

TECHNOLOGY AND ORGANIZATION OF CONSTRUCTION

ТЕХНОЛОГИЯ И ОРГАНИЗАЦИЯ СТРОИТЕЛЬСТВА



UDC 69.07:693

Subject Field Overview

<https://doi.org/10.23947/2949-1835-2026-5-1-68-78>

General Trends in the Development of Construction Technologies

Albert Kh. Baiburin , Andrey A. Melnik , Anna R. Lebed 

South Ural State University, 76 Lenin Ave., Chelyabinsk, Russian Federation

✉ abayburin@mail.ru



EDN: HSTYXP

Abstract

Introduction. The construction industry depends largely in compliance with the laws of the market with no in-depth analysis of its development trends as a system. Government regulation of the industry fails to make a full use of an evidence-based predictive analysis, but rather is more frequently guided by international experience in the form of small data. The aim of the study is to bridge this gap by means of a general overview of the research related to the general patterns of the development of construction technologies.

Materials and Methods. The research included the search for information from open sources, its analysis and synthesis in order to identify the general trends in the development of construction technologies. Materials from the authors' research were employed. The analysis was conducted using the laws of the development of technical systems.

Research Results. The stages of the evolution of building technologies including prefabricated, monolithic, and precast-monolithic methods are discussed. Ways of improving building materials by means of increasing their physical and mechanical properties, reducing weight, and lowering harmful emissions and costs are also identified. It is noteworthy that the improvement of these materials by their direct relationship with structures results in their dynamic development. It is found that the improvement of materials due to the direct relationship in the system with structures also leads to their dynamic development, they become more durable, lightweight, multifunctional and influence architectural and planning solutions increasing useful selling space. Issues hindering the development of digital technologies for the manufacture of structures are noted: control of early hydration of 3D-printed concrete and a relationship with rheology, ensuring interlayer adhesion, strength, introduction of automated reinforcement and generally the relationship between technology, material and performance characteristics in terms of both structural strength and durability. The basic requirements for the design of buildings and structures and their parts are designed: saving space, materials and energy through integrated design, which includes the integration of all the building systems (structural, mechanical, hydraulic, air and electrical) into a single system. The development of the technology of large-block (modular) construction is considered including the research of SUSU employees on the technology of sinking concrete. Attention is paid to the global experience of modular construction and the direction of development of modular integrated systems.

Discussion and Conclusion. It is concluded that the general trends in the development of construction technologies include: acceleration of large-block (modular) and monolithic construction by improving materials (high-functional concretes, enlarged reinforced frames, fibers), use of automated efficient mechanisms, prefab elements, equipping modules with engineering networks; reducing the complexity and increasing the manageability of construction production by reducing labor costs in the proposed construction technologies, automation and digitalization of the major processes; use of information modeling technologies, neural networks, and rational layout of the interior of a building in complex design; improving the functionality and aesthetics of facade technologies.

Keywords: construction technologies, monolithic construction, 3D printing, modular construction, high-functional concretes, digitalization of construction projects, energy saving of buildings, prefabricated structures, robotization of construction.

Acknowledgments. The article was prepared with the support of the development company "Brusnika". The authors would like to thank the staff of the Department of Construction Production and Theory of Structures at South Ural State University who participated in the research on the technology of sinking concrete along with the authors of the article.

For citation. Baiburin AKh, Melnik AA, Lebed AR General Trends in the Development of Construction Technologies. *Modern Trends in Construction, Urban and Territorial Planning*. 2026;5(1):68–78. <https://doi.org/10.23947/2949-1835-2026-5-1-68-78>

Обзор предметного поля

Общие тенденции развития строительных технологий

А.Х. Байбури́н  , А.А. Мельник , А.Р. Лебедь 

Южно-Уральский государственный университет, Российская Федерация, г. Челябинск, пр. Ленина, 76

 abayburin@mail.ru

Аннотация

Введение. Развитие строительного комплекса происходит, главным образом, по законам рынка без глубокого анализа тенденций его развития как системы. Государственное регулирование отрасли не в полной мере использует прогнозный анализ на научной основе, а чаще ориентируется на мировой опыт в виде мало связанных данных. Цель работы – восполнить этот пробел общим обзором исследований с привязкой к общим закономерностям развития строительных технологий.

Материалы и методы. Исследование включало в себя поиск информации из открытых источников, её анализ и обобщение с целью определения общих тенденций развития строительных технологий. Использовались материалы авторских исследований и практического опыта строительства. Анализ проводился с использованием законов развития технических систем.

