Hindawi
Advances in Materials Science and Engineering
Volume 2021, Article ID 2487478, 5 pages
https://doi.org/10.1155/2021/2487478

Research Article

Experience Study on Long-Life Microsurfacing with High Water Resistance Performance

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Received 22 September 2021; Revised 7 November 2021; Accepted 24 November 2021; Published 14 December 2021

Academic Editor: Meng Jingjing

Microsurfacing is a standard preventive maintenance technology developed on the basis of slurry sealing technology. However, the high temperature and rainy season in Guangdong Province affect its expanded application because of its low water resistance and short service life. So, high-performance microsurfacing, a new microsurfacing technology, has been developed. The key to this technique is an appropriate proportion of water-based epoxy resin and waterborne epoxy curing agent, which could generate a chemical reaction to form a high-performance bonding network structure of space. And indoor wet-wheel wear test shows that its antiwear ability and resistance to water damage are evidently increased (to over 50%) compared with the conventional microsurfacing. Furthermore, from the long-term road performance results, the antisliding and water resistance performance of high-performance microsurfacing is much higher than the conventional technique.

1. Introduction

Microsurfacing technology is an economical, efficient, and effective technique to prevent pavement, which has a good effect on preventing the pavement from loosening, delaying the aging of pavement, increasing the friction, and keeping the stability of the pavement [1–4]. However, during the summer in Guangdong, the asphalt pavement maximum temperature would be up to 70°C. Under the high temperature and heavy vehicle crush, the microsurfacing surface's aggregate position and state would be rearranged. The big aggregate will be pressed into the lower part of the pavement, which accelerates the macrostructural attenuation. In addition, the rainy season in Guangdong puts the pavement under the action of a large hydrodynamic pressure, which makes microsurfacing start peeling off.

Aiming at the conventional microsurfacing shortcomings of poor abrasion resistance and short service life in a rainy place, this paper presents a new type of microsurfacing technology, high-performance microsurfacing. The core of this new technology is products called water-based epoxy resin and water-based epoxy curing agent, which make the chemical reactions at room temperature. And it would create a space-net structure with high adhesion performance, which significantly improves the wear resistance of microsurfacing [5–8]. Indoor wet abrasion test and accelerated loading test show that the high-performance microsurfacing has excellent abrasion resistance and antiwater damage ability. It would significantly improve microsurfacing's wear resistance and service life, which has a good application prospect [9–14]. Many scholars have studied the related performance of micropavement [15–18]. Various advanced research schemes have been used in the study of microsurfacing technology [19, 20]. Among them, grey modeling theory [21–26] is used most.

2. Raw Material Technical Index

2.1. Aggregate. Index about indoor test's aggregate can meet the requirements of <<microsurfacing and dilute's technical

guidelines for slurry seal >> (Table 1). Inside the guidelines, 5 ~ 10 mm gravel stone chips: 3 ~ 5 mm gravel stone chips: 0 ~ 3 mm stone chips = 3 : 1: 6 (mass ratio). And the aggregate grading curve is shown in Figure 1. From Figure 1, we can see that the proportion of coarse aggregate is larger, and the grading curve is quite lower.

2.2. Modified Emulsified Asphalt. Shell-modified emulsified asphalt was used in indoor tests, whose technical indicators are shown in Table 2. According to Table 2, modified emulsified asphalt can meet the technical requirements of <<microsurfacing and dilute's technical guidelines for slurry seal>>.

2.3. Water-Based Epoxy Resin and Waterborne Epoxy Curing Agent. The results of the indoor test on water-based epoxy resin and waterborne epoxy curing agent are shown in Table 3.

3. Results and Analysis of Wet-Wheel Wear Test

3.1. Wear Resistance of High-Performance Microsurfacing. The wear resistance of the microsurfacing mixture can be characterized by the wear value of 1H.

