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USE OF IRON ORE TAILINGS FOR PRODUCTION OF CONCRETE PAVING BLOCKS

Abstract

The possibility of using tailings from the iron mine (IOT) in the production of concrete elements for the pedestrian areas is shown in this paper. To determine the impact of the amount of tailings on the compressive strength of concrete, samples with varying percentage of replacement of aggregate fractions were made.

Based on the testing results it was assumed that it is possible to produce the concrete elements with tailings from iron mine as concrete component. The results show that partial replacing natural aggregate with IOT produces concrete elements which meet the requirements of EN 1338.

Key words

Tailing, aggregate, concrete, paving blocks.

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1. INTRODUCTION

One feasible solution for reducing pressures on the environment and achieving sustainability is to reuse waste materials as secondary resources. For this purpose, the concrete industry has already absorbed millions of tons of industrial by-products which contain toxic elements.

The possibility of using iron ore tailings for the replacement of natural aggregate in preparing UHPC under two different curing regimes was investigated. When the replacement level was no more than 40%, for 90 days standard cured specimens, the mechanical behavior of the tailings mixes could be compared to that of the control mix [1].

The results show that Engineered Cementitious Composites (ECC) with IOTs as aggregates can achieve tensile and compressive properties which can be compared to ECC with typically-used micro-silica sand, if the size of IOTs used is in the appropriate range which facilitates good dispersion of fibers. Thus, the feasibility of using industrial solid waste-iron ore tailings as aggregates in developing highly ductile and green ECC was established [2].

Paper evaluates the technical feasibility of using iron ore tailings from tailing dams (IOT) as construction material. Mortars with IOT had increased bulk density, an increase in the amount of mixing water, reduced levels of incorporated air, and improved mechanical properties when compared with the conventional ones. The results show that the use of IOT as construction material in the production of mortars for coating and laying of bricks is justified [3].

The possibility of substitution of up to 50% of natural aggregate by tailings from an iron mine in the production of concrete paving blocks was also investigated [4]. The use of coarse tailings fraction instead of natural aggregate has the effect of increasing the mechanical properties of concrete blocks as well as increasing the porosity. By varying the amount of tailings, blocks of different colors are obtained, thus increasing their potential in the design of exteriors [4].

Depending on the granulometric composition, tailings can be used in brick production or as a substitute for aggregate in cement composites [5].

2. EXPERIMENTAL WORK

2.1. THE RESULTS OF TAILINGS TESTING

The aim of this paper is to investigate a possibility of tailings from the iron ore mine (IOT) in concrete as a partial replacement of aggregate; also, using that type of concrete in the production of paving elements.

The results of the pozzolanic activity were low: compressive strength 1.8 MPa, flexural strength 0.9 MPa. Thus, it was concluded that this material is not suitable as a material to replace cement. Further research is focused on the possibility of using IOT as a partial replacement for aggregate in concrete. Due to the grain size, the tailings sample (Fig. 1), can be used as a substituent of the part of aggregate fractions 0/4 mm, 4/8 and 8/16 mm.

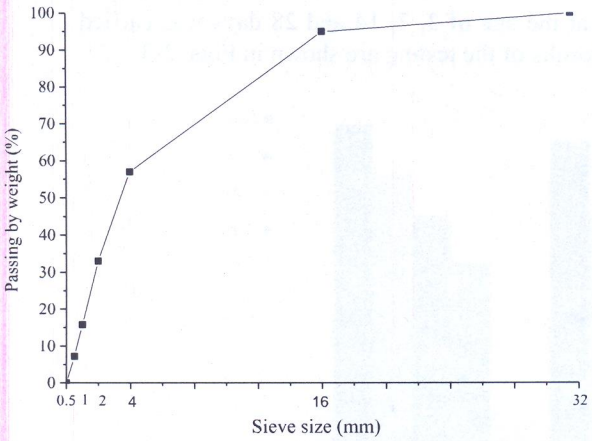

Figure 1. Iron ore tailings particle size distribution

2.2. THE RESULTS OF CONCRETE TESTING

For the tests described in this paper concretes with a part of the aggregate replaced with tailings from the mine were made.

