UDC 330.131.5
JEL: L74; O33
DOI: https://doi.org/10.32983/2222-4459-2024-1-167-177

THEORETICAL AND METHODOLOGICAL BASES FOR IMPLEMENTING BIM TECHNOLOGIES IN CONSTRUCTION COMPANIES: ESSENCE. CHARACTERISTICS. ECONOMIC EFFICIENCY

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UDC 330.131.5
JEL: L74; O33

Yashchenko O. F., Makatora D. A., Kubanov R. A., Zinych P. L., Prusov D. E. Theoretical and Methodological Bases for Implementing BIM Technologies in Construction Companies: Essence. Characteristics. Economic Efficiency

The theoretical concepts and methodological characteristics of implementing BIM technologies in construction companies have been defined. BIM is an information modelling of a construction object, which involves the collection and processing of all information about a building with all its interconnections and dependencies, when the building is considered as a single object. It should be noted that when analysing the definitions of BIM, it is possible to come to the conclusion that it is necessary to make a clearer distinction as to what type of object is meant. Thus, there are some definitions that refer directly to the building model (Building Information Model), the building lifecycle process (Building Information Modelling) and the entire investment and construction process system (Building Information Management). It is pointed out that the traditional approach to design is based on two-dimensional models – plans, drawings and paper documentation. In contrast, Building Information Modelling (BIM) technologies add new aspects – construction plans, time and costs. These can be presented in any convenient form using an information model of the object in virtual reality. The short and long term benefits of using BIM technology in the construction industry are analysed in this article. It was noted that BIM goes beyond standard CAD systems as it allows to create three-dimensional models, known as 3D models, as well as models defined as 4D, 5D, 6D and even 7D. An automated project management system is described on the basis of three elements: the structure of project activities, the structure of resources and the matrix of resource allocation to project activities. In an automated system that ensures effective project planning, control and execution, these elements form a project management model. However, effective cost management throughout the project lifecycle is crucial to the successful implementation of the information system and maximising its benefits to the organisation. According to the authors, the overall cost-effectiveness factor of using BIM technology is determined by several factors: reduction of the overall level of project risks due to proven, accurate and optimised design solutions for engineering systems; reduction of construction time and construction costs as a result of reducing the number of errors in installation and use of materials; improvement of the quality and efficiency of building use will help reduce the negative impact on the environment. The conclusions emphasise that the successful implementation of BIM technologies in a construction company can lead to economic efficiency through an increase in labour productivity, a reduction in the cost of resources and materials, as well as an improvement in the quality and safety of construction processes. In addition, using BIM can help improve the quality of buildings and optimise the use of resources, helping to reduce environmental impact. In fact, BIM is a significant cost driver through this comprehensive approach to project management in construction.

Keywords: *BIM technology, construction industry, BIM definition, project management model, economic efficiency, innovation activity, standards.*
Bibl.: *26.*

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УДК 330.131.5
JEL: L74; O33

Ященко О. Ф., Макатьора Д. А., Кубанов Р. А., Зінич П. Л., Прусов Д. Е. Теоретико-методичні засади впровадження BIM-технологій на будівельних підприємствах: сутність. особливості, економічна ефективність

Визначено теоретичні концепти та методичні особливості впровадження BIM-технологій на будівельних підприємствах. BIM – це інформаційне моделювання будівельного об'єкта, що передбачає збір та обробку всієї інформації про будівлю з усіма її взаємозв'язками та залежностями, коли будівля розглядається як єдиний об'єкт. Зазначено, що аналізуючи дефініції BIM, можна зробити висновок про необхідність чіткіше розрізняти, про який об'єкт ідеться. Так, є частина визначень, що стосуються безпосередньо моделі будівлі (Building Information Model), процесу життєвого циклу будівлі (Building Information Modelling) та всієї системи інвестиційно-будівельного процесу (Building Information Management). Вказано, що традиційний підхід до проєктування ґрунтується на двовимірних моделях – планах, кресленнях і паперовій документації. На відміну від цього технології будівельно-інформаційного моделювання (BIM) додають нові аспекти – плани будівництва, час і вартість, які можуть бути представлені в будь-якому зручному вигляді за допомогою інформаційної моделі об'єкта у віртуальній реальності. Було проведено аналіз коротко- та довгострокових переваг використання технології BIM у будівництві. Відзначено, що BIM виходить за межі стандартних систем CAD, оскільки дозволяє створювати тривимірні моделі, відомі як 3D-моделі, а також моделі, які визначаються як 4D, 5D, 6D і навіть 7D. Описано автоматизовану систему управління проєктом, що базується на трьох елементах: структурі робіт проєкту, структурі ресурсів та матриці призначення ресурсів на роботи проєкту. Ці елементи утворюють модель управління проєктом в автоматизованій системі, яка забезпечує ефективне планування, контроль і виконання проєктів. Однак успішність впровадження інформаційної системи та отримання максимальної вигоди на підприємстві залежить від ефективного управління витратами протягом всього терміну роботи проєкту. За думкою авторів, загальний фактор економічної ефективності від використання технології BIM визначається кількома чинниками: зниження загального рівня проєктних ризиків завдяки перевіреним, точним і оптимізованим конструктивним рішенням інженерних систем; скорочення термінів будівництва та зниження будівельних витрат шляхом зменшення кількості помилок при монтажі та використанні матеріалів; підвищення якості й ефективності використання будівель, що сприятиме зменшенню негативного впливу на навколишнє середовище. У висновках зазначено, що успішне впровадження BIM-технологій на будівельному підприємстві може привести до економічної ефективності завдяки збільшенню продуктивності праці, зменшенню витрат на ресурси та матеріали, а також поліпшенню якості та безпеки будівельних процесів. Крім того, використання BIM сприяє поліпшенню якості будівель та оптимізації використання ресурсів, що може зменшити негативний вплив на навколишнє середовище. Такий комплексний підхід до управління проєктами в будівництві справді робить технологію BIM значною константою економічної ефективності.

