# Application of digital technologies in construction for the purpose of rational energy consumption and achievement of environmental sustainability

*Tatyana* Kuzmina[1], *Polina* Bolshakova[1*], *Maria* Gordashnikova[1], and Daria Gordashnikova[1]

[1]Moscow State University of Civil Engineering, 129337 Moscow, Russia

**Abstract.** Managing the life cycle of a construction project using digital technologies has its own peculiarities and causes a number of problems which may have environmental consequences during the construction of facilities. The subject of the study is to review modern IT technologies in the field of construction work and design of buildings and structures. The purpose of the scientific work is to conduct a thematic content analysis and interpret information to assess the impact of the use of digital technologies on the rational use of various resources, including energy consumption, on the environmental sustainability of a construction site, and on the results of the work of a construction organization. In conclusion, it was considered that competent management of the life cycle of a construction project, the use of digital technologies, and the use of modern IT technologies affect the assessment of energy consumption, environmental consequences, the identification of hazardous factors and possible consequences of the impact of construction process. A strategy for the integrated use of digital technologies is needed, which, in turn, will ensure the synergistic effects of their use and will contribute to the further development of sustainable construction, without causing damage to the environment.

## 1 Introduction

The relevance of the study is to assess the impact of the use of digital technologies in managing the life cycle of a construction project on the environment and on the efficiency of a construction organization. The purpose of the work is to conduct a content analysis of scientific and practical works on the research topic, to interpret information on their application and impact on the environment, and on the results of the work of a construction organization.

The timeliness of studying the research issues is based on the analytical results of the use of digital technologies and their transformation of use at different stages of the life cycle of

* Corresponding author: BolshakovaPV@mgsu.ru

a construction project, formed on the basis of the works of Russian and foreign scientists [1, 2, 3, 4], who made a significant contribution to the formation of the theoretical basis of the study.

The study showed that the management of the life cycle of an object in the construction industry is determined by the specifics and scale of its activities, characterized by dynamism, the need for constant change and technological transformation. For the sake of environmental sustainability in construction, cloud technologies play an important role as a type of digital technology. With the advent of cloud technology, some equipment has been replaced by virtual services, which helped construction companies to switch to an ecological approach, while increasing energy efficiency.

One can note a number of studies in the field of environmental sustainability in the construction industry in terms of the rational use of natural resources, as well as in the field of the possibilities of cloud technologies in the construction sector, which are contained in the works of the following scientists: S.Kh. Bayramukov, Z.N. Dolaeva, A.U. Salpagarova; M.V. Petukhov; V.V. Garyaeva; Yu.B. Khatamov; S.Yu. Zharkov; V.A. Pestryakova, V.E. Ushakova; V.V. Talapov; F.K. Klashanov, T.S.N. Rachmawati, S. Kim, A. Talla, S. Mcilwaine and others.

Sustainability in the construction industry depends on the effective management of construction processes, taking into account the rational use of natural resources, increasing energy efficiency, and the ability to ensure environmental balance. The effectiveness of using BIM modeling and the subsequent use of the resulting model of the construction site is noted, which is crucial in promoting and ensuring the objectives of sustainable construction. The authors consider information modeling of construction projects as a technology for the development and use of a digital model of buildings and structures for the purpose of life cycle management [5].

The unity of the process of creating a BIM model and its operation, in turn, is pointed out by V.V. Talapov [6].The author considers the BIM model as a kind of virtual copy of a complex construction project and its components with geometric and numerical characteristics of buildings and structures, with certain structures and technical equipment, as well as properties.

In implementing the mechanism for managing investment and construction projects, the advantage of the BIM model as a cloud database, in this case, is the unity of the information environment:

- simultaneous connection of all process participants to the model from different places;
- flexibility of collaboration on a project;
- geographical indifference in the personnel aspect;
- simultaneous availability of up-to-date project data.

In addition, it should be noted that BIM modeling is aimed at ensuring that the requirements of advisory and regulatory documents are taken into account in order to comply with the environmental situation and energy efficiency of the construction site [7].

Based on theoretical calculations and practical experience, many authors [3-7] point out the advantages of using cloud technologies in construction: saving time for construction control engineers; reducing construction time while maintaining quality; direct management access to data from the construction site; the ability to download “heavy” files containing architectural drawings and work with them using cloud technologies.

In turn, S.Yu. Zharkov [8] shows that an electronic document management system based on digital technologies can reduce the time for confirming and signing contracts by 50-70%, reduce the cost of paper documents by 80-90%, increase the level of control and transparency of the process, and also reduce the risks of errors , loss or falsification of documents, as well. According to the results of the study, S.Yu. Zharkov suggests areas for further improvement of the system, such as the introduction of blockchain technology to ensure the immutability

and distribution of data, as well as the use of artificial intelligence to analyze and optimize contracts.

