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Experimental Study on the Influence of the Superpave and Marshall Design Methods on the Pavement Performance of Asphalt Mixtures

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Abstract

Surface course is an important constituent part of highway pavement structures with complex stress conditions. These conditions result in difficulty for the traditional mix proportion design method to simulate actual situation in asphalt mixture production and construction. In order to conform the actual load bearing situation of highway asphalt pavement mixtures, the study proposed to use Superpave method to design the mix ratio of asphalt mixture, and compared the pavement performance of SMA and AC asphalt mixtures designed by Marshall design method. By Marshall compaction test of three types of asphalt mixtures designed by two mix proportion design methods, the optimal asphalt-aggregate ratios of SMA-16, Superpave-16, and AC-16I were determined. Thereafter, according to the current standard test method, the immersion Marshall test, low temperature bending test, 60 °C rutting test and indirect tensile fatigue test were carried out on three types of asphalt mixtures, and analyzed the pavement performance test results comparatively. On this basis, the related factors affecting the pavement performance of the three asphalt mixtures were analyzed. Test results show that, the optimal asphalt-aggregate ratio of SMA-16 is considerably higher than those of Superpave-16 and AC-16I, indicating that the greater the amount of fine aggregate, the higher the asphalt content. Pavement performance test results manifest the significantly better high-temperature stability and skid resistance of SMA-16 and Superpave-16 than AC-16I, which can lengthen the service life of highway asphalt pavements. The conclusions provide a significant theoretical reference for applying the Superpave design method to the mix proportion design of asphalt mixtures.

Keywords: Superpave design method, Marshall design method, Asphalt mixture, Dense-graded asphalt mixture, Pavement performance

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1. Introduction

The pavement performance of surface course, which is an important constituent part of highway pavement structures, is the precondition ensuring the normal service of highways. Surface course materials applied to high-grade highways are supposed to have excellent stability and sufficient skid resistance. Moreover, partial load is directly borne by the strength of the surface course under a strong load action. The asphalt mixture surface course has been applied to numerous high-grade highways by virtue of good riding comfort and wear resistance. A good mix proportion design serves as an important condition for guaranteeing the pavement performance of asphalt mixtures, thereby ensuring the pavement performance of the asphalt mixture surface course. The key to a good mix proportion design lies in a reasonable mix proportion design method, which directly affects the pavement performance and durability of asphalt mixture surface courses. To achieve a good mix proportion design of asphalt mixtures and maintain the good pavement performance of pavement structures under a strong load action, adopting an asphalt mixture featured with reasonable mix proportion design and good stability, durability, and skid resistance will be crucial for lengthening the service life of high-grade highway pavements.

Compared with the cement concrete surface course, multiple mix proportion design methods are applied to asphalt mixtures, with varied corresponding gradation types. Studies conducted by numerous scholars on the mix proportion design method of asphalt mixtures have mainly focused on the Bailey, GTM, and Marshall design methods. Asphalt mixtures designed through these commonly used mix proportion design methods have presented good gradation and specific compression resistance. However, in practical engineering highway asphalt surface courses have strict requirements for stability, fatigue durability, and skid and wear resistance. In addition, the construction environment is affected by on-site temperature factors, and the construction process is complicated, thereby affecting the substantial promotion and application of asphalt mixtures. For example, the Bailey design method evaluates the aggregate gradation based on the filling characteristics of the aggregate to assess whether or not the aggregate skeleton performance is good. However, this method can hardly be applied in practical engineering owing to its strong theoretical property [1,2]. The GTM design method determines the optimal aggregate–aggregate ratio by controlling the linear plastic deformation and shear strength of asphalt mixtures, which is approximate to the change state of the mixture during the paving and rolling process of asphalt pavements; however, the durability, aging resistance, construction, and workability of asphalt mixtures are not considered [3,4]. The Marshall mix proportion design method, which is the most commonly used mix proportion design method for asphalt mixtures, can yield asphalt mixtures with compact mixture structure, small porosity, and

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good water stability; however, it is accompanied by poor high-temperature stability, skid and wear resistance, and rut resistance [5-8].

