Advanced technologies for the production and use of construction components

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Abstract. Currently, the shortage of resources and the imperative for their substitution give rise to the challenge of devising and implementing novel, cost-effective, and energy-efficient technologies for crafting building materials. The purpose of the article is to research production technologies and the use of construction components in manufacturing materials and products. The results demonstrate that the use of modern production technologies and the use of building components ensure more effective processing of the components as well as their preparation, processing, and application for manufacturing materials and products. Given the above, the use of modern technologies ensures resource conservation, properties enhancement of both materials and products (conductive, radiation-protective, physico-chemical), makes it possible to reduce the production cost and obtain high-quality construction products, address the problem of waste accumulation. Consequently, complex solutions are obtained as regards the problems of construction products' economy and environmental friendliness. In the scientific literature, special attention is paid to utilizing secondary resources in the production technologies of construction materials, solutions and concrete, which is gaining popularity among the relevant fields of scientific research. The applied use of construction component production technologies was examined using the example of Boss Technology's production of mineral powder for asphalt concrete mixtures.

Keywords: technologies in construction, construction components, construction materials, buildings, production technologies.

INTRODUCTION

In today's conditions of resources scarcity and the need for their replacement, the issue of developing and implementing new low-cost and energy-efficient technologies for the production of construction components comes to the fore. Enhancing the technological cycles of construction product manufacturing in the production facilities of the construction industry serves as a key driver for advancing competitive construction activities. The use of state-of-the-art technologies in the production of building components pertains new qualities to the final products, enhancing their strength, reliability, resistance to wear and tear, contribute to mitigating expenses associated with resource management during construction and allocating funds towards the production of building materials.

Purpose and methods of research

The purpose of the article is to investigate the methodologies of extracting, producing, and utilizing construction components in the manufacturing of materials and goods.

To achieve the goal, a detailed review of the scientific literature was undertaken, pertaining to the advancement and

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application of novel manufacturing methodologies as well as the use of building components in the manufacture of materials and products that contribute to energy efficiency, decrease resource consumption and reduce the cost of final products, thus having a positive impact on the environment. A detailed hands-on study examining the use of technologies by Boss Technology for the production of construction components was carried out on the example of the production of mineral powder for asphalt concrete mixtures.

RESULTS AND DISCUSSION

The scientific literature extensively examines production technologies and the application of construction components in the operational activities of construction enterprises. Pavlyuk and Lemeshev (2014) elaborate the use of industrial waste as components for the manufacture of composite building materials. Also, the said scholars analyzed the use of modern phosphogypsum processing technologies to obtain special-purpose construction materials. The complex resource-saving technology of manufacturing the composite material provided for the preliminary electromagnetic activation of the mixture of siliceous and metal components. Further, the following technological stage was the addition of a phosphogypsum and water mixture with subsequent blending of the constituent parts, which contributed to the intensification of physical and chemical interactions processes in the iron phosphate binder system. As a result, the use of complex resource-saving technology ensured the conductive properties of the composite material, and the manufactured samples can be implemented as elements of low-temperature underfloor heating systems for non-residential premises. Notably, the presence of conductive properties for floor covering elements will allow the installation of antistatic protection systems for industrial premises. Moreover, the use of complex resource-saving technology ensured the improvement of the products' radiation-protective properties, namely their acquisition of increased shielding characteristics compared to other materials with the same indicators of the average density of the products (Pavlyuk & Lemeshev, 2014).

This appears to be the case in a study conducted by Lemeshev, Sivak, Stadniychuk, and Sivak (2021), who investigate the practical possibility of the integrated use of phosphogypsum, metal sludge, and red bauxite sludge in the manufacture of construction products. The latter requires the development of new effective technologies for the processing and use of man-made industrial waste from the chemical industry. Such technologies should ensure the maximum degree of their use in the production of construction products. From this perspective, when choosing technologies for the preparation, processing and use of industrial waste, the said researchers take into account a number of factors, in particular the chemical and mineralogical, granulometric composition and the method of their production.

Furthermore, Berezyuk, Lemeshev & Hristych (2011) developed a new waste-free technology of phosphogypsum processing aimed at comprehensive processing of phosphogypsum waste, fly ash and metal sludge. Likewise, Marakhovska, Pavlenko, Kruglova, Platonenko (2011) elaborated and tested the sulfuric acid technology for extracting the final amount of titanium compounds from acid sludges for the purpose of comprehensive processing of titanium-containing waste. After extraction, the so-called secondary sludge is formed, which is 35-45% of the original material. The said sludge was investigated from the point of view of being utilized in the production of building materials, both separately and in a mixture with the original sludge.

