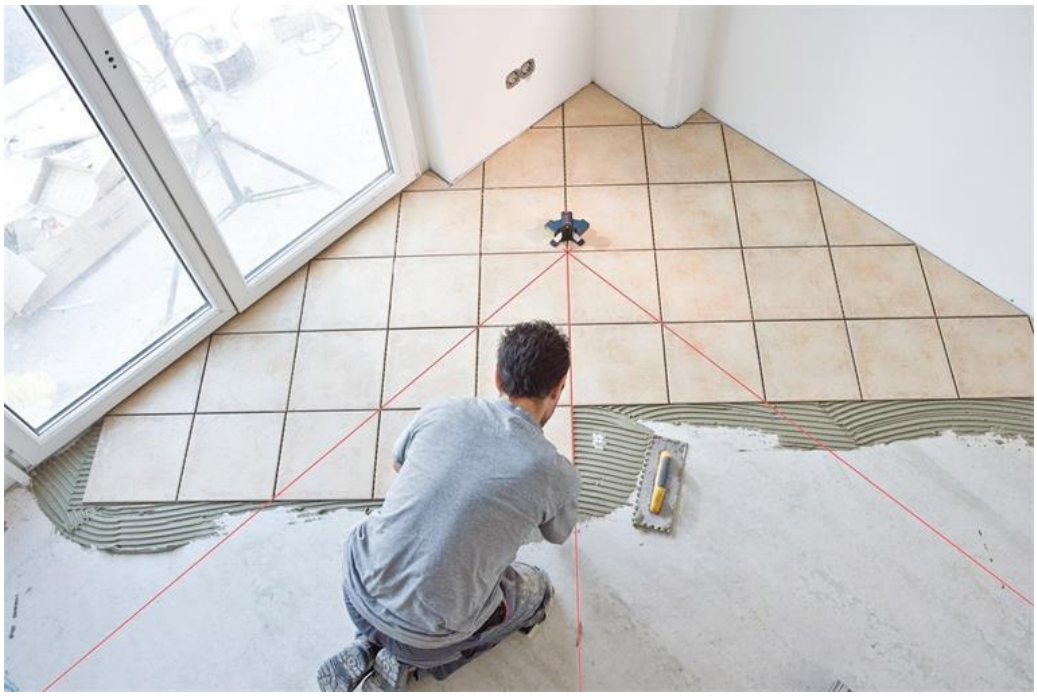
Study on Properties of Ceramic Tile Bonding Mortar

Ceramic tile is a widely used wall decoration material. However, since the ceramic tile mortar currently used is mostly the cement mortar, mortar of this kind is weak in the bonding force, poor in durability, and easy to peel off. Moreover, this kind of mortar uses the traditional method of stirring at the construction site and thick-layer construction, which on the one hand, will not only pollute the environment, but also will cause the instability of proportion, affecting the durability of ceramic tiles. On the other hand, the thick-layer construction will not only waste raw materials, but also greatly affect the speed of construction. Against the problems in the traditional mortar, the polymer modified dry mix mortar has been proposed. The addition of polymer can greatly improve the bonding strength and resistance to deformation of mortar. They are mutually combined with cement in the mortar, and play their respective strengths, making the bond strength of mortar on different substrates significantly improved. And it can meet the deformation of mortar caused by sudden changes in temperature and creep of buildings, and can significantly improve the resistance to falling off of ceramic tiles. Such a kind of mortar applies to the notched trowel technique for thin-layer construction, can save raw materials and improve the construction speed.



1. Experiment

1.1 Raw Materials

Cement: the cement used in this experiment is the domestically made ordinary portland cement, with a strength grade of 42.5.

Sand: ordinary yellow sand, with a grain size modulus of 2.75 for sand, belong to medium sand.

Polymer: the re-dispersible latex powder of RE5010 and RE5044 two kinds produced by Wacker Company, and the hydroxypropyl methyl cellulose with a viscosity of 50000 Mpa.s produced by Sidleycel.

1.2 Test Methods

The experiment of compressive strength and consistency is conducted referring to JGJ70-90 "Test Methods for the Basic Performance of Building Mortar". The flexural strength is tested according to the method of "Detection of Cement Mortar Strength". The test of dry shrinkage is conducted referring to JGJ51- 90 "Technical Specification for Lightweight Aggregate Concrete", with the size of test piece 40mm x 40mm x 160mm.