Результаты исследования. Определены этапы эволюции технологий – сборных, литевых (монолитных) и сборно-монолитных) – и пути совершенствования строительных материалов с повышением их физико-механических свойств и одновременным снижением массы, вредных выбросов, стоимости. Выявлено, что совершенствование материалов за счет прямой взаимосвязи в системе с конструкциями приводит также к их динамичному развитию, они становятся более прочными, легкими, многофункциональными и влияют на архитектурно-планировочные решения, увеличивая полезное продаваемое пространство. Отмечены проблемные вопросы, сдерживающие развитие цифровых технологий изготовления конструкций: контроль ранней гидратации 3D-печатного бетона и связь с реологией, обеспечение межслойного сцепления, прочности, внедрение автоматизированного армирования и, в целом, связь между технологией, материалом и эксплуатационными характеристиками как с точки зрения структурной прочности, так и долговечности. Сформулированы основные требования к разработке проектов зданий и сооружений и их частей: экономия пространства, материалов и энергии за счет комплексного проектирования, включающего объединение всех систем здания (структурных, механических, гидравлических, воздушных и электрических) в единую систему. Рассмотрено развитие технологии крупноблочного (модульного) строительства, в том числе и научные исследования сотрудников ЮУрГУ по технологии опускающегося бетона. Уделено внимание мировому опыту модульного строительства и направлению развития модульных комплексных систем.

Обсуждение и заключение. Сделаны выводы о том, что к общим тенденциям развития строительных технологий можно отнести: ускорение крупноблочного (модульного) и монолитного строительства за счет совершенствования материалов (высокофункциональных бетонов, укрупненных армокаркасов, фибры), применения автоматизированных эффективных механизмов, префаб-элементов, оснащения модулей инженерными сетями; уменьшение трудоемкости и повышение управляемости строительного производства за счет снижения трудозатрат в предлагаемых строительных технологиях, автоматизации и цифровизации ведущих процессов; использование в комплексном проектировании технологий информационного моделирования, нейронных сетей, рациональной компоновки внутреннего пространства здания; повышение функциональности и эстетичности фасадных технологий.

Ключевые слова: строительные технологии, монолитное строительство, 3D-печать, модульное строительство, высокофункциональные бетоны, цифровизация строительных проектов, энергосбережение зданий, префаб-конструкции, роботизация строительства.

Благодарности. Статья подготовлена при поддержке девелоперской компании «Брусника». Авторы благодарят коллектив кафедры строительного производства и теории сооружений Южно-Уральского государственного университета, участвовавший в научных исследованиях технологии опускающегося бетона совместно с авторами статьи.

Для цитирования. Байбурун А.Х., Мельник А.А., Лебедь А.Р. Общие тенденции развития строительных технологий. *Современные тенденции в строительстве, градостроительстве и планировке территорий*. 2026;5(1):68–78. <https://doi.org/10.23947/2949-1835-2026-5-1-68-78>

Introduction. The development of construction technologies is in line with the general patterns of development of technical systems: S-shaped development; completeness of system components; "energy conductivity" of a system; coordination of the rhythm of system components; uneven development of system composition; transition to a suprasystem; displacement of a human and an increase in the level of controllability; dynamization. These patterns have a multiplicative character, i.e. the implementation of one law occurs through the action of others. These trends can also be traced in construction while investigating the interaction of the "materials — structures — building parameters" system. The aim of this literature review is to identify the relationships and patterns of interaction between the elements of the system in order to concentrate on the most important and promising areas of development of the construction industry, which will be beneficial for all parties involved in a construction complex and student instruction.

Materials and Methods. The study employs the classical method of reviewing scientific literature with an analysis of a variety of factors and features identifying the relationships of elements in the construction system, promising areas of development, undesirable effects and possible ways to minimize them. Based on the considered information sources, the research data was systemized and generalized, hypotheses were set forth. According to the sources, the most important and informative ones were selected, including foreign and domestic ones, as well as describing the article authors' own developments.

Research Results. Based on the analysis of the global experience provided in the information sources, in the construction sector it is possible to note the evolution of the major technology options for the production of building structures (prefabricated, cast (monolithic) and prefabricated ones):

- hand-made masonry of small and large blocks, wooden products;
- mechanized installation of enlarged products (shields, panels, modules, blocks of large-span coatings);
- mechanized installation of enlarged products of increased or full factory readiness (with windows, trim, engineering systems) — the so-called prefab elements;
- automated and robotic assembly of prefabricated products.