To eliminate the deficiencies of the aforementioned mix proportion design methods, the existing mix proportion design methods of asphalt mixtures should be improved. Evidently, there is difficulty in simulating the actual status during the production and construction of asphalt mixtures if the mix proportion design is implemented using the preceding methods, thereby possibly causing poor pavement performance. Hence, this study recommended the Superpave design method to conduct the mix proportion design of asphalt mixtures and to explore their pavement performance.

2. State of the art

Owing to the different compositions of asphalt mixtures and the types of additives, there are many gradation types and design methods, and their pavement performance has advantages and disadvantages. To date, many scholars have conducted extensive research on the pavement performance of asphalt mixtures using indoor tests and finite element methods, and given some design methods of asphalt mixtures suitable for engineering practice. However, these studies have mainly concentrated on improving pavement performance by adding additives to asphalt mixtures. R. Ramin et al. [9] evaluated the low-temperature performance of asphalt mixtures at different ambient temperatures using four-point bending beam fatigue and semi-circular bending tests. The results show that the fatigue life of asphalt mixture is more affected by the density of asphalt mortar at a lower strain level. L. Guo et al. [10] prepared POE/PA6 modifier with enhanced reactivity using the twin-screw extrusion granulation process and added it to the asphalt mixture. The effects of the POE/PA6 modifier on high-temperature stability, low temperature crack resistance, and water stability of asphalt mixture were studied. The results indicate that the rutting resistance, maximum bending strain, and water stability of asphalt mixture adulterated with POE/PA6 are significantly improved. F. M. Navarro et al. [11] explored the improvement of the mechanical properties of high-modulus asphalt mixture by acrylic fiber in harsh environmental conditions. Thermal stress restrained sample, immersion rutting, freeze–thaw sensitivity, and UGR-FACT fatigue asphalt cracking tests were conducted under different working conditions. The results show that the mechanical behavior of high-modulus asphalt mixture is improved by using acrylic fiber. G. Tacettin et al. [12] investigated the influence of biomass waste—limed oak—on the mechanical properties (OA) of hot mix asphalt (HMA) mixture and evaluated its usability in road engineering. The test results show that the OA additive can improve the mechanical properties of asphalt mixture, effectively improve the ability of pavement to resist deterioration, and reduce the cost of road maintenance. In the preceding research, adding chemical additives is one of the most direct and effective ways to improve the pavement performance of asphalt mixture. However, after chemical additives are added, the environment around road construction may be relatively affected. Moreover, such chemical additives can only improve pavement performance in one aspect and there is difficulty in comprehensively improving the pavement performance of asphalt mixtures.

To avoid the influence of chemical additives on the environment and improve the pavement performance of asphalt mixture in an all-round manner, P. Cong et al. [13] studied the influence of asphalt types on the pavement performance of asphalt mixtures. G. Gribulis et al. [14] analyzed the production processes, advantages, and disadvantages of different asphalt mixtures and indoor test results, and provided the effects of different types of warm-mix asphalt mixtures in experimental road sections. B. MarcAndré et al. [15] explored the effects of laboratory mixer types (i.e., three different mixer types) and mixing times (i.e., four different mixing time) on HMA. The results show that the performance of HMA is significantly influenced by the mix type and time (volume characteristics and compressibility) and the type of mixer used (rigidity and crack resistance). T. Takaikaew et al. [16] evaluated the pavement performance of the mixture of 70# pavement petroleum asphalt (AC60/70), natural rubber-modified asphalt (NRMA), and polymer-modified asphalt (PMA) via such indoor tests as Marshall stability (MS), indirect tensile strength (ITS), resilient modulus (MR), and indirect tensile stiffness modulus (ITSM). The results reveal that the pavement performance of the PMA mixture is evidently superior to that of AC60/70 and NRMA. S. Liu et al. [17] selected Buton rock asphalt (BRA) to modify the Superpave mixture and evaluated its performance. The results reflect that compared with the conventional Superpave mixture, BRA-modified Superpave mixture exhibits improved high-temperature and water stabilities. However, low-temperature crack resistance declined slightly. M. Kozel et al. [18] improved the fatigue resistance and rutting resistance of asphalt mixtures using styrene–butadiene–styrene (SBS) polymer (containing polystyrene and polybutadiene compounds) at a specific low proportion. However, they did not perform life cycle analysis of pavements with unmodified, low-proportion modified SBS, and standard PMB binder courses. The results reveal that if the binder course is modified using 3% SBS polymer, then the rut parameter—pavement service life—can be lengthened by about 34.5%, with CO_2 and SO_2 emissions reduced by 9% and NOx emission reduced by 7.2% within 20 years.

