Research on Road Performance of Asphalt Mixture With Iron Waste Ore

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Case study

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Research on Road Performance of Asphalt Mixture with Iron Waste Ore

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Abstract: *In order to study the road performance of asphalt mixture with different kinds of iron waste ore , stripping waste rock rich in iron trioxide and stripping waste rock rich in iron oxide are used as aggregate to make the mixture.Through the test comparison, it is confirmed that the dynamic stability performance of asphalt concrete mixture mixed with iron trioxide mining and stripping waste rock is the best, namely its high temperature stability is best; followed by the one mixed with waste rock rich in iron trioxide. The residue stability of asphalt concrete mixed with mining and stripping waste rock increases obviously. It can found from the experiments that the residual stability can be up to 94.96% which kinds of asphalt mixture with waste rock rich in iron trioxide. Asphalt mixture mixed with stripping waste rock has a better anti-sliding performance than the common one, among which the one mixed with aggregates rich in iron trioxide is the best. Through tectonic depth, it is reflected that it also has a better performance on drainage noise reduction. In conclusion, using mining and stripping waste rock instead of mining gravel has a good economic efficiency,but also solved the problem of mining and stripping waste rock accumulation.*

Keywords: stripping waste rock; asphalt mixture; road performance; efficacy coefficient.

Introduction

With the continuous expansion of mining, mining waste rock has become an important solid pollutant affecting the air, soil and water.Some sulfide ores in the mine waste rock will produce certain oxidation reaction after contacting with the air, so as to release pollution gas, causing certain pollution to the air. Moreover, some very small waste rocks are very easy to form dust after drying in the air, thus bringing pollution to the air.After the wind and sun, surface runoff and other effects, the harmful components of mine waste rock will invade into the soil. The harmful substances and radioactive substances will cause serious damage to the soil. The excessive acid and salinization of the soil will change the composition of the soil and directly affect the growth of crops.Generally speaking, after a long period of weathering, the water-soluble compounds and heavy metal ions in the waste rock of open-pit mine will bring serious pollution to the water body after surface runoff or groundwater seepage[1].

In order to protect the environment, extensive research and comprehensive application have been carried out in the field of mining waste recycling at home and abroad.The research on the preparation of high strength concrete after the treatment of the mine stripping waste stone has been carried out, and its comprehensive performance is also very good[2-9].Waste rock contains trace elements needed for

crop growth and development, so it is made into soil conditioner [10-13].It also can be applied in sleeper and Bridge related fields, and also can effectively improve the waste consumption ratio, showing a high comprehensive application value [14-23].The research field of recycling of mine solid waste is expanding.In this paper, asphalt mixture with two kinds of iron waste ore are researched for road performance. In addition, stripping waste rock rich in Iron trioxide and stripping waste rock rich in Iron oxide are used as aggregate to make the mixture.

Materials

Asphalt

Asphalt is a mixture of different types of hydrocarbons and their non-metallic derivatives under certain combination conditions. Its components are very complex and show the characteristics of high viscosity.Using the characteristics of asphalt, various coarse and fine aggregates can be combined to form a mixture.In this test, the 90# bitumen produced by Panjin North Asphalt Co., Ltd was used. According to the Standard Test Methods of Bitumen and asphalt Mixtures for Highway Engineering[24], the main technical specifications of 90# asphalt are shown in Table 1.

Table.1 Main technical specifications of 90# asphalt

Performance indicators	Unit	Test results	Specified value
Penetration number（25℃，100g，5s）	mm	87	80～100
Softening point (R&B Method)	℃	46.5	≮45.0
Ductility（5cm/min，10℃）	cm	98.2	≮45
Ductility（5cm/min，15℃）	cm	144.6	≮100
Density	g/cm^3	1.018	实测
After the RTFOT Quality change	%	0.72	≯±0.8

Mining Waste Rock

In this paper, coarse aggregate in the raw material is collected from Dagushan iron mining area in Anshan.There are two main types of mining waste rock in this mining area, one is the iron-poor mining waste rock containing iron oxide, the other is the iron-poor mining waste rock containing iron trioxide. The samples are shown in Figure 1and Figure 2.

