THERMAL PROPERTIES OF CONCRETE PAVER CONTAINING EFFECTIVE MICROORGANISM

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DEDICATION

This thesis is dedicated to my father, who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my mother, who taught me that even the largest task can be accomplished if it is done one step at a time.

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ABSTRACT

Numbers of research have been developed and studied for the mitigation of the Urban Heat Island effect through the concrete pavements. Waste material that enhance the strength of structures, reducing noise in pavements as well as improving heat properties were introduced. In this study, the application of marine kaolin and effective microorganism (EM) as part of cementitious material is carried out as a solution to reduce the heat emittance produced by a cement-water chemical reaction known as hydration process. The idea of mortar laid on top of concrete pavers to observe its effect on thermal properties is carried out. This study consists of 3 objectives that are to determine the surface temperature of marine kaolin mortar mixed with EM, to identify its thermal conductivity and to determine the optimum mix proportion of marine kaolin and EM. Most of the research however has include either marine kaolin or EM with other substances in their studies, however very limited research incorporating both materials. The reliability and efficiency of different methods are demonstrated experimentally and compared. Previous studies implementing EM or marine kaolin separately in the concrete mix are also reviewed. However, the improvement of thermal properties is focused in this study. Therefore, the lowest surface temperature and thermal conductivity achieved was to incorporate 10% marine kaolin mortar with 10% EM content. The 10mm thickness mortar laid, had reduced the temperature by 4% compared to the controlled sample and 6% lower than normal mortar at day-52. Although the research knowledge on the chemical reaction affecting mortar thermal properties is limited, this is a good alternative in reducing surface heat temperature of concrete paver.

ABSTRAK

Sejumlah kajian telah dikembangkan dan dikaji untuk mengurangkan kesan Pulau Haba Bandar melalui turapan konkrit. Melalui penggunaan bahan kitar semula, peningkatan terhadap kekuatan struktur, pengurangan kadar kebisingan diatas jalan raya dan juga penambahbaikan suhu sekitar dapat dicapai. Dalam kajian ini, sebahagian lempung marin dan mikroorganisma berkesan (EM) digunakan sebagai bahan ganti di dalam campuran mortar. Ia dilakukan sebagai penyelesaian bagi mengurangkan penghasilan haba yang terhasil oleh tindak balas kimia simen dan air melalui proses penghidratan. Idea mortar diletakkan di atas lapisan atas konkrit dilakukan bertujuan melihat kepada pengaruh bahan mortar terhadap sifat terma. Kajian ini terdiri daripada 3 objektif iaitu mengenalpasti suhu permukaan mortar lempung marin yang dicampur dengan EM, untuk mengenal pasti daya pengaliran terma dan menentukan bahagian campuran optimum lempung marin dan EM. Sebilangan besar penyelidikan terdahulu dijalankan menggunakan lempung marin atau EM bersama bahan lain dan amat sedikit ujikaji mencampurkan kedua-dua bahan tersebut. Kebolehpercayaan dan kecekapan kaedah yang berbeza ditunjukkan secara eksperimen dan dibandingkan. Penggunaan EM atau lempung marin secara berasingan dalam campuran konkrit juga dianalisis. Walau bagaimanapun, kajian ini akan memfokuskan terhadap peningkatan sifat terma. Oleh itu, suhu permukaan dan daya pengaliran terma terendah yang dicapai adalah memasukkan mortar lempung marin 10% dengan kandungan EM 10%. Mortar dengan ketebalan 10mm, telah menurunkan suhu sebanyak 4% berbanding sampel terkawal dan 6% lebih rendah daripada mortar biasa pada hari ke-52. Walaupun pengetahuan penyelidikan mengenai tindak balas kimia yang mempengaruhi sifat terma mortar adalah terhad, ini adalah alternatif yang baik dalam mengurangkan suhu haba permukaan blok konkrit.

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LIST OF ABBREVIATIONS

EM	-	Effective Microorganism
ASTM	-	American Standard Testing Materials
BS	-	British Standard
MS	-	Malaysian Standard
CBP	-	Concrete Block Pavement
OPC	-	Ordinary Portland Cement
FA	-	Fly Ash
INDR	-	Indoor
OUTDR	-	Outdoor
CH	-	Chainage
SSD	-	Saturated Surface Density
SSD	-	Saturated Surface-Dry Density

LIST OF SYMBOLS

A	-	Mass of the surfaced-dried sample in the air after immersion,g
B	-	Apparent mass in the water,g

CHAPTER 1

INTRODUCTION

1.1 Introduction

Building construction is one of the largest industries nationwide and has begun back in ancient times triggered by the need of providing a natural basis or simply own shelter. According to a study made by (Picon, 2013), the material used in construction differ according to that particular time technological progress and since the characterization of the material, its properties and behaviour were not yet introduced, bones, as an example of common and readily available substance were chosen in the act as beam reinforcement. Over years, waste materials have been generated continuously without us knowing the potential of these by-products as the additive substance to improve concrete workability, durability, permeability, and strength. Engineers and researchers from civil engineering industries started to gain interest in the growing construction demand and have made considerable effort to develop various research. The objectives include promoting green technology and sustainable development.