In addition to adding chemical additives and using modified asphalt, the pavement performance of asphalt mixture can be improved by changing the gradation and mineral aggregate types. Z. Peyman et al. [19] used calcium carbide residue (CCR) as filler to improve the pavement performance of SMA and evaluated specimens through MS and ITS. The results show that if CCR is used as filler in SMA, then it can enhance the engineering performance of the pavement and reduce the production cost and environmental problems induced by asphalt mixtures. W. Cao et al. [20] compared the performance of three SMA mixtures: basalt coarse–fine aggregate, limestone coarse–fine aggregate, and basalt coarse aggregate–limestone fine aggregate. The results indicate that the rutting resistance of SMA mixtures is significantly affected by the aggregate type, but no significant differences are observed in the low-temperature cracking and water sensitivities between SMA mixtures. D. M. Mrawira et al. [21] studied the dynamic modulus, fatigue performance, and static creep of Superpave mixtures with 10 different gradation types. The results show that the resilient modulus is highly correlated with ITS, and the gradation type significantly affects the tensile strength ratio of asphalt mixtures. I. D. Sulaiman et al. [22] conducted the mix proportion design of asphalt mixtures through the Bailey method and substantially analyzed the influence of aggregate gradation on the mechanical properties of asphalt mixtures. In addition, they evaluated the pavement performance of asphalt mixtures through the traditional Marshall method. The results indicate that the asphalt mixture formed using the Bailey method exhibits better stability than that formed using the Marshall method.

Given that chemical additives can only improve the partial pavement performance of asphalt mixtures, asphalt modification is difficult, and the existing mix proportion design methods have difficulty in characterizing the actual status of asphalt mixtures. The current study proposed to perform the mix proportion design of asphalt mixtures using the Superpave design method, thereby enhancing the pavement performance of asphalt mixtures. On this basis, pavement performance was compared with those of the SMA and AC asphalt mixtures designed using the Marshall design method. Thereafter, the pavement performance of three types of asphalt mixtures was explored through immersion Marshall, low-temperature bending, 60 °C rutting, and indirect tensile fatigue tests. In addition, the reasons for the differences in pavement performance were discussed according to the differences and similarities between the different mix proportion design methods of asphalt mixtures. Hence, a theoretical basis is provided for applying the Superpave design method to the mix proportion design of asphalt mixtures.

The remainder of this study is organized as follows. Section III presents the testing method, physical and mechanical properties of raw materials, and gradation compositions of the AC-16I, SMA-16, and Superpave-16 asphalt mixtures. Section IV analyzes such test results as the optimal asphalt–aggregate ratio, water stability, low-temperature crack resistance, and high-temperature stability of the three types of asphalt mixtures. In addition, this section investigates the effects of the mix proportion design method on the pavement performance of asphalt mixtures. Lastly, Section V summarizes the entire research and draws relevant conclusions.

3. Methodology

3.1 Testing material

3.1.1 Immersion Marshall test

Two groups of standard Marshall specimens were fabricated through the Marshall compaction method, with at least 4 specimens in each group. Thermostatic water bath was regulated to 60 °C, heat preservation was performed for 30–40 min in one group and for 48 h in another group, and the Marshall stabilities of the specimens in the two groups were determined. The calculation formula for the residual stability of the immersion Marshall test is as follows:

$$MS_0 = \frac{MS_1}{MS} \times 100 \tag{1}$$

where MS_0 is the residual stability of the specimens (%), MS_1 is the stability after heat preservation of the specimens for 48 h (kN), and MS is the standard Marshall stability of the specimens (kN).

