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Porous Aggregate from Coal Mining Waste and Development Light Weight Concrete Based on It

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Abstract: *The article is devoted to determining the optimal composition of the charge for the production of artificial porous aggregate from coal mining waste and bentonite clays, which are considered local raw materials for the development of new generations of thermal insulation and ultra-lightweight and structurally strong concrete. When developing the optimal composition of the charge for the production of porous aggregates from mineral rocks and coal mining waste, a method was used that was used as the basic theory for the production of expanded clay.*

Calculated and proposed formulas for the optimal composition of the charge for the production of porous aggregates appropriate for both heat-insulating (porous, ultra-light) and structural (dense, heavier) categories, despite the fact that both types of aggregates were adopted in terms of true and bulk density on lightweight (porous) aggregates.

Keywords: *mineral rocks, industrial waste, secondary materials, porous aggregate, charge, carbonized clay, bentonite clay, glass phase, operational load, lightweight concrete.*

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Introduction

In Uzbekistan, almost only expanded clay gravel is produced from porous aggregates, the quality and volume of production of which cannot ensure the fulfillment of the plan for the industrial construction of civil and industrial facilities in the future, due to the limited reserves of clay for its production and low mechanical strength. Therefore, lightweight concretes based on artificial porous aggregates from local raw materials and industrial waste are of particular importance for construction, which makes it possible to significantly expand the raw material base and reduce the cost of their production.

Many regions of the republic have huge reserves of substandard raw materials: dune sands, loess-like loams, industrial waste, on the basis of which new types of artificial porous aggregates have been obtained - keramorite, camporite, carboporite, etc. [1.]

We found a way out of this situation in the possible production of porous aggregates on a production scale by replacing scarce clay raw materials (kaolinite, montmorillonite, mudstone clays) with wastes from the Angren coal deposit containing kaolinite clay and coal up to 30% (carbonized kaolinite clay). Local rocks - bentonite clays, as low-melting and widespread in the Navoi region, are used as the second component of the porous aggregate, which can dramatically reduce energy and resource costs [2].

The priority problems and tasks that need to be solved, first of all, include the development of methods for obtaining substances with a controlled fractal structure, which will make it possible to create materials with unusual mechanical properties, density, porosity, etc. [3].

Materials and methods

In the work, we used not only generally accepted methods of analysis, but also special ones. **X-ray diffraction analysis** was used to study the phase composition of aggregate samples subjected to heat treatment at different temperatures. This method was carried out on a URS-50 diffractometer with a Geiger counter and a BSV-3 X-ray tube. We used a tube with a copper anti-cathode - Cu and K radiation. The values of interplanar distances and the intensity of their line for each mineral were consistent with the reference data from the tabular data.

"The survey was carried out on a DRON-3 diffractometer with CoKα with filtered (Fe) radiation in the mode:I = 25-30mA, U = 30kV, Vdetect = 20 / min, Vdiff. tapes = 600mm / hour, measurement limit - 1x103 imp / s, τ = 0.5sec, slots: 1x4x1mm.The survey area is 2Θ = 2-750 for the initial samples.

A scanning electron microscope (SEM) is an electron microscope-class device designed to obtain an image of the surface of an object with a high (up to 0.4 nanometer) spatial resolution, as well as information on the composition, structure and some other properties of near-surface layers. 3nm (2nm) @ 30kV, SE, W (LaB6), 4.5 nm @ 30 kV, BSD (VP mode), 15 nm @ 30 kV, 1nA, LaB6,

Method. Study of topography and surface structure, image acquisition in secondary and backscattered electrons. X-ray microanalysis of elementalcomposition using energy dispersive and wave dispersive spectrometers (EDS,WDS). Electron Backscattered Diffraction Detector - Phase Composition and Texture Analysis (EBSD).

Analysis of the characteristics of bentonite clay

Bentonite clays got their name from the port of Benton, located in the state of Wyoming (USA), where the first commercial mining of them began at the end of the19th century. It is customary to call bentonite clays (bentonites) fine clays consisting of at least 60-70% of the minerals of the montmorillonite group, which have a high binding capacity, adsorption and catalytic activity. Mixed-layer minerals, hydromica, polygorskite, zeolites, kaolinite, etc. are found in bentonites as impurities.

