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The Shrinkage of Fine Recycled Aggregate Concrete

ŠEFFLOVÁ Magdaléna[1, 2 a]

[1]Czech Technical University in Prague, Faculty of Civil Engineering, Department of Building Structures, Thákurova 7, 166 29, Prague, Czech Republic

[2]Czech Technical University in Prague, University Centre of Energy Efficient Buildings, Třinecká 1024, 273 43, Buštěhrad, Czech Republic

[a]magdalena.sefflova@cvut.cz

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This paper is focused on the shrinkage of fine recycled aggregate (FRA) concrete. The durability of FRA concrete is connected with many uncertainties and doubts. This paper presents results of shrinkage measuring of FRA concrete. The FRA was originated from crushed old concrete structures. There were prepared a total four concrete mixtures. The first mixture (REF) was prepared with natural sand. In other concrete mixtures, natural sand was replaced by the FRA in various replacement ratios. There were tested the shrinkage of FRA concrete. The shrinkage was tested according to ČSN 73 1320. It is possible to say that the use of FRA influences the concrete shrinkage. The shrinkage of FRA concrete depends on the amount of FRA in concrete.

Introduction

Concrete is one of the most used building materials in the world. Concrete is popular for good mechanical properties, durability and simultaneously cost effectiveness. Concrete´s world production is estimated around 10 billion cubic meters per year [1]. With increasing production of new concrete elements, the amount of construction and demolition (C&D) waste on the landfills increases too. The C&D waste constitutes 1/3 of total waste production in the European Union. The targets for the reduction reuse and recycling of C&D waste were determined in connection with this problem. Minimally 70 % of the produced C&D waste must be reused or recycled by 2020 [2].

The use of recycled aggregate concrete, made from crushed C&D waste, is one of possible ways how save natural resources and simultaneously reduces the amount of C&D waste on landfills. Unfortunately, the use of recycled aggregate is connected with uncertainties and doubts [3]. The shrinkage is one of the most unknown aspects of recycled aggregate concrete.

Experimental research program

Materials. Portland cement CEM I 42.5 R, natural sand, water and the FRA were used in the experimental part. The FRA was obtained from recycling plant in the Czech Republic. The FRA originated from demolished concrete structures. The FRA were crushed from fraction 32/64 mm to fraction 0/16 mm and sieved to fraction 0/4 mm. There were tested geometrical and physical properties of the FRA. The physical properties were tested by pycnometric method according to ČSN EN 1097 – 6 [4]. The test results were compared with natural sand. The test results of physical properties are given in Table 1.

Table 1: Physical properties of aggregate

Aggregate	Fraction	Density [kg/m^3]	Water absorption capacity [%]
Natural aggregate	0 – 4 mm	2600	2.00
Fine recycled aggregate	0 – 4 mm	2090	8.29

Concrete mix proportion. A total four concrete mixtures were designed and prepared. All concrete mixtures were designed with the same w/c ratio and the same amount of cement. The amount of cement and water- cement ratio was designed according to the Czech standard CSN EN 206 [5]. The first concrete mixture was reference (FRA) which did not include the FRA. Natural sand was replaced by the FRA in concrete mixtures REC10, REC20 and REC30 in varying replacement ratio (10 %, 20 %, 30 %). Details of concrete mix proportion are given in Table 2.

Table 2: Concrete mix proportion, per cubic meter

Designation	REF	REC10	REC20	REC30
Cement [kg]	486	486	486	486
Water [kg]	243	243	243	243
Sand [kg]	1458	1312	1166	1021
FRA [kg]	0	146	292	437

Methodology. There were tested shrinkage and the development of compressive strength. The shrinkage was tested according to ČSN 73 1320 [6]. The shrinkage drains of dimensions 100x60x1000 mm u-shaped stainless steel profile were used for testing (see Fig. 1). The drains are covered with a removable neoprene sheet to avoid wall friction. On one side a removable anchor is fixed. On the other side this anchor is movable and sliding on three wheels. The motion of this anchor is registered by a high sensitive digital probe. Digital probes, connected over a digital bus system, were used for measurement. Concrete samples were kept in constant environment. The shrinkage was measured during 72 hours. The air temperature and humidity were monitored during the measuring period.

The compressive strength was tested according to ČSN EN 12390 – 3 [7]. Beams of dimensions 160x40x40 mm and 100 mm cubes were used for the testing. The compressive strength was tested at the age 7, 14, 28 and 90 days.

Fig. 1: The shrinkage drains

Test results.

The graph in Fig. 2 shows the development of shrinkage of FRA concrete. The use of FRA in concrete has negative influences on shrinkage of concrete. With increasing amount of FRA, shrinkage increases too.

