Effects of Fineness of Rubber Powder on Micro-Surfacing Performance

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Abstract. In order to research the effects of fineness of rubber powder on micro-surfacing, the control variable method was used. Through a series of basic performance tests, performance indexes such as mixing time, cohesion torque, wet track abrasion value and load wheel sand value were studied. The results showed that waste rubber powder with 40 mesh had good effects on non-construction time, anti-wear performance, the density and water sealed performance of micro-surfacing.

1. Introduction
Micro-surfacing as one of pavement preventive maintenance technologies, it had good effects on the repairsments of pavement rutting and other diseases, in particular, the waste rubber powder dry micro-surfacing, it had great advantages in anti-cracking, anti-wear, anti-fatigue, riding comfort and other aspects. However, the quality of material was good, after paved still there were lots of problems in micro-surfacing. The practice showed that aggregate gradation had great effects on mix performance of micro-surfacing. The practice showed that the fineness of rubber powder in the mixture had a significant effect on the mix performance and micro-surfacing layer after paving. Therefore, in order to ensure the quality of the material used in the micro-surfacing, how to used a reasonable particle size of the rubber powder on the quality of micro-surfacing was essential. The effected of fineness of the waste rubber powder on the micro-surfacing performance was studied.

2. Properties of materials
2.1. Modified emulsified asphalt
SBR modified emulsified asphalt was used, the parameters met the requirements of micro-surfacing and slurry seal technology guide, the test results were shown in Table 1[1, 2].

| Pilot projects | Technical requirements | Test results | Experiment method |
|----------------|------------------------|--------------|------------------|
| Demulsification rate | Slow breaking | Slow breaking | T0658 |
| The remaining amount on the sieve | ≤0.1 | 0 | T0652 |
2.2. Aggregate

The test aggregates were basalt, with a small particle size of more than 9.5 mm, which had been sieved before the test. The main technical indicators were shown in Table 2[3].

| Evaporation residue properties | Penetration (100g, 25℃, 5s)/0.1mm | 40~100 | 88 | T0604 |
| Evaporation residue content/% | ≥60 | Cation+ | 62.5 | T0651 |
| Evaporation residue properties | Ductility (5℃)/cm | ≥20 | 80 | T0605 |
| Evaporation residue properties | Softening Point/℃ | ≥53 | 56 | T0606 |
| Evaporation residue properties | Solubility (trichlorethylene)/% | ≥97.5 | 99 | T0607 |
| Storage stability | 1d/% | ≤1 | 0.6 | T0655 |

Table 2. Aggregate technical properties and test results.

| Pilot projects | Technical requirements | Test results | Experimental method |
| Stone crushing value/% | ≤26 | 12 | T0316 |
| Los Angeles wear loss/% | ≤28 | 13.6 | T0317 |
| Stone polished value/BPN | ≥42 | 46 | T0321 |
| Ruggedness /% | ≤12 | 0.9 | T0314 |
| Stone needle-like content/% | ≤15 | 0.5 | T0312 |
| Synthetic mineral sand equivalent/% | ≥65 | 69.5 | T0334 |

2.3. Filling

Filling mainly cement and waste rubber powder. The cement used in this test was an ordinary portland cement without any additives, cement strength of 42.5MPa, the amount of 1.5% (with the mass ratio of aggregate). The role of waste rubber powder was mainly to improve the road surface flexibility, improve the mixture of water damage and anti-wear performance. The waste rubber used in this test was 40 mesh, 60 mesh, 80 mesh, the amount of 2% (with the mass ratio).

2.4. Water

The amount of water should be minimized when the requirements were met. The test used drinking water, and the content of water was 6% [1].

3. Performance of micro-surfacing
3.1. Mineral aggregate gradation

According to the design method of the International Slurry Seal Association, the MS-3 micro-surfacing gradation was used to design the mix ratio. According to the sieving results of the aggregates, the gradation used was shown in Table 3[4].

Table 3. Aggregate gradation table.

| Gradation type | Percentage of mass by the following sieve (mm)% |
|----------------|-----------------------------------------------|
|                | 9.5    | 4.75  | 2.36 | 1.18 | 0.6  | 0.3  | 0.15 | 0.075 |
| 5-10mm         | 100.0  | 9.7   | 2.0  | 1.9  | 1.9  | 1.8  | 1.8  | 1.7   |
| 3-5mm          | 100.0  | 93.8  | 3.4  | 1.5  | 0.9  | 0.8  | 0.7  | 0.7   |
| 0-3mm          | 100.0  | 100.0 | 77.8 | 57.9 | 42.6 | 29.0 | 20.9 | 15.1  |
| MS-3Upper limit| 100    | 90    | 70   | 50   | 34   | 25   | 18   | 15    |
| MS-3Lower limit| 100    | 70    | 45   | 28   | 19   | 12   | 7    | 5     |
| Median of gradation | 100.0 | 80.0  | 57.5 | 39.0 | 26.5 | 18.5 | 12.5 | 10.0  |
| Synthetic Gradation | 100.0 | 80.4  | 53.7 | 40.0 | 29.5 | 20.2 | 14.7 | 10.7  |

