Innovative building materials in creation an architectural environment

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Abstract. Progressive building materials and technologies can ensure not only the durability of buildings and structures that are operated in difficult conditions and the consumption of a minimum amount of energy with little impact on the environment, but also will contribute to the creation of an effective and harmonious architectural environment in accordance with the requirements of sustainable development. An important role in solving these problems is assigned to recycled (reusable materials); traditional natural and local building materials that due to technical progress have gained new prospects for use in modern environmental and energy-efficient structures and buildings (“old-new” natural materials); nanomaterials and nanotechnologies, the use of which will not only improve the quality and properties of materials, and, accordingly, the environment, but also create completely new materials and architectural solutions with a set of properties. The purpose of this study is generalization, systematization and examination of these innovative materials and products.

Introduction

At the present stage of society's development, the goal of international humanitarian action and one of its socio-economic objectives is to ensure a “Sustainable Development of the Architectural Environment”. It is currently one of the European Union's regulatory requirements. The need to ensure an ecological balance between meeting the modern needs of mankind and protecting the interests of future generations, including their need for a safe and healthy environment, defines current global construction trends, which indicate that the most promising direction is the development of urban environment based on energy-saving technologies, as well as environmentally friendly building materials.

The construction industry is the biggest sector of the economy as regards management and in terms of raw materials flow. Most capital, both the financial and the natural, is invested in building structures.

Leadership in Energy and Environmental Design (LEED) is a set of rating systems for the design, construction, operation, and maintenance of green buildings, which was developed by the U.S. Green Building Council. Another certificate system that confirms the sustainability of buildings is the British BREEAM (Building Research Establishment Environmental Assessment Method) for buildings and large-scale developments. Currently, World Green Building Council is conducting research on the effects of green buildings on the health and productivity of their users and is working with World Bank
to promote Green Buildings in Emerging Markets through EDGE (Excellence in Design for Greater Efficiencies) Market Transformation Program and certification [1].

It is well known that green building is based on two basic principles. First, at all stages of project implementation the negative environmental impact should be minimal. Second, maximum comfort and safety should be created for those who work or reside in the building. These aspects are the focus of the certification systems mentioned above. "Green" building as a trend is becoming increasingly popular. More and more green projects of various functional buildings are being implemented every day.

In addition to environmental problems it is also important to solve the problem of energy conservation. To solve these issues, it is necessary to analyze carefully building materials and choose those that will contribute to the efficient use of energy, greater comfort and lower costs taking into account the life cycle of the materials, which includes its production, use and disposal (recycling).

Building materials ‘creation (taking into account all the technical advantages that the scientific base of modern materials science gives) must consider the economic, environmental, social and ergonomic aspects in the life activity of mankind and production, including: ensuring the minimum energy costs at all stages of production and use; possibility of material renovation, maximum re-use of material (recycling), preservation of environment. In this regard, a new term has emerged - “Eco-friendly materials”. It is applied to materials and structures that promote a healthy lifestyle and the conservation of natural resources.

In building, environmentally-friendly materials (also known as green building materials) are those in which, for their production, placing and maintenance, actions of low environmental impact have been performed. They have to be durable, reusable, include recyclable materials in their composition and have to be from resources of the area where the building activity will take place –they have to be local materials. These materials also have to be natural (soil, adobe, wood, cork, bamboo, straw, sawdust, etc.) and must not be spoilt by cold, heat or humidity.

The idea behind sustainable architecture is to build in a way that reduces harmful impact on the environment. The leading components of a sustainable building architecture are the application of sustainable building materials such as organic compounds or recycled materials and the use of environmentally friendly methods of waste management. The key role is played here innovative materials, including traditional ("old - new") building materials made on the basis of modern technologies.

There are different views and opinions in the modern scientific literature regarding the typology of modern innovative building materials. The most complete classification of innovative materials is presented in the book “Smart Materials in Architecture, Interior Architecture and Design” [2]. Along with this, the purpose of this study is to get acquainted with such innovative materials and products as: recycled (reusable materials); traditional natural and local building materials that due to technical progress have gained new prospects for use in modern environmental and energy-efficient structures and buildings (“old-new” natural materials); nanomaterials.

**Recycled materials**

The reuse of building materials and industrial waste is currently under development. With the improvement of processing technologies for various types of materials suitable for re-production and waste there is an intensive expansion and use of them in world practice. The use of industrial waste is particular relevance in conditions with limited sources of supply of material and financial resources.