3.1.2 Low-temperature bending test

Bending strain energy density was measured using the low-temperature bending test, and the low-temperature crack resistance of the three types of asphalt mixtures was evaluated. The test specimen was formed using the wheel grinding method and cut into asphalt mixture beam specimens with the following dimensions: 30 mm × 35 mm × 250 mm. Test temperature was 0 °C, and the constant loading rate was 50 mm/min. The bending strength and maximum bending strain data of the test specimen were fitted and analyzed. The calculation formula for the bending strain energy density is as follows:

$$\frac{dW}{dV} = \int_0^{\varepsilon_{ij}} \sigma_{ij} d\varepsilon_{ij} \tag{2}$$

where $\frac{dW}{dV}$ is the strain energy density function, σ_{ij} is the stress component, and ε_{ij} is the strain component.

3.1.3 60 °C rutting test

The index to evaluate the high-temperature stability of asphalt mixture is dynamic stability, which is measured using the rutting test at 60 °C. The dimensions of the specimen used in the rutting test were 300 mm × 300 mm × 50 mm, and the specimen was formed by rolling with a wheel mill and cooled thereafter. After heat preservation in the rut meter at 60 °C for 6 h, test was performed under standard conditions: load of 0.7 MPa and rate of 42 times/min. The calculation formula for the dynamic stability is as follows:

$$DS = \frac{(t_2 - t_1) \times N}{d_2 - d_1} \times C_1 \times C_2 \tag{3}$$

where DS is the dynamic stability of asphalt mixture (times/mm), d_1 is the deformation at corresponding time t_1 (mm), d_2 is the deformation at corresponding time t_2 (mm), N is the to-and-fro rolling speed of the test wheel, generally being 42 times/mm, C_1 is the correction coefficient for the tester type, and C_2 is the coefficient for specimens, the value of C_1 and C_2 in this test is 1.0.

3.1.4 Indirect tensile fatigue test

Fatigue life of three types of asphalt mixtures was measured using the indirect tensile fatigue test, and their fatigue durability was evaluated. The fatigue criterion of a single asphalt mixture was obtained from the test of specimens. Taking the logarithm of initial strain as the independent variable and the logarithm of fatigue life as the dependent variable, the fatigue equation is as follows:

$$\lg(N_f) = k + n * \lg(\varepsilon_0) \tag{4}$$

$$N_f = k * (\frac{1}{\varepsilon_0})^n \tag{5}$$

where N_f is the number of loading times (times), ε_0 is the tensile strain in the center of the specimen, and k, n is the constants related to the material.

3.1.5 Skid resistance test

Skid resistance of the three types of asphalt mixtures was evaluated by using a 1/3-scale small pavement accelerated loading test system. The 1/3 small-scale accelerated loading test system simulates pavement rolling by real vehicles under different loads and different environmental conditions at a proportion of 1/3. The objective is to simulate the state of the vehicle wheels under a real road surface condition in a long-term traffic scene, as shown in Fig. 1. According to the gradation composition of the three types of asphalt mixtures, the plate specimens (2.8 m × 0.9 m × 0.3 m) were formed by a super-large wheel rolling forming machine. During the test, tire pressure was 750 kPa, tire load was 2.4 kN, running speed of the test wheel was 2.1 m/s, and total number of action times was set to 200,000. After the number of action times was completed, the pendulum value and texture depth of each specimen were measured.

