Eco-concrete as ecological solution for green building industry

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Abstract. The article discusses the environmental safety of construction production from eco-concrete. The purpose of the work is to assess the environmental hazard of building materials (for example, eco-concrete), in the production of which production and consumption wastes are used. In the process of research, the following tasks were solved: the chemical composition of eco-concrete samples was analyzed; a qualitative and quantitative assessment of the exhalation of potential chemical contaminants from concrete was given; the possible risk to human health from the emission of pollutants was assessed. The object of the study was eco-concrete. The tasks are solved by methods of searching for information on the issues under consideration within the framework of an analytical review with subsequent discussion and conclusions. It is known that in recent years, environmental impact review has become more demanding in assessing and permitting construction due to adverse experiences with adverse environmental impacts. As a result, general information was obtained about modern trends in the field of ecological construction.

1 Introduction

The problem of environmental pollution has been troubling humanity for decades. Comfort and safety are now in the first place in the design and construction of objects around a person. Environmental protection is also one of the priority tasks in any project, including in construction. Changes in the natural order and pollution of the natural environment lead to disruption of the overall balance of processes on Earth, which also significantly affects human life. The article discusses the most innovative environmentally friendly materials that have a wide potential for use in the construction industry and design. The authors selected and illuminated materials obtained as a result of the processing of natural raw materials and human waste, as well as those produced on the basis of biotechnology, which today is an urgent solution to the problem of environmental pollution.

Materials used for finishing external surfaces or internal premises should protect humans from pathogenic influences. The search for perfect materials is constantly going on, mankind produces experimental products using unique technologies, uses unusual raw materials. The most striking examples are the replacement of various building materials with something more environmentally friendly, for example, the use of eco-concrete in

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construction instead of ordinary concrete. This example will be covered in this article below.

Concrete (Fig. 1) - its use is no longer limited to the standard composition in the form of cement, crushed stone, sand and water. It is known that concretes are artificial materials obtained as a result of solidification of a thoroughly mixed and compacted mixture of a binder with water (less often without water), fine and coarse aggregates, taken in certain proportions.

Fig. 1. Concrete mix.

There is a lot of research going on to develop a more sustainable concrete with the goal of reducing the clinker content of the final product as much as possible.

Eco-concrete is the same scientifically grounded approach, plus chemical and non-chemical additives with the disposal of industrial waste from various industries, which ensure the environmental safety of the structure, taking into account the most important physical and chemical properties of water, without which an environmental conglomerate cannot be formed. The eco-friendly version of concrete, eco-concrete, has a strong porous structure in which concrete particles are glued to each other. The total pore space in the volume of the material is 15-20%.

Cement and concrete are both low environmental impact materials. The reason cement and concrete have a big impact on the environment is because we use them in large quantities. In fact, they have much less impact than any other substitute. Thus, replacing cement or concrete with other materials that have a greater environmental impact will not improve the situation.

Just because concrete or cement materials account for more than half of all building materials we use, their overall impact is quite high in terms of CO_2 emissions.

When calculating the environmental impact of concrete, you must also consider what happens after the demolition of the concrete building. Concrete can be reused and recycled - Aggregates from collapsed buildings can be used in unrelated applications such as road subfloors, or as aggregates in new concrete.

2 Materials and Methods

Materials of the analysis of the environmental safety of construction of structures are a very important item of reputable scientific publishers, information in the form of news and reports on environmental decisions in construction and operation projects from reliable sources. The methods are based on an extensive analytical review of the found up-to-date information with the subsequent classification of leading ideas.

At the beginning of the 21st century, Palingenesis Manufacturing Inc. (PMI) has developed a technology known as the "Palingenesis Process" to use solid household and construction waste as aggregate for concrete blocks.

This process is based on the technology of homogenization of cement with a fraction (from 25 to 40%) of pre-crushed and processed waste included in it. For the pre-treatment of waste and the binding of toxic impurities, proprietary chemical additives are used, including hydrogen peroxide (H_2O_2), hydrochloric acid (HCl), ferric chloride ($FeCl_3$), sugar, caustic soda (NaOH), etc. The goal of this process is to limit the spread of pollutants by leaching due to the high structural integrity of the final product. The bulk of the waste consists of solid municipal waste (screening - fraction 0-3 mm), which is hazard class IV - low-hazard waste and class V - practically non-hazardous waste.

The general analysis of the chemical composition of the concrete block samples was carried out using a certified X-ray fluorescence method (measurement error 20–35%). The study of concrete block samples for gas evolution was carried out using a climatic chamber with subsequent chemical analysis of the air mixture. Laboratory testing of the samples was carried out under the following conditions: exposure of the sample in a climatic chamber - 72 h; chamber volume - 2500 cm^3; the area of the samples is 2130 cm^2. Test conditions: temperature - 40 ° C; humidity - 45%.

