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New energy-efficient materials for construction

Abstract. *Today in the world there is a huge amount of energy-efficient materials and goods, that help solve energy saving issues in the operation of various buildings and structures, such as interior and external load-bearing and enclosing construction of buildings.*
Hevertheless, these materials may not always possess the necessary mechanical and physical qualities, nor high strength, to be used in major building's load-bearing sections. Strengthening, decreasing heat conductivity, enhancing weather and moisture resistance, and cutting costs are all critical responsibilities in the development of energy-efficient structures and goods.
As a result of comprehensive research, the authors have developed new cellular concretes with high strength characteristics, low thermal conductivity and low cost based on local raw materials and waste. This approach leads to a significant reduction in energy and resource consumption and promotes the introduction of environmentally friendly production methods while maintaining high product quality standards.
Experiments were conducted in a specially designed laboratory chamber. This installation ensured uniform temperature control inside the chamber, as well as uniform temperature distribution throughout the entire thickness of the products. This was achieved through a rational combination of energy sources used.
The article presents the outcomes of investigations into the mechanical and physical characteristics of foam concrete and the structural features of the material. The manufacturing of superior goods became possible thanks to a combination of mild heat treatment conditions and the exothermic properties of cement. In addition, the impact of additional electrical energy at a minimum consumption (10-20 kWh/m^3) on the hardening process of foam concrete is characterized by a periodic and short-term effect. In contrast, traditional heat treatment methods require significantly higher energy consumption - from 80 to 100 kWh/m^3.
The results of X-ray and electron microscopy studies confirmed that the developed energy-efficient materials have high physical and mechanical properties and low cost.
Keywords: *Concrete, Heat Transfer, Thermal Insulation, Porosity, Temperature, Hardening, Heating, Thermal Conductivity, Air Conditioning, Energy Conservation*

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Introduction

The search for new energy sources ranks among the most pressing global challenges today. Traditional energy sources, such as oil and gas, are considered indispensable. However, the simplest and cheapest source of energy nowadays is solar energy. Numerous studies are now being conducted within the Kazakhstani Republic to examine different strategies for utilizing solar energy in the heat treatment procedures of concrete product and structure production facilities. For the first time, the authors applied a new method of bilateral use of solar and electric energy for foam concrete products.

The traditional foam concrete manufacturing technology involves energy-consuming heat treatment in autoclaves or steaming chambers utilizing conventional energy sources. The innovative technique makes use of both electrical and solar power.

When there is a high number of bright, warm days throughout the year, along with favorable solar radiation and weather, it is possible to use existing solar technology for the manufacturing of foam concrete. For instance, the long, hot summers in Kazakhstan's southern areas are distinguished by consistently high outdoor temperatures of over 35 °C and low humidity levels of less than 28%. The current climate and weather conditions are perfect for installing solar fields, which will be utilized to make foam concrete products. Additionally, the data indicates that, in addition to Kazakhstan, the southern regions of the Russian Federation and a number of Central Asian republics, including Uzbekistan, Tajikistan, Turkmenistan, and Kyrgyzstan, also have good weather during warm and hot seasons for the field production of foam concrete products using solar technology. Therefore, there is great potential for replacing conventional energy sources with solar radiation in the vast geographic areas where weather and climate conditions allow the manufacture of foam concrete using solar energy. [1].

The literature review reveals that the entirety of known research and development endeavors within the construction industry related to solar technology have predominantly focused regarding the standard concrete's heat treatment [2,3,4,5,6,7,8,9]. There hasn't been any thorough investigation on the utilization of solar energy to produce foam concrete, which is a very successful building material.

Foam concrete differs greatly from traditional concrete in a number of areas, such as production process, composition of raw materials, rheological qualities, porous structure, and other essential features [8,9]. As a result, the approved helio-thermal treatment techniques that were created for conventional concrete cannot be used in the manufacturing process of foam concrete.

When creating structures and goods made of foam concrete, the utilization of thermal energy to expedite the hardening process is essential, leading to a notable increase in energy consumption during manufacturing.

As a result, an increasing number of foam concrete manufacturers are gradually reducing their reliance on heat treatment. However, in order to meet the requirements for properties of constructions and manufactured goods, without resorting to heat treatment, manufacturers are forced to resort to higher consumption of binders, employ superior grades of cement, and incorporate specialized additives that accelerate the hardening process. In addition, the prolonged curing time required for concrete to harden within metal forms necessitates the allocation of substantial areas for the hardening of products and structures.

Previously, the authors had exclusively applied two-way heat treatment to conventional concrete, yielding positive outcomes. Nevertheless, a novel approach has been introduced for the first time, which involves dual-sided heat treatment by combining the utilization of both solar and electric energy, precisely customized to foam concrete products.