Figure1 Waste rock containing iron trioxide Figure2 Waste rock containing iron oxide

The stripping waste rock is crushed twice on the jaw crusher. The first time is the coarse aggregate, and the coarse aggregate is further crushed to make fine aggregate within 4.75mm. After crushing, select sand washing machine to clean, and finally get machine-made sand. In this experiment, two kinds of aggregates were obtained according to the steps of first coarse breaking and then fine breaking. That is, stripping waste rock coarse aggregate: 5mm-20mm, stripping gravel fine aggregate less than 5mm, and then carry out various physical and mechanical tests. For example, the test indicators of waste rock aggregate containing iron trioxide with particle size of 16-20mm are shown in the Table2.

Table 2 Physical properties index of waste rock aggregate containing iron trioxide

Physical property index		Crushed value (%)	Losangeles weared value(%)	Apparent relative density (g/cm^3)	Water absorption(%)	Robustness (%)	Content of needle flake particles (%)	Soft stone content (%)	Proportion of particles less than 0.075 mm(%)
Specified value[25]		≯26	≯28	≮2.6	≯2.0	≯12	≯15	≯3	≯1
16-20 mm	Test results	16.2	21.3	3.283	0.81	3	12.3	0.2	___
13.2-16 mm	Test results	19.2	14.312	3.254	0.83	___	10.1	0.2	0.87
9.5-13.2 mm	Test results	19.8	13.312	3.240	0.66	___	12.1	2.1	0.8
4.75-9.5 mm	Test results	22.4	18.01	2.921	0.93	___	14.9	1.9	0.98

2.36 - 4.75 mm	Test results	25.2	19.1	2.516	1.12	—	13.6	—	0. 99

Asphalt Mixture Proportioning Design

Gradation Composition Design

In this paper,according to the requirements of 《Technical specification for highway asphalt pavement construction》 [26], the mix proportion design of AC-20 asphalt mixture containing iron oxide stripping waste rock, iron oxide stripping waste rock and common limestone mineral aggregate is carried out respectively. The results of trial synthetic gradation of three different mineral aggregates are shown in Figure 3.

