Research on Preparation of a Binding Material Mixed with Blast Furnace Slag, Steel Slag and Portland Cement

Gang Tan[1, a], Yongjie Xue[1, b *] and Teng Wang[2, c]

[1]State Key Laboratory of Silicate Materials for Architectures, Wuhan University of Technology, China

[2]Resources and Environmental Sciences, Wuhan University, China

[a]tg666happy@126.com, [b]xyjskl@whut.edu.cn, [c]835473515@qq.com

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Abstract. The application of blast furnace slag and steel slag mixed as the replacement of cement is an important way to improve the utilization ratio of steel slag .This paper focuses on the performances of the mortar specimen which made by different proportion of blast furnace slag , steel slag and portland cement. Through mortar test to find the best proportion that 3d, 7d, 28d compressive and flexural strength are the highest.

Introduction

Nowadays, the world is facing a grim situation of energy conservation and emission reduction. It was estimated that about 38% of the total energy are consumed by buildings including space heating, ventilation and air conditioning. It was reported that the production of steel slag is over 70 million tons in recent years with the slag generation rate of about 0.08–0.15 ton per ton steel . From the theoretical point of view, steel slag can be used to substitute partially as clinker for producing composite Portland cement.

With the raising of the idea that industrial waste can be recycled in the construction industry, various kinds of waste have been put into researches and application in the cement industry.Waste utilization is an attractive alternative to disposal in that disposal cost and potential pollution problems are reducedor even eliminated along with the achievement of resource conservation. Nevertheless, the utilization strategy must be coupled with environmental and energy considerations to use available materials most efficiently. Because the use of these slags as cementing components needs only grinding, it will save substantial amounts of energy compared with the production of Portland cement. For example, the energy required to grind granulated blast furnace slag is only approximately 10% of the total energy required for the production of Portland cement.

Materials and Methods

Materials

Oriental brand P • O 42.5 ordinary portland cement; the steel slag is from WU XIN Building Materials Co., Ltd. and the particle size is 4.75 mm or less; S95 grade blast furnace slag; gypsum; standard sand. The chemical composition of the experimental materials is listed in Table 1.

Table 1 Chemical composition of the experimental materials(%)

Material	Chemical composition(%)					
	CaO	SiO_2	Al_2O_3	MgO	Fe_2O_3	MnO
Steel slag	45.90	15.60	2.66	6.34	23.28	2.18
Blast furnace slag	38.45	34.56	14.75	7.62	0.27	-
Portland cement	57.59	23.10	7.10	2.18	3.67	-

Experimental method

The size of the module for this experiment is 40mm*40mm*160mm.Binding material mixed as the set ratio ,then start the experiment according to GB/T17671-1999《Cement mortar strength test method (ISO method)》,and test the strength of 3d,7d and 28d.The experiment fluidity test according to GB/T2419-94《Cement mortar fluidity measurement method》,and the sand meet standard GB 178-77.The prepared mortar will be pour to the fluid module for two steps instantly and then stirring evenly. After stirring, use scraper make the mortar surface be smooth ,then take off the module and start the jumping table,30s later measure diffusion diameter , repeat twice calculate averages to get the fluidity of the cement mortar.

Experimental ratio

The ratio of each material shows in Table 2.

Table 2 Chemical composition of the experimental material(%)

material / number	Steel slag (%)	Blast furnace slag (%)	Cement (%)	Gypsum (%)
1	20	0	75	5
2	20	15	60	5
3	20	30	45	5
4	20	45	30	5
5	20	60	15	5
6	20	75	0	5
7	35	0	60	5
8	35	15	45	5
9	35	30	30	5
10	35	45	15	5
11	35	60	0	5
12	50	0	45	5

