Research on the Influence of Green Building Materials on the Early Crack Resistance of Concrete Based on the Lifetime Durability

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Abstract: In recent years, with the continuous development of economic resources and the increasing demand for infrastructure, the durability of concrete structure is becoming increasingly prominent. The research on the durability of concrete materials and structures and their life-cycle performance has become a hot topic in the world. The durability of concrete determines the service life of concrete structures and components, and is a crucial performance of concrete materials. Since the study of concrete durability has an inseparable relationship with the early state of concrete, starting from the source of the concrete life cycle, it is of great significance to study the law of the influence of material properties on the durability of concrete during its early age during construction. Based on the research of the whole life cycle theory, this paper proposes a series of solutions from the factors affecting the durability of concrete.

1. Introduction

In the traditional concept, people always think that reinforced concrete structure is made of the most durable concrete materials, which has a high expectation for the service life of the structure and ignores the durability of the concrete structure. However, the durability of the concrete structure inevitably occurs in the actual service process [1]. The problems of resources, energy and environmental protection caused by structural durability failure are also becoming more and more prominent. Durability is the comprehensive performance of a structure. Durability failure will not only cause changes in the appearance of the concrete structure and cannot meet the requirements of normal use, but also lead to deterioration of the bearing capacity and ultimately affect the safety of the whole structure. This process is the change process of structural performance with time, in which "health" and "life" dominate the whole service period of concrete structures [2].

In practice, many concrete structures were found to be prematurely damaged by the environment and did not reach the expected service life. Therefore, it is urgent to introduce the concept of "full life" of the structure in the study of the durability of concrete structures in order to grasp the overall performance of the structure from a global perspective. With the continuous improvement of the requirements for the overall structural performance, safety performance and durability in engineering, the term "full life" appears more and more frequently in the field of structural engineering [3]. The "full life" of a structure can be divided into several major time periods such as construction, operation, aging and abolition. For concrete structures, durability plays an important role in the whole life research system, which becomes a key clue throughout these several stages. Whether durability failure is related to the practicability and safety of the structure, thus affecting the development and change of life control durability, which can comprehensively reflect the optimization of the overall cost [4]. Fully analyze the influence of early age material performance of concrete on its later durability in construction period, establish the relationship between the material performance of concrete in construction and the durability of concrete structure under service conditions, and then realize the durability control based on the early age material performance, which is an important content in the research of the whole life performance of concrete structure [5].

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2. Research on the Theory of Life Cycle

The three core indicators of structural durability based on the full life theory include time indicators, reliable quality indicators, and economic indicators. In addition to the three core indicators, the green goal level of environmental protection, energy saving, and sustainability needs to be considered. It mainly refers to user satisfaction indicators, social and environmental benefit indicators, and sustainable development indicators [6].

2.1 Durability of Concrete

Durability of concrete refers to the ability of concrete to resist the action of environmental media and maintain its good service performance and appearance integrity for a long time, thus maintaining the safe and normal use of concrete structures. The design service life of the structure will also determine the selection of the main construction materials of the structure. The longer the service life, the better the strength and durability of the structure. The lower the service life, the better the strength and economy of the material [7].

