Performances of the Mortar Made with Roller Steel Slag as Aggregate

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Abstract. The roller steel slag has many advantages due to the special process can be used as sand in commercial mortar. The parameters of the slag from MCC Baogang Steel Technology Services Co., Ltd were researched, and with 20~60 vol. % slag replaced for sand, six strength grade mortars were prepared. The results show that the workability and soundness can meet the standard; the compressive strength of the mortars was improved with the dosage of the slag increasing.

Introduction

Nowadays, the production and application of the commercial mortar is a new popularized technology in China. In order to protect the environment against the pollution and reduce the cost of the commercial mortar, some industrial solid wastes including steel slag used as aggregate in the mortar [1].

The procedures for the steel slag include hot splashing process, converter process and roller process. In three types of the slag, the roller steel slag with some advantages, such as the lower content of free calcium oxide (*f*-CaO), better grain shape and gradation, higher strength [2], is suitable for the aggregate in the commercial mortar.

In this work, the parameters of the roller steel slag from MCC Baogang Steel Technology Services Co., Ltd were tested, and the performances of the mortars with different replacement ratio for sand were researched.

Experimental

The roller steel slag was supplied by MCC Baogang Steel Technology Services Co., Ltd, the apparent density was 3 260 kg/m^3, the bulk density was 1 940 kg/m^3 and the modulus fineness was 3.53. The Ordinary Portland Cement (OPC) 42.5 were obtained from Shaanxi Shengwei Cement (Group) Co., Ltd and the mechanical properties according to Chinese standard GB175-2007 were listed in Table 1. The two grade fly ash was obtained from Shaanxi Weihe Power Co., Ltd. The standard sand was obtained from Xiamen ISO standard sand Co., Ltd.

Table 1 the mechanical properties of the cement

Compressive strength (MPa)		Banding strength (MPa)	
3d	28d	3d	28d
26.0	47.0	6.0	9.3

Phase composition of the steel slag was investigated by means of X-ray diffraction analysis with a Rigaku X-ray Diffract meter model D/MAX-3C with Cu *Kα* radiation. Furthermore, The

lithofacies was performed with a polarizing microscope.

The compositions of the M30, M25, M20, M15, M10 and M5 mortars were designed according to Chinese standard JGJ/T 98-2010 [3] and listed in Table 2. In the compositions, the replacement ratios of the slag for standard sand were 20 vol. %, 40 vol. % and 60 vol. %, respectively.

Table 2 Composition of the mortars containing the roller steel slag

No.	Strength grade	Dosage of slag (vol. %)	Composition (kg/m^3)				
			Cement	Fly ash	Sand	Slag	Water
1	M30	0	455	0	1450	0	270
2		20	455	0	1160	374	270
3		40	455	0	870	748	260
4		60	455	0	580	1122	250
5	M25	0	385	0	1450	0	250
6		20	385	0	1160	374	250
7		40	385	0	870	748	250
8		60	385	0	580	1122	250
9	M20	0	370	0	1500	0	260
10		20	370	0	1200	387	250
11		40	370	0	900	774	250
12		60	370	0	600	1161	250
13	M15	0	264	66	1500	0	260
14		20	264	66	1200	387	250
15		40	264	66	900	774	250
16		60	264	66	600	1161	250
17	M10	0	240	60	1500	0	250
18		20	240	60	1200	387	250
19		40	240	60	900	774	250
20		60	240	60	600	1161	250
21	M5	0	192	48	1500	0	250
22		20	192	48	1200	387	250
23		40	192	48	900	774	250
24		60	192	48	600	1161	250

The soundness of the mortars was tested by the boiling process for 3 h. The compressive strength of the mortars was tested according to Chinese standard JGJ/T 70-2009 [4].

Results and Discussion

Phase composition. The phase composition of the roller steel slag was tested by XRD and the lithofacies method, and the resulted were shown in Fig. 1 and Fig. 2. From Fig. 1, the main phases in the slag were tricalcium silicate (C_3S), dicalcium silicate (C_2S), which indicated that the slag can participate the hydration reaction owing to the certain activity of C_3S and C_2S. The slag also contained a certain amount of pure Fe, hematite (Fe_2O_3), magnetite (Fe_3O_4) and calcium hydroxide ($Ca(OH)_2$), but it contained almost no *f*-CaO.

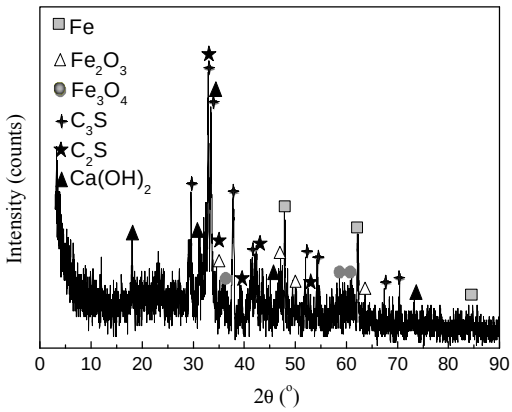

Fig. 1 the XRD results of the roller steel slag

The lithofacies analysis results were shown in Fig. 2. From Fig. 2(a), C_3S and C_2S were symbiotic together and there was a certain degree of crystallization. Fig. 2(b) showed that Fe_2O_3 was embedded in the internal of C_3S. The lithofacies results matched with the results of XRD.