These are not only materials for prefabricated construction that are evolving, but also methods of connecting prefabricated elements: from wet processes and labor-intensive welding, they are moving to dry and technological connections (bolted, pin, coupling, loop, etc.).

In injection molding technology using concrete solutions and other building mixtures, the same stages are observed with the displacement of humans and the increase in controllability:

- manual injection molding technology;
- mechanized production, transportation and laying of mixtures;
- use of formwork units and reinforced formwork blocks;
- robotic technology for 3D printing and installation of buildings from pre-printed 3D blocks.

At the same time, materials are being improved with an increase in their physical and mechanical properties and a reduction in weight, harmful emissions, and cost. On top of that, the development of materials is moving from the macro to the micro and further to the nanoscale. The prediction and design of material properties first takes place at the level of macrostructures, then molecules, atoms and elementary particles. Traditional concretes are being replaced by highly functional, high-strength, self-sealing ones with extensive use of mineral and chemical additives. New functions of materials are emerging, such as self-purification by adjusting the microstructure using photocatalytic additives.

Heat-efficient hollow bricks and stones are replacing solid ones. According to the development line of technical systems, the next step should be a capillary-porous material (CPM) with a certain structure, e.g., increasing the vapor permeability of a material from the inner surface to the outer due to the size of the pores. Pores can be filled with another substance, such as glue that will be released from the surface layer of the wall blocks holding them together. Due to the controlled microstructure, the principle of self-renewal of paints on the facade can be implemented.

Various building composites with special properties are broadly employed: self-cleaning; healing of cracks; absorption of greenhouse gases. Simple reinforcement of cast structures is being replaced by an adjustable prestressed or ferromagnetic fiber with the ability to control the magnetic and thermal fields.

The evolution of materials is the foundation for improving structures. Structures are evaluated by specific indicators of the ratio: mass to span, height or overlapped area; operational characteristics (strength, heat resistance, sound insulation, durability, etc.) to their own weight, cost of production and installation. These simple relations expressing the law of increasing the degree of ideality show how progressive changes occur in building materials, structures and structures over time.

Recently the term "digital concrete production" has been coined [1]. Digital methods for production of concrete and binders have become the subject of a great number of studies and industrial activity, and the industrialization of technologies such as 3D printing is becoming more and more realistic. The potential for revolutionary changes in construction is growing not only by means of reducing costs, but also by increasing environmental sustainability and functionality. The problems associated with materials for printed concrete are plenty. The major ones are control of early hydration and a relationship with rheology, provision of interlayer adhesion, strength, introduction of automated reinforcement and generally a relationship between technology, material and performance, both in terms of structural strength and durability. An interdisciplinary approach is crucial as this field brings lots of disparate areas together and has so far been driven only by areas such as architecture and construction.

New structures, becoming more durable, lightweight, and multifunctional, affect architectural and planning solutions, increasing the useful selling space. A simple example of such a solution is obvious while replacing a frame with crossbars protruding beyond the ceiling plane with a frame with "secret" crossbars forming a flat ceiling together with the ceilings (e.g., houses of the MKT construction built in Miass, Chelyabinsk region). So, if the bolt protrudes beyond the ceiling plane by 30 cm, in a 10-storey building when smooth ceilings are installed, a full floor is lost. In office, commercial, and sports buildings, loss of space is associated with installation of dimensional engineering systems at a ceiling or floor level. Reducing the thickness of external enclosing structures by means of innovation provides significant savings in usable space in multi-storey buildings. The "3 for 2" concept (3 floors for 2) is aimed at saving space, materials and energy by means of integrated design [2]. As the world adapts to the twin trends of climate change and urbanization, high-rise office buildings in hot and humid climates are the first in line for a significant change in design approach. An integrated design approach pays special attention to reducing the size of engineering communications introducing a new paradigm for optimizing use of space, materials and energy in buildings: integrated integration of all building systems - structural, mechanical, hydraulic, air and electrical ones - throughout the life cycle of a building from early design to construction and operation.

The "3 for 2" concept has been implemented in a pilot project of a non-profit international school in Singapore¹. In Singapore's new commercial buildings, up to a third of the enclosed volumes are typically occupied by technical systems and structural elements taking up valuable space that could otherwise be reserved for residents. The standard centralized air conditioning systems currently in use are among the main consumers of this space. The 3 for 2 project demonstrates air conditioning technologies that were previously seldom used in commercial buildings in Southeast Asia, such as passive cooling beams and distribution ventilation systems.