The test piece of adhesive mortar prepared in the experiment should first be cured for 28 d in the standard curing box, then dried for 20 h in an oven at 50 ℃, and then soaked in water for 4 h, so repeated for 60 cycles, and finally conduct the performance test of specimens. The experiment of bond strength refers to the experimental method of bond strength recommended by the Institute of Japanese Materials Science, and the bond strength is given by the bonding flexural strength. The experiment of bond strength uses the prism sample of 160mm x 40mm x 40mm. Put the sample of ordinary mortar made earlier cured to the age of 28 d, cut into two halves, the other half to make the sample respectively with ordinary mortar or polymer mortar, shown in Figure 1. Then by natural curing to a certain age, conduct testing and calculating by reference to the test methods above for the flexural strength of cement mortar.

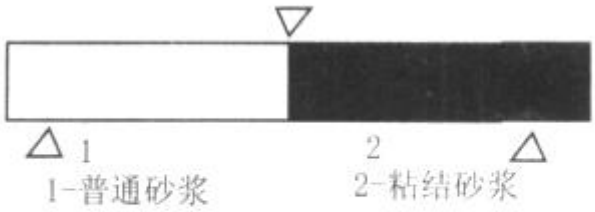


图 1　粘结抗弯强度试样及实验示意图

1-普通砂浆;2-粘结砂浆

1.3 Determination of Orthogonal Experimental Design and the Best Solution

1.3.1 Selection of Factors and Levels

This test uses the orthogonal design experiment of three levels and four factors, shown in Table 1. The selected factors are: RE5010, RE5044 and the dosage of cellulose ethers (%). The levels respectively are: RE5010, RE5044 and hydroxypropyl methyl cellulose ether.

Table 1 Orthogonal Factors and Levels

Levels	（ A ）RE5010/%	(B)RE5044/%	（C）Cellulose Ether
1	1.2	1.2	0.05
2	1.5	1.5	0.10
3	1.8	1.8	0.15

1.3.2 Test Results and Differential Analysis

L9 orthogonal experiment table is used for the experiment for the bond strength of ceramic tile bonding mortar, and the results are shown in Table 2.

Table 2 Test Result and Its Intuitive Analysis

No.	A	B	C	D	Bond

					Strength 28d/MPa
1	1	1	1	1	4.6
2	1	2	2	2	5.1
3	1	3	3	3	5.35
4	2	1	2	3	4.88
5	2	2	3	1	5.4
6	2	3	1	2	4.75
7	3	1	3	2	5.01
8	3	2	1	3	4.8
9	3	3	2	1	4.925
K1	15.05	14.49	14.15	14.92	
K2	15.03	15.3	14.905	14.86	
K3	14.73	15.02	15.76	15.03	
K1	5.01	4.83	4.71		
K2	5.01	5.1	4.96		
K3	4.91	5.00	5.25		
R	0.31	0.81	1.61	0.17	

It can be seen from Table 2 that the three factors A, B, C on the test results are in the order C→B →A.

In the case without considering the interaction, the best solution should take the level corresponding to the K value of each factor, i.e., A1B2C3, namely, the adding amount of 1.2% for RE5010, the adding amount of 1.5% for RE5044, and the adding amount of 0.15% for cellulose ethers.

2. Results and Analysis of Performance Test

2.1 Basic Mechanical Properties

Use the best solution to test the comprehensive properties of ceramic tile bonding mortar, and the results are shown in Table 3.