The authors [9, 10, 11] consider promising technologies of Construction 4.0:

- intelligent, mobile, geographic information (GIS) and cloud technologies;
- technologies of mathematical and computer modeling;
- Big Data and radio frequency identification (RFID) technologies;
- 3D scanning and printing technologies, Internet of Things (IoT), etc.

Scientific works of A.I. Konikov [12] and K. Farghaly, W. Collinge, M.H. Mosleh, P. Manu, C.M Cheung [13] are aimed at identifying cloud technologies in the construction industry as well as one of the promising areas in the field of construction management information systems, allowing to increase the efficiency of construction companies, reducing costs for information technology infrastructure and flexible response to changes in computing needs, using the properties of computational elasticity of cloud services. A.I. Konnikov highlights promising cloud CRM systems from 1C and the Bitrix-24 CRM system, which are characterized by on-demand self-service and elasticity.

## 2 Materials and methods

The study used theoretical and practical research methods. An analysis of scientific works on the effectiveness of using digital technologies in managing the life cycle of a construction project was carried out. An analytical generalization of the author's points of view on the influence of digital technologies on the environmental sustainability of the object was carried out, as well. A comparison method was used based on the popularity of the applying of digital technologies and IT systems by construction organizations. In the context of the entire scientific research, the measurement method was also used. Quantitative assessments of the effectiveness of the use of digital technologies at the stages of the life cycle of capital construction, their impact on the environmental sustainability of the construction project, on time and financial costs are presented. Content analysis of text arrays was used to meaningfully interpret the data.

## 3 Results and discussion

The results of the study are a quantitative assessment of the effectiveness of the use of digital technologies at the stages of construction of buildings and structures in terms of reducing time and financial costs, project risks, and reducing the impact of design decisions on the environment.

Based on the study, summarizing the opinion of the team of authors [14, 15], the results of an analysis of the use of digital technologies at all stages of the life cycle of capital construction are presented, indicating the effectiveness of the construction site management mechanism.

**Table 1.** Application of digital technologies in construction site management

| Life cycle stage | Digital technologies | Efficiency of the control mechanism |
|---|---|---|
| Design, financing and procurement | *Drones* for surveillance, inspection and surveying | Reduce design time by 10-30% |
| | *Collaborative designv*for team work in virtual reality (VR) / augmented reality (AR) mode | |
| | *Database analysis using artificial intelligence* in real time to provide insight and comparison with previous projects. Digital technologies | |

| | | |
|---|---|---|
| | make it possible to process a significant amount of information, which can be structured and analyzed, identifying patterns and influencing factors on variables. The software manages the database and generates reports | |
| | *Blockchain* to create a safe communication environment between the customer, the execution team, contractors, suppliers and other project stakeholders | |
| Construction | *Modular design* and construction to create mock-ups in a controlled and safe environment, limiting activities on site for installation and commissioning of the construction project | Reducing costs for construction and installation work by 5–10%. Reducing project deadlines, financial costs and risks.<br>Identifying conflicts and inconsistencies in planning |
| | *Augmented and virtual reality* using AR technologies to view design diagrams while working on a construction site. Digital technologies facilitate the verification of a modeled design to detect errors, and also facilitate the virtual inspection of construction sites for the purpose of coordinating and monitoring construction processes | |
| | *Mobile/tablet solutions* to provide staff with access to projects and work instructions | |
| | *BIM (Building Information Modeling)* for the use of a single information model of the object by all participants in the construction process, as well as for generating reports in real time | |

According to research in the construction business at different stages of the life cycle of construction of buildings and structures the most popular digital technologies are electronic document management (29%), service (mobile) application (25%), dynamic pricing system (25%) (Figure 1). Digital transformation of construction makes it possible to increase the efficiency of the mechanism for managing investment and construction projects, including indicators of cost, expenses and implementation time:

- delivery time is reduced by 30%;
- the cost of the project is reduced by 30%;
- the duration of the project is reduced by 40%.

