Experimental Study On Preparation Of C30 Concrete By Replacing Fine Aggregate With Molybdenum Tailing Slag

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Abstract—Which is composed of crystalline silica, a small amount of mica and molybdenum ore salts, and is non-radioactive. As a fine aggregate of concrete, the water demand of fresh concrete will be increased. By increasing the dosage of water-reducing agent, the construction performance of concrete mixture can reach the actual pumping concrete slump-flow (500±30) mm under the condition of unchanged water demand, and the same construction performance as that of mechanical sand concrete can be obtained. With the gradual increase of the replacement ratio, the compressive strength gradually decreases. When the replacement ratio does not exceed 40%, the 90d compressive strength decreases less than 3.1% compared with the mechanical sand concrete, which has less impact on the strength and can fully meet the requirements of the mechanical properties of C30 concrete.

1. INTRODUCTION
Molybdenum is in the forefront of China's reserves in the world, Shaanxi Hua County Jinduzhen, Liaoning Huludao, Jilin, Shanxi, Henan, Fujian, Guangdong, Hunan, Sichuan, Jiangxi, Gansu, Inner Mongolia and other provinces have molybdenum mines, and large reserves, good development conditions, production occupies an important position in the China[1]. With the development and utilization of molybdenum mineral resources, a large number of tailings are piled up around mines, causing land encroachment and environmental pollution. For this reason, some scholars proposed to replace the concrete fine aggregate with tailing slag to prepare tailing concrete, which not only solved the problem of excessive consumption of concrete fine aggregate, but also solved the problem of a large number of tailing encroachment of land and environmental pollution[2].

Since tailing slag is different from natural sand and mechanical sand in particle morphology, stone powder content and particle gradation, it is not suitable to prepare concrete directly[3]. It is understood that part of the molybdenum tailings may be associated with radioactive substances, and this type of molybdenum tailings slag can not be used for concrete fine aggregate, so how to safely and green resource utilization is particularly critical[4]. By testing the performance of molybdenum tailing slag, according to the characteristics of molybdenum tailing slag, the replacement ratio of molybdenum tailing slag to the mechanism sand was adjusted, and the performance of C30 concrete mixture and the development law of concrete strength were studied, providing application reference for comprehensive utilization of molybdenum tailing slag.
2. EXPERIMENTAL

2.1 Molybdenum tail slag
Molybdenum tailing slag was obtained from a molybdenum tailing plant in Shangluo, Shaanxi, with fineness modulus 0.9, MB value 2.0, bulk density 1390kg/m$^3$ and apparent density 2720kg/m$^3$. According to GB 6566, the radioactivity test of molybdenum tailings slag was carried out, among which the external exposure index was 0.4, and the internal exposure index was 0.1, both lower than 1.0[5]. Scanning electron microscope was used to test the morphology of molybdenum tailing slag 1000 times. As shown in Figure 1, scanning electron microscope showed that molybdenum tailing slag was composed of materials with sharp edges and corners and heterogeneous shapes. XRD is used to analyze the crystal phase and crystal type of molybdenum tailings. The analysis results are shown in Figure 2. The analysis results show that molybdenum tailings mainly contain crystalline silicon dioxide, a small amount of mica and molybdenum mineral salts. It can be seen from the radioactive and XRD results that molybdenum tailing slag is not radioactive and has no harmful components that affect the durability and volume stability of concrete, so it is suitable for concrete preparation.

![FIG.1 scanning electron microscopy (SEM) at 1000 times](image1)

![Fig.2 XRD analysis test diagram](image2)

2.2 Test raw materials
- Cement: P.O. 42.5 ordinary Portland cement produced by Shaanxi Jingyang Jidong Cement Factory is adopted. The initial setting time and final setting time are 190min and 295min respectively, and the compressive strength is 27.1mpa and 45.8mpa respectively on 3d and 28d, with qualified stability.
- Fly ash: adoption of shaanxi weihe power plant production II grade fly ash, 23% fineness, ignition loss by 2.38%, the ratio of 98%.
Slag: Grade S95 ore powder from Deron, Shaanxi was used, activity index of 7d and 28d were 88% and 102% respectively, and fluidity ratio of 102%.