Table 3 Basic Physical and Mechanical Properties of Binding Mortar /MPa

Types of Mortar	Consistency /cm	Water Retention Rate/kg/m^2	Flexural Strength		Compressive Strength		Flexural-Compressive Ratio		Flexural Strength
			7d	28d	7d	28d	7d	28d	
Ordinary Mortar	6.7	0.291	5.95	7.72	37.71	45.63	0.158	0.169	2.35
Adhesive Mortar	6.9	0.137	5.4	5.9	17.94	28.58	0.301	0.206	5.48

When the water-cement ratio of binding mortar is controlled at 0.44, its consistency is greater than that of ordinary mortar, and the water retention is much better than that of ordinary mortar. It explains that the dry mix binding mortar has better construction workability than ordinary

mortar, and can meet the requirement of thin-layer construction. Moreover, the dry mix ceramic tile adhesive mortar has better mechanical properties. Although the compressive strength and flexural strength is lower than those of ordinary mortar, the flexural-compressive ratio is much superior to that of ordinary mortar. For 7d, the flexural-compressive ratio has been increased by 90.5% than ordinary mortar, and for 28 d, the flexural-compressive ratio has been increased by 21.89%. This shows the flexibility of the adhesive mortar is far superior to ordinary mortar. The bond strength of adhesive mortar has been greatly improved. The bond strength of 28 d reaches up to 5.48 MPa, 2.33 times that of ordinary mortar. Especially when damaged, ordinary mortar is damaged more from the interface between the mortar and substrate, while the damage of adhesive mortar mostly occurs inside the substrate of mortar, which indicates that the bonding between adhesive mortar and the substrate is very firm. Under normal circumstances, the phenomenon of decorative brick peeling off due to the lack of adhesive force will not occur.

2.2 Study on Weather Resistance

Ceramic tile bonding mortar is more used for the bonding ceramic tiles of exterior wall, often affected by the dry and wet role, so changes will also take place in the bonding between it and substrate, as well as its own strength, which will directly affect its weather resistance. Table 5 is the comparison of the mechanical properties of mortar after 60 wet and dry cycles.

Table 5 Basic Physical Properties of Adhesive Mortar

Mortar	Benchmark Bond Strength/MPa	Strength Loss/%	Length Loss	Surface Condition
Ordinary Mortar	2.35	4.51	0.75	A little peeling off on the surface
Adhesive Mortar	5.48	2.31	0.23	Intact

As can be seen from Table 5, the effects of 60 dry and wet cycles are more serious on ordinary mortar, but relatively smaller on the adhesive mortar. After 60 wet and dry cycle test, although the bond strength of adhesive mortar has been decreased, it is slight, and can also ensure better bonding with the ceramic tile surface. Ceramic tile bonding mortar has the excellent properties above, on the one hand since the addition of compound admixture enables the mortar itself to have better bond strength. The reason is that when the polymer is in contact with water, the hydrophilic polymer and the liquid phase of cement suspension will penetrate together into the substrate pores and capillary, and the polymer will form films inside the pores and capillary and firmly adsorbed on the substrate surface, thus ensuring good bond strength between the cementing material and the substrate.

And the film-formed polymer will obviously form secondary adhesion complexes, distributed between the mortar and the substrate in the form of bridge bonds and apertured polymeric films, absorb and transmit energy, macroscopically showing the improvement of adhesive force. On the other hand, the addition of polymer enables the mortar to to have a better ability to adapt to the shrinkage deformation of substrate. When shrinkage and expansion occur during the wet and dry cycles of mortar, due to the high flexibility and elasticity of adhesive mortar, it can transmit the stress generated at the interface, thereby preventing the loss of adhesive force. Furthermore,

when the polymer is dispersed in contact with water, it will be gathered in the water-rich area (i.e., the cavity). With the progress of drying process, the emulsion is dewatered again, and the polymer has formed a layer of continuous film around the cavity, strengthening these weak parts. At this time, the polymer thin film not only plays a hydrophobic role, but also does not block the capillary, making the material with good hydrophobicity.

3. Conclusion

It can be obtained by the orthogonal experiment that the ratio of compound admixture is A1,B2,C3, i.e., the adding amount of 1.2% for RE5010, the adding amount of 1.5% for RE5044, and the adding amount of 0.15% for cellulose ethers; after adding the compound admixture, as opposed to ordinary mortar, the mechanical properties of adhesive mortar have got improved, especially the bond strength of mortar, 2.33 times that of ordinary mortar; It proves by the wet and dry cycle test that mortar has better weather resistance, stable properties and good durability; the cost performance of adhesive mortar is 2.17 times that of ordinary mortar, indicating that the ceramic tile bonding dry mix mortar is low in the cost-benefit ratio, high in the performance, and relatively more reasonable in the economy.