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Research on Mass Concrete Additives in Tropical Coastal Areas

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Abstract. The tropical coastal region of Malaysia has a hot climate, high average annual temperature, and varying quality of local raw materials, making it challenging and difficult to carry out large volume concrete projects in this region. In this paper, we developed a special admixture for bulk concrete in subtropical coastal environment by modifying the basis of acrylic acid-based polycarboxylic acid admixture. The concrete prepared with this admixture has good ease, no water secretion, excellent mechanical properties and greatly improved exothermic characteristics. The C50 mass concrete prepared with this admixture has an initial slump/extension of 220/585mm, a 2h slump/extension of 210/570mm, and a crack resistance class I.

Keywords: Mass concrete; Admixture; Coastal; Compatibility; Crack resistance.

1. Introduction

After the placement of mass concrete, the cementitious material hydrates and exothermic and starts to cool down slowly after the temperature peak, forming large tensile stresses and highly susceptible to the formation of temperature cracks [1-2]. The tropical coastal region of Malaysia has a hot climatic environment, high average annual temperatures, varying quality of local raw materials, and lack of mineral admixtures [3-4]. It is challenging to carry out large volume concrete projects in this region with high engineering difficulty [5]. Retarders can reduce the rate of hydration and have a great positive effect on the release and reduction of heat of hydration [6-7]. Therefore, it is necessary to develop an admixture suitable for large volume concrete in tropical coastal areas.

2. Test materials and test equipment

2.1 Concrete materials

CIMA (a subsidiary of UEM Group) CEMI42.5N silicate cement was used for this bulk concrete cement; S95 grade mineral powder produced by EnGro (full name EnGro Corporation Limited) was used; natural sand with hard particles and good grading was used for this project, which were fine sand (0-1mm) and coarse sand (0-5mm) in proportion to Mixing; crushed stone is prepared by two kinds of crushed stone in the range of particle size 5-10mm and 10-20mm.

2.2 Additive design

In this paper, a new type of improver (molecular structure as shown in Figure 1) is introduced into the common admixture, and acrylic acid is introduced into the improver molecule to develop a special admixture for large volume concrete in tropical coastal areas. The special admixture according to the water reducing agent adsorption and dispersion mechanism its carboxylate ion can be well adsorbed on the surface of cement particles, seize the adsorption point on cement particles thus partially inhibit the adsorption of polycarboxylic acid water reducing agent, play a role in reducing the sensitivity of polycarboxylic acid water reducing agent and reducing water secretion.

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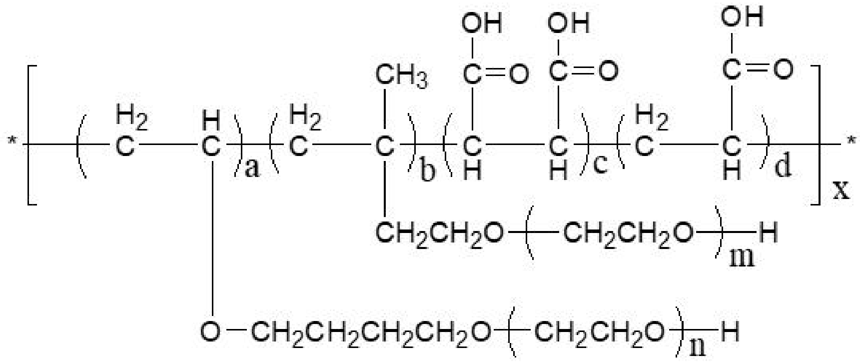

Figure 1. Molecular structure of the new improver

2.3 Test design

Concrete slump test and water secretion test were carried out according to the national standard (GB/T50080-2002), shrinkage test was carried out according to the national standard (GB/T29417-2012), and concrete slab shrinkage cracking test was carried out according to the specification (JTG3420-2020).

3. Experimental results and analysis

3.1 Effect on the workability of concrete

Table 1 Influence of admixtures on the workability of concrete

Samples	Content	initial slump / slump flow（mm）	2h slump/slump flow（mm）	Status Description
General admixture	2.0%	210/605	190/580	More serious water separation and secretion
Special admixtures	2.0%	220/585	210/570	No water retention and good compatibility

From Table 1, it can be seen that the addition of new improved special admixture has little effect on the initial dispersion performance of concrete at 2.0% admixture dose, but the slump retention ability is significantly improved due to the cross-linked mesh structure of the improver, and it can be seen from Fig. 2 and Fig. 3 that the concrete has a greater improvement in the concrete's compatibility and a significant reduction in water secretion.

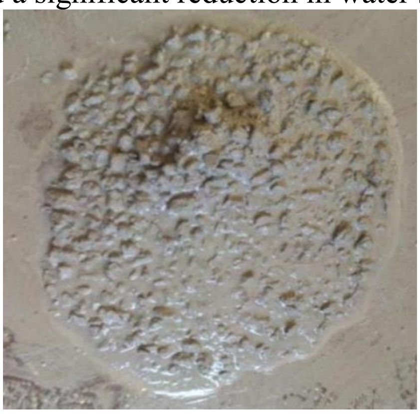

Figure 2. General admixture

Figure 3. Special admixture

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3.2 Effect of admixtures on the shrinkage reduction effect of mass concrete

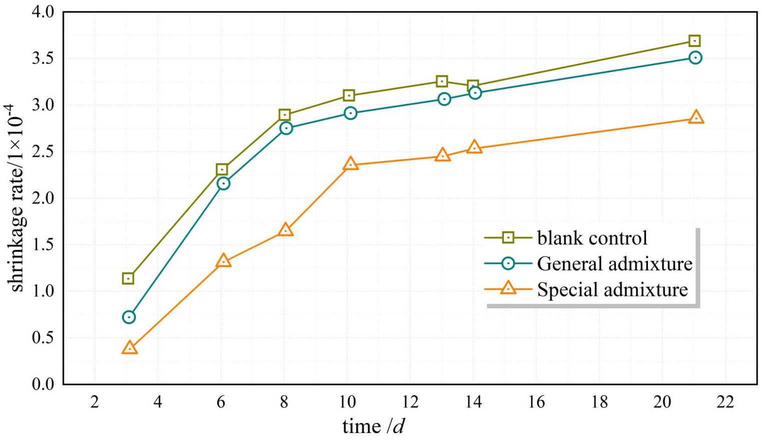

Figure 4. Effect of additive on the shrinkage of colloidal sand

The shrinkage test of mastic sand test block and simulated windy sunshine were used to verify the cracking resistance of concrete. From the shrinkage test results of the colloidal system in Fig. 4, it can be seen that the addition of the admixture can reduce the shrinkage of the colloidal system, and this special admixture can further reduce the shrinkage of the colloidal system than the ordinary admixture.

Figure 5. Effect of additive on the crack resistance of concrete

Figure 5 shows the concrete flat slab shrinkage cracking test (size 61×48×8 mm) with a large fan simulating sea breeze plus sunlight, and the results show that the concrete did not crack.

4. Conclusion

In this paper, we developed a special admixture for bulk concrete in subtropical coastal environment by modifying the base of acrylic acid-based polycarboxylic acid admixture. The concrete prepared with this admixture has good ease, no water secretion, excellent mechanical properties and greatly improved exothermic characteristics. The C50 mass concrete prepared with this admixture has an initial slump/extension of 220/585mm, a 2h slump/extension of 210/570mm, and an anti-cracking grade of Class I (flat plate anti-cracking method), which meets the requirements of engineering index control under the service environment of tropical coastal conditions.

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