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FEATURES OF APPLICATION OF SMART TECHNOLOGIES IN CONSTRUCTION

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A study of aspects of the use of smart technologies in construction. This technology originated in the IT industry with the advent of digital devices. Until now, this technology has been invested primarily in the concept of "smart home" with digital control technologies. Then smart technologies spread to the technology of energy-efficient housing and its maintenance. Today, this technology also includes technologies of ecological and energy-saving construction, i.e. smart technologies for the construction of, first of all, modular. Thus, smart technology in construction in any sense means the organization of "smart", i.e. healthy, economical, safe and comfortable human housing at all stages of its life cycle. The surge in interest in "smart" homes and technology is a consequence of the global "digitalization" of human life. In 2017, Ukraine adopted the Law “On Energy Efficiency of Buildings”, which defines the legal, socio-economic and organizational principles of activities in the field of energy efficiency of buildings and aims to reduce energy consumption in buildings. This law defines the basic principles of state policy of Ukraine in this area, namely: ensuring the appropriate level of energy efficiency of buildings in accordance with technical regulations, national standards, norms and rules; stimulating the reduction of energy consumption in buildings; ensuring the reduction of greenhouse gas emissions into the atmosphere; creating conditions for attracting investments in order to implement measures to ensure increase the energy efficiency of buildings; ensuring thermal modernization of buildings, stimulating the use of renewable energy sources; development and implementation of a national plan to increase the number of buildings with close to zero energy consumption. The article considers five areas of implementation of these requirements - energy independence, environmental friendliness, comfort, economy and safety.

Most effectively, in terms of minimizing the components of the technological process, and the cost-effectiveness of the implemented project, these principles can be implemented using materials and technologies that can integrate these requirements in one complex. When implementing the requirements laid down in the above four areas when using smart technologies in construction as a material that combines these areas, it is possible to provide products based on basalt fiber-rigid and semi-rigid thermal insulation boards, mats, harnesses and other materials. These materials can be used in the development of part of the requirements of the fifth direction - security. They are implemented in the development of environmental safety of housing, fire resistance of the building, biological safety of the material, indoor air quality and other aspects of smart technologies.

Keywords: smart technologies, smart home, energy efficiency, ecology, safety, alternative energy sources.

Introduction. The word "smart" is by definition "clever". This technology originated in the IT industry with the advent of digital devices. Until now, this technology has been invested primarily in the concept of "smart home" with digital technologies for its management, which at this time was transformed into a component of smart technology: the concept of "Internet of Things" (IoT). Then smart technologies spread to the technology of energy-efficient housing and its maintenance. Today, this technology also includes technologies of ecological and energy-saving construction, i.e. smart technologies for the construction of, first of all, modular. Reason such a strong difference in the interpretation of the concept of smart technology - the information vacuum in the construction and equipment of "smart" homes [1]. But the researchers are united in one thing: smart technology is an innovative solution. Thus, smart technology in construction in any sense means the organization of "smart", i.e. healthy, economical, safe and comfortable human housing at all stages of its life cycle. The surge in interest in "smart" homes and technology is a consequence of the global "digitalization" of human life. What seemed strange and incomprehensible yesterday is now a faithful helper to millions of people around the world. Even familiar objects, in particular, windows and furniture, acquire new properties.

Results and discussion

But what should a house be like to be considered "smart"? Currently, there are several areas of technology development in construction.

The first direction, which was called "Construction of energy efficient buildings" [2]. In 2017, Ukraine adopted the Law “On Energy Efficiency of Buildings”, which defines the legal, socio-economic and organizational principles of activities in the field of energy efficiency of buildings and aims to reduce energy consumption in buildings. This law defines the basic principles of state policy of Ukraine in this area, namely: ensuring the appropriate level of energy efficiency of buildings in accordance with technical regulations, national standards, norms and rules; stimulating the reduction of energy consumption in buildings; ensuring the reduction of greenhouse gas emissions into the atmosphere; creating conditions for attracting investments in order to implement measures to ensure (increase) the energy efficiency of buildings; ensuring thermal modernization of buildings, stimulating the use of renewable energy sources; development and implementation of a national plan to increase the number of buildings with close to zero energy consumption.

