PALM OIL CLINKERS AS COMPOSITE MATERIALS IN MARSHALL MIX DESIGN

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ABSTRACT

Palm oil industry becomes one of the main Malaysian commodities as indicated in Ninth Malaysian Plan (RMK9). As Malaysian focus on biotechnology industry, it is expected that million tones of waste produced annually and treated as disposal waste. By recycle the waste, it is not only can save the disposal area but also can sustain green environment. The Economic growth has lead to the rapid increase of the demands for the aggregate for use in civil engineering field. The roads are the main links for all type of transportation to travel from one to another place. The growth of economy in a country also depends to the system of roads of the country itself. Besides, the decreasing of natural aggregate in our country is turning out to be a problem as its important for future generation. Since the road construction in Malaysia really developing rapidly and costs a lot in a project, an alternatives method or material need to been identified to minimize the cost and gives a good quality of pavement for long term usage. Malaysia also produce a large volume of palm oil waste and the usage of palm oil clinker in hot mix asphalt will make benefits for the environment and solid waste management. Malaysia is known as main manufacturers of palm oil in Asian region. Every oil mill produces a waste by-product, known as clinker. Clinker was found to be suitable to replace normal gravel aggregate in concrete mixture and also mix design for pavement. For this project, palm oil clinkers will be mix together with the natural aggregate in Hot Mix Asphalt with different composition. The proportion for each category varies as Sample A contains 90% Natural Aggregate and 10% Palm Oil Clinker, Sample B contains 80% Natural Aggregate and 20% Palm Oil Clinker, Sample C contains 70% Natural Aggregate and 30% Palm Oil Clinker. From the experiment, the values of LA Abrasion for natural aggregate and palm oil clinker are 34.4% and 47%. This value will be compared with the JKR Standard which specifies the value for LA Abrasion should be less than 60%.The aggregate impact Value for natural aggregate is 16.62% and for palm oil clinker is 18.08%. JKR requirement For AIV Test is Not Exceed 30%.

ABSTRAK

Dalam Rancangan Malaysia Kesembilangan, Industri minyak sawit menjadi salah satu komoditi utama Malaysia. Sebagai tumpuan kepada industri bioteknologi Malaysia, pembuangan sisa dijangkakan mengeluarkan jutaan tan sisa setiap hari. Oleh itu, pengitaran semula sisa-sisa ini, bukan sahaja dapat menjimatkan kawasan pelupusan tetapi juga boleh mengekalkan persekitaran hijau. Pertumbuhan ekonomi yang pesat telah membawa kepada peningkatan permintaan untuk agregat untuk digunakan dalam bidang kejuruteraan awam. Jalan merupakan per hubungan utama untuk semua jenis pengangkutan untuk bergerak dari satu ke tempat lain. Pertumbuhan ekonomi dalam sesebuah negara juga bergantung kepada sistem jalan raya negara itu sendiri. Selain itu, pengurangan agregat semulajadi di negara kita telah bertukar menjadi masalah kerana ianya penting bagi generasi akan datang. Sejak pembinaan jalan raya di Malaysia benar-benar berkembang pesat dan kos pembinaannya agak tinggi, kaedah alternatif atau bahan yang perlu dikenal pasti untuk mengurangkan kos dan memberikan kualiti yang baik untuk turapan bagi penggunaan jangka panjang. Malaysia juga menghasilkan sejumlah besar sisa minyak sawit dan penggunaan klinker kelapa sawit dalam asfalt campuran panas akan memberi manfaat untuk alam sekitar dan pengurusan sisa pepejal. Malaysia dikenali sebagai pengeluar utama minyak sawit di rantau Asia. Tiap-tiap kilang minyak menghasilkan sisa, dikenali sebagai klinker. Klinker telah didapati sesuai untuk menggantikan agregat kerikil di dalam campuran konkrit biasa dan juga mencampurkan reka bentuk untuk turapan. Untuk projek ini, klinker kelapa sawit akan dicampurkan bersama-sama dengan agregat semulajadi dalam Asfalt Campuran Panas dengan komposisi yang berbeza. Bahagian bagi setiap kategori berbeza seperti Contoh A mengandungi agregat 90% aggregate Asli dan 10% klinker kelapa Sawit, Sampel B mengandungi 80%agregat asli dan 20% klinker kelapa Sawit, Contoh C mengandungi 70% agregat asli dan 30% klinker kelapa Sawit dengan mengunakan peratusan kandungan bitumen 4.0%, 4.5%, 5.0%, 5.5% dan 6.0%. Daripada ujian LA Abrasion, nilai untuk LA Abrasion untuk agregat semulajadi dan klinker kelapa sawit adalah 34.4% dan 47%. Nilai ini akan dibandingkan dengan Piawaian JKR dan ianya melepasi piawaian JKR iaitu kurang dari 60%. Untuk ujian Aggregate Impact Value (AIV) untuk agregat asli adalah 16% dan untuk klinker kelapa sawit adalah 18.08%. Dengan keputusan ini, ujian AIV melepasi piawaian JKR iaitu kurang daripada 30%.

