STUDY OF THE PROPERTIES AND APPLICATION OF PVA FIBRE MODIFIED CRACK-RESISTANT CEMENT

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ABSTRACT

Cracking-resistance is one of the major problems for cementitious material that seriously influences the physical and mechanical properties and durability of cementitious material. In this paper, the properties and application of modified crack resistance cement mixed with PVA fibre have been studied. Experimental results show that, compared with the normal cement mortar, the strength and deformation performance, durability and crack-resistance of PVA fibre reinforced anti-crack mortar has obviously been improved. PVA fibre reinforced anti-crack mortar has been applied in engineering.

KEYWORDS:

PVA fibre; cement mortar; strength; plastic crack; durability

INTRODUCTION

Cement has been widely used in many building materials for a long time. Cement-based materials are still the main product in the construction because of their excellent economy and wide availability. However cracking is a well-known problem with all cement-based products. Cement products will crack because of drying shrinkage, carbonation shrinkage etc and cracks develop over time as influenced by the environment. Once cracks have occurred, the mechanical performance of the product may be reduced even resulting in the collapse of the construction, if cracks are not well controlled. So it is necessary to develop products with better crack resistance and modified crack-resistance cement containing PVA fibre was created for this purpose. This paper introduces the production of this modified cement with good crack resistance and its mortar product.

EXPERIMENT

1. Character of PVA fibre

The chemical structure and elemental composition of Polyvinyl alcohol (abbreviated PVA) are shown in figure1.

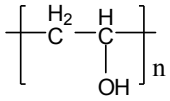

Figure 12 chemical structure of PVA

Table 1 lists the specifications of different PVA fibres and PP fibre another common fibre used in concrete. High strength and high modulus PVA fibre has 1300 ~1500 MPa tensile strength, E-modulus is 37.6Gpa and its elongation is 6~8%. PVA fibre is much stronger than PP fibre.

Table 1 - Character and property of different fibres.

Fibre	Density (g/cm3)	Diameter (□m)	Tensile strength□MPa□	Modulus of Elasticity (GPa□	elongation□%□
High strength and high modulus PVA fibre	**1.3**	**20±2**	**1428**	**37.6**	**6~8**
Medium strength and medium modulus PVA fibre	**1.3**	**20±2**	**900**	**20.7**	**9~12**
Modified PVA fibre	**1.3**	**12~13**	**800~900**	**14~16**	**11~12**
PP fibre	**0.91**	**15±2**	**276**	**3.79**	**15**
Modified PP fibre	**0.9**	**100~800**	**500~700**	**9**	**7~9**

The surface of high strength and high modulus PVA fibre (HM PVA fibre) is hydrophilic property that gives good adhesion between cement particles and PVA fibre via van der Waals forces. Furthermore hydrogen bonding can form between the molecular group □-C-OH□of PVA and molecular group (-OH) of cement hydrated product that increases the bonding strength between cement particle and PVA fibre. Therefore PVA fibre has a visible reinforcement effect on concrete and cement mortar.

2. Production of modified Crack-resistance Cement mixed with PVA Fibre

Crack-resistant cement is produced with ordinary cement mixed with some additives and 0.2-6mm long HM PVA fibre. The process to make the modified cement was as follows,

A. Prepare the raw materials according to the dosage
B. Disperse the HM PVA fibre in mixer equipment (special design).
C. Add cement and other additives into the mixer as dry powder.
D. Blend all the materials to reach the qualified dispersion quality.
E. Package

The production equipment and process was patented in China (patent no. ZL200410026255.1).

The main applications of crack-resistance cement mixed with PVA fibre is as below and the third application, the mortar product is introduced in this paper.

A. Concrete construction. High quality highways, airport runways, long span bridges, dams and other concrete project.
B. Cement product. Corrugated sheet, flat sheet, siding and ceiling products and other cement-based products.
C. Mortar product.

