UTILIZATION CERTYD TYPE AGGREGATEIN BUILDING CERAMICS

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1. Certyd type aggregate

In recent times, building and industrial waste has been a major problem in specially prepared landfills. Increasingly, they tend to process and recycle them in the production of new products. A number of research projects aim to create a waste treatment technology so that it can be reused. This article focuses specifically on the description of the technology of secondary aggregate production, whose properties are similar or better than those of natural aggregates. This is important not only because of the disposal of overburdened building or industrial waste, but also because of the drastically decreasing amount of natural aggregate deposits. One of the options for processing industrial waste is the innovative LSA technology that allows it to be recycled into secondary aggregates, which is not only safe and environmentally friendly but also economically and energy-efficient.

LSA's waste-free technology addresses the problems of industrial waste management as well as the production of secondary aggregates with very good physico-mechanical properties that can be used in construction, road construction or horticulture. This technology involves the proper preparation of the ash raw material in order to subject it to a sintering process in a special rotary kiln. Used in the production of aggregates, CERTYD type, the raw material consists mainly of ash from coal combustion, slag, ash and boiler dust. These are anthropogenic raw materials, which are characterized by low carbon content and, at the same time, very good physico-mechanical properties. They are stored in silos on the factory square. After dividing into several batches consisting of several tons of raw material, they are subjected to mechanical pre-treatment, granulation, exhaust gas drying and subsequent sintering at a temperature of 1000 to 1200°C. After these four stages the aggregate will be cooled by means of air streams, where it will then be stored in the square. Properly prepared granules are crushed and sieved, thus allowing aggregate in the form of regular grains or broken grains with appropriate 2/4, 4/8, 8/16 mm fractions, whose granular composition is shown in Table 1. The additional product resulting from CERTYD aggregate is heat produced in the amount of about 3 MW [6]. It is a totally waste-free, environmentally friendly and environmentally friendly process that is protected by multiple patents.

Table 1 Grain composition of CERTYD aggregates determined according toPN-EN 933-1

	2/4 mm	4/8 mm	8/16 mm
Size of the mesh sieve [mm]	**Number of grains passing through sieve [%]**		
32,5	-	-	100
22,4	-	-	100
16	-	100	100 - 90
11,2	-	100	60 - 35
8	100	100 - 90	15 - 0
6,3	100	-	-
4	100 – 90	15 - 0	5 - 0
3,15	95 – 90	-	-
2	-	5 - 0	-
0,063	15 - 0	-	5 – 0

Source: own study based on [1]

The CERTYD aggregate produced is characterized by high quality which, from the initial stage of raw material preparation to loading, is positively assessed by Factory Production Control and according to the applicable standards PN-EN 13055-1: Light aggregates for concrete, mortar,rare mortar and EN 13055 -2: Light aggregates for unbonded and hydraulically bound bituminous mixtures and surface fixations. In addition to the quality, the physical, mechanical and chemical properties of the produced product are also checked by the LSA building research and development laboratory. CERTYD is characterized by low bulk density and low absorbency, so that during thermal treatment it does not swell and is very well sintered. Its low bulk density allows the road to be used in poor roads, and in construction to relieve buildings and structures, as well as mortar or plaster. This allows for lower construction costs, including transport [1,2,3].

CERTYD aggregate is used in lightweight concrete, where the most important parameters are frost resistance, absorbability and resistance to crushing. These three parameters are fully met by the LSA aggregate. The frost resistance test yielded results of 1% and below, which qualifies the raw material for use in lightweight concrete, and the crush resistance test showed significantly higher results than in the case of the commonly used formulation in construction, achieving results in 10 MPa. In addition, the aggregate has a low coefficient of conductivity λ = 0.16 W / m · K. The table below shows the heat transfer coefficients for each aggregate available on the market [1,2].

Table 2 Heat conductivity coefficients for selected aggregates available on the market

Aggregate	Thermal conductivity [W/m·K]
Perlite	0,05
Keramzyt	0,10
CERTYD	0,16
Dusty sand	0,55
Gravel	0,90

Source: own study based on [1]

CERTYD aggregate, in addition to the above mentioned features, is also characterized by its lightness, porosity and resistance to fungi, rodents and insects, environmentally safe, reusable, non-decaying and non-flammable.

In addition to the physico-mechanical properties, its chemical properties are also checked. It is subjected to a study on the content of humidity, carbon and sulfur and the content of natural radioactive isotopes K-40, Ra-226 and Th-228. In addition, the chemical properties of the aggregates are tested according to PN-EN 13055-1. Total sulfur content and potential alkalinity potential which have a significant effect on the strength of the concretes. Multiple studies conducted on CERTYD aggregates have shown that the raw material meets the conditions imposed by the standard and that the results are significantly lower than the limits [1].