According to DBN B.2.6-31: 2016 "Thermal insulation of buildings" under the energy efficiency of the building means the property of the building, its structural elements and engineering equipment to provide during the expected life cycle of the building household needs and optimal microclimatic conditions for its stay and / or living in premises of such a building at the normatively permissible (optimal) level of energy resources for heating, lighting, ventilation, air conditioning, hot water supply, taking into account local climatic conditions.

Of course, everyone wants to live in a house, where you do not need to insulate the walls of your apartment, get tired of the heat in summer and pay huge sums for heating in winter. The ideal option is to create a building where the need for external energy is close to zero (Fig. 1). The EU has decided that this should be all buildings built after 2019. Such a house is an independent facility, which actively uses alternative energy sources, such as solar, as well as energy produced by electrical appliances and the residents themselves. The main goal of the energy-saving concept is the rational use of resources, care for the environment and the creation of a comfortable building for living. Achieve maximum energy efficiency of the house is possible only with a comprehensive approach to all subsystems - insulation, carefully thought-out ventilation, lighting, heating and cooling, special windows, doors and roof, use of only ecological energy saving devices, etc. Control of home systems, namely: temperature, lighting, alarm - is through an application on a smartphone.

Fig. 1. The first serial energy efficient house in Ukraine

The second direction is environmental friendliness. The main purpose of the green direction in construction is to reduce the burden on the environment, while striving to improve the quality of buildings and ensure the most comfortable environment in the premises. The purpose of this area is the environmental safety of housing and indoor air quality. It is the principles of "external" ecology in construction that will help humanity to preserve the basics of our children's lives, will make it possible to leave them our Earth in a clean and pleasant form. While the "internal" ecology of each building will allow us to raise healthy offspring who will be able to fully enjoy their lives on a clean planet, in the absence of environmental, climatic and energy disasters. To achieve this goal, a separate direction in the industry of building environmentally friendly materials, such as building blocks of sea salt and wooden buildings. It is clear that the most environmentally friendly is engineering equipment that works on the basis of renewable energy sources. Ideally, an environmentally friendly building should use equipment that does not burn raw materials (getting very high temperatures, while in the building we only need some 30-50 degrees), but would work by producing only the really necessary "temperature delta" in the middle of the building. Such equipment includes, for example, heat pumps and solar collectors. By producing thermal energy, they do not burn electricity or other raw materials, but simply select the temperature delta we need to operate the buildings from the environment.

The third direction is comfort. This concept includes both comfortable housing and comfortable management of its operation. This direction is formed first of all from Internet things: the smartphone, the smart socket, the smart TV, the smart watch, the robot vacuum cleaner, etc., but has development and

further: hotel halls are equipped with terminals for independent electronic registration, hotel guests can adjust lighting, climate regulation, control of multimedia equipment and blinds [3]. With the help of a smart system it is possible to make changes in the light regime, you can quickly change both the interior lighting from intimate to the front, and the mode of use of the building (security mode, operating mode, presence simulation, etc.). No less important is the automation of switching on / off lighting fixtures, which allows you to save on utility bills.

The fourth direction is efficiency. Reducing the use of expensive gas and switching to renewable solar energy, energy-saving integrated construction technologies, including passive energy saving, passive cold, reducing water consumption through rainwater collection and aeration. The next step in the development of technologies for the construction of energy-efficient homes should be the creation of energy-efficient homes, that is, homes that produce more energy than they consume.

Most effectively, in terms of minimizing the components of the technological process, and the cost-effectiveness of the implemented project, these principles can be implemented using materials and technologies that can integrate these requirements in one complex. In the implementation of the requirements laid down in the above four areas in the application of smart technologies in construction as a material that allows you to combine these areas, it is possible to cite products based on basalt fiber-rigid and semi-rigid thermal insulation boards, mats, harnesses and other materials. These materials can be used in the development of part of the requirements of the fifth direction - security. They are implemented in the development of environmental safety of housing, fire resistance of the building, biological safety of the material, indoor air quality and other aspects of smart technologies.

