

THE INFILTRATION RATE OF DEVELOPED
AND UNDEVELOPED AREA IN UNIVERSITI
MALAYSIA PAHANG

NURAL FATIHA BINTI ROSLE

B.ENG (HONS.) CIVIL ENGINEERING
UNIVERSITI MALAYSIA PAHANG

THE INFILTRATION RATE OF DEVELOPED AND UNDEVELOPED AREA IN
UNIVERSITI MALAYSIA PAHANG

NURAL FATIHA BINTI ROSLE

Report submitted in partial fulfilment of requirements
for the award of the degree of
B. Eng. (Hons) Civil Engineering

Faculty of Civil Engineering & Earth Resources
UNIVERSITI MALAYSIA PAHANG

JUNE 2016

UNIVERSITI MALAYSIA PAHANG

DECLARATION OF THESIS / UNDERGRADUATE PROJECT PAPER AND COPYRIGHT

Author's full name : NURAL FATIHA BINTI ROSLE
Date of birth : 19 JANUARY 1993
Title : THE INFILTRATION RATE OF DEVELOPED AND UNDEVELOPED AREA
IN UNIVERSITI MALAYSIA PAHANG
Academic Session : 2015/2016

I declare that this thesis is classified as:

- ☐ **CONFIDENTIAL** (Contains confidential information under the Official Secret Act 1972)*
- ☐ **RESTRICTED** (Contains restricted information as specified by the organization where research was done)*
- ☒ **OPEN ACCESS** I agree that my thesis to be published as online open access (full text)

I acknowledged that University Malaysia Pahang reserves the right as follows:

1. The thesis is the property of University Malaysia Pahang.
2. The Library of University Malaysia Pahang has the right to make copies for the purpose of research only.
3. The Library has the right to make copies of the thesis for academic exchange.

Certified by:

SIGNATURE

(930119-14-5532)

Date: JUNE 2016

SIGNATURE OF SUPERVISOR

(MADAM HASMANIE BINTI ABD HALIM)

Date: JUNE 2016

NOTES: *If the thesis is CONFIDENTIAL or RESTRICTED, please attach with the letter from the organization with period and reasons for confidentiality or Restriction

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Bachelor (Hons.) of Civil Engineering.

Signature	:	_____
Name of Supervisor	:	MADAM HASMANIE BINTI ABD HALIM
Position	:	LECTURER
Date	:	JUNE 2016

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted for award for other degree.

Signature	:	_____
Name	:	NURAL FATIHA BINTI ROSLE
ID Number	:	AA12146
Date	:	JUNE 2016

TABLE OF CONTENT

	Page
SUPERVISOR'S DECLARATION	i
STUDENT'S DECLARATION	ii
DEDICATION	iii
ACKNOLEWDGEMENT	iv
ABSTRACT	v
ABSTRAK	vi
TABLE OF CONTENTS	vii
LIST OF TABLES	xi
LIST OF FIGURES	xiii
LIST OF SYMBOLS	xvi
LIST OF ABBREVIATION	xviii
 CHAPTER 1 INTRODUCTION	
1.1 Background Study	1
1.2 Problem Statement	2
1.3 Objectives	3
1.4 Scope of Study	4
1.5 Significant of Study	
1.5.1 Development Effect	5
1.5.2 Reduction of Imperviousness Area	5
 CHAPTER 2 LITERATURE REVIEW	
2.1 Hydrological Cycle	6
2.1.1 Terrestrial Water	7

2.2	Parameters in Hydrology	9
2.2.1	Initial Loss	9
2.2.2	Constant Rate	9
2.2.3	Imperviousness Percentage	10
2.2.4	Time of Coefficient	10
2.2.5	Baseflow	11
2.3	Precipitation	12
2.3.1	Frontal and Cyclonic Precipitation	13
2.3.2	Conventional Precipitation	13
2.3.3	Orographic Precipitation	14
2.4	Interception	14
2.4.1	Throughfall	15
2.4.2	Depression Storage	16
2.5	Runoff	16
2.5.1	Overland Flow	16
2.5.2	Saturation Excess Overland Flow	17
2.5.3	Antecedent Soil Moisture	17
2.5.4	Subsurface Flow	18
2.6	Infiltration	18
2.6.1	Infiltration Process	18
2.6.2	Instrument Use to Measure Infiltration Rate	19
2.6.2.1	Single Ring Infiltrometer	19
2.6.2.2	Double Ring Infiltrometer	20
2.6.3	Infiltration Calculation Method	21
2.6.4	General Hydrological Budget	22
2.6.5	Horton's Infiltration Method	23
2.6.6	Green Ampt Model	24
2.7	Soil Classification System	26
2.7.1	Textural Classification	26
2.7.2	AASHTO Classification System	30
2.7.3	Unified Soil Classification System	34