As already mentioned, CERTYD is widely used in construction, road building and horticulture. As an aggregate in the construction industry is used:

- for structural concretes, including lightweight concrete used in construction works, for the production of prefabricated concrete such as hollows for ventilation, chimney, wall, gas, palisades, foundation blocks and others,
- for filling and clamping materials, for heat-sensitive mortars as their own component, insulation on the ground and feet,
- for thermally insulating and molding roofs, for thermal insulation of basement and foundation walls and under floor coverings as acoustic and thermal insulation, industrial flooring on the ground,
- in geotechnics, to reduce the settlement of buildings or stabilize foundations, and others [1,2,3].

In road construction:

- for construction concrete, including light road applications, screens and other prefabricated acoustic guards,
- for substructure, to build embankments below freezing or frost when they are dry or insulated from water or are filled with stony and coarse soils, to frost-proof and draining,
- to prevent ground vibrations from road and rail communications, in road filtering and drainage layers,
- to protect against water erosion,eolian erosion and slope roads, to the French drain, replacing roadside ditches, and others [1,2,3].

In horticulture:

- for filtering and humecting layers under green and sports areas, as a drainage layer under arable land or a component for soil tillering, regulating water and air access,
- to substructure components with large surfaces of sports facilities, substrates, hydroponic crops, to protect plants growing in urban areas from water and air deficiencies, as an important substrate component for green roofing, and others [1,2,3].

It should be emphasized in particular that it meets all the requirements set by the standards and other technical documents in force in Poland. The most important advantages of aggregate are lightness, fire resistance, frost resistance and crush resistance. A number of these features allow for the complete replacement of natural aggregates with the CERTYD aggregate, and thus allows for the protection of natural resources, the reduction of industrial waste, and the recovery of land intended for the disposal of these wastes.

2. Building ceramics using CERTYD aggregate

The use of CERTYD aggregates in many areas of construction (such as structural concrete, prefabricated products and other products) is indicated in the previous section. However, its use in ceramics has not been studied. It is therefore reasonable to conduct a two-factor test to improve the properties of building ceramics by replacing the natural aggregate slimming material with CERTYD sintered aggregate. Of the many factors influencing physicochemical properties, two are significantly influenced by the differences in strength, absorbability and number of emerging cracks. The first one (A) is the fraction of added artificial aggregate. For the study, the aggregate fractions of 0 - 2 mm, 2 - 4 mm and 4 - 8 mm were used. The second factor (B) is the amount of CERTYD aggregate in relation to the amount of clay and aggregate. The content of 100, 300 and 500 kg / m3 was adopted. By observing the purpose of the study, a two-tiered plan was chosen, which is presented in Table 3.

Table 3 Plan for a full two-factor experiment

Serial number	**Code values**		**Actual values**	
	A	B	A	B
1	-1	-1	1	100
2	0	-1	3	100
3	1	-1	6	100
4	-1	0	1	300
5	0	0	3	300
6	1	0	6	300
7	-1	1	1	500
8	0	1	3	500
9	1	1	6	500
10	Control sample with quartz aggregate			

Source: own study

The study consisted of several stages. The first one was the calculation of the appropriate amount of each ingredient in relation to 1 m3 ceramic mix. A few minutes later the clay was mixed with the aggregate, which was placed in a mixer. After its start up, the dry ingredients were mixed for another 3 minutes, then water was gradually added. Water addition took 5 minutes, followed by stirring for another 20 minutes. The device used to mix the ceramic components is shown in Figure 1.

Figure 1. Mixer used to mix ingredients into a ceramic mass (Source: 4)

After the indicated time, the ceramic mass was pulled out and placed in foil bags for 24 hours. The finished mass was vented and placed in 4 cm in diameter and 2 cm in anti-adhesive molded mold release molds. The ceramic molded mass was subjected to densification in a device called balancing, as shown in Figure 2, and then deformed.

Figure 2. Balancing device used to compact the molded samples (Source: own study)

Finished samples, shown in Figure 3, were left in an air-dry condition for 24 hours and then placed in an oven at 105 ° C for 24 hours.

Figure 3: Molded ceramic samples (Source: 4)

Dried samples were pre-evaluated for the number of scratches and placed in the furnace shown in Figure 4.

Figure 4. Burn furnace for construction products (Source: 4)

The initial furnace temperature was 20 ° C and was raised by 2 ° C every 1 minute until the temperature reached 550 ° C, where the samples were kept for 120 minutes, then the temperature was raised again by 2 ° C for 1 minute until the furnace temperature was 950 ° C. 180 minutes. After this time, the stove was switched off and the samples were pulled out after the oven reached room temperature. Finished samples were tested for: compressive strength, absorbability, bulk density and freeze resistance.

