Analysis of Mechanical Properties of Cement Concrete Mixed with Waste Asphalt Mixture Powder

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Abstract: In order to solve the problem of reutilization of waste asphalt mixture, at the same time, in order to improve the mechanical properties of cement concrete, such as flexural tensile strength and so on, In this paper, based on the test of waste asphalt mixture powder obtained by special crushing and screening equipment, it replaces the quality of part of sand in cement concrete, and analyzes the influence of waste asphalt mixture powder on the mechanical properties of cement concrete. Through tests, it has been shown that the flexural tensile strength of cement concrete after replacing the 15% sand content in cement concrete with waste asphalt mixture powder is significantly improved, and the elastic modulus is decreased.

1 INTRODUCTION

With the gradual extension of the time of the road input and operation in China, the asphalt pavement of the early construction has entered the maintenance period, and the reutilization of the waste asphalt pavement material has been paid much attention. With the continuous popularization and application of cement concrete pavement, the quality requirements of the surface concrete material in the opposite layer are increasing. It is required that the surface concrete material should have higher flexural strength and lower elastic modulus. So as to avoid the occurrence of cracks in the early stage of pavement construction, improve the performance of cement concrete and prolong the service life of pavement. This article starts with these two common topics, blending waste asphalt mixture powder into cement concrete, and analyzing the effect of waste powder on the mechanical properties of cement concrete.

2 PRODUCT FEATURES OF WASTE ASPHALT MIXTURE POWDER

The waste asphalt mixture used in this experiment is used as the waste asphalt pavement milling material, and the waste asphalt mixture with grain size below 2.36mm is obtained by the self-made crushing and screening equipment.

2.1 Test of Waste Material Extraction and Three Major Index Tests

The test adopts the centrifugal asphalt mixture fast extraction instrument and takes the dry sample 1500g. According to the requirements of the test, three parallel tests are carried out, the average value is taken, finally obtains the asphalt content in the waste asphalt mixture powder to be 9.5%.

In order to characterize the properties of the waste material powder, the three indexes for recovering the asphalt were tested after the extraction test. The results are shown in Table 1.

Table 1 Extraction and recovery of asphalt properties.

index	25℃penetration (0.1mm)	15℃ductility (cm)	softening point（ring and ball method）(℃)
Value	28.6	1.2	56.2

2.2 Screening Test of Waste Asphalt Mixture Powder

In order to analyze the performance of waste material and determine its gradation, sieving test was carried out. Prior to each screening test, a small amount of lumps in the waste material powder were

crushed, and then a certain amount of waste material powder was taken and fully stirred and then sampled, two parallel tests were performed each time and a dry screening method was used. The test results are shown in Table 2.

Table 2 Results of screening test for waste material powder.

Screen size（mm）	2.36	1.18	0.6	0.3	0.15	0.075
Percentage passing (%)	100	99.0	87.7	76.0	46.7	26.7

3 ANALYSIS OF MECHANICAL PERFORMANCE OF CEMENT CONCRETE MIXED WITH WASTE POWDER

In this paper, the effect of waste material powder on the flexural tensile strength and elastic modulus of cement concrete is mainly analyzed. At the same time, the change of concrete compressive strength is analyzed, and the best dosage of the best waste material is summed up. The test program is based on the use of waste material powder instead of sand 0%, 10%, 15%, 20%, 25% five different mixing ratio of the mechanical properties of the test.

3.1 Flexural Tensile Strength

The flexural tensile strength of cement concrete for road pavement is the main strength index, and the compressive strength is used as a reference strength index. So when evaluating the performance of road cement concrete, we should first analyze whether its flexural strength meets the requirements. Through indoor standard test, the flexural tensile strength of concrete is shown in Table 3.

Table 3 The flexural tensile strength of concrete with different mixing ratios and ages.

Mixing ratios（%）	0	10	15	20	25
7d flexural tensile strength（MPa）	4.50	4.59	4.77	4.78	4.42
14d flexural tensile strength（MPa）	5.44	5.51	5.8	5.71	5.17
28d flexural tensile strength（MPa）	5.95	6.04	6.4	6.25	5.71

From Table 3 and Figure 1, we can see:

（1）When the mixing ratio is less than 20%, the flexural tensile strength of cement concrete mixed with waste material is improved, and when the proportion of mixing is 25%, the flexural tensile strength of the concrete is reduced to a certain extent.