Mortar or concrete is a material that contains cement, water, and aggregates. Nowadays, it is the most popular material being used around the world because of its strength, durability, and low cost. Due to the high demand for mortar concrete production, cement is the important basic material, thus correlate to its large mass production. The significant problem with cement production, its contribution to the emission of carbon dioxide which leads to air pollution (Laureti, Martinelli and Battisti, 2018) besides major drawbacks of undesired further cracks develop in which affecting the durability of mortar during a plastic stage or even after it hardened.

Experiencing climate change due to low wind speed causing insufficient air dispersion, the increasing built-up areas which lessening green areas and predominantly, heat due to large traffic. The effect of 'Urban Heat Island' has been on record for several years up to today. This is a response to the absorption of solar radiation on building materials and pavements which consecutively storing, turning, and dissipating heat to the environment (Penalty, 2015). Seeing that heat gains and cities overheating, a mitigation plan towards sustainability is vital. (Penalty, 2015) also indicated that road pavement contributes to the utmost heat emission, thus, improving its thermal performance showing the best approach. Numerous tests done involving raw material and compositions were brought in as additive to the cement. Made known by Teuro Higa from the University of Ryukyus, Okinawa, Japan, the development of Effective Microorganism (EM) technology was first created. The mixture of EM in concrete performed their first experiment through biolo1gical activity to heal concrete cracks (Martirena, 2016). According to (Ramachandran, Ramakrishnan and Bang, 2001), EM has been taken with the application associating agriculture primarily but later then it was introduced as a cement admixture improving the strength and mechanical properties. These positive outgrowths have led to various other studies to investigate reactions of constituents in both concrete and EM as any contribution towards promoting sustainable construction is welcome.

1.2 Problem Statement

During the production and hydration process of cement, carbon dioxide is produced. Based on experimental investigation, it has been proved that 1 ton of clinker produces around 1 ton of CO_2. Carbon emissions contribute to climate change, which can have serious consequences for humans and their environment (Tonduba, 2016). The cement industry contributes to around 5-8% of the annual global greenhouse gas emissions to the atmosphere (Saha, 2019). Along with that, cement is a very expensive construction material as the costs of cement production are quite high. 45% of the construction cost is from cement production. Thus, it is crucial to find new techniques and technology that be able to responsively enhance the mortar properties with fewer usage of cement material.

Production of concrete with high compressive strength is fundamental in design to withstand structure load. Present-day, aside from structural strength, a good measure of low heat building is another issue in the bargain. Heat works well in porous media. This implies that heat entering porous media tend to lose it in a short time in comparison with denser media. However, a concrete density contributes significantly to its strength and a denser concrete density is favorable. On the contrary, a denser concrete is a poor heat insulator whereas heat is trap for much longer time. This turns out to be challenging considering that utilizing porous material replacing concrete is risky and unsafe.

Recent studies of the development of low thermal mass cement-sand block utilizing peat soil and effective microorganism had used EM to replace water. Modified blocks replacing 30% EM successfully reduced the thermal conductivity of the block up to 74% (Idris and Yusof, 2018). The compressive strength and absorption rate of the sample also did show a good result. This shows that by mixing EM as an admixture on a certain percentage with marine kaolin mortar may as well reduce its thermal conductivity properties.

There is a heap on marine kaolin that can be found mainly in the coastal regions. Commonly it is treated as construction waste since large mass was scouted during excavation work. With, a study which supports Ordinary Portland cement being replaced partially with marine kaolin proves to gives positive outcome. Good activation index, at 30% cement replacement showing the index strength near 0.9 (Du and Dai, 2018). These good records from EM and marine kaolin reaction towards cement properties had given a possible view of bringing together both materials to investigate its effect on surface heat temperature, thermal conductivity and, conclusively determine whether previous results of EM and marine kaolin can be achieved on a concrete paver block.

1.3 Research Objectives

The objectives of this study are:

(a) To determine the optimum mix proportion of marine kaolin incorporating a percentage of EM.

(b) To measure the effect of EM on surface heat of marine kaolin mortar.

(c) To identify the thermal conductivity of marine kaolin mortar.

1.4 Significance of the Study

The approach of implementing marine kaolin and EM in the first place was due to the previous studies incorporating EM as an admixture. The outcome of denser concrete which suggests contributing to its high compressive strength and providing self-healing action to the mortars. Marine kaolin, on the other hand, had been introduced to the construction industries centuries ago. It is famous for its cooling properties but lacks in terms of durability that may be due to its large surface area which reacts to high moisture content. These positive outgrowths had triggered most researchers to investigate both ingredient potential in-depth, specifically on thermal properties.

The main significance of this research is to encourage the implementation of alternative materials to improve the design mix in the construction technology field. The needs are crucial as the current cement mix design are not yet relevant to the increasing annual temperature. The product tends to prolonged heat conserved upon releasing it which mainly impacts closely spaced area inducing high surrounding temperature. Therefore, the development and exposure gain from this study definitely benefit to a cooler environment while supporting sustainability.

1.5 Outline of the review

The content of this study is as below:

Chapter 1 presents the introduction background of the study, shortcomings of previous research, and outline of the study.

Chapter 2 presents reviews regarding the existing research implementing the usage of marine kaolin and EM on various aspects.

Chapter 3 describes the experimental procedure, description of specimens used, and the results obtained were discussed. The experimental data are also presented.

Chapter 4 studies the interaction of clay minerals and microorganisms. The influence of reaction occurred to the changes in concrete properties are studies.

Chapter 5 provides the conclusions and several recommendations to improve the accuracy of data obtained, and precaution measures to ensure the optimum results.

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