

Performance Evaluation of the Hot and Warm Stone Mastic Asphalt Mixture

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Abstract. Warm Mix Asphalt is a new type of asphalt mixture which can reduce the mixing temperature and emissions. A kind of warm agent (LRT) is chosen in this study. Hot and warm mix asphalt mixture were designed and their high temperature, low temperature, moisture sensitivity and fatigue pavement performance were evaluated. The test results show that HMA is slightly better in moisture resistance while WMA is slightly better in rutting and cold cracking resistance. About 30°C reduction in mixing temperature can be achieved by using LRT, which resulted in a significant reduction in fuel consumption and exhaust emission.

Introduction

Traditional HMA asphalt needs to be heated to 150°C~180°C, and aggregate needs to be heated to 170°C~190°C, heating up to such a high temperature need to consume a lot of energy, in the production and construction process will produce a lot of waste gas and dust, will cause serious environmental pollution[1]. WMA is a kind of green environmental protection of asphalt mixture production technology, this technology was first developed in 1995 by Shell and Kolo-veidekke. Relative to traditional HMA, WMA production and compaction temperature will be reduced by about 30°C, and mixture workability and road performance can be comparable with HMA, which not only reduces resource consumption but also reduces environmental pollution[2].

At present, there are many kinds of warm mix asphalt mixture, and the technology is mainly the following: Aspha-Min®, WAM-Foam®, Viscosity and Drag Reducer, based on Asphalt Emulsion, LEA, Sulphur Modified Asphalt. In this paper, WMA is achieved by adding a viscosity and drag reducer (LRT) in asphalt mixture. SMA-13 asphalt mixture was used to analyze the road performance of HMA and WMA[3,4].

Performance of WMA

The warm mix agent in this paper is called LRT which is a kind of viscous liquid. It can't dissolve in water but can dissolve in alcohol and aromatic hydrocarbon. The warm mix agent LRT is also a kind of surface active agent[5]. It can reduce the resistance during mixing between asphalt and aggregates. Thus, it can reduce the mixing and compaction temperature[6]. The content of LTR is so less that it could be only 0.2%~0.5% weight of asphalt. It is easy to add in asphalt and can simplify the production process and avoid equipment modification. Therefore, using of LTR can greatly facilitate the production of asphalt mixtures in factory. LRT has little influence on the physical and chemical properties of asphalt. The warm mix asphalt can be stably stored 7 days or more[7]. It greatly increases the flexibility and convenience. It can maintain the physical and mechanical properties the same as traditional hot mix asphalt well[8].

LTR can't easily dispersed in asphalt because of its viscous state. In order to ensure the full integration between LTR and SBS modified asphalt, SBS modified asphalt should be heated up to about 150°C and processed about 20min with high-speed cutting machine after LRT added.

Hot mix asphalt in this paper is SBS modified asphalt. Warm mix asphalt is prepared by adding warm mix agent. Some properties index is shown in Table 1.

Table 1 Performance index of SBS modified asphalt

Test item	HMA	WMA	Technical requirements of modified asphalt	Method
Penetration [25°C,100g,5s,0.1mm]	60	61	30~60	T0604-2011
Ductility[5°C,cm]	40	39	≥30	T0605-2011
Softening point[°C]	80	85	≥55	T0606-2011
Brookfield Viscosity[135°C,Pa·s]	2.18	1.03	≤3	T0625-2011

Mix Design

The raw materials of SMA asphalt mixture include coarse and fine aggregate, asphalt and fiber, and the performance indexes meet the requirements of the regulations. Related technical indicators of asphalt have been listed in the previous paper, Fiber selection of loose wood cellulose, its performance indexes are show in Table 2.

Table 2 Fiber performance index

Index	Unit	Test results	Technical requirements
Ash content	%	20.1	18±5, No volatiles
PH	--	7.5	7.5±1.0
Oil absorption	%	5.0	5.0±1.0 times of fiber quality
Water content	%	3.0	<5%(quality)

In this paper, SMA-13 asphalt mixture was used to mix proportion design. Three kinds of gradation are chosen as the test grade, through the comparison of the performance, final, chosen the gradation 2 as the mix design. asphalt mixture ratio and gradation curve are shown in Fig. 1.

