

Study on high and low temperature performance of straw fiber modified asphalt

Abstract : In order to study the performance of straw fiber modified asphalt, the influence of different fiber types (cotton straw fiber, basalt fiber and polyester fiber) on the performance of modified asphalt was studied by means of penetration, softening point and ductility. The results show that the addition of fiber reduces the penetration of asphalt, increases the softening point and viscosity, indicating that fiber can improve the high temperature stability of asphalt mortar, and can also improve the high temperature rheological properties and low temperature toughness of asphalt. Among them, cellulose fiber has the best effect on improving the high temperature rheological properties of asphalt mortar, and polyester fiber has the most obvious effect on improving the low temperature toughness.

Keywords : road material ; fiber type ; modified asphalt ; performance test ;

1 Introduction

In recent years, with the continuous use of asphalt pavement in the actual use of the complex climate environment and heavy traffic load and other conditions of the combined effect, accelerated the aging of asphalt, viscosity decline and pavement structure deformation, resulting in asphalt pavement in the expected service life before the occurrence of more pavement diseases, shorten the service life of asphalt pavement^[1]. The problem of resource waste and environmental pollution caused by crop straw burning is becoming more and more serious. The utilization of straw has been paid more and more attention. In addition to being used as feed and fuel, crop straw can also be used to prepare biomass

composites. Because the properties of straw directly affect the properties of composites, it is of great significance to study the composition and properties of straw^[2-7].

Crop straw fiber belongs to plant fiber, and its main components include cellulose, hemicellulose, lignin, pectin, protein and other impurities. According to the research, it is found that the content of each component of wheat straw accounts for 46 % of cellulose, 18 % of hemicellulose and 23 % of lignin, and its cellulose content accounts for the most, so the performance of crop straw fiber on asphalt pavement will be greatly improved^[7].

Based on this, this paper compares the high and low temperature performance of different fiber modified asphalt by optimizing the appropriate fiber pretreatment method, in order to provide reference for fiber selection in practical engineering^[8-14].

2 Preparation of crop straw fiber

2.1 Fiber pretreatment

The waste straw of cotton with high yield in China was selected as the research object, and the pretreatment process was carried out. The waste cotton straw was cleaned in warm water, and the impurities that were easily soluble in water on the surface of the straw were washed off. Then it was boiled with hot water for one hour. After soaking, it was manually cut to a length of 6 ± 2 mm (because the fiber specification for road use in asphalt pavement is less than or equal to 6mm, so the shear is a small section for convenient crushing). A small high-speed shear crusher was used for crushing, and then dried and screened to obtain qualified straw fiber.

The fibers were prepared by wet method. The main factors affecting the preparation of straw fibers were soaking time, material weight and crushing time. Because the crushing instrument is a small

high-speed shear crusher, the material weight has been observed for many times, and the best feeding quality is determined to be 50 g, leaving a certain space for effective crushing.

2.2 Effect of soaking time on oil absorption rate of cotton straw fiber

The effects of soaking time and crushing time on the oil absorption rate of the fiber were analyzed. Determine the material into the quality of 50 g, the length of the broken in 1.5 min, the length of the immersion in 1d, 2d, 3d, 4d, 5d preparation, and calculate the oil absorption rate of the fiber, see Table 1, Figure 1.

Table 1 Effect of soaking time on oil absorption rate of fiber

Soaking time/d	1	2	3	4	5
Oil absorption ratio/%	38.19	42.41	47.02	44.12	32.56

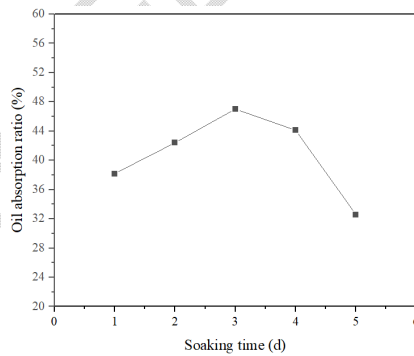


Fig. 1 Relationship between fiber oil absorption rate and soaking time

According to the chart analysis, with the change of fiber soaking time, the oil absorption rate of the prepared cotton stalk fiber increased first and then decreased rapidly. When the soaking time was 3d, the oil absorption rate of cotton stalk fiber was the highest, which was 47.02 %. Too much or too little water content of cotton stalk will lead to uneven breakage. The longer the soaking time is, the lower the oil absorption rate will be. Therefore, the optimum soaking time of cotton stalk fiber is determined to

be 3d.

2.3 Effect of crushing time on oil absorption rate of cotton straw fiber

The feed amount of raw materials was determined to be 50 g, and the crushing time was prepared at 1min, 1.5min, 2min, 2.5min, and 3min, respectively, and the oil absorption rate of the fibers was calculated respectively, as shown in Table 2 and Fig.2.

