Effect of aging on low-temperature crack resistance and water stability of polyester fiber asphalt mixture

Jinrong Wu 1, 2, 3, Zhaoxu Niu 2, *, and Haiyan Chen 2

1 Engineering Research Center of Underground Mine Construction, Ministry of Education, Anhui University of Science and Technology, Huainan, 232001, People’s Republic of China
2 School of Civil Engineering and Architecture, Anhui University of Science and Technology, Huainan, 232001, People’s Republic of China
3 State Key Laboratory of Mining Response and Disaster Prevention and Control in Deep Coal Mine, Anhui University of Science and Technology, Huainan, 232001, People’s Republic of China

* Author to whom any correspondence should be addressed.
E-mail: niuzhaoxu@126.com

Keywords: polyester fiber, asphalt mixture, aging, water stability, low-temperature performance

Abstract

In order to study the influence of different aging conditions on the low-temperature crack resistance and water stability of polyester fiber asphalt mixture. Prepare standard Marshall specimens of asphalt mixture with 0.4% polyester fiber doping, and carry out water immersion Marshall test and low temperature splitting test through indoor asphalt mortar aging, asphalt mixture short-term aging and long-term aging. The results show that: under the three aging conditions, when the water immersion and low temperature time are fixed, with the increase of the aging degree, the water stability and low temperature crack resistance of the asphalt mixture decrease. When the immersion time is 2 h, the stability of asphalt mortar aging and short-term aging decreases by 6.0% and 11.8%, respectively, compared with unaging, but the long-term aging is only 3.6% lower than the short-term aging. When the temperature is −5 °C, the split tensile strength of asphalt mortar aged and short-term aged increases by 4.24% and 14.35%, respectively, compared with unaging, while long-term aging only increases 4.18% compared with short-term aging. This indicates that the short-term aging condition has the most significant effect on the water stability and low-temperature crack resistance of polyester fiber asphalt mixes. At the same time, this study established a regression equation between the test temperature and the low temperature evaluation index through quadratic fitting (the correlation coefficient is 0.960–0.998), and the regression relationship can be used to estimate the low temperature evaluation index at different test temperatures.

1. Introduction

Asphalt pavement is a seamless continuous pavement, and the integrity of the pavement gives it good mechanical properties. At present, asphalt pavement has been widely used in municipal roads and high-grade highways around the world due to its advantages of smooth running, comfort, no noise, no dust, etc. It can also better transfer the load generated by vehicles [1–3]. However, due to the short-term aging effect of the asphalt mixture in the mixing, transportation and paving process, and the long-term and ultra-long-term aging effect in the process of use after completion and opening to traffic [4–8]. Therefore, aging has gradually become one of the main causes of asphalt pavement cracks, loosening, potholes and other diseases [9, 10].

At the beginning of this century, in order to solve a series of asphalt pavement diseases caused by asphalt aging, scholars at home and abroad conducted in-depth research on asphalt aging, which promoted the development of highway engineering [11, 12]. At the same time, scholars have also noticed the problems caused by short-term aging and long-term aging of asphalt. However, due to the long time required for long-term aging and the lack of relevant technical experience and test methods, domestic scholars have mainly focused on short-term aging of asphalt. As shown in the literature, Wang et al. [13] believed that some aging indicators of residues
after short-term aging can predict long-term anti-aging ability and can be used as a basis for evaluating asphalt anti-aging ability; Zhang et al. [14] analyzed the effect of aging on the viscoelasticity of asphalt binders by performing TOFE (film heating test), RTOFT (rotating film heating test) and PAV (pressure aging test), but did not find which test method is more in line with the actual situation. Therefore, it is considered that the short-term aging test cannot fully reflect the aging resistance of asphalt.

In recent years, the aging research of asphalt and asphalt mixture has changed from short-term aging test to long-term aging test and whole process aging research [15–17]. On the one hand, Arega et al. [18] investigated the fatigue resistance of asphalt mixtures after aging and compared the stiffness and fatigue cracking resistance of long-term aged specimens and found that long-term aging had less effect on the fatigue cracking resistance performance. On the other hand, the effect of aging on the performance of fine-graded asphalt and coarse-graded asphalt has also been studied, and the elastic modulus and tensile strength of fine-graded asphalt mixes were found to be better than those of coarse-graded asphalt mixes [19]. In addition, The scholars analyzed the dynamic modulus, fatigue self-healing, and low-temperature properties of asphalt mixes by performing tests with different aging effects [20–22], and found that the mechanical properties of the aged asphalt mixes all decreased. Of course, it is not only the thickness of the aggregate that affects the aging performance of asphalt, but also the aging time and temperature. Therefore, some scholars analyzed the influence of time and temperature on asphalt aging and found that the longer the aging time and the higher the temperature, the deeper the aging of asphalt and the worse the paving performance of asphalt mixes [23–26]. At the same time, in order to further understand the aging process of asphalt, it was found through microscopy that aging causes changes in the chemical functional groups of asphalt, which results in the nanomorphology and micromechanical properties of asphalt being affected [27–31].