According to [10], "with a two-way supply of heat to the hardening concrete, the greatest uniformity of moisture distribution is observed and thus, as a result, a uniform distribution of strength is achieved". Based on this, it is advised to carefully combine extra electrical energy with solar energy in order to improve the foam concrete products' ability to solidify in fields and to provide uniform product heating while reducing temperature gradients. This supplementary electrical energy may exert a periodic and short-term influence on the concrete hardening process.

Based on the aforementioned, as a result of comprehensive research, the authors have developed a novel method for accelerating the hardening of foam concrete, which enables the application of the solar heating of products under soft conditions coupled with the use of traditional energy sources, specifically electricity. This approach enables a substantial reduction in energy costs for expediting the hardening, and facilitates the organization of environmentally friendly production while maintaining the high quality of products.

The objective of the paper was to develop a method and technology for the production of foam concrete products at landfills situated in regions by dry and hot climates. This was accomplished by leveraging solar radiation, with natural intensity, to expedite the hardening process, along with incorporating an additional electrical energy source, based on research and the generalization of existing knowledge.

To achieve this goal, the following tasks were addressed: establishing the correlation between the strength characteristics of foam concrete products and the length of time that solar radiation is exposed to during solar thermal treatment; investigating the connection between the amount of solar energy that enters the system and the type of temperature field development that occurs in solar-heated goods with varying thicknesses and surface areas; investigating the structural characteristics and physical-mechanical attributes of aerated concretes that have been heated by the sun.

Finally, it can be concluded that the all-encompassing method of using additional electrical energy in conjunction with heat treatment and solar radiation to quickly harden foam concrete products inside metal forms with helio-coating lids is a novel way to accelerate the process. This technology combines the natural exothermic capabilities of cement with moderate heat treatment techniques to enable the fabrication of high-quality products. Additionally, the effects of using more electrical energy at the lowest possible energy consumption (8–18 kWh/m3), Concrete shows a periodic and transient nature on the hardening foam. However, the amount of electrical energy required for heat treatment using traditional methods is significantly higher, ranging from 75 to 100 kWh/m3.

The results of X-ray and electron microscopic studies confirm that a favorable humid environment for hardening and a mild temperature regime for thermal solar treatment of goods contribute to the formation of a high-quality structure and increased the mechanical and physical characteristics of foam concrete.

Research methods

Experimental studies were conducted in the summer weather conditions in Kyzylorda, the Republic of Kazakhstan. These experiments focused on factory compositions of foam concrete wall products D700 (B2) that meet the requirements of GOST 25485 (State standard) “Cellular concrete. Technical conditions”. The composition utilized included cement from the Dzhambulsky plant PC400-D20, quartz sand with size of M_{size}=1.2 (fraction of sand) and the LASTON foaming agent (made in Italy).

Fig.1 The laboratory apparatus utilized for the studies is depicted in 1; it has an electric heating element at the mold’s base and a cover with helio coating. A sensible mix of solar, exothermic, and electric energy produces both homogeneous temperature fields across the thickness of the products and stable temperature conditions inside the chamber.

Fig.1 Apparatus for the laboratory with an electric mold heater and heliocoat

The bottom of metal forms undergoes cyclical electric heating based on the temperature specified by the thermal sensor; this means that the heating effect on the concrete hardening process is short-term and periodic.

Upon filling with a foam concrete mixture, cassette forms are immediately placed in a thermal chamber and kept at a temperature of 28-36°C for three to four hours. The lid of the chamber is hermetically sealed with helio-coating material.

When the concrete achieves 360–590 gr/cm^2, which is the plastic strength value needed for heat treatment, the forms containing the goods are moved into an open solar field. The heating of products in solar forms should start no later than 10 a.m. in order to guarantee a full production cycle and sensible use of solar energy during the day. In addition, the helio-chamber's temperature rises at a rate of 7-8°C per hour for five to six hours. This is followed by isothermal heating for three to four hours at a temperature of 61 to 65°C. The foam concrete products are then progressively cooled in the evening and at night until they are 32±5°C in temperature.

The newly created technology yielded data that showed that foam concrete products acquired a strength of 45 to 55% of their predetermined strength during the 20–22 hour solar thermal treatment, depending on the bulk density.

Using samples of comparable composition and age that underwent varying techniques and hardening circumstances, an analysis of the mechanical and physical characteristics of foam concrete was conducted [11,12,13].

The kinetics of foam concrete heating during solar thermal treatment were studied using a 4-channel temperature control device called "Thermodat-17M5".

