Analysis of Influencing Factors and Evolution Law of Surface Anti-slide Performance of SMA-13 Based on Expressway Physical Engineering

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Abstract. Relying on the physical projects of Guangdong Province Chaohui expressway, Wushen expressway Renbo Section and Foqingcong expressway, based on asphalt and asphalt mixture test and on-site SFC test detection, through mathematical statistics, the factors affecting the skid resistance of SMA-13 asphalt mixture are obtained. At the same time, based on the observation of anti-skid performance of SMA-13 asphalt pavement from one year after construction to one year after opening to traffic, the change law of anti-skid performance of SMA-13 asphalt pavement from post-construction, temporary pass, acceptance and opening to traffic is obtained. The research results show that factors such as asphalt binder, mineral aggregate synthesis gradation, different oil-stone ratios and aggregate processing technology are possible factors that affect the anti-skid performance of SMA-13. The early anti-skid performance of SMA-13 asphalt pavement usually cannot meet the acceptance standard of SFC=54. However, the SMA pavement after construction can be spread with 3~5mm gravel to improve its early anti-skid performance, and the on-site treatment effect is better.

Keywords: Road Engineering, SMA-13, Anti-skid Performance, Evolution Law.

1. Introduction

As people pay more attention to traffic safety, higher requirements are put forward on the anti-skid ability of road surfaces. Especially in the rainy season, because of the existence of water film on the road surface, the anti-skid performance is greatly reduced, which makes the vehicle slip out of control and causes great loss of life and property. Therefore, the asphalt concrete pavement must have good
wear resistance and anti-skid performance to resist the wear loss of vehicle tires on the road surface, delay the attenuation of the pavement texture structure, maintain the anti-skid performance of the road surface, extend the service life of the road, and improve the economics and safety of the road [1-3].

SMA is a very eye-catching asphalt mixture in the world recently. It is famous for its excellent anti-rutting performance and anti-skid performance, but it also has the characteristics of thick asphalt oil film. This not only affects the comfort of the car, but also endangers the safety of the car. However, as far as the current research is concerned, there are relatively few studies on the early anti-skid mechanism of SMA-13 [4]. However, to clarify its anti-skid mechanism, it is necessary to clarify the factors that influence the anti-slide performance of SMA-13 and the evolution rule of anti-slide performance must be made clear. Therefore, through the analysis of the performance of the raw materials and mixtures of three asphalt pavements in Guangdong Province with SMA-13 anti-skid surface layer, the factors that affect the anti-skid performance will be clarified. According to the long-term observation results, the evolution law of skid resistance of SMA-13 asphalt pavement is obtained.

Chaohui expressway, Renbo section of Wushen expressway and Fuqingcong expressway are located in the east, north and central part of Guangdong Province. Chaozhou-Huizhou expressway in Guangdong Province also known as Chaohui expressway (Code C in the text). Chaohui expressway is an important part of the "fourth horizontal" in the "nine verticals, five horizontals and two rings" of the "Guangdong Expressway Network Planning (2004-2030)". Chaohui Expressway starts at Guxiang Town, Chaozhou and ends at Daling Town, Huidong County, Huizhou. The total length of the route is about 246km. Wuhan-shenzhen expressway, named Wushen expressway (Code W in the text) for short, is the Wuhan-shenzhen expressway planned by the State Grid. The total length of the project is about 1083km. Its renbo section is located in Guangdong Province. Foqingcogn expressway (Code F in the text) is divided into the southern section (Foshan border section) and the northern section (Guangzhou and Qingyuan Border Section) according to the boundary between Foshan and Guangzhou, with a total length of about 84 km. The three expressways are all in high temperature and high humidity environment and heavy traffic environment all year round. They have high requirements on the anti-skid performance of the road surface. Therefore, the upper layers of the three expressways all use SMA-13 anti-skid asphalt mixture, and the asphalt layer structure is shown in Fig. 1.

![Figure 1. Schematic diagram of asphalt layer structure of three expressways](image)

2. **SMA Composition Analysis**

SMA has the advantages of anti-skid, wear-resistant, compact and durable, anti-fatigue, anti-rutting and anti-low-temperature cracking. It is widely used in road construction all over the world. SMA is a kind of asphalt mastic binder composed of asphalt, mineral dust and fiber stabilizer. It is filled in the discontinuous graded mineral skeleton to form an asphalt mixture. The composition of the Stone mastic asphalt mixture is shown in Fig. 2. It can be seen from this figure that because SMA is a dense skeleton structure, its design concept is that the coarse aggregate forms a stone-stone contact skeleton, and enough asphalt mastic is filled in the gap of the coarse aggregate skeleton. Therefore, its performance will be affected by the coarse aggregate skeleton and the performance of asphalt mastic.
3. Analysis of the Difference in Composition of Three Expressway SMA-13 Materials

3.1. Analysis of performance difference of asphalt binder
Fig. 3 is a comparative analysis diagram of the performance of the asphalt binder used in the three expressways. From the graph, it can be seen that there are some differences in penetration, softening point, penetration index and kinematic viscosity of three highway asphalt binders. Among them, the difference of Penetration Index PI was the biggest. The $P_{IC}$ was 2.3 times of the $P_{IW}$. The $PI_F$ was 9.1 times of the $PI_W$. The softening point of Chaohui expressway is close to that of Renbo section of Wushen expressway. Both are 13.7% larger than Foqingcong’s expressway softening point.

