THE USE OF MINE TAILINGS AS A PARTIAL AGGREGATE REPLACEMENT IN SCC CONCRETE

Ksenija Janković [1]
Dragan Bojović [2]
Marko Stojanović[3]
Ljiljana Lončar[4]

УДК: 666.972.12
DOI:10.14415/konferencijaGFS 2015.007

Summary: *In previous work, we found the tailings has no pozzolanic activity and that its application in mortar and concrete can be made in the form of replacement of participation in a certain percentage of aggregates. In this paper we discuss the possibility of applying tailings in self-compacting concrete (SCC). Testing of some properties of fresh and hardened SCC concrete in which 10 and 20% fractions of 0/4 mm aggregate was replaced with tailings was performed. The test results of compressive strength were compared with the standard.*

Keywords: *talings, self-compacting concrete, aggregate*

1. INTRODUCTION

By increasing metal production, the amount of tailings increases, which presents a major environmental problem. In industrial areas, during the flotation of ore from the mine, and technogenic raw slag from the furnace, large quantities of flotation tailings is generated. Thomas et al, investigates the possibility of using tailings from the copper ore as a partial replacement for natural river sand in concrete [1]. It uses mining waste from copper ore (substitution of up to 60%) in concrete, and it displays good strengths and durability characteristics.The effect of the application of copper tailings which substitute 0%, 5% and 10% of cement mass on the properties of fresh and hardened concrete has been determined [2]. Mortars with copper tailings showed greater strength and resistance to abrasion. Chemical, physical and microstructural properties of the lightweight aggregate, which is obtained in the mining process and from industrial waste, including soil pollution from the mines and the combustion of coal products was investigated [3]. The same authors present a study on the effectiveness of thermal treatment in the

[1]PhD Ksenija Janković, Institute IMS, Bulevar vojvode Mišića 43, Belgrade, Serbia, tel: +381 11 2653645, e-mail: ksenija.jankovic@institutims.rs
[2] Dragan Bojović, PhD candidate, Institute IMS, e-mail: dragan.bojovic@institutims.rs
[3] Marko Stojanović, PhD student, Institute IMS, e-mail: marko.stojanovic@institutims.rs
[4] Ljiljana Lončar, BSCE, Institute IMS, e-mail: ljiljana.loncar@institutims.rs

immobilization of various chemical elements within the structure of artificial lightweight aggregates (LWAs) produced from contaminated mine soil and fly ash [4].

2. EXPERIMENTAL WORK

2.1. THE RESULTS OF TAILINGS TESTING

The aim of this study was to investigate the possibility of applying tailings in self-compacting concrete as a partial replacement of river sand.
A sample of tailings from the Pb and Zn mine was used for this study. Testing of chemical, physical and mechanical properties was performed on the sample. The chemical composition of the tailings sample was determined by using the classical chemical analysis in accordance with the SRPS EN 196-2 standard. The content of reactive SiO2 and CaO was calculated using the results of chemical analysis in accordance with the SRPS EN 197-1 standard. The physical properties of the tailings are determined according to SRPS B.C1.018 standard. The results of the pozzolanic activity were extremely low. Thus, it was concluded that this material is not suitable as a material to replace cement in concrete and mortar or as a pozzolanic additive for cement [5]. Further research is focused on the possibility of using tailings as a partial replacement for aggregate in concrete. Due to the grain size, the tailings sample (Table 1), can only be used as a substituent of the part of aggregate fractions 0-4 mm.

Table 1. The physical properties of tailings

Size of sieve openings, mm	Residue on a sieve with the mesh size, %
Fineness by sieving, (sample in the natural state)	
0,2 mm	20,4
0,09 mm	62,2
0,063 mm	75,2
0,043 mm	82,0

2.2. THE TESTING OF SELF-COMPACTING CONCRETE PROPERTIES

2.2.1. Fresh concrete

For the tests described in this paper self-compacting concretes with a part of the aggregate replaced with tailings from the mine were made (Table 2).
For the preparation of self-compacting concrete the following materials were used:

- Cement: CEM I 42.5 R, Lafarge BFC, Beocin
- Aggregate: river, washed and separated into fractions 0/4, 4/8, 8/16 mm