Based on the aforementioned findings, to cut down on energy consumption for heat treatment and justify environmentally friendly production process, a novel method for accelerating the hardening of foam concrete has been developed. This new method ensures that solar heating of products is completed by combining a conventional energy source—electricity—with soft modes.

It is possible to produce foam concrete products with solar energy to speed up the hardening process when the weather and solar radiation are right. The year-round availability of bright, warm days characterizes these settings. For instance, the southern parts of Kazakhstan have a long, hot summer with constant outdoor temperatures between 33 and 43 degrees Celsius and more than 6 kWh/m2 of solar radiation. Such meteorological and climatic circumstances offer a strong basis for setting up solar fields for the manufacturing of foam concrete goods.

Based on data from [14,15,16], in addition to Kazakhstan, other regions with favorable climates for field production of foam concrete products using solar technology during the warm and hot seasons include the southern regions of the Russian Federation and some Central Asian republics, including Uzbekistan, Tajikistan, Turkmenistan, and Kyrgyzstan. Considering the large number of places with ideal weather and climate, using solar energy in foam concrete production as an alternative to traditional energy sources, holds promising potential.

Results and Discussion

The heating dynamics of foam concrete products with dimensions 200x200x400 cm in accordance with the ambient temperature can be seen in Fig. 2. Analysis of the graph showed that heating occurred smoothly and gently until the maximum temperature in the concrete was reached at 60-65 degrees and the holding lasted up to 10 hours.

Subsequently, there was a period of conditional isothermal exposure lasting 3-4 hours. Following this, during the evening and nighttime hours, there was a gradual decrease in temperature, decreasing at a rate of 4-5°C per hour until it reached 33-35°C [17].

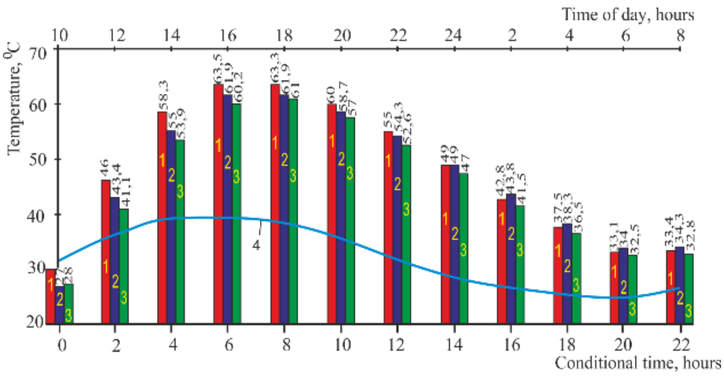


Fig.2 The process of heating blocks at natural air temperature: temperature change by 18-22 mm in the upper parts of the product (1); temperature changes by 90-110 mm in the upper parts of the product (2); temperature changes of 170-190 mm in product covers (3); air temperature (4)

It should be noted that when measuring temperature gradients in building blocks, the maximum jump was 65 degrees. However, temperature changes in the central and lower parts of the products were slightly lower than 63 and 59 degrees. The process of temperature changes occurs smoothly with a temperature difference of 4-6 degrees. Thus, in the morning, while the temperature on the concrete product's surface ranged from 32-33°C, its centre maintained a temperature of 34-35°C. This is primarily due to the low thermal conductivity of foam concrete, which in the retention of heat for an extended duration.

The results of the experiment demonstrate that this **hardening of building products when exposed to solar radiation subsequently has a great positive effect on their structure and basic technical properties.**

The dynamics of growth in compressive strength of foam concrete according to hardening conditions is shown in Table 1 and Fig. 3. Maturity level of the foam concrete subjected to solar and heat treatment (3) is 1023 degrees/hour, with achieved strength value of 1.6 MPa in one day, i.e., 55% of the grade (B2). Furthermore, after 28 days of hardening, the strength of concrete (3) significantly superior than the strength of samples that hardened at 21 degrees (1) by approximately 51%. The remaining strength of the concrete of normal hardening (1) is attained within 6 months.