The review "The Science of Concrete: the Past, Present and Future of Innovation" [3] notes that concrete, as the most commonly used building material, is rapidly evolving, but at the same time is facing challenges in terms of environmental impact, financial needs, public recognition and image. Studies of radical changes in three major aspects of concrete use are relevant: reinforcement, binder content, and manufacturing methods. It is assumed that, along with introducing robotic production methods, digital technologies can be key to introducing a number of innovations: reinforcement with no reinforcement bars using non-convex granular media; concrete structures optimized for compression using topology optimization, architectural geometry and 3D printing or origami-style formwork; genuinely digital concrete due to a combination of mass data collection and deep learning.

However, interlayer bonding is paramount for printed concrete as well as for traditional concrete. The bonding strength during the multilayer laying of self-sealing concrete was studied in [4]. SUSU studies [5, 6] indicated a positive effect of

¹ United World College, Singapore. URL: <http://www.systems.arch.ethz.ch/de/research/synergistic-buildings/3for2-beyond-efficiency.html> (accessed: 18.07.2025).

acoustic treatment of concrete on its water absorption, which increases the adhesion to old concrete, and also improves the quality of technological joints using printed matrices, various adhesives, additives, and slag-alkaline concretes.

For 3D printing of concrete, the problem of adhesion is addressed by installing reinforcement or introducing fiber into the mixture. As the use of steel reinforcement is compulsory in most building structures, there is an urgent need to develop reinforcement technology for 3D-printed structural elements. In [7], a justification was carried out for 3D printing of steel reinforcement using arc welding with a metal electrode in a protective gas environment. The mechanical characteristics of the printed rods demonstrated comparable mechanical properties to conventional steel reinforcement of the same diameter.

We find it reasonably more technologically advanced to make use of an additional 3D printer manipulator that unwinds and cuts wire reinforcement into the necessary segments, or to make use of fibers from various materials. The results of such developments were reported at the First RILEM 2018 International Conference on Digital Concrete.

It was noted that most studies of printed concrete had been conducted on small models and failed to take large-scale effects into account. Currently, bridges have been implemented among large-scale digital concrete (DFC) structures (e.g., in China, the Netherlands, and Spain), as well as two-storey houses printed in 22 days in China. Large-scale tests of elements manufactured using DFC technology have shown [8] that caution is required as tests of materials related to DFC are being developed, and the large-scale effects of DFC have not been studied in practice. Therefore, it is recommended that large-scale tests in the range from 1:5 to 1:1 are conducted if DFC is applied to responsible structures.

Another significant downside of printed concrete is its low productivity of digital DFAB production in construction. In [9], the costs and time for the robotic construction of a wall was analyzed. In this example, it was found that productivity was higher while using the robotic construction method for complex walls (e.g., an exterior and decorative one), which indicates a possibility of obtaining significant economic benefits from using additive DFAB specifically for construction of complex structures. However, DFC technology is not applicable for high-rise buildings. However, this does not mean that the traditional technology of prefabricated and monolithic housing construction will not be automated and robotized. Back in 1995, an all-weather automated system for the construction of high-rise reinforced concrete buildings was presented at a conference in Belgium [10]. For the first time in the world, it had been used in the construction of a 15-storey reinforced concrete building in Chiba Prefecture in 1995 (Fig. 1).

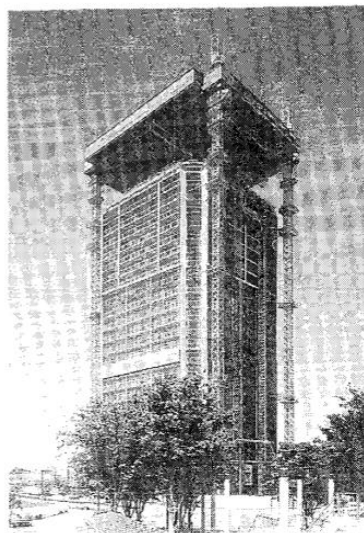
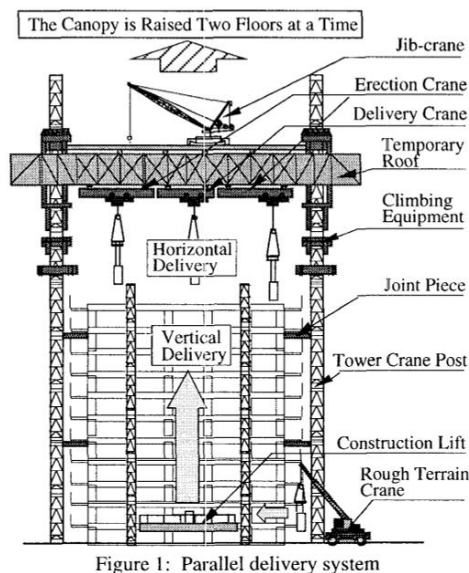


Fig. 1. Automated high-rise building construction system [10]

This system includes four major elements:

- 1) synchronously rising all-weather temporary structure;
- 2) parallel material supply system;
- 3) factory production and unification of building materials;
- 4) material management system.