Basalts and their structural analogues (diabases, amphiboles, etc.) are used for their production - mountain volcanic ecologically pure raw materials, the reserves of which in the world are practically inexhaustible. Structural and heat-insulating materials based on basalt fiber meet the above conditions. In addition to high technical properties should take into account their lower cost, compared with similar materials based on any other mineral, and even more organic, fibers. The strength of basalt reaches 18000-25000 kg/cm², basalt-containing materials can withstand much greater elastic deformations, because in the basalt fiber there are no plastic deformations in tension, and the elasticity is superior to steel.

The main difference between materials based on basalt fibers is their high strength at all types of stress and the ability to withstand large deformations. The relative deformation of materials based on basalt fibers, without the formation of cracks can reach 0.7 .... 0.9%, which is much higher than for conventional materials. In accordance with the provisions of DBN B.2.6-31: 2016 "Thermal insulation of buildings" requirements of regulations on thermal protection of buildings and structures have led to a growing trend to create new materials that ensure sustainable operation of structures and equipment in the face of intense

destructive external influences. Such materials are subject to a set of (sometimes mutually exclusive) requirements that must combine: physical and mechanical, chemical, hygienic, thermophysical, decorative and other properties of materials. In this regard, there is a need to create materials that at low average density, high strength can withstand significant temperature loads, the impact of extreme natural and operational factors. One such material is mineral fibers based on erupted rocks. The raw materials for their production are non-deficient, widespread in Ukraine main rocks of magmatic origin - basalts and their structural analogues - diabases, amphiboles and others. The relatively low melting point allows the use of these rocks for the production of mineral fibers in a simplified scheme, directly with the loading of rock into the smelting unit, which provides high efficiency of the product, stability of process parameters and no harmful load on the environment. In this case, the melting of raw materials is a one-step principle, the materials obtained on these drags are not only not inferior to traditional glass and mineral fibers, but in a number of properties far outweigh them. Table 1 shows a comparative description of the main technical characteristics of the fiber obtained from different raw materials.

Table 1

The main technical characteristics of mineral fiber-based various materials

#	Fiber material	Density, kg/m3	Tensile strength, MPa 103	Modul Jung, MPa 103	Elongation at tension, MPa 103
1	Steel fiber	7.8	0.8…2.15	200	3…4
2	Asbestos	2.6	0.91…3.1	68	0.6
3	Fiberglass	2.6	1.05…3.85	70… 80	1.5…3.5
4	Carbon	2.0	2.0	245	1.0
5	Basalt	1.1… 1.6	4.0…12.0	184…210	1.2…1.8

It is shown that obtaining structural and heat and sound insulation materials based on basalt fibers with high thermophysical and acoustic properties is possible when creating a porous system in the material with a predetermined textural characteristic of pores of different class, purpose and combination.

It should also be noted that basalt fibers and materials based on them have high thermal and insulating properties, as well as structural properties. In terms of temperature resistance, basalt fibers and products based on them significantly outperform similar indicators of heat and sound insulation products based on glass and mineral fibers. But the requirements of modern regulations on improving the heat and sound performance of buildings and structures raise questions about further improving the performance of thermal insulation materials.

As can be seen from the data given in table 2 heat-insulating products (TZIV), for the production of which basalt fibers were used have an unconditional advantage over other types of TZIV based on mineral fibers and, moreover, based on fibers made of polymeric materials. But at the same time

as meeting the growing needs of industry in the production of thermal insulation materials come to the fore requirements to improve their performance, including such as operating temperature, thermal conductivity, density and others. It should be noted that basalt fibers and materials based on them have high thermal and sound insulation and structural properties. In terms of temperature resistance, basalt fibers and products based on them significantly outperform similar indicators of heat and sound insulation products based on glass and mineral fibers.

