SCC with activated recycled concrete fines

Vitali Naruts[1], *Oksana* Larsen[1,*], and *Anton* Bakhrakh[1]

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

Abstract. The main application of concrete waste is its use as a coarse aggregate in concretes. Recycled concrete fines can be also used in concrete mixtures as fine aggregates or fillers. The paper describes an efficient activation method of recycled concrete fines to obtain technological, economical and ecological benefits. The idea is to combine mechanical and chemical methods of activation. According to various experiments the addition of superplasticizer into the mill speeds up grinding process. The present investigation shows that adding 0.5% by mass of recycled concrete fines allows obtaining higher specific area at the same processing time. Use of the prepared filler in SCC increases compressive strength more than 10% in compare with SCC containing limestone powder and mechanically activated recycled concrete fines.

1 Introduction

Mechano-chemical activation is an effective method of obtaining low water demand binders and active fillers for concretes. The substance of method is in adding dry superplasticizer into the mill droning grinding cement or other disperse materials [1].

Mechanical activation implies growth of specific area of grinded material. Higher specific area for cement and other active materials provides higher chemical reactivity [2]. Concrete based on mechanically activated cement with specific area more then 0.4 m^2/kg has higher compressive strength on 7, 14 and 28 day of hardening [3]. The main problem of superfine cements and fillers is high water demand, so that obtaining mortars with good flowability and high compressive strength becomes impossible [4, 5].

Chemical activation of cement and fillers with superplasticizers promotes the formation of polymer shell on the surface of grains [6]. Combination of chemical and mechanical activation provides faster grinding due the Rehbinder effect [7]. Mechanochemically activated cements and fillers have low water demand, application of such materials promotes reduction of water to cement ratio [8]. Use of mechanochemically activated fillers is appropriate in self-compacting concretes (SCC) due to their composition concept. Necessary components of SCC are various fillers, added in order to enlarge the amount of disperse paste, reduce segregation and optimise the granulometry of the mortar [9]. Self-compacting mortar is a mortar which can be used in reinforced constructions without any mechanical efforts [10]. SCC has very high flowability and at the same time cohesiveness

* Corresponding author: larsen.oksana@mail.ru

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 [11, 12, 13]. Application of mechanochemically activated concrete grinding fines will not only improve rheological properties of SCC mix, but also increase compressive strength of hardened concrete.

2 Experimental section

During experiments 3 compositions of SCC with different fillers such as limestone powder, mechanically activated concrete grinding fines and mechano-chemically activated recycled concrete fines were designed.

2.1 Materials

2.1.1 Cement

Cement used in the study was Ordinary Portland Cement type I 42.5N Mordovcement with content of $C_3A<8\%$ and $C_3S>55\%$.

Table 1. Quality parameters of cement.

Mechanical properties				
Water for 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

2.1.2 Concrete grinding fines

Concrete grinding fines used this investigation were produced by the Satori company and has grain size 0-5 mm.

Table 2. Quality parameters of concrete grinding fines.

Finneness modulus	Class	True density, g/cm^3	Inorganic impurities, %
3.0	II	2.64	0.2

Grading of concrete grinding fines shows that its granulometry is similar to ordinary quartz sand used as a fine aggregate in concretes.

Table 2. Grading of concrete grinding fines.

Sieve size, mm	5.0	2.5	1.25	0,63	0,315	0,16	Bottom
Residue on sieve, %	5.9	25.1	15.5	19.1	21.5	13.3	5.5
Full residue on sieve, %		25.1	40.6	59.7	81.2	94.5	100

Table 4. Chemical composition of concrete grinding fines, %.

SiO_2	CaO_2	Al_2O_3	Fe_2O_3	MgO	K_2O	SO_3	Na_2O	P_2O_5	TiO_2	SrO	SiO_2	CaO_2
68.08	18.45	5.41	2.3	1.66	1.43	0.726	1.03	0.128	0.238	0.385	68.08	18.45

2.1.3 Superplasticizers

Superplasticizer Melflux 5581F was used during mechano-chemical activation of concrete grinding fines. Melflux 5581F is based on polycarboxylates. Recommended dosage of superplasticizer by producer is 0.05-0.5 % from the mass of cement.

Superplasticizer used in SCC composition was Sika ViscoCrete S 600 SP.