On the other hand, Kucher and Lemeshev (2015) analyzed the prospects for the introducing modern technologies for the processing of industrial man-made waste for the purpose of obtaining special-purpose construction products. The scholars maintain that the use of metal

sludge of steel as part of a composite material makes it possible to obtain an electrically conductive material. Similarly, in the work of Cherepakh and Lemeshev (2019), it is proposed to use industrial waste from thermal energy enterprises and the chemical industry in the technology of manufacturing construction products. The use of such industrial waste is an economically beneficial and expedient solution. In the work of Pasenko (2013), technological solutions are proposed that ensure compliance with the requirements for resource conservation while implementing the technological process of construction; to reduce the cost of production and obtain high-quality construction products; to solve the problem of the accumulation of sludge waste from water treatment of thermal power plants and to reduce the anthropogenic burden on the environment. Drawing upon analytical studies, Serdyuk and Rudchenko (2020) show the prospects of using carbonate additives in the production technology of cement materials and autoclaved aerated concrete. From this perspective, Grabovchak (2013) devotes his dissertation research to the development of alkaline ash-containing cements due to the optimization of components in the system "ash - calcium-containing component - alkaline component - surfactant additive" and the technology of their use in concrete. Further, in the dissertation study of Sidlak (2015), the resource-saving technology of using fly ash in the production of construction mixtures was further developed, which will allow the use of up to 60% of activated ash as a binder. Accordingly, Hristych and Nesen (2023) substantiate the need for the development and implementation of new resource-saving technologies for the production of construction mixes using aggregates obtained as a result of complex processing of solid inorganic construction waste.

In the study of Muzira & Sych (2021), the complex technology of production of structural and heat-insulating wall products using industrial waste is thoroughly addressed, allowing for a significant expansion of the raw material base for manufacturing enterprises. Resource-saving production involves the use of physical-mechanical and mechano-chemical activation of man-made products to obtain complex binding systems due to the processes intensification of the structure formation of fine-grained concrete. It is worthy of note that research findings on the complex use of fly ash, phosphogypsum, Portland cement and fine-grained carbonate aggregate ensured the production of heat-efficient wall materials. Basically, in the production technology of heat-efficient building materials proposed by the authors, a comprehensive solution to the problems of economy and environmental friendliness of construction products was obtained. Moreover, the use of such technologies will contribute to reducing the costs of traditional energy-consuming binders for construction mortars and concrete. From this perspective, the applicable resource-saving technologies for obtaining new wall materials will satisfy the basic requirements for building materials: standardized strength indicators, increased water resistance, moisture impermeability and frost resistance (Muzira & Sych, 2021).

The study by Tverda et al. (2022) suggested a holistic methodology for resolving the issues of intensifying the extraction of construction raw materials and the production of construction materials in three directions (Table 1): 1) increase in production capacity, the introduction of economical explosive methods of destruction, the use of cyclic current technology in quarries of the construction industry, equipment modernization; 2) development of man-made deposits due to waste-free technologies of construction materials production; 3) disposal of construction waste and the use of man-made waste in the construction industry due to the reuse or processing of construction waste (for example, due to the use of technologies of mechanical, chemical and complex activation of ash and slag waste).

Table 1

Innovative technologies for extracting the construction raw materials and production of construction components and materials brokn down by directions

Direction	Proposed technologies of construction materials production.	Effects of technology implementation
1. Increasing the production capacity of mining and beneficiation plants without compromising the impact on the surrounding natural environment (improvement of mining technology or transition to resource-saving (waste-free) mining technologies, modernization of machines and equipment).	A cyclical-current technology for the production of crushed stone in granite quarries was developed. The said technology involves the use of a modern gyratory crusher, located on two paired ledges in the quarry area, and its combination with a steeply inclined conveyor. Two types of wellhead charges were developed, which, in addition to blocking explosion products, make it possible to completely neutralize harmful gases.	Reducing the number of intermediate transport and loading equipment and enhancing the quarry productivity, including the emergency seasonal works. Neutralization of harmful gases.
2. Development of man-made deposits.	A technological system for utilizing the mining waste for the production of glass fiber was developed. The said technology involves the extraction of rock from the dumps of stone crushing plants, fine grinding of waste.	Implementation of waste-free technologies for the production of building materials at mining and processing plants.
3. Utilization of construction waste and use of man-made waste in the construction industry.	Reusing individual components into the construction of new building segments (foundations, walls) or their individual structures (beams, slabs, columns) for their intended purpose. In the event that the primary plan cannot be implemented, the processing of technogenic, construction waste for their use as secondary (recycled) raw materials.	The reduction of raw material usage in the creation of construction materials is attributed to the repurposing or treatment of construction waste. Production of building materials with enhanced mechanical characteristics and high operational properties.

