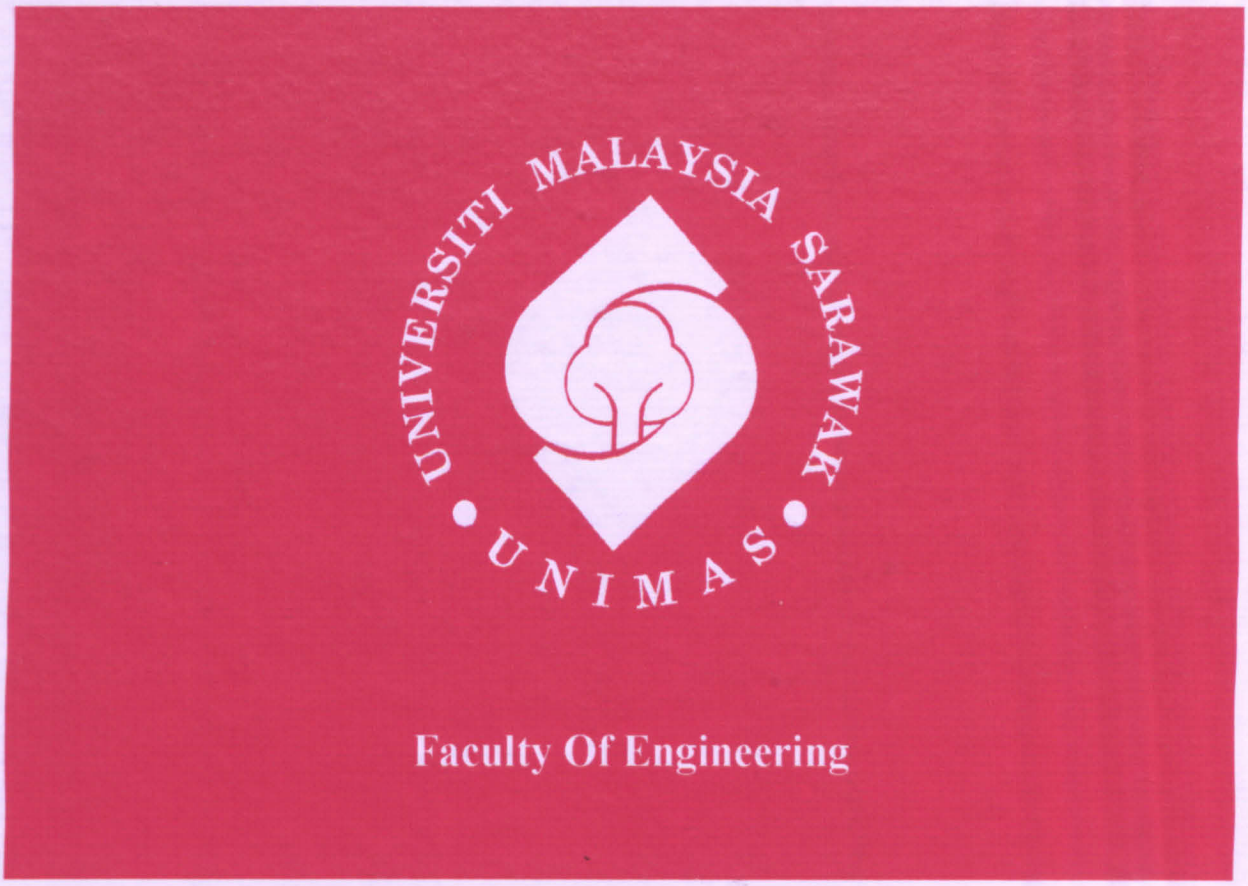

EFFECT OF AGGREGATE SYSTEM ON PERVIOUS CONCRETE

Nur Hijjah Syazalina Binti Abdul Rahim

Bachelor of Engineering with Honours
(Civil Engineering)
2019

UNIVERSITI MALAYSIA SARAWAK

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Dr. Norsuzailina Mohamed Sutan

Project Supervisor

Date: 10th June 2019

EFFECT OF AGGREGATE SYSTEM ON PERVIOUS CONCRETE

NUR HIJJAH SYAZALINA BT ABDUL RAHIM

A dissertation submitted in partial fulfilment

of the requirement for the degree of

Bachelor of Engineering with Honours

(Civil Engineering)

Faculty of Engineering

University of Malaysia Sarawak

2019

Dedicated to my beloved mother, a strong and gentle soul who taught me to trust in myself, believe in hard work and that so much could be done with little.