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CHAPTER ONE

INTRODUCTION

1.1 Background Information

In Ninth Malaysia Plan (RMK9), Palm oil industry becomes one of the main Malaysian commodities. As Malaysian focus on biotechnology industry, it is expected that million tones of waste produced annually and treated as disposal waste. By recycle the waste, it is not only can save the disposal area but also can sustain green environment. Four series of mixture were identified including series of using Palm Oil Clinker as coarse aggregates only, series combination of using palm oil clinker as coarse and fine aggregates as well as series using replacement of fly ash. All the series was compared with control mixture. As Palm Oil Clinker is a lightweight and porous material, it tends to adsorbs water and gave significant effects to the Marshall Mix Design properties especially to its durability.

This project is mainly focused on the Palm Oil Clinker (POC) and Natural Aggregate in different composition in Hot Mix Asphalt (HMA). The POC is mixed together with the natural aggregate to evaluate its performance in HMA. Asphalt concrete pavement or hot mix asphalt (HMA) pavement as it is more commonly called, refers to the bound layers of a flexible pavement structure.

1.2 Problem Statement

The Economic growth has lead to the rapid increase of the demands for the aggregate for use in civil engineering field. The roads are the main links for all type of transportation to travel from one to another place. The growth of economy in a country also depends to the system of roads of the country itself. Besides, the decreasing of natural aggregate in our country is turning out to be a problem as its important for future generation. Since the road construction in Malaysia really developing rapidly and costs a lot in a project, an alternatives method or material need to been identified to minimize the cost and gives a good quality of pavement for long term usage. Malaysia also produce a large volume of palm oil waste and the usage of Palm Oil Clinker in Hot Mix Asphalt will make benefits for the environment and solid waste management. Malaysia is known as main manufacturers of palm oil in Asian region. Every oil mill produces a waste by-product, known as clinker. Clinker was found to be suitable to replace normal gravel aggregate in concrete mixture and also mix design for pavement.

Natural aggregates also had been decreasing in Malaysia due to the deforestation and land use for construction (Oglesby, 1982). The aggregates produce naturally after the rocks undergo the physical and chemical process. An alternate material for natural aggregate needed to be obtained for solving up these upcoming problems (Neville A.M, 1995). There are some research been undergo to produce recycled aggregate. The applications of recycled aggregate in construction have started since end of World War II by demolished concrete pavement as recycled aggregate in stabilizing the base course for road construction (Olorusongo, et.al., 1999).

1.3 Research Objectives

The goal of this is Palm Oil Clinkers as composite material in Marshal Mix Design. The study is carried out to achieve this goal by the following objectives:

i To identify Palm Oil Clinker characteristic as a composite material in Marshall Mix Design.

ii To determine the ideal amount of Palm Oil Clinker (POC) needed for Marshall Mix Design.

1.4 Scope Of Your Research

This study is cover the Palm Oils Clinkers as composite materials in Marshall Mix Design. The Palm Oil Clinker (POC) was taken from the Lepar Hilir Palm Oil Mill Factory. The by-product that is collected from inside the boiler is called clinker or boiler stone. The clinker looks like a porous stone which is gray in color. All the clinkers are prepared to be crushed into required size. Clinker with nominal size of 20mm is used as coarse aggregate and size below 4.75mm is used as fine aggregate. Prepare 20 sample according the proportion for each category.