CHAPTER 3 METHODOLOGY

3.1	Introduction	41
3.2	Location of Research Area	41
3.3	Early preparation	42
3.3.1	Preparation of Apparatus and Necessities	42
3.3.2	Fieldwork Planning	42
3.4	Experiment of Infiltration	42
3.4.1	Research Method of Infiltration Experiment	43
3.4.2	Experimental Procedures on Site	44
3.5	Laboratory Work	46
3.5.1	Soil Sampling	46
3.5.2	Sieve Analysis	46
3.5.3	Method of Sieve Analysis	47
3.5.4	Procedures of Sieve Analysis	48

CHAPTER 4 RESULT AND DISCUSSION

4.1	Result Analysis	50
4.2	Analysis of Infiltration Rate	50
4.3	Infiltration Rate of Developed Area	51
4.4	Log Graph for Developed Area	53
4.4.1	Horton's Method	53
4.4.2	Point One for Developed Area	53
4.4.3	Point Two for Developed Area	55
4.4.4	Point Three for Developed Area	57
4.4.5	Point One for Undeveloped Area	59
4.4.6	Point Two for Undeveloped Area	61
4.4.7	Point Three for Undeveloped Area	63

4.5	Result Analysis	65
4.5.1	Comparison of Infiltration Rate Between the Developed and Undeveloped Area	66
4.6	Sieve Analysis	69
4.6.1	Particle Size Distribution	69
4.6.2	Particle Size Distribution for Point One of Developed Area	70
4.6.3	Particle Size Distribution for Point Two of Developed Area	72
4.6.4	Particle Size Distribution for Point One of Undeveloped Area	74
4.6.5	Particle Size Distribution for Point Two of Undeveloped Area	76
4.7	Overall Particle Size Distribution	78
4.8	Sieve Analysis Result	78
4.9	Result for Type of Soil	78
CHAPTER 5	CONCLUSION	
5.1	Background Study	80
5.2	Soil Classification	81
5.3	Infiltration Rate	81
5.4	Recommendation	83
REFERENCE		84
APPENDICES		86
APPENDIX A	Infiltration data for both areas	88
APPENDIX B	Data of sieve analysis for both data	95

LIST OF TABLES

Table No.	Title	Page
2.6.4.1	Typical f_I values	23
4.4.2.1	Values of time and F_p for point one of developed area	53
4.4.3.1	Values of time and F_p for point two of developed area	55
4.4.4.1	Values of time and F_p for point three of developed area	57
4.4.5.1	Values of time and F_p for point one of undeveloped area	59
4.4.6.1	Values of time and F_p for point two of undeveloped area	61
4.4.7.1	Values of time and F_p for point three of undeveloped area	63
4.5.1	Differences of infiltration rate for developed and developed area	65
4.8.1	Percentage of soils	78
5.2.1	The percentage of gravel, sand, silt and clay in the soil	81
5.3.1	The comparison of the two areas	82

LIST OF FIGURES

Figure No.	Title	Page
2.1.1	The hydrological cycle	7
2.6.2.1.1	Sing ring infiltrometer	20
2.6.2.2.1	Double ring infiltrometer	21
2.6.6.1	Hydrograph	25
2.7.1.1	Particle size curve	28
2.7.1.2	USDA textural classification	29
2.7.2.1	Classification of Highway Subgrade Materials	30
2.7.2.2	Classification of Highway Subgrade Materials	31
2.7.2.3	Range of liquid limit and plasticity index for soils in groups A-2, A-4, A-5, A-6 and A-7	33
2.7.3.1	Unified Soil Classification System	36
2.7.3.1	Plasticity index	37
3.4.1.1	Double ring infiltrometer	43
3.4.1.2	Double ring infiltrometer complete set	44
3.4.2.1	The placement of double ring infiltrometer	45
3.4.2.2	The water level inside the double ring infiltrometer	45
3.4.1.1	Mechanical sieve shaker	47
3.4.1.2	Test sieves	48
3.5.4.2	Soils that retained at the sieve pan	49
4.3.1	The graph of infiltration rate against time for developed areas	51
4.3.2	The graph of infiltration rate against time for undeveloped areas	52
4.4.2.1	Log F_p against time graph	54
4.4.3.1	Log F_p against time graph	56
4.4.4.1	Log F_p against time graph	58