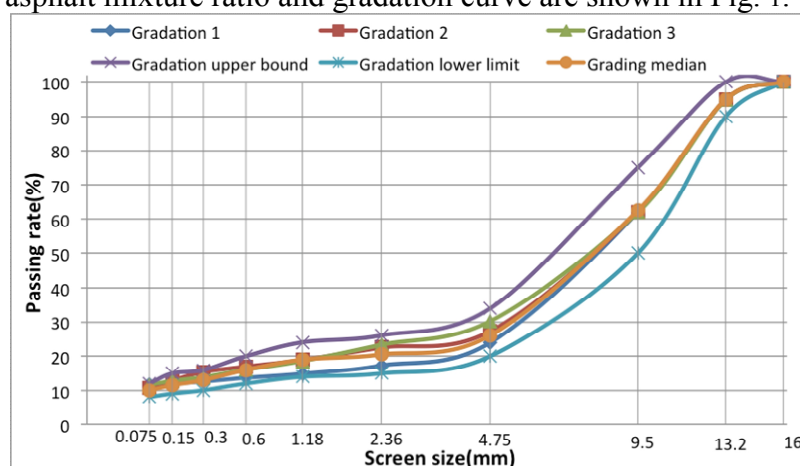


Fig. 1 Grading curve

In this paper, Marshall design method used to determine the optimum asphalt aggregate ratio, Asphalt dosage was determined to be 6.2%. In this asphalt content, asphalt mixture void ratio is 4.1%, the performance indexes meet the requirements of specification.

Pavement Performance of HMA and WMA

In this paper, the high temperature stability, water stability, low temperature crack resistance and fatigue performance of hot and warm SMA-13 asphalt mixture was compared and analyzed.

High temperature stability. To detection the ability of rutting resistance performance of asphalt mixture, in this paper, we choose the method of T 0719-2011 to test the high temperature stability of asphalt mixture, the results are shown in 3.

Table 3 High temperature stability

Type	Asphalt	Compaction temperature[°C]	DS[times/mm]	Method
HMA SMA-13	SBS modified asphalt	170	8630	T 0719-2011
WMA SMA-13	warm asphalt	140	9066	T 0719-2011

Water stability. To detection the ability of water stability of asphalt mixture, in this paper, we choose the method of T 0709-2011 and T 0729-2000 to test the water stability of asphalt mixture, the results are shown in Table 4 and Table 5.

Table 4 Water immersion performance of Marshall

Type	Asphalt	Compaction temperature[°C]	MS' ₀ [%]	Method
HMA SMA-13	SBS modified asphalt	170	92.5	T 0709-2011
WMA SMA-13	warm asphalt	140	85.4	T 0709-2011

Table 5 Performance of freezing and thawing

Type	Asphalt	Compaction temperature[°C]	TSR[%]	Method
HMA SMA-13	SBS modified asphalt	170	91.8	T 0729-2000
WMA SMA-13	warm asphalt	140	88.5	T 0729-2000

Low-temperature crack resistance. To evaluate low-temperature crack resistance, in this paper, we use the UTM-25 reference the test method of T0715-2011.

Test temperature: $-10^{\circ}\text{C} \pm 0.5^{\circ}\text{C}$; *Loading Speed:* 50mm/min.

Molding Methods: Roller compactor and cut beams. *Size:* 30mm*35mm*250mm. Put test specimen in the cryostat to -10°C over 3h before test. The results are shown in Table 6.

Table 6 Low-temperature crack resistance

Type	Asphalt	Compaction temperature[°C]	Failure strain[%]	Method
HMA SMA-13	SBS modified asphalt	170	2878	T 0715-2011
WMA SMA-13	warm asphalt	140	6157	T 0715-2011

Fatigue performance. To evaluate fatigue performance, in this paper, we use the UTM-25 reference the test method of T0739-2011.

Control modes: stress control ; *Temperature:* $15 \pm 1^{\circ}\text{C}$; *Loading wave:* Continuous haversine loading 10Hz; *Stress ratio:* 0.4、0.5、0.6、0.7.

Molding Methods: Shear compaction and cut beams. *Size:* 40mm*40mm*250mm. Test pieces of damage as the standard of fatigue damage. The results are shown in Table 7

Table 7 Fatigue performance

Type	Failure load [KN]	Bend strength [MPa]	Stress ratio and average no. of fatigue effects [%]				Fatigue equation and correlation coefficient
HMA SMA-13	1.44	6.75	0.4	0.5	0.6	0.7	$y = -3.87x + 5.73$ $R^2 = 0.9648$
WMA SMA-13	0.81	3.82	0.4	0.5	0.6	0.7	$y = -2.98x + 5.59$ $R^2 = 0.9778$

Through the above performance indicators can be seen that water damage resistance of HMA is slightly better than WMA, but the high temperature stability and low temperature cracking resistance of WMA is slightly better than HMA, and the fatigue property of WMA is obviously higher than that HMA.

Summary

The conclusions are got the study of performance evaluation and comparison of hot and warm stone mastic asphalt in this paper as following:

- (1) LTR as a surface action agent use in this study, it could reduce the temperature of asphalt mixture in mixing and compacting, by reducing asphalt and aggregate mixture resistance. The compaction temperature of WMA is 140°C, about 30°C reduction comparison with HMA, which resulted in a significant reduction in fuel consumption and exhaust emission;
- (2) The performance indicators satisfy the need of Technical Requirement Manual of Hot Stone Mastic Asphalt Mixture;
- (3) Comparison with HMA, WMA water stability is of relatively lower, rutting and cold cracking resistance is of relatively better, the fatigue performance is apparently higher.

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