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THE EXPERIENCE OF THE CHINESE CONSTRUCTION INDUSTRY IN THE IMPLEMENTATION OF THE WET SHOTCRETE

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At present, the research on the durability of shotcrete in our country is still very insufficient, and basically no fruitful elaboration has been carried out. Therefore, for the development of shotcrete technology, it is very necessary to carry out research in this area actively.

Since the 1980s, the design of concrete structures in developed countries has gradually transitioned from a strength-based design method to a method that emphasizes both strength and durability design, while modern concrete structure design is a design method that focus on durability, which requires concrete with high fluidity, high mechanical properties and high durability, high performance concrete was produced under this background. High performance concrete is an effective way to improve the durability of engineering structures [1]. Low water-binder ratio, high-efficiency water-reducing agent and large-volume mineral admixture are the salient features of high-performance concrete.

Among all building materials, concrete consumes less energy and creates less pollution. However, due to its wide application and large amount, it has caused a shortage of resources such as limestone and sand aggregates and has also damaged the natural environment. In order to save energy and reduce consumption, it is necessary to vigorously promote the preparation technology of machine-made sand sprayed concrete, and at the same time use various industrial wastes as the main source of cementitious materials, which can fundamentally reduce the amount of cement used.

Many engineers and technicians have done relevant experimental research and exploration on the use of machine-made sand to replace natural sand in concrete [2-3]. However, in previous experiments, machine-made sand was used as the fine aggregate of concrete. Due to the excessive stone powder content of machine-made sand, the concrete has a large water demand, poor workability, and reduced strength, which is difficult to meet the construction needs of the second lining of the tunnel. Therefore, machine-made sand is not suitable for use as fine aggregate of pumped concrete. If a certain amount of fine river sand is mixed into the machine-made sand as the fine aggregate of concrete without reducing the performance of concrete, it can not only solve the shortage of natural sand, but also reduce the cost of concrete and reduce the cost of concrete. pollution of the environment.

After mixing mineral admixtures, high-efficiency water reducers and alkali-free accelerators into high-performance wet shotcrete, the hydration mechanism of cementitious materials is different from that of ordinary wet shotcrete. The hydration hardening process of cementitious materials and its influence on the properties of cementitious materials are studied. Liu Wenbin [4] and other studies have shown that the water-binder ratio has a great influence on the performance of concrete. The greater the water-binder ratio, the worse the frost resistance and sulfuric acid corrosion resistance of concrete. If fly ash, slag powder, limestone powder and air-entraining water reducer are mixed in, the frost resistance and sulfuric acid corrosion resistance of concrete will be improved. Under the condition of low water-binder ratio, better mechanical properties can be obtained, and it has "super-stacking effect". Feng Chunhua [5] and other studies have shown that under the conditions of low water-binder ratio and insufficient curing, after the concrete is hardened with ordinary Portland cement, there are still a large number of unhydrated cement particles in the cement paste; substitution of cement of equal quality by admixtures can promote early hydration reactions, which is equivalent to increasing the water-cement ratio. In the early stage of hydration, fly ash and slag do not participate in the pozzolanic reaction; in the later stage of hydration, fly ash and slag react with cement hydration products to promote the hydration reaction of cement and improve the performance of concrete.

Pan Lisha [6] proposed that the use of high-efficiency water reducers is one of the most cost-effective methods to solve the durability of concrete. This paper summarizes the research status of the influence of water reducing agents on the durability of concrete in the past ten years and points out that it is urgent to systematically study the law of the influence of water reducing agents on the durability of concrete, so as to provide theoretical guidance for the correct selection of water reducing agents in engineering, so as to prepare concrete with good durability. high-performance concrete. Kennth C. [7] research shows that adding high-efficiency water-reducing agent to concrete can reduce the water-binder ratio of concrete, reduce the amount of water and cementitious materials, reduce the porosity of hardened concrete, improve the structure of the concrete interface zone, and improve the durability of concrete. Studies of Zhang Jianqiang etc [8] have shown that over-dense concrete is not durable, and it is beneficial to increase the durability of concrete by reasonably increasing the number of harmless pores and less harmful pores inside the concrete. Different water-reducing agents have different effects on improving the pore structure of the gel. The water-reducing agent with a large water-reducing rate and a small air content is beneficial to improve the pore structure inside the concrete. Naphthalene-based water reducer (FDN) and sulfamate-based water reducer (MAS) have excellent performance.

Wang Jiliang [9] studied the effect of fly ash and slag on the durability of high-strength concrete. The test results showed that: fly ash and slag reduced the early strength of concrete, but significantly improved the later strength of concrete. The growth rate of concrete strength is higher; both fly ash and mineral powder can significantly improve the compactness of concrete, and mineral powder has a better effect than fly ash, and the concrete compaction performance increases with the increase of the content. Zhao Qingxin [10] and other studies have shown that the addition of fly ash to concrete can improve the morphology of the interface transition zone, thereby enhancing its durability.

Xia Jitao [11], under the same conditions of cementitious material dosage, water-binder ratio, and sand rate, respectively mixed 0%, 15%, 25%, 35%, 45%, and 55% natural sand to replace Manufactured sand, to study the change law of the working performance and mechanical properties of concrete under different machine-made sand replacement rates, so as to find the best machine-made sand replacement rate suitable for tunnel secondary lining concrete is about 35%. and mechanical properties are well developed.

Therefore, the concrete in the future must reduce the amount of cement fundamentally, and must make more use of various industrial wastes as its raw materials; the concrete in the future must be high-performance, especially durable. With the development of concrete technology, corresponding changes have taken place in the composition and composition of concrete. High-performance concrete will surely become the type of material widely used in tunnel engineering in China.

