The microstructure and evaluation index of reclaimed asphalt pavement

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Abstract. A large amount of reclaimed asphalt pavements are produced every year, recycling and utilization of them as soon as possible can not only reduce the exploitation of natural aggregate resources and protect the natural ecological environment, but also help to solve the problem of reclaimed asphalt pavements. However, the complexity of structures and the lack of research on performance index have led to few successful applications about reclaimed asphalt pavements. In this paper the microstructure of reclaimed asphalt pavement was studied based on the X-ray CT scanning technology, by which the key factor in the evaluation of reclaimed asphalt pavement was found through analyzing the micrographs by VG Studio MAX image processing tool. The microstructure and evaluation index of reclaimed asphalt pavement provide a good foundation for application.

1. Introduction

For saving material costs, reclaimed asphalt pavements (RAP) are increasingly used to replace aggregate materials and virgin asphalt in asphalt mixtures, although RAP contains bitumen, it is only considered a special aggregate in design. Officially, for this reason, the use of more RAP often makes asphalt mixtures too stiff, consequently less workable, and difficult to compact in the field, which may ultimately lead to premature field failure of pavements [1].

Generally, RAP can be seen as a special black aggregate, aggregate surface was coated by asphalt [2], as shown in figure 1. In fact, the structures of RAP are complex, and the research on performance index is few [3].

In this paper the microstructure of RAP was studied based on the X-ray CT scanning technology in order to preliminary understanding the complex form, and through analyzing the micrographs by VG Studio MAX image processing tool, cast about for the key factor in the evaluation of RAP.

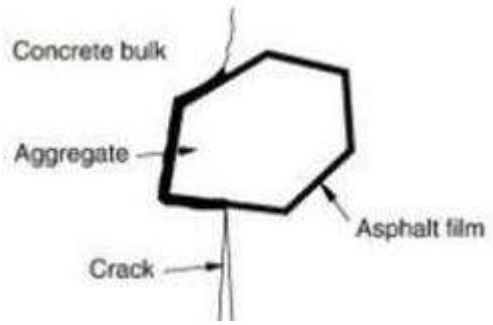

Figure 1. Special black aggregate (RAP)

2. Research methodology

X-ray is a combination of x-ray and computer technology; 3D reconstructed images of objects are obtained by using X-ray radiation imaging and computer 3D visualization technology [4].

The principle is that when x-ray penetrates the matter, its radiation intensity attenuates exponentially, and the attenuation rate is only related to the density of matter, which can establish the relationship between the density of matter and the absorption rate of ray, according to the conversion relation, the three-dimensional information of matter can be obtained by transforming it into the corresponding pixel gray value, and the three-dimensional reconstructed image of matter can be obtained by computer and 3D visualization technology [5].

In this paper, Rap in the range of 9.5-16mm sieve were collected for scanning by 225kv layered scanning CT produced in YX-LON Company of Germany. The sample being scanned is similar to the one shown in figure 2.

Figure 2. RAP sample being scanned

The principle of volume data visualization by VG Studio MAX is as follows: firstly, the discrete data are reconstructed to get the information of the continuous data field, then according to the visualization method selected in the software, the view line of view and the visual angle range are set. Based on the illumination model and display characteristics, the reconstructed data field is reused, and the re-sampled data is synthesized through the image to obtain the visualized image.

3. Microstructure of RAP

Based on the above experimental principles and techniques, the clear stereogram of rap could be collected as follows, shown in figure 3 and figure 4.