Table 2

Comparative characteristics of the main technical indicators of thermal insulation materials based on mineral fibers

#	Indicators	BTSH (10mm)	HSP (20mm)	BTSH (30mm)	SHAON (15mm)	SHAON (15mm)
1	Operating temperature, ^{0}C	700	700	1150	400	400
2	Thermal conductivity, VT/mK	0.055	0.055	0.055	-	-
3	Linear density, tex	25	60	100	56-79	200-240
4	Sorption hydration	2	2	16	-	-
5	Density, kg/m3	450	200	190	-	-

Analyzing the structure, mineral and chemical composition of the fibers, it is possible to conclude that there are common features in all thermal and sound insulation materials, which impose certain restrictions on improving their performance. Thus, a common feature of all thermal and sound insulation materials is the use for their production of fibers of dense structure with mineralogical and chemical composition, which is similar to the raw material, which predetermines the marginal performance. Therefore, one of the ways to increase the performance of products based on inorganic mineral fibers is to modify the structure of the fiber, as well as adjust its chemical and mineralogical composition in the direction of increasing the operating temperature and thermal insulation properties of the fibers.

The fifth direction is security. First, it is the environmental safety of housing, for example, fire protection of wood and provides a high level of fire resistance of the building, the quality of indoor air largely determines the quality of human health. Secondly, it is the safety of the person who lives in it. Of course, smart technologies have many different security and video surveillance systems that allow a person to feel protected. Thus, in the event of unauthorized intrusion into the house of strangers, the smart system will automatically notify the security service and the owners of the intrusion and may not include sound and light alarms, lighting, thereby assisting in apprehending criminals, and, conversely, turn on audible alarms and lighting to warnthe owners and scare the intruders. With the help of the emergency warning system, an emergency rescue service

will be automatically called, and in addition, the water will be cut off, the power supply will be turned off autonomously and the fire extinguishing system will be turned on. In the absence of the hosts, the smart system will notify you that someone has come, and thanks to the Internet, you can see who it is and through the Internet or SMS you can open the door and let the guest. You can always view the image broadcast from video cameras on a personal mobile gadget, portable (wall) displays or TVs online. For example, a smart system by displaying an image will let you know that a child has woken up in a child's room or a car has approached the gate. the power supply will be switched off autonomously and the fire extinguishing system will be switched on. In the absence of the hosts, the smart system will notify you that someone has come, and thanks to the Internet, you can see who it is and through the Internet or SMS you can open the door and let the guest. You can always view the image broadcast from video cameras on a personal mobile gadget, portable (wall) displays or TVs online. For example, a smart system by displaying an image will let you know that a child has woken up in a child's room or a car has approached the gate. The power supply will be switched off autonomously and the fire extinguishing system will be switched on. In the absence of the hosts, the smart system will notify you that someone has come, and thanks to the Internet, you can see who it is and through the Internet or SMS you can open the door and let the guest. You can always view the image broadcast from video cameras on a personal mobile gadget, portable (wall) displays or TVs online. For example, a smart system by displaying an image will let you know that a child has woken up in a child's room or a car has approached the gate. You can always view the image broadcast from video cameras on a personal mobile gadget, portable (wall) displays or TVs online. For example, a smart system by displaying an image will let you know that a child has woken up in a child's room or a car has approached the gate. You can always view the image broadcast from video cameras on a personal mobile gadget, portable (wall) displays or TVs online. For example, a smart system by displaying an image will let you know that a child has woken up in a child's room or a car has approached the gate.

Materials and methods

These areas have formed the composition of smart technologies in construction.

1. Modular assembly (Fig. 2) of buildings of any type: residential buildings, commercial, administrative and even industrial buildings. First of all, the demand for modular buildings is determined by the possibility of quick installation and relatively low price.

Fig. 2. Modular house (photo from http://ukrdream.in.ua)

The modular construction technology allows to erect the building with any necessary

sizes, planning, level of comfort in the minimum terms. Modular construction is developing rapidly in the construction of buildings and, in particular, hotels [4].