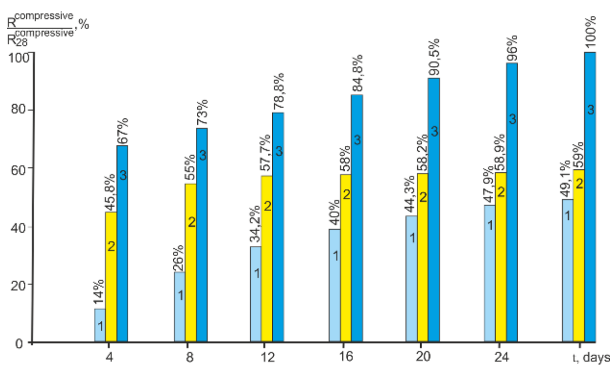


Fig.3 The graph of the change in time of foam concrete compressive strength, depending on the hardening conditions. 1 - normal hardening; 2 - aging foam without a care in natural conditions; 3 – new thermal method with the use of a solar cover with electric form heating

New energy-efficient materials for construction of excellent quality have been obtained. The authors have developed a new energy-efficient method for producing high-quality building products. New achievements allows production of high-quality products by capitalizing on the soft heat treatment modes and exothermic properties of cement. In addition, the influence of the minimal consumption of additional electrical energy (10-20 kWh/m^3) on foam concrete hardening is periodic and of short duration. In contrast, the traditional methods of heat treatment often require electrical energy consumption up to 80-100 kWh/m^3 [18].

Structural features of foam concrete hardened under different conditions were investigated. **X-ray diffraction studies of materials were carried out using a diffractometer X-PertPRO. Phase analysis using the powder method was used in preparing the experiments [4].** Tables 2,3,4,5 and Figure 4, and 5,6,7 show the results of X-ray examination of foam concrete samples with similar compositions but solidified under different conditions.

Foam concrete is represented by three samples: complex solar thermal treatment (1), heat treatment in a steaming chamber (2), normal hardening (3).

Table 1. Change in time of compressive strength of D700, B2 foam concrete depending on hardening conditions

Concrete Care Method	Concrete compressive strength ($\frac{MPa}{\%}$) in age, days.				
	1	3	7	14	28
Normal hardening	$\frac{0.09}{3}$	$\frac{0.29}{10}$	$\frac{0.67}{23}$	$\frac{1.09}{37.5}$	$\frac{1.43}{49.5}$
Maintaining foam concrete without care in natural conditions	$\frac{0.65}{22.5}$	$\frac{1.17}{40.3}$	$\frac{1.54}{53}$	$\frac{1.67}{57.5}$	$\frac{1.71}{59}$
Solar thermal treatment using a solar cover and a heated mold bottom	$\frac{1.60}{55}$	$\frac{1.89}{65}$	$\frac{2.09}{72}$	$\frac{2.38}{82}$	$\frac{2.91}{100.5}$

Table 2. Apparatus and methods

Number of identified phase	ID card number	Description of the phase by chemical formula	Isolated phase, in%
1	01-086-0402	Ca_3SiO_5	26
2	01-089-6427	$Na(AlSi_3O_8)$	28
3	01-083-0539	SiO_2	46

Table 3. Results of semi-quantitative phase analysis of a foam concrete sample subjected to complex solar thermal treatment

Number of identified phase	ID card number	Description of the phase by chemical formula	Isolated phase, in%
1	01-087-2096	SiO_2	57
2	01-086-2339	$Ca(CO_3)$	18
3	01-088-2111	AlO(OH)	2
4	00-030-0665	Fe_2SiS_4	24

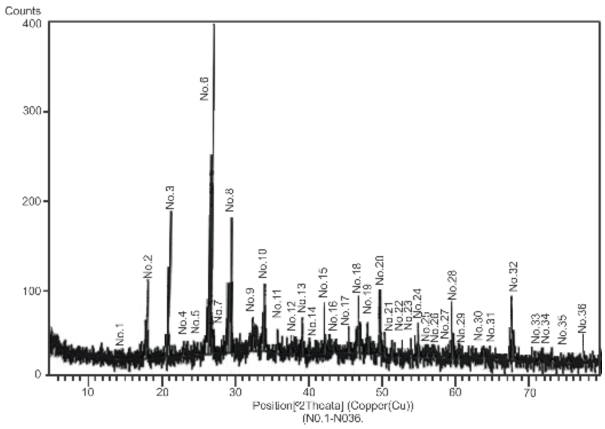


Figure 4. X-ray diffraction pattern of a foam concrete sample subjected to complex solar thermal treatment

Table 4. Table 4. Phase analysis of foam concrete samples from heat treatment in a steam chamber

Number of identified phase	ID card number	Description of the phase by chemical formula	Isolated phase, in%
1	01-085-0794	SiO_2	44
2	01-086-2339	Ca(CO)	21
3	01-074-1684	Mg_2SiO_4	16
4	01-089-1304	$(Mg_{0.03}Ca_{0.97})(CO_3)$	18