With the maturity of asphalt preparation technology, modified asphalt and modified asphalt mixture gradually appeared on the stage of asphalt, many scholars began to carry out research on its good anti-aging properties. For example, literature studies by Colbert et al. [32] and Omar et al. [33] provided a theoretical basis for binders to improve the aging resistance of asphalt mixes. In addition, Yusoff et al. [34] and Karnati et al. [35] studied the effect of nano-silica content on the aging of asphalt mixtures and concluded that nano-silica reduced the susceptibility of asphalt mixtures to water damage and improved their strength, fatigue resistance and rutting resistance. Moreover, many scholars have found in their research that modified asphalt mixes are better than matrix asphalt mixes in terms of anti-aging properties, and can enhance high temperature stability and low temperature crack resistance [36–42]. Therefore, the application of modified asphalt mixtures effectively extends the service life of asphalt pavements under the influence of aging.

In summary, scholars at home and abroad have conducted a lot of research on the aging of asphalt and asphalt mixtures, and obtained a series of research results. However, most of the above-mentioned tests are to study the influence of a single aging condition on various properties of asphalt mixture. Therefore, on the basis of previous research, this article analyzes the impact of three common aging conditions in engineering applications on the water stability and low-temperature crack resistance of polyester fiber asphalt mixtures through indoor simulation tests. The law of change obtained in this paper not only provides a test basis for the analysis of the road performance of the polyester fiber asphalt mixture after aging, but also provides reasonable suggestions for the road construction of the polyester fiber asphalt mixture. In addition, this paper found that the test temperature and the low temperature evaluation index have a good correlation through the second fitting, and thus established the regression relationship between the two. The regression relationship can be used to estimate the low temperature evaluation index at different test temperatures. It improves the reliability of the test data while reducing the test workload. It can be seen that the results of this study deeply analyze the changing laws of asphalt mixture road performance under different aging conditions. A regression equation between the test temperature and the low temperature evaluation index under different aging conditions is established, which provides an effective method to estimate the low temperature evaluation index.

2. Materials and methods

2.1. Materials

2.1.1. Asphalt

The asphalt used in this test is AH-70 provided by Zibo Lisen Petrochemical Co., Ltd. The various indexes of the asphalt are tested according to the requirements of the test regulations. The test results are shown in table 1.

2.1.2. Aggregates

Aggregate generally consists of coarse aggregate, fine aggregate and filler, which plays the role of skeleton and filler in asphalt mixture, and is the main source of strength of asphalt mixture. The aggregate used in this
experiment is limestone produced by Anhui Kunhong New Environmental Protection Building Materials Co., Ltd. The main technical indicators are shown in table 2.

The filler used in this test is limestone S95 grade mineral powder produced by the Yongdeshun Mineral Processing Plant in Lingshou County. The chemical composition of the mineral powder is shown in table 3, and the physical properties are shown in table 4.

2.1.3. Fiber
In recent years, the application of fiber into the asphalt mixture is becoming more and more widespread, which is used more polyester fiber, basalt fiber and wood fiber. However, polyester fiber can form a more stable spatial network structure in the asphalt mixture and produce a strong binding force, thereby improving the road performance of the asphalt mixture [43]. Therefore, this test uses the polyester fiber for Runfang Road produced by Nanjing Runfang Construction Technology Engineering Co., Ltd. The main technical indicators are shown in table 5.
2.2. Test design

2.2.1. Gradation curve

The asphalt mixture should have sufficient density and high internal friction resistance, the required gradation range can be calculated by the gradation theory, or it can be determined according to the gradation range recommended by the specification. Due to the AC-13 gradation density is relatively large, and it has good water stability, low temperature crack resistance and durability. Therefore, this test uses AC-13 type gradation, as shown in figure 1.

