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Foamed cement paste with micronized recycled concrete - measuring of compressive strength and thermal conductivity

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Abstract. This paper describes the possibility of using fine concrete recycled material to produce lightweight blocks. We focus on mechanical properties of foamed cement matrix. The samples contain 1: 1 cement and finely ground waste concrete. The matrix was lightened with various foam agents and subsequently compressive strength and thermal conductivity were measured. The results obtained from these samples were compared with reference samples.

Introduction

Waste materials from the construction industry have a negative impact on the environment. Some building materials can be partially or completely recycled and reused [1]. Old waste concrete could be recycled. First, it is sorted out and removed foreign materials (such as steel, bricks, wood, etc.) and subsequently milled into concrete recyclate [2]. Recycled concrete is commonly produced in many different fractions, large fractions are most commonly used as foundation under roads, but the fine fraction has almost no used. In previous researches, it has been shown that after grinding fine fractions with a high speed mill, the resulting product - micronized concrete can be used as a filler for cementitious composites [3].

One of the possibilities of using micronized recycled concrete is its application to lightweight blocks intended for peripheral masonry. This application is suitable, for example, for the Middle East, where there are many damaged or destroyed buildings due to frequent war conflicts. Concrete debris could be recycled and reused [4].

To achieve thermal insulation properties, it is advisable to lightweight the blocks. [5] Appropriate additives will be used to increase the strengths and obtain suitable properties for serial production. [6]

Materials and Samples

Six different foaming agents were selected for the tests. Two foaming agents for concrete, two industrial cleaners, fire-fighting foam and natural soap were selected. The foaming agent was selected in consultation with the manufacturers. In the case of building chemistry manufacturers, a foaming agent for cement composites was directly required. Mapeiair LP 800 from Mapei and Lightcrete-400 from Sika were used. Highly foaming and stable products were required at the industrial cleaner manufacturer. Based on experience, product 75-32 SUPER Universal Cleaner (Pink Cleaner) and 79-50 ULTRA Universal Cleaner (White Cleaner) from Metaflux were recommended. These products are intended as degreasing agents for industrial use. Foam used by firefighters was selected based on good results from previous works and natural soap from small-scale production was tested to compare results with conventional industrial products.

To determine the influence of foaming additives on the presence of the recycled concrete, test specimens containing only Portland cement CEM 42.5R (Radotin), micronized recycled concrete, water and foaming agent were produced. For comparison, test specimens with the same composition without micronized recycled concrete were produced too (Table 1). Sika Lightcrete - 400 (S), Mapei Mapeiair LP 800 (M) and Firefighters foam (H) were selected to produce test samples based on foaming and stability results.

Table 1: Composition of the samples

Set/Material	Cement [g]	Recyclate [g]	Foaming agent [ml]	Water [ml]	w/(c+r)
C	1500	0	0	480	0.32
CR	750	750	0.0	480	0.32
CS1.5	1500	0	1.5	480	0.32
CRS1.5	750	750	1.5	480	0.32
CS3	1500	0	3.0	480	0.32
CRS3	750	750	3.0	480	0.32
CM1.5	1500	0	1.5	480	0.32
CRM1.5	750	750	1.5	480	0.32
CM3	1500	0	3.0	480	0.32
CRM3	750	750	3.0	480	0.32
CH1.5	1500	0	1.5	480	0.32
CRH1.5	750	750	1.5	480	0.32
CH3	1500	0	3.0	480	0.32
CRH3	750	750	3.0	480	0.32

Experimental Methods and Results

Different types of foams were selected to produce concrete blocks. The most important properties of foams for a given application are stability and frothiness. Foam measurement was carried out in a graduated cylinder into which air is supplied by means of a compressor. The maximum amount of foam produced at a constant air flow rate was measured. Extruded polystyrene with a lead weight was placed on the foam surface at the beginning of the experiment to obtain flat level of foam to easy reading amount of foam. Moreover, the extruded polystyrene loaded the foam, which simulates the load from the cement matrix.

Stability measurements were made in the same measuring apparatus as the frothiness. In the graduated cylinder was produced 2000 ml of foam and then the time to reduce its amount to 1000 ml was measured.