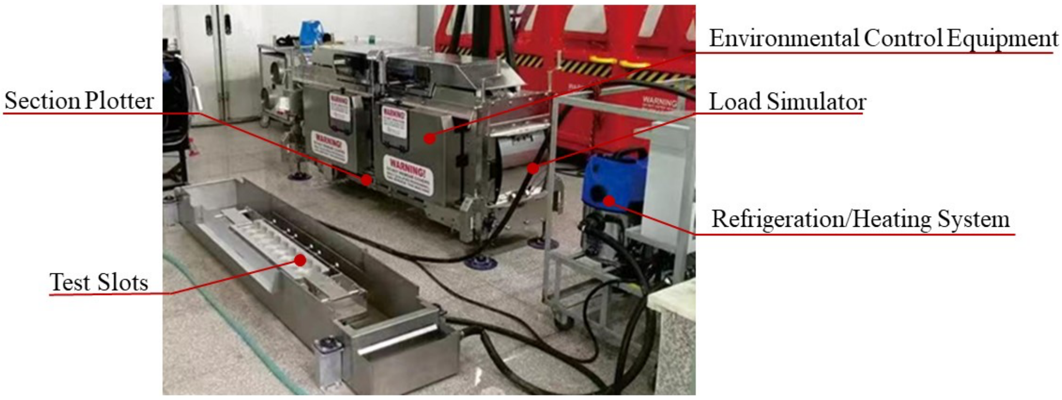


Fig. 1. A 1/3 small-scale pavement MLS accelerated loading test system

3.2 Test materials

3.2.1 Asphalt

Panjin heavy traffic road petroleum asphalt AH-90 was adopted. Its performance indicators are listed in Table 1.

Table 1. Asphalt performance indicators

Projects		Per-unit	Indicators
Degree of needle into（25℃）		0.01mm	91
Soften point		℃	47.2
Degree of postpone（25℃）		cm	＞100
Density（25℃）		g/cm^3	1.0203
Wax content		%	2.2
Mass loss		%	0.003
Film-heating test（163℃ , 5h）	Penetration ratio	%	65.3
	Degree of postpone（25℃）	cm	＞100
	$T_{1,2}$	℃	-18.4
	T_{800}	℃	48.6

3.2.2 Aggregate

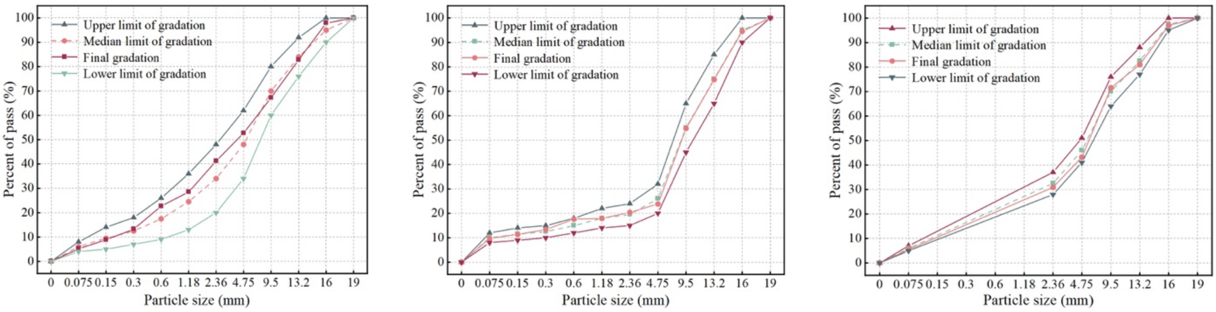
Limestone produced in Shaanxi was used as the aggregate, and the mineral powder was ground from limestone. The performance indicators are shown in Table 2.

Table 2. Physical property indicators of aggregate

Material	Projects	Per-unit	Indicators
Aggregate	Density	g/cm^3	2.7214
	Crush value	%	19.2
	Los Angeles wear value	%	24.3
	Needle sheet content	%	9.1
	Burnish value（BPN）	/	61
	Impact value	/	22.7
Mineral powder	Density	g/cm^3	2.6897
	Hydrophilic coefficient	/	0.7568

3.3 Gradation composition

Three types of medium-grained asphalt mixtures, namely, AC-16I, SMA-16, and Superpave-16, were adopted, graded with the median gradation as the target, and mixed systematically. The gradation composition is shown in Fig. 2.