Crushed stone: Continuous graded gravel with particle size of 5~31.5mm was used, with a bulk density of 1510 kg/m³ and a void ratio of 43%.

Manufactured sand: produced by a sand factory in Han zhong shaanxi province, fineness modulus 3.0.

Water-reducing agent: Shaanxi KZJ Point-400W polycarboxylic acid pumping agent, water reduction rate 23%, bleeding rate 20%, gas content 1.8%.

2.3 Performance test of concrete mixture
In this test, the mixture ratio of C30 concrete is adopted, the cementing material adopts three systems, and the mechanism sand is used as fine aggregate. The concrete mixture ratio is shown in Table 1. Molybdenum tailing slag was used to prepare concrete with 0, 20%, 40%, 60% and 80% proportion instead of mechanism sand respectively. It is required that the expansion degree of concrete extractor should be between (500±30) mm. By adjusting the dosage of water-reducing agent to ensure that the expansion degree is within the control range with different substitution proportions, the influence of different substitution proportions of molybdenum tailing slag on the construction performance of concrete is analyzed. At the same time, under the standard curing condition, the compressive strength of concrete of different ages, such as 7d, 28d, 60d and 90d, was tested and compared with the compressive strength of the reference concrete.

| Material            | C30   |
|---------------------|-------|
| cement              | 280   |
| fly ash             | 50    |
| slag                | 40    |
| manufactured sand   | 800   |
| Crushed stone       | 1050  |
| water               | 170   |
| Water-reducing agent| 7     |

3. EXPERIMENTAL RESULTS AND DISCUSSIONS

3.1 Workability of molybdenum tailing concrete
- When using molybdenum tailing slag to substitute mechanism sand to prepare concrete, the water consumption remains unchanged in the test. By adjusting the amount of water-reducing agent, the expansion degree of concrete mixture can reach (500±30) mm. By observing the water retention, cohesiveness and fluidity of concrete mixture under different substitution ratio, it is found that it is closely related to the substitution ratio of molybdenum tailing slag. It can be seen from the mixing of each group of molybdenum tailing slag with different replacement ratios that the large fineness modulus will affect the workability of concrete mixing, resulting in the reduction of cohesion of the mixing and the occurrence of bleeding and bone pulp separation after standing, which is particularly obvious when the replacement ratio is 0. With the increase of the proportion of molybdenum tailing slag, the fineness modulus decreases gradually, but the
The experimental results show that with the increase of molybdenum tailing slag replacement ratio, the concrete water demand increases gradually and the concrete expansion degree decreases gradually. In order to maintain the same expansivity, the increase of water demand for concrete containing molybdenum tailing slag can be effectively solved by adjusting the amount of water reducing agent. With the increase of the proportion of molybdenum tailing slag, the content of water-reducing agent increased gradually. The reasons are mainly due to the small fineness modulus of molybdenum tailing slag, the increase of stone powder brought in with the increase of substitution ratio, the increase of specific surface area of mixed sand, and the enhanced adsorption of additives. Because of molybdenum tail slag itself for sharp edges and corners, the uneven shape of a particle shape, with the improvement of replacement ratio, molybdenum tail slag in the fine aggregate proportion on the high side, our needs more freedom slurry for package, thus reducing the surplus plasma volume, decreased the fluidity of fresh concrete to lower concrete fluidity. It can be seen that the use of molybdenum tailing slag will increase the water demand of concrete, but the addition of water reducing agent is the key to make molybdenum tailing slag concrete meet the workability of construction.

3.2 Molybdenum tailing slag concrete strength

As can be seen from FIG. 3, the 28d compressive strength of all concrete specimens reaches the designed strength C30. It can be seen from the strength curves of the four ages of 7d, 28d, 60d and 90d under different substitution ratios that the strength continues to increase with the extension of the concrete age with the same substitution ratio, and the growth rate gradually decreases with the extension of the age, which is in line with the general law of the development of concrete compressive strength. When the proportion of molybdenum tailing slag was 40%, its 90d compressive strength was only reduced by 3.1% compared with that of pure mechanism sand concrete, and the strength loss was small. At the same time, it can be seen that the compressive strength of molybdenum tailing slag has been decreasing with the gradual increase of the proportion of sand replaced by mechanism, and when the proportion of sand replaced by mechanism exceeds 60%, the decrease of its strength has an increasing tendency.