4.4.5.1	Log F_p against time graph	60
4.4.6.1	Log F_p against time graph	62
4.4.7.1	Log F_p against time graph	64
4.5.1.1	The vegetation cover at developed area	67
4.5.1.2	The vegetation cover at undeveloped area	68
4.6.2.1	The particle size distribution for point one of developed area	70
4.6.2.2	USDA textural classification	71
4.6.3.1	The particle size distribution for point two of developed area	72
4.6.3.2	Graph of log K versus Log T	73
4.6.4.1	The particle size distribution for point one of undeveloped area	74
4.6.4.2	USDA textural classification	75
4.6.5.1	The particle size distribution for point two of undeveloped area	76
4.6.5.2	USDA textural classification	77

LIST OF SYMBOL

F_p	Infiltration capacity	23
k	Constant representing rate of decrease in f capacity	23
f_c	Final/equilibrium infiltration capacity	23
f_o	Initial infiltration capacity	23
e	Exponential	23
$f(t)$	Infiltration rate at time	23

LIST OF ABBREVIATION

KK2	Kolej Kediaman 2	4
USDA	United States Department of Agriculture	4
PIMP	Percentage imperviousness	10
VSA	Variable source area	17
AASHTO	American Association of State Highway and Transportation Officials	26
U.S	United States	28
UMP	Universiti Malaysia Pahang	41
USCS	Unified Soil Classification System	46

THE INFILTRATION RATE OF DEVELOPED AND UNDEVELOPED AREA IN
UNIVERSITI MALAYSIA PAHANG

NURAL FATIHA BINTI ROSLE

Report submitted in partial fulfilment of requirements
for the award of the degree of
B. Eng. (Hons) Civil Engineering

Faculty of Civil Engineering & Earth Resources
UNIVERSITI MALAYSIA PAHANG

JUNE 2016

ABSTRACT

Infiltration is a process whereby the water from land surface infiltrate into the soil. Infiltration represent component of biggest water loss from precipitation source. Water infiltrate into the soil through pore spaces such as cracks and slit. The main objective of this study is to compare the infiltration rate that happen before and after the area being developed at two different places. This study also conducted to determine the types of soil at the particular area. The scope of work include the fieldwork and also at the laboratory work in order to gain the related data. The measurement of infiltration rate was taken and done at the site during sunny day because from of the El Nino phenomenon that hit Malaysia where started Mac 2015, peaked in December and the situation remained the same for the first three months of 2016. Its effects started to wane since late April and are expected to completely wear off by June 2016. The duration for this final project is until May 2016 so the infiltration rate of the areas during the rainy days cannot be determine. For the laboratory work, the types of the soil at both areas should be classified. The method used to determine the infiltration rate is by Double Ring Infiltrometer meanwhile the sieve analysis method used to obtain the types of the soil. The types of soil can be classified using the USDA textural classification. After the obtained data had been analysed, the infiltration rate of the two different places can be determine using the Horton method. Based on the types and characteristics of the soil exist at both developed and developed areas, the factors that affect the infiltration rate can be sort out

ABSTRAK

Penyusupan adalah satu proses di mana air dari permukaan tanah menyusup masuk ke dalam tanah. Penyusupan mewakili komponen kehilangan air terbesar dari sumber hujan. Penyusupan air ke dalam tanah berlaku melalui ruang liang seperti retak dan celah. Objektif utama kajian ini adalah untuk membandingkan kadar penyusupan yang berlaku di antara kawasan sebelum dan selepas dibangunkan pada dua tempat yang berbeza. Kajian ini juga dijalankan untuk menentukan jenis tanah di kawasan tertentu. Skop kerja termasuk kerja lapangan dan juga kerja makmal untuk mendapatkan data yang berkaitan. Pengukuran kadar penyusupan telah diambil dan dilakukan di lokasi itu dalam masa dua keadaan, pada hari yang cerah kerana Malaysia diserang fenomena El Nino dari bulan Mac 2015, mencapai kemuncak pada bulan Disember. Kesan daripada El Nino menghilang secara perlahan bermula pada bulan April dan akan berakhir secara keseluruhannya pada Mei 2016. Ini menyebabkan kadar penyusupan air di kawasan sebelum dan selepas dibangunkan tidak dapat diperolehi semasa hari hujan. Alatan yang digunakan untuk menentukan kadar penyusupan adalah dengan menggunakan *Double Ring Infiltrometer*. Sementara kaedah analisis ayakan tanah digunakan untuk mendapatkan jenis tanah yang wujud di tempat kajian. Pengelasan tanah ditentukan melalui Sistem Pengelasan Tanah USDA. Selepas data yang diperolehi telah dianalisis, kadar penyusupan daripada dua tempat yang berbeza boleh ditentukan menggunakan kaedah Horton. Berdasarkan jenis dan karekter tanah, faktor-faktor yang mempengaruhi kadar penyusupan air ke dalam tanah dapat diketahui.