Figure 1.1 : Palm Oil Clinker

Table 1.1: 20 sample according the proportion for each category

No.	Description	No.
1	Control Sample (Asphalt Binder 4.0%, 4.5%, 5.0%, 5.5%, 6.0%)	5
2	Sample A- Mix proportion for 90% Natural Aggregate and 10% Palm Oil Clinker	5
3	Sample B- Mix proportion for 80% Natural Aggregate and 20% Palm Oil Clinker	5
4	Sample C- Mix proportion for 70% Natural Aggregate and 30% Palm Oil Clinker	5
	Total	20

1.5 Expected Outcomes

The expected outcomes is to the performance of Palm Oils Clinkers as composite materials in Marshall Mix Design can be determined. Study to compare Palm Oils Clinkers as composite materials Mix Design with conventional Mix Design will shows the Marshall Mix Design performance for the long-term durations which exhibits the overall performance of palm oil clinker. This paper will discuss the performance of palm oil clinker aggregate. Since there many other factors that influence the study, the variable undertaken for series undertaken will focus upon the size of the aggregate used and using Palm Oil Clinker aggregates as fine aggregates compared to conventional river sand while other parameters done assume constant.

The cost can be reduce due to rate Palm Oil Clinker (waste material) cheaper than natural aggregate and gives a good quality of pavement for long term usage.

1.6 Significance Of The Research

The significance of the proposed research is by using recycle materials as aggregate, the most beneficial potential for the use of industrial by-product is the environmental values. This efforts will not only benefits to the government in reduction of providing land for disposal, but also increase the economy growth in various sectors especially amongst construction industry. By replacing certain amounts of OPC will significantly reducing the dependent on its large amounts; thus emission of CO_2 or green house gases will be reduced as well.

In this paper, palm oil clinker which is a by-product from palm oil industry be used as conventional aggregate replacement in concrete mixture. Besides for sustaining green environment due to using recyclable materials, it was chosen because it has light density with specific gravity of 2.17 compared to conventional aggregates 2.6. This paper will discuss the performance of Palm Oil Clinkers characteristic as composite materials in Marshal Mix Design.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter discusses on some literature review carried out for the study. Section 2.2 discusses the materials use for this project. This section highlights the importance characteristic of materials for Marshall Mix design. Section 2.3 discusses the Marshall Method is the most common method widely for Marshall Mix Design.

2.2 The Materials in Marshall Mix Design

Hot-mix asphalt is a mixture of aggregates and asphalt binder in appropriate ratios to produce a high-performing material for asphalt pavements. The aggregate structure, which depends on the gradation, is an important factor in determining the volumetric properties of HMA. The design process to determine the optimal aggregate blend is currently iterative and engineers rely almost exclusively on experience. This approach is time consuming and often results in suboptimal HMA mixtures. This study presents linear programming optimization models and attendant solution procedures that minimize HMA aggregate cost and produce high-quality HMA. The models are validated with real-life examples, and results indicate that the models are useful to replicate HMA mixes during field modifications, reduce the aggregate cost in a mixture, and manage stockpile inventory. The application of optimization models will increase the application of the Bailey method in the United States. (Civ., 2009).

Modern HMA production involves (1) using different size distribution (gradation) aggregate stockpiles which are introduced into the plant through a set of feed bins or directly fed from the stockpiles; (2) blending and drying in a drum dryer; and (3) blending the hot aggregate with asphalt and storing in insulated silos for use in pavement construction. If desired, the operator can introduce recycle asphalt pavement (RAP) into the aggregate mixture after heating the aggregate to elevated temperatures. The use of quality materials (aggregates and asphalt binder) in optimal proportions is the key to producing optimally performing HMA. (Richardson, 2011)

Researchers have long recognized the significance of aggregate gradation in producing high-performing HMA (Richardson 1912; Goode and Lufsey 1962; Huber and Shuler 1992). The aggregate size distribution (or gradation) affects the volumetric properties— air voids, voids in mineral aggregate (VMA), and voids filled with asphalt (VFA)—of the mixture and consequently, the HMA performance. (Richardson, Aggregate Cost Minimization in Hot-Mix Asphalt Design, 2011)

The objective of HMA mix design is to determine the proportions of each available component (aggregate stockpiles and asphalt binder) that will provide optimal HMA performance. The aggregates portion is the key structural component and is typically more than 94% by weight of the mix. For durable aggregate, the literature recognizes the significance of the aggregate gradation (size distribution) in producing high-performing HMA (Richardson 1912; Goode and Lufsey 1962; Vavrik 2000). Different transportation authorities use different methods to design HMA mixes. Vavrik (2000).

