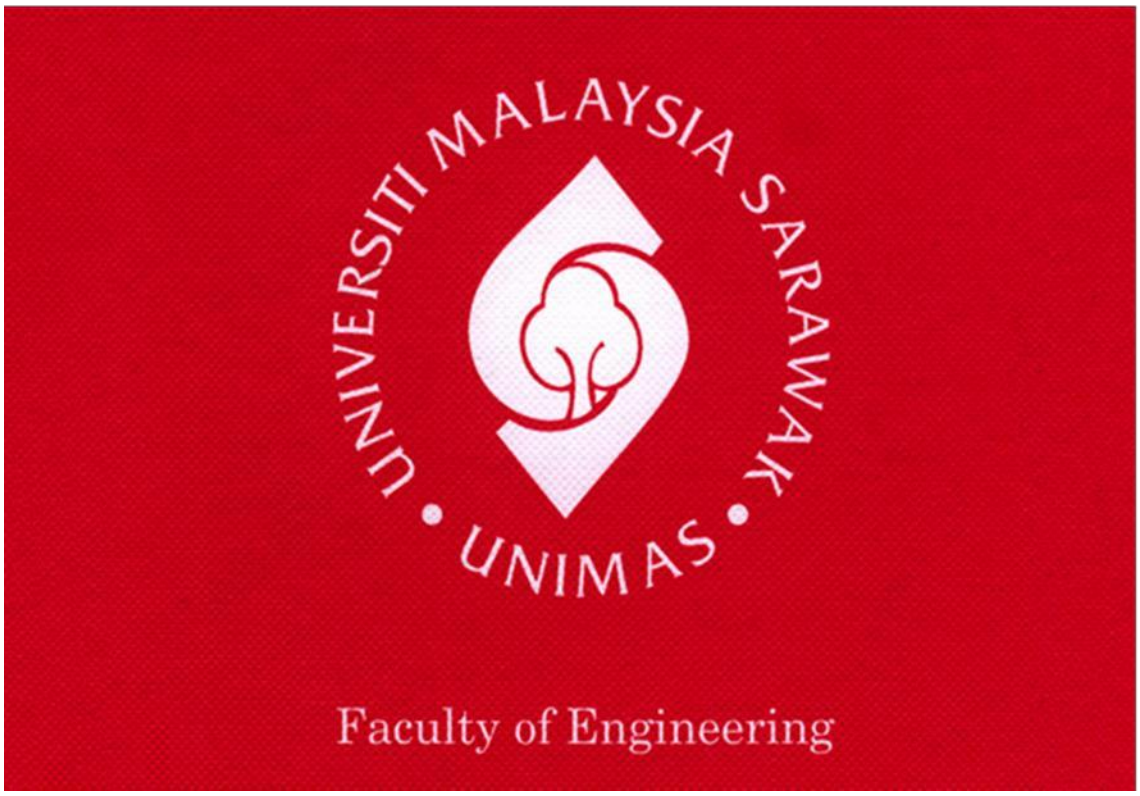

EFFECTS OF AGGREGATE CONCEPTS ON THE WORKABILITY OF PERVIOUS CONCRETE

BIANTI SHEANON LOJITAN

Bachelor of Engineering with Honours

(Civil Engineering)

2019

UNIVERSITI MALAYSIA SARAWAK

Grade: _____

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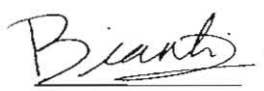
Student's signature:  Supervisor's signature: _____

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Supervisor’s Signature and Stamp

…….

Name: Dr Norsuzailina Mohamed Sutan

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EFFECTS OF AGGREGATE CONCEPTS ON THE WORKABILITY OF PERVIOUS CONCRETE

BIANTI SHEANON LOJITAN

A dissertation submitted in partial fulfillment
of the requirement for the degree of
Bachelor of Engineering with Honours
(Civil Engineering)

Faculty of Engineering
Universiti Malaysia Sarawak

2019

I called upon the LORD in distress:
the LORD answered me, and set me in a large place.

Psalm 118:5

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Lastly, I would like to thank God for giving me strength physically and spiritually. And most of all, myself, for holding on. You did it.

ABSTRACT

Pervious concrete is an agglomerated mass of paste-coated aggregates, or also known as no-fine concrete or porous concrete. It is generally made up of Portland cement, coarse aggregate, little or no fine aggregate, admixtures and water. The reduction or removal of the fine aggregate from the aggregate matrix results in an open structure with interconnected pores that allows water to pass easily through. The main objectives of this study are to investigate the effects of aggregate concepts on the workability of pervious concrete and to determine which kind of aggregate concept is best applied on pervious concrete for its optimum workability. The study is conducted through two types of lab experiments such as the inverted slump cone test and mouldability test that was recommended from Tennis et al. (2004), by forming a ball with the hand. The lab experiments are done by testing three shapes of aggregates which are angular, flaky and irregular with each shapes are further tested in different sizes of aggregates that are retained between pair of sieves of 20 mm to 14 mm, 14 mm to 10 mm, and 10 mm to 6.5 mm. The outcome of this study shows that aggregates with irregular shapes with sizes of aggregate that are retained between 14 mm to 10 mm pair of sieves is best applied on pervious concrete for its optimum workability.

