Prospects for the innovative technologies’ spread in construction and their impact on the urban environmental development

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Abstract. This article shows the impact of innovation in the field of construction technology on the urban environment development. The issue of the prospects for the use of the innovative technologies’ specific types in construction is considered. The expert opinions’ analysis results on the need and possibility of applying innovations in construction are shown.

Introduction
Modern society development is unthinkable without scientific and technological progress. The reality surrounding us is changing so rapidly that sometimes, looking back at the recent past, we are surprised how much our life has changed in a few years. The relevance of the topic is due to the importance that innovative processes have in relation to the modern urban environment development.

How does technological progress affect a person? It is impossible to unequivocally answer this question. Now we cannot imagine life without computers, mobile phones, we are accustomed to convenient taxi services, we are striving for the speedy development of smart cities, but many Russians, for example, miss the time when there were booths with pay phones on the streets, and believe that the days when there were no modern means of communication and communication were much happier.

As known, the urban environment as a complex system consists of three main subsystems: natural, technogenic and social. All three elements of the environment are directly (technogenic and social) or indirectly (natural) related to the human activities, and, therefore, with their ever-increasing ability to introduce innovations in the process of carrying out their activities.

Although the rural settlements (representing a set of dwellings, structures and agro-ecosystems) started standing out from the natural environment, it was the city that separated a person from the biosphere and allowed to create a new life - Technosphere [1].

The technogenic urban environment includes buildings and structures of housing for industrial, social, cultural, spiritual purposes; roads and railways, bridges, pipelines, gas pipelines, all types of transport, etc.

Technogenic urban environment is most affected by innovation. The technogenic urban environment is most shaped by such industries as construction, industry, transport and communications. The rapid growth of information technology, which is currently underway in the developed countries, has a positive impact on the economy as a whole [2], including the structure-forming construction sphere. It
is construction that creates a unique look of the city, forms a unique style of space for the dynamic life of its residents.

Innovative activity in the construction industry is characterized, in particular, by the intensive use by business entities of effective innovations, the dynamics of actions to create and implement the scientific developments in the field of construction technologies [3].

In the field of construction, the following main segments of potential innovations can be distinguished - directly the production of innovative building materials and the application of innovative technologies. Naturally, these two segments are inextricably linked.

If we talk about the building materials’ production, recently in this area there has been a significant “innovative boom”. The main tasks in the development of new or the modifications of the existing building materials are to reduce the construction costs, reduce construction time, increase energy efficiency and environmental friendliness of the construction products. To date, fiber cement, granular and block penocelite, innovative heat-insulating materials, liquid thermal insulation, “warm” wall blocks, linen boards, building materials from industrial and household waste, wood foam, soft tiles, glass-magnesium sheets, porous ceramic blocks, frame- panel constructions, glued beams, cellulose wool, leather floors, diamond nanowires - these are just some of the new or modified building materials introduced in the construction industry.

It is obvious that with the advent of new building materials, a need for creating innovations in the architectural and construction design of real estate has been formed [4].

It should be noted that not all the invented building materials are widely used in the construction industry. For example, flax boards in Russia are not widely used. With all the advantages of these plates (safety, natural heat transfer, natural anesthetic, ease of installation), there are also disadvantages (attractiveness for rodents and birds, odors’ accumulation), including a higher price compared to other similar materials. In this regard, Russian builders are more likely to use the chemical building materials. Of course, there are no ideal building materials that are perfect in terms of their physical, mechanical and environmental characteristics. All of them have both advantages and disadvantages [5].

Currently, attention is paid to energy conservation in the building materials’ development. This is facilitated by the state’s requirements for improving energy efficiency, as well as a significant increase in energy prices and, accordingly, an increase in the cost of housing and communal services.

As for the segment of innovations related to the construction production technology, the main goals here are to reduce the construction time, reduce costs, increase the structure’s durability. According to the experts in the field of construction technologies, one of the notable trends in construction should be the accelerated transition from the traditional technologies for erecting real estate directly at the construction sites to the prefabricated modular housing construction and then to almost conveyor production of objects from unified panel or modular components [6].

To date, a lot of almost fantastic building technologies have been developed that amaze the imagination and once again make you think about what new, amazing reality we live in.

Table 1 lists some of the most advanced and unusual technologies in construction.