The aggregates that used in mixtures should accordingly to its specifications for durability, soundness, hardness and others. The form of the aggregates must be crushed and contains some allowable percentage of sand composition (Freedy L.Roberts. et. al., 1996). The aggregates used should meet these five requirements such as it must be strong and tough, it must be durable, easy to crush without many flaky particles, low in porosity, low

in permeability and the particle size and the gradation is suitable for the pavement type (Yang H.Huang, 2004).

According to Asean Sources. Com. Malaysia for many decades has been known as the main manufacturers of palm oil. The waste that been produced in palm oil mill known as clinker (Omar .W. et.al. 2001). As the aggregates were decreasing rapidly, clinker was explored as a suitable material to replace aggregate in Hot Mix Asphalt. Palm oil clinker can be found easily in our country as Malaysia is the largest manufacturer of palm oil products. Malaysia is holding the main production for world palm oil production as 51%, 62% for the world exports and 30% for the oils and fats exportation (Asean Sources.Com, 2004).

Combustions of shell and fibre from the palm oil create clinkers as waste material which will be thrown away from mill [Omar .W. et.al. 2001]. The significant usage of clinker as the artificial lightweight aggregate in HMA in road pavement will benefit us from the aspect of waste management from palm oil mill and minimize the demand on natural aggregate in the road construction industry [Omar .W, et.al., 2001]. Usage of clinkers also will minimize the cost of the road construction due to the rate of palm oil clinker is cheaper than the natural aggregate [Neville A.M, 1995].

According to Atkins 2003, Surface texture refers to the surface patterns and the smoothness of the aggregate. Particle shape and surface plays a major role in creating bond between aggregate and material for cementing. For example, rough surface texture provides something to grip, create a good bond and produced stronger hot mix asphalt concrete. It also creates higher friction strength if there is a force to slide over a particle over a particle (Atkins, 2003). Some aggregates with good surface texture but the smoothness of texture might decay under the heavy traffic loading (Atkins, 2003).

Shapes of the aggregate particles are the main key for other elements such as the asphalt demand for hot mix asphalt, the workability and the strength of asphalt pavements (Chung Chan Kee, 2007). Crushed gravel or crushed stone normally used for this asphalt pavements. These crushed aggregates have various section of shape for instant irregular and

angular particles that will tend to interlock when compacted or consolidated (Yang H.Huang, 2004). Mixes that contain both round and angular particles tend to result in high workability. Normally, coarse aggregate particles are made of crushed stone or crushed gravel.

2.3 The Marshall Mix Design Method

The Marshall method conducted using several trial aggregate-asphalt binder blends which is 5 blends with 3 samples for each blend [Freedy L.Roberts. et. al., 1996]. The total samples are 15 specimens for 1 test with asphalt binder content varies from each test. Then, from this trial blend's performance, optimum asphalt binder content can be determined [Freedy L.Roberts. et. al., 1996]. The trial blends must contain a range of asphalt contents which includes both above and below the optimum asphalt content. Estimation of optimum asphalt content is necessary in this stage. Trial blend asphalt contents are then determined from this estimation (Yang H.Huang, 2004).

Marshall Mix is the most common method widely used producing trial mixes in obtaining the optimum asphalt content (Garber et.al. 2002). Marshall Method used to check the adequate of the voids in mixture in HMA design. 50 blows of the Marshall Hammer per side were used to prepare the specimens [Freedy L.Roberts. et. al., 1996]. 75 compaction blows were not advisable in Marshall Mix design since it would break down the aggregate into small particles. According to Yang H.Huang (2004), the Marshall method follows the procedure of heating, mixing and compact the mixture. Then, the sample will be subjected to a stability-flow test and a density-voids analysis.