Figure 1. General view of the rock – bentonite

On the territory of Uzbekistan, geologists have discovered more than 200 occurrences of bentonite and bentonite-like clays, the exploration reserves of which, according to preliminary data, amount to approximately more than 2 billion tons.

In this quarry, a quality management system has been developed and implemented in accordance with the International standard of the ISO 9001: 2000 series. In 2008, the QMS was assessed and certified as meeting the requirements of ISO 9001: 2000 by the international company SGS. In May 2011, the company received the International Certificate of the Swiss Institute for Quality Standards SIQS. The enterprise has a great customer satisfaction mail [4].

Table 2 Chemical composition (oxide) bentonite clays

Element	Line type	Conventional concentration	Ratio k	Wt.%	Sigma Wt.%	Reference name	Present reference
O	K series	5.97	0.02010	49.88	0.58	SiO2	Yes
Na	K series	0.25	0.00106	2.35	0.18	Albite	Yes
Mg	K series	0.16	0.00108	1.73	0.14	MgO	Yes
Al	K series	0.93	0.00666	8.77	0.23	Al2O3	Yes
Si	K series	2.67	0.02115	25.77	0.38	SiO2	Yes
Cl	K series	0.14	0.00120	1.34	0.11	NaCl	Yes
K	K series	0.26	0.00223	2.18	0.13	KBr	Yes
Ca	K series	0.27	0.00238	2.22	0.14	Wollastonite	Yes
Ti	K series	0.06	0.00055	0.54	0.12	Ti	Yes
Fe	K series	0.54	0.00544	5.21	0.27	Fe	Yes
Sum:				100.00			

When determining the chemical composition of bentonite clay with their specified weight ratios SiO_2 (75.19%) + Al_2O_3 (8.77%) + (Fe 5.21%) in this work spectrograms and tabular values of the chemical composition were obtained, similar to those presented in figure.

X-ray of bentonite clay

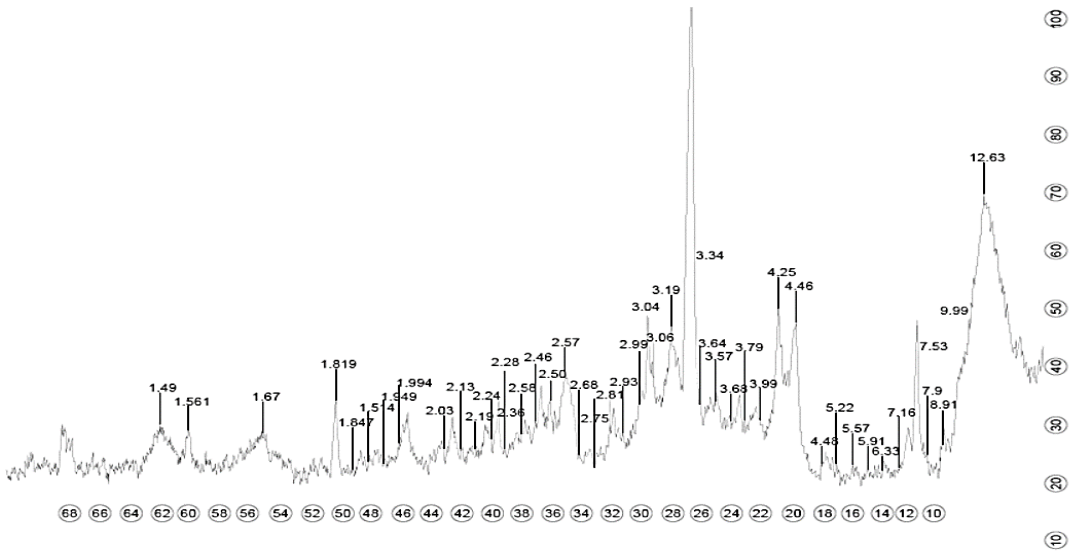

Figure 2. X-ray diffraction pattern of a bentonite sample from the Navbakhor deposit