（2）When the curing period was 7 days, the concrete flexural strengths of 10%, 15%, and 20% were higher by 2.0%, 6.0%, and 6.2%, respectively, than those of the concrete without blended waste powder.

（3）With a curing period of 14 days, the concrete flexural strengths of 10%, 15%, and 20%, respectively, increased by 1.3%, 6.6%, and 5.0%, respectively, compared with the concrete without undoped waste powder.

（4）When the curing age is 28 days, when the proportion of waste powder mixed is 15%, the concrete tensile flexural strength increases by 7.6%; the blending ratio is 20%, and the concrete flexural strength increases by 5.0%. Therefore, the integrated early concrete flexural tensile strength and 28-day standard strength, the best mixing ratio of waste powder is 15%.

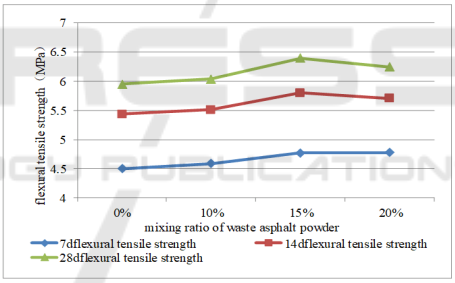

Figure 1 The flexural tensile strength of concrete with different mixing ratios and ages.

3.2 Elastic Modulus

Elastic modulus is one of the important mechanical properties of concrete. It reflects the relationship between concrete stress and its strain. It is one of the parameters necessary to calculate the deformation of concrete structure, crack cracking and temperature stress. In this paper, the compressive elastic modulus of cement concrete prism is analyzed, and the mechanical properties of cement concrete mixed with waste material powder are evaluated. The experimental results are shown in Table 4.

Table 4 Concrete compression elastic modulus with different mixing ratios and ages.

mixing ratios（%）	0	10	15	20	25
7d compression elastic modulus（MPa）	32760	31797	31348	30959	31774
28d compression elastic modulus（MPa）	33560	32996	32453	31983	32587

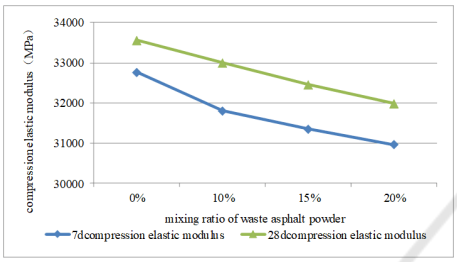

Figure 2 Concrete compression elastic modulus with different mixing ratios and ages.

From Table 4 and Figure 2 we can see:

（1）The compressive elastic modulus of cement concrete mixed with waste material is lower than that of the concrete without waste material, However, as the curing age continues to increase, the decrease in the elastic modulus at the later stage of the concrete becomes smaller, that is, the decrease in elastic modulus at the later stage is less obvious than at the early stage.

（2）When the proportion of waste powder mixed is 20%, the compressive elastic modulus of cement concrete decreases by a maximum of 4.7% over 28 days.

Combine the change rule of the compressive elastic modulus of the concrete of each age, and determine the best proportion of the waste material mixed is 20%.

3.3 Compressive Strength

According to the standard method, this test was made of cubic compressive specimens of 150mm x 150mm x 150mm, which were cured under standard curing conditions for 7d, 14d, and 28d. Their ultimate compressive load was measured according to the standard method. The test results are shown in Table 5.

Table 5 Concrete compression strong with different mixing ratios and ages.

mixing ratios（%）	0	10	15	20	25
7d compression strength（MPa）	29.9	30.1	28.9	27.6	25.3
14d compression strength（MPa）	35.9	33.8	33.1	31.9	30.2
28d compression strength（MPa）	40.7	39.1	38.9	37.2	36.1

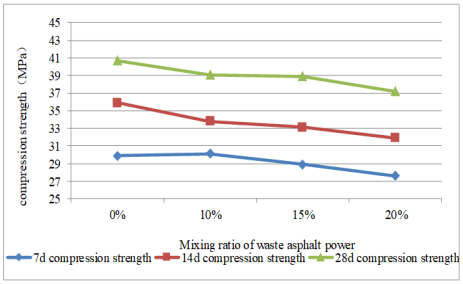

Figure 3 Concrete compressive strength with different mixing ratios and ages.

From Table 5 and Figure 3, it can be seen that the compressive strength shows a different degree of decline, and as the proportion of blending increases, the decrease extent increases. At curing age of 28 days, the compressive strength of concrete with a content of more than 20% decreased by 10%.Therefore, in order to ensure the compressive strength requirements of road concrete, it is recommended that the mixing ratio of waste material should not exceed 20%.

