

Research on the Application of Fine Iron Tailings in Surface Mortar for External Thermal Insulation on Outer-walls

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Abstract: Three gradations of fine iron tailings are selected to prepared surface mortar for external thermal insulation on outer-walls for replacing natural sand. The working performance and mechanical performance of the surface mortar for external thermal insulation on outer-walls are studied. The results show that the water requirements of surface mortar for external thermal insulation on outer-walls is almost no difference at same consistency when the dosage of 0-0.1mm, 0.1-0.3mm and 0.3-0.5mm fine iron tailings is respectively below 80g/kg, 100g/kg, 150g/kg, and the flexural strength, compressive strength and tensile adhesive strength at 28d of surface mortar for external thermal insulation on outer-walls is higher than it prepared natural sand. The water requirements of surface mortar for external thermal insulation on outer-walls prepared by fine iron tailings instead of all natural sand is 24% higher than it by prepared natural sand, the flexural strength, compressive strength and tensile adhesive strength at 28d of surface mortar for external thermal insulation on outer-walls is slightly lower than it prepared by natural sand. The working performance and mechanical performance of the surface mortar for external thermal insulation on outer-walls by fine iron tailings instead of all natural sand can meet requirements of JC/T 2084-2011.

Introduction

Fine iron tailing are a kind of solid mineral waste after processing and magnetic separation. Fine iron tailing were produced as high as 1.5 tons per year in china^[1-2]. The large amount of fine iron tailings not only cause serious pollution to the air and water, but also cause safety problems. Many experts and scholars have carried out systematic research on iron tailings for concrete^[3-5], and the concrete prepared by iron tailings has been used in the construction engineering. The particle size of fine iron tailings is less than 0.5mm; it is difficult and low added value that fine iron tailings prepared concrete^[6-7]. Natural sand is a kind of limited natural resources. With the development of china's infrastructure, the resources of natural sand are more and scarcer. The regulations prohibiting the exploitation of natural sand were promulgation to protect environment. Natural sand is more and more expensive, and the supply cannot meet the demand of engineering construction^[8-9].

The natural sand less than 0.5mm is selected to prepare surface mortar for external thermal insulation on outer-walls. Its dosage is more than 60%. The fine iron tailings meet particle size requirement of surface mortar for external thermal insulation on outer-walls. So the surface mortar for external thermal insulation on outer-walls is prepared by fine iron tailings instead of natural sand. That not only can solve the environmental problems and safety problems caused by fine iron tailings, but also ease the shortage of natural sand resources. Different particle sizes and different dosages of fine iron tailings are chosen to substitute the natural sand. The working performance and mechanical properties of the surface mortar for external thermal insulation on outer-walls are studied.

Experimental

Raw Materials

The surface mortar for external thermal insulation on outer-walls were prepared from P·O 42.5, fly ash, natural sand, fine iron tailings, sierzem powder, redispersion emulsoid powder, cellulose ether, water-reducing admixture, 5mm fiber and water. Chemical composition and physical-mechanical properties of P·O 42.5 are presented in Table 1,2. All parameters were determined by standard procedures described in GB 175-2007. The natural sand include 40-70 mesh (equivalent of 0.2mm-0.4mm) and 70-140 mesh (equivalent of 0.1mm-0.2mm). The fine iron tailings are divided 0mm-0.1mm, 0.1mm-0.3mm and 0.3mm-0.5mm three gradation. Chemical composition, X-ray diffraction pattern and radioactive detection of two fine iron tailings presented in Table 1, Figure 1 and Table 3. It can be seen from Table 1 and Figure 1, the main chemical composition, proportion and X-ray diffraction pattern of two fine iron tailings are very similar. The mineral composition of fine iron tailings mainly are diopside, magnesiohornblende, dolomite, scolecite. Table 3 shows the I_{inside} and I_{outside} of fine iron tailings are far below 1.0, radioactivity of two fine iron tailings can satisfy the requirement of GB 6566-2010. So the surface mortar for external thermal insulation on outer-walls prepared from two fine iron tailings don't have bad influence on health.