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ACKNOWLEDGEMENT

First and foremost, thank you to the Lord Almighty, Allah SAW for showing me the path, guidance and giving me the strength, I very much need throughout the whole process of successfully completing this final year project.

Massive thanks to my supervisor, Dr Norsuzailina Mohamed Sutan for the guidance, advice and valuable lessons during and throughout the whole project. I would also like to take this opportunity to thank everyone who has contributed either directly or indirectly throughout this project and the completion of this thesis.

I would like to express my utmost gratitude to my beloved family especially my mother, who would give me her endless supports, for I would not have been able to gather my strength to complete this thesis without her.

Lastly, I would like to thank my colleagues for their moral support and who has been undergoing the same topic as I am and making it possible. Final thank you notes for my friends and fellow course mates, who gave me support and help whenever I needed them.

ABSTRACT

The aim of this study is to evaluate the effects of aggregate system on pervious concrete. The ever-rapid growing of urbanization and the increasing threat of global warming have likely to cause the increase in runoff or precipitation in various regions. For many years, pervious concrete has been making a significant contribution to sustainable urban drainage system. Besides improving environmental condition, pervious concrete can help in minimizing risk of flooding, reducing runoffs and peak flows, improving the precipitation load on overstressed drainage system, recharging ground water and can improve water quality by capturing pollutants. This study is conducted by doing lab works that include sieving, mixing, compacting, casting and testing of hardened concrete at 7-day and 28-day. This study suggested that the usage of higher amount of smaller aggregate on pervious concrete had resulted in higher compressive strength than the one's with less amount of smaller aggregate. This study also suggested, the usage of higher amount of bigger aggregate on pervious concrete had resulted in higher value of permeability constant, K (mm/s) than the one's with less amount of bigger aggregate.

ABSTRAK

Tujuan kajian ini adalah untuk menilai kesan sistem aggregat dalam konkrit telap. Kadar pertumbuhan yang disebabkan oleh pembandaran telah menaikkan ancaman untuk pemanasan global yang secara tidak langsung telah menyebabkan peningkatan jumlah air larian di pelbagai kawasan. Untuk betahun-tahun konkrit telap telah memberi sumbangan yang penting kepada sistem saliran yang mampan. Selain daripada memperbaiki kondisi alam sekitar, konkrit telap boleh membantu dalam mengurangkan risiko banjir, mengurangkan jumlah air larian dan puncak aliran serta memperbaiki beban pemendakan yang berlebihan ke atas sistem saliran, konkrit telap turut membantu dalam pengisian semula air bawah tanah dan memperbaiki kualiti air dengan memerangkap bahan pencemar. Kajian ini dijalankan dengan melakukan kerja-kerja makmal termasuk pengayakkan, pencampuran, pemutusan dan pengujian konkrit mengeras pada hari ke-7 dan hari ke-28. Kajian ini mencadangkan bahawa penggunaan aggregat kecil yang lebih banyak dalam konkrit telap akan menyebabkan peningkatan dalam kekuatan mampatan berbanding daripada penggunaan aggregat kecil yang lebih sedikit. Kajian ini turut menyarankan bahawa penggunaan aggregat besar yang lebih banyak dalam konkrit telap akan menyebabkan nilai pemalar ketelapan, K (mm/s) lebih tinggi berbanding dengan penggunaan aggregat besar yang lebih sedikit.

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CHAPTER 1

INTRODUCTION

1.0 Introduction

This final year project (FYP) report will discuss on the impact of aggregate system on pervious concrete. This study is conducted to apply the knowledge of hydrology in stormwater management and concrete structure in engineering to contribute in social, economic, and environmental sustainability. Pervious concrete is a whole new concept of concrete that has various benefits that can be result in satisfying criteria of sustainability applied earlier to other concretes. By definition, pervious concrete is a concrete that contains high amount of porosity, allowing water to easily pass through it. Unlike the conventional concrete that are mostly dense and have high strength (Sabnis, 2011). The applications for pervious concrete can be applied in conditions where water from rainfall or other precipitation needs to be drained directly to soil. The findings of this study will also contribute to the exposure on the compressive strength and permeability rate of pervious concrete using different sizes and types of aggregates which can bring benefits to environment and economy. Eventually, this study will certainly enhance new knowledge into the advancement of pervious concrete structure.