Results and Discussion

Fluidity

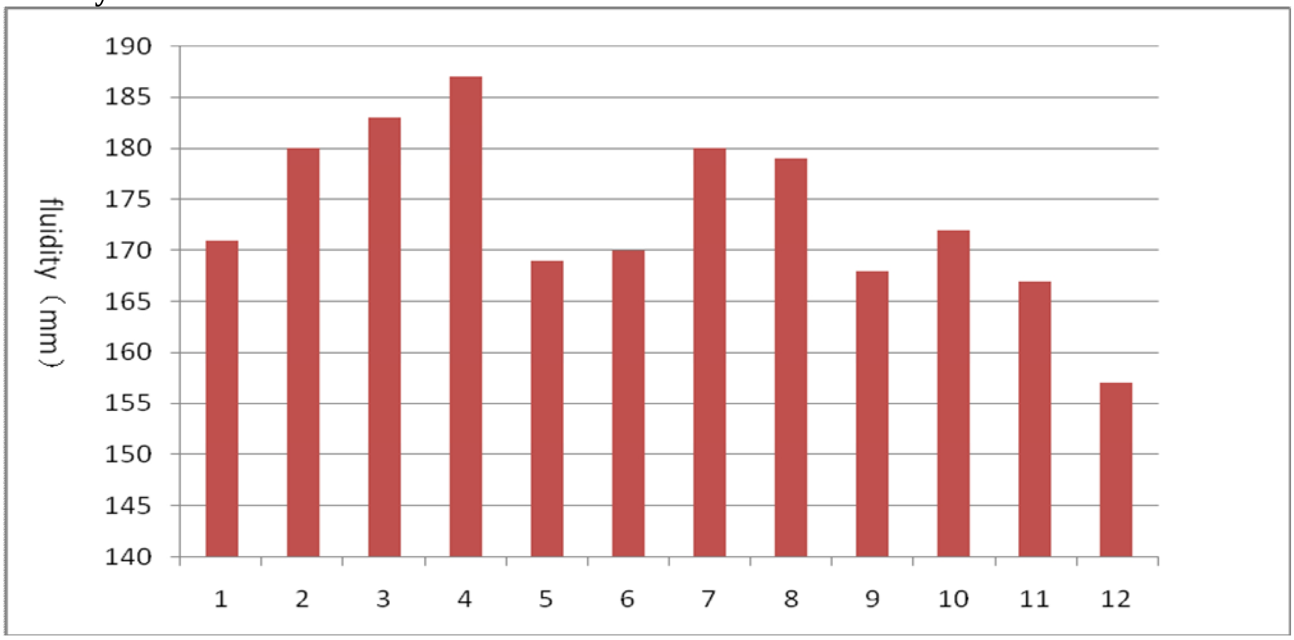

Fig 1 Fluidity of each group

From Fig 1, we can see that when the proportion of steel slag is lower than 50%, the fluidity is higher than 165 mm. When the content of steel slag reach 50%, the fluidity reduce rapidly to less than160mm.This shows that the steel slag absorbs water easily and if you want to improve the fluidity, you should to change the water-cement ratio, otherwise you cut down the dosage of steel slag.

Strength of each age
Flexural Strength

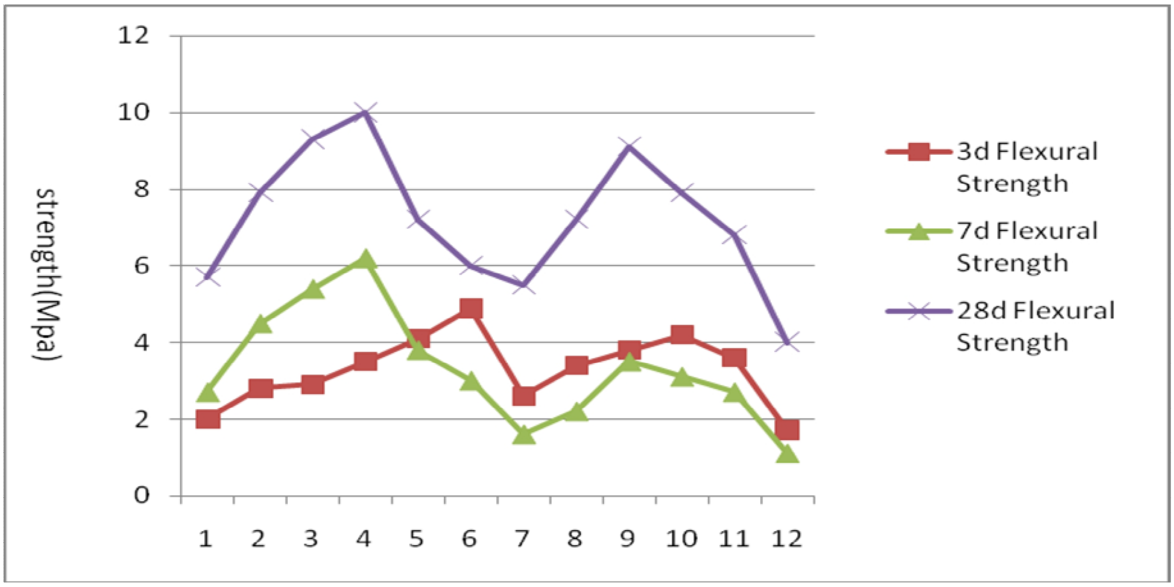

Fig 2 Flexural Strength of each group

Through Fig 2 we can get that as the proportion of steel slag grows the strength of the specimen decrease, and when the ratio of steel slag is fixed, the strength increase as the blast furnace slag grows within limits. We can easily see that when the ratio of the material is 20% steel slag, 45% blast furnace slag and 30% cement, the strength is maximal.