RESULTS AND DISCUSSION

Mortar samples were made of P.O. 325 cement without fibres and POf cement modified with fibres and the properties of the two mortars were compared.

1. Recipes of mortar

Cement, P.O. 325 cement ; modified crack-resistance modified cement mixed PVA fibre (POf cement)

Sand, pass sieve (size 2.36mm)

Water, tap water

Ratio of the materials, Cement: sand:water=1:3.5:0.55

2. Strength of the mortars.

The properties of two mortars are listed in table 2.

Table 2 Strength of the mortars

Cement type	3d		7d		28d	
	Bending strength (MPa)	Compressive strength (MPa)	Bending strength (MPa)	Compressive strength (MPa)	Bending strength (MPa)	Compressive strength (MPa)
32.5P·O	1.83	6.06	2.89	8.06	3.47	11.7
32.5POf	1.98	6.66	2.96	8.34	3.50	12.6
Increased level	8.2%	9.9%	3.5%	8.4%	3.7%	8.1%

Table 2 indicates that both bending strength and compressive strength are increased with PVA modification. 28 days bending strength was increased 3.7% and compressive strength was increased 8.1% compared to the reference sample. PVA fibre beneficially improves the strength of the mortar in the test and this is mainly attributed to the high tension and high modulus characters of PVA fibre.

3. Drying shrinkage of the mortar

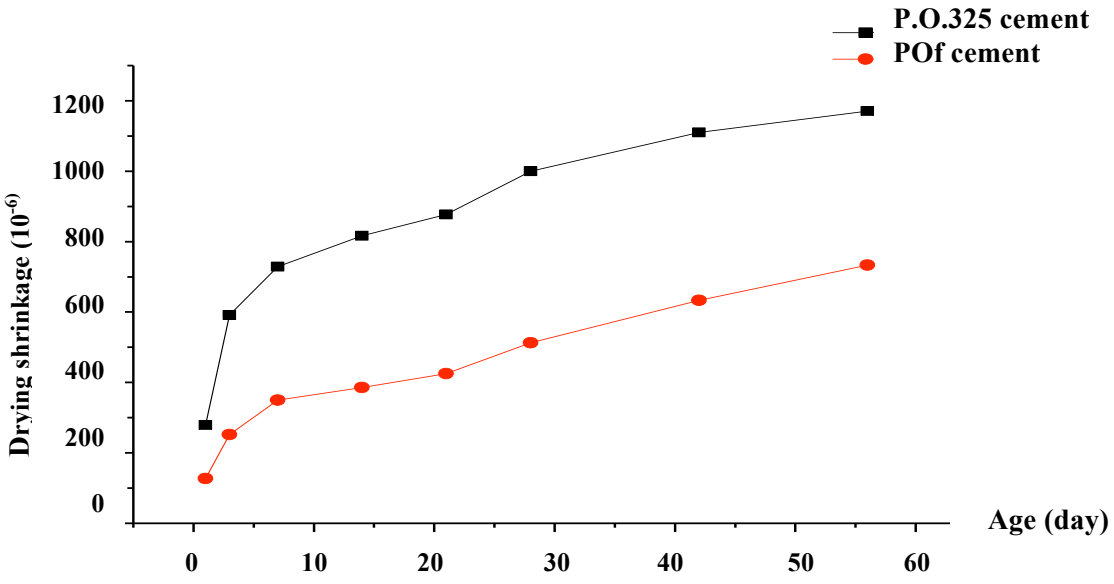

Figure 2 - Drying shrinkage

Drying shrinkage of mortar made of POf cement was studied. Ordinary Portland cement mortar sample was made for reference. Test results are shown in the figure 2.

It was shown from the figure 2 that the shrinkage of the mortar made of P.O. cement was 0.1% and 0.117% at 28 days and 56 days respectively; and the sample made of POf cement was only 0.051% and 0.071% at 28

days and 56 days respectively. Shrinkage was decreased visibly when used POf cement to replace P.O.cement, it was decreased 49% and 37.6% at 28 days and 56 days respectively in this test.

