Durability Assessment of Recycled Aggregate Concrete in Aggressive Environments

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Abstract: The durability of recycled aggregate concrete in harsh environment is faced with problems such as low strength, poor permeability resistance and insufficient freezing resistance, mainly due to the surface roughness and high porosity of recycled aggregate. This paper can improve the quality of the recycled aggregate, improving the aggregate treatment method and designing the concrete ratio reasonably. The use of admixture and admixture, fly ash, mineral powder and gas guiding agent, help to improve the freezing resistance, impermeability and chemical corrosion resistance of concrete. Scientific construction and curing methods play a key role in the long-term stability of concrete. These technical means can effectively improve the application performance of recycled concrete in the harsh environment.
***Keywords*:** recycled aggregate concrete, durability, admixture, construction, and maintenance

1. Introduction

Limited by the quality of the recycled aggregate, especially in harsh environmental conditions, the strength and durability of the recycled concrete is often inferior to conventional concrete. This problem is particularly prominent in extreme environments such as cold or salt, and directly affects the safety and stability of their long-term applications. It is of great engineering significance to explore the methods to improve the durability of recycled aggregate concrete, especially the application technology in the harsh environment. By improving the treatment of recycled aggregate, optimizing the concrete mix ratio, and using admixtures, this paper discusses the technical means to enhance the durability and performance of recycled concrete

2. Analysis of the durability problem of the recycled aggregate concrete in the harsh environment

The recycled aggregate usually has a large porosity and lower compactness, which leads to the poor overall compaction of concrete and is vulnerable to the penetration of corrosive substances such as moisture and salts[1]. The surface of recycled aggregate is rough and there is hardened cement slurry layer, which makes the bonding of cement substrate poor and reduces the strength and durability of concrete. The cracks and microstructural defects in the recycled aggregate will further aggravate the damage degree in the harsh environment, especially under the extreme conditions such as freezing and thaw cycle and acid and alkali erosion, the freezing resistance and impermeability of concrete are significantly reduced. In addition, the temperature and humidity change, salt corrosion and chemical reaction and other factors will accelerate the deterioration process of reclaimed concrete, especially in the long time exposure to the ocean, groundwater or industrial pollution environment, the concrete surface may occur significantly fall off and peel. Due to the fluctuation of the source and quality of the recycled aggregate, the durability of the concrete is therefore uncertain, which poses challenges to the long-term safety and structural stability of the project.

3. Technical means: An effective method to improve the durability of recycled aggregate concrete

3.1 Improve the aggregate quality and optimize the concrete ratio

Poor physical properties, rough surface and high porosity of recycled aggregate are often caused due to different sources, incomplete cleaning and hardened cement slurry. Therefore, a reasonable pretreatment of the regenerated aggregate is first needed to improve its quality. Common treatment methods include cleaning, screening and crushing, especially the removal of the cement slurry layer attached to the surface of the regenerated aggregate to reduce the interface strength between the cement slurry and the aggregate, thus improving the adhesion of the recycled aggregate. By optimizing the

ratio of concrete, to further improve its durability. The ratio of cement and sand in traditional concrete is generally 1:2:4, and the ratio of recycled concrete needs to be adjusted according to the performance of the aggregate. Generally speaking, appropriately increasing the amount of cement and reducing the water-cement ratio can effectively improve the compactness of concrete, thus reducing the porosity. Controlling the water - cement ratio at a lower level, which is a crucial factor in concrete mix design, helps to reduce the capillary pores inside the concrete and improve the impermeability and freezing resistance. In addition, the use of reasonable aggregate grading, optimize the proportion of coarse and fine aggregate, but also help to improve the compactness of concrete. In order to further optimize the performance of recycled concrete, recycled aggregates from different sources can be classified and screened according to their particle size and surface characteristics to avoid using aggregates containing excessive impurities or substandard quality. Through this process, the physical and mechanical properties of the recycled aggregate can be significantly improved, making it more suitable for concrete with high strength and high durability requirements. Table 1 shows the different aggregate treatment methods and their effects on the performance of recycled concrete. According to the data in the Table, the regenerated aggregate after cleaning and crushing treatment showed low porosity and high compactness, which significantly improved the compressive strength and durability of concrete.

