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PERFORMANCE OF WARM MIX ASPHALT BY INTEGRATING RECLAIMED ASPHALT PAVEMENT.

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Abstract

This Research is studied about the Warm mix asphalt (WMA) which are gently becoming popular in the road industries in century 21, the use of Warm mix asphalt (WMA) instead of Hot mix asphalt (HMA) because, WMA has great benefits, such as Consumption of low energy, lower emissions, and greater ability to integrate a high proportion of reclaimed asphalt pavement (RAP) in the mixtures. Including RAP in WMA can suffiently increase the sustainability benefits and improve the performance of WMA. This research studied about the evaluation performance of WMA by adding RAP in different proportions, from 0 up to 70% by mass of WMA. By adding RAP in WMA then the mixture performance of mixture was compared with the allowable control HMA. The proportion of RAP in WMA is the binder, 80/100 penetration grade, and two types of additives were use: a chemical warm mix additive and a rejuvenator, namely, Evotherm and SylvaroadTM RP1000, respectively. Labouratory test done on the viscosity of binder that are used in WMA and the mechanical performance of mixture such as moisture resistance, fatigue cracking, and rutting resistance. In this study, the semi-circular bending test was investigated to further study its applicability in asphalt pavement testing.

Results getting from laboratory tests confirmed that by adding two additive it will have reduced the binder viscosity. Mixtures with the chemical additive (Evotherm) performed better than other mixtures in terms of moisture resistance. Only the WMA mixture with the Sylvaroad rejuvenator showed a higher number of cycles to fatigue failure than the control HMA. For rutting resistance, the increase in RAP proportion greatly improved the performance of WMA mixtures. WMA without RAP had a lower number of cycles to reach *maximum rut depth than the HMA. All WMA-RAP mixtures showed considerably better rutting resistance than the HMA. The study of semi-circular bending test showed that the notch depths from 5 to 15 mm are suitable for 100 mm diameter samples. The indirect tensile strengths yielded by the semi-circular test and those from the indirect tensile method could be convertible.*

Keywords –*Warm Mix Asphalt, Hot Mix Asphalt, Reclaimed Asphalt Pavement, Performance.*

1. INTRODUCTION

Since in the late 1990 Warm mix asphalt (WMA) technology have been developed and have great impact on road technology [1]. WMA products are usually produced at temperatures between 110°C and 142°C [2], which are relatively lower than the mixing temperatures of conventional hot mix asphalt (HMA), usually ranging from 140°C to 180°C [3].

To reduce the temperature of mixing, the emission of WMA reduced significantly compared to traditional HMA, which benefits the environment. Moreover, WMA is also show compaction at cooler temperature while still assuring workability of mixtures, which extends both the haulage time and the construction season, especially for cold weather countries [4]. Compaction of WMA at lower temperatures requires less time to cool, reducing the time before the next layer can be placed or reducing the time the road can be opened to traffic [5]. WMA also saves fuel owing to its lower mixing temperatures.

Throughout the world millions of tons of asphalt pavement are removed and dismantle. In Europe alone, more than 50 million tons of old asphalt concrete are removed annually [6]. The recycling of old asphalt pavement can bring numerous benefits, such as reducing the use of new materials, saving space owing to mitigating landfill requirement for old asphalt pavement, and lowering the costs of the product. In recent years, the incorporation of reclaimed asphalt pavement (RAP) in WMA has become an important topic for researchers and practitioners since RAP can increase the sustainability benefits and enhance the performance of WMA compared to HMA.

1.1.Objective of the Research:

Is WMA and RAP being a new technology specially adopted in a road industry which are profitable technology then the former technology of using asphalt in pavement. Studies of WMA with high RAP as a structural asphalt layer in the upper part of the pavement structure, which is subjected to high stresses. Therefore, this study is necessary to investigate the feasibility of using high RAP content in warm mix asphalts. The objectives of this study are listed below.

- Investigation the impact of warm mix additives in warm mix asphalt.
- study the effect of RAP in WMA by evaluating the mechanical performance of WMA and WMA-RAP mixtures, and compare with control mix of HMA.
- investigate methods to increase the RAP content in WMA.

2. LITERATURE REVIEW

2.1.What is Warm Mix Asphalt (WMA)

Warm Mix Asphalt (WMA) is the generic term for a variety of technologies that allow producers of Hot Mix Asphalt (HMA) pavement material to lower temperatures at which the material is mixed and placed on the road Warm mix asphalt (WMA) is an emerging technology that has become an interesting and important topic among researchers and practitioners, since the technology promises to bring numerous benefits to society. Especially in the period when global warming and climate change are becoming worldwide issues, the use of WMA has become a priority. Besides the benefits that WMA can bring such as saving fuel, reducing gases during production, and extending the paving season, it is believed that WMA will last longer than HMA pavements. Although there have been many studies conducted in laboratories to investigate the behavior of WMA [7]. The use of WMA is still at trial levels and is still under observation. The main aim of WMA technologies is to reduce production temperatures while still providing a comparable or better performance than HMA. WMA technologies can be classified into three categories, including the foaming process, using organic additives, and using chemical additives.

