		4m		1.013			0.02347	0.015	4.815
		8m		1.008			0.01659	0.014	4.494
		30m		1.004			0.00857	0.013	4.173
		1hr		1.003			0.00606	0.012	3.852
		2hr		1.003			0.00429	0.012	3.852
		6hr		1.001			0.00247	0.012	3.852
		24hr		1.000			0.00124	0.010	3.210

lete as appropriate	Operator	Checked	Approved
arks :			

UNIVERSITI TECHNOLOGI PETRONAS
CIVIL ENGINEERING PROGRAMME
BANDAR SERI ISKANDAR
31750 TRONOH
PERAK DARUL RIDZUAAN

TICLE SIZE DISTRIBUTION (HYDROMETER SEDIMENTION)

ation		Job ref :	
		Borehole/Pit no	
description		Sample no :	
		Depth :	m
t method	BS 1377 : Part : 1990 : 9.6	Date :	
thod of preparation			

IBRATION AND SAMPLE DATA

drometer no.		**2**
niscus correction	cm	**0.0005**
ding in dispersant	R_o'	**0.998**
ibration equation H_r = _____ - _____ R_h		
mass of soil	m	50 g
ticcle density leasured/assumed*	ρ_s	2.65 g/m^3
cosity of water at _____	η	0.891mPa·s

D = 0.005531 (ηH

$100\rho_s$

PRETREATMENT

Pretreated with		
Initial dry mass of sample	m_o	g
Dry mass after pretreatment	m	g
Pretreatment loss	m_o - m	g
		%

$\sqrt{}$ mm

$$K = \frac{100\rho_s}{m(\rho_s - 1)} \times R_d \ \%$$

T DATA

e	Time	Elapsed Time t min	Temperature T °C	Reading R_h'	$R_h' + C_m$ = R_h	Effective depth H_r mm	Particle diameter D mm	$R_h' - R_o'$ = R_d	Percentage finer than D K %
	30s	**30s**	**25**	**1.025**		**135.13**	**0.04778**	**0.027**	**8.667**
	1m	**1m**		**1.020**			**0.03378**	**0.022**	**7.062**
		2m		**1.017**			**0.02389**	**0.019**	**6.099**
		4m		**1.013**			**0.01689**	**0.015**	**4.815**
		8m		**1.013**			**0.01195**	**0.013**	**4.173**
		30m		**1.0055**			**0.00617**	**0.0075**	**2.4075**
		1hr		**1.005**			**0.00436**	**0.007**	**2.247**
		2hr		**1.005**			**0.00308**	**0.007**	**2.247**
		6hr		**1.0015**			**0.00178**	**0.0035**	**1.124**
		24hr		**1.001**			**0.00089**	**0.003**	**0.963**

Delete as appropriate
marks :

Operator	Checked	Approved

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	FINAL YEAR PROJECT 2
	Topic : Developing of Percolating Sand Trap
	Supervised by : AP. Dr. Nasiman & Dr. Malay
	Prepared by : Leong Ban San

ERMEABILITY TEST

ocation :	Seri Iskandar	Job Ref :	Field/percolation/1
oil Description :	Loamy sand		
est Method :	**Percolation Test**	Date :	Sept 2007
ercolate Opening Diameter		5	inch

Volume (liter)	Cumulative Volume (liter)	Time		Cumulative Time (hr)	Remark
		s	hr		
21.75	21.75	2700	0.75	0.75	
18.85	40.6	2574	0.72	1.47	
18.85	59.45	2886	0.80	2.27	
18.85	78.3	3159	0.88	3.14	
18.85	97.15	3416.4	0.95	4.09	
18.85	116	3673.8	1.02	5.11	

ercolate Rate, Liter/hour = 19.863

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ERMEABILITY TEST

ocation :	Seri Iskandar	Job Ref :	Field/percolation/2
oil Description :	Loamy sand		
est Method :	**Percolation Test**	Date :	Sept 2007
ercolate Opening Diameter		4	inch

