MATEC Web of Conferences **106**, 03016 (2017) DOI: 10.1051/matecconf/201710603016
SPbWOSCE-2016

SCC with high volume of fly ash content

Anton Bakhrakh[1], *Artyom* Solodov[1], *Oksana* Larsen[1,*], *Vitaly* Naruts[1], *Olga* Aleksandrova[1], and *Boris* Bulgakov[1]

[1]Moscow State University of Civil Engineering, Yaroslavskoe shosse, 26, Moscow, 129337, Russia

Abstract. Self-compacting concrete is a very perspective building material. It provides great benefits during the construction of heavily reinforced buildings. SCC has outstanding properties such as high flowability, dense structure and high strength due to specific quality of aggregates, fillers, their proportion in mix, use of polycarboxylate-based superplasticizers. Main disadvantages of SCC are high price and the difficulty of obtaining a proper mix. Use of fillers, such as fly ash type F, is a way to make SCC cheaper by replacing part of cement. Fly ash also provides some technological and operating advantages. In this paper the influence of high volume (60% from cement) fly ash type F on the properties of concrete mixture and hardened concrete is investigated. The result of the work shows the possibility of reduction the cost of SCC using ordinary fillers and high amount of fly ash. The investigated SCC has low speed of hardening (7-day compressive strength at the range of 41.8 MPa) and high volume of entrained air content (3.5%).

1 Introduction

Self-compacting concrete is a concrete which can be placed and compacted in reinforced constructions without any vibration efforts [1]. SCC has very high flowability and at the same time cohesiveness enough to exceed bleeding or segregation. Self-compacting concrete provides such benefits as reduction of construction time and labour cost, refusal of vibration, reduction of noise pollution, high compressive strength and dense structure.

SCC mixture can be obtained using high amount of cement, high quality aggregates, microfillers such as fly ash, slag, metakaolin, quarry dusts and superplasticizers. The amount of cement paste in SCC is increased and amount of aggregates is limited to achieve flowability. Microfiller is added to exceed segregation or bleeding and to reduce the dosage of expensive superplasticizer, due to round shape, which produces extra flowability [2, 3].

High dosage of cement and superplasticizer causes high price of self-compacting concrete. Introduction of high amount of fly ash can decrease the cost of the SCC.

Fly ash has pozzolanic activity, produces not only technological and economical benefits, but also operating advantages such as high compressive strength and corrosion resistance [4].

Previous investigations show that the maximum size of coarse aggregate should be 10 mm and fine aggregate with fineness modulus of 1.25 [5, 6].

* Corresponding author: larsen.oksana@mail.ru

DOI: 10.1051/matecconf/201710603016

The present work investigates the ability of obtaining SCC using ordinary aggregates (crushed granite with a maximum size of 20 mm and quartz sand with fineness modulus of 2.5) with 60% type F fly ash.

2 Materials and mixture composition

During experiments 12 mixes with different amount of superplasticizer and water/cement ratio were obtained to get needed flowability and exceed bleeding.

2.1 Cement

Cement used in this study was Ordinary Portland Cement type CEM I 42.5R Mordovcement with content of C_3A<8% and C_3S>55%. Mechanical properties, chemical and mineralogical composition of cement are presented in Table 1.

Table 1. Mechanical properties, chemical and mineralogical composition of cement.

Mechanical properties					
Standard consistence, %	**Time of setting, min**	**Compressive strength, MPa**		**Expansion, mm**	
		2-day	28-day		
26.0 - 28.0	160	23.0	51.7	0	
Chemical composition of cement					
SO_3	Admixtures	Loss on ignition	Insoluble residue	Cl^-	
2.92	4.34	1.27	4.17	0.006	
Mineralogical composition of cement					
C_3S	C_2S	C_3A	C_4AF	CaO/SiO_2	MgO
59.97	16.55	6.58	13.12	3.01	1.12

2.2 Fly ash

Fly ash used in this work was ordinary fly ash from Cherpetskaya thermal power station, containing CaO of 2.67% and MgO of 1.52%, loss on ignition of 6.52% and specific surface of 250 m^2/g.

2.3 Coarse aggregate

Crushed granite with a maximum size of 20 mm and specific gravity of 2700 kg/m^3 was used as coarse aggregate. The amount of flake form coarse aggregate was 20%. The Sieve residue (in %) of coarse aggregate is shown in Table 1.

Table 2. Grading of coarse aggregate.