2.2 Factors Affecting Durability of Concrete

There is a direct relationship between the change of physical and chemical properties of materials in concrete structure and its durability. Corrosion, freeze-thaw of reinforcement and the physical and chemical effects under corrosive environment will reduce the durability of concrete structure. Impermeability refers to the ability of concrete to resist the penetration of water, oil and other pressure liquids. The causes of concrete quality deterioration are all related to water. Without the direct effect of water or as the carrier of corrosive impurities into concrete, concrete diseases will not occur. Corrosion of steel bar refers to the damage of protective film on the surface of steel bar. In the presence of oxygen and water, electrochemical corrosion occurs on the surface of steel bar, and chemical reaction occurs on the anode iron ion to generate ferrous oxide, iron hydroxide and other corrosive substances. There are two kinds of freeze-thaw damage of concrete. One is that when pouring at low temperature, the concrete is frozen before hardening, the hydration reaction of cement is very weak, the cement hydrate generated is less, and the strength is low. The other is the damage caused by long-term freeze-thaw cycles in the service process of concrete, mainly manifested as internal damage and surface erosion. The failure mechanism is mainly the crystallization of water and salt in the pores of concrete, which generates pressure on the pore wall and causes damage. The existence of chloride ion is another important reason for steel bar corrosion. Erosion resistance refers to the ability of concrete to suffer chemical erosion and not be destroyed by physical action in the environment containing erosive medium. The erosion resistance mainly depends on the type of cement, concrete compactness and pore structure. When concrete structures are in ideal saturated chloride environment, chloride ion transport and erosion in concrete is a diffusion process, moving from saturated state to unsaturated state. However, in most cases, concrete is not in a saturated state. It is generally believed that the transmission of chlorides in concrete is a comprehensive result of different combinations of various mechanisms such as diffusion and capillary absorption.

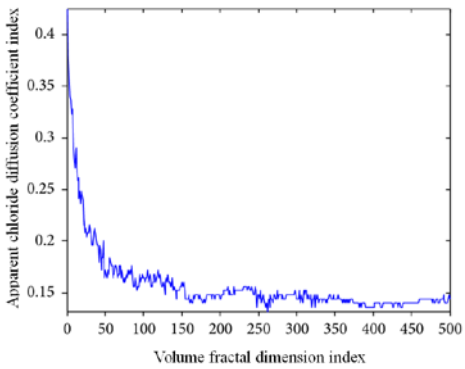

Fig.1 Relationship between System Fractal Dimension and Chloride Diffusion Coefficient

3. Method for Improving Early Crack Resistance of Concrete

3.1 Concrete Burn-in Curing

During the construction period, the quality of concrete seriously affects the performance of concrete structure in the later service process. In recent years, the early cracking of concrete causes the invasion of harmful media, which leads to the deterioration of concrete and the decrease of durability. The research on the whole life process of concrete structure from the aspect of durability can reveal the potential danger due to the insufficient durability of the structure, and plan reasonable and effective maintenance and repair activities in the period of structural performance degradation, so as to extend the service life of the structure and reduce the economic loss. At the same time, it can improve the theory and method of structural durability design, make the new structure have enough durability in the future, adapt to the current sustainable development strategy, and reduce the environmental problems caused by durability failure. The research on this subject is in line with China's concept of building a people-oriented resource-saving and environment-friendly society, and it can provide technical support for China to build a harmonious society with sustainable scientific development. Depending on the temperature and humidity used, there are usually three types of concrete curing methods: standard curing, natural curing, and rapid heating. The early construction and maintenance conditions play a vital role in the formation and development of the initial internal defects of the concrete and the hole structure, and then have an important impact on the durability of the concrete in the later stages.