From 1948 to 1953, Austria used shotcrete support when constructing the Mier Tunnel of the Kapron Hydropower Station. This is the first shotcrete project in the world. This is the "New Austrian Method" theory that was later generally recognized by the engineering community. Since the 1980s, China first used shotcrete in the construction of Dayaoshan Tunnel, and the application of shotcrete has a history of more than 30 years. At present, shotcrete has become an indispensable and important part of the railway tunnel structure system.

Shotcrete is widely used in underground engineering, geotechnical engineering, repair and reinforcement engineering, thin-walled structural engineering, fire-resistant engineering, protective engineering and other civil engineering fields (especially water conservancy engineering, tunnel engineering construction) [12]. In the past 10 years, with the construction of large-scale high-speed railways and highways in China, the amount of sprayed concrete has been increasing. According to the "Medium and Long-term Railway Network Plan" approved by the State Council, the main channel of China's high-speed railway will reach 45,000 km, the connecting line of high-speed railway will be about 10,000 km, and the intercity railway will reach more than 10,000 km. By 2030, a large number of high-speed railway and intercity railway tunnels will continue to be built, with a total scale expected to be over 10,000 km [13]. According to statistics, by the end of 2020: my country has 2,746 railway tunnels under construction (total length 6,083km), and planned 6,354 railway tunnels (total length: 16,255 km); my country has 1,811 high-speed railway tunnels under construction (total length: about 2,750 km), and planned 3,525 high-speed railway tunnels (The cumulative length is about 7966 km) [14]. In the process of tunnel construction, it is difficult to accurately calculate the amount of shotcrete used in highway, railway, and water conservancy projects, which is related to many conditions such as the area of the tunnel section of each project, the thickness of the designed shotcrete, and the grade of surrounding rock. Combined with scientific theoretical calculations and relevant data of actual tunnel engineering, it can generally be estimated by using 20 m^3 shotcrete per linear meter of the tunnel [15]. It can be estimated that 177 million m^3 of sprayed concrete is required for the railway and high-speed railway tunnel projects under construction in my country, and 484 million m^3 of sprayed concrete is required for the currently planned projects to be constructed. Therefore, a large number of railway tunnel construction projects need high-quality shotcrete as support, and the development of my country's infrastructure projects also requires the continuous development of shotcrete technology, so shotcrete has a lot of development space and market potential in my country.

Shotcrete has been used in engineering for more than half a century. Its raw materials and technology have matured. Wet spraying of spraying process gradually replaces dry spraying and tidal spraying. The injection quality has been guaranteed by technology. Shotcrete design has moved from a purely thickness design to a comprehensive performance design. Under different surrounding rock conditions. Shotcrete with different properties. It is an important development trend of the current shotcrete technology.

In general, the performance of shotcrete is closely related to its supporting function. At present, shotcrete is mainly used in the initial support and permanent support of tunnels and underground projects. In terms of performance design, according to its different engineering uses, it should be treated differently and different design parameters should be adopted.

Shotcrete as a permanent support must not only meet the basic performance requirements of shotcrete, but also meet the structural waterproof, anti-cracking and anti-stripping performance requirements. In a corrosive environment, it must also meet the anti-corrosion durability performance requirements.

In China, tunnels constructed by mining methods mostly adopt composite lining structures. Shotcrete is located between the surrounding rock and the second lining, in a relatively closed space, isolated from the atmospheric environment, and is slightly affected by the external environment. Shotcrete is affected by carbonization. The possibility of wind erosion and abrasion is very small, and shotcrete is generally used as primary support to seal surrounding rock and form a shell-like structure to distribute external forces. In structural design, shotcrete is generally used as temporary support, and secondary lining is used as permanent support. Therefore, it is generally believed that the durability of shotcrete used as primary support can be ignored. Therefore, when designing the tunnel structure, only the safety performance and serviceability of shotcrete are regulated, and there are no special regulations on its durability. Therefore, domestic research on the durability of shotcrete in composite linings is still blank.

The durability of shotcrete used as primary support is directly related to the environmental conditions of surrounding rocks. For tunnel structures, unlike ground structures, the corrosive environmental conditions in the tunnel mainly come from the erosion of groundwater and harmful substances in surrounding rocks. There may also be a freeze-thaw environment in cold regions. Therefore, when designing shotcrete, the durability performance in erosive environment and freeze-thaw environment is mainly considered. The durability performance of shotcrete includes the following aspects.

The peeling resistance is related to factors such as the adhesion strength of shotcrete and cracking caused by drying shrinkage. At present, the test methods and standards for evaluating the anti-stripping performance of shotcrete have not yet formed a standard, but the adhesion strength of shotcrete can be used for evaluation. From the current engineering practice, if the adhesion strength of shotcrete exceeds $1.0N/mm^2$, it can basically guarantee that the shotcrete will not peel off.

At present, the cracking mechanism of shotcrete cannot be explained clearly, and further research is needed. The cracking of shotcrete is related to factors such as autogenous shrinkage, drying shrinkage, temperature shrinkage, load action, and construction quality. After shotcrete cracks, it provides erosion channels for groundwater, and the concrete will undergo corrosion, chemical corrosion, and freeze-thaw damage.

For tunnel structures, the intrusion of chloride ions mainly comes from the content of groundwater and surrounding rocks containing chloride ions. The subsea tunnel mainly comes from the intrusion of seawater. Submarine tunnels in European countries mostly use steel fiber shotcrete as permanent support, and the intrusion of seawater must be checked.

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