X-ray phase study of samples of bentonite occurrences Navbahor observed lines refers to montmorillonite d = 0.446; 0.257; 0.246; 0.1496; 0.250; 0.278; 0.293; 0.275; 0.224; 0.1949 nm, quartz: d = 0.425; 0.334; 0.1994; 0.1819; 0.154.1 nm, palygorskite: d = 1.263 nm, bydelite: d =

0.1695; 0.228 nm, illite: d = 0.357 nm. There are also lines close to polygarskite clays d = 0.304; 0.228; 0.1517 nm. In addition, there are lines d = 0.324; 0.1670; referring to both illite and montmorillonite.

A similar line d = 0.1517 nm corresponds to quartz and polygarskite clays. It does this by overlaying some of the lines on top of each other. The results of the analysis of X-ray frames of bentonite correspond to those obtained earlier from the Navbakhar deposits [5].

Analysis of the characteristics of the Angren carbonized clay

The coal industry is among the industries with the greatest negative impact on the environment. The currently relevant technologies of coal mining and enrichment at various stages provide for the formation of solid wastes, which take out of use large areas of land and worsen the state of water resources. In addition, the coal industry incurs significant costs associated with waste disposal.

Figure 3. General view of coal mining waste - carbonized kaolinite clay

These areas of application of waste from coal mining and processing in construction work and in the production of materials provide for the possibility of using in the charge from 25% to 100%, depending on the chemical composition[6].

Table 3 Chemical composition (oxide) waste from coal mining

Element	Line type	Conventional concentration	Ratio k	Wt.%	Sigma Wt.%	Reference name	Preset reference
C	K series	0.10	0.00101	5.06	0.60	C Vit	Yes
O	K series	9.47	0.03185	54.81	0.47	SiO2	Yes
Al	K series	2.33	0.01672	15.06	0.19	Al2O3	Yes
Si	K series	3.19	0.02531	23.75	0.26	SiO2	Yes
Ca	K series	0.05	0.00049	0.34	0.05	Wollastonite	Yes
Ti	K series	0.08	0.00077	0.57	0.07	Ti	Yes
Fe	K series	0.06	0.00055	0.40	0.09	Fe	Yes
Sum:				100.00			

Analyzing the chemical composition given in Table 3it can be concluded that, in terms of the amount of silica, alumina and water (pp), the kaolin of the Angren deposit is close to the theoretical formula of kaolin - $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$.[7].

Spectral analysis was used to study Angren clay, which showed the presence of O-H bonds of hydroxyl groups with absorption waves of 3700-3670-3650-3630 cm-1, characteristic of kaolinite and Si-O bonds, characteristic of quartz sand in the region of absorption waves of 1800-800 cm $^{-1}$. The content of quartz monomineral on the IRS, confirmed the region of bonds Si-O 1800-800 cm^{-1}. Quartz porphyries contain OH bonds of hydroxides 3670-3600 cm-1. According to Fe-O bonds,

absorption lines 3000 cm-1, Ca-O - absorption lines in the region 1400-1200 cm-1 refer to carbonates.