It ensures high quality, improves working conditions, reduces construction time, labor force and waste, and increases the overall productivity. As shown in Fig. 1, in the BIG CANOPY project a parallel element supply system was installed for three automated overhead cranes to be set up and one large construction lift under an all-weather lifting temporary mounting beam.

The project makes use of a materials management system using a database linked to the CAD system, unification of building materials, factory manufacturing, as well as parallel installation. The major advantages of the technology are increased productivity and quality; shorter construction time; improved production conditions (workers can safely and comfortably work under a temporary roof); reduction in the amount of garbage.

A similar technology (only related to injection-molded structures rather than prefabricated ones) has been patented and is being developed at the SUSU Department of Construction Production and Theory of Structures [11–13]. The shuttering system is made up of two vertical decks with minimal expansion at the bottom. Vertical decks are stationary. The horizontal deck located between them is lowered or raised with hydraulic jacks. The horizontal deck is connected to the lifting or lowering mechanisms with a metal vertical rod. The new technology is a kind of anti-sliding formwork system that moves upward.

The process is performed as follows: in the initial state, the horizontal deck of the formwork is lowered relative to the top of the vertical deck. The composite material (concrete mix) is fed into the formwork where the mix is placed in the space between the horizontal and vertical deck. There is a film between the concrete deck system which moves downwards with the mixture. This method removes effects such as adhesion and cohesion leaving only a minimum friction between the film and the vertical deck and provides protection against premature drying of the concrete. The first layer of the concrete mixture gains a specific strength with a possibility of heat treatment, acoustic and other effects on the working seams. The horizontal deck is lowered with jacks along with the first layer down. Then the second layer is laid on the first one and having gained strength, it descends. The third layer is laid (Fig. 2). Then the lower sufficiently hardened layers extend beyond the vertical deck, etc.

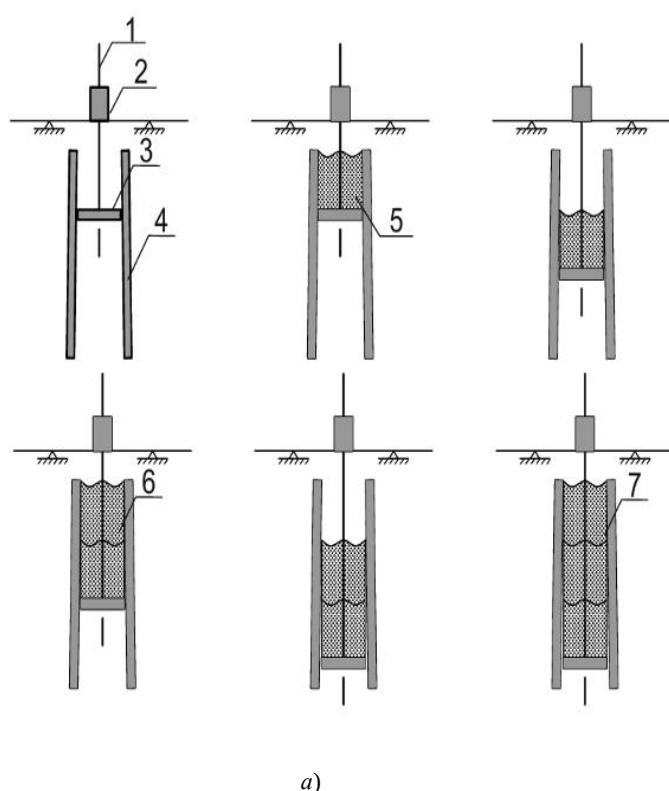


Fig. 2. a) method of forming reinforced concrete structures by means of lowering concrete (patent 2566540):

1 – metal rod or cable; 2 – lifting and lowering equipment (hydraulic jack); 3 – horizontal deck; 4 – vertical deck; 5 – first layer of concrete; 6 – second layer of concrete; 7 – third layer of concrete; b) experimental SUSU setup for the technology development

The technology of sinking concrete can be employed for construction of deep underground structures (mines, hazardous waste storage facilities, underground military installations, etc.), underwater structures on a shelf, manufacture of block rooms in mobile workshops for modular construction, etc. Structures lowered by means of the counterweight

method can provide lifting of aboveground structures by implementing the top–down construction technology. The advantage of the new monolithic technology is the immobility of the formwork system and a possibility of equipping complex systems for processing and monitoring the condition of the concrete mixture and concrete under protection from external influences, up to full automation of production processes.

