Analysis on the De-noise Effect of Anti-skid Noise Reduction Asphalt Pavement

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ABSTRACT: Through the field test for the noise of anti-sliding and noise-reducing asphalt pavement in the test section and the compare the test results with dense gradation asphalt pavement in the adjacent test section, the analysis results showed that the anti-sliding and noise-reducing asphalt pavement possessed obvious noise reduction performance, but it has a certain attenuation in the later process of using. In general, the anti-sliding and noise-reducing asphalt pavement generates smaller noise than the ordinary dense gradation asphalt pavement, and it has a broad application prospect in urban road.

Keywords: Anti-skid noise reduction asphalt pavement; The noise; Noise-reduction performance; Application prospect

INTRODUCTION

In recent years, with the rapid development of highway traffic, the traffic noise pollution is increasingly serious, which has the serious influence to people's normal life and work. In the last 20 years, studies on low-noise asphalt pavement at home and abroad was mainly in the grading, the material, thickness, porosity, etc., and since 2000, a lot of test sections had been already paved for practical research[1]. Since the 1950s, open graded asphalt mixture has been widely used in many parts of the United States and Japan, the technology is becoming more and more mature[2]. The traffic noise pollution in many city is more and more serious and the noise in the downtown of many city is more than 80 dB. Along with the progress of The Times, it has made a big progress in the control of the mechanical noise, and now the noise between tire and ground has become the main source of traffic noise. The research appears that study only on the design of the tire can reduce 1 ~ 2 db noise. In order to improve the noise pollution further, the most effective way is to improve pavement performance, and the most important method is to reduce the radiation noise.

Indoor acoustics noise research on porous surface shows that the porous material indeed has a sound of absorption effect in theory. The noise measurement are done in open grading test road and adjacent dense gradation asphalt pavement, In the paper, by comparing the two kinds of pavement measured results the noise reduction effect is analysed.
THE NOISE REDUCTION PRINCIPLE

Apparently, non-slip noise asphalt has a larger gap between the cover face structure, which can make the noise produced tire contact with the road surface has larger dissipation space, reduce the air pressure, thereby significantly reducing noise\cite{3}. The road surface and tire noise is an important part of the pump noise, so, anti-sliding and noise-reducing asphalt pavement can effectively reduce noise pollution, when the car runs, the tires will extrude air high speed, the noise produced in ordinary dense gradation pavement almost is reflected into the air from a crack between the pavement and tire, and format the jet noise. The voids of antiskid noise reduction asphalt pavement is bigger. The air is through the gap in the process of tire quickly squeeze, pressure balance, most of the noise quickly swallowed up, which will be weakened the pump noise, the noise reduction effect thereby. Second, particle size of the stone of antiskid noise reduction asphalt pavement is larger than the dense gradation asphalt pavement, so, the road surface is flat after compaction, grain is less, in a certain extent which is, reduce the tire vibration noise.

TEST SECTION

The test section introduction. Test road is S103 line Liu yang section (K67 + 000 ~ K68 + 000), in Changsha city, Hunan province, located in north latitude 30 degrees to the south, which belongs to the subtropical monsoon climate, warm spring, early summer rainy, high temperature and heavy traffic load. The test road is a 1 km long and 12 m wide, design speed of 60 km/h and is secondary reconstruction road. The design gap rate of test section was 20%. The thickness of the surface layer is 4 cm OGFC - 13 asphalt mixture, which has the greatest effect of noise reduction\cite{4}. SBS modified asphalt in China petrochemical is used as binder oil, using diabase continuous gradation hot mix asphalt mixture paving, and steel roller compaction finally used forming. due to the large viscosity of modified asphalt, iron roller is not recommend to use \cite{5}. Structure of its surface is in the Fig. 1.

![Figure 1. Anti-slip noise reduction asphalt pavement structure.](image)