Tab. 1 Chemical compositions of cement and fine iron tailings /%

chemical compositions	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	SO ₃	R ₂ O	Loss
cement	21.10	5.45	3.87	61.23	2.01	1.96	2.43	1.95
fine iron tailings-Z	39.27	9.63	14.97	15.12	10.93	0.90	-	-
fine iron tailings-F	39.16	9.64	15.79	13.47	11.66	1.99	-	-

Tab. 2 Physical properties of cement

specific surface/m ² /kg	Water for standard consistency/%	setting time/min		flexural strength/MPa		compressive strength/MPa	
		initial	final	3 d	28d	3d	28d
365	29.6	75	250	7.08	9.04	35.5	53.2

Tab. 3 Radioactivity of fine iron tailings

species	test weight/g	Ra	Th	K	I_{inside}	I_{outside}
fine iron tailings-Z	277.27	3.27	2.13	228.85	0.016	0.072
fine iron tailings-F	318.04	1.67	1.6	227.05	0.008	0.065

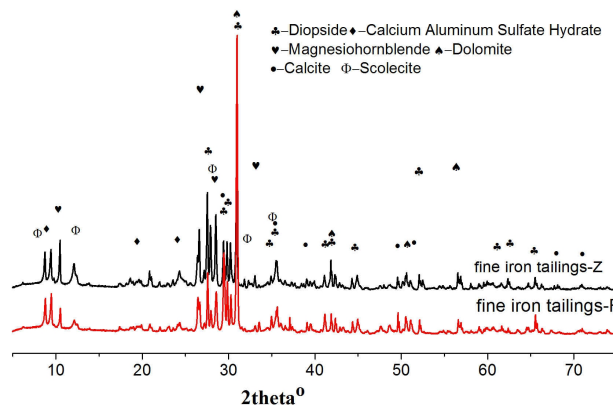


Fig.1 X-ray diffraction pattern of fine iron tailings

Experimental process

Different gradation of the fine iron tailings-F is only selected to prepared surface mortar for external thermal insulation on outer-walls because fine iron tailings-F is similar to fine iron tailings-Z. The proportion of 0-0.1mm fine iron tailings-F replaces 70-140mesh natural sand is 60g/kg, 80g/kg, 100g/kg, 120g/kg; The proportion of 0.1-0.3mm fine iron tailings-F replaces 70-140mesh natural sand is 50g/kg,100g/kg, 150g/kg, 200g/kg, 300g/kg; The proportion of 0.3-0.5mm fine iron tailings-F replaces 40-70mesh natural sand is 50g/kg, 100g/kg, 150g/kg, 200g/kg. Finally, the 0mm-0.1mm, 0.1-0.3mm and 0.3-0.5mm fine iron tailings-F replace all 40-70 mesh and 70-140 mesh natural sand, the proportion of 0mm-0.1mm, 0.1-0.3mm and 0.3-0.5mm fine iron tailings-F and fine iron tailings-Z is

respectively 120g/kg, 300g/kg and 200g/kg. The fine aggregate mix proportions of surface mortar for external thermal insulation on outer-walls are shown in Table 4.

The consistency, bulk density, water-retention rate, application property flexural strength, compressive strength and tensile adhesive strength of surface mortar for external thermal insulation on outer-walls are determined when its consistency is 95 ± 3 mm as described in JC/T 2084-2011.