X-ray diffraction pattern of Angren clay

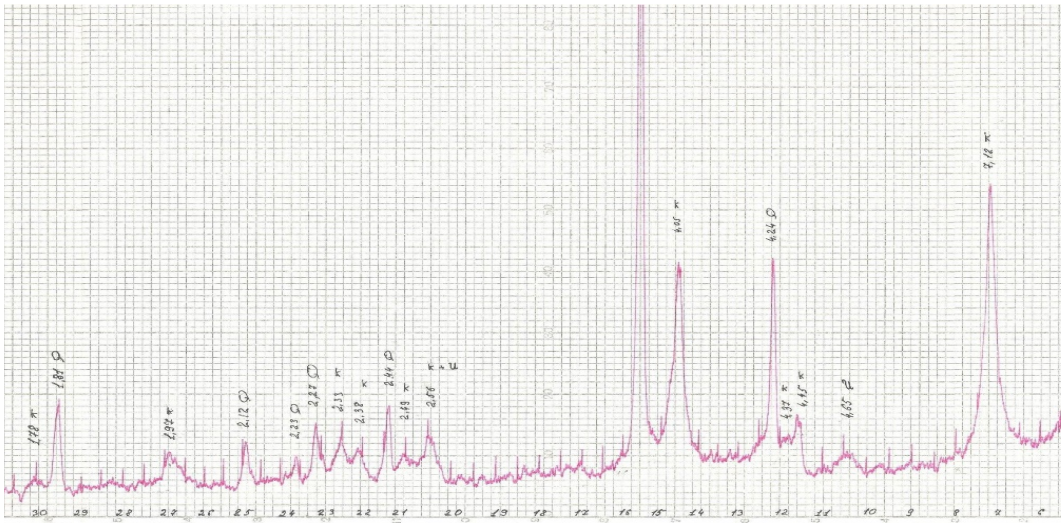

Figure 4. X-ray diffraction pattern of Angren clay

The X-ray diffraction pattern of Angren clay shows peaks characteristic of kaolinite with d = 0.459; 0.355; 0.253; 0.233; 0.150; 0.178; 0.148; 0.145; 0.128; 0.125; 0.123; 0.119 nm. The lines d = 0.424 were determined; 0.336; 0.245; 0.183; 0.166; 0.153; 0.138 nm related to quartz. Peaks 0.302 are noticeable; 0.227; 0.203; 0.199; 0.192 nm for carbonates

Literature Review. Due to the lack of raw materials for the production of expanded clay and aggloporite inUzbekistan, there is an urgent problem of obtaining other types of porous aggregates - keramporite, camporite, quartzite, glass porous and carboporite, obtained on the basis of local raw materials and industrial waste at the Tashkent Polytechnic Institute (now TIACE) under the leadership of L.M. Botvina.

In the works of Botvina L.M. and Bilyalova KB to obtain porous fillers, the raw materials for production were dacite porphyries, loess rocks, dune sands, waste from sawing dolomite rocks and glass industry waste. The granules were molded using plasticizers and pore-forming agents. New types of lightweight aggregates were sintered in a rotary kiln. [8,9,10]. However, due to the complexity of the composition of the charge, such a porous filler is not produced.

Results. In the Republic of Uzbekistan, expanded clay gravel is produced for the needs of construction. These include large unused reserves of bentonite clays and carbonized clay of the Angren coal deposit, the annual dumps of which amount to 4-4.5 million tons.Heat treatment of aggregate granules was carried out within the range of 1000-1100 ° C, determined in the course of preliminary studies.

The firing time was 30 minutes. The porous aggregate test was performed using standard methods. [GOST 9758-2012, Group Zh19, INTERSTATE STANDARD, POROUS INORGANIC FILLERS FOR CONSTRUCTION WORKS[11]].

Analysis of the literature data and the results of preliminary studies showed that the average density and compressive strength of the porous aggregate are most influenced by such technological parameters as the temperature of preliminary drying of granules, the temperature and duration of their thermal region [12].

For the preparation of porous aggregates, the following optimal parameter values were set:

- temperature of preliminary drying - 100°C;
- temperature of heat treatment of granules - 1100°C;
- the duration of the heat treatment of the granules - 30 minutes.

The obtained porous aggregate in its properties meets the standard requirements for expanded clay.

