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Application of Iron Tailing Sand in Pavement Base

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Abstract

Iron tailings are solid wastes produced after iron ore is refined. Based on the analysis of the development of road engineering in our country, the application status of iron tailings sand in road engineering in recent years is summarized. The optimal moisture content, maximum dry density and compressive strength of iron tailings cement stable macadam are evaluated by using the compaction test and unconfined compressive test. The results show that UNDER the condition OF a certain amount of cement and the content of iron tailing sand is 10%-20%, iron tailing sand can be used as semi-rigid pavement base material in road engineering construction. Finally, the author puts forward his own views on the future research direction.

Keywords

Iron Tailing Ore; Solid Waste; Pavement Base Material.

1. Introduction

In recent years, along with the rapid development of Chinese economy, the abuse of traditional economic growth pattern has been increasingly evident, which makes the contradiction of Chinese resource shortage more and more prominent, the environmental pressure is more and more intense. Taking tailings as an example, tailings are solid wastes discharged by the mine after crushing, screening and beneficiation of the ore under specific economic conditions. In 2015, the stock of tailings in China was 14.6 billion tons, including 7.5 billion tons of iron tailings. The discharge and stock of iron tailings account for the largest proportion among the tailings[1]. From 2010 to 2015, the comprehensive utilization rate of iron tailings was about 10%, and has increased to 31.8% by 2020[2]. Although the utilization rate is constantly increasing, the accumulation of iron tailings has also increased from 17.3 billion tons at the end of 2015 to 22.26 billion tons at the end of 2020[3]. The massive accumulation of tailings not only wastes resources seriously, but also causes harm to the surrounding environment and residents.

On the other hand, the total mileage of expressways in China is increasing. By the end of 2021, 117,000 kilometers of expressways have been completed, 257,700 kilometers of ordinary national highways have been opened to traffic, and more than 98% of the pavement has been paved with asphalt or cement concrete. The National Highway Network Planning (2013-2030) introduced in 2013 proposed that by 2030, the total scale of highways and ordinary national highways in China will reach 136,000 km and 265,000 km respectively[4]. With the continuous increase of highway mileage, the amount of natural sand and gravel consumed every year is also increasing. In many places, excessive exploitation even occurs, which seriously damages the local ecological balance. If the natural sand and stone can be replaced by iron tailings, it is of great significance to solve the problem of environment and highway construction material shortage.

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2. Research Status

Li Ronghai[5]used iron tailings as backfill of subgrade and tested the slope stability. The test results showed that when the embankment height was 3m and 15m, the slope stability coefficient was 1.38 and 1.28, which both met the requirement of slope stability 1.25 in JTG D30-2015 Code for Design of Highway Subgrade.

Wan Lei[6]used iron tailing sand from Wuhan Iron and Steel Group Mining and Metallurgy Co., LTD to conduct research. The particle size distribution of the tailing sand did not meet the national requirements and could not be used as base material alone. Coarse aggregate should be added to improve grading. Determine the best mix ratio of cement: gravel: iron tailings: biological polymerase =5:30:68:2, the application of this mix to make the pavement base meets the national standard of first-class highway.

Liu Jinglei[7]used iron tailing sand from Xuanhua District of Zhangjiakou and added cement and soil coagulant to iron tailings respectively. Taking cement, soil coagulant and compaction degree as variables and based on unconfined compressive strength test, he obtained a 7-day unconfined compressive strength model of improved iron tailings. Results show that under the condition of the guarantee degree of compaction, the strength of the modified tail ore increases as the curing agent content, while the dosage of curing agent was 8%, meet the F20 JTG/T - 2015 the rules of highway pavement base construction technology of secondary and secondary roads in the strength of the highway pavement base course materials, including cement as curing agent effect is better.

Xue Dengfeng[8]used iron tailing sand instead of stone debris to prepare water-stabilized crushed stone mixture. Under the condition that the total amount of stone debris and iron tailing sand remained unchanged, the content of iron tailing sand and the amount of cement were determined through compaction test and unconfined compressive strength test. Two 700m test sections were laid. The dosage of cement in both sections was guaranteed to be 5%, and the dosage of iron tailing sand was set at 10% and 20% respectively. The results show that both test sections meet the requirements.

At present, the study of iron tailings are still in a rising stage, most of the research is to iron tailings applied in pavement base, and ratio of cement and gravel to form cement stabilized macadam, but tail of iron ore in the cement stabilized gravel in the share is less, can't achieve the result of much solid waste, solid waste comprehensive utilization of the research is still a long way to go.