The preliminary measurement showed insufficient foaming of the natural soap. Based on preliminary measurements, 3 different concentrations of foaming solutions were selected. The foaming solution was made up of 50 ml of water and 30, 60 or 120 μl of foaming agent. The measurement of each solution was repeated six times. The measurement results are shown in Fig. 1. With increasing amounts of foaming agent, frothiness increasing approximately linearly.

Foaming solution for stability measurement contained foaming agent and water in ratio 1:1. The measurement of each solution was repeated four times. The measurement results are shown in Fig. 2.

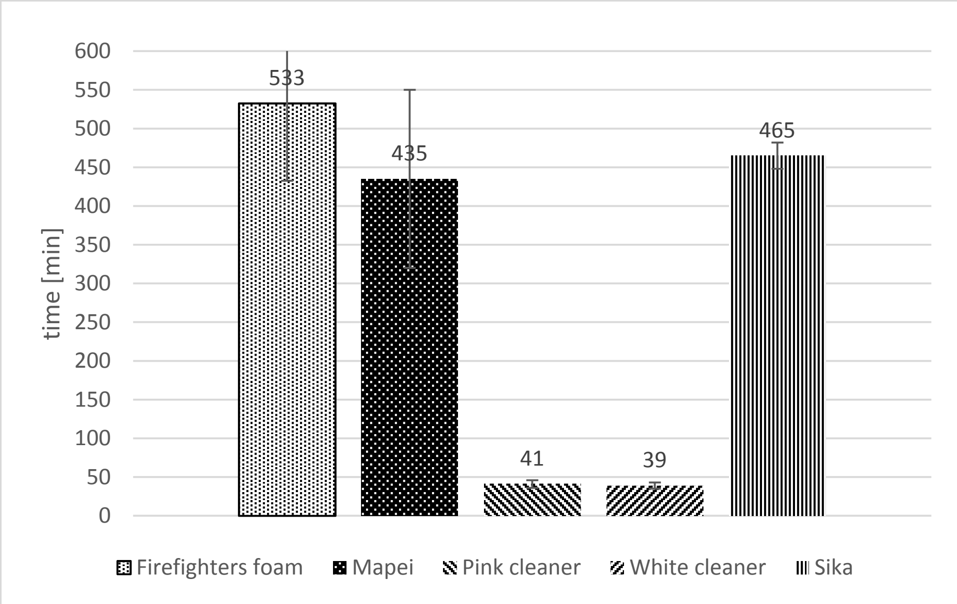

Figure 1: Stability results

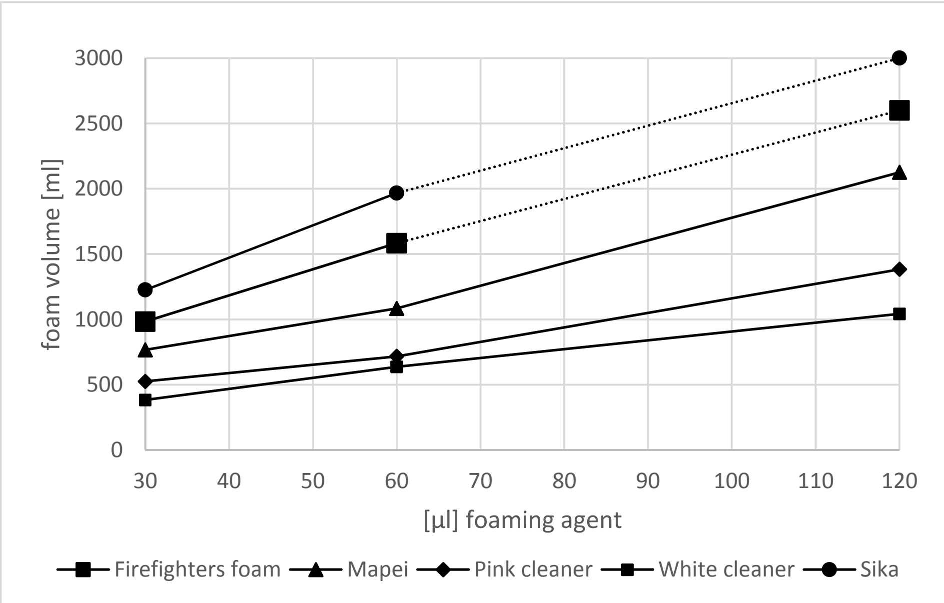

Figure 2: Frothiness results

There were made six sets of samples, each set contains three testing samples. The dimensions of the test samples were 40 x 40 x 160 mm. First, all the dry ingredients were mixed thoroughly at 132 rpm and then the mixing water was added together with the foaming agent and the mixture was stirred for 3 minutes at 421 rpm. Subsequently, all