Asphalt mixture of test section. This aggregates selected is provided in the stone material factory at the junction of Jiangxi and Fujian. There are four kinds coarse aggregate of diabase 0 ~ 2.36mm, 2.36~4.75mm, 4.75 ~ 9.5mm, 9.5 ~ 13.2mm and limestone ore powder. By drawing the more advanced countries design method on drainage asphalt pavement in the United States, Japan and so on, combining with the characteristics of China, and Hunan local climate conditions, the corresponding standard is formulated. The grading range is recommended by the technical specification for construction of highway asphalt pavement OGFC - 13 gradation scope, refer to the United States and Europe at the same time new OGFC gradation scope. The passing rate on the standard 9.5 mm mesh is changed from 60% ~ 80% to
50% ~70%, namely the new grading range is more coarse than that of the original. The coarser gradation will improve the drainage function of mix and rutting resistance. The mixture ratio design method of drainage asphalt mixture is used the volume method of Marshall specimen, and the void fraction is used as the main indexes of proportioning design. The mixture is separately done through fort shellen analysis leakage test and Kentucky fort flying test, the optimum proportion of oil and mineral aggregate determined is 5.0%. Goal proportion of each material design is 4#:3 #:2 #: 1 #: = 12.0% : 2.0% : 36.0% : 44.0% : 6.0%, mixture gradation composition are shown in Table 1.

<table>
<thead>
<tr>
<th>Mesh</th>
<th>Aggregate gradation, The mesh (mm) pass rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>13.2</td>
</tr>
<tr>
<td>Synthetic gradation</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 1. Mixture gradation composition.

Based on the mix proportion design of target gradation and screening test results of hot bin, the grading combination design of proportion of production and debugging are done, the hot bin and mineral powder mass ratio is: 4 # warehouse: 3 # warehouse: 2 # warehouse: 1 # warehouse: powder = 13.0% : 4.0% : 35.0% : 43.0% : 5.0%. With objective optimum asphalt quantity ±0.3% three oil-stone ratio, in marshall stability test, the optimum production bitumen aggregate ratio finally determined by the experimental is 4.9%. Mineral Composition of production ratio are shown in Table 2.

<table>
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</tbody>
</table>

Table 2. Composition design of aggregate gradation of production mixture ratio.

The sampling inspection of test section. Test road was paved, at noon on January 4, 2015. In order not to affect the traffic, single mode is used in paving. The traffic should be opened after paving layer cool completely or surface temperature is lower than 50 °C. The sharp turn and emergency brake should be prohibited. In test road paving, in charge of transport vehicle some test samples are carried out and tested. test results is in Table 3.

<table>
<thead>
<tr>
<th>Test item</th>
<th>Void rate (%)</th>
<th>Marshall stability 60°C (KN)</th>
<th>Leakage loss (%)</th>
<th>Asphalt content in extraction test (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test results</td>
<td>20.8</td>
<td>13.2</td>
<td>0.44</td>
<td>4.81</td>
</tr>
<tr>
<td>Technical requirement</td>
<td>18~25</td>
<td>≥ 5.0</td>
<td>&lt; 0.8</td>
<td>4.7~5.0</td>
</tr>
<tr>
<td>note</td>
<td>T0708</td>
<td>T0709</td>
<td>T0732</td>
<td>T0722</td>
</tr>
</tbody>
</table>

Note: The leakage loss indicator of non-skid noise reduction asphalt pavement surface is not more than 0.8.
It can be seen from the table that asphalt mixture indicators meet the technical requirements.

**PAVEMENT PERFORMANCE TEST AND ANALYSIS**

After paving the testing road, the conventional performance test to the pavement are respectively made in January, April, June, September in 2015, including the structural depths (sand patch method), the pendulum type friction coefficient, roughness (3 meters in straightedge), water permeability coefficient and noise. At the same time, corresponding test to the adjacent dense gradation testing section are carried out for comparison. The noise is only analyzed in this article.

**Noise measurement.** On the process of the field noise testing, due to the large disturbance in the traffic, method of closing transportation for a short period was taken for 20m away from the manual measuring point, and it measured with the TES-1352 H type noise meter by putting it 2 ~ 2.5 m far from right tyres and 1 m height from ground. On both sides of the measuring point are the pond and fields, so the effects of noise reflection is out of the question. Test vehicle was a same ordinary car and it passed by the test road with 40 km/h, 60 km/h, 80 km/h speed accordingly. The mechanical noise was the main at low speed. In addition, S103 is a secondary road, for some security reasons, the maximal test speed should not exceed 100 km/h. The average noise comparison of two types of asphalt surface is shown in Fig. 2:

![Figure 2. Average noise contrast.](image)

It is shown in Fig.2 that the average noise of anti-skid and noise reduction asphalt pavement is apparently much smaller than the ordinary dense gradation asphalt pavement. With the increase of speed, the noise level of two kinds of pavement is lifted. It can be seen from the contrast data of the average noise, with the increase of testing speed, the net increment of traffic noise also increased accordingly, and the noise in dense gradation asphalt pavement at the speed of 60 km/h increased by 3.2 dB than that of 40 km/h, and the noise from anti-skid noise reduction asphalt pavement increase by 1.8 dB. At the speed of 80 km/h, the noise of dense gradation increased 5.5 dB than 60 km/h and the noise of anti-skid noise reduction asphalt pavement increased 4.5 dB. It can be concluded with the increase of speed, the noise reduction effect of the anti-skid and noise reduction pavement is more obvious and the noise reduction is more 1.8 ~ 4.5 dB than that of the ordinary dense gradation asphalt pavement.

