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Research on The Design And Application of Micro-Expansive Concrete Mix Ratio

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KEYWORDS

Micro expanding concrete;
Mix ratio;
Expanding agent;
Concrete performance;

ABSTRACT

This paper focuses on the mix ratio of micro-expansive concrete, and introduces the types and properties of micro-expansive agents, the working principle of micro-expansive concrete and key construction techniques.

INTRODUCTION

Building structure construction projects are collaborative, systematic projects whose implementation requires high standards for various construction techniques and types. As a common construction material in today's building structures, the advantages of expansive concrete are becoming increasingly prominent. It has a positive impact on project quality, effectively enhancing structural stability and extending the service life of buildings. Expansive concrete incorporating expansive agents can effectively improve internal stress and shrinkage characteristics of the structure, reducing the likelihood of concrete cracks.

In recent years, with the gradual improvement of process evaluation and control methods and standards related to building structure construction, the engineering technology system of expansive concrete has continued to improve. However, in practical applications, expansive concrete technology still faces some problems. Based on this, this paper studies expansive concrete construction technology in combination with the actual construction of building structures. Taking the implementation principles and technical advantages of expansive concrete construction technology as the starting point, it discusses in detail the application process of expansive concrete construction technology in building structure construction and proposes key control points in the actual application of expansive concrete construction technology.

1.Analysis of the advantages of expansive concrete construction technology

Leakage, cracking and other defects are common quality issues in the design and construction of building structures. The application of expansive concrete technology not only improves the overall anti-seepage and anti-cracking properties of the building structure, but also helps reduce project costs [1]. Therefore, it is widely used in actual building structure projects. The main advantages are as follows:

1.1.Good structural crack resistance and anti-seepage effect

Cracks in building structures are primarily caused by excessive structural stress and excessive external construction temperatures. Cracks in concrete structures can seriously impact the strength of the building [2]. Expansive concrete, through the mixing and expansion process during its preparation, creates expansion stress, effectively offsetting the concrete's inherent shrinkage caused by setting. This improves the concrete's internal structure, enhancing its stability and water resistance, and preventing cracks[3].

1.2.Structural seismic effect

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The added expansion agent forms a chemical reaction after mixing with concrete, which has good connectivity. The expanded concrete achieves a good adhesion effect with adjacent materials, thereby effectively improving the earthquake resistance of the building structure and further improving the overall stability of the building structure.

1.3.Long service life of the structure

Concrete achieves stress compensation through shrinkage pressure, effectively improving structural stability and extending the service life of structures. Expansive concrete incorporating expansive agents generates a specific prestress within the concrete, which resists additional stress and provides excellent shrinkage compensation throughout the concrete[4]. Scientifically controlling the initial and final setting times of concrete, and accurately controlling the amount and timing of water spray during concrete maintenance, based on the actual project needs and environmental characteristics, can ensure effective shrinkage compensation, thereby improving overall construction quality and extending service life.

2.Mix design and testing

2.1.Experimental materials and equipment

Test materials and equipment are important components in the study of micro-expansive concrete mix proportions, which determine the accuracy and repeatability of the test. In this study, high-quality raw materials were strictly selected and standardized equipment was used for testing to ensure the reliability of the test results.

The test used a mix design method for slightly expansive concrete with a slump of 180-200 mm and a design strength grade of C25W8F100 as an example. The materials included cement, expansive agent, fly ash, aggregate, and water. P • 042.5 cement was used; the fly ash was Class F II fly ash produced by Manufacturers 1 and 2; the water reducer was GK-3000 retarding high-performance water reducer; the expansive agents were UEA II expansive agent produced by Manufacturer 3 and HME-IV high-efficiency concrete expansive agent produced by Manufacturer 4. Aggregates used were manufactured sand with a fineness modulus of 2.4-2.8 and continuously graded crushed stone with sizes of 5-20 mm and 20-40 mm, as used in the Kara Hydropower Station concrete project[5]; and drinking water that met relevant water quality standards was used to ensure the purity of the concrete. The physical properties of the expansive agent are shown in Tables 1 and 2.

Test items	GB/T 23439-2017 Technical Specifications Type II		Test results	Test conclusion
Magnesium oxide content/%		≤ 5	2.52	qualified
Alkali content/%		≤ 0.75	0.53	qualified
Specific surface area/($m^2.kg^{-1}$)		≥ 200	278	qualified
1.18mm sieve residue/%		≤ 0.5	0.0	qualified
Coagulation time difference/min	Initial condensation	≥ 45	217	qualified
	Initial condensation	≤ 600	243	qualified
Limit expansion rate/%	7d in water	≥ 0.050	0.064	qualified
	21 days in air	≥ -0.010	-0.007	qualified
Compressive strength/Mpa	7d	≥ 22.5	37.4	qualified
	28d	≥ 42.5	47.5	qualified