Automation of the installation of multi-storey buildings was proposed back in the USSR by replacing free installation with cranes for forced installation with manipulator cranes² [14]. A traditional mounting crane provides only one of the 16–20 operations of the assembly of prefabricated structures, and the remainder are performed manually by workers whose labor costs are 4–5 times more than the operating time of the crane. Experiments were performed with an automatic crane based on the BKSM-5–5A tower crane, but a low positioning accuracy of ± 20 cm was obtained, which prevented a transition to industrial development accuracy of ± 20 cm was obtained, which prevented a transition to industrial development.

In Japan, a two-stage system is employed controlled by a single operator and consisting of free feeding of the prefabricated element by a conventional tower crane and a robot (manipulator) installing the element at the design location.

In Russia, three variants of forced installation have been developed. The idea behind the new method is that in order to increase the productivity and accuracy of installation, the mounted element is gripped rigidly and fed into the design position with registration of linear and angular displacements along the three axes X, Y, Z (in six coordinates). At the same time, there is a task of ensuring the stability of the elements after their installation and uncoupling of the crane handle. This is achieved by using the spatial self-fixation method using locking traps of various designs, which at the same time reduces the requirements for positioning accuracy. A manipulator crane with a rigid connection between the working body and the transportation device has been developed that has a minimum required number of degrees of freedom of the movement device, and thereby a minimum number of drive mechanisms.

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However, the suggested sparsely populated technologies were not commonly used in the USSR due to the lack of digital design, the complexity of the design of cranes, gripping devices, and the need to retrofit prefabricated elements with self-locking devices. As the rest of the operations (suturing, welding ties, sealing) are performed manually in the traditional way, there is a law of uneven development of parts of the system and misalignment. As shown by the further development of the construction industry, complete robotization was achieved not in the assembly, but in the injection molding technology of 3D printing, and only when the power of computing complexes had allowed to carry out digital building projects [15], and the rheology of concrete composites had been managed [3].

The record of Chinese builders who had worked on a prefabricated 10-storey building in 29 hours was confirmed by means of the method of the fastest construction of large blocks (prefab blocks, modules). Block rooms were designed in a few cities of the USSR (Krasnodar, Minsk, Verkhnyaya Salda, etc.) but were limited by the lifting capacity of cranes and transport dimensions. The incentive for the development of that type of housing construction was a number of advantages of those houses over large-panel ones [16, 17]: manufacturing volumetric blocks of full factory readiness in factory production with built-in furniture, plumbing and electrical equipment; transferring 85% of labor costs to a factory or house-building complex; reducing labor costs on the construction site to 25%; reducing the number of mounting elements by 4–5 times; reducing construction time by 3–4 times; reducing labor intensity by 2.5–2.8 times; reducing concrete consumption by 25–28%; significantly reducing overhead costs and costs for temporary facilities, etc.

The sizes and weight of the reinforced concrete blocks were small. The Krasnodar House-Building Plant produced blocks in the form of a ribbed box of the "lying glass" type measuring 3□5 m and weighing 5–9 tons depending on the

² Vilman YuA Technology of Construction Processes and Construction of Buildings. *Modern Progressive Methods: a Textbook*. Moscow: ASB; 2011. 336 p.

equipment. The modular product of JSC SZ "OBD" in Krasnodar has presently been significantly improved and reaches a weight of 20 tons and allows for the construction of a 16-storey building (16,000 m²) in 4 months. Minsk "cap" type blocks of approximately the same size and weight were used for three-dimensional block houses of the 3A-OPB series. Since 2012, the block house construction plant "Choice-OBD" has been operating in Voronezh for the production of reinforced concrete modules of the „cap“ type [18].

The development of the construction industry has now made it possible to significantly increase the size and weight of modules for block construction. The Moscow plant of Concern MonArch LLC (Fig. 3) produces the world's largest room blocks with dimensions up to 15,5×7,5×3,75 m, with an area of over 100 m² and weighing up to 40 tons in a basic frame and 55–58 tons with complete finishing.