4. Plastic crack resistance

The crack characteristics of the mortar samples made with P.O. cement and POf cement were analyzed. The crack lengths and widths are listed in table 3.

Table 3 - Crack-resistance results.

crack width (mm)	Weight index	P.O. cement	POf cement	crack resistance ratio□%□
		crack length (mm)	crack length (mm)	
3>d≥2	2	35	-	93.6
2>d≥1	1	25	-	
1>d≥0.5	0.5	10	12.8	
Crack index(mm)		100	6.4	

For the sample made from P.O. cement, the crack widths were mainly from 2~3mm and the maximum width was 2.5mm in the test. For the sample made with PVA modified cement (POf), the crack width was entirely below 1mm and the maximum width was 0.75mm. Crack resistance was improved by 93.6%.

5. Freeze-thaw resistances

Table 4 shows the strength variation and weight loss of the mortar samples after it had been subjected to 100 cycles of freezing and thawing.

Table 4 - Freeze-thaw resistance test results (100F/T cycles)

Sample ID	Room temperature		After 100 cycles Freeze-thaw		Strength lost (%)		Weight lost
	Bending strength (MPa)	Compressive strength (MPa)	Bending strength (MPa)	Compressive strength (MPa)	Bending strength	Compressive strength	
P.O.	4.34	15.0	2.41	5.1	44.5%	66.0%	3.5%
POf	4.49	15.4	3.46	12.9	22.9%	16.2%	2.6%

For the mortar sample made of P.O cement, weight loss was ~3.5% after 100 F/T cycles compared to the unexposed reference group; bending strength loss was 44.5% and compressive strength loss was 66.0%.

For the mortar sample made of POf cement, weight loss was ~2.6%, bending strength loss was 22.9% and compressive strength loss was 16.2%. Strength loss was much lower compared to the sample made of P.O cement.

It was shown that freeze-thaw resistance was improved visibly as P.O. cement was replaced by POf cement to make mortar.

6. Resistance of sulphate and chloride attack

To evaluate the sulphate and chloride resistance of the sample made of POf cement, mortar samples were soaked in three types of solutions for 30 days and residual compressive strength was measured. Compressive strength loss level is listed in table 5 for each solution type.

For the sample made with P.O. cement, the loss of compressive strength was 6.7%, 5.3% and 34.7% respectively after soaking in different solutions for 30 days. For the sample made with PVA modified (POf) cement, strength loss was 6.1%, 3.1% and 32.5% respectively. It was shown that the strength loss of the mortar sample made of POf cement was reduced compared to the unmodified mortar.

Table 5 - Sulfate and chloride resistance result

Sample ID	5% sulfate solution	3.5% chlorine solution	H_2SO_4 (pH 4~5)
	Compressive Strength loss		
PO	6.7%	5.3%	34.7%
POf	6.1%	3.1%	32.5%

APPLICATION OF CRACK-RESISTANCE MORTAR

Autoclaved aerated concrete panel is widely used in construction in China for its light weight and good performance. However surface cracking is a common problem in many projects affecting confidence in the use of such economic products in China. When the new type of mortar made of crack-resistance cement was introduced into the market, crack problem was reduced and got very positive market feedback. One example to use crack-resistance mortar is shown in figure 3. It is an apartment project of 19 floors constructed in 2007. The construction building area is 233612 m^2 including 191262 m^2 ground area and 42350 m^2 basement area. The surface of the wall shows no visible cracks and has shown good performance until now.

Figure 3 Effect of the wall treated by the new type crack-resistance mortar

CONCLUSION

It allows us to make the following conclusions on this crack-resistant cement mixed with PVA fibre

(1) Strength and shrinkage of the mortar were improved visibly
(2) Crack resistance and freeze-thaw resistance were improved.
(3) The market application shows that this crack-resistant mortar was very beneficial in solving the problem of cracking, flaking and other common problems of aerated concrete panels.

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