ABSTRAK

Konkrit telap adalah jisim aglomerasi agregat yang bersalut pes, atau juga dikenali sebagai konkrit berliang. Secara umumnya, ia terdiri daripada simen Portland, agregat kasar, agregat halus, bahan tambahan dan air. Pengurangan atau penghapusan agregat halus dari matriks agregat menghasilkan struktur terbuka dengan liang yang saling berkait yang membolehkan air untuk melalui liang konrit dengan mudah. Objektif utama kajian ini adalah untuk mengkaji kesan konsep agregat mengenai kebolehmampuan konkrit telap dan untuk menentukan jenis konsep agregat yang terbaik digunakan pada konkrit telap untuk kebolehkerjaan yang optimum. Kajian ini dijalankan melalui dua jenis eksperimen makmal seperti ujian kericihan terbalik and ujian acuan yang disyorkan dari Tennis et al. (2004), iaitu membentuk bola dengan menggunakan tangan. Antara kerja-kerja makmal yang dilakukan adalah dengan menguji tiga bentuk agregat yang bersifat bersegi, bersifat nipis dan panjang dan bentuk dengan permukaan yang bersifat tida sekata. Setiap bentuk diuji lagi dalam berbagai ukuran agregat yang dipertahankan antara sepasang saringan 20 mm hingga 14 mm, 14 mm hingga 10 mm dan 10 mm hingga 6.5 mm. Hasil kajian ini menunjukkan bahawa agregat dengan permukaan yg bersifat tida sekata dengan saiz agregat yang dikekalkan di antara sepasang saringan yang bersaiz 14 mm hingga 10 mm adalah lebih baik digunakan oleh konkrit telap untuk kebolehkerjaan yang optimum.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Pervious concrete also referred to as no-fine concrete or porous concrete is a type of concrete consisting of Portland cement, coarse aggregate, little or no fine aggregate, admixtures and water (ACI 522 Committee, 2010). It is a zero-slump concrete with voids continuously interconnected and requires a special design mixture and compaction to produce high voids ratio concrete with reasonable durability and strength (Liew et al, 2018).

There are many advantages associated with the use of pervious concrete. Firstly, because of its environmentally friendly material, it is important to solve urban problems and to mitigate the impact of climate change. For example, floods, hot city islands and groundwater are declining (Liu, Luo, Wei, & Yu, 2018). Second, it reduces the volume of runoff and the accumulation of storm water as a pavement material. It not only retains storm water on site and replenishes groundwater, but also makes lad use much more efficient by mitigating the need to retention ponds, swales and other tools for storm water management. This reduces the overall project costs on a premium basis.

On the other hand, despite of the many advantages of pervious concrete, there are also several issues that are related to it. These issues can be classified into three major categories as:

i. Workability and mixture proportioning related
ii. Hardened properties and usability related
iii. Future performance and durability related

However, this thesis will focus primarily on the issues related to the workability of pervious concrete in which is influenced by aggregate concepts.

Workability is the property of concrete, which how easily it can be mixed, positioned, consolidated and finished (ACI 211 Committee, 2002). Some of the workability issues that are common to pervious concrete mixes include harsh and dry mixes, rapid loss of workability, a requirement of longer mixing time, lack of achieving the desired density and sealing of the finished surface with paste (Jimma, 2014).

Moreover, these issues are related to various factors. Its open-graded aggregate gradation, the reduction or elimination of fine aggregate, the restriction on its paste content and poor paste flowability are the main sources for poor workability (ACI Committee, 2010). Hence, it is very important to have a proper mix design process as well as having excellent aggregate concepts in order to address these workability issues in pervious concrete.

1.2 Problem Statement

This thesis focuses on the effects of aggregate concepts on the workability of pervious concrete. This research is essential in order to solve the workability related issues in pervious concrete and also for the advancement of the industry.

Up until now, there are many research attempted in order to address the workability aspect of pervious concrete. However, less attention was given to the effects of aggregate concepts on the workability of pervious concrete.

Nevertheless, the majority of pervious concrete mixes use single-sized aggregates such as 3/8 and 3/4 inch sizes based on previous research. In case of the determination of aggregate gradations, the variations were quite limited (Ghafoori, 1995). Although permeability can be a major concern in the application of pervious concrete as pavement material, other applications can focus more on strength, fluidity or sound adsorption depending on their intended use. Porous asphalt, for example, relies on the distribution of total strength sizes while providing adequate drainage properties (Kandhal, 2002).

1.3 Objectives

The specific objectives for this thesis are:

- To investigate the effects of aggregate concepts on pervious concrete workability.
- To determine which kind of aggregate concept is best applied on pervious concrete for its optimum workability.