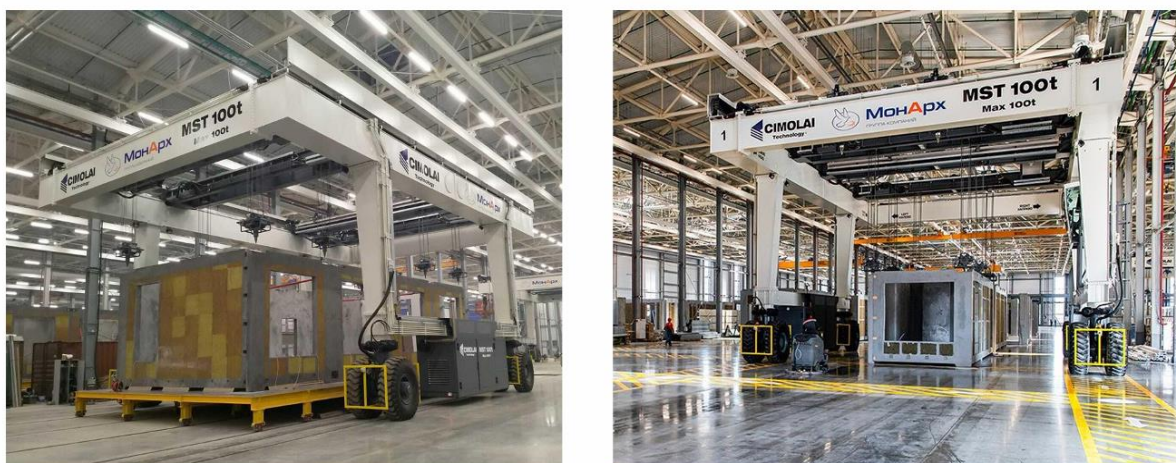


Fig. 3. Technological portal conveyor (Q=100 t) for conveyor assembly of MonArch Group modules

The technology allows for the installation of 25 modules (1800 m²) per day, 450 thousand square meters of ready-made housing per year. For the first time the world has witnessed the production of three-storey modules for stairwells and elevator shafts. Due to the maximum robotization and automation of factory module manufacturing processes, there has been a significant reduction in the construction time of houses. The first stage of the Vnukovo plant was launched in July 2023.

Among the major difficulties of MonArch's modular construction technology, the complex logistics of overnight delivery of modules using two lanes of traffic and the need for powerful cranes (typically manufactured in Germany or China) is to be noted.

The MonArch concern is currently producing about 2000 modules per year and participates in the renovation program. In 2025, a kindergarten with 300 places was built in two weeks' time from 114 large-sized modules in Sireneviy Boulevard in Moscow.

Foreign modular construction systems have been known since the days of Habitat 67 residential complex (1967) and Nakagin Tower in Tokyo (1972) mainly make use of metal-framed blocks such as ADK Modulraum (Germany), Vision Modular, Assael (England), etc. The metal frame is also used for production of block cabins for cruise ships.

Special MEP modules can also be supplied in block design [19]. Modular engineering systems — "mechanical, electrical, and plumbing systems" (MEPs) — involve the pre-fabrication and assembly of engineering system components under controlled factory conditions before they have been delivered to a construction site to be installed. This approach provides lots of benefits, including increased efficiency, cost savings, faster project deadlines as well as improved quality control.

These modules combine various MEP components such as pipelines, ductwork, electrical wiring, and equipment into a single unit. Equipment installed in the MEP units: frames with heat exchangers, pumps or other engineering equipment with integrated pipelines and electrical systems; fully equipped bathrooms with plumbing, electrical and HVAC components (Heating, ventilation, and air conditioning); suspended mechanical racks with pipelines, ducts and electrical systems for efficient distribution in a building or a structure.

Problems related to environmental friendliness, alternative energy sources and lifestyle changes (e.g., due to the pandemic) have led to a surge in the production of buildings using modern construction methods, particularly in residential

construction. These methods involve use of new technologies as an alternative to traditional construction in smart buildings. Against the background of the development of industry 4.0, there is an urgent need for integrated design using machine learning, neural network and generative algorithms [20].

On top of that, it is essential to pay attention to the research results where optimization tools were employed in order to develop energy-efficient and rational construction schedules [21]. As the growing global awareness of environmental issues is on the rise, the construction industry is forced to make use of innovative materials and methods in order to make the construction process more energy efficient and environmentally friendly. Project managers should employ optimization tools in their planning procedures in order to address these issues in the early stages of project justification.