In the recent past, construction sites that had to be demolished were destroyed in such a way - they were blown up, and then the landed mass was taken out. As a result, there were huge blockages of concrete, metal, glass, which was not easy to disassemble. Recycling allows to reuse construction waste without harming the environment. Throughout the world, recycling of construction waste is a very profitable industry. The volume of construction waste is increasing every year and, according to the participants of this promising market, the main problem is not transportation, but recycling and, importantly, ecological disposal of construction waste. Due to improvements in technology and legislation, countries such as Denmark, Netherlands, Sweden, where more than 90% of waste is
currently being recycled, have been able to reach a very high level of construction waste recycling. Thus, construction based on recycled materials can be an effective means of saving money and protecting the environment. Against this background, let's consider a good examples of recycling various building materials.

**Recycling of rocks.** The mining, quarrying and processing of rocks in quarries and stone works generates a lot of waste, the amount of which can reach up to 80% of the volume of rocks under development. From an economic and environmental point of view, it is advisable to use this waste for the production of rubble, sand, artificial blocks and decorative plates [3, 4]. In the manufacture of granite-crushed stone, a large amount of siliceous waste in the form of pulp (when washing crushed stone) or screenings with grain sizes up to 5 mm is formed. This waste can be used in the production of silicate bricks, cellular concrete, as well as decorative extruded products. Crushed stone and sand with high decorative properties are used for the manufacture of artificial blocks and slabs.

**Recycling of ceramic materials.** The problem of ceramic waste recovery is very acute for manufacturers of ceramic products. The most advantageous solution, given the high cost of disposing of such waste and, consequently, causing damage to the environment, is the possibility of returning it to the production process using special technology that should take into account economic (cost of raw materials), technological (adding chamotte to ceramic masses without extension grinding cycle) and environmental aspects. Disposal of obsolete ceramic bricks is possible as a thinner additive in the composition of the ceramic mass to obtain a ceramic shard for construction purposes and for the partial replacement of natural sand in the production of concrete for small-sized road paving elements. The fired waste of both glazed and non-glazed products can be returned to the production cycle using a line whose main equipment is grinding equipment for preliminary crushing of ceramic waste whose dimensions can reach 300 mm and a hammer mill, which ensures crushing to a powder state with the formation high content of fine fraction.

**Recycling of glass and mineral melts products.** The problem of processing for broken glass waste has now become one of the most pressing, because the production of glass products requires huge energy costs and glass is one of the most difficult to recycle waste. Glass is not subject to destruction under the influence of water, atmosphere, solar radiation, frost. In addition, glass is a corrosion-resistant material that does not break down under the influence of an overwhelming amount of strong and weak organic, mineral and bio acids, salts, as well as fungi and bacteria. Therefore, if organic waste (paper, food waste, etc.) is completely decomposed after 1...3 years, polymeric materials - after 5...20 years, then glass, like steel, can survive for tens or even hundreds of years without much damage [4]. Glass waste is divided into returnable (own) and secondary (purchased), which is due to two sources of their formation (production and consumption). The returnable glass waste is fully consistent in chemical composition with the glass produced on this furnace, in connection with this glass factories use almost all of their own glass waste, with the exception of the broken reinforced glass, triplex, mirrors and high-quality glassware made of colourless glass. Secondary glass waste is formed in the sphere of consumption (food industry, trade, house-building plants, construction) and, as a rule, in chemical composition does not correspond to the glass of the furnace into which it is loaded. Currently, secondary glass wastes are used in the manufacture of glass containers, glass mosaic and facing tiles, roofing materials, floor tiles, artificial slate, marble, staple fiberglass, etc. The processing of glass bottles (specifically, defective and broken bottle) directly at the glass factory itself is an example of rational waste management.

**Secondary processing of metals.** Ferrous metals include iron and its alloys, which make up more than 90% of the total global metal production. A large share in the total volume of solid waste belongs to metal waste. Secondary metal resources are made up of scrap (43%) and waste (57%) [3]. Utilization of ferrous metal is an important aspect for the preservation of the environment and the conservation of natural resources. For example, the steel cladding and wood used in the shed project are completely recycled and reused (Fig. 1, a). Scrap is sorted both by chemical composition and by the overall dimensions of products or structures. If the work is carried out with large metal structures, then loading equipment is used for sorting. Sorting by chemical composition is carried out taking into account the metal quality indicator, as well as by its type. In addition, when sorting, separation can take place upon
the fact that the alloying and carbon components are contained in the scrap metal. In small enterprises, sorting is often done manually, right at the acceptance stage. If the pieces of metal are small in size and weight, then they are pressed into briquettes. Also sheets of metal are subjected to grinding in shredders (cutting sheets into fragments).