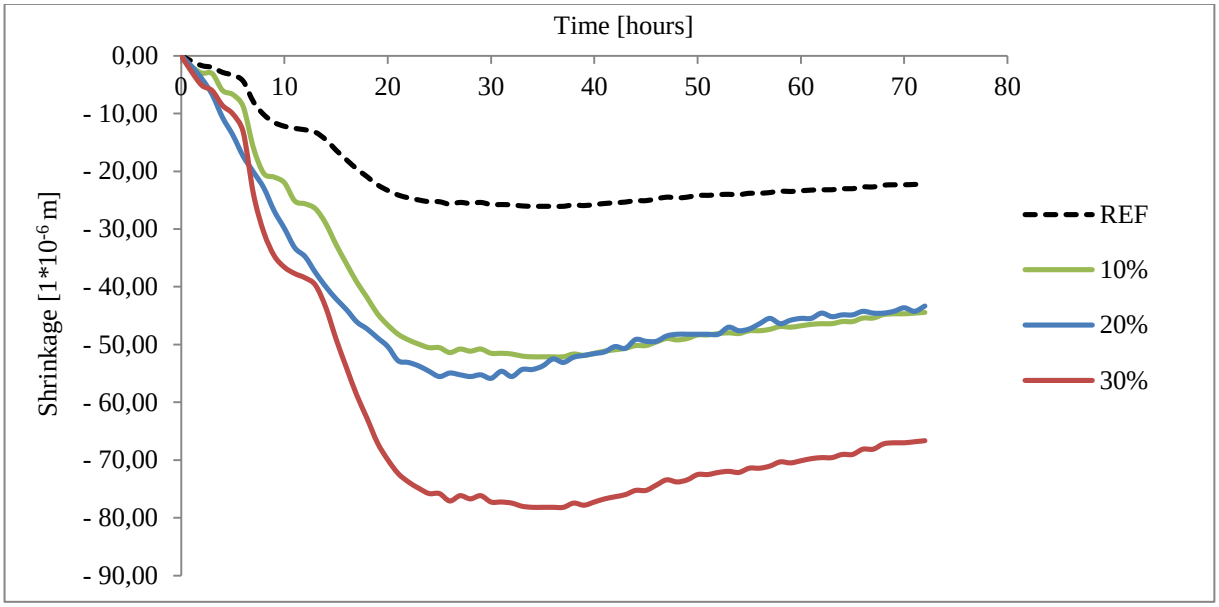

Fig. 2: The shrinkage development of concrete

The graph in Fig. 3 shows the development of the compressive strength at the age 7, 14, 28 and 90 days. Concrete samples with FRA show a mild improvement of the compressive strength of FRA concrete with comparison of reference concrete. However differences of the compressive strength between each FRA concrete mixtures are minimal.

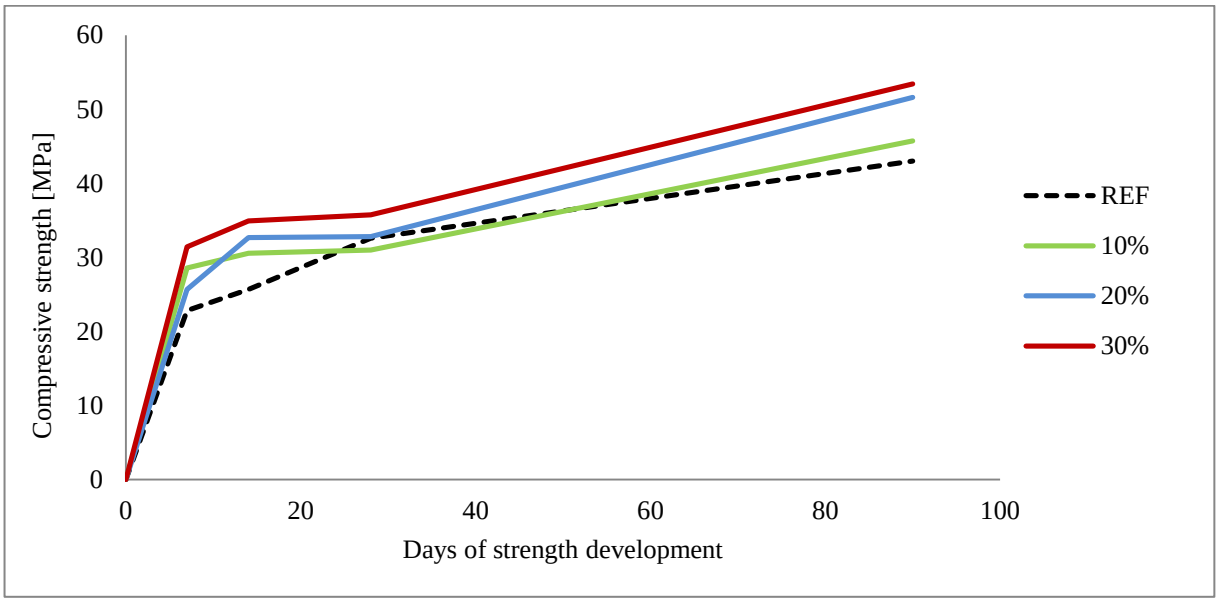

Fig. 3: The development of compressive strength

Conclusions

In this paper, experimental results of the shrinkage testing of FRA concrete are presented and discussed. From the test results, the following conclusions are drawn:

- The use of FRA as partial replacement of natural fine aggregate influences the resultant properties of concrete.
- Concrete samples with FRA show a mild improvement of compressive strength with comparison of reference concrete.
- By the way of the contrast, the use of FRA in concrete negative influences the shrinkage of concrete.
- This influence depends on the amount of FRA in concrete.
- With the increase of the amount of FRA, the shrinkage of recycled aggregate concrete increases too.

However, FRA concrete has a big potential for the use in the manufacturing of building structures, but it is necessary to test durability and lifespan of FRA concrete.

Acknowledgement

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