Volume (liter)	**Cumulative Volume (liter)**	**Time**		**Cumulative Time (hr)**	**Remark**
		s	**hr**		
18.85	18.85	2574	0.72	0.72	
18.85	37.7	2886	0.80	1.52	
18.85	56.55	3159	0.88	2.39	
18.85	75.4	3400.8	0.94	3.34	
18.85	94.25	3689.4	1.02	4.36	
18.85	113.1	3884.4	1.08	5.44	

ercolate Rate, Liter/hour = **18.550**

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ERMEABILITY TEST

ocation :	Seri Iskandar	Job Ref :	Field/percolation/3	
oil Description :	Loamy sand			
est Method :	**Percolation Test**	Date :	Sept 2007	
ercolate Opening Diameter			3	inch

Volume (liter)	Cumulative Volume (liter)	Time		Cumulative Time (hr)	Remark
		s	hr		
18.85	18.85	2880	0.80	0.80	
18.85	37.7	3198	0.89	1.69	
18.85	56.55	3471	0.96	2.65	
18.85	75.4	3712	1.03	3.68	
18.85	94.25	4001	1.11	4.80	
18.85	113.1	4196	1.17	5.96	

ercolate Rate, Liter/hour = 17.095

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ERMEABILITY TEST

ocation :	Ipoh-Lumut Expressway	Job Ref :	Field/percolation/4
oil Description :	Sandy		
est Method :	**Percolation Test**	Date :	Aug 2007
ercolate Opening Diameter		5	inch.

Volume (liter)	Cumulative Volume (liter)	Time		Cumulative Time (hr)	Remark
		s	hr		
20.3	20.3	630	0.18	0.18	
20.3	40.6	720	0.20	0.38	
20.3	60.9	792	0.22	0.60	
20.3	81.2	873	0.24	0.84	
20.3	101.5	936	0.26	1.10	
20.3	121.8	981	0.27	1.37	
20.3	142.1	1017	0.28	1.65	
20.3	162.4	1053	0.29	1.95	
20.3	182.7	1080	0.30	2.25	
20.3	203	1098	0.31	2.55	

rcolate Rate, Liter/hour = 67.855

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ERMEABILITY TEST

ocation :	Seri Iskandar	Job Ref :	Field/percolation/5
oil Description :	Loamy sand		
est Method :	**Percolation Test**	Date :	Aug 2007
ercolate Opening Diameter		4	inch

Volume (liter)	Cumulative Volume (liter)	Time		Cumulative Time (hr)	Remark
		s	hr		
20.3	20.3	741	0.21	0.21	
20.3	40.6	819	0.23	0.43	
20.3	60.9	881	0.24	0.68	
20.3	81.2	952	0.26	0.94	
20.3	101.5	1006	0.28	1.22	
20.3	121.8	1045	0.29	1.51	
20.3	142.1	1077	0.30	1.81	
20.3	162.4	1107	0.31	2.12	
20.3	182.7	1131	0.31	2.43	
20.3	203	1155	0.32	2.75	

ercolate Rate, Liter/hour = 64.615

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ERMEABILITY TEST

ɔcation :	Seri Iskandar	Job Ref :	Field/percolation/6
ɔil Description :	Loamy sand		
ɜst Method :	**Percolation Test**	Date :	Aug 2007
ɜrcolate Opening Diameter		3	inch

Volume (liter)	Cumulative Volume (liter)	Time		Cumulative Time (hr)	Remark
		s	hr		
20.3	20.3	897	0.25	0.25	
20.3	40.6	975	0.27	0.52	
20.3	60.9	1037	0.29	0.81	
20.3	81.2	1108	0.31	1.12	
20.3	101.5	1162	0.32	1.44	
20.3	121.8	1201	0.33	1.77	
20.3	142.1	1233	0.34	2.11	
20.3	162.4	1263	0.35	2.47	
20.3	182.7	1287	0.36	2.82	
20.3	203	1310	0.36	3.19	

ɜrcolate Rate, Liter/hour = <u>63.163</u>

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ERMEABILITY TEST

ocation :	UTP New Academic Building	Job Ref :	Field/percolation/7	
oil Description :	Sandy Loam			
est Method :	**Percolation Test**	Date :	Aug 2007	
ercolate Opening Diameter			5	inch