3.4 Mechanism of Action Analysis

（1）Influence of waste powder on flexural tensile strength of cement concrete

From the observation of the truncation of the test specimens of concrete flexural tensile strength test, it can be seen that compared with the ordinary concrete specimens, the cross section color is relatively dark, the surface pores are relatively small, and the sand on the surface is relatively less.

The following analysis of the mechanism of action of waste powder in concrete from three aspects:

①Filling mechanism. The strength of concrete depends mainly on the strength of the cement slurry, and the porosity is a decisive factor in the strength of the cement slurry, so the porosity of the concrete

structure is an important factor affecting its strength. The waste material used in this test is a kind of powder like mineral powder on the particle size. It effectively fills the void in cement concrete structure in cement concrete structure, making the whole structure of concrete more dense and improving the flexural strength.

②Viscoelastic mechanism. The old asphalt in the waste material has a certain bonding effect, which forms a chain or reticular structure inside the concrete structure under the effect of temperature. On the one hand, this kind of bonding can reduce the appearance of early micro cracks or prevent the further expansion of the cracks. On the other hand, the waste material powder, as an elastic medium, exists in the concrete. The strain of the material is buffered under the stress action, that is, a certain buffer action is played when the micro cracks appear under the action of load and temperature.

③Reaction mechanism. Along with the hydration of cement, the bitumen and mineral powder in the waste material will react with the concrete and the aggregate minerals in a series of physical and chemical reactions mainly by acid and alkali neutralization reaction. It is mainly reflected in the hydration and exothermic environment. The acid aging asphalt in the waste material is reacted with the cement to produce some kind of material. At the same time, the mineral powder reacts with some minerals of the aggregate in the concrete, and the physical and chemical changes occur.

（2）Influence of waste powder on elastic modulus of cement concrete

The waste asphalt mixture powder that replaces part of the sand in this test is a powdery substance with a particle size of 2.36 mm or less and has viscoelastic properties. After mixing with cement paste in concrete, it is equivalent to increasing the fluidity of the mixture and exerting its viscoelastic characteristics, thus reducing the modulus of elasticity of concrete.

4 CONCLUSIONS

Through the mechanical performance test and analysis, we can get the following conclusions.

（1）The waste material which is replaced by sand 15% can obviously improve the flexural strength of cement concrete, and its modulus of elasticity has a downward trend, and has little effect on the decline of compressive strength.

（2）After processing the waste asphalt mixture through the special crushing and screening equipment, the waste material is obtained. Replacing some of the sand in the cement concrete can obviously improve the mechanical properties of the concrete, such as the flexural tensile strength and so on, thus reducing the production of pavement cracks and prolonging the life life of the pavement.

REFERENCES

1. Huang, X.M. Zhao, Y.L., et al. Analysis of Asphalt Pavement Recycling Test [J], Chinese Journal of Geotechnical Engineering, 2001(04):468-471.
2. Wang, H.P. Research on crack resistance of cement-stabilized macadam with mixed waste materials[D], Chang'an University, 2011.
3. Liu, Z.H. Research on the Recovery Test and Recycling Technology of Used Asphalt Pavement [D], Chongqing traffic University, 2012.
4. Zhang, D.S. Wang, H.P., Research on Crack Resistance of Cement Stabilized Crushed Stones Mixed with Waste Old Asphalt Mixtures[J].China Foreign Highway,2006(05):221-225.
5. Bi, H.J., Zhang, X.H., The recycling of used asphalt mixture[J], Traffic World, 2006(01):70-73.
6. Ru. B., continued macro. Application of asphalt milling material regeneration technology [J], Shanxi Architecture: 2003(06):111-112.
7. Qu, Q.Y., Zhang, L.J., Fu, C.C., The performance of self-compacting concrete mixed with used asphalt mixture[J], Subgrade Engineering, 2017(02):118-121.
8. Shang, H.S., Zhao, Y.G., Research on the Test of Waste Stabilized Bituminous Mixtures[J].Journal of Gansu Sciences,2016(06):85-88.
9. Wang, H.P., Zhang, D.S., Lu, J.J., Impact of mixed fine asphalt mixture on the compressive strength of cement stabilized macadam [J], Highway, 2012(06):204-208.
10. JTG E30-2005. Test protocol for cement and cement concrete in highway engineering [S], Beijing: China Communications Press, 2005.