Key words:
concrete, cenospheres, compression strength, disintegrator

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EFFECTS OF CENOSPHERES ON DIFFERENT COMPOSITIONS OF CONCRETE

Cenospheres are light, waterproof alum-silicate spheres. The direction of the research is the cenospheres as component of various concrete 0%, 30%, 40%, 50% by volume. Depending on the properties of the desired cement type and mixing ingredients with water and superplasticizer - concrete properties are experimentally researched immediately or after 3 days. To determine how much the increase of surface adhesion area after grinding the particles of the cenospheres affects the resulting samples, grinding mill or disintegrator were used to grind the particles. The aim of the research is to obtain scientifically based data about the crushed cenospheres, depending on the time of mixing (right after the milling process or after 3 days of delay) for the impact on quality of concrete by different composition of cement – CEM II, Aalborg White and Gorkal 70. It is predictable that the cenosphere additive increases concrete porosity, reduce compressive strength and density. An optical microscope examines compressed samples that shows adhesion properties of spheres and concrete. These concrete materials can be used as a light-weight concrete material for thermal insulation as slabs or special walls.

INTRODUCTION

MATERIALS AND METHODS

Cenospheres are light, inert, waterproof alum-silicate spheres. Due to its low density, it is used in lightweight concrete as a bulk fill to increase porosity. [1]

Three types of cement were used as ingredients in the test mixture: CEM II A-LL 42.5 N, Aalborg White and Gorkal 70. They differ in price, strength and thermal resistance. Portland cement CEM II A-LL 42.5 N is widely known, easily available, and

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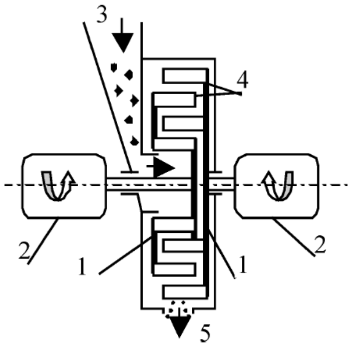
therefore relatively inexpensive. Aalborg White has very high strength, white cement. Refractory aluminum cement Gorkal 70 provides fire resistance up to 1700 °C.

Grinding mill or disintegrator DSL-175 (Tallinn University of Technology, Estonia) was used for grinding the mixture of cenospheres, sand and cement for maximum smooth shuffle [2-4]. Its principle of operation is shown in Figure 1 a, b, c. Two rotors with diameter 175 mm are rotating with the speed up to 12000 rpm. Disintegrator teeth crush the material particles to the size of micrometers.



b) Schematic representation of the disintegrator equipment: [2] 1 – rotors; 2 – electric drives; 3 – material supply; 4 – grinding elements; 5 – output

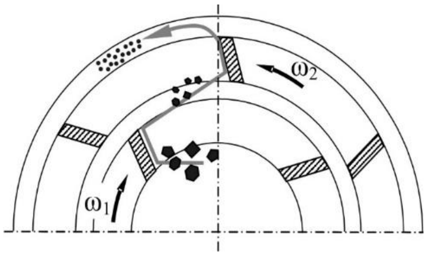


Fig.1 Disintegrator system DSL-175

a) Disintegrator system DSL-175 in lab of Tallinn Technology University, Estonia

c) Principal scheme of process of raw material milling (longitudinal section) [2], where ω_1, ω_2 – radial velocity of disintegrator wheels.

After the samples were kept in distilled water for 3 days, the sample weight and density were determined, as well as the number of pores according to the Archimedes method.

The microstructure of cracks' surface surfaces was examined by the optical microscope KAYENCE VH-Z500W - how cleaved and unshackled are the cenospheres, as well as visually evaluated pores in open spaces.

EXPERIMENTAL PART

Concrete with 3 types of cement CEM II A-LL 42.5 N, Aalborg White and Gorkal 70 composition were mixed. The next step was adding 30%, 40% and 50% additive to the mixture, mixed with cement and sand and milled in a disintegrator, then added to the water and superplasticizer SuperPlast Sikament 56 in two recipes - immediately and after 3 days of waiting – to find out if this waiting gives any reasonable results.

Hardened concrete samples first in bars 3x3x45 cm (see Fig. 2 a) and then cut into cubes of 3x3x3 cm (see Fig. 2 b) were pressed after 3, 7, 28 and 56 days under compression force with 2 types of compression machines Zwick Roell and Automax 5. The test speed of the samples was 0.5 mm/s. By measuring the sample dimensions compressive plane, stress values were obtained.

Fig.2 a) Sample lanes in molds, dimensions 30x30x450 mm

b) Specimens, dimensions 30x30x30 mm

RESULTS AND DISCUSSION

COMPRESION TESTS

As one of the scopes of the experiment, the compression stresses of hard concrete specimens after 3, 7, 28 and 56 days were obtained. As an example, the results of the refractory Gorkal 70 specimens (shown in Figures 3 and 4) are shown after 28 days for four different sample types of cenospheres. 5 sample cubes were pressed. As it is seen the upper curve of the G00 (with 0% cenosphere) has the highest strength - an average of 60.97 MPa. In the G03 samples, or 30% cenospheres, the compression resistance is reduced to an average of 27.14 MPa, G04 to 18.17 MPa and G05 to 10.58 MPa, respectively. Here it can be estimated the compressive test efficiency, most possible cenospheres are not applicable in the high-strength structures. Similar results are also for the 3-day settler material. The compression strength is decreasing, but for the specimens without cenospheres - G30 increases.