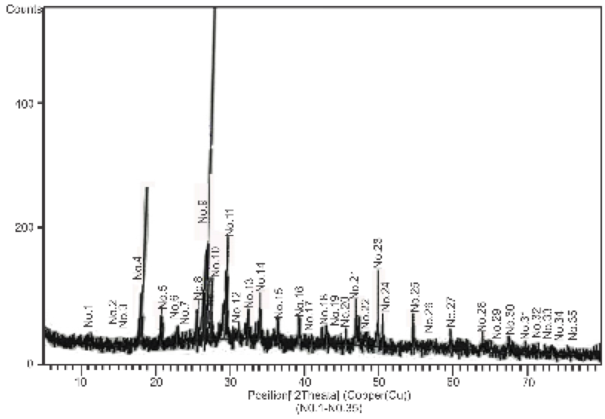


Figure 5. X-ray diffraction pattern of a foam concrete sample subjected to heat treatment in a steaming chamber

Table 5. **Phase analysis of foam concrete samples from** normal hardening

Number of identified phase	ID card number	Description of the phase by chemical formula	Isolated phase, in%
1	01-085-0795	SiO_2	17
2	01-073-0599	$Ca_3(SiO_4)O$	23
3	01-070-1433	$MgCO_3(H_2O)_3$	12
4	01-083-1612	$Na(AlSi_3O_8)$	32
5	01-086-0402	Ca_3SiO_5	21

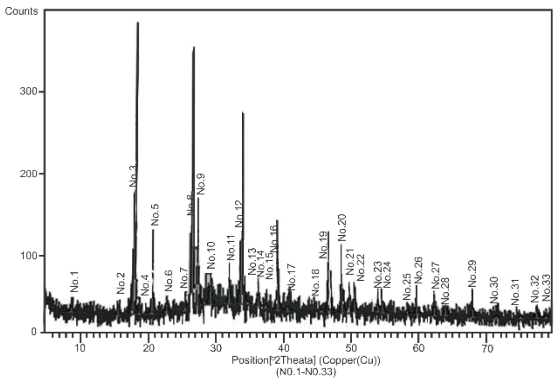


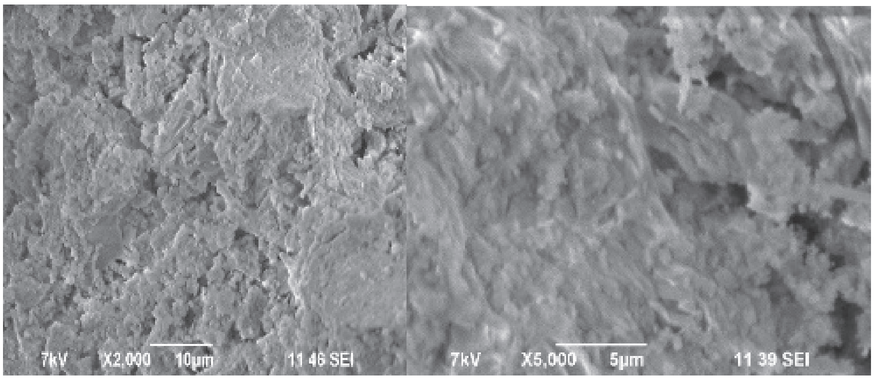
Figure 6. X-ray diffraction pattern of a sample of foam concrete of normal hardening.

Upon analyzing the data of X-ray phase analysis, it can be noted, first of all, the percentage of silicon dioxide for each of the hardening methods 1, 2 and 3. For 1 it is SiO_2 = 57%, for 2 it is SiO_2 = 44%, for 3 it is SiO_2 = 16%. These percentages may indicate one of the characteristics regarding the depth of interaction between the cement slurry and the filler sand for each of the three samples. **From these observations, one can infer that there is a deeper interaction of SiO_2 with the solution during normal hardening, followed by decreasing orders of interaction.**

It is important to note that in sample 1 the percentage of calcites $Ca(CO_3)$ is 18%, while in sample 2, it is 21% and a compound denoted as (Mg0.03 Ca0.97) (CO_3) is 18%. In contrast, in foam concrete subjected to normal hardening, crystalline state $MgCO_3$ $(H_2O)_3$ is detected at 11%.

The presence of magnesium silicate (Mg_2SiO_4 = 16%) characterizes of foam concrete hardened in the steaming chamber and under normal conditions, and for foam concrete hardened in the solar chamber – calcium silicates $Ca_3(SiO_4)O$ at 22%, Ca_3SiO_5 at 20% and sodium aluminosilicate $Na(AlSi_3O_8)$ at 20% are noted. These results align with existing knowledge about phase formation processes during concrete hardening under various thermal conditions. The impact of the protein foaming agent and superplasticizer does not affect the phase-mineralogical crystalline composition. It is more likely that organic compounds form amorphous composites, which are not visible in the diffraction patterns of X-ray diffraction patterns.

