GARNET WASTE AS SAND REPLACEMENT FOR SUB BASE LAYER

MOHD ASNAWI BIN ABD WAHAB

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Dedicated to Allah S.W.T,
my beloved wife Fardhila Syahira Bt Salmi Nordin
and family.

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Finally, I hope that my findings in this research will expand the knowledge in this field and contribute to all of us in future.

ABSTRACT

Pavement quality is an important element in ensuring user satisfaction. Quality pavement layer will increase the life span of road. As such, it involves a layer of sub base by replacing with garnet as a replacement material for sub base layer of sand. This study addresses the usage of sand as sub base layer by reused garnet waste as sub base layer up to 100 % replacement. The replacement of garnet for sub base layer will minimise the abandoned the garnet waste. The objectives of this study are to determine the degree of density and value of California Bearing Ratio (CBR) value and categorize coefficient of permeability for the sub base mixture between sand and garnet. There are several laboratory tests were conducted such as compaction test, CBR and permeability of sand and garnet with ratio of 10 %, 20 % and 30 % in the mixture. The tests were conducted to determine the maximum mix proportion as sand replacement for sub-base layer. The results showed the CBR value coefficients of permeability were meet to the CBR value of sub base 20% and range permeability coefficient 0.001-1.000 cm/s. As conclusion, the mixture of 70% sand and 30% garnet was maximum mix proportion that can be used in the construction layers of sub base.

ABSTRAK

Kualiti turapan adalah elemen penting dalam memastikan kepuasan pengguna. Lapisan turapan yang berkualiti akan meningkatkan jangka hayat jalan raya. Oleh itu, ia melibatkan lapisan sub base dengan menggantikan dengan garnet sebagai bahan pengganti untuk lapisan sub base pasir. Kajian ini menangani penggunaan pasir sebagai lapisan asas oleh sisa garnet sebagai lapisan sub base sehingga penggantian mencapai 100%. Penggantian garnet untuk lapisan sub base akan mengurangkan sisa garnet yang berlebihan. Objektif kajian ini adalah untuk menentukan tahap ketumpatan dan nilai nilai California Nisbah Galas (CBR) dan mengkategorikan pekali kebolehtelapan bagi campuran sub base antara pasir dan garnet. Terdapat beberapa ujian makmal telah dijalankan seperti ujian pemadatan, CBR dan kebolehtelapan pasir dan garnet dengan nisbah 10%, 20% dan 30% di dalam campuran. Ujian telah dijalankan bagi menentukan perkadaran campuran maksimum sebagai pengganti pasir untuk lapisan sub base. Hasil kajian menunjukkan pekali nilai CBR kebolehtelapan adalah mencapai nilai CBR sub base 20% dan julat bagi pekali kebolehtelapan 0.001-1.000 cm/s. Kesimpulannya, campuran 70% pasir dan 30% garnet adalah campuran maksimum bahagian yang boleh digunakan dalam lapisan pembinaan sub base

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LIST OF ABREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ASTM	Standard Test Method for Permeability of Granular Soils (Constant Head).
BS 1377	British Standard Methods of test for soils for Civil Engineering purposes
NSSGA	National Stone, Sand and Gravel Association
ATJ	Arahan Teknik Jalan
CBR	California Bearing Ratio
JKR	Jabatan Kerja Raya
MS	Malaysian Standard
TMD	Theoretical Maximum Density
MPCT	Modified Proctor Compaction Test
VMA	Voids in Mineral Aggregate
AC	Asphalt Concrete
PCC	Portland Cement Concrete
PAC	Porous Asphalt Concrete
HMA	Hot Mix Asphalt
SRP	Semi-Rigid Pavement
VTM	Void Ratio in Mix
VFB	Void Filled Bitumen
OBC	Optimum Bitumen Content
OMC	Optimum Moisture Content
MDD	Maximum Dry Density
g	gram
mm	millimetre