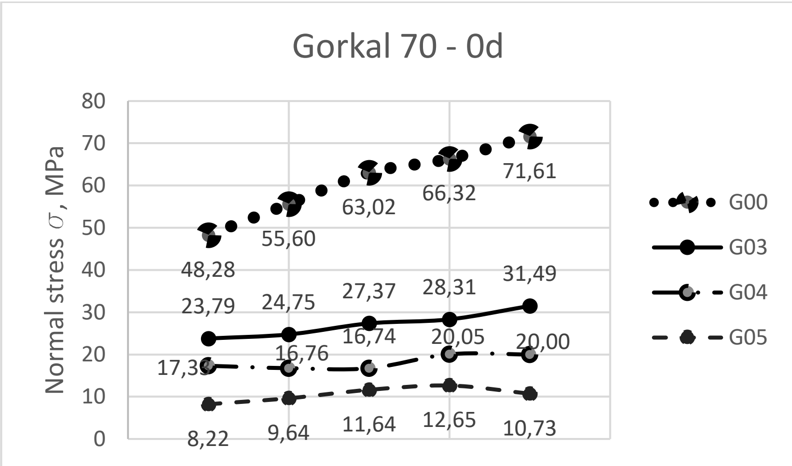


Fig. 3 Normal stress of Gorkal 70 samples after 28 days of hardening (they were mixed with water and superplasticizer immediately after grinding - 0d)

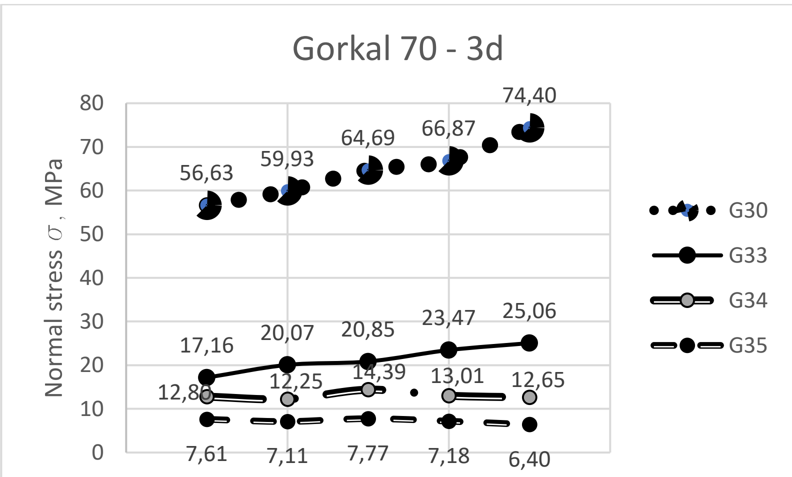


Fig. 4 Normal stress of Gorkal 70 samples after 28 days of hardening (they were mixed with water and superplasticizer 3 days after grinding - 3d)

OPTICAL MICROSCOPY

Visual inspection of broken surfaces with optical microscope displays the adhesion properties of cenosphere and concrete. After the observation, it is concluded that the adhesion is poor, because after the applied compression the forces in the material were not strong enough for the cenospheric particles to remain on the concrete, but they kept or tended to keep the shape of the sphere. Visually it is seen in Figure 5 – there are still spheres or spheres' imprints from the other side of the crack.

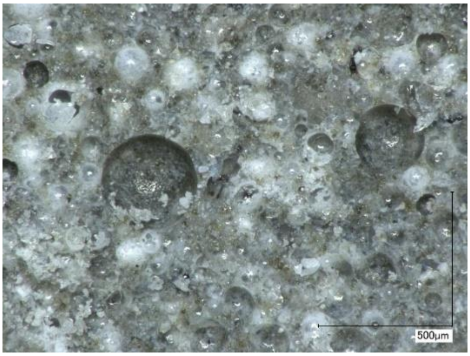


Fig.5 Surface research with the optical microscope. White spheres are cenospheres. Big dark spheres are pores. Small dark spheres are cenospheres' adhesion result with cement.

CONCLUSION

Engaging the disintegrator and waiting for 3 days without cenospheres increases the compressive strength of CEM II and Gorkal 70, while Aalborg White decreases.

For high-strength concrete like Aalborg White, it is not appropriate to use cenospheres because the more cenosphere, less normal stress.

If cenospheres are blended immediately instead of 3 days, the average compression strength is larger than 20%.

Waiting for 3 days increases the average stress on the cement by 3.7 MPa but samples with the cenospheres' participation are significantly reduced.

Inspection of the material's broken surface with an optical microscope showed low properties of the cenosphere and concrete adhesion.

These concrete materials can be used as a lightweight concrete material for thermal insulation as slabs or special walls where compression strength is not a priority.

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