Electron-microscopic studies were conducted on a JEOL JSM-6490 LA scanning electron microscope-microanalyzer. **Preparations were made according to the standard procedure. The voltage at the anode was 7 kV**. Over 100 areas were examined, with the most typical ones selected. **Direct inspection of the surface allowed us to see microstructure of the material using scanning electron microscopy at magnifications from x2000 to 5000 times** (Figure 7).



a) b)

Figure 7. Morphology of foam concrete samples subjected to complex solar thermal treatment: a) x2000; b) x5000

The morphology of the examined foam concrete samples reveals dendrite-like aggregates of flat sintered particles. It is evident that these structures are compositionally homogeneous, especially in the basal directions.

Differences in phase-mineralogical composition depend on the method and conditions of hardening. The soft process of normal hardening broadens the spectrum of phases, while the more rigorous process reduces their number.

Thus, the results of X-ray and electron microscopic studies confirm that a favorable humidity environment for hardening and a mild temperature regime contribute to the production of energy-efficient concrete.

Conclusions

Thus, to control production, a system for operational control of the parameters of new energy-efficient materials was developed. The developed system includes strength growth graphs, temperature control during the melting process and non-destructive testing upon completion of the process of obtaining new materials.

The operation of solar sites in Central Asia for the production of new energy-efficient materials lasts more than 8 months a year, approximately from March to October. To obtain environmentally friendly, cheap, energy-efficient materials, the air temperature must be above +20°C.

Research has shown that in order to obtain new energy-efficient materials, it is necessary to increase strength indicators due to optimal combinations of the exothermic properties of cement in concrete and smooth heating and cooling modes [19,20,21].

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References

1. Pattaranan Hanma, Sarawut Thepanondh, Chutarat Chompunth, Suphaphat Kwonpongsagoon, Lalidaporn Panya, Nuttakit Sukjit Extent and magnitude of industrial stack emissions on ambient particulate concentrations nternational. Journal of GEOMATE, Aug., 2021, Vol.21, Issue 84, pp.202-209ISSN: 2186-2982 (P), 2186-2990 (O), Japan, DOI: https://doi.org/10.21660/2021.84.j2189

2. Namsone E., Sahmenko G., Korjakins A. Durability Properties of High Performance Foamed Concrete. Procedia Engineering. 2017. 172. Pp. 760–767. Doi: 10.1016/j.proeng.2017.02.120.

3. Muthu Kumar E., Ramamurthy K. Effect of fineness and dosage of aluminium powder on the properties of moist-cured aerated concrete. Construction and Building Materials, 2015. 95. Pp. 486–496. Doi: 10.1016/j.conbuildmat.2015.07.122.

4. Aruova L., Dauzhanov N. Energy and resource saving technologies of building materials production using solar energy. MOJ Civil Engineering. 2017. 3(3). Pp. 287-292. Doi: 10.15406/mojce.2017.03.00068.

5. Aruova L., Dauzhanov N., Utkelbaeva A., Shashpan Sh. Innovative Technologies for Producing Foam Concrete Products Using Solar Energy. International Journal of Engineering and Technology (UAE). 2018. Vol. 7. Pp. 36–41. Doi: 10.14419/ijet.v7i4.7.20376.

6. Aruova L. B., Aruov A. B., Shashpan Zh. A. Manufacturing arbolitic building products using solar energy. Journal of Mechanical Engineering Research and Developments. 2018. Vol. 41. Pp. 49–55. Doi: 10.26480/jmerd.02.2018.49.55.

7. Pinsker, B. A. State and problems of production and use of cellular concrete. Proceedings in E3S Web of Conferences. 2019. Vol. 116. P. 8, [Online]. URL: https://www.e3s-conferences.org/articles/e3sconf/ref/2019/42/e3sconf_asee18_00092/e3sconf_asee18_00092.html. (date of application: 03.10.2016).

8. Falikman V.R., Gusev B.V. Structural Concrete In The Age Of Sustainable Development. ACI Symposium Publication. 2015. Vol. 305. Pp. 36.1-36.12. URL: https://www.concrete.org/publications/internationalconcreteabstractsportal/m/details/id/51688596 (date of application: 01.09.2015).