3. Feasibility Analysis of the Application of Iron Tailings in Road Engineering

3.1. Composition of Iron Tailings

Table 1. Chemical composition of iron tailings

Iron ore name	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	TFe	SO_3
Tangshan iron ore	72.79	6.08	6.20	4.85	3.16	4.48	0.10
Handan iron ore	31.98	6.49	10.23	30.77	13.84	-	3.89
Meishan iron	27.88	7.27	25.00	14.62	1.78	-	-
Anshan iron	75.91	0.65	-	1.82	1.51	11.69	-
Jinling iron	36.47	5.32	8.27	19.48	13.21	-	0.54

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Iron tailings is a kind of complex mineral, due to the different origin and processing process, the content of its chemical composition is also different. The following table lists the composition of iron tailings in several typical mining regions in China.

As can be seen from the above table, there are some differences in the chemical composition of iron tailings in different regions. However, the main composition of most iron tailings is silicate, which is very similar to construction materials such as sand and clay. Theoretically, it can be applied to road engineering only by adding a small amount of other raw materials for the ratio.

3.2. Compaction Test

The content of iron tailings was determined as 0%, 10%, 20% and 30%, and the amount of cement was determined as 4%, 5% and 6%. According to the "Test Rules for Stable Materials of Inorganic Binder for Highway Engineering" (JTG E51-2019), the compaction test of cement stabilized crushed stone mixture was carried out, and the optimal moisture content and maximum dry density were measured. The test results are shown in Table 2.

Table 2. Compaction test results of water-stabilized crushed stone mixture

Iron tailing sand content /%	Optimum moisture content /%			Maximum dry density /%		
	4% cement	5% cement	6% cement	4% cement	5% cement	6% cement
0	4.3	4.7	5.2	2.353	2.374	2.384
10	4.6	4.9	5.3	2.365	2.380	2.389
20	4.8	5.1	5.4	2.376	2.387	2.392
30	5.2	5.5	5.9	2.349	2.359	2.354