The greater the wear value of 1H, the worse the wear resistance ability of the mixture, otherwise, the better. In order to evaluate the high-performance microsurfacing's wear performance, this paper will put 1%, 2%, and 3% doses (compared with the quality of emulsified asphalt) of water-based epoxy resin and related waterborne epoxy curing agents (water-based epoxy resin: waterborne epoxy curing agent = 1 : 1.5 (mass ratio)) into modified emulsified asphalt. Then, according to the ratio of modified emulsified asphalt, aggregate, filler, and water, we finish the high-performance microsurfacing mixture. Test results of the 1H wet-wheel wear test about different mixing amounts of waterborne epoxy additives are shown in Figure 2. The following conclusions can be obtained according to Figure 2:

(1) Compared with conventional microsurfacing, the wear resistance of the microsurfacing with different proportions of waterborne epoxy additives was significantly improved. The reason may be as follows: the water-based epoxy resin and waterborne epoxy curing agent will create a chemical reaction, which increases aggregate and asphalt's bonding ability. And it improves the performance of microsurfacing.

(2) When mixed with 2% water-based epoxy resin, the one *h* wet-wheel wear value was the smallest. And the wear resistance of the microsurfacing has improved by 56%.

(3) When the amount of water-based epoxy resin was 3%, the 1h wet-wheel wear value was increased. The reason may be as follows. The 1h wet-wheel wear test's conservation time is relatively short. However, the high water percentage of water-based epoxy resin required an extended conservation time when the amount of water-based epoxy resin is large.

Table 1: Technical specifications of aggregate.

Test items	Test results	Technical indicators
Crushing value/%	12	≦26
Los Angeles wear value/%	13	≦28
Stone polished value (BPN)	53	≧42
The roughness of coarse aggregate/%	3	≦12
Needle sheet Mass fraction of coarse aggregate/%	5	≦15
Sand equivalent/%	78	≦65

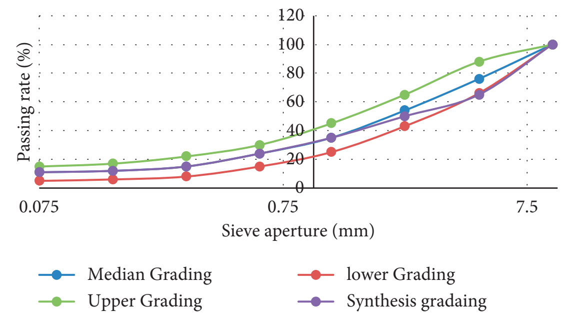

Figure 1: Grade curves of microsurfacing.

Table 2: Technical specifications of modified emulsified asphalt.

Test items	Test results	Technical indicators
Evaporation residual mass fraction/%	63.6	≧60
Remaining amount on the screen/% (1.18 mm screen)	0.02	≦0.1
Storage stability/1d	0.8	≦1
Enge La viscosity/E_{25}	11.76	3–30
Residual penetration/0.1 mm	70.5	40–100
Residual softening point/°C	57	≧57
Residual ductility	26	≧30

Table 3: Test results of water-based epoxy resin and waterborne epoxy curing agent.

Test items	Waterborne epoxy resin	Waterborne epoxy curing agent
Solid capacity	98	50
Epoxy equivalent(total)	188	
Amine hydrogen equivalent(total)		286
The concentration of volatile organic compounds quality	1	1
pH	8	8

3.2. Water Damage Resistance of High-Performance Microsurfacing. The wear value of 6D can characterize the water damage resistance of the microsurfacing mixture. The greater the 6D wet-wheel wear value, the worse the mixture's antiwater damage ability, otherwise, the better. In order to evaluate the high-performance microsurfacing's water resistance performance, 1%, 2%, and 3% doses (compared with the quality of emulsified asphalt) of water-based epoxy resin

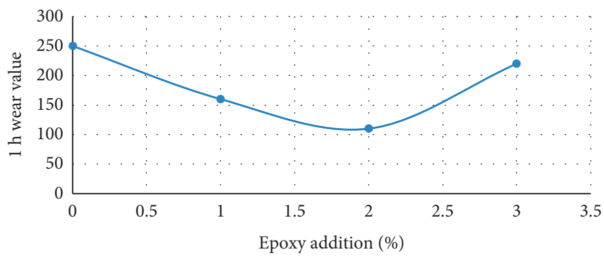

Figure 2: Test results of water-based epoxy resin and waterborne epoxy curing agent.

and related waterborne epoxy curing agent was put into the modified asphalt. Then, we obtained the microsurfacing mixture. Test results of the 6D wet-wheel wear test about different mixing amounts of waterborne epoxy additives are shown in Figure 3. The following conclusions can be obtained from Figure 3:

(1) With the increase of waterborne epoxy additives amount, the water damage resistance of microsurfacing is enhanced. Compared with the conventional micro 6D wet-wheel wear test results, the 6D wet-wheel wear value of the microsurfacing with 2% water epoxy resin was reduced by 57%.

