Study on Adaptability of Different Asphalt Materials to Large Stone Porous Asphalt Mixture

Qunqun Bao¹, Weidong Chen², Xiaoxia Liu², Fei Yang³,*

¹Inner Mongolia High-grade Highway Construction and Development Co., Ltd. Hohhot, Inner Mongolia autonomous Region, China
²Wuhai City Transportation Bureau, Wuhai, Inner Mongolia autonomous Region, China
³Shandong Institute of Traffic Science. Jinan, Shandong province, China

*Corresponding author: yangfei@sdjtky.cn

Abstract. In order to explore the adaptability of different asphalt materials to the Large stone porous asphalt mixture, this paper respectively carried out four different binder technical indicators testing, lspm-30 mixture design and mixture performance testing. The research shows that rubber asphalt, SBS modified asphalt and MAC modified asphalt can be used as the binder of the Large stone porous asphalt mixture.

1. LSPM binder design concept
LSPM is a kind of open-graded pervious asphalt gravel mixture with nominal maximum diameter of no less than 26.5mm. Compared with ordinary asphalt mixture, LSPM is a multi-functional mixture in pavement structure, with functions of drainage, rutting resistance, fatigue resistance, and relief of reflected cracks [1-2]. LSPM mixture on the gradation design requirement not only coarse aggregate meet considerable embedded crowded requirements, at the same time also to the requirement of binder is higher than ordinary asphalt macadam mixture, the binder used can make the LSPM mixture has more than ordinary asphalt macadam mixture modulus, higher water stability and stronger resistance to permanent deformation at high temperatures and durability, and design requirements in accordance with the specific volume index, in order to meet the drainage and alleviate the functions of the reflective crack [3]. Therefore, the large diameter permeable asphalt mixture generally needs to use the high viscosity asphalt as the binder. On the one hand, high viscosity asphalt can improve the overall strength, resistance to permanent deformation and fatigue of the mixture, on the other hand, make the mixture obtain a thicker asphalt film, enhance the adhesion of asphalt and stone, and improve the water stability of the mixture [4].

2. Comparative study of asphalt binder for LSPM
According to the characteristics of LSPM grading and application requirements, it is necessary to ensure that the aggregate has a certain thickness of asphalt film without leakage, and that the binder has a certain viscosity to improve the anti-flying performance of the mixture. MAC modified asphalt, SBS modified asphalt, rubber asphalt, matrix asphalt +fiber and other contributions to the performance of the mixture are different, which need to be further studied [5].
In this paper, four binder materials including SBS modified asphalt, rubber asphalt, matrix asphalt + fiber, and MAC modified asphalt were used for the test. The technical indexes are shown in the figure below:

![Figure 1. Comparison of technical indexes of different binders.](image)

By comparing the technical indexes of different asphalt binder, it was found that there was no obvious difference in the penetration indexes of the four binder. The penetration between SBS modified asphalt and MAC asphalt is close to 50 (0.1mm), which is harder than matrix asphalt and rubber asphalt. The softening point of MAC asphalt is 117°C, which is the largest of the four binders. The softening points of four binder materials from large to small are MAC modified asphalt > SBS modified asphalt > rubber asphalt > matrix asphalt. The kinematic viscosity (135°C) of the four kinds of binder also showed great difference. MAC asphalt and rubber asphalt were significantly larger than matrix asphalt and SBS modified asphalt. The residual penetration ratio (25°C) of the four materials all reached good indexes, among which the residual penetration ratio of MAC modified asphalt, SBS modified asphalt and rubber asphalt exceeded 80%.

3. Mix ratio design of LSPM mixture

After testing, the four kinds of binder meet the specification requirements. In this paper, four kinds of binder were used to design the mixture ratio of LSPM-30. The mixture was tested with local limestone, and the aggregate specification and raw material density met the specification requirements. The pass rate of LSPM-30 at all levels is shown in Table 1.
Table 1. LSPM-30 Grading.

| Mesh size (mm) | Ratio (%) | 31.5 | 26.5 | 19 | 16 | 13.2 | 9.5 | 4.7 | 2.3 | 1.1 | 0.6 | 0.3 | 0.1 | 0.07 |
|---------------|-----------|------|------|----|----|------|-----|-----|-----|-----|-----|-----|-----|------|
| 20-30         | 40        | 89.5 | 62.5 | 9.2| 3.5| 2.2  | 1.2 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.5  |
| 10-20         | 37        | 10   | 10   | 90. | 79 | 65.  | 43. | 13  | 5.3 | 3.2 | 3.2 | 3.2 | 3.2 | 2.2  |
| 5-10          | 13        | 10   | 10   | 10  | 10 | 96.  | 32. | 12  | 4.6 | 2.2 | 2.2 | 2.2 | 2.2 | 1.6  |
| 2.36-5        | 3         | 10   | 10   | 10  | 10 | 10   | 97. | 18  | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 1.6  |
| ≤2.36         | 6         | 10   | 10   | 10  | 10 | 10   | 96. | 30  | 3.5 | 3  | 1  | 2   |     |      |
| Quicklime powder | 1        | 0    | 0    | 0   | 0 | 0    | 0   | 0   | 0   | 0  | 0 | 7  | 6   | 91.4 |

In order to simulate the actual compaction condition of the mixture, four kinds of binder specimens were formed respectively by Superpave rotating compaction forming instrument (SGC). The test results show that the LSPM mixture is mainly large particle size aggregate, and the matrix asphalt drops more seriously during demodulation, and the rubber asphalt has the best adhesion to fine materials, and the core sample is more complete.

