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Foreign Technology and Performance Evaluation of Warm Mixture Asphalt

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Abstract: At the present, the asphalt pavement in road construction mostly adopts the traditional material HMA (Hot Mixture Asphalt). However the usage of HMA causes negative effects, including environment damage, excessive consumption of energy and so on. For these reasons, a new energy-saving and environment-protecting product WMA (Warm Mix Asphalt) is developed to fetch up the shortage of HMA.WMA is a kind of mix asphalt technology which can force asphalt to be mixed and compacted in comparatively low temperature by means of reducing its viscosity with the help of certain techniques. Meanwhile, it could maintain its performance which does not below that of HMA. In order to develop the warm mix asphalt and prompt the sustainable development of pavement, the existing characteristics of the warm asphalt mix are summed up, the principle of existing technologies and the state quo are analyzed. And it gives emphasis to a review on problems of warm mix asphalt in application. This paper introduces the technology and performance evaluation of WMA used in Europe by comparing with HMA, as well as the advantages and disadvantages of WMA and the problems to be solved.

Keywords: Road engineering; Asphalt pavement; Warm mixture asphalt; Technical performance; Evaluation

1. Introduction

Warm mix asphalt (WMA) is a new type of asphalt mixture. Its mixing and construction temperature is between HMA (150~ 180) and CMA (room temperature) due to specific technologies or additives, while the performance of WMA is as good as HMA. The discussion of lowering the heat used to produce asphalt mixes is not new. The idea of saving energy and lowering emissions in the asphalt industry has been discussed for decades[1]. At present hot mix asphalt(HMA)is the primary road surfacing material at the bituminous pavement.

WMA was first developed in Europe by Shell and Koloveidekke in 1995 and was used in a field test in 1996. Early in the development and use, WMA is the use of soft asphalt and emulsified asphalt to produce warm mix asphalt, although this produced WMA and HMA in performance can be comparable, but the production costs are higher than HMA20. To reduce costs, without reducing the performance of WMA, Shell and Kolo-veidekke began in 1998 with foam bitumen and asphalt to produce soft warm asphalt, and prepared for WMA, this kind of WMA was conducted a field comparison test with HMA in 1999. It was revealed WMA had a good performance after a year of spring and winter track observation. Therefore, WMA was first put forward by Shell and Kolo-veidekke at international conference Eurobitume 6-Euroasphah in 2000. Subsequently, Japan and European countries began to use WMA extensively. In 2001 the usage of WMA amounted to 8000t, 2002 grew to 15000t, 2003 reached up to 30000t. From the substantial increase in usage, we can see the very good development momentum of WMA.

2. Warm Mixture Asphalt Technologies

At present, there are 3 kinds of technology for producing warm mixture asphalt in European countries.

a). In the process of plant mixing, a synthetic zeolite called Aspha-M in will be added in cementing material to produce bubble effect.

b). Use a kind of cementing material called WMA-foam (warm mix the foam asphalt mixture) which can be divided into soft and hard types. Use the soft and hard binder at the different stages of the production respectively in plant.

c).Using additives such as Sasobit (Fischer—Tropsch paraffins) and Asphaltan B (E votherm, a low modulus of esterification wax)

2.1. Aspha-Min warm mix agent

Aspha-Min is made by German Ltd Eurovia-Services. It is a very fine, white powder synthetic zeolite (sodium silicate), and has been crystallized by hot liquid. The mass fraction of water inside the zeolite is 21, and is released at 85 ~ 182 °C. When the binder and Aspha-Min are added to the mixture at the same time, a very small water jet phenomenon is produced. The release of water can make the cement material volume become larger, which leads to the emergence of asphalt foam reaction which can increase the coverage of the material at a lower temperature.

Eurovia recommends the added Aspha-Min accounting for 0.3% of the mass percentage of the mixture, so HMA typical production temperature can be lowered 12 ℃. According to the report, lowering the temperature 12 ℃ can save 30% of fuel consumption. Eurovia said Aspha-Min can be added to all common bitumen and polymer modified bitumen, including recycled asphalt.