9. Ali Basrah Pulungan, Lovely Son Syafii, Syamsul Huda, Ubaidillah Ubaidillah Improvement of a solar panel tracking system using additional mass position adjustment. International Journal of GEOMATE, Oct., 2021, Vol.21, Issue 86, pp.92-99 ISSN: 2186-2982 (P), 2186-2990 (O), Japan, DOI: https://doi.org/10.21660/2021.86.j2293

8. Hu C., Li H., Liu Z., Wang Q. Research on properties of foamed concrete reinforced with small sized glazed hollow beads. Advances in Materials Science and Engineering. 2016. art. no. 5820870. Pp. 1-8. doi: 10.1155/2016/5820870

9. Sathya Narayanan J., Ramamurthy K. Development of solid, foam concrete interlocking blocks and studies on short masonry specimens. Masonry International. 2013.26 (1). Pp. 7-16.

10. Kearsley E.P., Wainwright P.J. Ash content for optimum strength of foamed concrete. Cement and Concrete Research. 2002. 32(2). Accessed: Aug. 23, 2020. Pp. 241-246. [Online]. Available: https://elibrary.ru/item.asp?id=910534.

11. Vu K.D., Bazhenova S.I. Modeling the influence of input factors on foam concrete properties. Magazine of Civil Engineering. 2021. 103(3). Article No. 10311. Pp.131-140. DOI: 10.34910/MCE.103.11

12. Nikolsky S.G., Pertseva O.N., Ivanova V.I. Substantiation of the express method for determining the frost resistance of porous materials. Magazine of Civil Engineering. 2015. No. 8 (60). S. 7-19. DOI: 10.5862 / MCE.60.2.

13.Krutilin A.B., Rykhlenok Yu.A., Leshkevich V.V. Thermophysical characteristics of low-density autoclaved cellular concrete and their influence on the durability of the outer walls of buildings. Magazine of Civil Engineering. 2015. No. 2 (54). S. 46-55. DOI: 10.5862 / MCE.54.5.

14. Mugahed Amran, Y. H. Structural Performance of Precast Foamed Concrete Sandwich Panel Subjected to Axial Load. KSCE Journal of Civil Engineering, 2018. 22(4). Pp. 1179–1192. Doi: 10.1007/s12205-017-1711-6.

15.Aruova L., Dauzhanov N., Comprehensive heat treatment using solar energy to produce high quality foam concrete. Proceedings International Conference on Advances in Energy Systems and Environmental Engineering (ASEE19). 2019.116(00092). Pp.1-8. https://doi.org/10.1051/e3sconf/201911600092

16. Aruova L., Dauzhanov N. Innovative Technologies For Producing Foam Concrete Products Using Solar Energy, International Journal of Engineering & Technology. 2018. N7 (4.1). Pp.36-41.

Website: www.sciencepubco.com/index.php/IJET. Scopus.com https://www.scopus.com/authid/detail.uri?authorId=8953635700

17. Thuy Bich Thi Nguyen1, Anh Kiet Bui1,Trong Phuoc Nguyen, Somnuk Tangtermsirikul Influence of initial temperature of fresh concrete on compressive strength of concrete. International Journal of GEOMATE, April2023, Vol.24, Issue 104, pp.11-18. ISSN: 2186-2982 (P), 2186-2990 (O), Japan, DOI: https://doi.org/10.21660/2023.104.3291

18. Aruova L., Dauzhanov N. Process Parameters of Production of Non-Autoclaved Aerated Concrete on the Basis of Complex Use of Ash and Gypsum-Containing Wastes. Mediterranean Journal of Social Sciences, Accessed: Aug. 23, 2020. Pp.2565-2571. DOI10.5901/mjss.2014.v5n23p2565

19. Cease M.E., White D.H. Emulsification of thermal energy storage materials in an immiscible fluid. International Journal of Energy Research, 1983. 7 (2). Pp. 109-119. doi: 10.1002/er.4440070203

20. Shoib Bashir Wani, Junaid ahmed Influence of Bi-directional Fibreglass Grid Reinforcement on Drying Shrinkage and Mechanical Properties of Lightweight Foamed Concrete. International Journal of Engineering. 2020. 34(1). Pp. 10-18. doi: 10.5829/ije.2021.34.01a.02

21. Ivanov A.N., Trembitsky M.A. Foam concrete of a given average density for warming attic floors // Magazine of Civil Engineering. 2011. No. 8 (26). P. 19-24. DOI: 10.5862 / MCE.26.3.

Новые энергоэффективные материалы для строительства

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Аннотация. Существование огромного количества энергоэффективных, экологически чистых материалов среди которых различные конструкции зданий общеизвестно. И эти энергоэфективные материалы позволяют решать вопросы энергосбережения в общественных и жилых зданиях. К новым материалам сегодня в первую очередь предъявляются требования по энергоэффективности, экологической безопасности и недорой стоимости. Поэтому ученые в своих исследованиях ставят на первое место усиление прочности, низкую теплопроводность, увеличение атмосферостойкости и влагостойкости и низкую стоимость материалов.

