Transactions of the Materials Research Society of Japan 25 [3] 681-683 (2000)

Application of Carbonized Waste Wood for Construction Engineering

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The use of recycled waste wood is not popular in the Japanese construction industry, with the use of waste wood generally being limited to fuel and chipboard. Although the relatively cheap prices of alternative materials have meant that there has little incentive to reuse waste wood, the present author believes that the recycling of waste woods could be developed for some application. One such application is the use of carbonized waste wood as an aggregate for pavements. This paper reports the results of laboratory tests of this aggregate that sought to investigate the possibilities of this application.
Key Words: Pavement, Aggregate, Wood Ceramics

1. INTRODUCTION

The recycling of waste wood from construction sites is not common. An analysis of the reasons for this revealed that the principle reason is that in the main markets for waste wood of fuel and board it is not very competitive in terms of price compared to virgin materials, resulting in little incentive to recycle. Waste wood is also at a disadvantage in terms of product quality. One way to solve this situation is to create a new market for the waste wood, in which no alternative materials exist.

To this aim, the author has been investigating new applications of waste wood in the field of civil engineering, and in particular, the use of carbonized waste wood as an aggregate for pavements. The author believes that the porous characteristic of this material provides the aggregate with specific properties.

2. TEST METHOD

This paper reports the results were conducted on a particular kind of carbonized waste wood, developed by Okabe, which is usually referred to as 'wood ceramics.' The test materials were formed from cubes of middle-density fiber board of one cubic centimeter in volume, which were carbonized in a vacuum at 800℃ after absorbing phenol resin. The weight ratio of the resin was 60% of the board. These specimens were then placed in a rolling compactor and crushed. The resultant aggregates were then sorted according to size and average diameter, before being used in the tests.

2.1 SPECIFIC GRAVITY AND WATER ABSORPTION TEST (based on JIS A 1109 and 1110)

The purpose of this test was to measure the specific gravity and water absorption rate both of coarse and fine aggregates. The specific gravity and water absorption rate of normal aggregates for asphalt mixtures are recognized as indices of durability against abrasion and of asphalt absorption, respectively. An acceptable absorption rate for asphalt is approximately 70 % volume.

2.2 ABRASION TEST OF COARSE AGGREGATE (based on JIS A 1121)

The abrasion loss of coarse aggregate is regarded as an index of the durability against wear and tear. It has been reported that the incidence of ruts increases when abrasion loss exceeds 20%.

2.3 RESISTANCE TO ASPHALT-FILM-STRIPPING TEST OF COARSE AGGREGATE (based on JPI-5S-27)

The purpose of this test is to identify the resistance to the stripping phenomena of hot asphalt mixture in the coarse aggregate.

2.4 SOUNDNESS TEST WITH SODIUM SULFATE (based on JIS A 1122)

The purpose of this test is to identify the durability of coarse and fine aggregates against the cold and melting.

The methodological details of the tests were determined with reference to the Pavement Laboratory Test Manual [2].

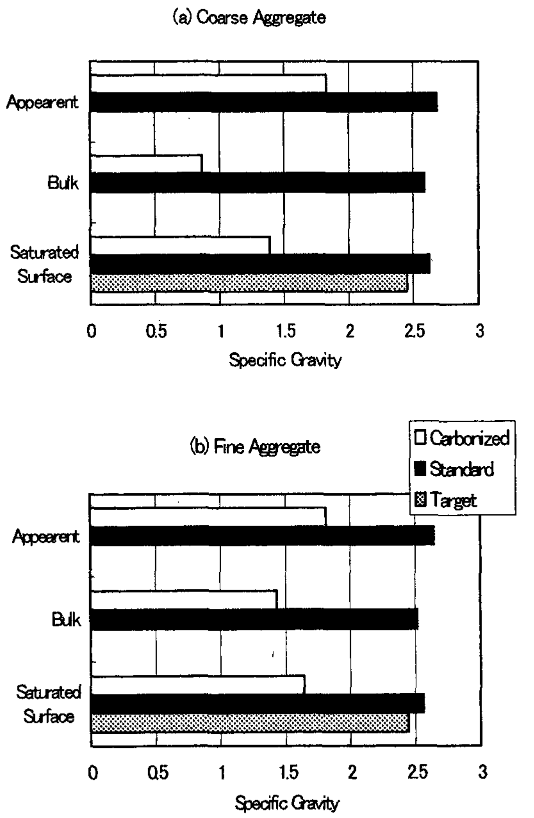

Fig.1 Specific Gravity

3. RESULTS

3.1 SPECIFIC GRAVITY AND WATER ABSORPTION TEST

Fig. 1 shows the specific gravity of the aggregates in a dry-surface condition.Fig.2 indicates the water absorption rates. The carbonized waste wood coarse and fine aggregate did not meet target values of less than 2.45% and 3.0%, respectively. The rate for the carbonized coarse aggregate was particularly high at 60%. The discrepancy between fine and coarse aggregate in the absorption rate was not identified in this paper, however, it might be influenced by the producing process of specimen. The crushing process could cause a lot of powder size of material and it could block the more pore of fine aggregate than those of coarse one because it took more crushing time for producing fine aggregate than for doing coarse one. Moreover, it was impossible to fill the total void with water within the absorption time interval 24 hours. The actual absorption rate might, therefore, be larger than the measured rate. The fact that there was considerable variation in the results for different samples of fine aggregates also suggests that the actual rates for these could be larger.