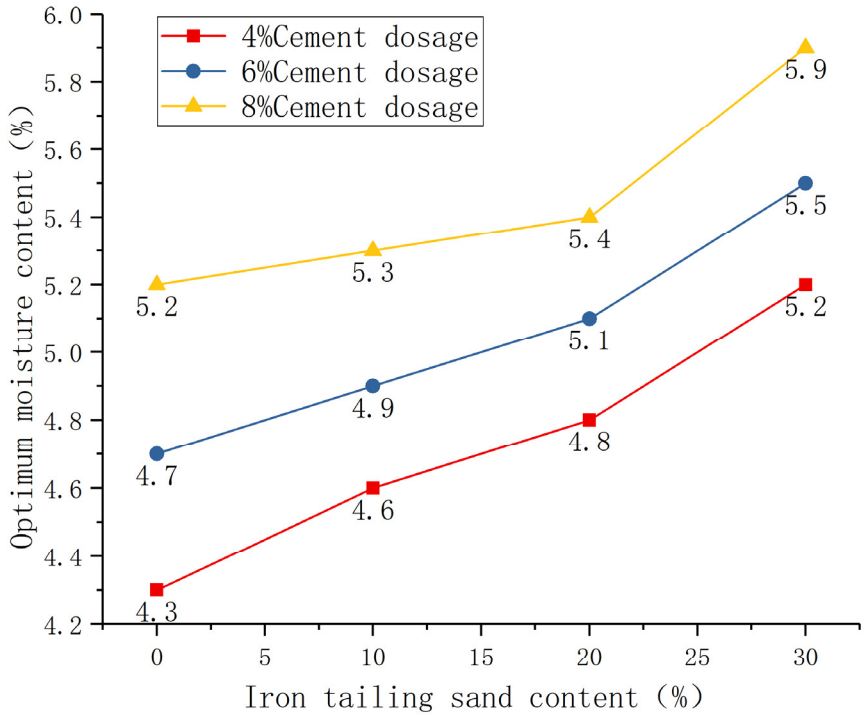

Figure 1. Optimal moisture content curve of mixture

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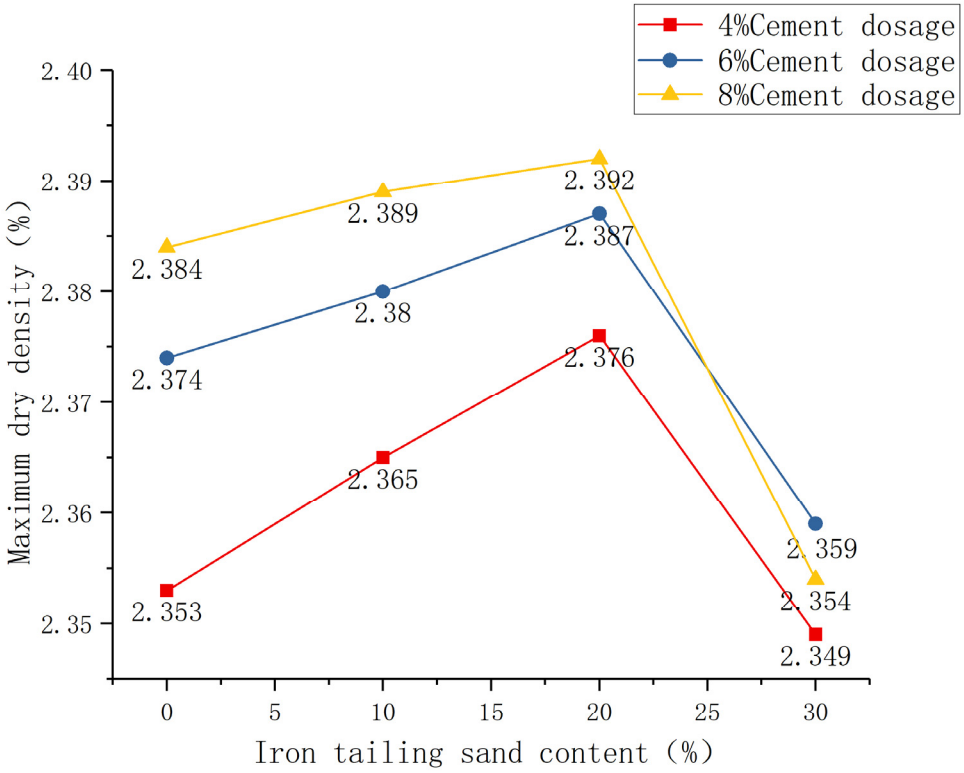

Figure 2. Maximum dry density curve of mixture

It can be seen from Figure 1 that the optimal water content increases with the increase of iron tailings sand content. When the iron tailings sand content is 30%, the optimal water content of three groups of different cement dosages are 5.2%, 5.5% and 5.9%, respectively, which are 0.9%, 0.8% and 0.7% higher than that of pure natural sand and stone mixture. This is because there are many fine pores on the surface of iron tailing sand, which can absorb more water, so as to show that the more iron tailing sand content, the higher the optimal water content of the mixture.

It can be seen from Figure 2 that, different from the change law of the optimal water content, the maximum dry density increases first and then decreases with the increase of iron tailing sand content. The maximum dry density of three cement-stabilized macadam mixtures with different cement content reaches the maximum when the iron tailing sand content is 20%. This is due to the low iron tail sand fineness modulus, at the end of iron ore content of 10% ~ 20%, iron ore filling the end between fine aggregate and coarse aggregate pore, make a mixture between more closely, at the end of continue adding iron ore, can make the fine aggregate occupy more space, can't closely compacted mixture, then the maximum dry density of the cement stable macadam mixture, reduce.

3.3. Unconfined Compressive Strength Test

The specimens were prepared according to 94% compaction degree according to different iron tailings sand content and cement content, and the unconfined compressive strength test was conducted after curing. The test results are shown in Table 3.

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Table 3. Unconfined compressive strength test of water-stabilized crushed stone mixture

Iron tailing sand content /%	Unconfined compressive strength /MPa		
	4% cement	5% cement	6% cement
0	3.6	4.2	5.0
10	3.6	4.5	4.8
20	4.2	4.7	5.8
30	2.8	2.9	3.3