2.1.4 Aggregates

Crushed granite with a maximum size of 20 mm and true density of 2700 kg/m^3 was used as coarse aggregate. The amount of flake form coarse aggregate was 20%. Quartz sand with true density of 2640 kg/m^3 and fineness modulus of 1.8 was used as fine aggregate in this investigation. Base filler was limestone powder MP-1 produced by the «Gurovo-Beton» company.

2.2 Experimental part

Experimental part was performed in two stages. The first one was mechanical and mechanochemical activation of concrete grinding fines. Designing composition of SCC with 3 types of fillers, preparing of mixes and compressive strength tests of hardened concrete was the second one.

2.2.1 Activation of concrete grinding fines

Concrete grinding fines were activated in a laboratory vibration mill. Value of specific area of the material grinded together with superplasticizer is 14.3% percent higher than of material activated mechanically at the same time of grinding. Results of specific area determination prove the effect of superplasticizer on strength of the crushed material.

Table 5. Specific area of grinded filler.

Dosage of Melflux 5581F (%)	Grinding time, min / Specific area cm^2/g						
	30	45	60	75	90	120	150
0	2903	3315	3599	3789	3825	3923	3978
0.5	3115	3705	3989	4186	4268	4473	4546

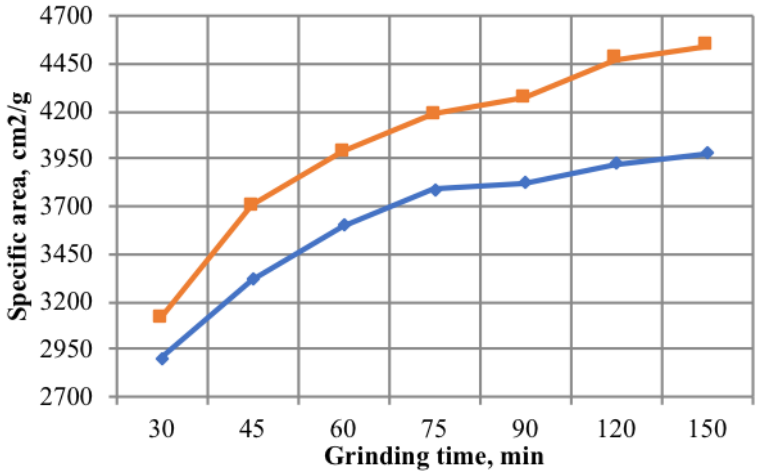

Fig 1. Specific area of grinded filler.

2.2.2 Determination of effect on SCC compressive strength

Three compositions of SCC with different types of fillers were designed. Proportions of raw materials were constant in all compositions. Compositions were designed in accordance with recommended proportions of components for SCC in order to obtain proper flowability.

Table 6. SCC compositions.

Fixture	Filler type	Material consumption per 1 m^3, kg					
		Cem.	Filler	Granite	Sand	Sika ViscoCrete S 600 SP	Water
1	MP-1	400	200	810	810	2.4	180
2	Grinded concrete	400	200	810	810	2.4	180
3	Grinded concrete + Melflux 5581F	400	200	810	810	2.4	180

All three mixes were prepared and their reologic properties were invstigated. Composition mix №3 demonstrated slump flow test results of 772 mm which is highest result comparing with compositions № 1 and №2.

3 Results

Cubic samples 100x100x100 mm were made from prepared mixes in order to determine compressive strength on 3, 7 and 28 days of hardening. Samples with mechanochemically activated filler showed highest test results. Composition №3 with compressive strength on the 3 day was 43.6 MPa, 7-day and 28-day compressive strength was of 52.1 MPa and 67.2 MPa respectively.

Table 7. Compressive strength of SCC.

Mix	Compressive strength, MPa		
	3-day	7-day	28-day
1	41.2	48.9	60.4
2	39.5	46.5	58.1
3	43.6	52.1	67.2

4 Conclusions

According to the results of the present research effective use of concrete grinding fines in SCC requires mechanochemical activation by grinding with polycarboxylate superplasticizer.

Introduction of Melflux 5581F superplasticizer into the mill in amount of 0.5% from the mass of grinded fillers speeds up the dispersion process. Filler milled in the presence of superplasticizer has 14.3% larger specific area comparing to single milled filler at the same activation time.

Use of mechanochemically activated concrete grinding fines in SCC as a filler provides better rheological properties of mortar and higher compressive strength of hardened concrete at all periods of curing.

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