- Mineral additive Type I: filler
- Mine tailing
- Chemical admixture: Superplasticizer VSC 5380 (polycarboxylate), Sika – Serbia
- Water: potable water

Table 2. Composition of concrete mixtures

Mix number	Aggregate 0/4mm fraction		Tailings for replacement 0/4mm fraction		Superplasticizer VSC 5380	
	%	kg/m³	%	kg/m³	%	kg/m³
J_SCC-0%	45%	782.0	0%	0	0.8	3.6
J_SCC-10%	45%	703.8	10%	78.2	0.8	3.6
J_SCC-20%	45%	625.6	20%	156.4	0.8	3.6

Cement = 350 kg/m³; Aggregate=1738 kg/m³; Filler=100kg/m³; Water=180kg/m³; w/b=0.4

Fresh concrete is designed to meet the minimum properties of self-compacting concrete, according to SRPS EN 209-1 standard. A referent mixture and two mixtures in which a part of the fine aggregate (10 or 20%) was replaced with tailings were prepared. By testing the properties of fresh SCC concrete it should be demonstrated what impact the replacement of fine fractions of aggregate has on the rheological properties of fresh SCC concrete. The following properties of SCC concrete were tested: slump flow, testing with V-funnel and L-box according to SRPS EN 12350-8, SRPS EN 12350-9 and SRPS EN 12350 -10 standards. Slump flow testing is used to obtain insight into the horizontal flow of self-compacting concrete if there are no obstacles. V- funnel testing is used to estimate the viscosity of SCC concrete and represents the amount of time the concrete needs to flow from the funnel. The L-box is used to test the ability of SCC concrete to pass through the narrow passages between the armature and other obstructions without segregation and blocking. Method with three bars was used. The limit values for SCC concrete compacting according to different classes are shown in Table 3.

Table 3. Slump flow, viscosity and passing ability classes [6]

Class	**Slump flow classes**
	Slump flow in mm
SF1	550 to 650
SF2	660 to 750
SF3	760 to 850
Class	**Viscosity classes – V funnel**
	V-funnel flow time (s)
VF1	< 9
VF2	9 to 25
Class	**Passing ability classes - L-box**/Sposobnost prolaza klase
	L-box ratio
PL 1	≥ 0,80 with 2 bars
PL 2	≥ 0,80 with 3 bars

The properties of self-compacting concrete with and without tailings are shown in Table 4. Bulk density of fresh concrete was tested according to SRPS EN 12350-6 standard and ranged from 2370 to 2390 kg/m^3. In addition to this testing, the testing of entrained air in fresh concrete was performed according to SRPS EN 12350-7 standard.

Table 4. The properties of self-compacting concrete with and without tailings

Mix number	Slump flow SRPS EN 12350-8 (mm)	V funnel SRPS EN 12350-9 (sec)	L-box (3 bars) SRPS EN 12350-10 PL=H2/H1	Entrained air SRPS EN 12350-7 %
J_SCC-0%	610	6.7	0.84	2.7
J_SCC-10%	600	7.1	0.91	0.8
J_SCC-20%	600	7.6	0.96	1.7

a) Slump flow *b) Passing ability – L_{box}*

Figure 2. Testing of compacting ability of SCC

2.2.2. Hardened concrete

Samples for testing compressive strength of concrete were made. Concrete was compacted without vibration in metal cube-shaped molds with an edge length of d = 100 mm, and the samples were cured in water at a temperature of + 20 ° C until they were tested according to SRPS EN 12390-2 standard.
Testing compressive strength of concrete at the age of 3, 7 and 28 days was carried out according to SRPS EN 12390-3 standard. Bulk density of hardened concrete was tested according to SRPS EN 12390-7 standard and ranged from 2350 to 2450 kg/m^3. The test results are shown in Table 6 and in Figure 3.