(a) (b) (c)

Fig. 2. Gradation composition diagram. (a) AC-16I. (b) SMA-16. (c) Superpave-16

4. Result analysis and discussion

4.1 Marshall stability

The optimal asphalt–aggregate ratio of AC-16I, SMA-16, and Superpave-16 is determined through the Marshall compaction test. The test results are listed in Table 3.

As shown in Table 3, the optimum asphalt–aggregate ratio of SMA-16 is significantly higher than that of AC-16I and Superpave-16, and the Marshall stability of AC-16I is the highest, followed by SMA-16 and Superpave-16. At present, AC asphalt mixture is widely used in highway engineering, belongs to a typical suspended-compact structure, and with a large amount of dense asphalt mortar manifested in the relatively high Marshall stability in mechanical properties. Superpave-16 is a skeleton-void structure with high coarse aggregate content, along with the declining corresponding proportion of asphalt mortar, low cohesion, and large internal friction resistance. Hence, its Marshall stability is lower than that of AC-16I and SMA-16. However, gap grading is adopted for stone matrix asphalt, which was a skeleton-compact structure with high coarse aggregate content, low content of medium-sized aggregate, and high fine aggregate content, filling the entire skeleton void. Therefore, the overall structural compactness of SMA-16 is high, along with relatively high cohesion and internal friction resistance. Hence, the Marshall stability of SMA-16 is between AC-16I and Superpave-16.

Table 3. Marshall test of asphalt mixtures

Projects	**Per-unit**	**Grading type**		
		AC-16I	**SMA-16**	**Superpave-16**
Optimum asphalt-aggregate ratio	%	4.7	5.6	4.7
Marshall stability	kN	9.35	8.0	7.79
Voids in mineral aggregate	%	13.85	17.89	16.28
Flow value	0.1mm	30.1	38.2	39.8
Voids filled with asphalt	%	79.0	81.0	74.6
Density	g/cm^3	2.4820	2.5108	2.4187
Air voids	%	3.89	3.2	3.56

4.2 Water stability
The water stability of asphalt mixtures is expressed by the Marshall residual stability. The Marshall residual stabilities of the AC-16I, SMA-16, and Superpave-16 asphalt mixtures are shown in Table 4.

Table 4. Water stabilities of asphalt mixtures

Type	**AC-16I**	**SMA-16**	**Superpave-16**
Marshall residual stability (%)	82	73.6	87

Table 4 shows that Superpave-16 has the best water stability, followed by AC-16I and SMA-16. The water stability of the asphalt mixture generally depend on the adhesion between asphalt and aggregate and the mortar filling effect of fine aggregate. The better the adhesion between asphalt and aggregate and the mortar filling effect of fine aggregate, the better the water stability. Under consistent asphalt and aggregate, water stability is highly correlated with the residual void ratio (VV). VV of AC-16I, SMA-16, and Superpave-16 are 3.89%, 3.2%, and 3.56%, respectively. Therefore, SMA-16 and Superpave-16 show relatively high coarse aggregate content, and their fine aggregate mortar compactly fill in the gaps of the coarse aggregate. Thus, VV is small, and the corresponding water stability is good.

4.3 Low-temperature crack resistance
The 0 ℃ bending strain energy density of AC-16I, SMA-16, and Superpave-16 are determined by low temperature bending test. The test results are presented in Table 5.

Table 5. Asphalt mixtures' 0 ℃ bending strain energy densities

Type	**AC-16I**	**SMA-16**	**Superpave-16**
0 ℃ bending strain energy density (kJ/m^3)	60	84	40

Table 5 shows that the low-temperature crack resistance of asphalt mixture is as follows: Superpave-16, AC-16I, and SMA-16. The aggregate of the Superpave-16 asphalt mixture is "coarsened," but the asphalt content is similar to AC-16I. The result is its high low-temperature stiffness, thereby relatively affecting its low-temperature crack resistance, and its bending strain energy density at 0 ℃ is low. However, although the content of coarse aggregate in the SMA-16 asphalt mixture is high, the content of asphalt and mineral powder is correspondingly high, forming dense asphalt mortar, which can provide good low-temperature ductility in low-temperature environment. Therefore, the SMA-16 asphalt mixture has good low-temperature crack resistance.

