The distribution and performance of reclaimed asphalt pavement materials

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Abstract. The asphalt content in reclaimed asphalt pavement has a great influence on the pavement performance of recycled asphalt mixture. However, few people have studied the distribution of asphalt content and its effect on the performance of reclaimed asphalt pavement. In this paper, the above problems are studied by means of SEM analysis, combustion test and other scientific means, and it is pointed out that the adherence rate of fine aggregate is an important index to measure the distribution of reclaimed asphalt pavement, and has a significant effect on the pavement performance of recycled asphalt mixture. In addition, this paper also analyzes the factors that have an important effect on the adherence rate of fine aggregates.

1. Introduction
In China, about 95% of the pavement structure is asphalt concrete, and its service life is always less than ten years, so that a large amount of reclaimed asphalt pavement (RAP) materials will be produced every year.

Reclaimed asphalt pavement material is often used as aggregate in recycled asphalt mixture. However, the biggest difference between reclaimed asphalt pavement materials and aggregates is that it contains a certain amount of aged asphalt[1], which makes the actual performance of the recycled asphalt mixture is different from that of the new mining aggregates[2, 3]. As a result, the pavement performance of recycled asphalt mixture is not good [4, 5]. Therefore, it is of great practical significance to study the distribution and performance of asphalt in recycled asphalt pavement for improving the road performance of recycled asphalt mixture.

2. Research method
In order to study the distribution of asphalt in RAP, this paper uses the 225kv industrial layered CT scanning system produced by YX-LON company in German to scan RAP, and selects the upper layer asphalt mixture which has been in service for 6 years. The mixture type is SMA-13, which are in the range of 9.5~16mm particle size. The scanned stereo simulation is shown in figure 1.
In addition, in order to compare the asphalt distribution difference between newly formed asphalt concrete and RAP, two asphalt concrete specimens formed in laboratory were scanned, as shown in figure 2. In order to avoid the destruction of aggregate caused by Marshall Test compaction, the forming method of the specimen is rotary compaction.

In addition to that CT scan, the combustion method also used to carry out the asphalt content of RAP in this paper, which is compared with the asphalt distribution rule of CT scan. At first, the RAP is crushed and sieved to be 9.5-16 mm, 4.75-9.5 mm, 2.36-4.75 mm and 0-2.36 mm, then the asphalt content test is carried out by using the combustion method, and the content of RAP asphalt with different particle sizes is measured.

3. Test results and discussion

3.1. Scanning results
From scanning, we found that in the RAP particle, the fine aggregate cements around the coarse aggregate, and there are many gaps in the concrete. In the view of the x-ray scanning, it is not the asphalt film covered in the coarse aggregate surface that improves the crack resistance of the concrete, which is not covered with the asphalt film in the coarse aggregate surface in the rap. Rather, it is attached to the fine aggregate micelles between coarse particles within the RAP.

The surface grayscale of different particle size is very different, the grayscale is different, the content of asphalt is different, the bigger the grayscale is, the greater the content of asphalt is. With reference to figures 1 and figures 2, the distribution of aggregate and asphalt in asphalt mixture specimen is uniform, the gap between aggregate and aggregate is filled evenly between asphalt and mineral powder, and the boundary between coarse aggregate and asphalt mortar is clear. In contrast, the coarse aggregate distribution in RAP is messy, and there are more spaces between fine aggregate and coarse aggregate, and the distribution of asphalt is not uniform.

The smaller the particle size in RAP is, the larger the gray scale of aggregate surface is, which indicates that the content of asphalt is higher. It is concluded that there are great differences between RAP and new-formed asphalt concrete in asphalt, coarse aggregate and void distribution.
3.2. Results of combustion
The bitumen aggregate ratio of four types of gradation is shown in Table 1. From the results of the experiment, we can see that, the smaller the particle size of RAP is, the larger the asphalt content is. Fine RAP particle has rich asphalt mortar.

As can be seen from the CT scanning section, 9.5~19mm RAP is a mixture of various types of RAP. Vgstudio max software was used to calculate and identify the cross-section data of 9.5~19mm RAP particles. The coarse RAP particles larger than 2.36mm accounted for 54% of the total cross-section area, and the fine aggregate micelles (fine RAP particles smaller than 2.36mm) accounted for 46% of the total cross-section area.

| particle size range (mm) | Proportion (%) | bitumen aggregate ratio (%) | asphalt content (%) |
|-------------------------|----------------|----------------------------|--------------------|
| 0~2.36                  | 25.3           | 7.66                       | 7.11               |
| 2.36~4.75               | 30.6           | 6.47                       | 6.08               |
| 4.75~9.5                | 19.8           | 4.62                       | 4.42               |
| 9.5~19                  | 24.3           | 3.59                       | 3.47               |
| Total (0~19)            | 100            | 5.70                       | 5.40               |

Fine aggregate micelles adsorbed 3.27% of the total asphalt content of 3.47%, accounting for 94% of the total asphalt content, while 2.39~19mm aggregate asphalt content was only 0.37%, accounting for only 6% of the total asphalt content. It can be seen that fine aggregate micelles adsorb asphalt in a large amount and the adsorption ratio is more than 90% in the 9.5~19mm RAP. Therefore, the adhesion rate of fine aggregate in RAP is an important index to evaluate the performance of RAP.

3.3. Influencing factors for RAP performance
As mentioned above, the adhesion rate of fine aggregate in RAP has a significant impact on RAP performance, so what factors affect this indicator? The effects of particle size, asphalt content and asphalt aging degree on the adhesion rate of fine aggregate in RAP are analyzed separately.

Particle size  The adhesion rate of fine aggregate is related to the particle size of RAP. The type of 9.5 ~ 19mm, 4.75 ~ 9.5mm and 2.36~4.75mm particle size, is 22.3%, 27.7% and 47.6% respectively. Therefore, the smaller the size of RAP, the adhesion rate of fine aggregate is higher.
Asphalt content The adherence rate of fine aggregate is correlated with the asphalt content of RAP. The asphalt content of 9.5~19mm, 4.75~9.5mm and 2.36~4.75mm RAP are 3.47%, 4.42% and 6.08% respectively, while the adherence rate of fine aggregate about the same RAP is 22.3%, 27.7% and 47.6% respectively. It can be seen that the adherence rate of fine aggregate increases with the increase of rap asphalt content.

Asphalt aging degree In addition, the adherence rate of fine aggregate with different service life also was tested in this paper. The sampling site was an expressway in Yichun, Jiangxi Province, which was opened to traffic for 2 years, 5 years and 7 years respectively, and the RAP is from the same pavement structure, the experimental results are shown in Table 2. With the increase of the working life, the adherence rate of fine aggregate in RAP decreases relatively.

Table 2. The adherence rate of fine aggregate with different service life

| service life (year) | Fractional sieving residue (%) | Cumulative sieving residue (%) | Passing through ratio (%) |
|---------------------|-------------------------------|-------------------------------|--------------------------|
| 2                   | 5.9                           | 79.9                          | 20.1                     |
| 5                   | 6.3                           | 81.7                          | 18.3                     |
| 7                   | 6.6                           | 82.3                          | 16.7                     |

4. Conclusion

Through the above argument, it is concluded that there are great differences between RAP and new-formed asphalt concrete. The smaller the particle size of RAP is, the larger the asphalt content is. Fine RAP particle has rich asphalt mortar. The particle size, asphalt content and asphalt aging degree of the RAP all have important impact on performance of RAP.

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