2.2.2. Optimal asphalt content

The amount of asphalt is closely related to the road performance and directly affected the mechanical properties of the mixture. Therefore, it is necessary to determine the optimum asphalt content. In order to determine the optimum asphalt content, five asphalt content were selected to make Marshall standard specimens, which were used to acquire the values of Marshall stability, flow value, bulk volume density, and voids. The test results are shown in table 6.

Table 6. Test results of Marshall test.

| asphalt-aggregate ratio (%) | Bulk volume density (g·cm⁻³) | Voids (%) | Marshall stability (kN) | flow value (mm) |
|-----------------------------|------------------------------|-----------|------------------------|----------------|
| 4.0                         | 2.423                        | 5.7       | 7.92                   | 2.12           |
| 4.5                         | 2.432                        | 5.4       | 8.84                   | 2.23           |
| 5.0                         | 2.455                        | 4.9       | 9.35                   | 2.34           |
| 5.5                         | 2.465                        | 4.2       | 9.78                   | 2.59           |
| 6.0                         | 2.454                        | 3.3       | 9.32                   | 3.61           |

According to table 6, the relationship between asphalt dosing and Marshall stability is plotted (as shown in figure 2). After curve fitting, the optimum asphalt dosing in the test was finally determined to be 5.66%.

2.2.3. Aging test design

Asphalt mortar aging: this test method is a bitumen film heating test. The asphalt-filled stainless steel pan was quickly placed in the oven, and the oven door was closed, and the sample was kept at 163 °C ± 1 °C for 5 h.

Short-term aging: first, heat the prepared aggregate, asphalt, etc to the corresponding temperature, and then mix well in the mixing pot. The stirred asphalt mixture was then placed and placed in a stainless-steel tray prepared in advance. According to the specification requirements, the asphalt mixture should be loosened from about 21 kg m⁻² to 22 kg m⁻², and then the paved asphalt mixture is placed in a blast oven for aging for 4 h ± 5 min. In order to ensure uniform heating, use a small shovel to mix once every hour. During each mixing, change the position of the stainless-steel plate to prevent the test error caused by the temperature difference of each layer in the oven. Thus, the aging conditions of the 4-tray asphalt mixture are as consistent as possible, reducing the test error.
Long-term aging: indoor long-term aging simulation tests are based on short-term aging simulation tests. The molding test piece was placed in an oven at a temperature of 85 °C ± 3 °C and heated continuously for 5 d under forced ventilation. Do not move the test piece during the long-term aging test to prevent damage or deformation of the test piece during this process. After 5 d, the oven was closed, and the oven door was opened to allow the test piece to naturally cool to room temperature, and the cooling time was not less than 16 h. The test block is then removed for testing.

2.3. Test methods

2.3.1. Immersion Marshall test design

The standard methods for evaluating the water stability of asphalt mixtures include immersion Marshall test, freeze-thaw splitting test, and immersion rutting test. Comprehensive consideration of the test conditions and economic limitations, the immersion Marshall test method is adopted in this experiment. The influence of different aging conditions (un-aging condition, asphalt mortar aging, asphalt mixture short-term aging, asphalt mixture long-term aging) and different immersion time (0 h, 0.5 h, 2 h, 12 h, 24 h, 36 h, 48 h) on the stability and residual strength ratio of asphalt mixture is analyzed. The test is in accordance with ‘Standard Test Methods of Bitumen and Bituminous Mixtures for Highway Engineering’ (JTG E20-2011) [44]: First put the test piece in a constant temperature water tank at 60 °C ± 1 °C, after reaching the immersion time, take out the test block and wipe the surface moisture dry, and then load the test block through a Marshall tester to failure (loading speed is 50 mm min⁻¹), and finally record the test piece data. The test piece is immersed in water as shown in figure 3, and the test load is shown in figure 4. The residual strength ratio can more intuitively reflect the influence of different aging conditions and water immersion time on the stability and strength of the polyester fiber asphalt mixture. The calculation formula is (1).

\[ M_{S_0} = \frac{M_{S_1}}{M_{S_0}} \times 100 \]  

Where \( M_{S_0} \) is residual strength ratio of the test piece (%); \( M_{S_1} \) is the stability of the specimen after immersion in water (kN); \( M_{S_0} \) is test piece immersed in water for 0 h stability (kN).