Aspha-Min can be added to the mineral filler or separate feed directly to the batch mixer.

The zeolite is a net silicate group, in which there is a huge space to accommodate the larger cations, such as sodium ion, potassium ion, barium ion, calcium ion, and even the relatively large molecules and cations group, such as water molecules. In the zeolite, the space is connected to each other, and it forms a variety of different length and width alleyway depending on the space types. These channels can make the ions and molecules more easily get in and out the zeolite. The most common use of zeolite is water softener. The characteristics of the zeolite are that they can absorb and loss water without destroying their crystalline structure. They can discharge the water in the structure by heating or other methods. Therefore, zeolite can be used as a new fluid transport system.

2.2. WAM-Foam warm mix agent

WAM-Foam is a joint venture product of the British Shell Oil Co.Ltd and Norway Kolo-Veidekke. In the WAM-foam, two cementing materials are used separately in mixing stages, soft and hard cementing material added in the form of foam, namely bituminous material of two different hardness. Penetration degree of the soft cementing material is larger, so can make it has a certain fluidity to facilitate uniform mixing with mineral aggregate and cover them. The minimum storage temperature should be controlled when placing soft material, mixture can be placed in 80 ℃ which reduces by 50~60 ℃ compared with HMA, hard binder is added in the form of foam asphalt.[2] According to the requirements of the road, penetration degree of hard asphalt should be between 10 ~ 100 (0. 1 mm) at 25 ℃.

According to the penetration degree of harmonic asphalt, determine the mixing ratio of soft and hard cementing material. If needed, anti-stripping agent can be added into the binder to reduce water damage.

In the first stage, blend the soft blinder and mineral aggregate mixture at about 100 ℃, initially covering mineral aggregate, mineral aggregate of heating temperature is 100 ~ 120 ℃. And then add hard binder in the foam and mix fully at 90~ 120 ℃. The combination of hard foam and soft binder achieves the desired final asphalt product composition and properties.

As for the mineral aggregate gradation, design of mix proportion, mixing equipment and so on of WMA, it can be fully referred to the related methods and regulations of HMA.

Shell pointed out that WAM-Foam requires a careful selection of the composition of the soft and hard binder. In the first stage of the mixing, the initial coating of the aggregate is essential for preventing the water from contacting the binder. The water must be discharged from the asphalt mixture to ensure the high quality of the product.

Shell reported that the use of WAM-foam leads to lower production temperature, which can save 30% of fuel and reduce 30% of the CO2 mission.

2.3. Sasobit warm mix agent

Sasobit is the product of South African company Sasol—Wax (Formerly SchumannSasol). Sasobit is considered as a modifier or "asphalt flow improver". It is a fine crystal, which can be present in the form of a sheet or powder. Fischer- Tropsch (FT) is long chain aliphatic hydrocarbons from coal gasification in the production process, also known as the F T solid paraffin.

Sasol- Wax noted that the melting point of Sasobit is about 99 ℃, and it can reduce the viscosity of asphalt binder at more than 116 ℃. This can reduce the temperature of production by 12 ℃. When the temperature is below the melting point, Sasobit will be in the form of a lattice structure which is the basis for the stability. At end-use temperature, the anti rutting ability of Sasobit modified asphalt is enhanced. In addition,Sasol-Wax reports that its compaction increased compared to non-modified bitumen in the same wheel loads.

Sasol-Wax suggests Sasobit should be added in an amount of 3% of mixture mass in order to lower the viscosity to meet the required standard, and should not exceed 4%, so as not to adversely affect the performance of the binders at low temperature. It is not recommended solid Sasobit directly mixed, because this can not be evenly distributed in the asphalt.

2.4. Asphaltan B

Asphaltan B is the product of German company Romonta-Gmbh, Amsdorf. It can be stored in granular. It is specially developed for asphalt concrete, which is a mixture of lignite wax and high molecular hydrocarbon.