1.1 Background of Study

Stormwater management is an effort that can help to reduce runoff of rainwater or any other discharge from various sites to improve the water quality. In Malaysia especially, the rapid growth of urbanization and population growth leads to an increased demand for water but spiked the levels of water pollution (The Borgen Project, 2017). Situated in South-East Asia amid latitude 1° and 7° with longitudes of 110° and 119° is a country known as Malaysia. Comprising the states of Sabah and Sarawak which are both located on the north to western coast of Borneo, are divided from Peninsular Malaysia, approximately about 529.9 km to the south china sea, but are sharing the same borders with its neighbouring country, Brunei Darussalam and Indonesia. On the other hand, Peninsular of Malaysia is enclosed to the North by Thailand, Singapore to the South, by the South China Sea and the Indonesian Sumatran Island to the East (Othman & Aminur, 2012).

Stormwater is filtered when it is absorbed into the soil and eventually replenishes aquifers or flows directly back into streams and rivers. However, sometimes during heavy rainfall season, the soil became soaked by water and enabling excess moisture to run across the surface into drains and street ditches. This water has a high chance of carrying chemicals, bacteria, eroded soils and other sorts of pollutants directly into streams and rivers. Stormwater management helps the urban and developed areas from flooding, erosion, muddiness, sanitary system overflow and sometimes an infrastructure damage. It's design and green infrastructure capture and reuse stormwater to maintain or restore natural hydrologies (The Borgen Project, 2017).

The main primary purpose of stormwater management is to detain and remove pollutants. One of the applications that can be used to detain runoff and lessen the amount of pollutants without having to disturb the existing drainage is through pervious concrete pavements. Big cities in the high-developed countries are mostly relying on pipe network systems, which have been widely established since 19th century. Traditional systems as we know it, detent precipitation and runoff, and afterward distributing it to the nearby streams or drainage system. Over the years, some of these systems have become less effective and inefficient. Studies also have shown that these systems usually cost more than what its efficiency can offer (Schluter & Jefferies, 2004).

Permeable pavements that are using pervious concrete is one of the alternatives to the traditional impermeable concrete pavements. Interconnected spacing between voids of the pavements allows stormwater from runoff and precipitation to permeate into a temporary sub-surface storage zone during rainfall season. The captured water penetrates the subsoil in areas with high content of permeable soils. Whereas, area that has lower soil permeability, water can discharge the pavement through an underdrain system installed.

Pervious concrete pavement usually contains water, aggregates and a Portland cement binder. The porosity is present with the lack of fine aggregates (Othman & Aminur, 2012). Pervious concrete products have been proven to be useful as pollution sinks, this is caused by the particle retention capacity of pervious concrete during infiltration. High amount of porosity of pervious concrete leads to air exchange rates and great infiltration. Pervious concrete that were installed in parking lots have been widely used and are successful in various places. The pavement was successful in allowing infiltration of stormwater runoff, Although there have been some arising problems with the installation of the materials (Imran, Akib, & Karim, 2013).

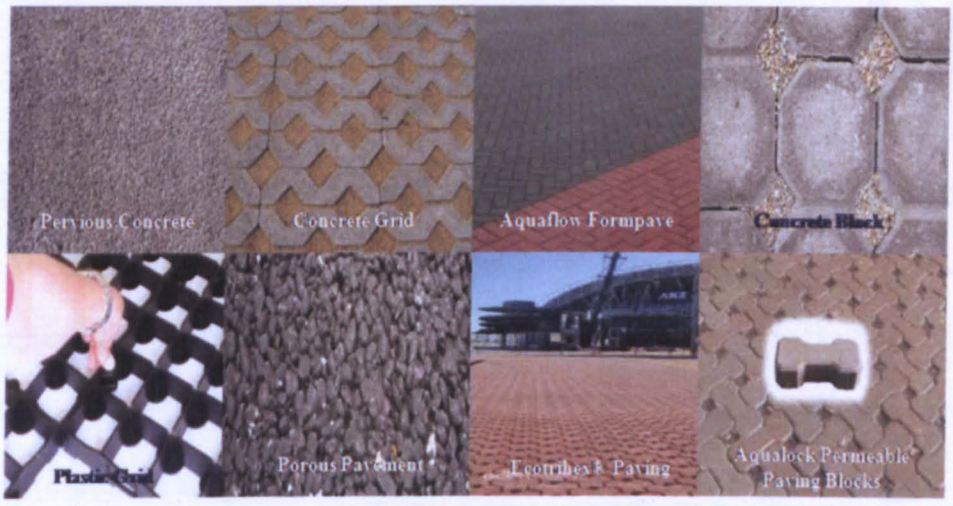

Figure 1.1: types of permeable pavement system (Imran, Akib, & Karim, 2013)

1.2 Problem Statement

Uncontrolled stormwater runoff especially at places having heavy rainfall during monsoon seasons will create drainage problems and major flash floods. Another arising problem is that uncontrolled stormwater runoff also generates an extensive threat to water quality and the environment. Stormwater runoff can be defined as rainfall that runs off the ground or any impermeable surfaces such as highways, car parking lots and buildings. Stormwater runoff usually drains into either man-made drainage ways or natural ways. In most cases, stormwater runoff flows directly into nearby river, streams, lakes, and the ocean (Carson, Eaker, Gibson, & Randall, 2014).

