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PROSPECTS FOR CREATING SMART BUILDINGS USING SMART CONCRETE

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Problem statement. The concept of "Smart Home Technologies" today is associated with a network of various sensors, controllers and devices to automate and optimize functions in buildings, including heating, ventilation and air conditioning, lighting, security systems, etc. Along with the undeniable advantages of smart building technologies that improve the quality of life, they may become highly complex resulting in failure. Therefore, along with the development of high technologies, it is advisable to use processes that occur in living nature. We think no one will deny that it is nature that has created the most perfect technologies.

One of the elements that supports life on Earth is carbon. Along with oxygen, it is the most common in the human body and biosphere. The life on earth is sustained by the process of photosynthesis. Photosynthesis is the process by which plants use sunlight, water, and carbon dioxide to create oxygen and energy in the form of sugar [1].

Modern achievements in materials science make it possible to create concrete carbon composites, which are energy-harvesting systems that imitate natural processes.

Purpose of the study. The purpose of this research is to identify the possibilities of creating "smart" concrete, which, thanks to the properties of electrical conductivity, thermal conductivity, electromagnetism, and piezoresistive properties, can be used to create hybrid structures with systems for monitoring the structural condition of load-bearing structures; energy generation, transformation and storage; perform the functions of lighting, heating and heating systems of buildings.

Maine results. Carbon in natural and modified forms (Table 1−3) is widely used in industry [2]. The invention of graphene and its modifications creates new possibilities within materials technology and electronics.

Graphene is an allotrope of carbon consisting of a single layer of atoms arranged in a hexagonal lattice nanostructure [3]. The name is derived from "graphite" and the suffix-ene, reflecting the fact that the graphite allotrope of carbon contains numerous double bonds.

Single-layer graphene was explored theoretically in 1947. But only in 2004 Konstantin Novoselov and Andre Geim (University of Manchester, United Kingdom) successfully produced this material, graphene, and mapped its properties: incredibly thin but still incredibly strong, good heat and electrical conductivity, almost entirely transparent yet very dense. At 2010 Andre Geim and Konstantin Novoselov was awarded The Nobel Prize in Physics "for groundbreaking experiments regarding the two-dimensional material graphene".

Despite its relatively young age, 20 years, graphene and its modifications are used today in many industries, including construction.

Prospective directions of use in construction are composites and energy. On the basis of graphene and its modifications, as well as carbon materials, composites with outstanding properties have already been obtained. Thus, on the basis of the assembly of graphene and carbon nanotubes (CNTs), ultra-flyweight aerogels (UFAs) were obtained, which are 7.5 times lighter than air and can be used as an ultra-effective thermal insulating material [4].

Table 1

Natural carbon forms

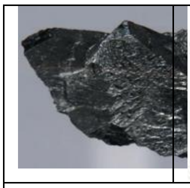
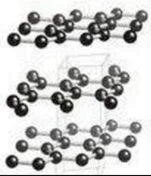
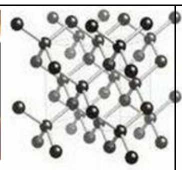
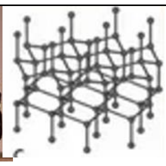
 	 	 
graphite	diamond	lonsdale – diamond

Table 2

Amorphous carbon modifications

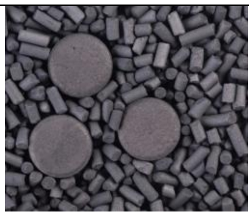
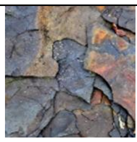
			
carbon black	activated carbon	charcoal	coke

Table 3

Carbon in compounds

						
peat	brown coal	coal	anthracite	oil shale	oil	gas

Carbon fiber composite materials, also known as carbon fiber reinforced plastics (CFRP), are composite materials made of carbon fibers and resin (mainly epoxy resin) [5]. Carbon fiber can also be referred to as graphite fiber or carbon graphite. As light, strong, and hard materials, they are used in wide range of applications. In Construction Carbon Fiber Fabric is used: for Precast Concrete Construction, as Reinforcement, in Bridge Construction.

On the basis of the concrete matrix and functional fillers with physical effects, it is possible to obtain smart − concretes and, first of all, energy-generating and energy-storing ones. Combination in a certain way the most used artificial material in the world, cement, whose age reaches two thousand years, with technical carbon it is possible to obtain an electrically conductive nanocomposite, a supercapacitor or a battery.

Thermoelectric Generators (TEGs) [6]. are devices generating electrical power directly from thermal energy. The thermoelectric properties of cement-based materials have been achieved using certain types of additives, such as carbon and steel fibers, carbon nanotubes, graphite and metal oxides.

Pyroelectric behavior refers to the change in electric polarization in a material due to a change in temperature. In this way, thermal energy is converted to electrical energy and concrete becomes a smart material [7].

When piezoelectric materials are added to concrete, the produced concrete has the ability to convert mechanical energy into electrical energy. Piezoelectric cement is composite comprising 50 % lead plumbum zirconate titanate (PZT) particles [8].

The principle of operation of Conductive concrete [9] is the absorption of electromagnetic waves of a certain length and their transformation into thermal energy or shields against damaging radiofrequency electromagnetic field or Electromagnetic Pulse. The conductive concrete mix, which was developed at the University of Nebraska, contained 1.5 % of steel fibers and 20 % of steel shavings per volume. The steel fibers and shavings that were added to a regular concrete mixture aimed to achieve the required electric resistivity for electrical resistance heating.

Light-emitting concrete is a type of energy harvesting concrete that possesses the ability of absorbing and storing external light (natural light or artificial light) radiation energy, and then releasing the stored energy in the form of visible light in darkness [10].

Thermal-storing concrete has the ability to collect, store, transport, and release thermal energy by means of energy conversion inside the material. It use Phase Change Materials (PCMs) [11].

Self-sensing concrete is a smart concrete technology that can sense the stress, strain, and damage in itself. It is also called as self-monitoring or piezoresistive, or pressure-sensitive, or intrinsically smart concrete. Piezoelectric cement, carbon nanotubes (CNT), carbon fibers (CF) are used as components in such concrete [12].

Self-healing concrete is a process in which the material repairs itself by repairing internal cracks. This process can occur through autogenous or autonomous healing. Special admixtures or bacteria are introduced into such concrete during production.

Conclusion. Smart concrete provides an opportunity to create multifunctional building structures that combine both traditional functions − load-bearing and enclosing, as well as functions of generation, storage and transformation of electrical, thermal, electromagnetic, mechanical, and light energy. In this case, they act as generators of electrical energy, heat energy, accumulators of electricity, thermoaccumulators, elements of protection against electromagnetic fields, have functions of self-diagnosis of the technical condition, as well as self-healing from defects and damage in the form of cracks.

Today smart concretes with the help of innovative technologies imitating natural processes make it possible to create smart houses.

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