Discussion and Conclusion. Thus, among the main trends in the development of construction technologies, the following are to be noted:

- rapid evolution of building materials with an emphasis on high-functional concretes, new composites, capillary-porous materials and environmentally friendly waste materials with the possibility of their recycling and reuse;
- digitalization of projects and technologies: BIM design (with the development of 3D, 4D, 5D...); transition to electronic document management (GOST 70108-2025 "Executive Documentation. Formation and Maintenance in Electronic Form"); 3D printing of structures and formwork; automation of supply processes, construction control, organization and management; precise positioning and automation of construction machinery;
- improvement of factory readiness, dimensions, and architectural and structural quality of prefabricated elements (the so-called precast and prefabric technologies);
- development of modular construction in Russia from large-sized frame and reinforced concrete blocks with partial and complete finishing;
- improving the functionality and aesthetics of facade technologies: architectural and structural facade panels; self-cleaning and self-healing of facade materials; intelligent facades;
- development of monolithic construction using highly functional concretes, enlarged reinforcing frames, fibers, high-performance mechanisms, as well as prefabricated elements for complex multi-part building elements in order to speed up construction;
- complete robotization of some finishing processes;
- implementation of energy-saving and "green" solutions in engineering systems of buildings (not only unique ones);
- improving the quality of landscaping, infrastructure, and the urban environment quality index.

As a result of the review of the global experience, the general trends in the development of technologies in construction have been formulated that are to be noted by construction companies concentrated on continuous development and aspiring for the leading positions in the industry.

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About the Authors:

Albert Kh. Baiburin, DrSc. (Eng.), Associate Professor, Professor of the Department of Building Technologies and Structural Engineering at the South Ural State University (76 Lenin Ave., Chelyabinsk, 454080, Russian Federation), [ResearcherID](#), [ScopusID](#), [ORCID](#), abayburin@mail.ru

Andrey A. Melnik, Cand. Sci. (Eng.), Associate Professor of the Department of Building Technologies and Structural Engineering at the South Ural State University (76 Lenin Ave., Chelyabinsk, 454080, Russian Federation), [ScopusID](#), [ORCID](#), melnikaa@susu.ru.

Anna R. Lebed, Senior Lecturer at the Department of Building Technologies and Structural Engineering at the South Ural State University (76 Lenin Ave., Chelyabinsk, 454080, Russian Federation), [ScopusID](#), [ORCID](#), lebedar@susu.ru.

Claimed contributorship:

AKh Baiburin: forming the basic concept of the research, setting aims of the research, analyzing information, identifying connections and ways of development, preparing the manuscript, forming the conclusions;

AA Melnik: analysis of information sources, search for ways to develop the construction industry, systematization and generalization of the review, revision of the manuscript, correction of the conclusions;

AR Lebed: search and analysis of information sources.

Conflict of interest statement: the authors do not have any conflict of interest.

All authors have read and approved the final version of manuscript.

Об авторах:

Байбурин Альберт Халитович, доктор технических наук, доцент, профессор кафедры строительного производства и теории сооружений Южно-Уральского государственного университета (454080, Российская Федерация, г. Челябинск, пр. Ленина, 76), [ResearcherID](#), [ScopusID](#), [ORCID](#), abayburin@mail.ru

Мельник Андрей Анатольевич, кандидат технических наук, доцент кафедры строительного производства и теории сооружений Южно-Уральского государственного университета (454080, Российская Федерация, г. Челябинск, пр. Ленина, 76), [ScopusID](#), [ORCID](#), melnikaa@susu.ru

Лебедь Анна Рафиковна, старший преподаватель кафедры строительного производства и теории сооружений Южно-Уральского государственного университета (454080, Российская Федерация, г. Челябинск, пр. Ленина, 76), [ScopusID](#), [ORCID](#), lebedar@susu.ru

Заявленный вклад соавторов:

А.Х. Байбурин: формирование основной концепции исследования, постановка цели и задач, проведение анализа информации, выявление связей и путей развития, подготовка текста, формирование выводов;

А.А. Мельник: анализ информационных источников, поиск путей развития строительства, систематизация и обобщение обзора, доработка текста, корректировка выводов;

А.Р. Лебедь: поиск и анализ информационных источников.

Конфликт интересов: авторы заявляют об отсутствии конфликта интересов.

Все авторы прочитали и одобрили окончательный вариант рукописи.

Received / Поступила в редакцию 12.08.2025

Reviewed / Поступила после рецензирования 10.09.2025

Accepted / Принята к публикации 01.10.2025