The arising problem is that one of the potential leading cause for water pollution is stormwater because when it runs off solid surfaces, it accumulates pollutants along the way. For example, pesticides, oil, bacteria, dirt and other harmful chemicals. Which then deposited into our available streams. If the amount of pollutant is too high, it can jeopardize marine life, and make our place a morbid place to live. If untreated stormwater is entering our streams it can affect our drinking water supplies with harmful contamination while at the same time

prohibits swimming, fishing or boating uses. It can also cause injuries to aquatic plants and animals.

The other problem that occurs when the existing drainage cannot cater to the stormwater runoff is flooding. Flooding rises as impervious and solid surfaces exchange the natural vegetation, because when the stormwater is unable to slowly infiltrating the land. Stormwater deposited sediments will decreases the depth of waterways, which then further increase the rate of flooding (Carson et al., 2014). Flooding caused by stormwater runoff are higher in places where rapid development has occurred. Various modification in land use have crucial effect on quality of stormwater runoff. Natural hydrology of a certain area can get intensely altered because of poor and mismanaged urbanization. Because the rapid growth of impenetrable cover reduces the amount of rainwater that can naturally infiltrate into the soil and rises the volume and rate of stormwater runoff. All these alteration leads to more recurrent and severe overflowing of streams and channels, thus will highly broke the public and private properties.

Malaysia has experience major floods since 1920 (Sulaiman, 2007). In fact, the most upsetting natural calamity experience in Malaysia is flood. Throughout Malaysia, its main channels are flowing right to the South China Sea with a total of 189 river basins and 85 of the river basins are prone to persistent flooding (D/iya, BarzaniGasim, EkhwanToriman, & Abdullahi, 2014). The Peninsular of Malaysia has a total of 89 river basin, while Sabah alone has 78 and Sarawak has 22 river basins altogether. Total predicted areas that are exposed to flood catastrophe is almost 29,800 km^2 or nine percent of the total Malaysia and continue affecting nearly 4.82 million people which is around twenty-two percent of the total population of Malaysia (DID, 2009).

According to Malaysian Drainage and Irrigation Department, floods in Malaysia can be categorized in two, which are flash flood and monsoon floods (DID, 2000a). by hydrological perspectives, the big variation between these two floods is that flash floods only take several hours before it returns to regular water level, while monsoon floods can last for up to a month before the water level return to normal (Noorazuan, 2006).

Poor drainage condition is one of the main cause of floods (D/iya et al., 2014). It is finally agreed upon that, government management together with local community should be taking essential actions to guarantee adequate drainage system is build and clear during heavy rainfall season.