**Recycling of concrete.** Concrete scrap is formed during the dismantling of structures, slabs of temporary roads, piles, during the testing of structures and the accumulation of substandard reinforced concrete products, which occur during the replacement of housing stock and in cases of natural disasters. Crushed concrete stone is used as a large aggregate in various branches of construction industry. The embodiment of concrete processing products as one of the most common building materials in the world is the Hanil Visitors Centre & Guest House project (Fig. 1, b). The facade is made with both gabion walls, as well as concrete cast with fabric. This saves raw materials and improves the environment.

![Image](https://www.bmiaa.com/circular)

**Figure 1.** Examples of using recycled materials in architectural environment

Upon receipt of crushed stone from concrete, fuel consumption is 8 times less than during its extraction in natural conditions, and the cost price of concrete on secondary crushed stone is reduced by 25% [5]. The most promising is the mechanical method of activation of crushed stone from concrete. With mechanical activation methods, self-grinding by mixing crushed stone in mixers or grinding in ball mills with metal balls is provided. The efficiency of using crushed stone from concrete increases if it replaces the aggregate from natural stone material in the manufacture of precast concrete structures directly at the enterprise that processes substandard products. Since the material is the result of waste
processing, the initial stage of production is the collection of construction waste. The production process consists of the following steps: selecting the right starting material, evaluating its suitability, collecting garbage and transporting it to a recycling point, crushing concrete (asphalt concrete, brick) using hydraulic shears/hydraulic hammers, crushing pieces in a crusher, sifting crushed stone: identifying glass and metal residues fractionation using screens.

**Recycling of wood.** Wood is one of the most important materials of human life. The use of wood in the production of building materials, furniture manufacturing and in other sectors of economic activity is often uneconomical and is accompanied by the formation of a significant amount of waste (35 ... 45%), which can be recycled. Therefore, the processing of wood waste is one of the pressing issues of economical production [6]. The resources of the integrated use of wood include all lumpy waste from the woodworking industry, coniferous and deciduous low-grade wood (firewood), small-sized wood from thinning, bulk waste (sawdust) and bark, as well as logging waste (branches, branches, stumps), and even used wood panels (Fig. 1, a). The “Circular Pavilion” building follows the principles of circular economy, where one person’s waste is another person’s resource (Fig. 1, c). Thus, the façade is made of 180 wooden doors recuperated from the rehabilitation of an apartment building; the stone wool comes from the disassembly of a supermarket roof; the floor is composed of used wooden exhibition panels; the furniture is collected from the different junkyards in Paris; the lighting comes from obsolete street lights; the windows and the wooden strips are taken from Parisian building sites surp. Stemwood, which is the main object of forest exploitation, accounts for 70% of the total mass of the tree, the bark is about 9%, twigs 8, stumps and roots 13%. Thus, wood waste is represented by scraps of wood, roots, stumps, bark, wood chips, twigs, shavings and sawdust. Wood debris is produced in large quantities at enterprises engaged in woodworking, sawmilling, plywood, furniture, etc.

**Recycling of polymer woodworkings.** Plastics are used relatively little as secondary raw materials. This is explained by the variety of types of plastics, which in addition to polymers contain a large number of other components, which complicates the sorting and processing of plastic waste, especially household waste. In all civilized countries society is responsible for the proper disposal of plastic waste. The most environmentally friendly solution for the disposal of polymer waste lies in its recycling. Indeed, it is in this way that natural resources are saved and the environmental impact is minimized. The need for polymer processing is because for the complete decomposition of plastic products it will take about 150 years. Decaying, plastic releases toxic substances that adversely affect human health. Plastic processing is necessary for improving the ecology of our planet and the economical use of its resources; reduction of waste in landfills; creating raw materials for its recycling; creating fuel material [3]. The main directions of plastic waste disposal: landfill; processing using factory technologies; co-incineration of plastic waste with municipal waste; pyrolysis and separate burning in special furnaces; the use of plastic waste as a finished material for other technological processes. The processing of plastic waste by factory technologies can be considered as the optimal method of their use for obtaining building materials, including plastic blocks, bricks, profiles. Plastic bottle architecture is fantastic at turning a problem into an eco-friendly opportunity. The amazing EcoARK in Taipei (Taiwan) is one such example (Fig. 1, d). Built from 1.5 million recycled plastic bottles, this massive pavilion is surprisingly strong enough to withstand the forces of nature - including fires and earthquakes.