2.2.Technologies involved in Warm Mix Asphalt

Technology that are involved in warm mix asphalt are is under

2.2.1. Foamed Technology

Foaming technology has impact to reduced asphalt binder for improving coating and workability of the asphalt at low mixing and compaction temperatures. The mechanism of these technologies is to introduce a small amount of water into the hot binder. The binder expands in volume due to water evaporation and encapsulation in the bitumen, lowering binder viscosity and allowing better coating and workability [8]. There are various foaming technologies, but they can be divided into two groups: water-based and water-containing [9]. In water-based technologies, water is injected directly into hot bitumen. In the second case, zeolites containing water in their structures are blended with hot bitumen and at high temperature (above 85°C), the water is released to foam the binder [10]. In the United States, there are several projects using commercial synthetic zeolites such as Aspha-min and Advera [11]. Most of the water-based technologies can lower the production temperature by 20-30°C compared with HMA, while using zeolite can reduce it by around 30°C [12].

2.2.2. Organic Additives

At higher temperatures, waxes reduce the viscosity of the binder, to compensate for the lower mixing temperature compared with HMA. At the cooling phase, the binder stiffness increases due to the crystallization of waxes that form a lattice structure of microscopic particles [13]; this improves the rutting resistance of the mixture [14]. Moreover, waxes are also believed to improve the lubrication of the binder, which results in improving mix workability at lower temperatures [15], increasing the compact ability of the mix.

The organic additives used in WMA are Sasobit, Asphaltan-B, and ThiopaveTM, and among them, Sasobit is the most commercial product ([16]. Using organic additives can reduce mixing and compaction temperatures by up to 20-30°C [17].

2.2.3. Chemical additives

Different types of chemical additives have been used throughout world wise in the last decade, amongst which Evotherm, being used from 2005 and Resident, being used from 2007 [18], and Cecabase RT are popular products. Although information on the chemical components of these products is not disclosed, they are reported to have surfactants, emulsification agents, aggregate coating enhancers and antistripping agents to improve the coating, stripping and adhesion at lower production and compaction temperatures [19]. A reduction of roughly 30°C can be achieved for mixing and compaction by using chemical additives [20].

2.3.What is Reclaimed Asphalt Pavement (RAP)

Reclaimed asphalt pavement (RAP) is the term given to removed and/or reprocessed pavement materials containing asphalt and aggregates. These materials are generated when asphalt pavements are removed for reconstruction, resurfacing, or to obtain access to buried utilities. RAP contains aggregate and binder, the latter of which becomes very hard after long-term ageing. Re-using RAP not only utilizes the old material, but also saves the costs of dumping and processing the waste of old pavement. Every year, the construction of new roads requires a huge amount of asphalt concrete. According to the available data, in 2007 alone, the world produced about 1.6 trillion metric tons of asphalt [21]. The production of fresh asphalt concrete requires a huge amount of non-renewable materials. With the continuous use of nonrenewable materials without any replacement, a shortage of materials will be inevitable. For sustainable development, the use of RAP is vital and necessary.

2.4.WMA and RAP Consolidation

Warm mix asphalt is a very promising technology. However, the technology is still under observation and needs to be improved as the long-term performance of WMA is still unknown. The warm mix asphalt technology would have a severe setback if the new technology made the pavement fail sooner than the HMA. This would also have an adverse influence in terms of protecting the environment, as rebuilding means more excavating, mixing and compacting, which release dust and gases that contaminate the environment.

The use of RAP has been considered by researchers and practitioners, as using RAP can obviously bring many benefits. Adding RAP in warm mix asphalt technology increases the sustainability of the technology. The idea of using RAP in WMA is not only because RAP can enhance the sustainability of the technology, but also because RAP can improve the stiffness of the WMA and therefore improve the rutting resistance.

3. MEHODOLOGY:

To start the experimental study, materials preparation was firstly carried out. The materials preparation part consists of securing reclaimed asphalt pavement (RAP), warm mix additives, virgin aggregate, and binder. The preparation part also comprises determining RAP's properties, including RAP's binder content, grading for extracted aggregate, specific gravities, and absorption.

The next part covers the mixtures design, which includes designing aggregate gradation, choosing mixing and compaction temperatures, and determining the optimum binder contents for each mix type.

The research covers the viscosity test of the unaged and long term aged binder for the modified and unmodified binders. The final part is the mechanical performance tests, which cover the study of moisture resistance of mixtures, fatigue cracking, rutting resistance, and semi-circular bending (SCB) test.

