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ENERGY EFFICIENCY IN CONSTRUCTION

ANNOTATION

The article covers issues of energy efficiency in construction, i.e. design, construction and operation of energy-saving buildings and structures. An energy-efficient building is a set of architectural, planning and engineering solutions that best meet the goals of minimal energy consumption to ensure the microclimate in the premises of the building. A literary review of foreign literature on energy efficiency as a dominant feature of modern types of construction and prospects for the use of energy-saving buildings in construction were carried out. The results show that insufficient thermal resistance of the surrounding structures most significantly reduces the energy efficiency of buildings. The authors examine energy-efficient technologies and composite materials obtained by scientists from the West Kazakhstan Agrarian and Technical university named after Zhangir khan. Methods for increasing energy saving are shown, these include the introduction of fundamentally new types of building structures and the use of new energy-efficient materials. This applies to the construction of both existing and newly introduced buildings and structures. Energy-efficient materials are expanded clay and ceramic bricks, which are obtained from local loams with the addition of oil sludge. They also include foam glass, which is obtained from glass production waste with the addition of various corrective additives. Examples of energy efficient houses from different countries are shown.

Key words: *energy efficiency, energy consumption, technology, composite materials, energy saving.*

Introduction. Currently, the energy resources used by humanity are gradually running out, the cost of their production is increasing, and irrational use affects the environment [1]. Efficient use of energy resources through the use of innovative solutions is the key to solving this problem. Only energy saving in any area of human activity can minimize useless energy losses, which is one of the priorities today.

Modern energy-saving technologies can significantly increase the efficiency of using any type of energy, the use of which brings quite real benefits - saving energy and costs associated with its use, as well as maintaining the necessary environmental balance. The design and construction of energy-efficient buildings is one of the most important issues in the energy-saving policy of every developed country [2]. The problem with creating and operating a modern building is that in most cases its creators do not take into account the idea of energy saving. Already created buildings constantly lose heat through windows

(about 19% of heat loss) and walls (5% of heat loss). And the climate systems created in the building still do not meet modern energy saving standards, the cost of operation of which is several times higher than all the combined costs of maintaining the building [3].The main directions for increasing energy saving are the introduction of fundamentally new types of building structures, as well as the use of effective thermal insulation materials. We are talking about both modern methods of constructing new buildings for residential and industrial purposes, and about the comprehensive reconstruction of existing buildings. The topic being studied is of very high relevance, since the development and economic success of any state directly depends on the rational use of energy resources. The latest energy-saving technologies in construction, in addition to saving financial resources, also open up fundamentally new opportunities for reducing emissions of harmful substances into the atmosphere that are formed during heating and cooling of buildings. The relevance of introducing modern energy-saving technologies is, in fact, comparable to direct energy production. Energy-saving technologies represent a more profitable and environmentally friendly way to meet the growing demand for energy resources every year.

The purpose of this work is to study the issue of energy-efficient buildings.

Materials and research methods. Energy-efficient houses are divided into: «passive» houses, which have several times lower specific heat consumption compared to conventional modern buildings; «active» houses, which, in addition to low specific heat consumption, also have built-in energy sources; buildings with zero consumption, which, with low energy consumption, only need their own energy sources.

When building a «passive» house, integral formwork technologies made from insulation are used, which makes it possible to reduce heating costs by up to 62% and achieve air permeability of the room. The technology of heating the supply air from the supply and exhaust ventilation system with heat reuse is also used. The double-glazed windows are filled with inert gas, which makes the room additionally heated by the sun's rays. They use the technology of spraying metal oxide onto glass, which reflects heat indoors in winter and outside in summer.

An «active» home is a combination of a «passive» and a «smart» home. He spends little energy. Energy savings come from the use of solar energy, wind energy, earth heat, etc. The concept of «green building» is not just the name of the concept of construction and operation of energy-efficient houses, which aims to reduce the level of consumption of energy and material resources while simultaneously improving the quality of buildings and their comfort, as well as saving natural resources.

A «green house» is energy efficient, economical to operate and environmentally friendly. This means that its energy consumption is at least 25% less than usual, and to achieve this, during construction it is necessary to use materials that do not emit harmful substances either during the operation of the house or after its dismantling. Reuse is recommended. An economical approach to natural resources also involves minimizing the consumption of clean water, for which effective treatment and recycling of rain and wastewater is organized. A «green building» should be built taking into account the characteristics of the local climate, traditions and culture of the population and in harmony with the landscape [4, 5].

Results and discussion. To analyze the efficiency of energy conservation, the concept of energy is used - embodied energy, i.e. useful share of expended energy. Energy values are considered when comparing building options at all stages - from the extraction of materials, the manufacture of building parts, and right up to the dismantling and reuse of materials and elements. A more efficient building is one in which energy is maximum or its losses during construction; operation and dismantling of the building are minimal. The concept of energy is beginning to be widely used in practice [6].