(2) When the amount of waterborne epoxy additive is 3%, the 6D wet-wheel wear value in micro is very big compared with 1h wet-wheel wear value. The reason may be as follows. The maintenance time of the 6D wet-wheel wear test is long. So, the curing time for water-based epoxy additives is full. And it greatly improves the water damage resistance of microsurfacing.

(3) According to laboratory tests and engineering economy results, this paper suggests that the amount of water-based epoxy resin should be controlled by 2%.

4. Results and Analysis of Accelerated Loading Test

4.1. Pavement Function Accelerated Loading Test System. In this paper, the road performance of high-performance microsurfacing is evaluated by the “tire drive type pavement accelerated loading test system” developed by the South China University of Technology, as shown in Figure 4 [27, 28].

Test conditions: the ambient temperature is 25 °C, the tire pressure is 0.7Mpa, and the driving wheel’s speed is 1500 r·min^{-1}. The cementitious concrete test is used as the carrier of microsurfacing conservation, and the pavement is simulated according to the actual construction conditions and thickness. In order to ensure that the water-based epoxy additive can be fully consolidated, the curing time of the microsurfaced specimen is 2h, and the accelerated loading test is carried out after the installation of the specimen.

4.2. Study on Antisliding Property of High-Performance Microsurfacing. Figures 4 and 5 show the relationship between the antisliding performance and the microsurfacing action times with different amounts of water-based epoxy additives. According to the experimental results, it can be known that the weakening of antisliding performance in the high-performance microsurfacing is slower than that of the conventional micro; the higher the amount of waterborne epoxy additives, the better the antisliding performance of high-performance microsurfacing.

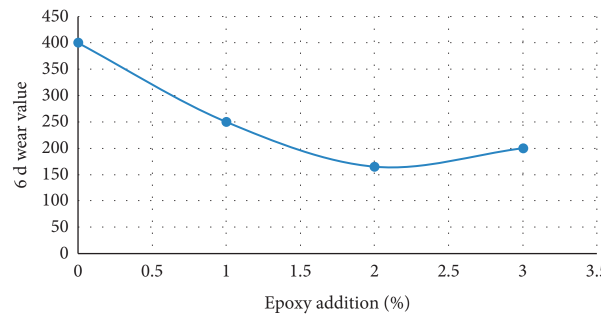

Figure 3: 6D wet-wheel wear values of high epoxy performance microsurfacing.

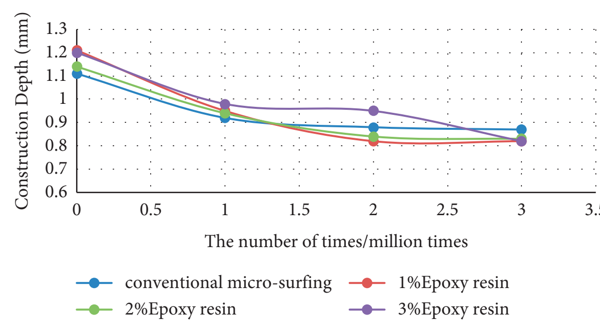

Figure 4: Curve of texture depth of epoxy high-performance microsurfacing.

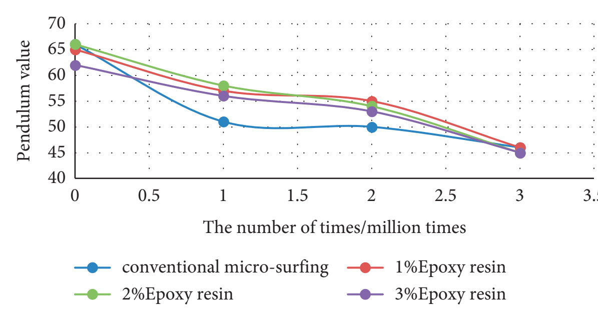

Figure 5: Curve of British pendulum number of epoxy high-performance microsurfacing.

4.3. Study on Antipeeling Performance of High-Performance Microsurfacing. Figure 6 shows the antipeeling performance of the high-performance microsurfacing and the conventional microsurfacing:

(1) With the addition of the water-based epoxy additive, the mass-loss rate of the mixture in the microsurfacing was obviously decreased, and the antipeeling performance was significantly improved.