Table 1. Aggregate Treatment Methods and Their Influence on the Properties of Recycled Concrete

Methodology of aggregate treatment	Pporosity (cm^3)	Densiity (g / cm^3)	Compressive strength (MPa)	Impermeable properties (cm)
The original aggregate	15.2	2.05	28.0	17
Aggregate after cleaning and treatment	12.3	2.12	30.5	13
Cleaning + screen treatment	10.1	2.15	33.2	10
Cleaning + screening + crushing	8.7	2.20	35.8	8

Data source: experimental data of a research institution

3.2 Use of admixture and admixture to enhance the durability

admixture can effectively improve the microstructure of concrete and improve its anti-seepage, frost and chemical corrosion resistance. Common admixture materials include fly ash, mineral powder, silicon ash and blast furnace slag. These admixtures promote the cement hydration reaction by filling the gap between the aggregates, thereby improving the compactness of the concrete and reducing the formation of capillary pores[2]. In addition, the use of admixture helps to reduce the amount of cement, reduce the carbon footprint of concrete, and further improve its environmental protection performance. Under harsh environmental conditions, the use of admixture is particularly important to improve the durability of concrete. The gas guide can introduce tiny bubbles to reduce the water expansion of the concrete and improve the frost resistance; while the water reducing agent and efficient water reducing agent can reduce the water-cement ratio and enhance the compaction and strength of the concrete. In addition, the use of impermeable agent or waterproof agent can effectively improve the impermeability of concrete, prevent moisture and harmful substances infiltration, reduce the deterioration rate of concrete. After adding admixture such as fly ash and mineral powder, the compressive strength and freezing and thawing circulation ability of concrete are significantly improved. The mass loss rate of the concrete mixed with fly ash is much lower than that of the concrete without fly ash. In addition, dmixtures such as silica fume and mineral powder can silica ash and mineral powder can significantly improve the chemical erosion resistance of concrete, especially in the high humidity and high salt environment. In engineering practice, the selection and ratio of admixture should be adjusted reasonably according to the use environment and requirements of concrete. Through scientific material selection and accurate ratio, the durability problem caused by uneven aggregate quality can be overcome to a certain extent, and its long-term stability in harsh environment can be improved.

4. Comprehensive evaluation and durability performance in engineering application

4.1 Performance of recycled aggregate concrete under different environmental conditions

In the high humidity and high temperature environment, the cement substrate is prone to hydration reaction. If the water-cement ratio is too high, the porosity of the concrete increases, resulting in the decrease of its compressive strength and durability. In a saline environment, chloride ion will accelerate the corrosion of steel bars and reduce the long-term performance of concrete. Therefore, in the design of reclaimed concrete, it is necessary to strictly control the water cement

ratio, use a lower water - cement ratio to improve the compactness of concrete, reduce porosity, so as to effectively improve its impermeability and frost resistance. In wet and saline environments, adding mineral powder and fly ash can improve the durability of recycled aggregate concrete. Adxture can reduce the formation of capillary pores by filling the gap between aggregates, improve the density of concrete, and then improve the water permeability resistance and freeze and thaw resistance. a freeze - thaw cycle test, the optimized recycled concrete showed lower mass loss rate and better freeze-thaw cycle resistance. The data show that the mass loss rate of reclaimed concrete mixed with fly ash and ore powder is lower than that of unmixed concrete after 50 freeze and thaw cycles, and the impermeability is significantly improved, which proves the effectiveness of admixture in harsh environment.

4.2 The key role of construction and maintenance in durability improvement

In the construction process, reasonable vibration and pouring technology can effectively reduce the bubbles and gaps in the concrete, avoid cracks and honeycomb phenomenon, so as to improve its compactness and strength[3]. For the recycled aggregate concrete, it is necessary to pay special attention to the uniformity of concrete to ensure the full combination of aggregate and cement slurry, and avoid the performance of the concrete due to the rough or impurities of the recycled aggregate surface. In the curing stage, the appropriate temperature and humidity control can promote the complete progress of the cement hydration reaction. Steam curing and wet curing can effectively improve the strength and durability of recycled concrete. Keeping the concrete surface wet helps to ensure the full reaction of cement and water, promote the generation of hydration products, and then enhance the overall compactness and strength of concrete. Suitable humidity can prevent the concrete surface from drying too fast, reduce the cracks caused by shrinkage, so as to improve its crack resistance. Temperature control is also important, too high the temperature will accelerate the cement hydration process, but may lead to water evaporation too fast, thus affecting the normal development of strength. On the contrary, the temperature is too low will delay the cement hydration, affecting the strength growth and hardening quality of concrete. Therefore, by optimizing the curing conditions, to ensure that the concrete in a reasonable temperature and humidity range of curing, can greatly improve its compressive strength, freezing resistance and overall durability, especially in the early stage, the curing quality directly affects the long-term performance of concrete.

5. Conclusion

Reclaimed aggregate concrete is faced with insufficient strength and durability problems in the practical application, especially in the harsh environment, its performance is particularly critical. By optimizing the quality of recycled aggregate, reasonably adjusting the ratio of concrete, and making scientific use of admixture and admixture, its freezing resistance, impermeability and chemical corrosion resistance can be significantly improved. The standardized management of the construction and maintenance process also plays an important role in improving the durability of concrete. On the whole, the technical means proposed in this paper can effectively solve the performance bottleneck of recycled aggregate concrete in the harsh environment, and provide technical support for its wide application.

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