To develop the concept of an energy-saving house, they certainly rely on the experience of operating various buildings. The energy efficiency of a building is determined by a combination of many factors. Research shows that during the operation of a traditional multi-story residential building, up to 40% of heat is lost through the walls, through windows - 18%, basement - 10%, roof - 18%, ventilation - 14%. Therefore, it is possible to obtain minimal heat loss only with an integrated approach to energy saving. Thus, Italian scientists presented a methodology for setting up the design of a predictive control model for energy-efficient thermal regulation of buildings [7].

From the data presented it follows that insufficient thermal resistance of the precipitating structures most significantly reduces the energy efficiency of buildings. However, by insulating only enclosing structures, it is impossible to achieve a significant reduction in heat loss [8], since a significant share of it falls on the so-called “cold bridges” [9], that is, areas of intense heat exchange with the environment. Such areas most often form in places where floor slabs contact load-bearing walls, in places where internal walls and partitions adjoin external walls, as well as when low-quality thermal insulation material

subsides in three-layer enclosing structures with insulation as a middle layer [10], through the roof [11]. Some energy saving measures include the following:

1. Energy-efficient space-planning solutions [12, 13].
2. Use of effective thermal insulation of external walls [14].
3. The use of energy-saving windows, vents, blinds [6].
4. Construction of a winter garden to a height of one or two floors, embankment of a part of the building, installation of a roof-lawn, roof-winter garden [15, 16].
5. Use of different types of energy for efficient design [17].

Modern insulation systems provide for the creation of a comprehensive protective thermal shell around building structures. Such a shell includes the insulation of foundation structures in contact with the ground in combination with the insulation of pitched or flat roofs, as well as the installation of ventilated facades that move the zone of positive temperatures into the load-bearing structures. This set of measures eliminates the appearance of «cold bridges», increases the thermal resistance of the fence and prevents condensation, which adversely affects the thermal insulation and other operational characteristics of structures. Another important problem is heat loss through windows [18]. The simplest approach to solving this problem - reducing the window area - is not always acceptable, since it worsens the comfort and microclimate of the premises. This dilemma is best resolved by using modern triple-glazed windows with low thermal conductivity. In the future, translucent and vacuum thermal insulation, glass in passive heating systems that transmit solar radiation in the most energy-intensive part of the spectrum, selective light-absorbing coatings, and automation systems that coordinate the action of energy-saving systems with temperature conditions outside and inside the building should be used. An ideal energy-efficient building requires the use of the latest technologies [19].

In Europe, the industry for the construction of energy-efficient and passive buildings is quite developed in a number of countries, for example, in Japan, Germany, etc. Thus, several tens of thousands of such houses have already been built in Europe. They are available to ordinary consumers, since the difference in costs between building an energy-efficient and a conventional house is 10-15%, and energy bills are reduced several times. Thus, choosing an energy-efficient home often becomes even beneficial for the consumer [20].

When designing heating and ventilation systems for residential buildings, the following technical solutions are used to increase their energy efficiency (Figure 1).

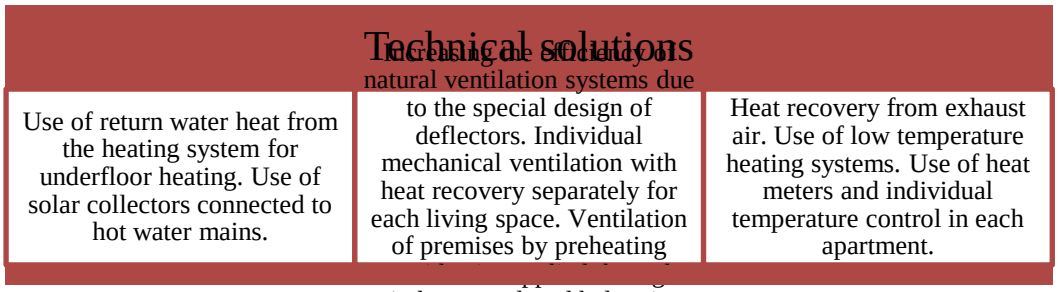

Fig. 1 – The following technical solutions are used when designing heating and ventilation systems for residential buildings

Today, many scientists around the world are considering and researching energy-saving technologies and materials for the construction of energy-efficient houses [21-24].

Energy-efficient materials obtained by scientists from Zhangir Khan WKATU include: expanded clay, ceramic brick, ceramic paving stones, foam glass, etc. The technologies of these materials are considered energy efficient due to the fact that various additives are used in the compositions, for example, in the production of expanded clay and ceramic bricks use loess-like loams with the addition of oil industry waste [25, 26]. In the production of foam glass, cullet is used [27]. The physical and mechanical properties of some materials are presented in Table 1.