Table 4 Test results of ceramic samples containing CERTYD aggregate

Sample	Compressive strength	Impregnability	Volumetric density	Frost resistance
Research 1 - amount of water 20%				
1	35,55	8,87	1,875	-
2	36,31	8,77	1,871	-
3	53,81	9,29	1,873	-
Research 2 - amount of water 20%				
1	21,89	9,36	1,638	About 12 cycles
2	23,89	9,28	1,760	
3	24,00	8,98	1,730	
4	23,80	9,25	1,656	
Research 3 - amount of water 20%				
1	42,60	9,21	1,902	About 12 cycles
2	40,80	9,27	1,921	
3	50,60	9,08	1,921	
4	42,60	9,20	1,918	
Research 4 - amount of water 18%				
1	43,00	9,11	1,921	About 12 cycles
2	27,87	9,19	1,921	
3	34,63	9,29	1,941	
4	39,81	9,24	1,931	

Source: own study

The best results were obtained with samples containing CERTYD aggregate of 0-2 mm in aggregate at 100 kg / m3 aggregate. The worst results were obtained in samples with aggregate of 1 - 4 mm in the amount of 500 kg / m 3 of aggregate. The samples with the aggregate fraction of 4 - 8 mm were omitted because of the large number of scratches after the drying step already in samples containing 1 - 4 mm fraction. In further investigations, the focus was on the execution of CERTYD aggregate samples of 0-2 mm in aggregate at 100 kg / m3 aggregate. The results of each study are summarized in Table 4. Compression strength was achieved within the range of 21.89 - 50.60 MPa, which shows the diversity, but at a high level. Good results were also obtained with absorbability of 8.77 - 9.36%. The weakest results were obtained with-frost resistance. Ceramic products should withstand 20 to 45 defrosting and freezing cycles [5,6,7,8]. CERTYD aggregate samples withstood about 12 cycles, significantly less than the required limits.

3. Conclusions

After the first study, according to the plan of the experiment, the results showed that the best physico-mechanical properties exhibit samples containing 100 kg / m3 of CERTYD aggregate. Samples containing 1 to 4 mm aggregates showed numerous cracks and cracking, and these defects increased in proportion to the amount of aggregate used. Consequently, the production of samples with larger fractions was excluded.

The best results for the compressive strength test showed samples of the first series, ie with CERTYD aggregate fraction of 0 - 2 mm in the amount of 100 kg / m3. These samples also showed better results in the study of absorbability. All conducted studies have shown that the increase in CERTYD aggregate and the fractional grading increase both the strength of the samples and the absorbability.

Taking into account the conclusions of the first study, in subsequent studies, focus was placed on the samples containing CERTYD aggregate fractions of 0-2 mm in the amount of 100 kg / m3. The results obtained in subsequent studies were characterized by divergent compressive strength results. This may be due to the fact that the aggregate used to make the ceramic samples had an irregular shape. The average absorbency was approximately 9.16%, which is typical for semi-glossy products, where water absorption is required to 12%.

The worst results were obtained when testing frost resistance. Samples that had undergone defrosting and freezing cycles withstood less than 12 cycles, followed by breakthroughs. This prompts you to try to use a spherical aggregate in subsequent tests to see if the shape of the aggregate affects the results obtained during the test. Thermal insulation tests of ceramic products containing CERTYD aggregate are also required.

REFERENCES

1.Features and application of CERTYD - lightweight artificial aggregate / M. Bardan-Aggregate Warehouse,2016 -№1/2016 - 58-62 p.

2.Certyd - new, lightweight, high strength sintered aggregate /K. Łuczaj, P. Urbańska- Builing Materials, 2015 - № 12/2015 - 42-45 p.

3.Lightweight CERTYD - a unique construction product / P. Olszak- Aggregate Warehouse, 2016 -№ 4/2016, 38-42 p.

4.Properties of ceramic products with Certyd-type aggregate / Ł. Kasianowicz - Master's thesis, 2017

5.Strength of Materials. Laboratory of ceramic research / J. Błaszczak [et al.]. -AGH Publishing House, 1996

6. Ceramic building materials. Methods of testing raw materials and products / E.Brylska [et al.].-AGH Publishing House, 2014

7.I'm building a house with pottery / J.Jadczak, R. Jarmontowicz - Central Building Information Center, 2000

8.Building Materials / E. Osiecka- Publishing House of the Warsaw University of Technology, 2003