2.3.2. Low-temperature splitting test design

Studies have shown that the split test and the low-temperature bend test are consistent in the evaluation of the low-temperature properties of asphalt mixtures. However, the split test has the characteristics of the relatively simple test method, easy implementation, and simple preparation of the test piece [43]. Therefore, this test uses the split test method, as is shown in figure 5 before and after the test load. The influence of different aging conditions and temperatures (10 °C, 5 °C, 0 °C, −5 °C, −10 °C and −15 °C) on the low-temperature performance of asphalt mixture is analyzed. The test is in accordance with ‘Standard Test Methods of Bitumen and Bituminous Mixtures for Highway Engineering’ (JTG E20-2011) [44]: First put the test piece into the high and low temperature test box, the heat preservation time shall not be less than 6 h (the number of parallel test pieces is 4, the distance between the test pieces is greater than 10mm), and then the test piece is placed on the
universal testing machine and loaded to failure (loading rate 1 mm min$^{-1}$). $R_T$, $S_T$, and $\delta_T$ are calculated by the following formula.

$$R_T = \frac{0.00628 P_T}{h}$$ (2)
Where $R_T$ is splitting tensile strength of the test piece (MPa); $S_T$ is destructive stiffness modulus of the test piece (MPa); $\varepsilon_T$ is the destructive tensile strain of the test piece; $P_T$ is maximum load value of the test piece (N); $X_T$ is total deformation of the maximum damage load in the horizontal direction (mm); $Y_T$ is total deformation of the maximum failure load in the vertical direction (mm); $\mu$ is the Poisson ratio, 0.25; $h$ is test piece height (mm).

3. Results and discussion

3.1. Analysis of results of water-immersed Marshall test

3.1.1. Analysis of water stability performance under different aging conditions

For convenience in drawing, N represents an un-aging condition, A represents an asphalt mortar aging condition, S represents a short-term aging condition, and L represents a long-term aging condition. According to the results obtained by the Marshall test, the relationship between the aging condition and the residual water stability of the asphalt mixture is plotted, as shown in figure 6. The relationship between the aging condition and residual intensity ratio is shown in figure 7.

It can be seen from figure 6 that under the same immersion time, the residual water stability of the polyester fiber asphalt mixture shows a downward trend with the deepening of aging degree. For example, after 2 h of immersion, the residual water stability is 11.78 kN, 11.07 kN, 10.39 kN, and 10.02 kN under the condition of un-aging, mortar aging, short-term aging, and long-term aging, respectively. Compared with un-aging, asphalt mortar aging and short-term aging decreased by 6.0% and 11.8%, respectively, but long-term aging decreased by only 3.6% compared with short-term aging. Other immersion time also showed the same change rule, indicating that aging greatly influences the stability of polyester fiber asphalt mixture, especially short-term aging.

It can be seen from figure 7 that the residual strength ratio tends to decrease with the deepening of the aging degree. That is to say, the deeper the aging degree, the worse its ability to resist water damage. Similarly, the residual strength ratio after 2 h of water immersion was analyzed. The residual strength ratio is 29.6%, 29.1%, 27.5%, and 27.1% under the condition of un-aging, mortar aging, short-term aging, and long-term aging, respectively. Compared with the un-aging, the asphalt mortar aging and the short-term aging condition decreased by 1.7% and 7.1%, respectively, and the long-term aging of asphalt mixture decreased by only 1.5% compared with the short-term aging condition, indicating once again that the short-term effect was serious.
Other immersion time is also the same change rule, indicating that the aging seriously affects the water stability of the polyester fiber asphalt mixture.

Through the analysis of the various rules of figures 6 and 7, it can be known that under the same immersion time, as the aging degree deepens, the residual water stability and the residual strength ratio of the mixture both decreases. The reason is that ketones and surfactants are formed when the asphalt is aging. They are highly hydrophilic, which will increase the solubility of asphalt molecules in water and weaken the adhesion between mixtures and increase the damage of asphalt mixture. Another reason is that as the aging degree deepens, the light components of the asphalt play and decrease, and the transition from sol-gel-type asphalt to gel-type asphalt reduces the fluidity [20].

From the analysis of the above data, it can be concluded that short-term aging has a severe impact on the residual water stability and residual strength ratio. Short-term aging is to simulate the aging of asphalt mixtures during mixing, transportation, and paving. Since almost all the asphalt mixture is in contact with the outside world, oxidation and polymerization reactions will occur when the asphalt is in contact with the air, reducing the cohesion of the asphalt mixture. As a result, the adhesion between asphalt and aggregate becomes worse, and the internal structure of the asphalt mixture is damaged. Therefore, the residual water stability and the residual strength ratio of the asphalt mixture decrease rapidly.