specimens were stored for 28 days under water in a laboratory environmental at 22 ± 1 °C. The specimens were halved during the bending test. The samples were subsequently stored for 28 days in a laboratory environment at 22 ± 1 ° C and a relative humidity of 50 ± 2%. The thermal conductivity coefficient λ was determined by ISOMET 2104 device of all 8 halves of the samples and then a compressive strength test was performed (Fig. 3).

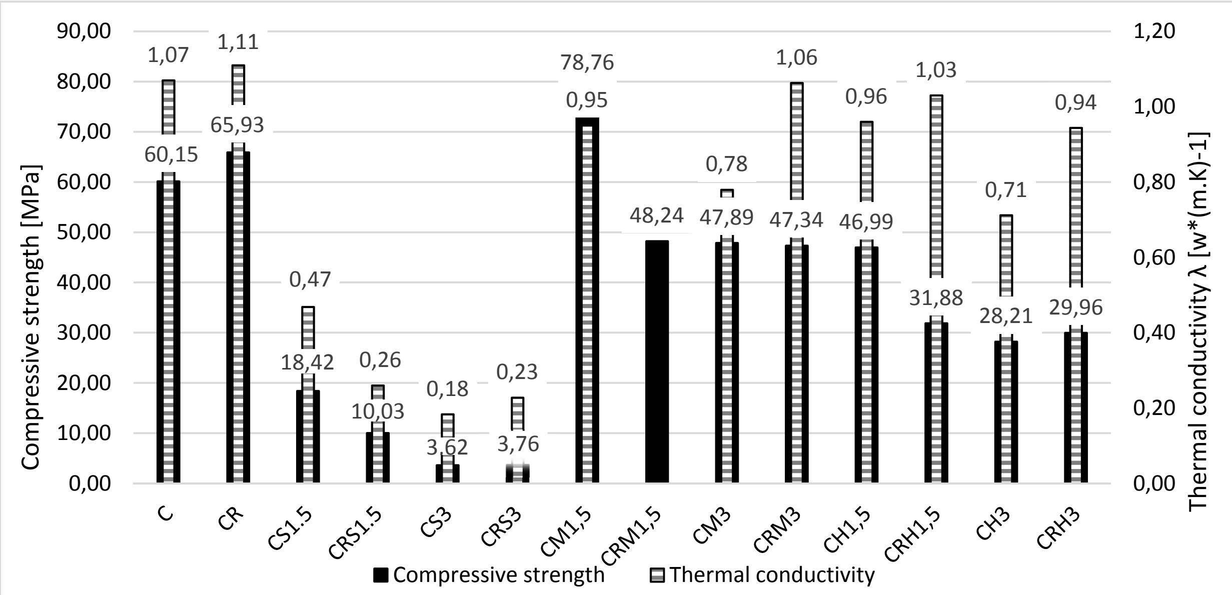

Figure 3: Compressive strength and thermal conductivity

Conclusions

The most suitable foaming agent for this application is SIKA Lightcrete 400, other foaming agents could achieve better results, for example, when using a foam generator. The most foamed samples achieve a sufficiently low thermal conductivity to utilize blocks in Middle East. The compressive strength is relatively high, but it is not yet sufficient for practical use. To produce blocks, it is planned to add suitable additives and dispersed fiber reinforcement to the mixture to provide sufficient compressive strength.

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