"Old-new" natural materials

In recent years, an ecological trend is developing in construction, which aims to use natural materials. These materials can be of both plant and animal origin. This eco-building model does not require high-energy expenditure for production and contributes to the development of energy-saving investments that meet current technical requirements. These types of products are perceived as healthy and cheap, in many cases locally available. In addition, the above material solutions can have a significant impact in modern construction due to the increase in prices of traditional construction products and due to energy savings during construction and when using the investment. Building materials of natural origin can be used as materials for thermal insulation, e.g. straw, sheep's wool or cellulose, and can be used as construction or finishing materials, such as plywood, wood fiber materials with external gypsum or
wooden board or clay plaster with straw [7]. Examples of materials of natural origin are: dried and compacted earth, wood, plywood, wood or hemp fiber insulation boards, straw, sheep's wool, cellulose, chipboard with an external gypsum board or wooden etc.

One of the oldest building materials is land. In each region and in the history of each country, we can find monumental buildings, as well as rural buildings made from land mixed with other natural materials. Buildings from the ground are seen as healthy, friendly to people and the environment [8]. Common soil products are unfired, dried bricks and blocks or walls made of rammed in formwork. Due to the potentially low production impacts, rammed earth has recently become a highlight amongst eco-friendly and sustainable architect for a vernacular green building material for its “Eco Houses”.

The next group of products is building materials made of fibers natural, such as flax, hemp or wood. These products are characterized by good heat and sound insulation. Their disadvantage is their flammability, which is why they must be protected with fireproofing impregnates. They are also not resistant to rodents and show poor resistance to moisture. They are often used with "housing", i.e. with gypsum boards, plasterboard or also wood-like ones [7].

Straw under the right conditions of collection is a very good heat-insulating material that can be used in construction. High heat engineering properties are possessed by wheat, rye and barley straw. A house that is built from straw or straw blocks is called an ecohouse (ecological house) and building houses from straw is called green building (Fig. 2.a). Every year a huge amount of straw is produced in the world, most of which remains in the fields or burned. This raw material can be used in construction, which would solve many social and economic problems in various countries of the world [9]. Straw is a renewable raw material that is cheap, easy to turn into building material, and also easy to dispose of after many years of use: burn or leave for decay in the open. Two types of straw blocks are used for construction: the first – from pressed dry straw, and the second - pressed straw blocks treated (coated) with clay mortar.

The technology of building houses from reeds has been developed. It provides the buildings’ construction based on wooden frame panels with reed stems; the reed cavity is covered with clay. Hemp fiber lay between them so that there are no bridges of cold. Then the panels are installed, plastered with clay and lime, and brick partitions are made inside. Reed mats are made on special machines - reeds are evenly placed between the wooden racks of the machine and pressed. The advantages of a house made of reeds are: environmental friendliness, resistance to decay, seismic resistance and ability to withstand strong winds, water resistance, low thermal conductivity (thermal conductivity of reeds is 4 times lower than that of wood; 7 times lower than that of brick), high noise insulation, does not require additional ventilation. Yet, with all the obvious advantages of a reed house, there are some points that need to be considered during construction. Bulrush is a natural material. Reed slabs and reed roofs are cellulose-containing building materials; therefore, they are fire hazardous and need to be treated with protective agents - flame retardant. This will not only create refractoriness, but also give water-repellent properties and provide bio-protection.

Sun-dried clay is one of the oldest building materials that has been used for more than 10,000 years to build houses, mosques, churches, palaces and cities. Currently one-third of the global population lives in this vernacular architecture made with the man-made stone-like construction material. This building material, commonly made from a mix of clay and organic materials, is resisting the long span of time and weathering (Fig 2, a). Used correctly, the clay making technology has many benefits: the technique used is very simple with zero maintenance cost, local availability and affordability, and has a good thermal and acoustic insulation. Because of this, earthen architecture has many advantages from a sustain ability perspective. The use of this eco-friendly construction material nowadays could be a viable alternative to solve our 21st Century big concerns of energy and climate change. For this reason, it is important to understand this material characterization, diagnosis and suitability in construction, and to understand how can it be a good construction material for a particular site [10]. Modern clay architecture uses clay tiles, bricks, plasters, beaten clay, ready to use mortar and other clay brick products made for different uses. The creation of expressive and interesting architectural forms using clay bricks is also possible by combining it with modern materials like glass or clean plastered surfaces that create
contrasting solutions One of the good examples of contemporary clay brick architecture is the famous Indian Institute of Management – Ahmedabad building.