The calculation method and the actual measurement method were respectively used to calculate the void fraction of the specimen. The calculation results of porosity are shown in Table 2.

Table 2. Performance Index of asphalt mixture (3.2% asphalt content).

| Binder         | MAC Modified Asphalt | Matrix Asphalt | SBS Modified Asphalt | Rubber Asphalt |
|----------------|----------------------|----------------|----------------------|---------------|
| Calculate Voidage (%) | 16.5                | 16.9           | 15.9                 | 16.7          |
| Measured Voidage (%)   | 16.6                | 15.3           | 15.9                 | 16.9          |

It can be seen from Table 2 that the void fraction of the four binder asphalt mixtures has little difference, all between 15% and 17%. There is little difference between the calculated and measured voidage values of LSPM-30 mixture. However, due to poor adhesion of matrix asphalt and serious material dropping, the measured voidage loss is relatively large. Therefore, IT is not recommended to use matrix asphalt as binder for LSPM.

4. Comparative evaluation of mixture performance

For the asphalt mixture with large diameter, leakage and dispersion are the key indexes of the performance of the mixture. In this paper, the maximum asphalt consumption to ensure that asphalt does not flow is determined by leakage analysis test, and the minimum asphalt consumption to ensure that drainage asphalt mixture does not fly is determined by flying test. The test results are shown in the figure below.
Figure 2. Lspm-30 insertion and dispersion tests for different binder materials.

It can be seen from Figure 2 that the leakage indexes of the four binder asphalt mixtures are all less than 0.3%. The leakage index of SBS modified asphalt was the most serious, reaching 0.28%. This is because under the same volume index, the amount of SBS modified asphalt is smaller than that of other binder, so the possibility of leakage of SBS modified asphalt becomes greater under the same amount of asphalt. Because of its hardness, rubber asphalt has better adhesion and is not easy to leak out, and the leakage index is obviously better than the other three binder.

The flying loss of the four binder asphalt mixtures in this test all exceeded 20%. One of the main reasons for this result is that LSPM has a large void fraction and less filling. In addition, due to the high ambient temperature of the specimen forming, the mixture is also prone to material dropping. The test results showed that the SBS modified asphalt mixture had the lowest flying loss and the best adhesion to aggregate, the mass loss of MAC asphalt and rubber asphalt was close to that of MAC asphalt, and the mass loss of matrix asphalt was the largest, reaching 42.7%.

In order to verify the high-temperature stability of LSPM mixture, the research group used MAC modified asphalt, SBS modified asphalt and rubber asphalt to conduct the lspm-30 rut test. The rut test specimen was 8cm thick. The experimental results are shown in Table 3.

Table 3. LSPM-30 rutting test of different binder.

| Binder                  | MAC modified asphalt | SBS modified asphalt | Rubber asphalt |
|-------------------------|----------------------|---------------------|----------------|
| Dynamic stability (mm/min) | 4632                | 3723                | 4479           |

It can be seen from Table 3 that the three kinds of mixture formed by the combination materials all meet the recommended indexes in The Technical Specification for The Application of Large Diameter Pervious Asphalt Mixtures (DB37/T1161-2009). MAC modified asphalt and rubber asphalt dynamic stability is more than 4000mm/min, high temperature stability is good.

5. Conclusion
In this paper, four kinds of different binder technical indexes were tested. LSPM-30 mixture design and mixture performance testing work, the main conclusions are as follows:

(1) From the perspective of the properties of matrix asphalt, rubber asphalt, SBS modified asphalt and MAC asphalt, rubber asphalt, SBS modified asphalt and MAC asphalt can all be used as cementing materials in the design of LSPM, among which the performance indexes of rubber asphalt are close to or better than MAC asphalt.

(2) During the mixture ratio design of matrix asphalt, there are obvious differences between the voidage data obtained by calculating algorithm and measured method. Due to the poor bonding ability
of matrix asphalt, compared with other binder, it is more likely to lose the material, so it is not suitable for use as LSPM binder.

(3) Leakage analysis and dispersion tests of four asphalt binder asphalt mixtures show that SBS modified asphalt is more likely to produce leakage analysis than other asphalt mixtures. Rubber asphalt has the best adhesion and leakage test index. The quality loss indexes of the four materials are close, among which SBS modified asphalt is the best.

(4) Rut test shows that rubber asphalt, SBS modified asphalt and MAC asphalt forming mixture have good high temperature stability, and the dynamic stability of rubber asphalt and MAC asphalt is more than 4000 mm/min.

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