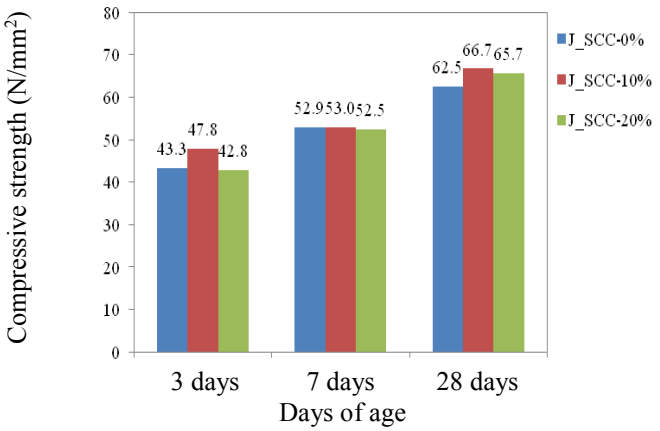

Figure 3. Compressive strength of SCC concrete at a certain age

Table 6. Compressive strength of self-compacting concrete with mine tailing

Mix number	Compressive strength N/mm^2		
	3 days	7 days	28 days
J_SCC-0%	43.3	52.9	62.5
J_SCC-10%	47.8	53.0	66.7
J_SCC-20%	42.8	52.5	65.7

3. CONCLUSION

By using tailings to replace a part of fine aggregate SCC concrete was obtained, and it can be classified into following classes based on the properties in fresh state: SF1 (*Slump flow*), VF1 (*V-funnel flow*) and PL2 (*Passing ability*).

The testing of compressive strength of concrete at the age of 3 days has shown that the replacement of 10% of tailings in aggregate contributes to the 9.4% increase of concrete strength when compared to the reference concrete. Application of tailings had no influence on the compressive strength of concrete at the age of 7 days. Concretes with 10% and 20% addition of tailings achieved higher strengths when compared to the reference concrete at 28 days of age.

The results presented in this paper show that it is possible to use tailings from the Pb and Zn mine in self-compacting concrete and that the best effect is achieved by replacing the fine fractions of aggregate with 10% of the tailings. Future research will be conducted on the impact of tailings on the durability of SCC concrete, as well as the application to other types of cement.

ACKNOWLEDGMENTS

The work reported in this paper is a part of the investigation within the research project TR 36017, supported by the Ministry for Science and Technology, Republic of Serbia.

REFERENCES

[1] Thomas B. S., Damare A., Gupta R.C. Strength and durability characteristics of copper tailing concrete, Construction and Building Materials 48, **2013,** 894–900
[2] Onuaguluchi O., Eren O. Recycling of copper tailings as an additive in cement mortars, Construction and Building Materials 37, **2012,** 723–727
[3] González-Corrochano B., Alonso-Azcárate J., Rodas M. Effect of prefiring and firing dwell times on the properties of artificial lightweight aggregates, Construction and Building Materials 53, **2014,** 91–101
[4] González-Corrochano B., Alonso-Azcárate J., Rodas M. Effect of thermal treatment on the retention of chemical elements in the structure of lightweight aggregates manufactured from contaminated mine soil and fly ash, Construction and Building Materials 35, **2012,** 497–507
[5] Janković, K., Miličić, Lj., Bojovic, D., Loncar Lj., Stojanović, M. **2014**: "The possibility of using mine tailings as a partial aggregate replacement", DIMKS, INTERNATIONAL SYMPOSIUM, Proceedings, Vrnjačka Banja, 131-136 (ISBN 978-86-87615-05-2, COBISS.SR-ID 210812172)
[6] Concrete - Part 9: Additional Rules for Self-compacting Concrete (SCC)

UPOTREBA JALOVINE IZ RUDNIKA KAO PARCIJALNE ZAMENE ZA AGREGAT U SCC BETONU

Rezime: *Jalovina koja se koristi u ovom istraživanju nema pucolanska svojstva, pa je ona upotrebljena kao zamena dela sitne frakcije agregata u malteru i betonu. U ovom radu je prikazana mogućnost primene jalovine u samougrađujućem betonu. Izvršeno je ispitivanje nekih svojstava svežeg i očvrslog SCC betona kod kojeg je frakcija agregata 0/4 mm zamenjena sa 10 i 20 % jalovine. Rezultati ispitivanja upoređeni su sa odgovarajućim etalonom.*

Ključne reči: *jalovina, samougrađujući beton, agregat*