3.2. Analysis of aggregate diversity
Fig. 4 is a comparative analysis of three expressways aggregate performance. It can be seen from this figure that there is a certain difference between the Los Angeles abrasion value and the aggregate crush value. In terms of the Los Angeles abrasion value of aggregate, the aggregate crush value of Chaohui expressway is about 30.8% and 48.9% higher than that of Renbo Section of Wushen expressway and Foqingcong expressway. In terms of aggregate crushing value, the aggregate crushing value of Chaohui expressway is about 17.5% and 27.9% higher than that of Renbo Section of Wushen expressway and Foqingcong expressway.
3.3. Analysis on the difference of Fiber Stabilizer

Fig. 5 is a comparative analysis of the properties of three expressways fibers. It can be seen

![Figure 5. Comparative analysis of fiber performance](image)

From this figure that the fiber oil absorption rate of the Renbo section of Wushen expressway is about 17.7% and 21.8% than that of Chaohui expressway and Foqingcong expressway.

3.4. Analysis of the difference of SMA-13 synthetic gradation and asphalt aggregate ratio

Mix Design of asphalt mixture mix includes three stages: target mix ratio design, production mix ratio design and production mix ratio verification[5]. Fig. 6 is the comparative analysis result of three expressways SMA-13 production mix ratios. Table 1 is the comparative analysis result of three expressways SMA-13 mixture test results. In table 1, The Pa is the asphalt aggregate ratio. The MS is the marshall stability. The DS is the dynamic stability. The $\gamma_f$ is the bulk specific gravity of bituminous mixtures. The VV is the percent air voids in bituminous mixtures. The VMA is the percent voids in mineral aggregate in bituminous mixtures. The VFA is the percent voids in mineral aggregate that are filled with asphalt in bituminous mixtures.

![Figure 6. Analysis of differences in SMA-13 production gradation of three expressways](image)

**Table 1.** Comparative analysis of test results of three expressways SMA-13 mixtures

| Expressway Name | Pa/\% | MS/\% | DS | $\gamma_f$ | VV/\% | VMA/\% | VFA/\% | MS/kN |
|----------------|-------|-------|----|------------|-------|--------|--------|-------|
| C              | 5.8   | 91.1  | 9356 | 2.397      | 3.8   | 17.0   | 77.6   | 8.40  |
| W              | 6.2   | 92.4  | --  | 2.513      | 3.9   | 17.8   | 77.8   | 8.94  |
| F              | 5.8   | 93.7  | 9012 | 2.522      | 3.8   | 16.9   | 77.4   | 7.86  |
| Technical requirements | --   | ≥80    | ≥5000 | 3~4.5      | ≥17.0 | 75~85  | ≥6.0   |
It can be seen from Figure 6 that there is a certain difference between the 9.5 mesh pass rate of SMA-13 and the 4.75 mesh pass rate that affects the formation of the aggregate embedding mode. The grading of Chaohui and Wushen expressways in Renbo section is thicker than that of Foqingcong expressway. As can be seen from Table 1, the asphalt aggregate ratio of three expressways SMA-13 asphalt mixtures is different.

4. Analysis of Anti-skip Performance of SMA-13 Asphalt Pavement

According to the previous analysis, factors such as different asphalt binders, synthetic gradations of mineral aggregates, different asphalt aggregate ratio and aggregate processing techniques will affect the anti-skip performance of SMA-13. As can be seen from Fig. 7, the SFC of SMA-13 pavement structure in Renbo section of Wushen expressway reaches 60.6 after 9 months, while the SFC of Chaohui expressway reaches 60.3 after 1 year. This shows that the technical parameters of the raw materials and mixtures of SMA-13 and the refinement of the construction process may affect the anti-skip performance of the SMA-13 pavement structure.

![Figure 7. SFC comparison analysis of two expressways on different opening dates](image)

Fig. 8 shows the long-term performance development trend of Chaohui expressway SFC. From this diagram, we can know the evolution law of early anti-skip performance of SMA-13 asphalt pavement, which is a physical project represented by Chaohui expressway. It can be seen from this figure that with the extension of traffic time, the anti-skip performance of the pavement surface gradually increases, which is divided into the following three stages.

1. From 0 to 4 months, because the temperature is still low, the traffic volume is small, the asphalt film of the pavement is worn out and the edges and corners of the aggregate are slowly revealed. Although the anti-skid performance of the pavement has increased, the SFC still can’t reach more than 54.

2. In 4 to 6 months, as the temperature gradually rises, the asphalt film on the surface wears more and more, and the edges and corners of the coarse aggregate gradually become prominent. This stage is a relatively slow growth stage in the anti-skip performance of the road surface. At the end of the month, the SFC basically reached 54.

3. In 6-9 months, as the high temperature weather continues and the traffic volume increases, the asphalt film on the road surface is depleted and the edges and corners of the aggregate are exposed. The anti-bone pavement mainly depends on the rough surface of the road surface aggregate. SFC is growing rapidly, and SFC can basically reach more than 60 after one year of opening to traffic.
5. Conclusion

Based on the investigation of the raw materials and mixture properties of the anti-skid surface layer of SMA-13 expressway in Guangdong Province, Chaohui expressway, Renbo section of Wushen Expressway and Foqingcong Expressway, it is proposed that factors such as asphalt binder, mineral aggregate synthesis gradation, different asphalt aggregate ratio and aggregate processing technology are possible factors that affect the anti-skid performance of SMA-13. Based on the observation of the anti-skid performance of the SMA-13 pavement from post-construction to the opening of traffic for one year, the change rules of the SMA-13 pavement structure during post-construction, temporary traffic, construction acceptance, and traffic opening are obtained. At the same time, it is proposed to spread 3-5mm gravel on the completed SMA pavement to improve its early anti-skid performance.

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