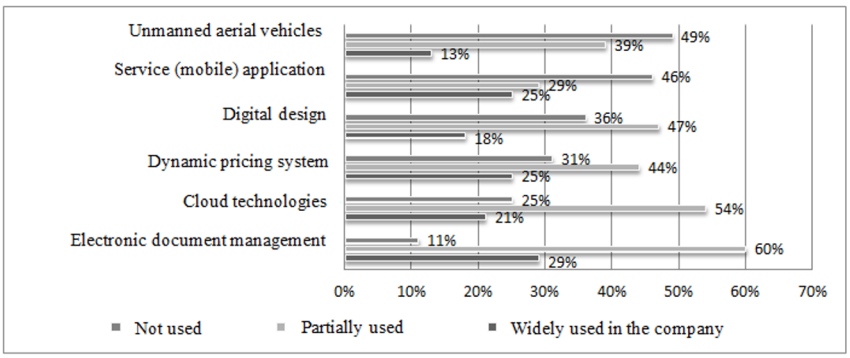


**Fig. 1.** The most popular digital technologies among development and construction companies, % of respondents [16]

However, it should be noted that only 16% of construction companies note a comprehensive increase in management efficiency due to digital transformation. This happens due to a number of reasons, or rather problems faced by organizations when introducing and implementing digital technologies (Fig. 2):

- high risks of disruption of existing processes (18%);
- lack of clear incentives to increase the level of digitalization (18%);
- lack of necessary IT solutions for the Russian market (18%).

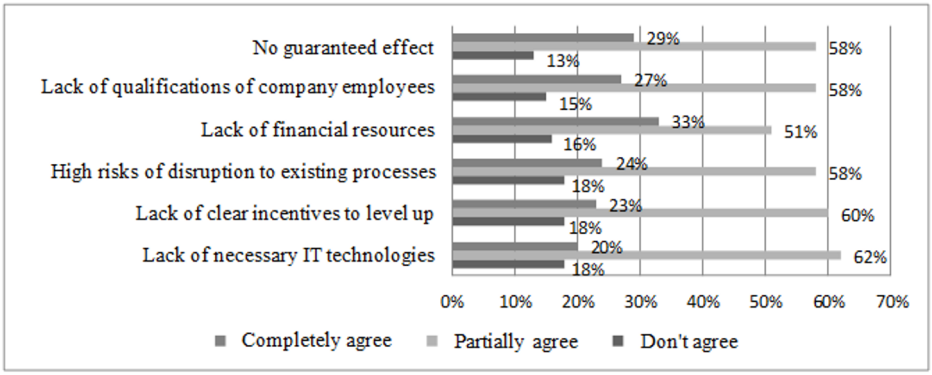


**Fig. 2.** Key problems and limitations for the implementation of digital technologies for development and construction companies, % of respondents [16]

In this connection, the construction sector is inferior to the financial sector, trade and education. According to the results of a study by the National Research University Higher School of Economics, in 2022 the construction industry occupied the penultimate place, even behind waste management and agriculture. At the same time, the industry in the Russian Federation is systemically important, and the state is interested in its accelerated development. Although it should be noted that in the Russian Federation, 6% of GDP (5.5 trillion rubles) is spent on construction, in contrast to global spending - 13% of world GDP ($1.6 trillion).

Information statistics confirm the need for further digital transformation of the construction industry, the development of environmentally friendly sustainable construction, which, in turn, is connected with an increase in economic activity by 2056 - 5 times, with an increase in energy demand - 3 times [5].

## 4 Conclusion

Conducted studies of scientific and practical work confirm that digital technologies not only have a management impact on the life cycle of a construction project, but also help the development of sustainable construction, without causing damage to the environment. Therefore, speaking about the positive aspects of using digital technologies at the stages of construction of buildings and structures, it is necessary to pay attention to the problems of project management in the investment and construction sector:

- lack of clarity in defining the value of digital transformation for the construction business;
- inconsistency between the information systems used;
- weak integration association of the digital tools with business processes;
- significant period of return on investment in the development of digital technologies:

- lack of qualified personnel who use digital technologies in their professional activities;
- conservatism of the management and personnel of the construction organization in the use of digital technologies;
- insufficient financial resources for the acquisition of digital technologies and their implementation in a construction organization.

Modern construction practice is characterized by the active use of advanced digital technologies, changing both the ecology of construction and the integration of renewable energy sources. Digital technologies are enabling construction to actively move towards sustainability and green practices. Digital technologies make it possible to use energy-efficient building materials and use renewable energy sources to reduce environmental consequences and hazardous factors. However, only 16% of construction companies note a comprehensive increase in management efficiency through digital transformation. Accordingly, attention should be paid to the main problems of using digital technologies in managing the life cycle of a construction project:

- firstly, this is lawmaking, the difficulties of adapting to changing legislation. In this case, it should be noted that there are conflicting requirements for digital technologies in regulatory legal acts, and the existence of disunity in their wording. There is a need to use basic terms and definitions that are aimed at optimizing the process of development and implementation of digital technologies, at consolidating the actions of all participants in the construction process (state, designers, operators, software developers);
- secondly, this is financing. When using digital technologies, there is an additional financial burden. In this case, we should talk about the development of specialized measures to stimulate construction organizations, for example, the possibility of using correction factors for the costs of preparing design estimates in the format of information models.