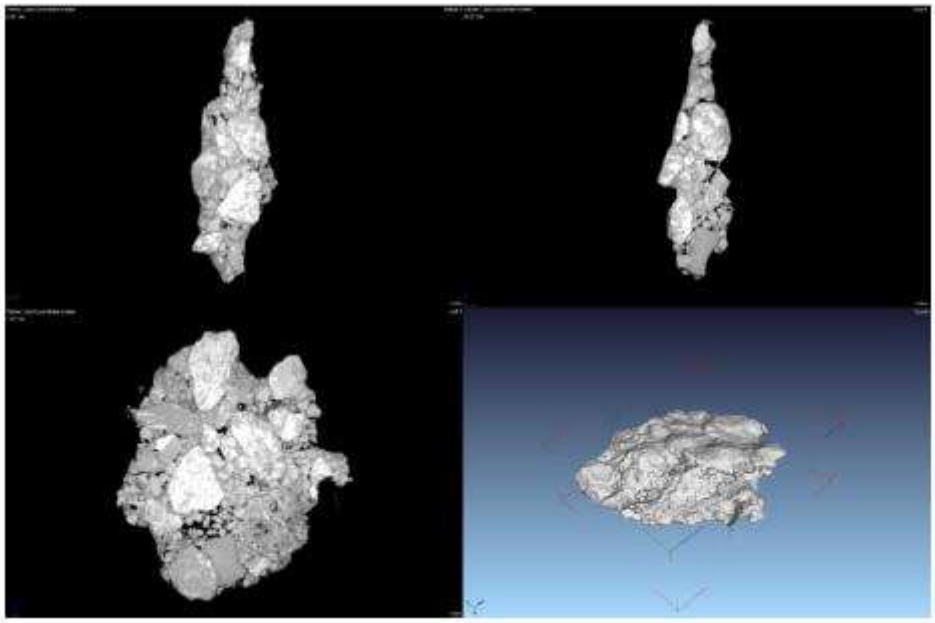

Figure 3. The Stereoscopic Perspective of RAP Ⅰ

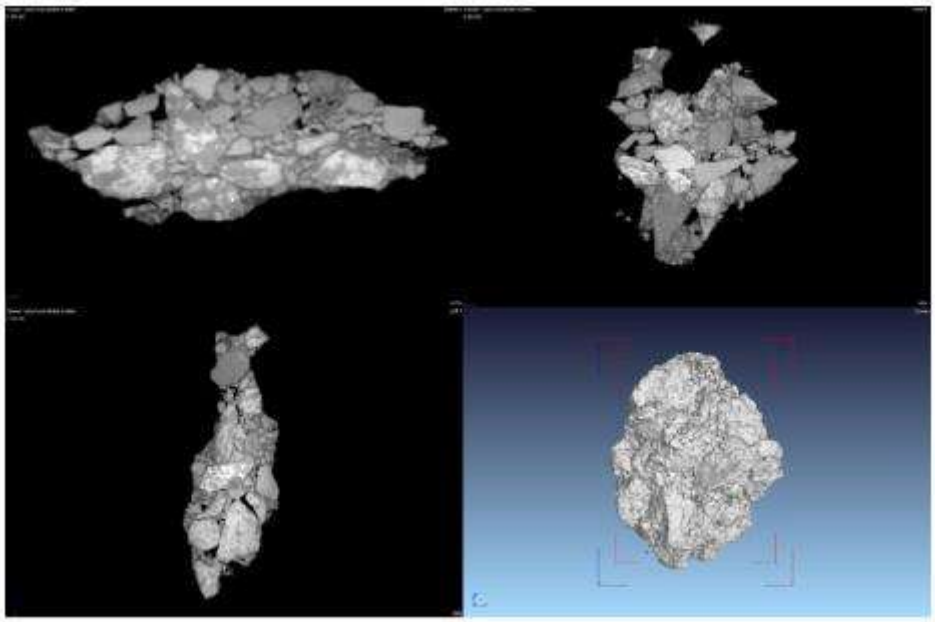

Figure 4. The Stereoscopic Perspective of RAP Ⅱ

The results show that the fine aggregate cemented in RAP particles adheres to the coarse aggregate, which is different from the above model in figure 1, in the figure 5 the cross-section of RAP can confirm this conclusion. The concept of 'black aggregate' is obviously not suited to RAP's real structure. It is necessary to find an evaluation index to explain the microstructure of RAP.

In the Figure.6, Cross-section of new asphalt mixtures contrast with figure 5, It can be found that the distribution of coarse aggregate is messy, the pore between coarse aggregate and fine aggregate is more, the distribution of asphalt content is uneven, and the smaller the rap particle, the larger the asphalt content, and the undispersed fiber also adsorbs a large amount of asphalt. There are great differences between RAP and new asphalt mixtures in asphalt, coarse aggregate, fine aggregate and porosity distribution.