![A cottage built using straw blocks](https://www.google.com/url?sa=i&source=images&cd=&cad=rja&uact=8&ved=2ahUKEwiE5JDqgsrMAhYtysKHahebDfixedQiR6hBAnBEAQ&url=http%3A%2F%2Fposelok.com.ru%2Ffoto-dom-i-iz-gliny-i-solomy.html&psig=AOvVaw25R5q&ust=1577130324176303)

![Load-bearing structures made of bamboo](https://www.lifegate.com/people/lifestyle/bamboo-construction)

**Figure 2.** Examples of using "Old-new" natural materials in architectural environment

**Bamboo** as a construction material is traditionally associated with the cultures of Central and South America, Asia and the South Pacific. It can be used to build entire homes and other structures that are earthquake-resistant and can survive strong winds and storms. Only a few of thousands of known bamboo species can be used for construction purposes. Bamboo, which may be cut and laminated into sheets and planks, is an ideal construction material as it is durable, sustainable, and environmentally friendly. It is as strong as steel in terms of tension, and because it is cylindrical and hollow, it is stronger than concrete in terms of compression, thereby giving it a high strength-to-weight ratio. It also weighs much less than traditional building materials such as wood, concrete, and steel. As a flexible material, bamboo may be curved or flattened by the application of heat and pressure (Fig. 2, b). It is also naturally water-resistant, so unlike wood, it does not have the tendency to warp due to heat or dampness. Bamboo has poor fire-resistance and limited durability when exposed to UV rays and humidity. This can cause excess swelling and the lack of humidity can cause shrinking and/or cracking [11]. At the same time, the use of this original material in Europe has been gaining ground recently. Bamboo is used as a facing and finishing material in the exterior decoration of various buildings, as well as decorative material in interiors.

**Nanomaterials**

An analysis of current trends in the introduction of new building technologies and materials in economically developed countries of the world suggests that the basis for the dynamic implementation in practice for the next 10…20 years will be materials and technologies obtained on the basis of achievements and developments in the field of nanotechnology [12]. The decisive factor is that the very nanoscale of the system components results in new functionalities and properties for improving products or developing new products and applications."

Today in the world with the help of nanotechnology on an industrial scale, cement, ceramics, metal alloys, plastics, paints and other materials with unique properties are produced. Nanomaterials are used to improve thermal properties, increase the efficiency of energy transfer, lighting, heating [12]. The use of nanomaterials in construction is important not only to improve the properties of materials, but also from the point of view of solving the problems of energy conservation and ecology.
The work of scientists in the field of nanotechnology in construction was reflected in the production of materials such as high-strength concrete, high-strength steel, structural composites, nanocoatings, innovative films, nanocomposite pipes, fiberglass composite reinforcement. Energy-efficient mineral-based heat-insulating materials with low thermal conductivity, sorption humidity and increased noise absorption, nanoscale organic-mineral modifiers for road concrete are being developed; nanometric metal-mineral biocidal additives for paints and varnishes, mortars and concrete, working in conditions of biological aggression; high-strength concrete with a low average density; nanometric compensators of internal stresses, etc.

Nanomodified concrete (including lightweight), taking into account its cost, is effectively used in the construction of high-rise structures; in bridge construction, road works and in the construction of hydraulic structures; in seismically active territories, regardless of climatic zoning. Structures do not require waterproofing, are characterized by high crack resistance. Also, such concrete can be used in interior design. For example, a high workability index allows you to create products by casting or other methods. Such concrete is used for the manufacture of original interior items, as well as countertops, sinks and other products.

Self-sealing multilayer composite nanomodified coatings with improved waterproofing and anticorrosion properties can be used for surfaces that work in an aggressive environment, as well as for decorative finishes, for example, for floor coverings. The use of composite reinforcement in concrete allows to increase such properties as corrosion resistance, durability, and also helps to reduce the weight of concrete structures. In addition, surface modification of such reinforcement using carbon nanocomponents increases its adhesion to concrete, increasing the strength and crack resistance of the structure at the macro level.