According to Freedy L.Roberts (1996), density is measuring of the weight per unit of volume of a substance. In another hand, Specific gravity is the ratio between the densities of the substance to the water (Freedy L.Roberts. et. al., 1996). Specific gravity will helps us in determining the amount of asphalt needed in the hot mix asphalt. Highly absorptive aggregate will absorb asphalt at the starting of the mixture until the mix cools

down. Then the aggregate will undergo the bonding process whereby the porous aggregate needs more asphalt compared to less porous asphalt (Yang H.Huang, 2004).

Gradation (or grain-size analysis) is the one of most common test performed on aggregates to determine the main property such as stability, stiffness, permeability, durability, workability, fatigue resistance and frictional resistance (Freedy L.Roberts. et. al., 1996). According to Freedy L.Roberts (1996), this gradation is a most concern matter in HMA mix design. This gradation usually measured by sieve analysis. Sieve analysis is carried out by using the sample of dry aggregate of known weight is separated through a series of sieves with small and tiny openings (Freedy L.Roberts. et. al., 1996).Then the aggregates separated and mass retained on each sieves measured and compared to the total sample weight (Freedy L.Roberts. et. al., 1996).

The significant properties of aggregates are the internal pore characteristics. The strength of the aggregate, surface texture, abrasion resistance, specific gravity, bonding capabilities and resistance to freezing depends on the pores of an aggregate (Freedy L.Roberts. et. al., 1996). Absorption mainly refers to the particle's ability to absorb the liquid into it. Porosity is a ratio of the volume of the pores to the total volume of the particle. Moreover, permeability refers to the particle's ability to allow liquids excess through it (Yang H.Huang, 2004).

2.4 Conclusion

In a conclusion, many road pavement agencies have been using Marshall Mix Design method for designing HMA mixtures and it is believed that fundamental changes must be made in the aggregate components of HMA to reduce rutting to tolerable levels. The waste that been produced in palm oil mill known as clinker as the aggregates were decreasing rapidly, clinker was explored as a suitable material to replace aggregate in Hot Mix Asphalt. Palm oil clinker can be found easily in our country as Malaysia is the largest manufacturer of palm oil products. Properties of Hot-mix asphalt mixtures such as stability, durability, and resistance to permanent deformation (rutting) can be largely affected by aggregate gradation. Hence, gradation is considered as the centerpiece property of aggregate that influences the performance of asphalt pavement.

In Malaysia, rutting has been a continuous problem and it has become necessary to give more attention to selecting materials that could minimize this problem.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

The purpose of this study was to investigation the palm oil clinkers as composite materials in Marshall Mix Design. This chapter discusses several test that will be conducted to achieve the objectives of study. In order to evaluate characteristic the palm oil clinkers as composite materials in Marshall Mix Design, laboratory experiments have to be done to identify the performance of the modified mix with palm oil clinker compared to the unmodified mix. All the laboratory experiment are based on the standard specification on JKR/SPJ/2008.

Study will be carried out by using experiment methods to evaluate the characteristic of palm oil clinkers and it suitability in road pavement especially in hot mix asphalt. The sample testing on palm oil clinkers as modifier mix is carried out through the aggregate test and Marshall mix design procedures

The objective the Marshall Mix Design is to determine the optimum bitumen content (OBC) to ensure the mixture is durable, stable, sufficient void ratio, economic and quality.

Testing on aggregate have to be carried out is Aggregate Impact Value Test and Los Angeles Abrasion Test in order to ensure it performs well on the specification. Both tests were carried out to test whether the modified mix was appropriate. The Aggregate Impact Value Test in the consistency test to determine the aggregate impact value of road stone meanwhile LA Abrasion Test is the consistency test to determine the degradation of aggregate by abrasion using LA Abrasion Test.

This study used Marshall Method, and the type of mixes that was designed is ACW 14. Percentages of bitumen content used in the mixes is 4.0%, 4.5%, 5.0%, 5.5%, and 6.0%.

3.2 Research Design

3.2.1 Flow Chart Of Methodology

Figure 3.1: Flow Chart Of Methodology