1.4 Research Significance

The outcome of this research will be beneficial to various parties. One of those would be parties that are involved in the pervious concrete business. The outcome of this research will contribute in helping to design reliable pervious concrete mixes in a short time since it no longer needs blind trial and error attempt for achieving workability.

Furthermore, this research will contribute and promote the widespread acceptance of pervious concrete as one of the solutions to storm water runoff problem and other urban problems. If pervious concrete are widely used, land developers will be able to decrease the size of retention areas and by doing so, they will also have a larger size of land to develop on their property.

Lastly, the outcome of this research will also promote a greener way of construction in which it can contribute to promote a much more environmental friendly construction that will do less damage and future casualties.

1.5 Organisation of Dissertation

This dissertation is organized into few notable chapters in which will discuss on the effects of aggregate concepts on the workability of pervious concrete.

Chapter 1 presents the background of study, problem statement, objectives and research significance.

Chapter 2 is a comprehensive literature review on pervious concrete which includes its general background and history, comparison of conventional and pervious concrete, engineering properties, materials, and general material relationships, effect of aggregates and workability of pervious concrete.

Chapter 3 presents the methodology and the overall layout of the research work.

Chapter 4 discusses comprehensively on the results and findings of this research.

Chapter 5 is the conclusion and the recommendations for this research.

CHAPTER 2

LITERATURE REVIEW

2.1 General Background and History of Pervious Concrete

Pervious concrete is an agglomerated mass of paste-coated aggregates, or also known as no-fine concrete or porous concrete. It is generally made up of Portland cement, coarse aggregate, little or no fine aggregate, admixtures and water. The reduction or removal of the fine aggregate from the aggregate matrix results in an open structure with interconnected pores that allows water to pass easily through it (ACI 522 Committee, 2010).

Figure 1: Pervious concrete. (Source: http://www.civilengineeringforum.me/pervious-concrete/)

Historically, pervious concrete has been used for a variety of applications. Its first and earliest usage dated all the way back to 1852, in which two buildings in England provinces of Isle was constructed. It is then re-introduced to England in 1923 after 70 years of dormancy (Jimma, 2014).

After World War II, the use of pervious concrete spread widely throughout the world (Baxter, Hastings, Law, & Glass, 2008). This is due to an increase in housing requirements and limitations in the supply of building materials. Pervious concrete also require less cement paste than conventional concrete and therefore promotes its greater use.

Nowadays, the use of pervious concrete has slowly increased. It is mainly used in buildings as pavements to reduce uncontrolled storm water flow. Although pervious concrete is versatile, its limitations have hindered the design for typical traffic loads, soil with low permeability, heavy vehicular traffic and impermeable materials (Baxter et al., 2008). Moreover, pervious concrete has been applied to a road surface in which noise are reduced and excellent water absorption of such layer.

2.2 Conventional and Pervious Concrete Comparison

Conventional and pervious concrete can be compared to show its usefulness in different applications. Firstly, pervious concrete has less strength than conventional concrete due to its 15 to 25 percent voids and lower density. However, the durability of both concrete types is similar.

In terms of appearance, both types of concrete are open graded. Unlike conventional concrete, pervious concrete generally has aggregate size of 3/8 inches (10 mm), maximum size round pea gravel with little to no fine aggregate at all.

Pervious concrete also has lesser shrinkage and has lower water-to-cement ratio. In most cases, the setting time for pervious concrete is faster although it is modifiable. Lastly, the curing sensitivity of pervious concrete is much higher if compared to conventional concrete.

2.3 Pervious Concrete Engineering Properties

2.3.1 Void Ratio

The void ratio is a measurement of the total open space in the ceiling. It compares the void volume to the total cement paste and aggregate volume. In general, the void ratio for pervious concrete ranges from 18 to 35 percent in which it was considered ideal for strengthening while allowing adequate hydraulic conductivity (ACI, 2010). In addition, the reduction in the aggregate to cement ratio increases the void ratio. As the amount of cement covering each aggregate increases, the voids are filled in the preceding concrete and the void ratio decreases. The void ratio increased as the weight of the unit decreased (Wang et al., 2006).

2.3.2 Compressive Strength

Compressive strength is a measure of the pervious concrete strength. It ranges between 2.8 and 28 MPa (400 to 4000 psi) (ACI, 2010). The compressive strength of 2500 psi (about 17 MPa) is generally used to comply with similar requirements as conventional concrete. Furthermore, properties and methods such as increased water-to-cement ratio, decreasing aggregate to cement ratio, stronger coarse aggregate, higher compaction energy and reduced void ratio have been shown to increase the compressive strength of pervious concrete (Anderson, I., Walsh, D., Oka, L., Limberg, S., Sevi, A., Schmeckpeper, 2015). Not to mention, curing time also affects the strength of pervious concrete in which greater strength are developed through longer curing times.