4.4 High-temperature stability
The dynamic stability of AC-16I, SMA-16, and Superpave-16 is determined by 60 ℃ rutting test. The test results are presented in Table 6.

Table 6. Dynamic stabilities of the asphalt mixtures

Type	**AC-16I**	**SMA-16**	**Superpave-16**
Dynamic stability (times/mm)	813	1581	877

Table 6 shows that the dynamic stability of asphalt mixtures is sorted as SMA-16 > Superpave-16 > AC-16I. The high-temperature rutting resistance of asphalt mixture is affected by aggregate gradation and asphalt performance. In a high-temperature environment, asphalt mortar becomes soft, and resistance to permanent deformation caused by traffic load mainly depends on aggregate gradation. The coarse aggregate of dense-graded asphalt mixture is suspended in fine aggregate asphalt mortar, and the rutting resistance is significantly affected by temperature. Hence, dynamic stability is not high. With the increase of coarse aggregate content in Superpave-16, coarse aggregates are embedded and locked with each other. Eventually, a spatial skeleton structure is formed, thereby effectively improving the plastic deformation resistance of the Superpave-16 asphalt mixture under traffic load (i.e., improved the high-temperature stability of the asphalt mixture). The content of coarse aggregate above 4.75 mm in SMA-16 is as high as 75%, which is higher than that in Superpave-16. Coarse aggregates are embedded and locked with each other, forming a skeleton-compact structure. Fine aggregate asphalt mortar plays a role in filling the gaps of the coarse aggregate and minimally affects the high-temperature rutting resistance. Thus, SMA-16 asphalt mixture achieves the best high-temperature stability.

4.5 Fatigue durability
The fatigue durability test results of AC-16I, SMA-16, and Superpave-16 are presented in Fig. 3 and Table 7.

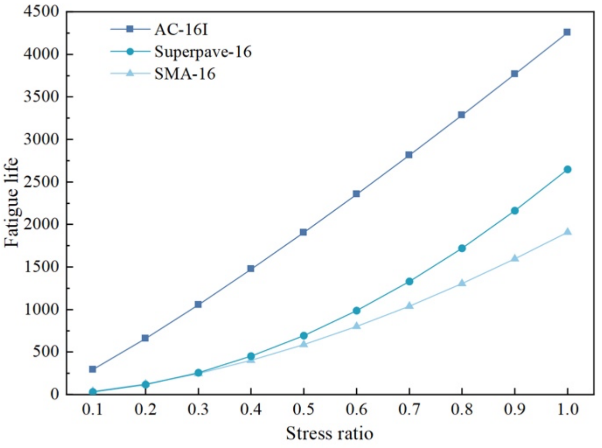


Fig. 3. Fatigue test results of the three asphalt mixtures

Table 7. Fitted equations of the asphalt mixture fatigue test

Type	Fitted equations
AC-16I	$N_f = 4256.2(\frac{1}{\sigma})^{-1.1595}$ $K = 4256.2$ $n = 1.1595$ $R^2 = 0.9731$
SMA-16	$N_f = 1908.5(\frac{1}{\sigma})^{-1.7013}$ $K = 1908.5$ $n = 1.7013$ $R^2 = 0.9875$
Superpave-16	$N_f = 2648.9(\frac{1}{\sigma})^{-1.9341}$ $K = 2648.9$ $n = 1.9431$ $R^2 = 0.9442$

Table 7 indicates that SMA-16 and AC-16I show good fatigue durability, both of which are higher than that of Superpave-16. The asphalt mortar content is high in the SMA asphalt mixture, which fully fills in the gaps between coarse aggregates, and the void ratio is relatively small, so it exhibited good fatigue durability. In the Superpave asphalt mixture, the coarse aggregate content is high, but the asphalt mortar content is low, thereby contributing to the hardening trend of the asphalt mixture. Hence, the fatigue durability of the Superpave asphalt mixture is slightly poor.