3.1.2. Analysis of water stability performance by water immersion time

Water damage is caused by the retention and erosion of water on asphalt pavement. The longer the water stays in the pavement, the deeper the erosion degree, and the lower the water stability of asphalt pavement. According to the water immersion Marshall test results, the relationship between the water immersion time and the residual water stability, residual strength ratio is shown in figures 8 and 9.

From the observation of figure 8, it can be concluded that the stability of the polyester fiber asphalt mixture exhibits a downward trend with the increase of immersion time under the same aging condition. In the short-term aging, the residual water stability of the polyester fiber asphalt mixture after the immersion time of 0 h, 0.5 h, 2 h, 12 h, 24 h, 36 h, and 48 h is 37.90 kN, 10.58 kN, 10.39 kN, 10.35 kN, 10.33 kN, 10.29 kN, and 9.66kN, respectively. Compared with the un-immersion, the stability decreased by 72.1%, 72.6%, 72.7%, 72.7%, 72.8%, and 74.5%. Under the long-term erosion of water, the water stability of asphalt pavement is seriously affected.

It can be seen from figure 9 that the residual intensity ratio shows a downward trend with the increase of the immersion time. The change in the residual intensity ratio in the short-term aging condition is also analyzed. The residual strength ratios before and after immersion for 0.5 h, 2 h, 12 h, 24 h, 36 h, and 48 h is 27.9%, 27.5%, 27.4%, 27.3%, 27.1%, and 25.5%, respectively. The above analysis indicates that with the increase of the immersion time, the water damage resistance of the mixture becomes worse, especially after immersion for 48 h, the residual strength ratio is less than that of other periods. It is inferred that the test block may lose its bearing capacity if the immersion time exceeds 48 h.

In conclusion, the residual water stability and residual strength ratio decrease with the increase of immersion time. The main reason for this phenomenon is that when water intrudes into the interface between asphalt and
aggregate, the asphalt film will fall off and slowly peel off, and finally, the adhesion between asphalt mixture becomes weaker [16], and the overall strength of the asphalt mixture becomes worse.

3.2. Analysis of splitting test results

3.2.1. Analysis of low-temperature performance under different aging conditions

According to the results of the low-temperature test, the relationship between the aging state and the low-temperature evaluation index (splitting tensile strength, failure stiffness modulus, and failure tensile strain) is shown in figures 10–12.

It can be seen from figures 10 and 11 that the splitting tensile strength and the failure stiffness modulus of the polyester fiber asphalt mixture show the same change law at the same test temperature. As the degree of aging deepens, the splitting tensile strength and the failure stiffness modulus of the polyester fiber asphalt mixture show an increasing trend. Take −5 °C as an example, and the splitting tensile strength was 1.673 MPa, 1.744 MPa, 1.913 MPa, 1.993 MPa under the un-aging, mortar aging, short-term aging, and long-term aging, respectively. Compared with un-aging, asphalt mortar aging, short-term aging, and long-term aging increased by 4.24%, 14.35%, and 19.13%, respectively. However, compared with short-term aging, the splitting tensile strength of long-term aging only increased by 4.18%. The failure stiffness modulus is 241.360 MPa,
253.334 MPa, 290.776 MPa, 307.418 MPa under the condition of un-aging, mortar aging, short-term aging, and long-term aging, respectively. Compared with un-aging, asphalt mortar aging, short-term aging, and long-term aging increased by 4.96%, 20.47%, and 27.37%, respectively. Nevertheless, compared with short-term aging, the splitting tensile strength of long-term aging only increased by 5.72%. The results indicate that aging has an obvious influence on the splitting tensile strength and failure stiffness modulus of polyester fiber asphalt mixture. Furthermore, Short-term aging has the most significant influence on the splitting tensile strength and failure stiffness modulus of polyester fiber asphalt mixture.

As can be intuitively seen from figure 12, the failure tensile strain of polyester fiber asphalt mixture shows the same change rule under the same test temperature: with the deepening of aging degree, the failure tensile strain of polyester fiber asphalt mixture shows a downward trend. Similarly, take −5 °C as an example. The failure tensile strain is 11979.15, 11893.33, 11373.37, 11216.88 under the un-aging, mortar aging, short-term aging, and long-term aging. Compared with un-aging, asphalt mortar aging, short-term aging, and long-term aging decreased by 0.72%, 5.06%, and 6.36%, respectively. However, compared with short-term aging, the failure tensile strain of long-term aging decreased by 1.37%. It indicates that aging has an obvious effect on the failure tensile strain of polyester fiber asphalt mixture, and short-term aging has the most significant effect on the tensile strain of asphalt mixture.
In conclusion, aging can reduce the low-temperature performance of asphalt mixture. Aging is caused by polar substances, which will accelerate the oxidation reaction of low polar substances in asphalt and accelerate the aging of asphalt and asphalt mixture. The oxidation and polymerization of polar molecules can decompose and reduce the light components in asphalt. It leads to the hardening and embrittlement of the asphalt binder and weakens the anti-deformation ability of the asphalt mixture.