Two reference concrete (Table 1) with crushed aggregate (Dmax=16 mm) from quarries Dobrnja near Banja Luka were prepared. Concrete with tailings were made as crushed aggregate (fractions 0/4, 4/8 and 8/16 mm) was replaced with 25% or 50% iron ore tailings.

All the concrete mixtures tested within the experimental research were made using CEM II/B-S 42.5 N cement, manufactured by CEMEX.

Table 1. Mix proportion

Concrete mixture	C1	C2
Cement [kg/m^3]	320	360
Water-cement ratio W/C	0.40	0.40
Aggregate-cement mix ratio A/C	6.0469	5.2778

Adding tailings to the mix increases the amount of water required to obtain concrete of the same workability [1]. The tailings have a larger specific surface area than the natural aggregate, and the fineness modulus of the aggregate decreases with increasing the amount of tailings causing an increase in the water-cement ratio to produce concrete of the same consistency as the reference [1].

To obtain the same consistency as for reference concrete, for mixtures with 25% replacement of natural aggregate with tailings, the amount of water was increased 4%, and for mixtures with 50% replacement of natural aggregate with tailings, this increase was 8%.

The consistency of the fresh concrete was class S1 according to SRPS ISO 4103/1997 standard.

Testing of concrete compressive strength at the age of 3, 7, 14 and 28 days was carried out according to SRPS EN 12390-3 standard. The results of the testing are shown in Figs. 2-3.

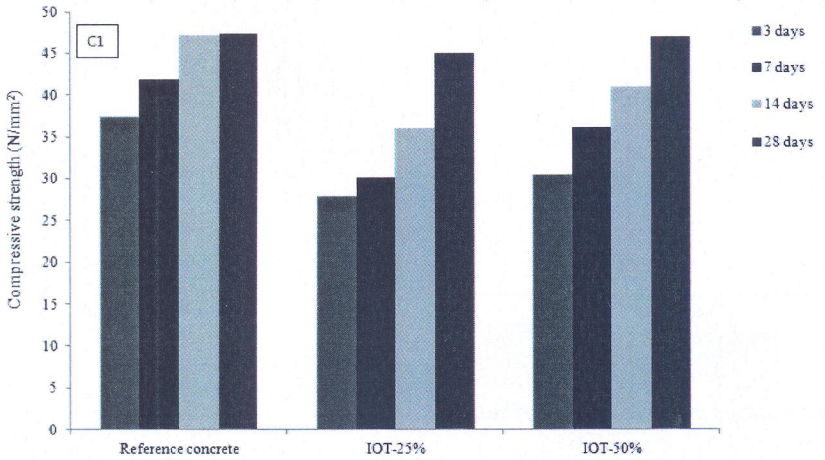

Figure 2. Compressive strength of concrete C1

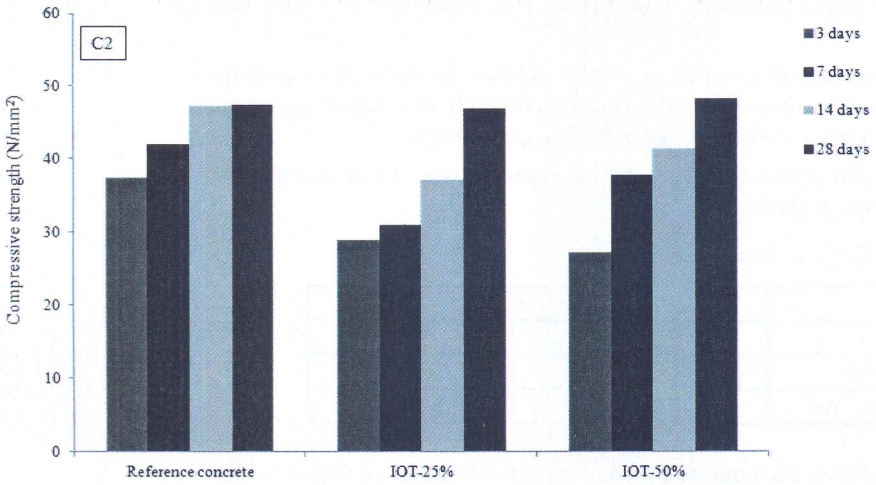

Figure 3. Compressive strength of concrete C2

Concrete with tailings mixes showed comparable mechanical properties to the control mix.