Romonta pointed out that the proposed percentage of mass of added Asphaltan B is 2 %～4%. Romonta Asphaltan quality of the proposed B is 2% ~ 4%.It can be added to the asphalt mixer, or directly to the cementing material production machine, also can be added to the polymer modified cement. The melting point of Asphaltan B is about 99 ℃.Similar to the

sidered as "asphalt flow improver" which can reduce the production temperature. Like FT wax, the compaction and anti rut ability will be enhanced.

3. Laboratory Evaluation of Properties of Warm Mix Asphalt and Comparison with HMA

3.1. Laboratory evaluation of properties of warm mix asphalt

NCAT (National Asphalt Technology Center) tested the warm mix asphalt mixture in the laboratory, in order to determine the feasibility of these processes, the typical paving process and the performance of mixture in the most common environment which includes the fast transport section and high temperature environment.

The above-mentioned three kinds of warm mix technology are to improve the compaction capability of Superpave Gyratory Compactor and vibration Compactor, these technologies have reduced porosity. Adding Aspha-M, Sasobit and Evotherm additives did not affect the rebound modulus of asphalt mixture, and the results showed that there was no increase in the rut of asphalt pavement analyzer (APA).

The decrease of the mixing and compaction temperature did increase the amount of the rut, which due to the aging of asphalt at lower temperature .In the production of warm mix asphalt mixture, the lower compaction temperature may increase the possibility of water damage. The following conclusions are drawn as follows:

Whether using Superpave Gyratory Compactor or vibration, three kinds of warm mix technology have increased the degree of compaction, reducing porosity 0.77% on average with Alpha-Min method, Sasobit 0.89% and Evotherm 1.53%. With the three additive, compaction degree at 88 ℃ are improved.(Figure1).

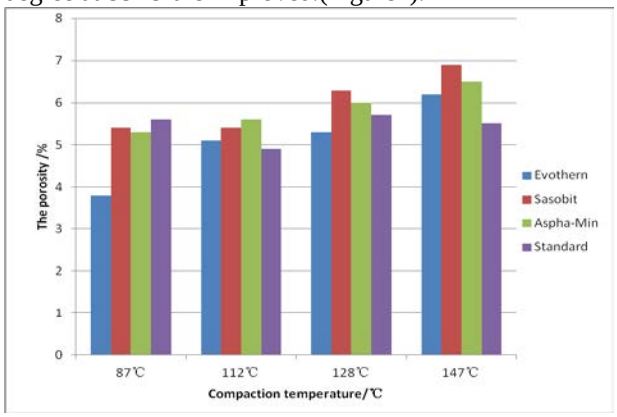

Figure 1. Comparison of compaction properties of 3 kinds of warm mix asphalt

Three kinds of additives (Aspha-Min, Sasobit and Evotherm) do not increase the rut of the mixture. The decrease of the mixing and compaction temperatures of the mixture increases the rutting rate, which may be due to the decrease of the aging the asphalt. However, when Sasobit is added to the mixture, the sensitivity of the rut is lower when temperature decreases (Figure 2).

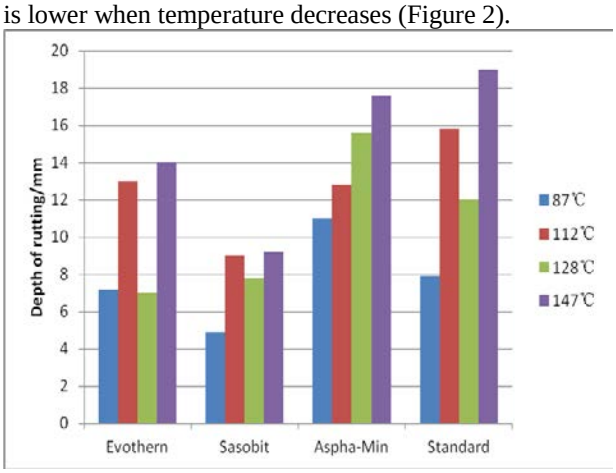

Figure 2. Depth of rutting (PG 64-22 granite)

The indirect tensile strength of the mixture made of Sasobit is lower, and the decrease of the tensile strength may be due to the ability of Sasobit to resist aging. Other lab tests show that the addition of Sasobit has a good ability to resist rutting.

