

Mechanical Properties and Prospect of Coal Gangue Concrete

Chao Liu, Jiayi Zhao, Shichao Fan, Hongwei Han, Nan Zhang, Meng Sun, Qilin Lei*

Ordos institute of technology, Ordos, Inner Mongolia, China

*Corresponding author: wjwwhsjmh@163.com

Abstract

Coal gangue has more reserves in China, with low carbon content and high hardness. It can be seen in beaches, embankments and other water flow places. The research on the utilization of gangue in China originated in the mid-1950s. It has large emissions and low utilization. The finished products made of sand by coal gangue sand making equipment can be used in the fields of building aggregate and road construction. It is a good substitute for the traditional aggregate of concrete, and can protect the environment and save resources. It is mainly reflected in the fields that it can be used as coal cinder, raw materials for brick factories, recycled bricks, building materials, etc., and as the base material for paving roads in the field of road construction.

Keywords

Coal Gangue Concrete; Prospect; Mechanical Properties.

1. Introduction

As a large industrial country, the discharge and accumulation of industrial solid waste are increasing year by year. Coal gangue is an industrial waste abandoned in the mining and washing process of coal mine stone. It is estimated that coal gangue is an industrial solid waste discharged in coal mining and coal washing, the annual emission accounts for about 10% of the coal output, the country has accumulated more than 5 billion t, occupied about 430,000 mu of land[1-2].

Gangue is a kind of carbonaceous rock with high ash content and low calorific value associated with coal. It is a mixture of inorganic matter and a small amount of organic matter. The chemical composition of coal gangue is listed in Table 1.

Table 1. Chemical composition of coal gangue

SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	Na ₂ O	K ₂ O	C
30-60	15-40	2-10	1-4	1-3	1-2	1-2	20-30

Coal gangue has large reserves in China, low carbon content, high hardness and easy to mine. After crushing and sand making, the finished product has uniform particle size and strong plasticity. Therefore, the use of coal gangue aggregate in concrete is conducive to saving the project cost and reducing the cost. Because there is no dry industrial waste, its coarse bone content is lower than that of ordinary concrete. Therefore, the cost of coal gangue concrete structure is relatively low. Moreover, the accumulation of coal gangue is increasing day by day, which not only occupies precious land resources, but also seriously pollutes the natural environment, which has become one of the difficult problems to be solved in today's society. Therefore, from the perspective of resource development, waste utilization and sustainable development, it is very necessary to seek the development and utilization of coal gangue.

1.1 Gangue Cement

Coal gangue clinker free cement is made of spontaneous combustion coal gangue or coal gangue calcined at 800 °C as the main raw material, mixed and ground with lime and gypsum, and a small amount of Portland cement clinker or blast furnace slag can also be added[3-4]. Instead of grinding raw materials and calcining clinker, the cement directly mixes and grinds active materials and activators in proportion. This kind of cement has low hydration heat and is suitable for cementitious materials of various building blocks, large plates and prefabricated components.

The production of cement from coal gangue requires high content of coal gangue components, and the sulfur content should not be too high, otherwise the cement production will be affected. The production process is complex, and limited by the transportation cost, the cement plant should not be too far away from the origin of coal gangue, and there should be relatively stable construction users around, so a large-scale coal gangue cement plant cannot be formed, Therefore, it has limited effect on the treatment of coal gangue.

1.2 Lightweight Coal Gangue Aggregate Concrete

The process of producing lightweight aggregate from coal gangue can be roughly divided into two categories: the production of sintered coal gangue porous alkane binder with sintering agent and the production of expansive coal gangue ceramsite with rotary kiln. The lightweight aggregate produced from coal gangue has good performance, and the lightweight aggregate can be used to prepare high-performance concrete.

The lightweight concrete prepared with lightweight aggregate produced from coal gangue has the characteristics of low density, high strength and low water absorption. It is suitable for making prefabricated parts of various buildings. Gangue ceramsite is a promising lightweight aggregate. It not only finds a new way to deal with coal industrial waste and reduce environmental pollution, but also provides a basis for the development of high-quality and lightweight building materials.

New resources are a way of comprehensive utilization of coal gangue, but the treatment capacity is small, which plays a limited role compared with the current storage capacity of coal gangue.