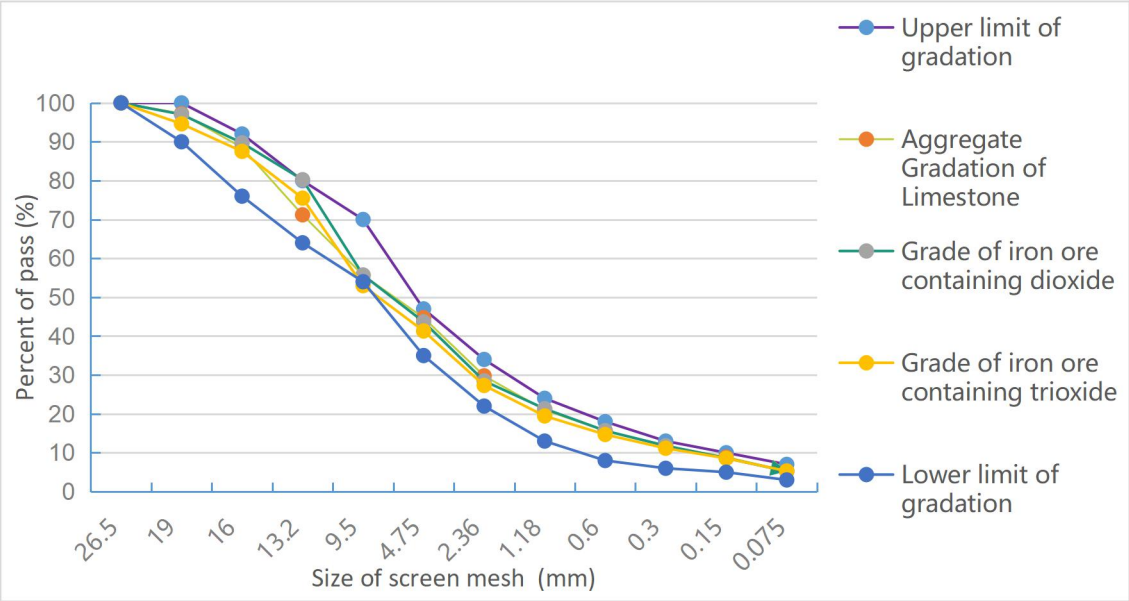

Figure3 Trial synthetic gradation of three different mineral aggregates

Optimal Asphalt Content

This paper design the optimum oil-stone ratio by Marshall method.The optimum oil-stone ratio of three different asphalt mixtures is shown in Table 3.

Table 3. Optimum oil-stone rate of three kinds of asphalt mixtures

Oil-stone ratio index	*Three kinds of asphalt mixtures*		
	Fe_3O_4 waste stone asphalt mixture	*Fe_2O_3 waste stone asphalt mixture*	*common limestone asphalt mixture*
Optimum oil-stone rate (%)	*4.45*	*4.26*	*4.65*

Experimental Study on Pavement Performence of asphalt Mixture

High Temperature Stability Performance

The high temperature stability of asphalt mixture is the most important performance of road performance, and the high temperature stability of asphalt concrete pavement

is also its weak link. In this study, wheel tracking test is used to detecting the high temperature stability performance of the three kinds of asphalt mixtures.The specimen used in the test is 300×300×50mm specimen formed by rolling method, and the applied load is 0.7±0.05MPa. Specimen is shown in Figure 4.

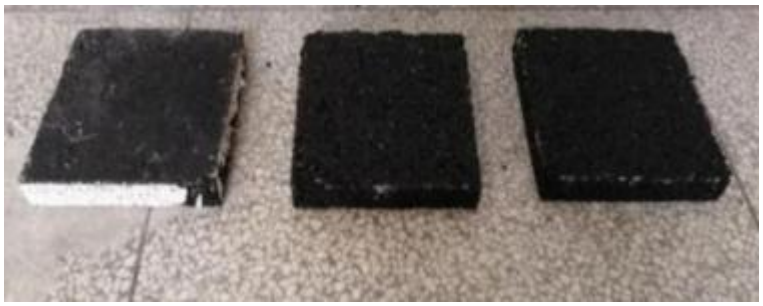

Figure 4. Test specimen for wheel tracking test

Wheel tracking test results of asphalt mixture are shown in Table 4.

Table 4. Wheel tracking test results of three kinds of asphalt mixture

Index	*Fe_2O_3 waste stone asphalt mixture*			*Fe_3O_4 waste stone asphalt mixture*			*common limestone asphalt mixture*		
45min displacement(mm)	*1.511*	*1.533*	*1.520*	*1.417*	*1.467*	*1.433*	*1.508*	*1.509*	*1.524*
60min displacement(mm)	*1.832*	*1.822*	*1.861*	*1.731*	*1.720*	*1.742*	*1.961*	*1.896*	*1.953*
Dynamic stability(time/mm)	*1963*	*1954*	*1937*	*2006*	*2012*	*2009*	*1391*	*1387*	*1419*
Relative deformation rate(%)	*3.664*	*3.602*	*3.644*	*3.462*	*3.387*	*3.451*	*3.922*	*3.897*	*3.923*

Every kind of asphalt mixture has three specimen in the experimental study on high temperature stability. The higher the dynamic stability value,the stronger the deformation resistance of the asphalt mixture at high temperature. From the Table 4, it is found that compared with the other two asphalt mixtures the dynamic stability of Fe_3O_4 waste stone asphalt mixture is higher and the relative deformation rate is lower under the same test conditions. It can be seen from the Figure 5 that the high temperature stability of Fe_3O_4 waste stone asphalt mixture is the best, which is about 44.2% higher than that of common limestone asphalt mixture, and the high temperature stability of Fe_2O_3 waste stone asphalt mixture is also 41.1% higher than that of common limestone asphalt mixture. Therefore, the high temperature stability of common asphalt mixture is obviously lower than the former two. Relative deformation rate reflects the deformation of asphalt mixture under repeated loads at high temperature.