Source: systematized by the author according to the data of Tverda et al. (2022); Berezyuk et al. (2023); Kovalskyi, Burlakov & Kovalskyi (2020).

That said, within the scientific literature considerable emphasis is placed on the utilization of secondary resources and byproducts across diverse industries in the production technologies of construction materials, mortars and concrete, which are gaining popularity among the existing directions of scientific research. According to a study by Morkovska & Abdelrahem (2019), in most European countries the level of recycling of construction waste exceeds 90% on average. For instance, in the Netherlands, about 90% of construction waste is reused, in Belgium - 87%, in Denmark - 81%, in Great Britain - 45%, in Finland - 43%, in Austria - 41%. It is worth noting that overall, the average level of construction waste processing in the EU countries, according to data for recent years, is 28%, and the share of secondary construction raw materials there is growing rapidly.

Typically, building materials exhibit enduring properties over an extended period of time, being subdivided into natural (stone, lumber, clay, sand) and artificial (cement, glass, lime). Construction materials (natural and artificial stone materials, binders, polymers, metals, composite materials, wood) and special-purpose materials (acoustic, heat-insulating, roofing, waterproofing, protective, anti-corrosion) are distinguished by working conditions and purpose (Gudenko, 2010, 6).

Scientists refer to construction products as pre-made structural elements of houses and buildings - reinforcing mesh, embedded parts, window and door blocks, columns, trusses, beams, block rooms, etc. Building structures are products that exhibit the highest degree of technical consolidation and readiness (Gudenko, 2010, 7).

Accordingly, each type of building materials and products requires a specific production technology with its own regulations, mode parameters, the minimum amount of spent energy, raw resources, the achievement of cost-effective results and high quality indicators of finished products. Given the wide variety of specific technologies of materials and products, they also contain a number of typical operations (processing). This is due to the fact that they are based on the same physical or physico-chemical dependencies, similar kinematic schemes of action of equipment and machinery, general methods of using thermal or other energy and so forth. Typical transformations that determine the processes of structure formation in materials and products include as follows (Matsevich et al., 2022):

- preparatory works;
- mixing from dosed raw components;
- shaping of the resulting mixture (mass) and compaction of the molded products;
- special processing of compacted products until they are completely hardened;
- technical quality control of finished products;
- control over the condition of the technological regulation;
- transportation of raw materials and blended mixtures (mass);
- transportation of finished products;
- storage of raw materials and manufactured products (finished or semi-finished products);
- storage of materials in warehouses.

Building components are utilized in the process of manufacturing building materials and products: in particular, they include building raw materials for the preparation of mixtures, solutions, which in the process of mixing and production pertain new qualities and characteristics to building materials and products. It is the use of modern technologies in the production of building components that ensures the

improvement of the quality of building materials and products, and ultimately - economic effects (reduction of financial costs, resource costs), energy efficiency, enhancing the potency and durability of the final building materials.

From the standpoint of modern technology, efficient utilization of material, technical and energy resources alongside with the enhancement of work methodologies, as well as implementation of effective methods of technological preparation for the execution of construction processes are crucial factors in increasing the efficiency of construction production. The complex of these issues is an integral part of construction production technology. Given the above, technology is a set of methods of manufacturing, processing, changing properties, internal state, shape of material, semi-finished products in the process of manufacturing products. Construction technologies are elaborated as a result of applied research that reveals the patterns of effective application of chemical, physical, biological, socio-economic and other natural and artificial processes or phenomena. That being said, such studies are the subject of the technology of construction processes as a science (Gudenko, 2010, 8).

