Laboratory Study on Rubber Particle Asphalt Mixture

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Abstract. In this paper, the indoor experiment of AC-16 rubber particle asphalt mixture was studied. Mix design method of mixing amount of rubber particles asphalt mixture for 3%, two kinds of rubber particles with different gradation were used for the experiment. The rubber particles were mixed into the mixture by dry mixing method, and the road performance was tested. In addition, analyzing the change of void content under different indoor molding conditions of Marshall specimens, the experimental conditions suitable for indoor molding were selected. At the same time, after determining the optimum asphalt content, the comparison between the different asphalt mixture performance, the rubber particles asphalt mixture after adding high viscosity, improve road performance, and choose a type of rubber particles suitable for application on the road.

Introduction

According to statistics, as of 2015, China's production of waste tires in about 330 million, weighing 12 million tons. Waste tire, waste rubber China produced annually, with 8% - 10% of the rate increased sharply[1], becoming a kind of new pollution cannot be ignored. Therefore, how to deal with waste rubber tires has become one of the urgent problems of today's society to solve. In road engineering, the rubber particles are usually divided into two kinds of dry and wet to pave road[2,3,4], dry method is employed herein. Due to the high elasticity rubber particles, rubber particles asphalt pavement has good effect on noise reduction; In the cold area of winter, asphalt pavement surface prone to ice[5], mixed with rubber particles in the asphalt mixture, the stress state of pavement has been changed, which can inhibit the ice on the road under the vehicle load.

Performance testing of raw materials

The aggregate used in this paper is the sandstone of Guyuan area in Ningxia, and the asphalt of Karamay is 90# asphalt. The technical properties of asphalt, aggregate and rubber particles were tested respectively.

Detection of the technical properties of asphalt

Table 1 90 # matrix asphalt technical indicators

Test projects	Specification requirements	Measured value
Penetration（25℃，5s，100g）/0.1mm	80-100	87
Softening point, ℃	≥45	46.3
Ductility（15℃，5cm/min）/cm	＞100	>120
Flash point，℃	≥245	>280
Density（15℃），g/cm^3	Measured	0.9839

The technical properties of aggregate. The technical properties of coarse aggregate

Table 2　Technical specifications for coarse aggregate

Test projects	Specification requirements	S9	S12	S14
Crushed stone value /%	⩽26	25.6	22.3	23.8
Weared stone value /%	⩽28	18.9	15.6	13.2
Apparent specific gravity	⩾2.60	2.709	2.670	2.683
Bulk density /g/cm^3	--	2.620	2.519	2.421
Particle content which<0.075/%	⩽1	0.46	0.65	0.74

The technical properties of fine aggregate

Table 3　Technical specifications for fine aggregate

Test projects	Specification requirements	S16
Apparent specific gravity	⩾2.5	2.705
Sand equivalent(%)	⩾60	84
Particle content which<0.075/%	⩽3	2.45

The technical properties of mineral filler

Table 4　Technical specifications for mineral filler

Test projects	Apparent specific gravity	Appearance	Particle size range（%）		
			<0.6mm	<0.15mm	<0.075mm
Measured value	2.75	No agglomeration	100	99.89	98.54
Specification requirements	⩾2.5	No agglomeration	100	90-100	70-100

The technical properties of rubber particles. In this paper, two different grades of rubber particles are used to test and replace partial S14 aggregates and S16 aggregates, and the gradation of the two rubber particles is shown in fig.1:

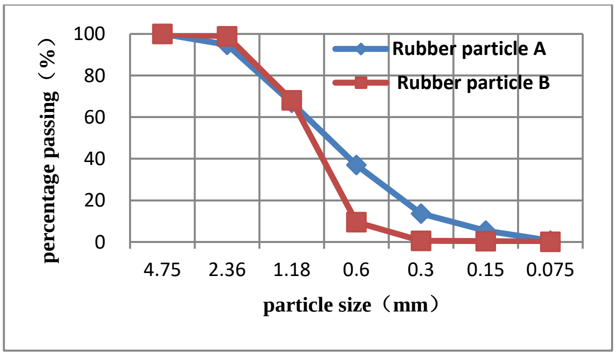

Fig.1 Gradation of two kinds of rubber particles

The density of rubber particles is smaller than that of aggregate density, and is close to the density of water. It is not suitable to measure the density of rubber particles with water, So, this paper uses kerosene to measure the density of rubber particles. The density of the rubber particle A is 1.128g/cm^3, and the density of the rubber particle B is 1.151 g/cm^3.

