RECYCLED COARSE AGGREGATE AND FLY ASH EFFECT ON COMPRESSIVE STRENGTH OF SELF-COMPACTING CONCRETE

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Abstract

The paper presents experimental results of the tests conducted on Self-Compacting Concrete (SCC) with recycled coarse aggregate, and fly ash as filler component. A fine fraction of aggregate originated from a riverbed, while coarse aggregate was obtained either from a riverbed or by crushing laboratory concrete cubes as recycled concrete aggregate. The larger coarse aggregate grains than typical for SCC were used, to highlight the possibility of application in structure elements with sparse reinforcement bars. Four mixtures of concrete were made, in order to compressive strength as the dominant property of any concrete. All of the fresh concrete mixtures displayed proper behavior for this kind of concrete, whereas recycled concrete aggregate induced several challenges. Hardened concrete mixtures showed that beyond the use of natural coarse aggregate, there is the possibility to obtain proper mechanical behavior needed for structural concrete, with moderate amounts of cement. Such an approach paves a way for a cleaner and more sustainable civil engineering practice.

Keywords: self-compacting concrete, recycled aggregate, fly ash, sustainable development

INTRODUCTION

The reuse of **industrial waste and by-products** (e.g. fly ash, sludge, etc.) in concrete production represents the appropriate way for **developing sustainable construction**.

Fly ash represents a fine powder collected on electrostatic precipitators from flue gases in thermal power plants. As a waste, it is deposited in landfills that are typically located near thermal power plants, representing **a global concern** for which the solutions are constantly pursued. Its use reduces the consumption of **non-renewable** natural resources and has **economic** significance.

Most commonly, it is used as a **supplementary cementitious material** in the production of Portland cement concrete due to its pozzolanic properties.

The utilization of **recycled concrete aggregate** and fly ash in SCC (self-compacting, self-placing, self-consolidating concrete – which, unlike normal concrete, is **not additionally externally compacted** when placed in the formwork of reinforced concrete structures) also has the potential to reduce both the environmental impact and financial cost associated with the increasing demand for this construction material.

The aim of this study was to investigate **the impact** of used recycled aggregate and fly ash on the properties of SCC. The usage of the fourth fraction of aggregate (16 – 31.5mm, the grain size uncommon for SCC) was hereby **promoted**, in such cases whenever there are no restrictions for its application.

EXPERIMENTAL

Materials of samples were:

- OPC, PC 42.5 R without additions, Beočin, Serbia;
- Fly ash, Nikola Tesla B, Obrenovac, Serbia
- Superplasticizer Cementol Hiperplast 463, TKK, Slovenia;
- Natural aggregate of all four fractions (0-31,5 mm), Gradient, Serbia;
- Recycled aggregate of the fourth fraction (16-31,5 mm), smashed test concrete cubes;
- Water devided in two portions: first for hydration and the second for absorption of aggregate.

	Quantities [kg/m^3]			
Component	I	II	III	IV
Cement	300.0	300.0	270.0	270.0
Water	155.8	155.8	155.8	155.8
Additional absorption water	11.5	49.2	11.5	49.2
Fly ash	150.0	150.0	180.0	180.0
Natural aggregate, I fraction (0<d<4mm)	657.0	657.0	657.0	657.0
Natural aggregate, II fraction (4<d<8mm)	274.0	274.0	274.0	274.0
Natural aggregate, III fraction (8<d<16mm)	402.0	402.0	402.0	402.0
Natural aggregate, IV fraction (16<d<31.5mm)	492.0	-	492.0	-
Recycled aggregate, IV fraction (16<d<31.5mm)	-	492.0	-	492.0

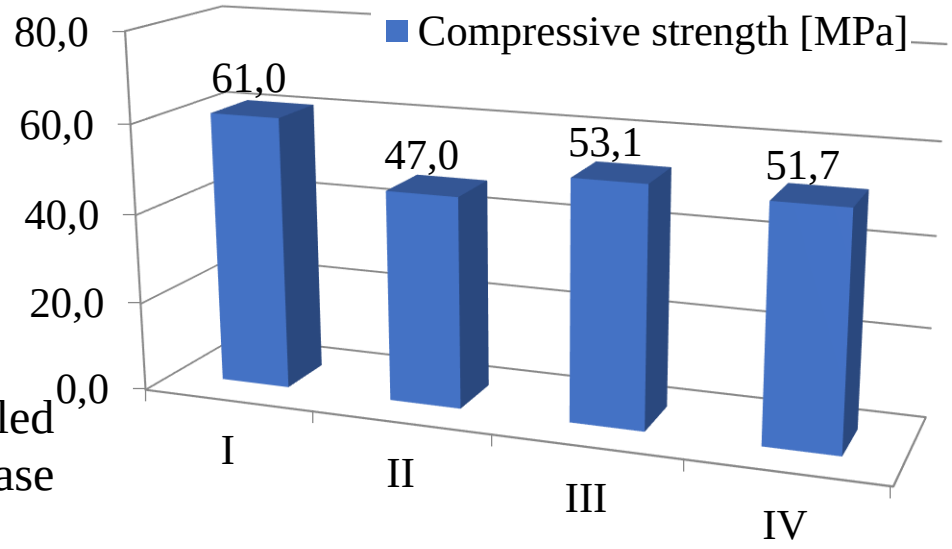
Fly ash was used in the SCC mixtures as the **solitary filler and without prior activation.** The samples were molded and cured for 1 day in the air, covered with a wet cloth. After demolding, the samples were cured in 20˚C water for 28 days and removed from water a little prior to testing.

RESULTS AND DISCUSSION

All of the fresh concrete mixtures displayed proper behavior for this kind of concrete, with slump-flow diameters ranging between **650 and 800 mm**; whereas recycled concrete aggregate induced several challenges:

1. The amount of water had to be carefully waged, based on **absorption** values.
2. Therefore, the consistency of the series with the recycled coarse aggregate was **more fluid** immediately after mixing.
3. Due to the absorption process, the consistency of the series with recycled concrete was more **rapidly changing in time**, in comparison to the series without recycled concrete aggregate.

The compressive strength tests were performed according to the standard SRPS EN 12390-3:2010 on triplet 10 cm cubic samples at the age of 28 days.



The addition of fly ash mixed with recycled aggregate showed a positive effect by the increase in compressive strength

CONCLUSION

1. The introduction of recycled concrete aggregate **induced challenges** regarding the consistency.

2. The consistency of the series with the recycled coarse aggregate was **both more fluid and more rapidly thickening**.

3. Although the reference series showed the highest compressive strength, the coarse recycled aggregate had a **moderate influence on a drop in strength**.

4. Also, the differences of the SCC series made with and without the recycled coarse aggregate and with higher amount of fly ash were almost **neglectable (2.6%)**.

5. The **sustainability aspect of SCC was improved** through the use of recycled concrete aggregate and fly ash, with respect to the reduction in cement and natural aggregate for concrete, which illustrates the potential of concrete to improve in light of its environmental and sustainability impacts.

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