2. Technology in the interior: concept Smart House -these are robot vacuum cleaners, sockets (Fig. 3) with a Wi-Fi module and light bulbs, which can be controlled using a smartphone. Even familiar objects, in particular windows and furniture, acquire new properties, for example, touch furniture facades are compatible with the concept of "smart" houses: connecting furniture with the surrounding space, smart management, adaptation to different life situations and people's daily routine. Modern smart TVs are a combination of rich functionality and stylish appearance. For example, Samsung's The Frame has a "chip" in the form of interchangeable frames in six colors. With this design, it is difficult to immediately understand whether you have a TV or a picture. Complements such sensations and a special mode "Picture", which turns off the TV automatically: instead of a boring black screen, the device displays works of art, turning the room into a personal gallery. In the built-in Art Store application you can choose from more than 1,200 works by famous artists and photographers from the largest galleries and museums in the world. Smart technology has touched almost furniture. "Smart" furniture is characterized, first of all, by the compactness and comfort (Fig. 4), extreme ergonomics coupled with convenient functionality. That is why it is so popular with pragmatic, "advanced" interior designers. Especially when it comes to the so-called Smart-apartments, ranging from 9 to extreme ergonomics coupled with convenient functionality. That is why it is so popular with pragmatic, "advanced" interior designers. Especially when it comes to the so-called Smart-apartments, ranging from 9 to 30 m^2. Although smart furniture is becoming increasingly popular with young families who have a little more, but still not very many square meters.

Fig. 3. Smart socket HS110 (photo from https://www.wildberries

Fig. 4. Smart furniture (photo from https://mebshop.kiev.ua)

3. A house built and equipped with smart technologies does not become "smart".

To make it so, you need something more, namely an IT platform that will integrate all communications into a common network and allow you to connect them to cloud services. In addition, the classic concept of Smart House provides for the presence in the building of such qualities as energy efficiency, as well as a high level of comfort and safety of residents. In addition to automatically controlling the entire complex of electronics in the house, the smart system can transmit a failure signal to the owners, service personnel, emergency services via voice message to a mobile phone, SMS or Internet message.

The system is controlled via a global computer network or mobile phone, thus providing the ability to choose heating modes, optimal climate in the right rooms, adjust the water temperature, the usual or special lighting design, background music and news of interest.

To do this, simply send an SMS to the smart system. Despite the variety of data transmission technologies used in "smart homes", the composition of smart systems and the scheme of operation are not fundamentally different. Components of any smartsystems: IT platform (controller, processor), actuators (actuators, regulators, etc.), controls (windows, doors, heaters, air conditioners, home theater, etc.), communication lines (wireless, in the environment Wi-Fi or using Z-Wave wireless technology).

Conclusions

1. The house of the future of each of us will be built on smart technologies.

2. In the long run, not only houses will become "smart", but also cities and even (some) states [5]: every resident will be provided with free Internet access, the city will develop a computer program to combat street crime, on the wheels of cars special sensors will be installed, which collect information about each pothole on the road and send data to the utility server, the program of introduction of electric vehicles will be implemented, garbage in the city will be collected by cleaning robbers, mail will be delivered by postmen. The authorities of any city can set an ambitious goal: to bring the level of emissions of harmful gases to absolute zero by 2025.

3. The main disadvantage of these systems is the dependence on the availability of the Internet and mobile communications. Without these types of communication, all of the above ceases to exist.

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ОСОБЛИВОСТІ ВИКОРИСТАННЯ РОЗУМНИХ ТЕХНОЛОГІЙ В БУДІВНИЦТВІ

Дослідження аспектів використання смарт-технологій в будівництві. Ця технологія виникла в IT-галузі з появою цифрових пристроїв. До цього часу ця технологія вкладалася головним чином у концепцію «розумного будинку» з цифровими технологіями управління. Потім розумні технології поширились на технологію енергоефективного житла та його обслуговування. Сьогодні ця технологія також включає технології екологічного та енергозберігаючого будівництва, тобто розумні технології для будівництва, насамперед, модульні. Таким чином, розумна технологія в будівництві в будь-якому сенсі означає організацію «розумного», тобто здорового, економічного, безпечного та комфортного житла людини на всіх етапах його життєвого циклу. Сплеск інтересу до "розумних" будинків та технологій є наслідком глобальної "цифровізації" людського життя. У 2017 році Україна прийняла Закон «Про енергоефективність будівель», який визначає правові, соціально-економічні та організаційні принципи діяльності у сфері енергоефективності будівель та спрямований на зменшення споживання енергії в будинках. Цей закон визначає основні принципи державної політики України у цій галузі, а саме: забезпечення належного рівня енергоефективності будівель відповідно до технічних регламентів, національних стандартів, норм та правил; стимулювання зменшення споживання енергії в будівлях; забезпечення зменшення викидів парникових газів в атмосферу; створення умов для залучення інвестицій з

метою здійснення заходів щодо підвищення енергоефективності будівель; забезпечення теплової модернізації будівель, стимулювання використання відновлюваних джерел енергії; розробка та реалізація національного плану збільшення кількості будівель з майже нульовим споживанням енергії. У статті розглянуто п'ять областей реалізації цих вимог - енергетична незалежність, екологічність, комфорт, економія та безпека.