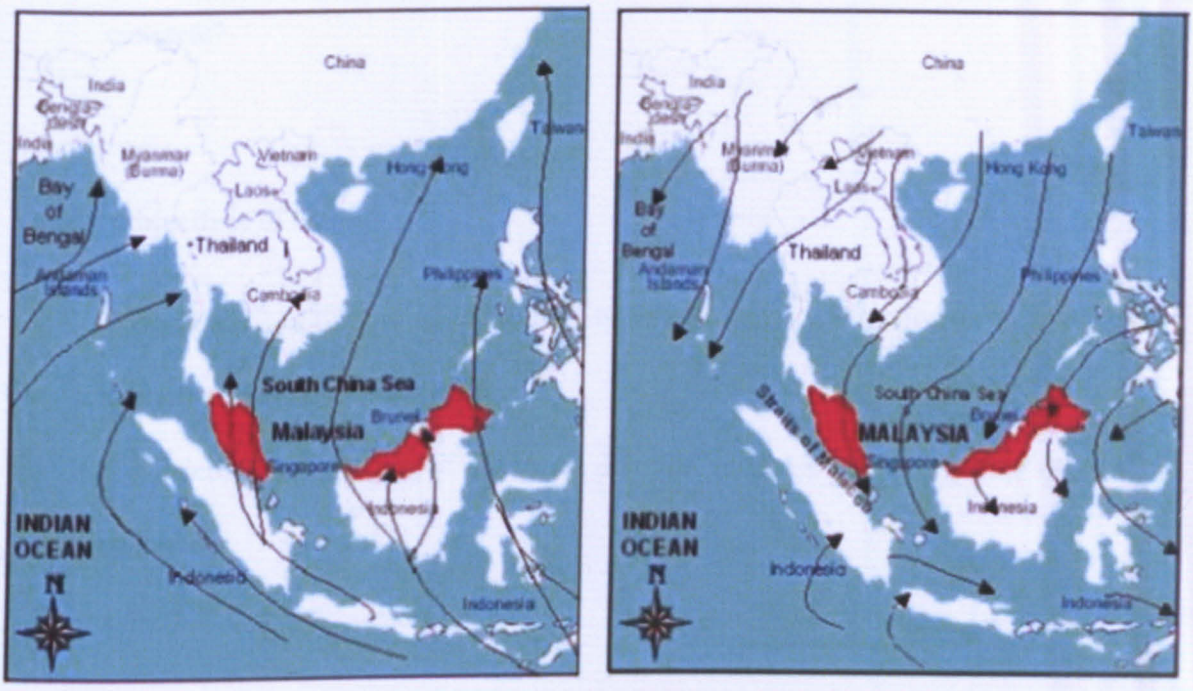

Figure 1.2: monsoon affecting Southwest and Northwest (Sulaiman, 2007).

Natural causes that triggered flash floods are local weather changes, while non-natural causes are drainage system that is no longer efficient in serving its purpose and together with the increase in impermeable surfaces such as building, roads and parking spaces. Due to these reasons the risk and exposure to floods has recently increased (Chan, 1996).

1.3 Research Question

i. Which aggregate fraction (fine: coarse) will have greater compressive strength on the pervious concrete?

ii. What is the relationship between porosity and permeability rate, K of pervious concrete?

1.4 Objectives of Study

i. To evaluate the effect of using different types and aggregate fraction on the compressive strength of pervious concrete.

ii. To determine the effect of aggregate fraction on the permeability rate of pervious concrete.

1.5 Scope of Study

To achieve the research goals, the research will be limited to the following work. The study begins by gathering all related literature reviews on the latest study of pervious concrete. Study under the objectives are revolving around the usage of different sizes and types of aggregates, and to evaluate the effect of each corresponding aggregates on pervious concrete by preparing several pervious concrete mixtures using the corresponding aggregates and testing the hardened pervious concrete specimens in the laboratory.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

United Nation once defined sustainability as development that meets the needs of today without compromising future generations ' ability to satisfy their own needs (Sabnis, 2011). This is by trying to balance economic, social and environmental effects. Concrete can contribute to sustainability from its various components that mainly consists of aggregate, water and cement.

For as long as human knows how to build and construct any structure. concrete was always referred to as dense, solid and durable construction material. However, over current years various studies have shown that even a 'less solid concrete' can be useful, durable and can donate to sustainability in numerous ways possible.

Less solid concrete above refers to pervious concrete that can be defined as another type of concrete that possesses high amount porosity characteristic and is permeable for water and other precipitation sources to pass through it.

On the other hand, aggregates are inert materials which are mixed with a binding material in fixed proportions to produce concrete (Inam, 2017). The aggregates act as a component that increases the concrete volume and performs its responsibility as fillers, as well as the strength, hardness and durability of the concrete.

2.2 Fundamental of Pervious Concrete

Pervious concrete was first used in 1852 (National ready mixed concrete association, n.d). Although it is not a new technology, more people around the world should be interested on pervious concrete and what it has to offer. Simply because the water flow rate through the pervious concrete can allow rainfall to infiltrate and percolate into the ground, thus reducing the surcharge of groundwater and at the same time supporting sustainability in construction industry. Traditionally, Pervious concrete is used in carparks, light traffic areas, footpaths and greenhouses. Nowadays it can be use as pavement to help capturing rainwater by its permeable characteristic that allows water to seep through the ground. As mentioned above, it is also very good in recharging groundwater, reducing stormwater runoff and at the same time can benefit our environmental stormwater regulation if pervious concrete is largely applied in Malaysia.

As a matter of fact (Tennis, Leming, & Akers, 2004) stated that the use of pervious concrete is one of the best management practices (BMP) for first-flush pollution control and was recommended by the United States of America's EPA (Environmental Protection Agency). This is because this pavement technology has made land use more efficient by eliminating the need for detention ponds, swales and other tools for storm water management.

Materials used to make pervious concrete are almost the same as conventional concrete, with the exception of the presence of fine aggregates and the size distribution of the coarse aggregate should be kept small. Following these will provide a good hardened property but will also result in mixture that demand all sort of different kind of considerations during mixing, placing, compacting and curing. Proportions of mixture of pervious concrete are slightly less lenient than conventional concrete mixtures.