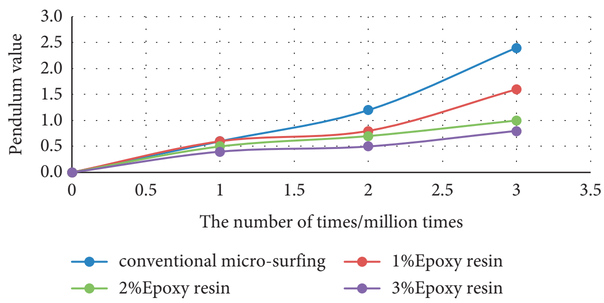

Figure 6: Curve of mass loss of epoxy high-performance microsurfacing.

(2) The greater the amount of waterborne epoxy additives, the better the antistripping performance. When the dose of additive reaches 2%, the mass-loss rate of the high-performance microsurfacing is 1.08%, which is much smaller than the mass-loss rate (2.36%) of the conventional one. It is shown that the bond strength between asphalt and aggregate can be greatly increased by the addition of waterborne epoxy additives. And the phenomenon of the drop in the microsurfacing is obviously decreased, and the antistripping ability is obviously improved.

(3) The mass-loss rate of the microsurfacing with 3% and 2% waterborne epoxy additives was slightly less, which were 1.08% and 0.78%, respectively. According to the results of the accelerated loading test, this paper suggests that the amount of waterborne epoxy additives should be controlled within 2%.

5. Field Test

In order to further verify the actual performance of high-performance micrometers in this paper, the high-performance microsurfacing work was carried out in a high-speed section from Guangzhou to Qingyuan. The mix design was carried out in accordance with the design method of ISSA. The raw materials of all test sections meet the requirements. The raw materials of this test section are 0–3 mm mineral material, 3–5 mm mineral material, 5–10 mm mineral material, and mineral powder [29]. The specific raw material experimental results can be seen in Table 4. The composition of the mixture at the micrometer is 0–3 mm: 3–5 mm: 5–10 mm: mineral powder = 30 : 30 : 30 : 10.

The test used Portland cement without any additives, numbered 425. Water should be used as a source of potable water, the amount of which should be determined according to the moisture content of the aggregate and the consistency of the slurry mixture during construction. This test is based on dry aggregate, and the amount of water used is about 3.5% of the aggregate.

After the laying of the experimental section, the materials of some high-performance microsurfacing materials were inspected, mainly the road friction coefficient experiment, the road structure depth experiment, and the flatness experiment, and compared with the ordinary micrometers laid at the same time. Table 5 data are obtained.

Table 4: Aggregate screening results.

Aggregate specification	Screen (mm) pass rate/%								
	12.5	9.5	4.75	2.36	1.18	0.6	0.3	0.15	0.075
0–3	100	94.3	8.1	1.7	1.4	1.2	1.1	1.1	1.0
3–5	100	100	94.2	21.7	3.4	1.2	1.1	1	0.9
5–10	100	100	100	97.5	62.3	37.8	19.3	9.3	4.8
Mineral powder	100	100	100	100	100	100	100	100	80

Table 5: Field test results of the micrometer.

Specification	Friction coefficient	Construction depth (mm)	Flatness
High-performance micrometer	56.8	0.78	2.1
Ordinary micrometer	50.1	0.41	3.0

6. Conclusion

Based on the results of the indoor wear test and accelerated loading test, the main conclusions are drawn as follows:

(1) Compared with conventional microsurfacing, the wear resistance and water damage resistance of high-performance microsurfacing are increased by about 60%, so the service life of microsurfacing can be greatly improved.

(2) The antisliding performance and spalling resistance of high-performance microsurfacing are obviously better than that of conventional microsurfacing; especially, the problem of falling particles in the conventional microsurfacing is solved.

(3) Water-based epoxy additives should be added appropriately. In this paper, the content of the waterborne epoxy additive is 2%.

(4) According to the market price of waterborne epoxy additives, the use of high-performance microsurfing at the mixed material will increase the engineering cost by 3–6 yuan per square meter. The increasing cost in engineering is relatively small, so it has good engineering application prospects.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare no conflicts of interest.

Acknowledgments

This study was supported by the Guangdong Provincial Natural Science Foundation of China (Grant no. 2019A1515011397).

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