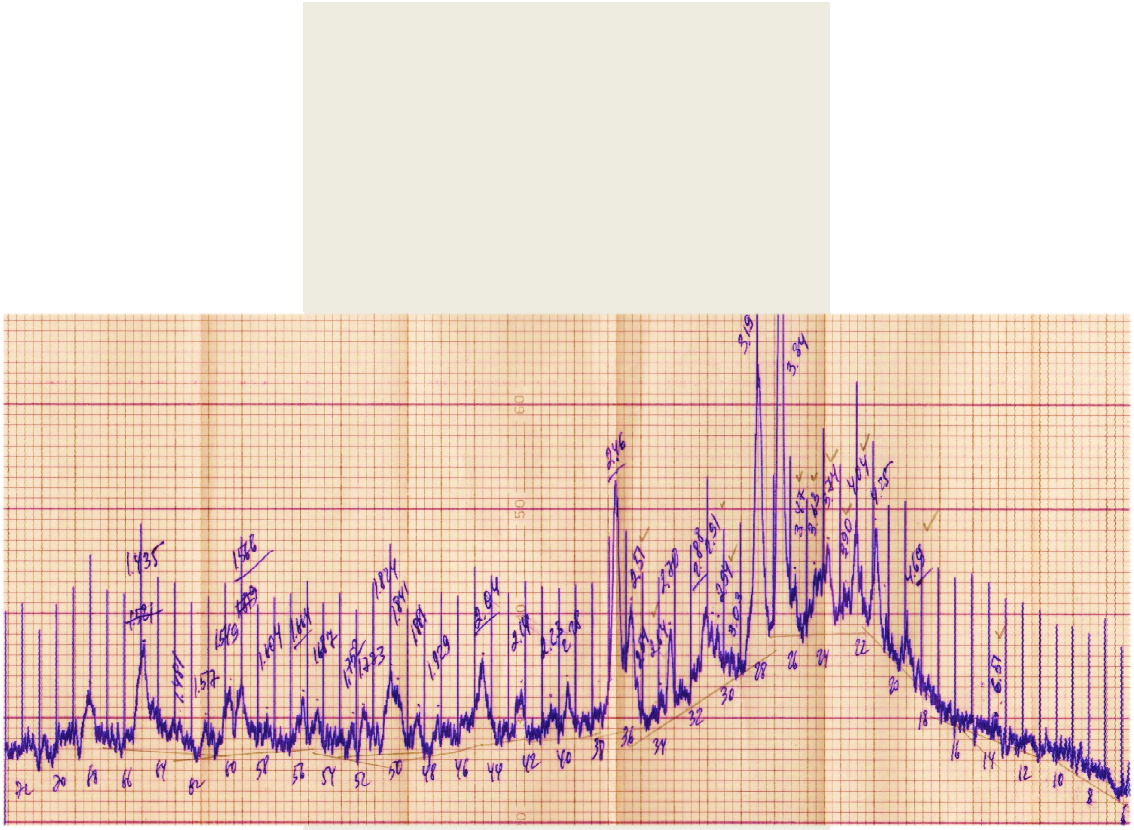

Figure 5 X-ray diffraction pattern of a porous gravel-like aggregate, fired at 1100 ° C and holding for 30 minutes

At a temperature of 950°C, the X-ray diffraction patterns of the studied compositions also show the appearance of hematite (d/n=0.228; 0.270; 0.374 nm, Fig. 5).With an increase in the firing temperature to 1000°C, cristobalite lines appear on the X-ray diffraction patterns of samples of compositions 1.2 (d/n = 0.192.9; 0.404 nm).The phase composition was determined by X-ray diffraction analysis of the finished product for a complete representation of the physical and mechanical properties of the porous aggregate fired at a temperature of 1100 ° C. As can be seen from Fig. 12, the reflections are d = 0.425; 0.334; 0.246; 0.223 nm, characteristic of quartz. In addition to the lines of - quartz and newly formed mullite, diffraction lines of the polymorphic form

of silica - β cristobalite with d / n are found. β = 4.04; 2.88; 2.51; 2.14; 1.57; and etc.[12].Differences in the structures of expanded clay and granules from bentonite clays can be explained by the peculiarity of their pore formation. Bentonite clay granules acquire porosity due to the combustion of coal and organic matter.

Conclusions. The possibility of obtaining a porous filler from bentonite clay and carbonized kaolinite clay of the Angren coal deposit has been determined. The composition of the charge for the aggregate has been optimized. The best physical and mechanical properties of the aggregate are provided when the content of bentonite clay (90%), carbonized kaolinite clay (10%) and the moisture content of the charge is 30%.

The technological regime (firing) of obtaining a porous aggregate has been optimized. It is shown that the regulatory requirements are achieved by preliminary drying of granules at a temperature of 100 ° C, firing at 1100 ° C and holding in a furnace for 30 minutes.

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