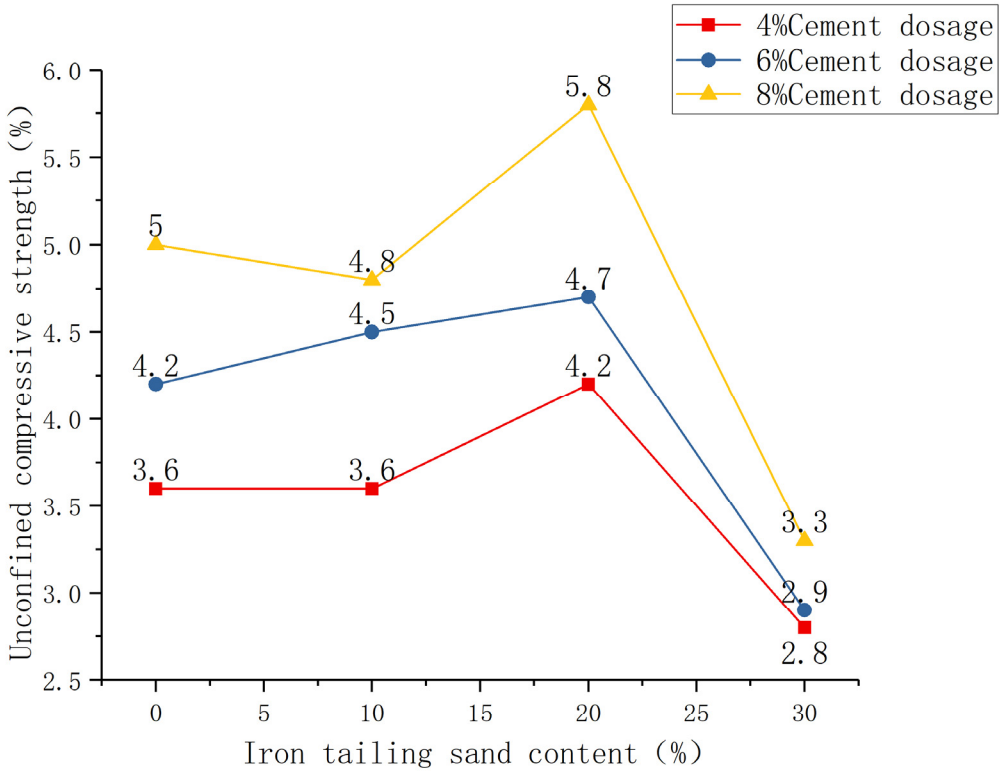

Figure 3. Unconfined compressive strength curve of the mixture

As can be seen from Figure 3, with the increase of iron tailing sand content, the unconfined compressive strength of cement-stabilized macadam mixture first increases and then decreases. When the iron tailing sand content reaches 20%, the unconfined compressive strength of three groups with different cement content are 4.2mpa, 4.7mpa and 5.8mpa, respectively. Compared with the pure natural sand and stone mixture, the unconfined compressive strength is 0.6MPa, 0.5MPa and 0.8 MPa higher, respectively. When the iron tailing sand content continues to increase, the unconfined compressive strength will decrease. This is mainly because of the large surface area of fine aggregates such as iron tailing sand, which requires more cementing materials to stabilize, resulting in unstable areas inside the mixture, which are easy to crack under load, thus reducing the strength of concrete.

The test results show that the unconfined compressive strength of iron tailings with 10% cement stabilized MACadam and 20% cement stabilized MACadam meet the design requirements, and iron tailings can be used as semi-rigid base material in road engineering construction.

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4. Summary and Prospect

Lots of engineering examples show that the iron tailing was applied to road construction, not only can satisfy the requirement of the road engineering construction, bring economic benefits to the people and the country, also can solve our natural sandstone resources shortage and iron tailings security problem brought by the large number of hoarding, iron tailings into the construction of ecological civilization and ecological environment protection is of great significance.

Although we have made some achievements in the research of the application of iron tailings in road base construction, most of these achievements only stay in the theoretical and experimental parts, and have not been applied to a large number of practical engineering projects. To realize the large-scale application of iron tailings in road engineering, I suggest the following measures: (1) The government should strengthen guidance and establish relevant laws, regulations and policies, especially in the direction of laws, regulations and taxation, so that universities and research institutes can focus on these projects through government guidance; (2) Fully aware of the development prospects of the application of iron tailings in road engineering, according to the composition and distribution characteristics of iron tailings, it should be applied to different areas and different types of pavement structure; (3) In terms of technology, from the generation of iron tailings to the application, a complete production chain should be established to fundamentally solve the problem of iron tailings accumulation. At the same time, a systematic basic analysis of iron tailings resources and their applications should be carried out to provide data support for the application of iron tailings resources in road engineering.

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