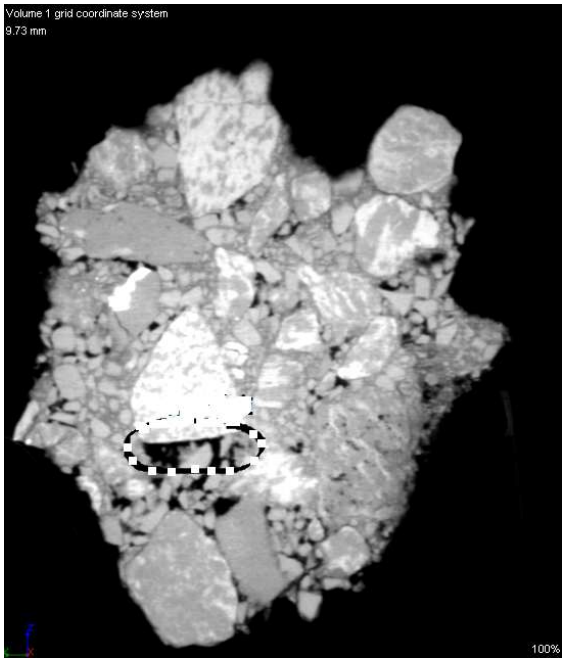

Figure 5. Cross-section of RAP

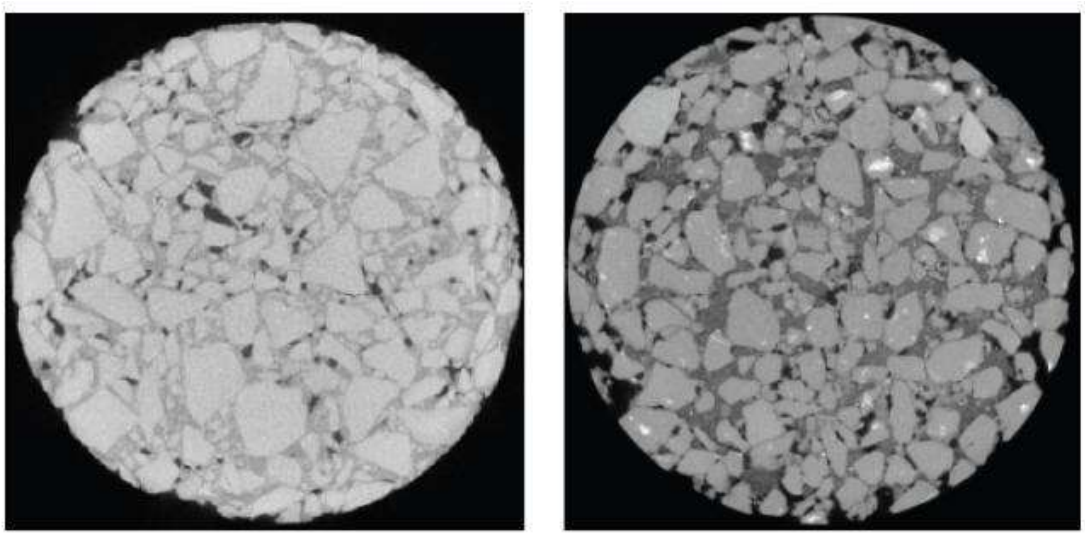

Figure 6. Cross-section of new asphalt mixtures

4. Evaluation index of RAP

From the above microstructure study of RAP, we conclude that the presence of asphalt in RAP materials is the key factor that distinguishes them from ordinary aggregates. Therefore, the distribution of asphalt is the key to evaluating the performance of RAP.

RAP in the range of 9.5-16mm sieve were mixture of various sizes of RAP, such as RAP in the range of 4.75-9.5mm, 2.36-4.75mm, 0-2.36mm sieve, through the combustion test, we have measured the asphalt content of RAP in the range of 9.5-16mm , 4.75-9.5mm, 2.36-4.75mm, 0-2.36mm sieve are 3.47%, 4.42%, 6.08%, 7.11%.

Recognition and calculation of RAP profile data by VG Studio MAX image processing tool, the following conclusion have been gain, the proportion of RAP above the range of 2.36mm sieve is 54%, the left RAP is fine RAP under the range of 2.36mm sieve, which proportion is 46%,named fine aggregate micelles, This ratio is multiplied by the asphalt content(7.1%), and the asphalt content of fine aggregate micelles is 3.27%(7.1%×46%=3.27%), it means that the most asphalt(3.27%÷3.47%=94%) were absorbed by fine aggregate micelles in RAP, which is the most significant impact on RAP performance, so that number of fine aggregate micelles attached to coarse aggregate particles in RAP is recommended to Evaluating index for RAP.

5. Conclusion

In this paper, the microstructure of reclaimed asphalt pavement was studied based on the X-ray CT scanning technology, by which an evaluation index of RAP were developed through analyzing the micrographs by VG Studio MAX image processing tool. Based on the test results, the following conclusions can be made.

(1) In RAP, the fine aggregate cemented in RAP particles adheres to the coarse aggregate, the concept of 'black aggregate' is obviously not suited to RAP's real structure.

(2) There are great differences between RAP and new asphalt mixtures in asphalt, coarse aggregate, fine aggregate and porosity distribution.

(3) Most asphalt were absorbed by fine aggregate micelles in RAP, number of fine aggregate micelles attached to coarse aggregate particles in RAP is recommended to Evaluating index for RAP.

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