CHAPTER 1

INTRODUCTION

1.1 Background Study

The combination of two hydrogen cations and an oxygen anion are the most important elements in our daily life as they have a unique behaviour that make them crucial to the universal requirement. One of the special characteristics of water is its ability to change the situation based on the Earth condition. Water can be classify into three states which are in gaseous, liquid and solid. These three elements play an important role to the hydrological cycle. The term hydrology literally is a combination of two words which is the science or study of ('logy' from Latin '*logia*') and water ('hydro' from Greek *hudor*) (Tim Davie, 2002). Hydrology is a scientific research about the water and its behaviours, distribution, occurrence, reactions and effect on the Earth surface, for the soils and also atmosphere (Richard Mc Cuen, 1998).

One of the subdivision that involved in the hydrological cycle is the infiltration process. Infiltration occur when the precipitation or water from surface runoff soaks into subsurface soils and moves into rocks through pore spaces and cracks. Water can be absorbed by the soil and may stay inside it for a long time until it gradually evaporated. But

if there are a lot of vegetative cover such as green plants, the infiltrated water can also be absorbed by plants roots and later give off water vapour through pores in their leaves during the transpiration process. Infiltration take place at the upper layers of the ground but may also continue further downward into the water table.

By depending on the saturation of the ground, the water can continue downwards to replenish water tables and aquifers and this is called percolation. In some cases where there are water bodies at the nearby area, the infiltrated water can also ended up in the water bodies. There are factors that affect the rate of infiltration for examples the types of soils, pre saturation levels, the amount of precipitation, the amount of vegetation cover over the area, the topography of the land as well as the levels of evapotranspiration in that region.

1.2 Problem Statement

The study of the infiltration rate is compulsory and important for particular places in order to determine the condition of the soil so that we can avoid any further damage occur after the places undergo the development process. And the consequences of the failure in obtaining both the infiltration rate and also the conditions of the soil may lead to one of the typical phenomenon which is flood. The suitable design of drainage system needed to be installed based on the condition and types of soil in accordance with the stated system. The precise planning with the consideration of a lot of aspects can save lives and properties from the natural disaster caused from our own clumsiness.

The low infiltration rate of a particular place caused it to be damaged by the flood. There are some safe ways that can be taken in order to face the any probabilities that may happen. The rapid development has caused the urbanization to take place in a larger scales in order to fulfil the necessity of the citizen and to achieve the nation's mission which is the newly industrial country. The development process involved the development of residential area, industrial and also the construction of the infrastructure. However, the effect from the development has been one of the major factor that lead to flood.

Besides that, the decrement of the places with high permeability of soils plays an important role in restraining the flood to occur. Forest and soil act as an absorbing agent for the natural rainfall. When the rain fall down, it created the surface runoff which is known overland flow where the water moves from the ground surface to a waterway. Surface runoff is affected by other process in the hydrological cycle such as precipitation and infiltration plus factors such as imperviousness and land slope. The function of the forest and soils are to increase the time taken for the runoff to flow into the drainage system which are river and drains. Moreover, most of the surface runoff had absorbed as the groundwater and the remaining get into the drainage system where the existing drainage system can withstand the volume of water flow inside it.

When the forest has been explored and cut off in order to objectify the development process, the natural surface of the soil ground had been changed to the impervious surface such as cement, bitumen, concrete etc. Based on these materials, the runoff cannot be fully absorbed like usual so that in a flash of light the drainage system becomes full and may lead to the excessive water and thus the flood.

1.3 Objectives

The main objective of this study is to obtain the infiltration rate of the water before and after the place is develop, therefore the objectives of this study are:

- i. To determine the infiltration rate of water at two different areas which is at the developed and undeveloped area using Double Ring Infiltrometer.
- ii. To compare both of the infiltration rate of the two different areas.
- iii. To classify the types of soil exist at the site using the sieve analysis method.