Notes: 5-10mm: 3-5mm:0-3mm=21%:11%:68%

3.2. Mixing time test and cohesion torque test

Through number of tests, it was determined that the best ratio of three different mesh rubber powders were used as aggregate: cement: used rubber powder: water: modified emulsified asphalt = 100: 1.5: 2: 6: 16, the test results were shown in Table 4 [1], [5-9].

The cohesion test was carried out using the same mixing ratio as the mixing test, and the value of 300g aggregate was used. The test results were also shown in Table 4 [1], [5-9].

Table 4. Results of mixing time and cohesion test.

| The fineness of rubber powder | Mixing time/s | Non-construction time/s | 30min Cohesion torque/(N•m) | 60min Cohesion torque/(N•m) |
|------------------------------|---------------|--------------------------|----------------------------|----------------------------|
| 40                           | >180          | 350                      | 1.8                        | 2.3                        |
| 60                           | 140           | 300                      | 1.6                        | 2.3                        |
| 80                           | 120           | 220                      | 1.15                       | 1.8                        |

It could be seen from table 4 that the mixing time of the mixture with 40 mesh powder was more than 180s, the mixing time of the mixture of 60 mesh powder was 140s, the mixing time of 80 mesh powder was 120s, and the non-construction time was the same law in descending order. Mainly because the rubber powder adsorption emulsified asphalt capacity than the aggregate was strong, 40 mesh powder particle size larger, so relative to 60 mesh and 80 mesh powder specific surface area were much smaller, adsorption of asphalt emulsion was also very less, so there were enough emulsified asphalt and intermediate with more powder combination, the mixture would not become sticky, so the mixing time was longer. The 80 mesh powder was opposite. Mixed with 40 mesh powder 30min and 60min cohesion torque were in line with the requirements, and mixed with 80 mesh powder 30min and 60min cohesion torque were not ideal. The reason was that 40 mesh powder surface area was small, the adsorption of emulsified asphalt less, thus ensured a sufficient emulsified asphalt and
powder combination, made the specimen after the internal compact, 80 mesh powder was the opposite [5], [7-10].

3.3. Wet track abrasion test
Wet track abrasion test used the same mixing ratio as the cohesion torque test, and value of 800g of the aggregate was used. The test results were shown in Table 5.

Table 5. Results of wet track abrasion test and load wheel test.

| The number of powder mesh | Asphalt-aggregate ratio /% | Abrasion value 1h (g/m²) | Abrasion value 6d (g/m²) | Adhesion sand amount (g/m²) |
|---------------------------|---------------------------|--------------------------|--------------------------|---------------------------|
| 40                        | 9                         | 451                      | 735                      | 269                       |
|                            | 10                        | 280                      | 499                      | 288                       |
|                            | 11                        | 274                      | 437                      | 350                       |
| 60                        | 9                         | 937                      | 1022                     | 208                       |
|                            | 10                        | 481                      | 562                      | 260                       |
|                            | 11                        | 293                      | 521                      | 327                       |
| 80                        | 9                         | 1204                     | 1522                     | 179                       |
|                            | 10                        | 548                      | 984                      | 246                       |
|                            | 11                        | 467                      | 535                      | 305                       |

3.4. Load wheel test
The load wheel test was still the same mixing ratio as the cohesion torque test, and value of 500g of the aggregate was used. The test results were shown in Table 5. The 40 mesh powder particle size was larger, the specific surface area was small, the adsorption of asphalt emulsion less, 10% and 11% of the asphalt stone ratio there was enough emulsified asphalt and powder combination, and the specimen dense. The 80 mesh powder was the opposite [5], [7-10].

4. Conclusions
(1) The use of 40 mesh of the rubber powder could properly absorb the mixture of excess emulsified asphalt, and asphalt emulsion was not reduced too much.
(2) The mixing time of waste rubber powder dry micro-surfacing was greatly affected by its fineness of rubber powder, the finer the powder, the shorter the mixing time.
(3) When the mesh of powder was greater than 60, the cohesion torque of micro-surfacing was lower than the specification requirements, rubber powder of 60 mesh or less was recommend. The powder mixture of 40 mesh powder had good abrasion resistance, and the asphalt emulsion by powder was less, and the specimen of 40 mesh rubber powder micro-surfacing was stabled and compacted.

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