The following methodology is adopted for warm mix asphalt.

- Preparation of asphalt material.
- To compute the temperature of different grade of asphalt, more over the temperature denser will be the asphalt, and after that prepared their mix design.

- Preparing the mix design their conduct a binder test and mixture mechanical performance test, in the binder test, the viscosity of the neat binder and long term aged binder was measured where in the mechanical performance tests covered the study of moisture resistance of mixtures, fatigue cracking, rutting resistance, and the SCB test.

4. RESULT ANAYLISES:

tests were done to evaluate the effect of warm mix additive Evotherm and the rejuvenator additive Sylvaroad on the consistency of unaged and aged binder. Furthermore, a variety of mechanical performance evaluations of mixtures were carried out, including moisture resistance, fatigue cracking, and rutting resistance, the indirect tensile tests were also studied for comparison.

From the viscosity and moisture resistance test results, it can be summarized that Sylvaroad greatly reduced the viscosity of the binder. This would help improve the coating of aggregate, especially in the case when adding high RAP content, because at lower viscosity, the binder is more mobile and thus coats the aggregate better. However, since the results from the previous part (Part 4.2.1) showed that Sylvaroad does not have a real effect on the moisture resistance of mixtures, the addition of anti-stripping additive is necessary to improve the moisture resistance of the mixtures with Sylvaroad. For this purpose, in this study Evotherm was chosen to add into the Sylvaroad mixtures as an anti-stripping additive to improve the moisture resistance. As shown by the results from the previous viscosity and moisture resistance tests, Evotherm not only increased the adhesion between aggregate and binder, but also reduced the viscosity of the binder. This was expected to help greatly improve the moisture resistance of Sylvaroad mixtures. For those reasons, the addition of Sylvaroad in the mixtures was reduced down to 1%, and the addition of Evotherm maintained at 0.5%. The reduction in Sylvaroad content was based on the expectation that the addition of Evotherm would reduce the viscosity of the binder, and thus would compensate for the reduction in the proportion of Sylvaroad.

For fatigue tests were carried out on beams with dimensions of 50 x 65 x 405 mm. The air void target of samples was 7 ± 0.5%. All the samples were subjected to a sinusoidal load with a frequency of 10 Hz and maximum strain amplitude of 400 microstrain at 20°C. At least three replicates were tested for each mixture. The fatigue test results, including the number of cycles to fatigue failure and the initial stiffness of mixture, are described in Figure 4.7. It can be seen that the WMA-S mixture performed best with regard to fatigue resistance. All the other WMA and WMA-RAP mixtures had significantly lower numbers of cycles to reach fatigue failure than HMA had. It can also be observed from Figure 4.7 that the increase in the RAP content enhanced the flexural stiffness, but reduced the number of cycles to fatigue failure for both Evotherm and Sylvaroad mixes. This indicates that RAP made WMA stiffer and more brittle.

5. RECOMMENDATION AND CONCLUSION:

Based on the outcomes of the study it is strongly recommended to

- Both Evotherm and Sylvaroad reduced the binder's viscosity and the reduction increased with the increase of additive content. In producing samples for the mechanical performance tests, Evotherm was added into the binder at a percentage of 0.5% by mass of the binder while Sylvaroad was added at 2%. The addition of Sylvaroad showed a greater reduction in viscosity than did Evotherm.
- The combination of Sylvaroad and Evotherm considerably improved the moisture resistance of WMA-RAP mixtures. All of them had TSR values equal to or higher than 80%.
- The addition of RAP stiffened the mixtures, improving the rutting resistance significantly, while reducing the fatigue resistance. This indicates that rutting is not a problem with WMA-RAP mixtures whereas fatigue still need more investigation and improvement. Sylvaroad mixtures showed better performance in fatigue resistance than Evotherm mixtures, while performing worse in rutting resistance.
- In this study, the addition of 0.5% Evotherm may not be sufficient and it is recommended that it be increased. With increasing RAP content, it is concluded that increasing the mixing temperatures, the binder content, or additive amounts are necessary to improve the mixtures' performance. Further study on the increase of the Evotherm proportion when increasing the RAP content is recommended.

- To maintain good fatigue resistance performance for mixtures with Evotherm, the maximum proportion of RAP into WMA is recommended to not exceed 50% by mass of the total mix if the binder is increased. For hot climates where rutting is the major failure type, while fatigue cracking is not a concern, the RAP portion can be increased to 70%.
- For Sylvaroad mixtures, RAP proportion can be added up to 70% if the moisture resistance of the mixture is satisfied and if the binder content is increased to maintain good fatigue resistance. The moisture resistance issue of Sylvaroad mixtures can be improved by combining Evotherm into the mixtures, and therefore an RAP proportion of 70% is possible.

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