**Table 1. Description of advanced innovative technologies in construction**

| Technology                                         | Country of Invention | Stage of implementation | Short description                                                                 | Impact on the urban environment |
|----------------------------------------------------|----------------------|-------------------------|----------------------------------------------------------------------------------|---------------------------------|
| The technology of building domed houses made of wood without nails | Russia               | It was widely used in pre-revolutionary Russia, at present it has found its new, “innovative” embodiment | The technology of building without nails, in fact, it is not new - even Russian architects-built houses without a single nail. Until the 19th century, Russian carpenters worked only with an | Ease of construction, the possibility of appearing in the city space in record time. An unusual dome shape that creates a special atmosphere |
| 3D printed houses | Parallel developments by the scientists from the USA, UK, Netherlands, China | Is applied | The essence of the technology consists in layer-by-layer hardening of a building mixture according to a 3D model prepared by computer 3D modeling [9]. 3D construction technology, as well as conventional 3D printing, is carried out by extrusion. In this case, the extruder lays concrete in a given shape for a given path [10]. | The ability to erect buildings of heterogeneous forms in the city with a fairly short construction period. Significant reduction in construction costs, the possibility of acquiring housing by the low-income citizens. High precision development of the construction projects. Popularization of the scientific achievements, increasing interest in science in society. |
| High-speed construction technology | China | Is applied | The house erection in record time. This is achieved due to the highest accuracy in logistics, a large number of workers and skillful management. Ready-made monolithic blocks are delivered from the factory to the site. | A unique opportunity to modify and improve the urban environment in a short time in accordance with the dynamically changing needs of the society. |
which are simply installed in the place [11]. Using this method, the Chinese company Broad Group built a 30-story building and finished the premises in 15 days.

| Project                          | Country   | Status                  | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|----------------------------------|-----------|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Algae House (Bio Intelligent Quotient (BIQ) House.) | Germany   | Is applied              | German builders first erected a building which walls are covered with aquariums with algae, which are the only source of energy for heating and conditioning the building [12]. The unusual appearance of the building fits beautifully into the urban environment. Green building, natural energy sources.                                                                                                                                                                                                                          |
| The use of carbon dioxide concrete | Canada    | Is applied              | The innovation is the production of concrete by binding carbon dioxide. For the production of concrete blocks, carbon dioxide is used, emitted by the large enterprises such as oil refineries and fertilizer plants [13]. This technology will reduce harmful emissions into the atmosphere. Lower cost of concrete production. Concrete blocks made using this technology can, like trees, absorb carbon dioxide.                                                                                     |
| Ropeless multidirectional elevators | Germany   | Pilot project has been developed and tested | In large high-rise buildings, it is planned to use several elevator cabins operating in a looped system (like a metro system) inside the building. The elevator car is mounted on a rail, some segments of which can be rotated 90 degrees. Due to this, he can move both vertically and horizontally. [14] The use of this technology leads to a higher throughput of the elevator, as well as to reduce waiting times for the passengers, which is very important for the employees of the large-sized shopping and office centers. Reduced waiting time helps reducing the likelihood of stressful situations. |
| Technology                  | Country   | Stage      | Description                                                                                                                                                                                                 | Implications                                                                                     |
|-----------------------------|-----------|------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|
| Use of drones in construction | USA       | Under development | The idea is to use many small drones instead of one giant construction crane that can deliver material to any point in the construction.                                                                  | Possibility of construction in hazardous climates. The release of human labor in favor of the other tasks’ implementation. |
| Bamboo cities               | China     | Under development | Due to the fact that bamboo is a strong, sustainable plant material and grows very quickly, China has developed a project to use bamboo as the main resource for building a city. Such a city will be sustainable, environmentally friendly and inexpensive to manufacture. Buildings in this city, if necessary, will be very easy to disassemble, since they will be created from bamboo stems and ropes. This material can then be reused [15]. | The bamboo city will be environmentally friendly, inexpensive to manufacture and will have a very unusual look. Designed for a small number of residents - up to 200 thousand people. It is noteworthy that, for example, the walls in buildings made of bamboo will be easy to move. |

All of the above-described technologies are very interesting and, of course, have their own development prospects. Their implementation will obviously have a significant impact on the urban environment. Firstly, the appearance of the city becomes very attractive. Just imagine: you are walking along the street and you see flying houses, houses made of algae. Moreover, each of the construction projects is individual and makes a difference in the outlines of the city, which was so lacking, for example, in our country in Soviet times.

But hardly anyone among the readers of this article is living in a house printed on a 3D printer or surrounded by beautiful algae. Some of the above-described technologies have not been applied in Russia, while some, having been tested, have not yet found widespread application.