2. Properties of Coal Gangue Concrete

2.1 Sulfate Resistance of Coal Gangue Concrete

Shi Mingyue and others studied the sulfate resistance of coal gangue concrete under different erosion environments by four factor and three-level orthogonal test. The results show that the dry wet cycle is more obvious than long-term immersion, and the addition of fly ash and coal gangue can inhibit the deterioration of concrete performance[5]. Li Yongjing and others studied the effects of fly ash content, dry wet cycle times and water binder ratio on the sulfate corrosion resistance of coal gangue concrete. The results show that the sulfate corrosion resistance of coal gangue concrete meets the requirements of general buildings[6]. Guo Jinmin coal gangue is used instead of crushed stone, and fly ash and slag are used instead of cement to prepare coal gangue concrete[7].The best mix proportion of coal gangue concrete was obtained by orthogonal test method and comprehensive balance method. The results show that sulfate erosion has little effect on the strength of coal gangue concrete. Platinum Ting performed a SEM analysis of the concrete mixed with gangue and gangue sand, and found that after sulfate erosion, the concrete with coal gangue and coal gangue sand will produce ettringite, resulting in small cracks in the concrete and reducing the strength[8].

2.2 Effect of Coal Gangue Mixing Quantity on Concrete Properties

Natural combustion gangue can be used as light aggregate to produce concrete. The test coal gangue is a mixture of spontaneous combustion coal gangue and tunnel gangue. The specific strength of concrete decreases. The compressive strength of concrete cube is divided by the apparent density to obtain the specific strength of concrete. The content of coal gangue has little effect on the performance of C20 concrete. When the content is less than 40%, the strength of C30 concrete decreases slowly. When the content is greater than 40%, the strength decreases by 10%, so the content of C30 concrete

should be controlled within 40%. The strength of C40-C50 concrete decreases linearly with the increase of the admixture. When the content of coal gangue is greater than 60%, the working performance of concrete decreases greatly; The analysis shows that for the concrete with strength grade above C40 and C50, the content of coal gangue has a great impact on the working performance. When the gangue content exceeds 20%, the performance of gangue concrete will be greatly reduced.

3. Development Prospect of Coal Gangue Concrete

According to the characteristics and actual needs of coal gangue, the development of new concrete with coal gangue as the main material, speed up the pace of comprehensive utilization of coal gangue, which will greatly improve the utilization efficiency of domestic coal resources. The coal gangue concrete is applied to the construction industry, compared with ordinary concrete, it will have the advantages of high strength, good freezing resistance, good permeability resistance and low cost. In terms of environment, coal gangue concrete handles a large amount of coal industrial waste, reduces pollution, saves resources, and produces positive benefits to environmental protection.

Due to the use of industrial waste can enjoy the national tax exemption policy, all products can pay less profits and taxes of about 17%, and a large number of laid-off workers and unemployed workers can also be arranged for employment, with obvious social benefits. In general, coal gangue concrete makes full use of mineral resources, increase social and economic benefits, while reducing the pollution to the environment, which can promote the sustainable development of resources and the environment.

4. Conclusion

Coal gangue concrete has the characteristics of high strength, good durability and low cost, which turns industrial waste into treasure and greatly improves the utilization efficiency of Chinese mineral resources. Therefore, the development station of coal gangue concrete is very necessary in the perspective of resource utilization and sustainable development.

Acknowledgments

This work was financially supported by Teaching Reform Project of Ordos Institute of Technology (20190207), Research Program of Science and Technology at Universities of Inner Mongolia Autonomous Region (NJZY22206), College Student Innovation and Entrepreneurship Training Program of Ordos Institute of Technology (20200116) and College Student Innovation and Entrepreneurship Training Program of Ordos Institute of Technology (20210114).

References

- [1] Cold light. Research and Application of comprehensive utilization of coal gangue [J]. Sichuan Architectural Science Research. 2000, (02).
- [2] Guo Yanxia, Zhang Yuanyuan and Cheng Fangqin, Industrialization and Prospect of the Comprehensive Utilization of Coal Gangue [J], Chemical Journal, 2014 (07).
- [3] Wang Yanfeng. On the comprehensive utilization of coal gangue [J], Northern Environment. 2011 (11).
- [4] Zhang Changsen et al. Experimental study on the configuration of spontaneous gangue as active admixture [J], Concrete and Cement Products, 2004 (6).
- [5] Shi Mingyue. Experimental study on deterioration of sulfate Erosion degradation of coal gangue lonely concrete [D]. Liaoning University, 2017.
- [6] Li Yongjing, Xing Yang. Experimental study on sulfate erosion resistance of coal gangue concrete [J]. Nonmetallic mine, June 39, 2016 (1).
- [7] Guo Jinming, Zhu Lingli. Orthogonal experimental study on the durability of coal gangue concrete [J]. Journal of Liaoning University of Engineering and Technology (Natural Science Edition), January 30, 2011 (4).

- [8] Platinum Ting, Li Guodong. Study on the sulfate erosion resistance of coal gangue aggregate concrete. 2021.(3).