2.3. THE RESULTS OF CONCRETE PAVING BLOCKS TESTING

Industrial testing was done in the same way as regular production, but the base layer was replaced with concrete with 25% substitution of the natural aggregate by tailings. Concrete with 25% tailings from the iron mine has slightly lower strengths than concrete with 50% tailings, but which do not deviate significantly from the standard for 28 days (Figs. 2-3). As the percentage of

tailings decreases as the workability decreases [1] and the porosity [4] of the concrete increases, this is the reason why concrete with 25% tailings from the iron mine was selected.

Concrete elements are consist of two layers. Base layer for 8 cm high elements according to mixture C1 is given in Table 1. Facing layer is made of quartz sand 0/2 mm and cement.

The concrete is casted in molds of various shapes 8 cm high by vibropressing.

Based on dimensions, by European standards, all products are categorized as concrete paving blocks. Concrete paving blocks have been tested for the following properties according to SRPS EN 1338: 2012 [6]:

- weather resistance,
- tensile splitting strength,
- abrasion resistance.

Weather resistance is defined by testing for freeze – thaw resistance with de-icing salt and water absorption. All types of concrete paving blocks had a water absorption of less than 6% and a mass loss after the freeze / thaw cycles ≤ 1.0 kg / m2 and meet the requirements for both Class 2 and Class 3 for weather resistance.

The minimum tensile splitting strength was from 3.3 MPa to 3.6 MPa, and T (characteristic tensile splitting strength) ranged from 4 to 4.4 MPa depending on the type of mold used. Therefore, all types of blocks met the criteria of the standard because the characteristic tensile splitting strength T was greater than 3.6 MPa and the minimum ≥ 2.9 MPa.

For all types of concrete elements, the volume loss was ≤ 18 cm3/50 cm2 per Bohme test and met abrasion resistance Class 4.

3. CONCLUSIONS

The feasibility of using iron ore tailings was studied. The results of the pozzolanic activity were low, so it was concluded that this material is not suitable as a replacement of cement in concrete.

Further tests were done to determine the possibility of using tailings as a partial replacement for aggregate in concrete. As the proportion of ore tailing in the mixture was increased, the compressive strength increased.

Based on the obtained results it can be concluded that the use of iron ore tailings as partial aggregate replacement is possible. Concrete made with this type of tailings can be used for the production of elements for pedestrian areas and various non-structural elements.

By replacing 25% of the natural aggregate with tailings from an iron mine, it is possible to produce concrete paving blocks that meet the requirements of European standard SRPS EN 1338: 2012.

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LITERATURE

[1] Sujing Zhao, Junjiang Fan, Wei Sun Utilization of iron ore tailings as fine aggregate in ultra-high performance concrete Construction and Building Materials 50 (2014) 540–548

[2] Xiaoyan Huang, Ravi Ranade, Wen Ni, Victor C. Li Development of green engineered cementitious composites using iron ore tailings as aggregates Construction and Building Materials 44 (2013) 757–764

[3] Wanna Carvalho Fontes, Júlia Castro Mendes, Sidney Nicodemos Da Silva, Ricardo André Fiorotti Peixoto Mortars for laying and coating produced with iron ore tailings from tailing dams Construction and Building Materials 112 (2016) 988–995

[4] F. L. da Silva, F. G. S. Araújo, C. G. Castro, J. J. Mendes, F. L. von Krüger: Recycling of concentration tailings of iron ore for the production of concrete block (Pavers), Mater.Sci.Forum 775–776 (2014) 631–634

[5] M. Yellishetty, V.Karpe, E.H Reddy, K.N.Subhash: Reuse of iron ore mineral wastes in civil engineering construtions: a casestudy, Resources, Conserv. Recycl. 52 (2008)1283–1289

[6] SRPS EN 1338:2012 Concrete paving blocks – Requirements and test methods, CEN