2 Design of mix proportion

2.1 Mix proportion design of common asphalt mixture. Gradation of aggregate. The grading form of this test is AC-16 and the gradation composition is shown in table 5:

Table 5 Gradation composition of AC-16

size（mm）	19	16	13.2	4.75	2.36	1.18	0.6	0.3	0.15	0.075
Synthetic gradation（%）	100.00	93.90	85.54	74.88	45.06	32.33	24.43	15.96	9.90	7.80
Range(%)	100	90-100	76-92	60-80	34-62	20-48	13-36	9-26	7-18	5-14

Determination of optimum asphalt content. The optimum asphalt content is determined by Marshall method, and the physical and mechanical indexes of Marshall specimen are determined by experiment. The result is shown in table 6:

Table 6 Physical and mechanical indexes of AC-16 Marshall specimen

OAC(%)	MS(kN)	FL(0.1mm)	VV(%)	Bulk specific gravity	VMA（%）	VFA（%）
4.76	11.7	31.1	3.6	2.378	13.14	72.5

Mix Design of Asphalt Mixture with Rubber Particle. Replacement of rubber particles. In this paper, the same volume method which the volume of aggregate is replaced by the same volume of rubber particles is used to mix the rubber particles. The replacement volume is 3%. For the continuous graded rubber particles asphalt mixture, we use rubber particles A to replace part of the S14 aggregate, with rubber particles B to replace part of the S16 aggregate.

Rubber particle matrix asphalt mixture. The asphalt in the rubber granule asphalt mixture was treated with Karamay 90 # asphalt, and the Marshall specimen was mixed and the physical and mechanical indexes of the Marshall specimen were measured. As a result of the swelling of rubber particles at high temperature, some Marshall specimens appear loose in a constant temperature water bath at 60℃, as shown in fig.2. The results show that the 90# matrix asphalt cannot meet the basic conditions for the formation of the sample when the amount of rubber particles is 3%. Therefore, it is suggested that the technical properties of the mixture will be improved by adding viscosity.

Fig.2 Loose drawing of specimen in water bath

Study on molding conditions after adding high viscosity. Due to the addition of rubber particles, the stability of Marshall specimen decreases, the flow value increases, and the change is irregular, therefore, the porosity of Marshall test specimen is used as the main evaluation index to determine the optimum asphalt content, and the main evaluation indexes of the forming Marshall specimen under different conditions are discussed in this paper.

High viscosity by dry mixing method is added to the mixture, the test conditions will also change, experiments were carried out under different conditions respectively, analyzed the variation of Marshall specimen index with mixing temperature, mixing time etc. After the addition of high viscosity agent mixture test in accordance with the following aspects:

a. Low temperature and short time

Mixing temperature of 170 ℃, adding every material mixing time is 90s.

b. High temperature and short time

Mixing temperature of 180 ℃, mixing time is still used for each input of a material mixing 90s.

c. Temperature and time control

Keep the mixing temperature of 180 ℃, the mixing time of the high viscosity agent and the aggregate control in the 4-5min , The mixing time of the remaining materials is kept 90s unchanged, the specimen is formed after mixing, and the porosity of the sample is calculated.

Under different test conditions, the porosity of Marshall specimen as follows:

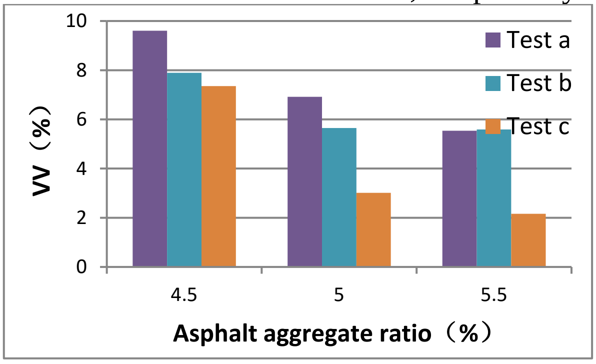

Fig.3 Porosity of rubber particle A specimens

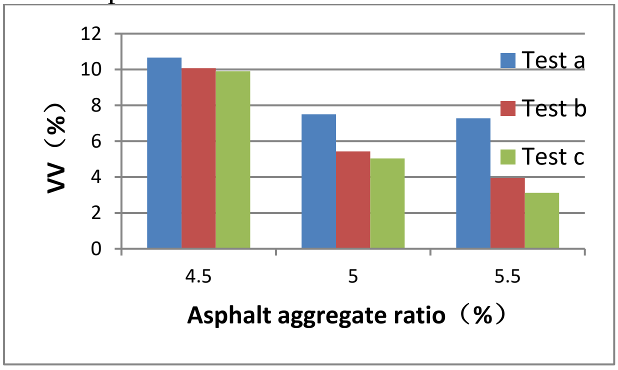

Fig.4 Porosity of rubber particle B specimens

It can be seen from the experimental data that only the porosity of the specimen formed under the test condition c meets the requirements of the specification, so the mixing of the mixture is selected. The optimum asphalt content of two kinds of crumb rubber asphalt mixture. Under the test conditions c mixed with the mixture, the formation of Marshall specimens, and ultimately determine the optimum asphalt content of the two kinds of rubber particle asphalt mixture, The mechanical indexes of the sample under the optimum asphalt content are shown in table 7:

Table 7 Indexes of asphalt mixtures with rubber particles

Types of rubber particles	Optimum asphalt content (%)	Ms(kN)	FL(0.1mm)	VV(%)	Bulk specific gravity	VMA（%）	VFA（%）
Rubber A	5.0	9.09	41.3	3.01	2.306	12.49	75.86
Rubber B	5.2	8.7	70.8	4.0	2.280	13.8	70.5

Through the analysis of Marshall mechanics index shows that after adding rubber particles of optimum asphalt content increases, after that the incorporation of rubber particles, the oil mixture increased; stability decreases, flow increases, from the experimental data, stability and flow values are presented irregular phenomenon.

Test of road performance

High temperature stability. Taking the average of the three measurements as the evaluation index of high temperature stability, the dynamic stability of the three mixtures is shown in Fig.5.

As the rubber particles A replace the relatively coarse aggregate, the proportion of the coarse aggregate decreases, resulting in a decrease in the dynamic stability of the asphalt mixture to which the rubber particles A are added.

Water stability. The water stability of the rubber granules asphalt mixture was evaluated by the freeze-thaw splitting test as the index. The water stability index of the three mixtures was shown in Fig.6.

The experimental results show that the freeze-thaw ratio of the asphalt mixture with rubber particles is increased compared with that of the ordinary asphalt mixture. This situation occurs because the rubber particles asphalt mixture adding the presence of high viscosity agent. High viscosity increases the adhesion between the mixture, reducing the water damage to the specimen.

Low temperature anti-cracking performance. The low-temperature crack resistance of the rubber granule asphalt mixture is evaluated by the ultimate bending strain measured by the low temperature bending test as the index. The ultimate bending strain of the three kinds of mixes is shown in Fig.7.

The experimental results show that the asphalt mixture with rubber particles increases the ultimate bending strain, because the rubber particles themselves are a kind of elastic material. After the rubber particles are added, the elastic modulus of the specimen is reduced. Under the same stress condition, deformation of the specimen will increase.

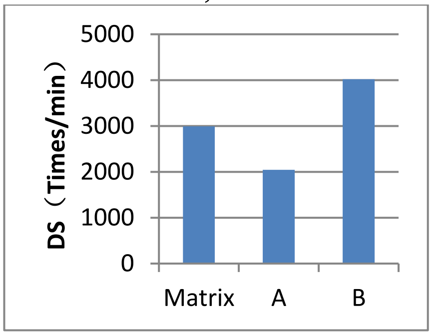

Fig.5 Dynamic stability of three asphalt mixtures

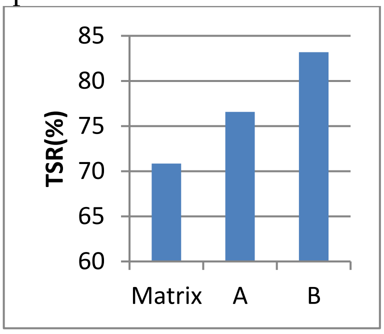

Fig. 6 Freeze-thaw splitting strength ratio of three asphalt mixtures

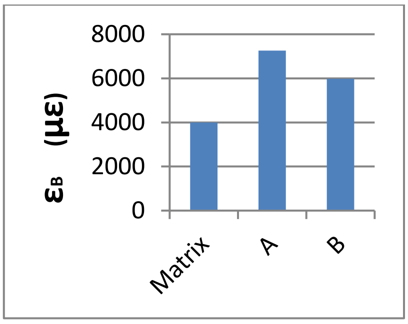

Fig.7 Ultimate bending strain of three asphalt mixtures

Summary

In the case of large amount of rubber particles, the use of matrix asphalt test is not enough to meet the conditions of the test piece. The rubber granules swell at elevated temperature environment, will lead to mix the specimen splitting phenomenon occurs. If the rubber particles' dosage is large, the modified asphalt should be used for the test.

The high-viscosity agent is added to the inside of the mixture through the dry mixing method. It is necessary to prolong the mixing time and increase the mixing temperature to ensure that the high-viscosity agent and the mixture are fully homogeneous and free from the mixing, so that the high-viscosity agent can be fully utilized.

Through the comparison of the road performance of three asphalt mixtures, it can be concluded that the pavement performance of the mixture with rubber particles and high viscosity is better than the common asphalt mixture; By comparing the road performance of two different rubber particles, the replacement of relatively fine aggregate with rubber particles is more suitable for application on the road.

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