4.6 Skid resistance

The skid resistance test results of the three asphalt mixtures with different gradations are presented in Fig. 4.

As shown in Fig. 4, SMA-16 presents excellent skid resistance, and the skid resistance of Superpave-16 is slightly higher than that of AC-16I. Therefore, the increasing content of coarse aggregates enlarges the macro-texture on the surface of the asphalt mixture and effectively enhances its skid resistance, especially the increment of texture depth is quite marked. Relative to the AC-16I asphalt mixture, the texture depth of SMA-16 increase by 61% and that of Superpave-16 increase by 22%. For asphalt pavements, a large texture depth can effectively prevent the “drifting and skidding” phenomenon of vehicles running at high speed in rainy days, ensure driving safety, postpone the attenuation of pavement skid resistance, and further lengthen the service life of highways.

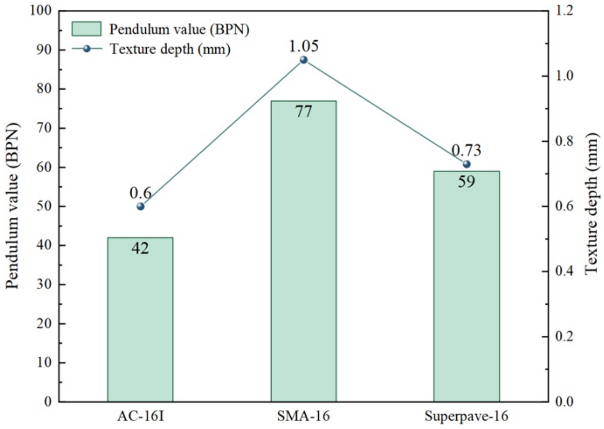


Fig. 4. Skid resistance of the asphalt mixtures

5. Conclusions

In order to eliminate the shortcomings of the current asphalt mix proportion design methods and improve the gradation type of the current mix design method, the Superpave method was proposed to use to design the mix proportion design of asphalt mixtures. In particular, the SMA-16, Superpave-16, and AC-16I asphalt mixture specimens were subjected to the immersion Marshall, low-temperature bending, 60 ℃ rutting, indirect tensile, and skid resistance tests. On this basis, their pavement performance, such as water stability, low-temperature crack resistance, high-temperature stability, fatigue durability, and skid resistance, was analyzed, and the related factors affecting the pavement performance of the three asphalt mixtures were analyzed as well. The following conclusions could be drawn.

(1) Asphalt mixtures of three different gradations (i.e., SMA-16, Superpave-16, and AC-16I) were utilized. The pavement performance of asphalt mixtures was influenced significantly by the gradation type, and increasing the content of coarse aggregates could markedly enhance the high-temperature stability and skid resistance of the asphalt mixtures. However, water stability and fatigue durability were relatively reduced.

(2) There were the aggregate “coarsening” of SMA-16 and Superpave-16. Compared with the traditional asphalt mixture AC-16I, SMA-16 and Superpave-16 showed better performance in high-temperature stability and skid resistance. However, SMA-16 was weaker than AC-16I in the aspect of water stability. Superpave-16 showed poorer low-temperature crack resistance than AC-16I.

(3) By comparing and analyzing the pavement performance of different types of asphalt mixtures, the content of fine aggregate asphalt mortar was found to have different effects on the pavement performance of asphalt mixtures, including in terms of water stability, low-temperature crack resistance and high-temperature stability. The higher content of fine aggregate mortar leaded to better high-temperature stability, fatigue durability, and skid resistance, as well as poorer low-temperature crack

resistance. This result indicated that the content of asphalt mortar influences different pavement performance indicators differently.

In this study, the Superpave-16 asphalt mixture showed good pavement performance, thereby providing technical support for the application of Superpave asphalt mixtures in high-grade highways. However, the number of specimens used was relatively small, and pavement performance indicators obtained were limited. Hence, the other influencing parameters need to be further explored.

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