Tab. 4 Fine aggregate mix proportions of surface mortar for external thermal insulation on outer-walls

species	40-70 mesh	70-140 mesh	0-0.1mm	0.1-0.3mm	0.-0.5mm
0-0	200	420	-	-	-
1-1	200	360	60	-	-
1-2	200	340	80	-	-
1-3	200	320	100	-	-
1-4	200	300	120	-	-
2-1	200	370	-	50	-
2-2	200	320	-	100	-
2-3	200	270	-	150	-
2-4	200	220	-	200	-
2-5	200	120	-	300	-
3-1	150	420	-	-	50
3-2	100	420	-	-	100
3-3	50	420	-	-	150
3-4	-	420	-	-	200
F-1	-	-	120	300	200
Z-2	-	-	120	300	200

Results and Discussion

Effect of fine iron tailings on working performance of surface mortar for external thermal insulation on outer-walls

The surface mortar for external thermal insulation on outer-walls is prepared according to Table 4. The water requirement of surface mortar for external thermal insulation on outer-walls is different because the consistency is controlled in 95 ± 3 mm. The water requirement, consistency, water-retention, bulk density and application property of surface mortar for external thermal insulation on outer-walls are shown in Table 5.

Tab. 5 Working performance of surface mortar for external thermal insulation on outer-walls

species	water requirement/g/kg	consistency/mm		water-retention rate/%	bulk density/kg/m ³	application property
		0min	30 min			
0-0	190	98	87	93.5	1637	good
1-1	190	87	82	94.5	1618	good
1-2	190	93	78	94.6	1625	better
1-3	200	97	85	95.1	1587	good
1-4	205	94	80	95.1	1602	good
2-1	190	98	86	94.2	1625	good
2-2	190	93	79	94.5	1598	good
2-3	195	92	75	94.7	1635	better
2-4	210	96	81	94.6	1598	good
2-5	215	94	78	95.0	1605	good
3-1	190	97	80	94.1	1592	good
3-2	190	95	74	94.2	1613	better
3-3	190	92	75	94.5	1586	good
3-4	200	93	78	94.7	1665	good
F-1	235	96	82	96.2	1623	good
Z-2	235	98	86	95.8	1614	good

It can be seen from Table 5 that when the dosage of 0-0.1mm, 0.1-0.3mm and 0.3-0.5mm fine iron tailings is respectively below 80g/kg, 100g/kg, 150g/kg, the water requirements of surface mortar for external thermal insulation on outer-walls is almost no difference at same consistency. When the dosage of 0-0.1mm, 0.1-0.3mm and 0.3-0.5mm fine iron tailings is respectively above 80g/kg, 100g/kg,

150g/kg, the water requirements of surface mortar for external thermal insulation on outer-walls are increased with increasing of the fine iron tailing dosages. The water requirements of surface mortar for external thermal insulation on outer-walls prepared by fine iron tailings instead of all natural sand is 24% higher than it by prepared natural sand. This is mainly because the shape of natural sand is round, its surface is smooth, while the shape of fine iron tailing is sharp and its surface is rough and uneven^[10]. The specific surface area of fine iron tailings is great, so the water requirement is high. Some fine iron tailings is added in surface mortar for external thermal insulation on outer-wall, the water requirement don't become high because some fine iron tailings make better gradation The water-retention rate of surface mortar for external thermal insulation on outer-walls prepared by fine iron tailings is higher than it prepared by natural sand, This is mainly because the fine powder of fine iron tailing can improve the water-retention rate of surface mortar for external thermal insulation on outer-walls. The application property of surface mortar for external thermal insulation on outer-walls prepared by fine iron tailings is good. Sometimes the application property of surface mortar for external thermal insulation on outer-walls adding some fine iron tailings is better.

Effect of fine iron tailings on mechanical performance of surface mortar for external thermal insulation on outer-walls

The mechanical performance of surface mortar for external thermal insulation on outer-walls mainly include the flexural strength, compressive strength, tensile adhesive strength with mortar board and expanded polystyrene board (EPS board) at 28d, tensile adhesive strength with mortar board and EPS board after soaking 2 days and dry 2 hours. The results are shown in Table 6.