Volume (liter)	Cumulative Volume (liter)	Time		Cumulative Time (hr)	Remark
		s	hr		
13.05	13.05	2818	0.78	0.78	
16.75	29.8	3477	0.97	1.75	
18.85	48.65	4524	1.26	3.01	
18.85	67.5	5148	1.43	4.44	
18.85	86.35	5577	1.55	5.98	
18.85	105.2	6084	1.69	7.67	

ercolate Rate, Liter/hour = **12.111**

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ERMEABILITY TEST

ocation :	UTP New Academic Building	Job Ref :	Field/percolation/8	
oil Description :	Sandy Loam			
est Method :	**Percolation Test**	Date :	Aug 2007	
ercolate Opening Diameter			4	inch

Volume (liter)	Cumulative Volume (liter)	Time		Cumulative Time (hr)	Remark
		s	hr		
18.85	18.85	4091	1.14	1.14	
18.85	37.7	4525	1.26	2.39	
18.85	56.55	5007	1.39	3.78	
18.85	75.4	5445	1.51	5.30	
18.85	94.25	5858	1.63	6.92	
18.85	113.1	6404	1.78	8.70	

ercolate Rate, Liter/hour = 11.497

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ERMEABILITY TEST

ocation :	UTP New Academic Building	Job Ref :	Field/percolation/9
oil Description :	Sandy Loam		
est Method :	**Percolation Test**	Date :	Aug 2007
ercolate Opening Diameter		3	inch

Volume (liter)	Cumulative Volume (liter)	Time		Cumulative Time (hr)	Remark
		s	hr		
18.85	18.85	4446	1.24	1.24	
18.85	37.7	4851	1.35	2.58	
18.85	56.55	5234	1.45	4.04	
18.85	75.4	5655	1.57	5.61	
18.85	94.25	6069	1.69	7.29	
18.85	113.1	6591	1.83	9.12	

ercolate Rate, Liter/hour = 11.115

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ERMEABILITY TEST

ocation :	Seri Iskandar	Job Ref :	Field/percolation/1
oil Description :	Loamy sand		
'ater Level :	Above Percolating Opening		
st Method :	**Percolation Test**	Date :	Oct 2007
ercolate Opening Diameter		5	inch

Volume (liter)	Cumulative Volume (liter)	Time		Cumulative Time (hr)	Remark
		s	hr		
1.45	21.75	6509	1.81	1.81	
1.45	23.2	6498	1.81	3.61	
1.45	24.65	6513	1.81	5.42	
1.45	26.1	6502	1.81	7.23	
1.45	27.55	6505	1.81	9.04	
1.45	29	6515	1.81	10.85	

ercolate Rate, Liter/hour = 0.802

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ERMEABILITY TEST

ocation :	Seri Iskandar	Job Ref :	lab/percolation/2	
oil Description :	Loamy sand			
'ater Level :	Middle Percolating Opening			
est Method :	**Percolation Test**	Date :	Oct 2007	
ercolate Opening Diameter			.5	inch

Volume (liter)	**Cumulative Volume (liter)**	**Time**		**Cumulative Time (hr)**	**Remark**
		s	**hr**		
1.45	1.45	5303	1.47	1.47	
1.45	2.9	5295	1.47	2.94	
1.45	4.35	5298	1.47	4.42	
1.45	5.8	5300	1.47	5.89	
1.45	7.25	5310	1.48	7.36	
1.45	8.7	5323	1.48	8.84	

ercolate Rate, Liter/hour = **0.983**

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ERMEABILITY TEST

ocation :	Seri Iskandar	Job Ref :	lab/percolation/3	
oil Description :	Loamy sand			
ater Level :	Below Percolating Opening			
st Method :	**Percolation Test**	Date :	Oct2007	
rcolate Opening Diameter			5	inch

Volume (liter)	Cumulative Volume (liter)	Time		Cumulative Time (hr)	Remark
		s	hr		
1.45	1.45	4350	1.21	1.21	
1.45	2.9	4362	1.21	2.42	
1.45	4.35	4341	1.21	3.63	
1.45	5.8	4355	1.21	4.84	
1.45	7.25	4351	1.21	6.04	
1.45	8.7	4359	1.21	7.26	

rcolate Rate, Liter/hour = **1.199**