Sieve size, mm	Percentage passing, %
20	96.9
10	26.6
5	2.8
2.5	1.0
bottom	0.0

2.4 Fine aggregate

Quartz sand with specific gravity of 2640 kg/m^3 and fineness modulus equal to 2.5 was used as fine aggregate. The Sieve residue (in %) of sand is shown in Table 3.

Table 3. Grading of fine aggregate.

Sieve size, mm	Percentage passing, %
5	96.2
2.5	87.1
1.25	76.8
0.63	53.9
0.315	21.9
0.16	3.9
bottom	0.0

2.5 Chemical admixture

Superplasticizer BASF MasterGlenium 115, polycarboxylate-based superplasticizer, was used to obtain flowability and decrease water/cement ratio. Recommended dosage is from 0.2% to 2.0% of cement mass.

2.6 Mixture composition

In this research 12 mixtures of SCC with different amount of chemical admixture and water content were obtained in order to get needed viscosity, flowability and exceed bleeding. The first mortar included the following amounts of components: 360 kg of cement, 215 kg of fly ash, water – 180 kg, fine aggregate – 750 kg, coarse aggregate – 810 kg and 10.4 kg of superplasticizer. Fly ash/cement ratio was fixed to 60%, superplasticizer – 1.8% of binder. For the experiment the 10 liters of mixture were prepared. Huge amount of admixture caused visible segregation and bleeding, slum flow test showed more than 800 mm. Dosage of 1.4% from the mass of cementous materials also showed segregation. Next mortars included the amount of superplasticizer at the range from 0.6% to 1.5% by mass of cement with water/cement ratio equal to 0.32.

Table 4. Final mixture composition.

Materials	Dosage of components, kg/m^3
Cement	360
Fly ash	215
Water	183
Fine aggregate	750
Coarse aggregate	810
Plasticizer	5.4

3 Results

The obtained SCC mixture demonstrated positive technological properties without any bleeding and segregation. It possessed good flowability and had 550 mm slump flow, high density (2255 kg/m^3) and 3.5% of entrained air content. The developed concrete showed relatively high compressive strength within 3 days at the range of 23.1 MPa while 7 and 28-day compressive strength gave 41.8 MPa and 71.5 MPa respectively.

4 Conclusions

It was determined the optimal dosage of superplasticizer (1.5% from the mass of cement) to achieve needed flow ability. It was investigated that addition 60% by mass of cement together with super plasticizer provides self-compaction without bleeding and segregation. At the same time it causes high volume of entrained air (3.5%) in SCC mixture. The obtained SCC mixture included for one cubic meter of the concrete mixture: 360 kg - cement, 215 kg - fly ash, 183 kg - water, 750 kg and 810 kg of fine and coarse aggregate respectively and 5.4 kg - super plasticizer. Such composition was selected in accordance with world experience [7, 8, 9] and mathematical patterns to achieve flow ability [10]. The designed SCC mixture demonstrated high early compressive strength. It can be explained by high water retention capacity on increase of the hydration degree by creating a high dense homogenous structure of the concrete [10]. Use of fly ash in SCC gives economical efficiency due to fly ash’s low price, reduces labour cost and time of construction [11].

References

1. H. Okamura, M. Ouchi, Journ. of Adv. Concr. Techn., **1**, 5 (2003)
2. T. Proske, S. Hainer, M. Rezvani, C.-A. Graubner, Cem. and Concr. Res., **51**, 38 (2013)
3. H.J.H. Brouwers, H.J. Radix, First International Symposium on Design, Performance and Use of Self-Consolidating Concrete SCC'2005, **21** (2005)
4. N. I. Makridin, V. I. Kalashnikov, K. N. Mahambetova, *Technology of concrete, building products and construction (in Russian - Tekhnologiya betona, stroitelnykh izdelii i konstruktsii)* (2014)
5. M. Karamloo, M. Mazloom, G. Payganeh, Constr. and Build. Mat., **123**, 508 (2016)
6. S. Barbhuiya, Constr. and Build. Mat., **25**, 3301 (2011)
7. J. Zhang, X. A, D. Nie, Con. and Buil. Mat., **116**, 355 (2016)
8. A. F. Bingol, I. Tohumcu, Mat. and Des., **51**, 12 (2013)
9. W. Wongkeo, P. Thongsanitgarn, A. Ngamjarurojana, A. Chaipanich, Mat. and Des., **64**, 261 (2014)
10. S. Girish, R.V. Ranganath, J. Vengala, Constr. and Build. Mat., **24**, 2481 (2010)
11. F. V. Muellera, O. H Wallevika, K. H Khayat, Cem. and Concr. Comp., **54**, 117 (2014)