Table 1 – Physical and mechanical properties of some materials

№	Name	Indicators			
		thermal conductivity, W/m*K	density, kg/m^3	compressive strength, MPa	water absorption, %

1	Expanded clay	0,07-0,1	350-600	2,1-4,9	16,2-17,8
2	Keramdor	0,1-0,5	850-1250	9,2-14,2	14,1-28,1
3	Ceramic brick	0,3-0,38	1370-1450	10,4-11,7	22,8-28,2
4	Ceramic paving stones	0,8-0,84	1480-1580	14,1-18,2	16-20
5	Foamglass	0,043-0,045	400-650	10,2-15,2	1,8-2

Data analysis showed that the materials have relatively low physical and mechanical properties. In the production of materials, industrial waste was used, which contributed to the intensification of processes and the production of materials with improved performance. Production using such waste has been able to solve several problems: energy and resource conservation, environmental friendliness, manufacturability and efficiency.

Examples of energy efficient houses are shown in Figure 2.

25storey skyscraper CIS Tower in Manchester (England)

Energy efficient house in the Czech Republic

309meter Pearl River Tower in Guangzhou

Modern horticultural glass house made of prefabricated hydroponic light steel

Seoul Energy Dream Center

163-meter Deutsche Post Tower (Bonn, Germany)

Fig. 2 – Examples of energy efficient houses

Conclusion. Thus, energy-efficient buildings, the main feature of which is low energy consumption and almost complete energy independence, are gradually conquering the global market for construction services [28]. Despite the fact that the prices of such buildings have a higher market value, they are very popular nowadays due to the low cost of operating the building.

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РЕЗЮМЕ

В статье освящены вопросы энергоэффективности в строительстве, т.е. проектирование, строительство и эксплуатация энергосберегающих зданий и сооружений. Энергоэффективное здание - совокупность архитектурно-планировочных и инженерных решений, которые наилучшим образом отвечают целям минимального расхода энергии на обеспечение микроклимата в помещениях здания. Произведен литературный обзор зарубежной литературы по вопросам энергоэффективности как доминанта современных видов строительства, перспективы использования энергосберегающих зданий в строительстве. Результаты показывают, что недостаточное термическое сопротивление ограждающих конструкций наиболее существенно снижает энергоэффективность зданий. Авторами рассматриваются энергоэффективные технологии и композиционные материалы, полученные учеными ЗКАТУ имени Жангир хана. Показаны методы повышения энергосбережения, к ним относят внедрение принципиально новых типов конструкций зданий, использование новых энергоэффективных материалов. Это касается строительства как существующих, так и вновь вводимых зданий и сооружений. Энергоэффективными материалами являются керамзит, керамический кирпич, которые получены на основе местных суглинков с добавлением нефтяных шламов. Также к ним относят пеностекло, которое получают из отходов стекольного производства, с добавлением различных корректирующих добавок. Показаны примеры энергоэффективных домов разных стран.

ТҮЙІН

Мақалада құрылыстағы энергия тиімділігі, яғни энергия үнемдейтін ғимараттар мен құрылыстарды жобалау, салу және пайдалану мәселелері қарастырылған. Энергияны үнем-дейтін ғимарат – бұл ғимараттың үй-жайларындағы микроклиматы қамтамасыз ету үшін энергияны минималды тұтыну мақсаттарына жақсы жауап беретін сәулеттік, жоспарлау және инженерлік шешімдердің жиынтығы. Қазіргі заманғы құрылыс түрлерінің басым сипаты ретінде энергия тиімділігі және құрылыста энергия үнемдейтін ғимараттарды пайдалану перспективалары туралы шетелдік әдебиеттерге әдеби шолу жүргізілді. Нәтижелер қоршаған құрылымдардың жеткіліксіз жылу кедергісі ғимараттардың энергия тиімділігін айтарлықтай төмендететінін көрсетеді. Авторлар Жәңгір хан атындағы Батыс Қазақстан аграрлық-техникалық университетінің ғалымдары алған энергия үнемдейтін технологиялар мен композиттік материалдарды зерттейді. Энергияны үнемдеуді арттыру әдістері көрсетілген, оларға құрылыс конструкцияларының жаңа түрлерін енгізу және энергияны үнемдейтін жаңа материалдарды пайдалану кіреді. Бұл қолданыстағы және жаңадан енгізілген ғимараттар мен құрылыстардың құрылысына да қатысты. Энергияны үнемдейтін материалдарға керамзит және керамикалық кірпіш жатады, олар мұнай шламын қосу арқылы жергілікті саздақ топырақтан алынады. Оларға, сонымен қатар, әртүрлі түзеткіш қоспалар қосылған шыны өндірісінің қалдықтарынан алынатын көбікшынылары жатады. Әртүрлі елдердегі энергияны үнемдейтін ғимараттардың мысалдары көрсетілген.