LIST OF SYMBOL

%	Percent
k	Coefficient of permeability
Δh	Head of water
K_{20}	The permeability at any temperature 20°C
K_T	The permeability at any temperature T
η_T	The viscosities at the temperature, T
η_T	The viscosities at the temperature 20°C
G	A sample of Garnet
S	A sample of Sand
R	Coefficient of correlation
SD	Standard of Deviation
COV	Coefficient of Variation
10S	100 % of Sand
9S:1G	90% of Sand and 10% of Garnet
8S:2G	80% of Sand and 20% of Garnet
7S:3G	70% of Sand and 30% of Garnet
10G	100% of Garnet

CHAPTER 1

INTRODUCTION

1.1 Introduction

Sub base is the portion of the pavement structure between the base course and the subgrade. It mainly acts as a structural layer helping to spread the wheel loads so that the subgrade is not over-stressed. It also plays a useful role as a separation layer between the base and the subgrade and provides a good working platform on which the other paving materials can be transported, laid and compacted. It can also act as a drainage layer (Department For International Development, 2000). It functions primarily as platform for road base and assists in distributing loads from vehicles, drainage layer and temporary access road during construction. Normally, the sub-base course consists of lower quality materials than the base course which is better than subgrade soils. Nowadays, three factors to be considered in the design are failure mechanism, traffic loading and environmental factors to improve quality of pavement. The quality of pavements depend on the strength of the natural soil present at the site (Ramasubbarao and Siva Sankar, 2013). The design, behaviour and thickness of these flexible pavements must be emphasized in the process of the construction of pavement layer.

1.2 Background of Study

Sub base may be constructed of granular materials, cement treated materials, lean concrete or open graded. For light traffic pavements such as residential streets, secondary roads, parking lots and light duty airport, the use of sub base layer is not required. The sub base or base thickness of pavement is governed by CBR value of subgrade soil along with some other parameters such as traffic intensity, climatic conditions (Ramasubbarao and Siva Sankar, 2013). The value of CBR is a measure of strength of the pavement to ensure lifetime of pavement can be increased. The strength of a stabilised material will depend on many factors (Department For International Development, 2000). These include:

a) The chemical composition of the material to be stabilised;
b) The stabiliser content;
c) The degree of compaction achieved;
d) The moisture content;
e) The success of mixing the material with the stabiliser;
f) Subsequent external environmental effects

1.3 Problem of Statement

Sand is a material used in the construction of sub base in pavement layer. Current trend of high demand for natural resources and low supply lead to price increase. So, this problem could be solved by substituting the appropriate material that has the same function in pavement layer. One solution to this crisis lies in recycling waste into useful products. Garnet also can replace function of sub base as drainage layer and prevent mud pumping, continuous support for slab and to protect subgrade damage (Anjaneyappa, 2011).

Garnet is a waste material in marine industry and it is used to clean ship's body as it has particle materials with different sizes. Physically, garnet shapes and sizes are similar to sand, but now, used garnet has become abundant without appropriate disposal to replace normal sand for sub base layer.

The sustainable reuse of waste materials become critical due to the enforcement of more stringent environmental regulations during the past few decades. Significant amounts of virgin material are being used annually in roadwork construction and development (Maghool et al., 2016).

1.4 Aim and Objectives

The aim of this study is investigate the maximum mix proportion of garnet to replace normal sand for sub-base layer.

The objectives of this study are as follows:

a) To determine the degree of compaction mixed proportion between sand and garnet,

b) To determine the California Bearing Ratio (CBR) values of sub base of mixed between sand and garnet,

c) To classify the coefficient of permeability of sub base mixed between sand and garnet.

1.5 Scope of Study

The scope of study for this research is to know the ability of garnet as waste material to replace normal sand content for sub base layer based on garnet proportion of 10 %, 20 % and 30 % of all mixture. It will be tested with compaction test, California Bearing Ratio (CBR) and permeability to determine the degree of compaction, CBR values and k value of permeability of mixture. The results can clarify the optimum mixture proportion of sub base which are suitable for road construction as an open graded drainage.

1.6 Significance of Study

The study is important for sustainable development through modification or recycling waste material using available technologies and knowledge (Odd E Gjov, 2000). Furthermore, the assume cost of construction can be reduced and at the same time the construction industry can be more sustainable with less pollution to the environment and also avoid the second mode of damaged and the problem of pumping.

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