It should be noted that some construction experts are very skeptical concerning a number of the above-mentioned innovations. They believe that sometimes there is such a principle: innovation for the innovation sake. For example, there is some skepticism regarding the construction technology based on 3D printing. Some experts note that the cost and construction time in the traditional way is no more than when using 3D printing. In addition, certain advanced technologies cannot be massively implemented; they can be applied only in individual cases.
We conducted a study regarding the experts’ opinions on the prospects for the application of the above-mentioned innovative technologies in the construction industry. We interviewed 100 respondents. 25 people among them are the representatives of the scientific community (scientists, researchers in the field of construction economics, university professors), 25 people are the construction workers (heads of construction organizations, architects, designers), 25 people are the housing and communal services workers and 25 people are the representatives of various areas of activity (trade, medicine, heavy and light industry, etc.). All respondents were asked a question: how do you assess the prospects for the development of this innovation in the next 5 years: it will be widely used in construction; will be used for a limited range of tasks, types of construction projects; will not find any wide application.

For the above-mentioned innovative technologies in construction, the respondents’ votes were distributed as follows (Table 2):

| Technology                                      | Respondents’ opinion (number of people who preferred a position) |
|------------------------------------------------|---------------------------------------------------------------|
| The technology of building domed houses made of wood without nails | Will be widely applied | Will be applied in a limited list of tasks, objects | Will not find any possible application in near future |
| 3D printed houses                               | 48                                                              | 36                                               | 16                                               |
| High-speed construction technology               | 17                                                              | 69                                               | 14                                               |
| Algae house                                      | 1                                                               | 8                                                | 91                                               |
| The use of carbon dioxide concrete               | 76                                                              | 21                                               | 3                                                |
| Drones use in construction                       | 9                                                               | 70                                               | 21                                               |
| Bamboo cities                                    | 0                                                               | 11                                               | 89                                               |
| Ropeless multidirectional elevators              | 19                                                              | 67                                               | 14                                               |

As the table shows, more than half of the respondents’ votes under the item “Will be widely applied” received only one innovation - the use of concrete made of carbon dioxide. Also, the majority of respondents (48 people) consider 3D technology in construction to be promising and in the near future widely applicable. The experts evaluated other technologies as applicable in the future in a narrow circle of tasks (domed houses without nails, high-speed construction technology or the use of drones). Indeed, for example, domed wooden houses will look beautiful like decorative buildings, objects of attractions, and their use in mass construction is unlikely. According to the respondents, algae houses and bamboo cities will remain only beautiful fantastic projects.

In the context of the current situation in the world associated with the pandemic, I want to pay attention to the high-speed construction technology. Note that the study was conducted before the spread of coronavirus infection around the world, the survey was conducted mainly in person, the opinions of experts were revealed through direct communication. Only 17 respondents were sure at that time that high-speed construction technology would be widely used. 14 respondents expressed the opinion that the technology would not be applied. In this case, we believe that if we conducted the study during or after the end of the COVID 19 pandemic, the answers would be different. We know how now in all countries, including Russia, the task of building new hospitals to treat infected COVID19 in record time has arisen. For example, in Volgograd a hospital with an area of 5300 sqm was erected in 40 days m2 for 100
We are confident that now many respondents would speak out in favor of the statement that high-speed construction technology would be widely implemented in the near future and, we think, would be right. The need for the high-speed construction technologies in the modern world has become obvious, and in our opinion, in the near future this technology will be very actively improved and distributed.

Of course, innovations in the technogenic urban environment are very important and have a decisive influence on the life and look of a modern city. It should be noted that in Russia the conditions for a purposeful, gradual transition to an innovative development path based on a program-targeted approach have been created [15].

Summary
Based on the foregoing, the following conclusions can be drawn. Innovations in construction have a significant impact on the urban environment. They allow, firstly, to reduce the buildings and structures’ construction cost and, as a result, increase the construction projects’ implementation effectiveness, free up the financial resources for use in other projects; secondly, to achieve a reduction in the construction time and, as a result, the possibility of a more rapid change in the appearance of the urban environment, the necessary objects’ appearance possibility in the city territory within the given time frame; thirdly, to improve such characteristics of construction objects as the strength of buildings, energy efficiency, environmental friendliness.

To date, unique, almost fantastic building technologies have been created and are constantly being developed. When developing them, it is necessary to understand that any innovative idea in construction, even if it is talentedly developed by the inventors, should be easy to implement and use and, most importantly, effective, that is, the cost of implementation should not be higher than the implementation effect. According to the interviewed respondents, not all announced that the innovative technologies in construction will find wide application.

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