In the production of warm mix asphalt mixture, lowering the compaction temperature may increase the possibility of water damage. Lower mixing and compaction temperature will lead to the collection not completely dry, the result is water damage.

Add a variety of anti stripping agent to reduce the water damage. Hydrated lime and zeolite are effective in the granite aggregate. Adding 1.5% hydrated lime can increase the binding capacity and the ability of resisting water damage with respect to the mixture without adding lime.

The results of the test show that the addition of Sasobit is helpful to the anti rutting ability and the ability of resisting water damage of warm mix asphalt. The results of the test of the Hamburg wheel shaft also show that adding lime to the warm mix asphalt with Aspha-Min can increase the anti rutting ability, because lime increases the strength of asphalt mixture.

4. The Advantages and Disadvantages of Warm Mix Asphalt Mixture

4.1. Advantages of warm mix asphalt

a) The results of the Superpave rotary compaction apparatus show that the warm mix asphalt can reduce the content of optimum asphalt.

b) Extend the construction period. Warm mix asphalt can be used as paving material of road surface in cold weather because the construction temperature of warm mix asphalt is 30 - 50 DEG C lower than HMA, do not have to worry about the loss of temperature in cold weather.

c)It can reduce production and construction temperature about 30 ~ 50 ℃, which can save about 20% energy.
Simplify asphalt means, saving investment.
d) Reducing the storage temperature, and thus easier for storing. This material flow-ability of the material is greater, so static roller can be used to get the required density, without using a vibratory roller.
e) Reducing emissions. Warm mix asphalt can greatly reduce the emissions of industrial plants compared with the traditional hot mix asphalt.
f) The durability of the pavement can be enhanced because the light source portion of the liquid asphalt in the mix will not be expelled by heating.
g) Can speed up the asphalt pavement construction.
h) The asphalt can be transported to a further distance, without worrying about the critical loss of temperature, which is helpful to the development of the market.
i) Reduce the aging of the asphalt in the hot mixing process, and prolong the life of the asphalt pavement, and at the same time, do not need to add new construction equipment.
j) Can improve pavement performance, easiness of mixing, paving and compaction.

4.2. Disadvantages of warm mix asphalt

a) For the foreseeable future, the advantages of warm mix asphalt technology can be achieved only through the proprietary products, and may lead to additional charges.
b) Some techniques have improved the rut sensitivity.
c) Due to the weakening of the aging of the cementing material, the rut increases with the decrease of the temperature.
d) Lower production temperature may increase the likelihood of wet damage because the aggregate is not completely dry. One technique may increase the humidity sensitivity.
e) A number of processes or additives are required to improve plant equipment or production conditions. Fuel saving can not fully compensate for the increase of costs.

5. Conclusion

Compared with hot mix asphalt (HMA), warm mix asphalt (WMA), which reduces the mixing and compaction temperatures and energy consumption and emissions, while maintaining the quality of HMA, is a new energy-saving and environment-friendly paving material, with a broad prospect[3].
Although there are still some unresolved issues in the use of warm mix asphalt mixture, warm mix asphalt is widely used in Europe because of the advantages of WMA.
In the United States, warm mix asphalt has gradually attracted the attention of various aspects. Taking the NCAT as the center, H W A N, A P A F and some other research machines are involved.
In China, the research and application of warm mix asphalt mixture is relatively small. Warm mix asphalt mixture is consistent with China's development of green and sustainable way. With the gradual perfection of the technology, its superiority will gradually come out, and has a broad application prospect. Of course, WMA is a new type of hybrid material, which inevitably has many technical and application problems, such as choosing the technical standard of soft and hard asphalt, how to determine the appropriate proportion of soft and hard asphalt to prepare mixed asphalt, the micro analysis of asphalt mixture, the performance of asphalt mixture, the selection of asphalt grade and so on.

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