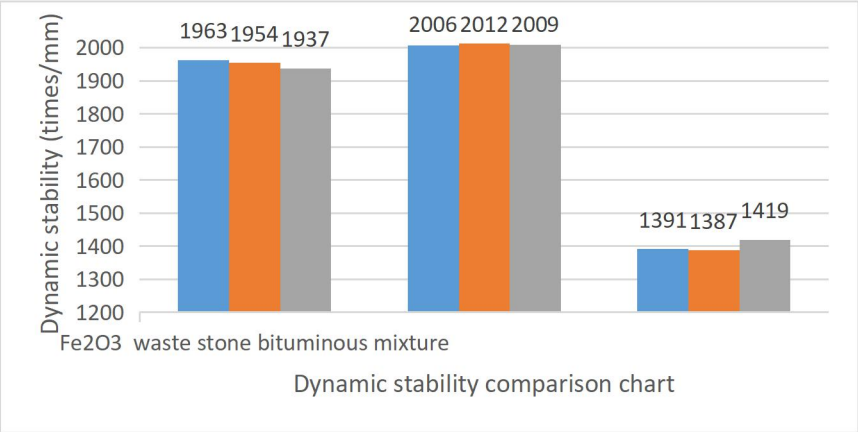

Figure 5 Dynamic stability comparison chart

It can be seen from the wheel tracking test results that the relative deformation rate of asphalt mixture containing iron ore waste stone is lower than that of common limestone asphalt mixture under the same conditions. Through the two indications of dynamic stability and relative deformation rate, it is reflected that under high temperature conditions,the high temperature stability of asphalt mixture containing iron ore is higher than that of common limestone asphalt mixture. And in this paper, the Fe_3O_4 waste stone asphalt mixture has better high temperature stability.

Water Stability Performance

Water stability is an important indicator of road performance of asphalt mixture, which directly affects whether asphalt mixture is vulnerable to water damage.According to "Standard Test Methods of Bitumen and Bituminous Mixtures for Highway Engineering",this paper evaluates the water stability of different rock asphalt mixture by immersion Marshall test. The specimen is a cylinder with a diameter of 101.6mm and a height of 63.5±1.3mm, as shown in Figure 6. The specimen is in a constant temperature water bath furnace at 60℃ for 48 hours, and the stability was measured.

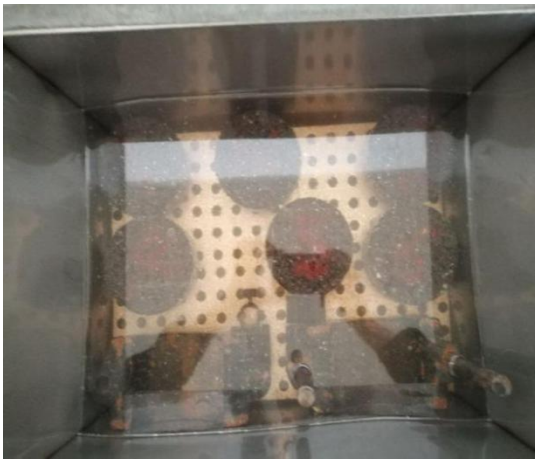

Figure 6. Constant temperature water bath immersion specimen

The average values of immersion Marshall test results for three asphalt mixture are shown in Table 5. From Table 5, it shown that the residual stability of iron ore waste stone asphalt mixture meets the standard requirements, and it is significantly higher than the common limestone asphalt mixture's.The residual stability of Fe_3O_4 waste

stone asphalt mixture and Fe_2O_3 waste stone asphalt mixture has little difference, which is 8.6% and 5.7% higher than that of common limestone asphalt mixture respectively. Compared with the three kinds of asphalt mixture, the water stability of Fe_2O_3 waste stone asphalt mixture is the best, and its residual stability is 94.96%. In general,water stability performance of iron waste ore asphalt mixture is excellent.