3 Results

One of the ways to solve the environmental problem is the disposal of solid municipal and construction waste, where it is possible to use waste as a secondary raw material for the production of environmentally friendly building materials. But the uniqueness of environmentally friendly materials is not limited only to processing, their innovativeness also lies in the use of high-tech devices at the production stage. Concrete is still the most common building material due to the fact that it is relatively cheap, easy to use, durable, resistant to fire and explosions. As part of the production of eco-concrete, sand and gravel fillers are replaced with crushed waste, including construction waste (for example, frozen concrete crushed into pieces) (Fig. 2-3).

Fig. 2. Blocks from eco-concrete.

Fig. 3. Art blocks from eco-concrete.

After mixing the composition, concrete blocks are formed and can be used in construction. This technology is quite promising, because it will significantly reduce the volume of garbage disposal at landfills, reduce the cost of building materials, for example, paving stones, tiles, storm trays, blocks for low-rise construction. Only according to preliminary calculations, the cost of the blocks will be 10-15% lower than analogs on the market.

The results of quantitative chemical analysis made it possible to establish the content of 30 substances in the concrete block. The largest percentage is contained in the following elements: total carbon – 8%, total fluorine - 0,023%, Na_2O - 0,61 %, MgO - 1,63%, Al_2O_3 - 5,2%, SiO_2 - 23,9%, P (P_2O_5) - 0,15%, S - 0,3%, K_2O - 1,02%, CaO - 37,2%. Eco-concrete is a mixture of natural and man-made materials.

The results of the analysis of the concrete block for gas emission showed that the content of phenol, formaldehyde, acetone, benzene in the air does not exceed the permissible levels. The concentration of ammonia exceeds the maximum permissible norm by 13 times and is 0.53 mg / m3.

Modern technology for the production of concrete implies the presence of numerous organic additives, additives and modifiers introduced to regulate the properties of concrete, concrete mix and save cement. Under normal conditions, these compounds are stable in the alkaline environment of concrete and are held by its pores. However, when combined with other organic or inorganic compounds (especially typical for complex additives), a pressure of gases is created in the pores of concrete, which, being intensely released into the air of a dwelling, can intensify the process of decomposition of a nitrogen-containing substance with the release of ammonia.

The most likely significant sources of ammonia in concrete are:

1. Increased content of grinding intensifiers in cement (triethanolamine, etc.) - technological additives added during clinker grinding directly into cement mills in order to reduce energy consumption, increase grinding efficiency and obtain high fineness grinding;
2. Ammonized ash (fly ash) used as a mineral additive in cement and concrete;
3. Chemical additives-modifiers of concrete mix and concrete (ammonium salts, carbamide (urea), etc.), used as hardening accelerators and antifreeze additives and capable of forming ammonia.

An overdose of nitrogen-containing compounds is the reason for the significant release of ammonia from concrete. It depends mainly on environmental as well as human factors. So, in accordance with the standards, changes in the quality of cement produced with the

use of a grinding intensifier are not documented in any way, i.e. the manufacturer is not obliged to indicate in the passport the content and type of grinding intensifier. In this regard, it is necessary to obtain more complete information from the manufacturer, indicating in the material composition of the cement not only the type of grinding intensifier used, but also its amount.

Also, as a possible reason, it is possible to name the insufficient knowledge of the compatibility of such compounds with other components of the concrete mixture and concrete in general. The actual problems associated with the emission of ammonia from concrete are indoor air pollution, which causes uncomfortable conditions and poses a threat to human health, as well as a decrease in the strength and operational safety indicators of reinforced concrete structures. The potential risk to public health from inhalation exposure to ammonia can be reduced by applying methods to reduce ammonia emissions from concrete stone and using higher quality cement in the production of concrete products.

Currently, in order to get rid of concrete from ammonia and ammonia-containing additives, it is possible to use both physical and chemical methods. Physical include - intensification of air exchange, removal of ammonia from the gas phase, insulation of the concrete surface, heat treatment of the room, treatment of concrete with water. Chemical - processing of concrete with an aqueous solution of formaldehyde, application of a specially developed OxRed ammonia neutralizer to concrete structures. But these methods are ineffective and are mainly used during the targeted operation of concrete structures. That is why there is a need for research and development of new methods that will be obtained on the basis of the results of experiments. Upon completion of which we will gain the ability to reduce and neutralize negative the influence of nitrogen-containing concrete components not only during the period of their target operation, but also at the stage of preparing the concrete mixture.

The next example of a reinterpretation of concrete is translucent concrete. Hungarian architect Aron Losonczi, who invented litracon (transparent concrete), which is used as a material for the manufacture of translucent facade panels and partitions (Fig 4). About 5% of fiber-optic filaments are added to concrete with a standard composition, due to which it acquires a new property. Silhouettes can be seen through this material. Concrete with such a composition can continue to be used in load-bearing structures, since when adding fiber-optic threads, concrete does not lose its main property - strength.