**Noise reduction performance of anti-skid and noise asphalt pavement.** During the process of measuring the noise reduction of anti-skid noise asphalt pavement, it can
be found that not only the depth of the pavement gradually reduced, but also the noise increased under a same speed. The reasons mainly include, (1) the abrasion resulted from the running of all kinds of sedan cars, heavy freight cars, buses, etc. changes the structure of pavement, which leads to less space between tire and pavement and to the reduction of roughness of pavement, and in a certain degree, weakened the noise of the anti-skid effect and increase the vibration of tire/road; (2) The tested road is in rural area, and the tires of passing vehicle is not cleaned at both ends of the tested road, therefore lots of dust, dirt, and local household garbage gradually block small pores which significantly decreases the depth of pavement structure and finally affects the sound absorption performance of the anti-skid and noise reduction asphalt pavement. The details of the increased noise of two kinds of pavement are showed in Fig.3 and Fig.4 respectively.

![Figure 3. Change of dense graded asphalt pavement noise with speed and time.](image1)

![Figure 4. Anti-skid noise reduction asphalt pavement with the change of vehicle speed and time.](image2)

In Fig.3, after several months using under the same speed, the noise of the ordinary dense gradation asphalt pavement changed little, basically in the range of 1 ~ 2 dB. In Fig. 8, with the use of anti-skid and noise reduction asphalt pavement, the noise increased, but the noise had little and irregular change at the speed of 40 km/h. Sometimes the noise appears to be larger than that at the speed of 60 km/h, because at this speed it was greatly influenced by the noise of automobile engine. It can be seen in the Fig 4, with the noise at the speed of 60 km/h and 80 km/h, that noise of the anti-skid and noise reduction asphalt pavement increased by 1 ~ 2.5 dB over time. Thus, the noise reduction performance of the anti-skid and noise reduction asphalt pavement suffered from attenuation.

Because this provincial road was designed at the speed 60 km/h, and most of the cars driving on this road speed mostly on the left and right sides, average noise measuring for four times at this speed was analyzed and compared, the results is shown in Fig. 5.
It can be seen in the Fig. 5, under the conditions of 60 km/h, the noise of the dense gradation asphalt pavement had irregular fluctuations within the range of 0.3 ~ 1.4 dB. The noise of the anti-skid and noise reduction road increased over time, but eventually a steady trend appeared. On the whole, the noise of the latter one is smaller than the former one. Thus it can be seen although the noise reduction performance of the anti-skid and noise reduction pavement suffered from the attenuation, a certain amount of noise reduction performance was committed.

CONCLUSION

(1) Through the field noise testing to the anti-skid and noise reduction asphalt pavement and the ordinary dense gradation asphalt pavement, it can be concluded that anti-skid and noise reduction asphalt pavement has the excellent noise reduction performance which is lower than the ordinary dense gradation asphalt pavement for 1.8 ~ 4.5 dB.

(2) During the process of pavement being used, the noise reduction function of the anti-skid and noise reduction asphalt pavement is influenced in some degree, because of tires abrasive function to the road and lots of dust, dirt, and sundries block small pores. However, its noise reduction performance is better than the ordinary dense gradation asphalt pavement. Therefore, in the later using process, these small pores should be cleaned and dredge to ensure drainage noise performance of the pavement.

(3) Porosity of anti-skid and noise reduction asphalt pavement is larger and designed for 20% in this project. Macrovoid could effectively absorb the noise produced by the friction of tire/road, which reduces the traffic noise.

(4) Owing to the large porosity and skeleton type structure of anti-skid noise reduction asphalt pavement, there are relatively high requirements for the durability of pavement structure. In that structure, it is easy to storage water on the half of the effective porosity and to cause seriously damage to the skeleton structure during the winter freeze, which affects the service life of the pavement. In the tested section, the modified SBS viscous asphalt binder materials are used. There is a certain of noise reduction features itself and provides necessary guarantee for the durability of asphalt mixture.
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