3.2.2. Analysis of test temperature versus low-temperature performance

According to the test results, a scatter plot of the relationship between the test temperature, and the low-temperature evaluation index is drawn and fitted. As shown in figures 13–15.

From the observations of figures 13 and 14, it is found that the splitting tensile strength and the failure stiffness modulus of the mixture have a significant inflection point at 0 °C. At 10 °C ~ −15 °C, the tensile strength of the splitting increases with the decrease of the test temperature, and the changing trend are slower from 0 °C ~ 10 °C, while the changing trend from 0 °C ~ −15 °C is steep. The same is true for the damage stiffness modulus. Previous studies have shown that: between −15 °C and 15 °C, asphalt mixture's properties change significantly; which is a sensitive region for changes of elastomer and viscoelastic [45], and its crack resistance changes significantly. The temperature range used in this experiment is −15 °C~10 °C, and an
Inflection point appears near 0 °C, which may be because after the temperature is higher than 0 °C, asphalt starts to transform from viscoelastic to Newtonian fluid.

A comprehensive analysis of figures 13–15 found that the low-temperature evaluation index has a good correlation with the test temperature, and the correlation coefficient is 0.960–0.998. The fitting effect is good, indicating that the quadratic function can more accurately reflect the relationship between the temperature and the low-temperature performance evaluation indicators of the asphalt mixture. Therefore, the regression relationship can be used to estimate the splitting tensile strength and the failure stiffness modulus and failure tensile strain at different test temperatures and improve the test data’s reliability while reducing the test workload. Moreover, according to the scatter plot, it is found that the splitting tensile strength and the failure stiffness modulus of the asphalt mixture after long-term aging are greater than those after short-term aging, which is consistent with the actual situation [46].

Adding a proper amount of fiber to the asphalt mixture can improve the toughness and temperature sensitivity of the asphalt mortar, and at the same time, it can strengthen and consolidate the aggregate. The 0.4% polyester fiber content can make the fibers evenly distributed in the asphalt mixture [47]. Form a dense network structure, improve the plasticity of the asphalt mixture, and have a certain restraint effect on the expansion of cracks. At the same time, The incorporation of polyester fiber increases the amount of asphalt and the thickness of the asphalt film. The dense and thick asphalt film and the uniform network structure formed by the polyester
fiber can disperse and transfer the stress well, thereby alleviating local stress concentration. In addition, when the asphalt mixture is subjected to external forces, the fiber is deformed by tension, and when the external force disappears, the fiber elasticity is restored, which has the tendency to prompt the asphalt mixture to return to its original form, which enhances the self-healing ability of the material and reduces the damage caused by external forces, thus improving the durability and low-temperature crack resistance of the asphalt mixture.

4. Conclusions

This paper mainly studies the variation of water stability and low-temperature crack resistance of asphalt mixture under different aging conditions and obtains the following conclusions.

1. The water stability and low temperature crack resistance of polyester fiber asphalt mixture is affected by aging. The deeper the aging degree, the worse the water stability and low-temperature crack resistance.

2. The water stability of the polyester fiber asphalt mixture is affected by the immersion time, and the longer the water immersion time, the worse the water stability.

3. The change in temperature affects the low-temperature properties of the polyester asphalt mixture. Through the quadratic fitting, it is found that the test temperature has a good correlation with the low-temperature evaluation index, and the regression relationship can be used to estimate the test data of the low-temperature evaluation index at different test temperatures.

4. The short-term aging state has the most significant influence on the water stability and low-temperature crack resistance of polyester fiber asphalt mixture. That is to say, the mixing and paving stage of pavement construction has the greatest impact on pavement performance.

Acknowledgments

This research was funded by the Natural Science Research Project of Colleges and Universities in Anhui Province (No. KJ2017A096), Graduate Innovation Fund of Anhui University of Science and Technology (No. 2021CX2033).

Data availability statement

All data that support the findings of this study are included within the article (and any supplementary files).

ORCID iDs

Zhaoxu Niu @ https://orcid.org/0000-0002-9782-8407

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