В результате комплексных исследований авторами разработан новые ячестые бетоны, обладающие высокими прочностными характеристиками, низкой теплопроводностью и невысокой стоимостью на основе местного сырья и отходов. Такой подход приводит к существенному снижению энерго и ресурсопотребления и способствует внедрению экологически безопасных методов производства при соблюдении высоких стандартов качества продукции.

Экспериментальные исследования проводились в специально спроектированной лабораторной камере. Такая установка обеспечивала равномерный контроль температуры внутри камеры, а также равномерное распределение температуры по всей толщине изделий. Это было достигнуто за счет рационального сочетания используемых источников энергии.

В статье представлены результаты исследований физико-механических свойств пенобетонов и структурных особенностей материала. Получение высококачественной продукции стало возможным благодаря сочетанию мягких режимов термообработки и экзотермических свойств цемента. Кроме того, воздействие дополнительной электрической энергии при минимальном расходе (10-20 кВтч/м^3) на процесс твердения пенобетона характеризуется периодическим и кратковременным эффектом. Напротив, традиционные методы термообработки требуют значительно большего расхода электроэнергии – от 80 до 100 кВтч/м^3.

Результаты рентгено- и электронно-микроскопических исследований подтвердили, что разработанные энергоэффективные материалы обладают высокими физико-механическими свойствами и невысокой стоимостью.

Ключевые слова: бетон, теплопередача, теплоизоляция, пористость, температура, нагрев, теплопроводность, кондиционирование воздуха, температура, энергосбережение

Құрылысқа арналған жаңа, энергия үнемдейтін материалдар

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Андатпа. Бүгінгі таңда әлемде әртүрлі ғимараттар мен құрылыстарды пайдалану кезінде энергияны үнемдеу мәселелерін шешуге мүмкіндік беретін, ғимараттардың ішкі және сыртқы жүк көтергіш және қоршау конструкцияларын қоса алғанда, энергия үнемдейтін материалдар мен бұйымдардың орасан көп мөлшері бар. Дегенмен, мұндай материалдар әрқашан жоғары беріктікке, сондай-ақ үлкен ғимараттың жүк көтергіш бөліктерінде қолдануға арналған физикалық және механикалық қасиеттерге ие бола бермейді. Осыған байланысты энергияны үнемдейтін құрылымдар мен бұйымдарды әзірлеудің өзекті міндеттері беріктігін арттыру, жылу өткізгіштігін төмендету, ауа-райына төзімділік пен ылғалға төзімділікті арттыру, сонымен қатар өзіндік құнын төмендету болып табылады.

Жан-жақты зерттеулердің нәтижесінде авторлар жергілікті шикізат пен қалдықтар негізінде беріктігі жоғары, жылу өткізгіштігі төмен және құны төмен жаңа ұяшықты бетондарды жасады. Бұл тәсіл энергия мен ресурстарды тұтынудың айтарлықтай төмендеуіне әкеледі және өнім сапасының жоғары стандарттарын сақтай отырып, экологиялық таза өндіріс әдістерін енгізуге ықпал етеді.

Эксперименттік зерттеулер арнайы жасалған зертханалық камерада жүргізілді. Бұл қондырғы камераның ішіндегі температураны біркелкі бақылауды, сондай-ақ өнімнің бүкіл қалыңдығы бойынша температураның біркелкі таралуын қамтамасыз етті. Бұған пайдаланылған энергия көздерін ұтымды біріктіру арқылы қол жеткізілді.

Мақалада көбік бетонының физикалық-механикалық қасиеттерін және материалдың құрылымдық ерекшеліктерін зерттеу нәтижелері берілген. Жоғары сапалы өнімдерді өндіру жұмсақ термиялық өңдеу жағдайлары мен цементтің экзотермиялық қасиеттерінің үйлесімі арқасында мүмкін болды. Сонымен қатар, минималды тұтыну кезінде (10-20 кВт/м3) қосымша электр энергиясының көбік бетонның қатаю процесіне әсері мерзімді және қысқа мерзімді әсермен сипатталады. Керісінше, дәстүрлі термиялық өңдеу әдістері айтарлықтай жоғары энергия тұтынуды талап етеді - 80-ден 100 кВтсағ/м3 дейін.

Рентгендік және электронды микроскопиялық зерттеулердің нәтижелері әзірленген энергияны үнемдейтін материалдардың физикалық-механикалық қасиеттері жоғары және құны төмен екенін растады.

Түйін сөздер: Бетон, жылу өткізгіштік, жылу оқшаулау, кеуектілік, температура, жылу өткізгіштік, ауаны баптау, энергияны үнемдеу

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