Thus, through the use of nanomaterials, one can easily control the structure, density and other characteristics of concrete. With the advent of nano-concrete, architects and designers have new opportunities for creating highly complex structures that allow the realization of the most daring architectural solutions [12]. In addition to the use of nanotechnology, all buildings of unusual shapes are modeled using programs in 3-d graphics. An example of such a building constructed using IT technology is the Guangzhou Opera House.

A great achievement in the field of nanocoatings was the imitation of the effect of lotus petals, which are completely invulnerable to water. "Lotus-Effect" is one of the best-known means of designing surfaces with nanomaterials. As a result, the building of the Bolshoi National Theater (architect Paul André) appeared in Beijing, its huge egg-shaped dome made of glass with nanocoating based on the TiO$_2$ catalyst, due to which the dome is not subject to contamination and wetting by precipitation and is capable of self-cleaning (Fig. 3).

Translucent nanocoatings have the ability to accumulate solar energy, so they can be used on windows and facades of buildings not only to create the effect of solar panels, which reduces energy costs, but also gives the facade a stylish look.

Nanoglass is obtained by applying a thin layer of In-SnO$_2$ metal oxides by pyrolysis in the process of producing float glass. The heat transfer coefficient of such glass is reduced by 70...80%, and the thermal conductivity of the glass with its use is 2...2.5 times. If a special composition with titanium oxide nanoparticles is sprayed onto the surface of the still-float glass, this coating ensures the neutralization of organic compounds on the glass surface and complete hydrophilization, which contributes to self-cleaning of the glass.

A product known as Nanogel, a form of aerogel, not only provides high performance thermal insulation but also effective sound insulation. It is almost as if it derives from another star, or at least fresh from the NASA laboratories. The latter is not so far from the truth, as this is where aerogels were first developed for various applications designed for outer space. In reality aerogel is relatively banal: it is simply an ultralight aerated foam that consists almost 100% of nothing other than air (the exact figure varies between 95% and 99.9%).
The remaining foam material is a glasslike material, silicon dioxide, also known as silica. In addition to its thermal insulating properties, aerogel also acts as a sound insulator according to the same basic principle. The air molecules immovably trapped in the nanopores of the aerogel stop sound waves from passing through the material.

The prospects for the further development of building nanomaterials are as follows: the foundations of buildings with a self-regulating system for compensating soil shrinkage; load-bearing structures of buildings, monitoring their own stress-strain state; building envelopes and roofs that accumulate the energy of the sun; coatings that respond to the psychophysical state of people, photocatalytic coatings. All these characteristics should become the basis of the modern “smart home” of the new generation.

The use of nanomaterials in construction: allows the use of new architectural solutions; reduces construction costs and the pace of construction of buildings; improves the quality of structures and its operational characteristics; contributes to the preservation of the environment; ensures compliance with safety standards and requirements; allows designers to adapt buildings to biologically similar forms, creating a model of architecture that fully interacts with the climatic, chemical, kinetic and social aspects of life, reducing the ecological footprint of modern society in an urban environment.

Conclusion
The need to ensure an ecological balance between meeting the modern needs of mankind and protecting the interests of future generations determines the current world construction trends, which indicate that the most promising direction is the development of architectural environment based on energy-saving technologies also environmentally friendly building materials. It is shown that all modern building materials should meet the requirements of the concept of sustainable development and green building. The modern problems of environmental protection are connected with the problem of energy saving. To solve these issues, it is necessary to analyze carefully building materials and choose those that will contribute to the efficient use of energy, greater comfort and lower costs taking into account the life cycle of the materials, which includes its production, use and disposal (recycling).

The leading components of a sustainable building architecture are the application of sustainable building materials such as organic compounds or recycled materials and the use of environmentally friendly methods of waste management. The key role is played here innovative materials, including traditional (“old - new”) building materials made on the basis of modern technologies. These types of products are perceived as healthy and cheap. In addition, the above material solutions can have a significant impact in modern construction due to energy savings during construction and when using the investment.

The use of nanomaterials in construction is important not only to improve the properties of materials, but also from the point of view of solving the problems of energy conservation and ecology. The use of
nanomaterials in construction: allows the use of new architectural solutions; promotes environmental conservation; ensures compliance with safety standards and requirements; allows designers to adapt buildings to biologically similar forms, creating a model of architecture that fully integrates with the climatic, chemical, kinetic and social aspects of life.

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