It can be seen from the test that the particle morphologies of molybdenum tailings are all granular materials with non-uniform sharp edges and corners, with poor grading, high content of stone powder and small fineness modulus, which cannot be used alone. The experimental results show that the concrete fluidity of the molybdenum tail slag can meet the requirement of expansion degree (500±30) mm in the actual production of commercial concrete, the actual water consumption does not increase, and the water-cement ratio W/C remains unchanged. On the other hand, a small amount of stone powder in molybdenum tailings slag can increase the slurry volume of fresh concrete, improve water retention, reduce the rate of bleeding, reduce free water aggregation in the interface, which is beneficial to the improvement of the slurry-aggregate interface. Because the particle size of the stone powder in molybdenum tailings is between fine aggregate and cementing material, and the sharp edges and corners of molybdenum tailings are not uniform in shape, according to the filling theory of concrete skeleton, molybdenum tailings cannot fill between fine aggregate in a compact way. The surrounding area needs a large amount of slurry to wrap and fill, which leads to the decrease of the density of the structure and the decrease of the strength of the concrete. When the proportion of molybdenum tail slag replacement exceeds 40%, the fineness modulus of mixed sand has reached the range of fine sand, the fineness modulus is too small, the content of stone powder in fine aggregate is too high, which leads to the increase of concrete water demand, the increase of admixture, the increase of concrete viscosity, the poor fluidity, the increase of shrinkage, thus...
leading to the decrease of strength. Moreover, when the proportion of molybdenum tailing slag replacement is less than 40%, the influence on the strength of each age is small, especially the strength of 90d age, which has been reduced by less than 3.1%. Therefore, on the basis of comprehensive consideration of concrete strength and fluidity, the replacement proportion of molybdenum tailing slag should not exceed 40%.

![FIG. 3 Concrete strength at different substitution ratios](image)

3.3 Micro morphology of molybdenum tailing concrete

When molybdenum tailing slag is replaced by 40%, the SEM morphology of concrete on 90d (FIG. 4) is obtained. In this concrete structure, a large amount of ettringite and C-S-H gel are generated, while a small amount of Ca(OH)₂ crystals are generated. A large number of micro-void structures can be found in the microstructure, which is mainly due to the fact that the particle morphologies of molybdenum tailing slag are all angular and sharp, and there is mutual support. On the one hand, it reduces the accumulation density and increases the void ratio; on the other hand, it increases the cement slurry needed to wrap the aggregate. C-S-H gel could not completely fill the void between aggregates, leading to more void in the microstructure and affecting the structure's compacting and stability. Therefore, the proportion of molybdenum tailing slag needs to be strictly controlled in consideration of the structural compactness and stability of concrete.

![Figure 4 SEM morphology of concrete at 40% replacement ratio](image)
4. CONCLUSIONS
Molybdenum tail slag is a material with sharp edges and corners and non-uniform shapes. It is mainly composed of crystalline silicon dioxide, a small amount of mica and molybdenum mineral salts, and is non-radioactive. It can be partly used as concrete fine aggregate.

Molybdenum tailing slag belongs to special fine sand with high content of stone powder and poor gradation. Through partial replacement mechanism of sand, when the replacement proportion is no more than 40%, the fineness modulus of molybdenum tailing slag basically meets the requirements recommended in GB/T 14684-2011 standard for preparation of concrete sand.

Molybdenum tailing slag is used as concrete fine aggregate, which will increase the water demand of fresh concrete. Under the condition that the water demand remains unchanged, the pumping concrete can be satisfied by increasing the amount of water-reducing agent, and the construction performance is the same as that of sand concrete.

C30 concrete is prepared by replacing mechanism sand with molybdenum tailing slag, the compressive strength decreases with the gradual increase of replacement ratio. When the replacement ratio is not more than 40%, the 90d compressive strength is only reduced by 3.1% compared with the mechanical sand concrete. The mechanical properties of C30 concrete is prepared by using molybdenum tailing slag as fine aggregate.

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