Compressive Strength

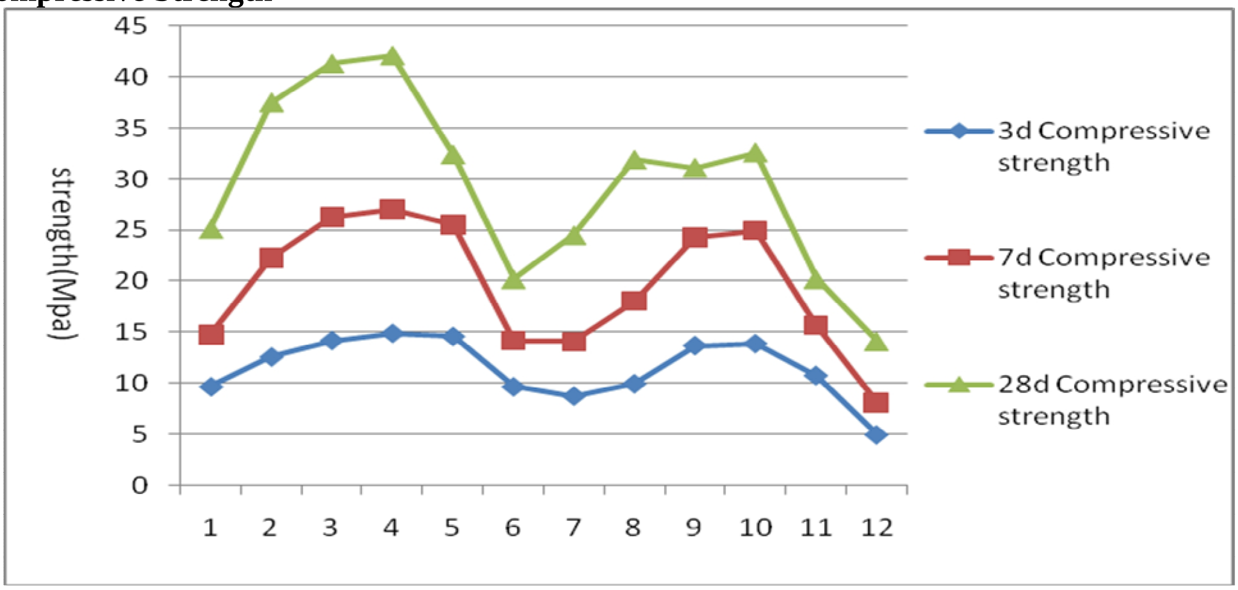

Fig 3 Compressive strength of each group

Through Fig 3 we can see the same properties of the flexural Strength, also when the proportion is20% steel slag, 45% blast furnace slag and 30% cement, the strength is maximal.

Conclusion

When 20% of the steel slag, 45% blast furnace slag and 30% cement mixed, the binding material get the highest strength, and the 28d Flexural Strength is 10.0Mpa, 28d Compressive strength is 42.1Mpa.The fluidity is 187mm.

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References

[1]M.S. Imbabi, C. Carrigan, S. McKenna, Int. J. Sustain. Built Environ. 1 (2) (2012) 194–216.
[2] A.A. Usón, A.M. López-Sabirón, G. Ferreira, E.L. Sastresa, Renew. Sust. Energ. Rev. 23 (2013) 242–260.
[3] H. Shon, S. Vigneswaran, H.H. Ngo, J. H. Kim: Water Res. Vol. 39 (2005), p. 2549
[4] I. Barros Valentim, I. Joekes: Coll. Surf. A: Physicochem. Eng. Aspects Vol. 29 (2006), p. 106
[5] Petr Praus, Martina Turicova, Sona Studentova, Michal Pitz: J. Colloid Interf. Sci. Vol. 304 (2006), p. 29
[6] S. Vassilev, D. Baxter, L. Andersen, C. Vassileva and T. Morgan: Fuel Vol. 94 (2012), p. 1
[7] R.K. Vempati, R. Borade, R.S. Hegde and S. Komarneni: Micropor. Mesopor. Mater. Vol.93 (2006), p. 134
[8] A.A. Khan, W. de Jong, P.J. Jansens and H. Spliethoff: Fuel Process Technol. Vol. 90 (2009), p. 21
[9] C.A. Jordan, G. Akay: Fuel Vol. 91 (2012), p. 253
[10] T. Abbasi, S.A. Abbasi: Renew. Sust. Energy Rev. Vol. 14 (2010), p. 919
[11] U.Y.A. Tettey, A. Dodoo, L. Gustavsson.Energy Build., 82 (2014), pp. 369–377
[12] F. Ardente, et al. Energy Build., 40 (1) (2008), pp. 1–10
[13] L.C. Ram, R.E. Masto.Earth Sci. Rev.128 (2014), pp. 52–74
[14] H. Zhang, et al. Appl. Energy, 112 (2013), pp. 956–966