Найефективніше, з точки зору мінімізації компонентів технологічного процесу та економічної ефективності реалізованого проекту, ці принципи можуть бути реалізовані з використанням матеріалів та технологій, які можуть інтегрувати ці вимоги в один комплекс. При реалізації вимог, викладених у вищезазначених чотирьох областях, при використанні інтелектуальних технологій у будівництві як матеріалу, що поєднує ці сфери, можна пропонувати вироби на основі базальтових волоконних та напівжорстких теплоізоляційних плит, матів, джгутів та інших матеріалів. Ці матеріали можуть бути використані при розробці частини вимог п'ятого напрямку - безпеки. Вони впроваджені в розробку екологічної безпеки житла, вогнестійкості будівлі, біологічної безпеки матеріалу, якості повітря в приміщеннях та інших аспектів розумних технологій.

Ключові слова: розумні технології, розумний дім, енергоефективність, екологія, безпека, альтернативні джерела енергії.

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ОСОБЕННОСТИ ПРИМЕНЕНИЯ УМНЫХ ТЕХНОЛОГИЙ В СТРОИТЕЛЬСТВЕ

Исследование аспектов использования умных технологий в строительстве. Эта технология зародилась в ИТ-индустрии с появлением цифровых устройств. До сих пор эта технология вкладывалась в основном в концепцию «умного дома» с технологиями цифрового управления. Затем умные технологии распространились на технологии энергоэффективного жилья и его обслуживания. Сегодня в эту технологию входят также технологии экологического и энергосберегающего строительства, то есть интеллектуальные технологии для строительства, в первую очередь, модульные. Таким образом, интеллектуальные технологии в строительстве в любом смысле означают организацию «умного», т.е. здорового, экономичного, безопасного и комфортного жилья человека на всех этапах его жизненного цикла. Всплеск интереса к «умным» домам и технологиям - следствие глобальной «цифровизации» человеческой жизни. В 2017 году Украина приняла Закон «Об энергоэффективности зданий», который определяет правовые, социально-экономические и организационные принципы деятельности в области энергоэффективности зданий и направлен на снижение потребления энергии в зданиях. Этот закон определяет основные принципы государственной политики Украины в этой сфере, а именно: обеспечение надлежащего уровня энергоэффективности зданий в соответствии с техническими регламентами, национальными стандартами, нормами и правилами; стимулирование снижения потребления энергии в зданиях; обеспечение снижения выбросов парниковых газов в атмосферу; создание условий для привлечения инвестиций с целью реализации мероприятий по повышению энергоэффективности зданий; обеспечение тепловой модернизации зданий, стимулирование использования возобновляемых источников энергии; разработка и реализация национального плана по увеличению количества зданий с почти нулевым потреблением энергии. В статье рассматриваются пять направлений реализации этих требований - энергонезависимость, экологичность, комфорт, экономичность и безопасность.

Наиболее эффективно, с точки зрения минимизации составляющих технологического процесса и рентабельности реализуемого проекта, эти принципы могут быть реализованы с использованием материалов и технологий, позволяющих объединить эти требования в один комплекс. При реализации требований, изложенных в вышеуказанных четырех областях, при использовании интеллектуальных технологий в строительстве в качестве материала, объединяющего эти области, можно предоставлять изделия на основе жестких и полужестких теплоизоляционных плит из базальтового волокна, матов, жгутов и других материалов. материалы. Эти материалы могут быть использованы при разработке части требований пятого направления - безопасности. Они реализованы в разработке экологической безопасности жилья, огнестойкости здания, биологической безопасности материала, качества воздуха в помещениях и других аспектов интеллектуальных технологий.

Ключевые слова: умные технологии, умный дом, энергоэффективность, экология, безопасность, альтернативные источники энергии.

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