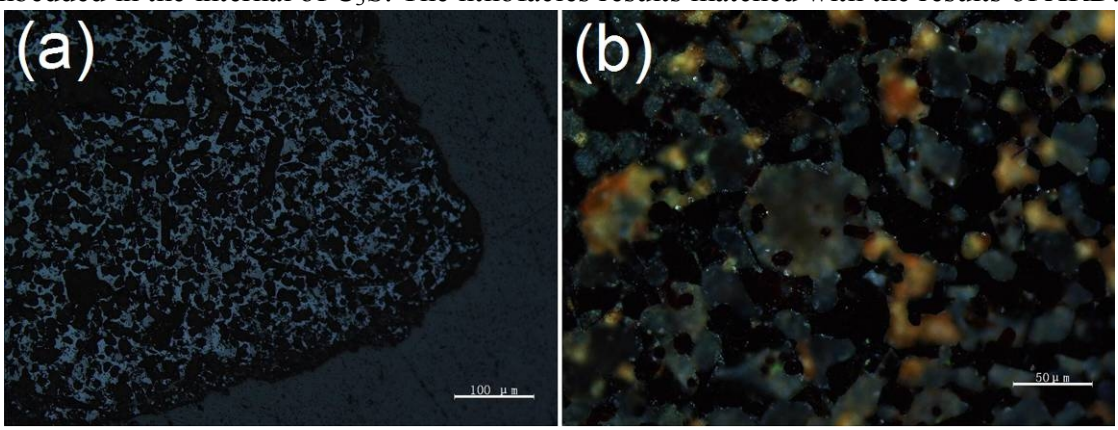

Fig. 2 the lithofacies analysis results of the roller steel slag

Workability, soundness and compressive strength of the mortars. The results of the workability, soundness and compressive strength of the mortars were listed in Table 3. From Table 3, the workability and the soundness with the boiling process both meet the construction requirements and standards.

Table 3 the results of soundness, workability and compressive strength of the mortars

No.	Strength grade	Dosage of slag (vol. %)	Workability	Soundness with boiling process	Compressive strength (MPa)	
					7d	28d
1	M30	0	Good	Up to standard	24.0	36.0
2		20	Good	Up to standard	24.8	37.4
3		40	Good	Up to standard	34.2	41.6
4		60	Good	Up to standard	36.2	42.6
5	M25	0	Good	Up to standard	18.8	22.0
6		20	Good	Up to standard	21.4	24.0
7		40	Good	Up to standard	22.2	28.6
8		60	Good	Up to standard	21.0	29.2
9	M20	0	Good	Up to standard	16.8	22.8
10		20	Good	Up to standard	17.8	25.4
11		40	Good	Up to standard	18.8	26.8
12		60	Good	Up to standard	22.0	27.6
13	M15	0	Good	Up to standard	9.6	17.4
14		20	Good	Up to standard	9.4	17.8
15		40	Good	Up to standard	9.4	18.4
16		60	Good	Up to standard	9.0	18.8
17	M10	0	Good	Up to standard	7.8	12.0
18		20	Good	Up to standard	8.0	13.2
19		40	Good	Up to standard	8.0	13.4
20		60	Good	Up to standard	8.6	13.8
21	M5	0	Good	Up to standard	3.0	6.0
22		20	Good	Up to standard	3.0	6.4
23		40	Good	Up to standard	3.2	7.2
24		60	Good	Up to standard	3.8	7.4

The compressive strength of the mortars was tested at 7d and 28d. From the results, all of the compressive strength at 28d can meet the strength grade and 1.2 times the strength standard values, which indicated that the roller steel slag does not reduce the strength of the mortars and can used in all of mortars with different strength grade.

Furthermore, the compressive strength of the mortars was improved with the dosage of the slag increasing. The causes of the above phenomena may be that C_3S and C_2S in the slag participated in the hydration reaction and improved the interfacial strength of slag and cement paste.

Conclusion

The phases in the roller steel slag were tricalcium silicate (C_3S), dicalcium silicate (C_2S), pure Fe, hematite (Fe_2O_3), magnetite (Fe_3O_4) and calcium hydroxide ($Ca(OH)_2$). The mortars from strength grade M30 to M5 all can be prepared with 20~60 vol. % slag replaced for sand, both the workability and soundness can meet the standard. Furthermore, the compressive strength of the mortars was improved with the dosage of the slag increasing.

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