Tab. 6 Mechanical performance of surface mortar for external thermal insulation on outer-walls/MPa

species	flexural strength	compressive strength	tensile adhesive strength		tensile adhesive strength after soaking	
			mortar board	EPS board	mortar board	EPS board
0-0	15.7	5.9	0.569	0.096	0.563	0.062
1-1	16.1	6.2	0.596	0.106	0.603	0.065
1-2	16.5	6.7	0.604	0.105	0.608	0.068
1-3	15.4	6.5	0.586	0.102	0.578	0.059
1-4	14.8	5.8	0.564	0.084	0.546	0.058
2-1	16.0	6.3	0.575	0.098	0.564	0.063
2-2	16.3	6.4	0.586	0.098	0.572	0.067
2-3	16.9	6.9	0.613	0.115	0.605	0.076
2-4	15.6	6.3	0.563	0.101	0.552	0.054
2-5	15.0	5.8	0.532	0.089	0.521	0.051
3-1	16.2	6.2	0.578	0.099	0.565	0.065
3-2	16.8	6.9	0.595	0.102	0.587	0.069
3-3	15.6	6.3	0.608	0.106	0.601	0.070
3-4	15.4	6.4	0.559	0.096	0.552	0.057
F-1	14.6	6.2	0.543	0.105	0.556	0.054
Z-2	13.0	6.0	0.527	0.094	0.538	0.058

It can be seen from Table 6 that When the dosage of 0-0.1mm, 0.1-0.3mm and 0.3-0.5mm fine iron tailings is respectively below 80g/kg, 100g/kg, 150g/kg, the flexural strength, compressive strength and tensile adhesive strength at 28d of surface mortar for external thermal insulation on outer-walls is higher than it prepared natural sand. This is mainly because sharp shape and rough surface of fine iron tailings improve friction among fine aggregate. When the dosage of 0-0.1mm, 0.1-0.3mm and 0.3-0.5mm fine iron tailings is respectively above 80g/kg, 100g/kg, 150g/kg, the flexural strength, compressive strength, tensile adhesive strength with mortar board and expanded polystyrene board (EPS board) at 28d of surface mortar for external thermal insulation on outer-walls are decreased with increasing of the fine iron tailing dosages. This is mainly because water requirement is increased resulting in greater water-binder ratio, so the flexural strength, compressive strength, tensile adhesive strength with mortar board and expanded polystyrene board (EPS board) at 28d of surface mortar for external thermal insulation on outer-walls are decreased. the flexural strength, compressive strength and tensile adhesive strength at 28d of surface mortar for external thermal

insulation on outer-walls prepared by fine iron tailings instead of all natural sand is slightly lower than it prepared by natural sand, but the mechanical performance of surface mortar for external thermal insulation on outer-walls prepared by fine iron tailings still meet requirements of JC/T 2084-2011.

Conclusions

- (1) The application property of surface mortar for external thermal insulation on outer-walls prepared by fine iron tailings is good. The water-retention rate of surface mortar for external thermal insulation on outer-walls prepared by fine iron tailings is higher than it prepared by natural sand.
- (2) When the dosage of 0-0.1mm, 0.1-0.3mm and 0.3-0.5mm is respectively below 80g/kg, 100g/kg, 150g/kg, the water requirements of surface mortar for external thermal insulation on outer-walls is almost no difference at same consistency, the flexural strength, compressive strength and tensile adhesive strength at 28d of surface mortar for external thermal insulation on outer-walls is higher than it prepared natural sand.
- (3) The water requirements of surface mortar for external thermal insulation on outer-walls prepared by fine iron tailings instead of all natural sand is 24% higher than it by prepared natural sand, the flexural strength, compressive strength and tensile adhesive strength at 28d of surface mortar for external thermal insulation on outer-walls is slightly lower than it prepared by natural sand, but the mechanical performance of surface mortar for external thermal insulation on outer-walls prepared by fine iron tailings still meet requirements of JC/T 2084-2011.

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