Table 2 Effect of crushing time on extraction rate of fiber

Breaking time length/min	1	1.5	2	2.5	3
Oil absorption ratio/%	41.45	44.65	48.52	43.91	40.27

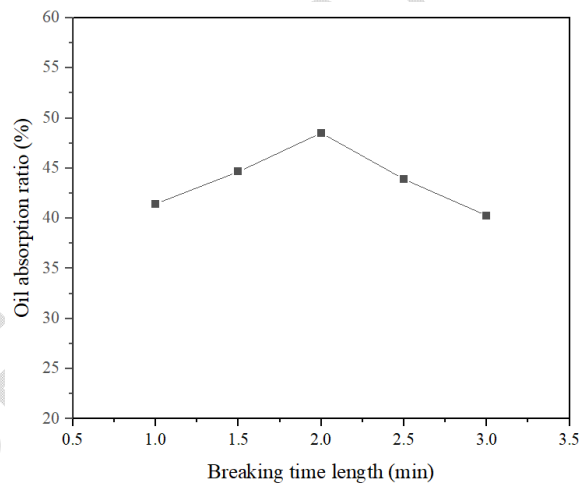


Fig. 2 Relationship between fiber oil absorption rate and crushing time

According to the chart analysis, with the increase of the breaking time of cotton stalk fiber, the oil absorption rate of the prepared cotton stalk fiber increases first and then decreases. When the breaking time is 2min, the oil absorption rate of the fiber is up to 48.52 %. Too much or too little cotton stalk breaking time will lead to uneven breaking and then the length is not up to standard. Too long fiber is easy to be powdered, and too long or too short time will reduce the oil absorption rate.

Therefore, it is determined that the best breaking time of cotton stalk fiber is 2min.

In summary, the best treatment process is that the soaking time is 3d, the material feeding quality is 50g, and the crushing time is 2min.

3 Analysis of basic properties of different types of fibers

3.1 Analysis of basic properties of crop straw fiber

The cotton straw fiber prepared by is similar to the flocculent lignin fiber. The performance test is carried out according to the requirements of lignin fiber in 'Lignin fiber for asphalt pavement' (JT/T 533-2004), see Table 3.

Table 3 Basic performance index of cotton straw fiber

Pilot project	Test data	Technical requirement
Fiber length (mm)	5.8	≥ 6
Ash content (%)	14.8	18 ± 5
PH value	7.3	7.5 ± 1
Oil absorption multiple	7.6	≤ 5
Moisture content (%)	3.4	< 5
Heat resistance 210 °C, 2h (%)	4.32	Thermal weight loss ≥ 6

3.2 Different types of fiber physical and technical testing

Two kinds of commonly used fiber basalt fiber and polyester fiber were selected to test the physical and technical indexes of the two fibers, as shown in Table 4.

Table 4 Basic performance index of fiber

Pilot project	Basalt fiber	polyester fiber	cotton straw fiber
Color	Golden brown	Milk white	Beige
Fiber length (mm)	6	6	5.8
Ash content (%)	—	—	14.8
Diameter (μm)	14	21	—
Tensile strength (MPa)	3.811	530	—
Elongation at break (%)	3.7	27	—

4 Basic performance test of different types of fiber modified asphalt

The prepared cotton straw fiber, basalt fiber and polyester fiber were selected with a content of 3 %, and the performance tests were carried out respectively, as shown in table 5.

Table 5 Basic properties of different types of fiber modified asphalt

Pilot project	Basalt fiber modified asphalt	Polyester fiber modified asphalt	Cotton straw fiber modified asphalt
Penetration (0.1 mm)	53	58	64
Softening point ($^{\circ}\text{C}$)	63.0	61.2	59.7
Ductility (cm, 15 $^{\circ}\text{C}$)	54	66	71

In different types of fiber modified asphalt, penetration : cotton straw fiber modified asphalt > polyester fiber modified asphalt > basalt fiber modified asphalt, indicating that the addition of basalt fiber has a greater improvement in asphalt consistency. Softening point : basalt fiber modified asphalt > polyester fiber modified asphalt > cotton straw fiber modified asphalt, indicating that the addition of basalt fiber can effectively improve the high temperature performance of asphalt. Ductility : polyester fiber modified asphalt > basalt fiber modified asphalt > cotton straw fiber modified asphalt, indicating

that the addition of basalt fiber can effectively improve the low temperature performance of asphalt.

5 Conclusion

The fiber treatment and preparation of natural cotton straw were carried out to determine the best treatment process of cotton straw fiber, and the basic properties of different types of fiber modified asphalt were studied.

- (1) The wet method was used to treat the prepared cotton stalk fiber, and the best treatment process was obtained. The soaking time was 3d, the material feeding quantity was 50g, and the crushing time was 2min, which all met the requirements of the basic performance index of the fiber.
- (2) Under the same conditions, the addition of straw fiber will increase the ductility of asphalt, reduce the softening point and penetration, among which polyester fiber and basalt fiber have a great influence on the penetration of asphalt.
- (3) The content of different types of fibers was selected to be 3 %, and the three indexes of fiber modified asphalt were tested. The test results showed that the performance of basalt fiber modified asphalt was better.

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