Accordingly, a strategy for the integrated use of digital technologies is needed, which, in turn, will ensure the synergistic effects of their use and will contribute to the further development of sustainable construction without causing damage to the environment.

## References

1. Radman K., Jelodar MB, Lovreglio R., Ghazizadeh E., Wilkinson S. Digital technologies and data-driven delay management process for construction projects.Frontiers in Built Environment. 2022. Vol. **8.** pp. 01-20.DOI 10.3389/fbuil.2022.1029586.
2. Chen X., Chang-Richards A., Ling F.Ye.Y., Yiu T.W., Pelosi A., Yang N. Developing a readiness model and a self-assessment tool for adopting digital technologies in construction organizations.Building Research and Information. 2022.Vol. **12.** Issue 3.pp. 241-256.DOI:10.1080/09613218.2022.2136130.
3. Schnell P., Haag P.H., Jünger H.Ch. Implementation of digital technologies in construction companies: establishing a holistic process which addresses current barriers.Businesses. 2022.Vol. **3.** Issue 1.pp. 1-18.DOI:10.3390/businesses3010001.
4. Huang YU, Peng H., Sofi M., Zhou ZH, Xing T., Ma G., Zhong A. The city management based on smart information system using digital technologies in China.IET Smart Cities. 2022.Vol. **4.** Issue 3. DOI:10.1049/smc2.12035.
5. Petukhov M.V. Formation of competitive advantages of "ecological" construction within the framework of the concept of sustainable development // Economics and Entrepreneurship. 2022. No. **2(139).** pp. 936-941. DOI 10.34925/EIP.2022.139.2.180.

6. Garyaeva V.V. Ensuring sustainable design and energy-efficient construction based on BIM modeling // Scientific and Technical Bulletin of the Volga Region. 2021. No. **3.** pp. 17-20. EDN
7. Talapov V.V. Introduction to building information modeling: monograph. Saratov: Vocational education, 2017.
8. Zharkov S.Yu. Electronic document management system based on cloud technologies for the construction and reconstruction sector // Nanotechnologies: science and production. 2021. No. 1. pp. 6-19.
9. Pestryakova V.A., Ushakova V.E. Cloud technologies in construction // International scientific and technical conference of young scientists of BSTU named after. V.G. Shukhova: Conference materials, Belgorod, April 30 – 20, 2021. Belgorod: Belgorod State Technological University named after. V.G. Shukhova, 2021. pp. 837-839.
10. Rachmawati TSN, Kim S. Unmanned aerial vehicles (uav) integration with digital technologies toward construction 4.0: a systematic literature review. Sustainability. 2022.Vol. **14.** Issue 9. DOI:10.3390/su14095708.
11. Talla A., Mcilwaine S. Industry 4.0 and the circular economy: using design-stage digital technology to reduce construction waste.Smart and Sustainable Built Environment. 2024.Vol. **13.** Issue 1. pp. 179-198.DOI: 10.1108/SASBE-03-2022-0050.
12. Konikov A.I. Promising directions in the field of information systems for construction management // Industrial and civil construction. 2019. No. **6.** pp. 64-69. DOI 10.33622/0869-7019.2019.06.64-69.
13. Farghaly K., Collinge W., Mosleh MH, Manu P., Cheung CM Digital information technologies for prevention through design (ptd): a literature review and directions for future research.Construction Innovation. 2021.Vol. **22.** Issue 4. pp. 1036-1058. DOI:10.1108/CI-02-2021-0027.
14. Olawumi T.O., Chan D.W.M., Yam M.C.H., Ojo S. Automating the modular construction process: a review of digital technologies and future directions with blockchain technology. Journal of Building Engineering. 2022.Vol. **46.** DOI:10.1016/j.jobe.2021.103720.
15. Sofiat O. Abioye, Lukumon O. Oyedele, Lukman Akanbi, Anuoluwapo Ajayi, Juan Manuel Davila Delgado, Muhammad Bilal, Olugbenga O. Akinade, Ashraf Ahmed. Artificial intelligence in the construction industry: A review of present status, opportunities and future challenges.Journal of Building Engineering. 2021. Vol. **44.** Issue 5. DOI:10.1016/j.jobe.2021.103299.
16. Macheret, PD Savchuk RR Experience and Prospects of Digitalization in the Construction Industry Based on the Application of Automated Systems // Proceedings of the 2022 Conference of Russian Young Researchers in Electrical and Electronic Engineering, ElConRus 2022, St. Petersburg, January 25–28, 2022. – St. Petersburg, 2022. pp. 1708-1710. DOI 10.1109/ElConRus54750.2022.9755794.