3.2 Material Level

In the research of concrete durability based on the theory of life cycle management, material level is the basic research of concrete structure durability research system. The main content of material level research includes the research on durability failure mechanism of various types of concrete, such as freeze-thaw, carbonation, alkali aggregate, chlorine salt erosion and other reactions, as well as the research on concrete high-performance measures under the influence of these durability deterioration factors. With the development and application of high-strength and ultra-high-strength concrete technology, it has become easy to realize the concrete strength requirements. Due to the requirements of early construction workability and long-term durability, the hydration heat release performance of cement and the compatibility with additives are also emphasized. Mineral fine admixtures have high surface energy, have microscopic filling effect on the voids of cement particles, and are chemically active, thus improving many material properties of ordinary concrete. The fine minerals commonly used in the preparation of concrete with durability requirements are fly ash, granulated blast furnace slag and silica fume. The tiny air bubbles in the concrete can alleviate some internal stresses and inhibit crack formation and propagation. Adding air-entraining agents, on the one hand, introduces small closed air bubbles, which can not only effectively improve the concrete's impermeability and frost resistance; on the other hand, it can significantly improve the concrete's ability to resist chemical attack. This is especially true for concrete that requires frost resistance. important. Mud content is an important indicator of aggregates. Mud content not only affects the strength of concrete, but also affects durability. The “mud” in the mud content includes clay particles, mud and dust particles. These very fine materials will wrap on the aggregate surface, hinder the bond between the aggregate and cement stone, form a weak interface layer, and become the weak area in the concrete. From the perspective of construction, these tiny particles greatly increase the specific surface area. If the superplasticizer is not introduced, the water consumption per square meter will be greatly increased, The cost of concrete with superplasticizer will be increased, and its strength and durability will be reduced even if it meets the requirements of workability. Aggregate grading is also one of the important performance characteristics, but there is little research on the relationship between aggregate grading characteristics and structural concrete performance. As shown in Figure 2, the variation diagram of cement slurry amount and aggregate gap is shown.

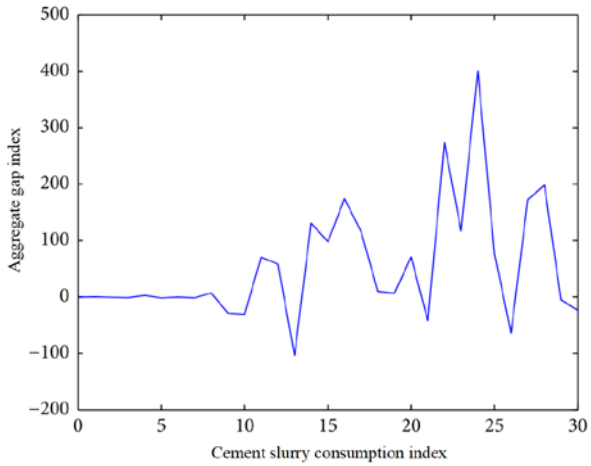

Fig.2 Aggregate Gap and Cement Slurry Dosage Change

3.3 Fair Use

Construction is the last process of concrete from raw materials to products. The quality of construction directly affects the durability of concrete. Many cases of insufficient durability of concrete structures are caused by unqualified construction quality. Therefore, it is necessary to strengthen the control of concrete production. Therefore, it is necessary to strictly control the chloride ion content in concrete aggregate and mixing water. Secondly, the compactness of concrete should be improved, the penetration of chloride ion and the carbonation speed of concrete should be reduced, so as to prevent the corrosion of reinforcement caused by carbonation. The negative effects of shrinkage and hydration heat increase caused by too much slurry in concrete cannot be solved by controlling the water-binder ratio. The main technical approaches to be solved are: (1) selecting coarse aggregate with good gradation and grain shape; (2) adding water reducing agent; (3) adding mineral admixture with low water requirement ratio. The methods of reducing cement dosage and increasing mineral admixture can effectively reduce the interfacial water-binder ratio, improve compactness and reduce calcium hydroxide enrichment. Reduce the amount of mixing water, thus increasing the amount of powder materials; Adding high-quality mineral fine powder admixture can make pores thinner and smaller, and can effectively reduce electric flux and chloride ion diffusion coefficient.

4. Conclusion

For the concrete structure, its durability failure process includes the whole life process of the construction, use and aging of the structure. The study of concrete durability has an inseparable relationship with the early state of concrete. Studying the influence of the characteristics of concrete materials on its durability during the construction period is an important part of the research on the full life performance of concrete, and it is of great significance to establish the durability control technology of concrete materials based on early age performance analysis.The methods of concrete durability evaluation and life prediction are mainly changed from deterministic evaluation to dynamic evaluation based on probability and reliability. Because of the complexity of concrete material composition, composition and external environment, the mechanism of durability damage is not completely clear, so there are still many problems in the field of concrete durability that need more in-depth study.

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