A critical take-away from these analyses is that contemporary construction technologies draw upon the execution of construction processes by complex mechanized methods with extensive use of automation systems for individual technological processes and operations, diagnostics of the technical condition of machines and optimization of their use parameters. The use of robotic technological complexes is ever increasing during the execution of earthworks, assembly, concrete, painting and other works and processes, flexible automated productions - factories and installations for the preparation of semi-finished products (construction mortars, concrete mixtures, paints, etc.), manufacture of reinforcing products and structures, etc. Moreover, the multi-purpose construction machines, which are equipped with a special working body (oftentimes two or more) is growing, which makes it possible to perform several work operations with one machine.

Let's delve deeper into the practical application of construction component manufacturing technologies by examining Boss Technology's production of mineral powder for asphalt concrete mixtures. Mineral powder is a crucial ingredient in the concrete industry as it reduces cement usage and boasts superior characteristics, due to cutting-edge equipment employed during its production.

In the production of mineral powder, the Boss Technology company uses two complexes for the production of crushed stone, granite crushed stone, and mills, due to which high-quality mineral powder is obtained.

Mineral powder as a building component pertains the following improved properties to the concrete: endurance, reliability, elasticity, wear resistance.

Mineral powders have gained widespread usage in the construction sector, as they are utilized to impart novel properties to mixtures, to reduce the amount of cement in the construction process. It should be noted that the said powder is produced from natural raw materials or those obtained by technical means (waste from blast furnace production, slag, ash, ground rock, microsilica, etc.).

Mineral powders, which are as a matter of fact additives for making concrete, are subdivided into activated and non-activated products, as well as MP1, MP2: MP1 is made from carbonate rocks; MP2 is obtained from slags of steel production.

In fact, additives differ from fillers in their small size - grains not exceeding 0.03 - 0.16 mm. When preparing a concrete mixture, cement and mineral additives (MA) fill the voids, which significantly strengthens the structure of the finished solution. The above method of preparing concrete helps to reduce the amount of cement required for work. Accordingly, the

components that are added to the solution to reduce the amount of cement used are usually called fillers, so if with the help of MA it is possible to reduce the proportion of cement in the mixture, then in this case they actually become mineral fillers.

Among the MA types there are those that have the ability to harden independently, increasing the strength of concrete. Such additives include ground blast furnace slag, which begins to harden quickly after adding lime to its composition. The composition of its particles has a significant influence on the MA characteristics - it determines the ability of components to react chemically, the expected density of concrete. Natural MA is obtained by grinding rocks of sedimentary or volcanic origin. Additives produced from technical raw materials (ashes, slags) have different mineral composition, particle size and affect the efficiency of their use in concrete.

The fractional composition of mineral powder roughly corresponds to regular cement. In the course of producing the mineral powder, in particular at the stage of grinding limestone into powder, the raw material is dried, otherwise the construction component will not be applicable in the production of asphalt and dry construction mixtures.

When it comes to technologies of using mineral additives, those are most often used as substitutes for cement. Technologically, they are added during the clinker grinding process or directly during mixing. Their cost price is low, and their presence in the concrete mixture gives a significant economic effect.

Microsilica is considered one of the most active technical MAs. It has viscous properties with a pozzolanic effect: it reacts with the components of concrete, improving its properties. Microsilica is a peculiar ball of microscopic size in fractions of microns. On the outside, it appears to be similar to dust, formed by small elements of silica. The presence of millions of such particles in the mixture helps to evenly mix the components, providing greater convenience in laying the concrete mixture. MAs are frequently utilized for the production of a mixture that is used in high-altitude works due to the ease of transportation with the help of a special pump.

Furthermore, TPP ashes produced during coal combustion are widely used as additives. Ashes can contain calcium oxide in different quantities - their use depends thereon. Ashes with a high percentage of CaO are typically utilized where concrete does not require special durability. Conversely, the low-calcium ashes in the presence of water and lime form hydrosilicates and hydroaluminates of calcium - the principal components of cement stone.

CONCLUSIONS

The application of the state-of-the-art production technologies and the use of building components ensure more effective processing of the components, preparation and processing thereof as well as utilization for the manufacture of materials and products. The use of modern technologies ensures resource conservation, enhancement of materials and products (in particular, as regards their conductive, radiation-protective, physico-chemical properties), reduction of the cost of production and obtaining high-quality construction products, addressing the issues of waste accumulation. Consequently, comprehensive solutions to the problems of economy and environmental awareness in terms of construction products are achieved. That being said, in the scientific literature special attention is paid to the use of secondary resources in the production technologies of construction materials, solutions and concrete, which is gaining popularity among the existing directions of scientific research.

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