Table.1. Expansion agent quality inspection results (Manufacturer 3) [6]

Test items	GB/T 23439-2017 Technical Specifications Type II		Test results	Test conclusion
Magnesium oxide content/%		≤ 5	1.90	qualified
Alkali content/%		≤ 0.75	0.53	qualified
Specific surface area/($m^2.kg^{-1}$)		≥ 200	362	qualified
1.18mm sieve residue/%		≤ 0.5	0.0	qualified
Coagulation time	Initial condensat	≥ 45	217	qualified

difference/min	ion			
	Initial condensation	≤ 600	292	qualified
Limit expansion rate/%	7d in water	≥ 0.050	0.064	qualified
	21 days in air	≥ -0.010	-0.006	qualified
Compressive strength/Mpa	7d	≥ 22.5	38.6	qualified
	28d	≥ 42.5	49.9	qualified

Table.2. Expansion agent quality inspection results (Manufacturer 4) [7]

The test equipment includes a cement standard scheduling water consumption meter, a setting time meter, a mortar strength flexural and compressive strength integrated machine, a slump cone, a vibration table, a curing room, an outside micrometer and an electronic scale. The equipment is strictly configured in accordance with relevant standards and can accurately measure various performance indicators of concrete.

2.2.Test mix ratio

Prepare a C25 slightly expansive pumpable concrete mix with a binder dosage of ≥300 kg/m². The water-cement ratio should be between 0.35 and 0.45. The mineral admixture should account for 20% of the binder mass. To prevent segregation, the sand content of pumpable concrete can be slightly higher than that of ordinary concrete to reduce pumping pressure. The key to expansive concrete mix design is ensuring reasonable expansion without compromising strength and workability. The experimental mix of C25 slightly expansive concrete is shown in Table 3.

Experiment number	Concrete material consumption/(Kg.m $^{-3}$)								
	water	cement	fly ash	expansion agent	sand	Xiaoshi	Zhongshi	water reducer	air-entraining agent
JB-144	155	245	69	31	76	607	499	2.2	0.007
JB-145	155	275	78	35	727	604	496	2.519	0.012
	155	314	89	40	688	597	490	2.879	0.018

Table.3. Concrete mix ratio test parameters [6]

Concrete cubes and durability test blocks with different raw material mix ratios were prepared according to standard methods. The compressive strength and durability of the test blocks were measured at 7 days and 28 days, respectively, to evaluate the mechanical properties of concrete at early and late stages. In practice, compressive strength is often used as the main parameter [7] . Concrete frost resistance, impermeability, and limited expansion rate are important indicators for measuring concrete durability [8].

3.Key points in the application of expansive concrete construction technology

3.1.Expansion zone construction

The layout design of the expansion zone is the key to the construction of the expansion zone. An unreasonable layout design will affect the implementation effect of the project. Wire mesh should be laid on both sides of the expansion zone to fix it, so as to ensure the balanced and stable ratio of the expansion concrete and avoid the instability of the expansion zone caused by the mixing of different materials [9] . Strictly control the ratio of the expansion concrete and the amount of various mixed materials in the expansion zone. Add 9% of the expansion agent to the concrete in the middle area of the expansion zone and 7% of the expansion agent to the concrete at the outer end to scientifically improve the uneven stress at both ends of the expansion zone and avoid the occurrence of construction cracks.

The standard expansion band width is set at 2m to ensure operational continuity and subsequent stability. Expansion band pouring construction should be completed according to design standards, and differentiated construction methods should be appropriately selected based on the work area.

3.2.Assembling reinforcement and compensation steel bars

In order to achieve the desired temperature control effect of the expansion zone, necessary temperature control measures should be implemented according to the characteristics of the expansion concrete. By configuring steel bars with binding reinforcement compensation function, not only can the temperature control of concrete construction be achieved, but also the problem of concrete cracking caused by poor material uniformity can be solved. It is necessary to ensure that the selected compensation steel bar material matches the concrete structure steel bar material, and the compensation steel bar diameter should be 1 to 2 grades lower than the structural steel bar diameter [10] .

During the assembly of the compensating reinforcement bars, the reinforcing strip and the compensating bars should be maintained perpendicular to each other, ensuring that the compensating bars are inserted into the concrete to a depth of more than 0.5m. If compensating bars are installed on the top plate, the top plate and the corresponding surface bars should be tied together[11]. For the rear of the wall panel, the same method should be used to tie the corresponding surface bars together. By installing compensating reinforcement bars, the stress-bearing properties of expansive concrete can be effectively improved. By adjusting the radius of the compensating bars, the stress on the expansion strip is uniform, thereby improving the overall stability of the concrete structure.

Conclusion

As a common construction technology in building structure construction, expansive concrete construction technology can effectively improve the earthquake resistance, waterproofness, crack resistance and overall structural stability of conventional concrete, and can effectively reduce construction period and construction costs.

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