Table 5 The average values of Marshall test

Index	*Fe_2O_3 waste stone asphalt mixture*	*Fe_3O_4 waste stone asphalt mixture*	*common limestone asphalt mixture*
40 min Stability(KN)	*14.2*	*16.82*	*11.26*
40 hours Stability(KN)	*13.56*	*15.56*	*9.85*
Residual stability(%)	*94.96*	*92.5*	*87.48*

Skid Resistance

The skid resistance of asphalt pavement is an important characterization of traffic safety. For road building materials, the structural depth, size and shape,grinding value and other characteristics of mineral materials and processing methods determine the skid resistance performance to a certain extent.In this paper, the friction coefficient and structural depth of different types of asphalt mixture were measured by pendulum instrument and electric sand paver. Figure 7 and Figure 8 show the fiction coefficient test and structural depth test respectively.

Figure 7 Friction coefficient test

Figure 8 Structure depth test

Comprehensive friction coefficient and structural depth index of asphalt concrete can analyze its skid resistance performance. It can be seen from the test data in Table 6 that the skid resistance performance of asphalt mixture containing Fe_2O_3 waste stone is the best, but it is not very different from that of asphalt mixture containing Fe_3O_4 waste stone. The structural depth of the asphalt mixture containing Fe_2O_3 waste stone and the asphalt mixture containing Fe_3O_4 waste stone is 19% and 14.3% higher than that of the common limestone asphalt mixture respectively. In spite of this, there is little difference in the friction coefficient.

Road Performance Analysis of Three Asphalt Mixtures

In this part, the efficacy coefficient method is used to compare the test indexes of waste stone asphalt mixture and common limestone asphalt mixture for comprehensive evaluation of road performance. It can be seen from the data in Table 6 that the efficiency coefficient of common asphalt mixture is the lowest. It indicates that in the comprehensive road performance including high temperature stability, water stability and skid resistance, the comprehensive road performance of common limestone asphalt mixture is lower than that of waste stone asphalt mixture containing iron ore.

Table 6 Efficiency coefficient of three types of asphalt mixture

Types	*High temperature stability*	*Water stability*	*Skid-resistance*	*Efficiency coefficient*
Fe_2O_3 waste stone asphalt mixture	*0.939*	*0.999*	*0.800*	*0.913*
Fe_3O_4 waste stone asphalt mixture	*0.964*	*0.933*	*0.840*	*0.912*
Common limestone asphalt mixture	*0.626*	*0.799*	*0.880*	*0.768*

Conclusion

In this paper, the road performance and influencing factors of AC-20 iron ore waste stone asphalt mixture are studied. The high temperature stability, water stability and skid resistance performance of common limestone asphalt mixture, waste stone asphalt mixture containing Fe_2O_3 and waste stone asphalt mixture containing Fe_3O_4 were compared and analyzed by test methods, and the following conclusions were obtained:

(1) It is concluded from the test for the three asphalt mixtures, the asphalt mixture with Fe_3O_4 waste stone has the best high temperature stability, and the asphalt mixture with Fe_2O_3 waste stone has the best water stability and skid resistance performance.

(2) Through the comprehensive evaluation of the road performance of two kind of iron-containing waste stone asphalt mixture by the efficacy coefficient method, it is known that the difference between the two is small. But asphalt mixture containing

iron ore wasted stone is better than common limestone asphalt mixture, especially on skid resistance performance.

(3) In terms of road comprehensive performance in this paper, it is a good recycling way to taking asphalt mixture containing iron ore wasted stone for road construction.

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