To create environmentally friendly building materials, it is not at all necessary to recycle construction waste; pre-processed waste from other industries, for example, textiles, is often suitable. The main object of this invention is the possibility of an additional light source in a room.

The recycling process is as follows: textile waste is sorted, washed, cleaned with chemical agents, and deflated (the material is divided into separate fibers). Next, the resulting mass is pressed into wood fiber using a steam machine.

Fig. 4. Litracon - translucent concrete.

This type of ecological concrete consists of fine-grained concrete and fiberglass strands, which are laid in layers. The thickness of the threads reaches up to 2 mm and fill about 4% of the total mass. Transparent concrete is characterized by high compressive and flexural strength, excellent sound insulation, thermal insulation, and water resistance.

Today Germany is the leader in the production of light-conducting concrete. Special factories in this country produce litracon in the form of black, gray and white blocks measuring 1200 x 400 millimeters.

Litracon production is currently carried out using a complex patented technology. Finished products can be formed in the form of blocks or plates, under the influence of a press, or by means of a vibratory casting method. It is also mentioned that the finished product has a chaotic pattern on the surface, but on request, you can create a product with a specific pattern. In the process of creating blocks, fiberglass is stirred perpendicular to the front surface, and after they have hardened, the outer side is sanded with a special tool.

Litracon, which is a full-fledged composite material, demonstrates the following characteristics: flexural and compressive strength - over 2 MPa and up to 35 MPa, respectively; frost resistance - more than 75 cycles; water resistance - not less than W4; moisture absorption - less than 6%.

Such indicators allow the use of transparent concrete as the main material for the construction of buildings.

4 Discussions

Having looked at many examples of environmental solutions, we will highlight the main ideas.

The first example in Russia, involving a mandatory environmental impact assessment, involves the use of waste as a secondary raw material for the production of environmentally friendly building materials.

In the environment around us, there is a constant cycle of water. So, rainwater gets to the surface, it is absorbed by the roots of plants, the excess enters the groundwater.

After that, evaporation occurs through the leaves of plants and from the surface of rivers, lakes, reservoirs. In cities, excess water is discharged outside using a rain drainage system. This disrupts the natural cycle, which makes the plants lack water and the groundwater lacks the necessary nutrition.

If permeable concrete is laid in the city, it will allow water to pass through and provide liquid access to the ground. This reduces the load on the drainage system, especially during rainy periods.

In addition, eco-concrete is much cheaper than asphalt pavement. The low price is due to the fact that 25% of the material is air. It is also important to consider that ordinary asphalt is a petroleum product that contains a large amount of toxins that can pollute the air and harm human health.

Ecological concrete tolerates a harsh climate. For example, the material is resistant to temperature extremes. As a result, the city authorities do not need to frequently change the asphalt road. If permeable concrete is laid on the roads, then the service life will be about 15 years.

The porous structure of concrete is very popular in the United States of America and many European countries, where sidewalks, parking lots, highways, coverings for recreation areas, ceilings and retaining walls are made of such material.

Landscape designers and architects have already appreciated the possibilities of organic concrete, because it allows you to create different "green" areas and structures.

The second example is litracon, which contains extremely safe, environmentally friendly ingredients that do not contain harmful impurities. Therefore, its use does not harm human health and the environment, which is very important in the modern world.

The disadvantage of the building material under consideration can be called the fact that it cannot be obtained directly at the construction site of the construction object. To create litracon, a method of layering concrete mixture and fiberglass is used. In addition, ready-made blocks, immediately after the mortar has set, require special processing to ensure high-quality light-transmitting ability. Therefore, transparent concrete for construction is purchased in the form of ready-made blocks manufactured at specialized industrial enterprises.

5 Conclusions

The problem of utilization of production and consumption wastes is one of the most pressing problems of environmental management. The modern approach to its solution in developed countries is based on the following principles:

- reduction of the volume of waste generation;
- reuse without changing the physical condition;
- involvement in secondary use through recycling.

We estimate the production of concrete blocks using the resource-saving technology "Process Palingenesis" as promising, however, it is necessary to refine the composition of eco-concrete in order to reduce the risk of negative impact on the environment. To improve the quality of the product and increase the efficiency of the process, it is recommended to improve the concrete matrix through the use of innovative building materials and various modifications of cement.

The development of the optimal composition of eco-concrete using a binder component - cement with improved properties and the regulation of the quantity and quality of additives (modifiers, intensifiers) will increase the density, and hence the strength of the material, which minimizes the possibility of the release of chemical compounds in toxic concentrations, while increasing the quality of the product and the level of environmental safety.

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