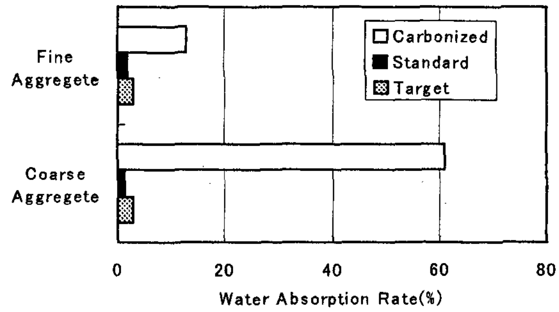

Fig.2 Water Absorption Rate

3.2 ABRASION TEST FOR COARSE AGGREGATE

The results are within the target value of 30% and indicate that the aggregate is sufficiently durable against abrasion. (refer Fig. 3)

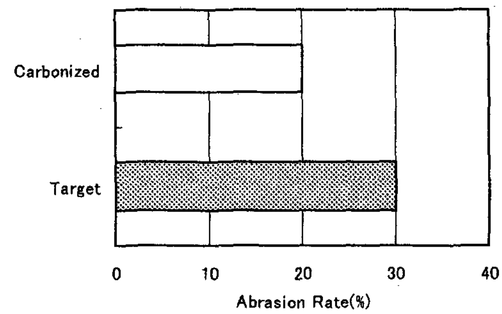

Fig.3 Abrasion Rate

3.3 RESISTANCE TO ASPHALT-FILM-STRIPPING TEST OF COARSE AGGREGATE

Fig. 4 shows the stripping area rates, which for the carbonized aggregate was 5%. Although, there is no clear standard or target value for this test, for straight asphalt coating with good quality aggregates the rate is thought to be less than 10%.Even for high-viscosity asphalt, which has very high coating performance, a value of 5% would be a good result. Consequently, the carbonized waste wood aggregates superior in terms of straight asphalt coating. However, about five times the amount of asphalt required for ordinary aggregates were needed to perfectly coat the carbonized aggregates, suggesting that these aggregates also absorb large amounts of asphalt, like water.

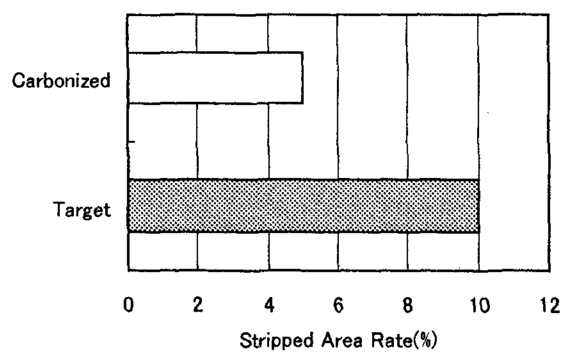

Fig.4 Stripped Area Rate

3.4 SOUNDNESS TEST WITH SODIUM SULFATE

Fig. 5 indicates the amount of loss due to sodium sulfate for all diameter sizes of coarse aggregates. All losses were less that the target of 12%. Aggregates with diameter of over 9.5mm had the greatest loss at 6.69 %. The coarse aggregate before testing contained a large amount of 9.5mm-sized aggregate. The reason for the greater loss is because the 9.5mm-sized aggregates passed through the sieve even when the loss was very small. The reason that the loss for the 4.75~9.5mm-sized aggregates was extremely small is due to contamination of these aggregates. Accordingly, it is possible that the actual loss for the carbonized aggregate might have been closer to 2%.

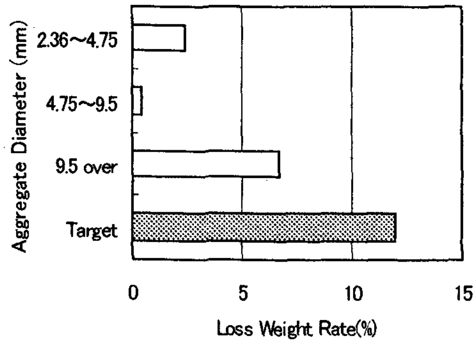

Fig.5 Weight Loss Rate

4. DISCUSSION

The carbonized aggregate did not meet the standards for specific gravity and water absorption rates. These are indirect indices of an aggregate's durability. In the results for the other tests, the aggregates showed relatively high performances. If the aggregates had failed in other tests apart from the test for specific gravity and water absorption rate, it would be easy to dismiss the aggregate as being unsuitable, but these mixed results make it impossible to reject the aggregate so lightly.

The present author plans to use the aggregate to develop an open-graded asphalt mixture. For this, it will be necessary to satisfy some conditions, however. The first is the need to develop a special point bonding for the aggregate. Secondly, the carbonized aggregate open-graded mixture will have to pass the relevant laboratory tests. Thirdly, it will also be necessary to conduct durability acceleration tests. Finally, the effects of the special surface treatment will need to be confirmed in the laboratory at least.

Once these four conditions have been satisfied, it should be possible to construct new pavements in a practical road as test construction. Good results in the follow-up research would be proof of the aggregate's identification.

5. CONCLUSION

The following results were obtained in the laboratory tests of carbonized aggregates:

(1) The carbonized aggregate failed to meet standards for specific gravity and water absorption rates.

(2) The carbonized aggregate did, however, pass tests for abrasion, resistance to asphalt-film-stripping test, and soundness.

These facts indicate the future possibility of developing carbonized waste wood aggregates for the pavement mixtures. However, it will necessary to meet four conditions outlined above and to conduct construction tests on site.

REFERENCE

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(Received December 16, 1999; Accepted March 30, 2000)