Ключові слова: *BIM-технологія, будівельна галузь, дефініція BIM, модель управління проєктом, економічна ефективність, інноваційна діяльність, стандарти.*
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The construction industry plays a key role in the renewal and expansion of productive and non-productive fixed assets, and therefore plays an important role in the country's economic system. The construction sector also carries out technical re-equipment and reconstruction of existing facilities, which contributes to the maintenance and development of the country's infrastructure. This sector of the economy is a catalyst for the accelerated growth of the economy, as it brings to life the investments made in all the sectors of the economy. Its activities have an impact on many other sectors, such as industry, transport, communications and services. The overall economic situation of a country can be significantly affected by the efficiency of the construction industry. Despite a considerable number of studies, innovation in the construction sector is dynamic. Therefore, in order to determine its potential for future development, it is necessary to analyse the current state and forecasts of increasing innovation activity in construction. In particular, Building Information Modelling (BIM) technology represents a fundamentally new approach to the design of construction projects.

There are a number of benefits that the introduction of BIM technology can bring to the Ukrainian construction industry. First of all, it ensures a high level of accuracy and efficiency in design and construction. Construction companies can identify potential problems and conflicts in advance. This reduces the number of errors and the amount of time spent on construction. Secondly, the use of BIM technology improves communication and collaboration between all stakeholders in construction projects, including architects, engineers, contractors and clients. All parties can work with information that is convenient, accessible and available in real time. Thirdly, the quality and safety of construction projects can be improved through the use of BIM technology. Three-dimensional visualisation and analysis can be used to identify potential safety issues and estimate construction costs. As a result, risks and errors are minimised, which in turn has a positive impact on the quality of construction projects. In addition, by encouraging the development of new technologies and materials, the introduction of BIM can stimulate innovation in the construction industry. This could positively impact the competitiveness of Ukrainian companies in the international market. In the long term, the introduction of BIM technology can contribute to an increase in the efficiency of the construction industry in Ukraine, a reduction in construction costs and construction time, an improvement in the quality of projects and ensure sustainable development.

In the works of Ukrainian and foreign scientists various aspects of this problem have been studied and presented, e. g: V. Adamenko [1]; V. Andrukhov, A. Potekha, I. Martynov [2]; V. Babayev, V. Torkatyuk, L. Shutenko [3]; I. Bashynska, A. Khristova [4]; R. Glibotskyi, A. Bespalova [5]; R. Grytseliak [6]; V. Donenko, O. Ishchenko, Y. Vakulyuk [7]; N. Zakharchenko [8]; V. Kalinin [9]; M. Savitsky, M. Babenko, M. Bordun [10]; E. Bilousov, I. Borisov [11]; M. Korin, Ya. Zaprudnov, S. Zybin [12]; O. Levchenko [13]; O. Pekarchuk [14]; O. Polinkevich [15]; P. Rebryna, I. Nesterenko [16]; R. Trach [17; 18]; A. Tugay, A. Pokolenko, A. Yesipenko, A. Dubinka [19]; O. Chertkov, Yu. Tsehelnyi, D. Yermolovych [20]; H. Bernstein, S. Jones, M. Ruso [21]; C. Panteli, A. Kylili, P. Fokaides [23]; M. Johansson, M. Rope, P. Bosch-Sijtsema [24]; W. Kimmell [25]; P. Yuan, M. Green, R. Lau [26].

The *purpose* of the study is to identify the theoretical concepts and methodological characteristics of the implementation of BIM technologies in construction companies.

Building Information Modelling (BIM) is an innovative approach to designing, constructing and operating buildings. It is based on the digital modelling of a construction project. This enables the integration of information from different sources and detailed analysis of all stages of design and construction. Improved collaboration between project participants, reduced risks and errors, lower costs and increased efficiency of the construction process are the main benefits of BIM technology. It also makes it possible to more accurately determine design schedules, forecast construction costs and ensure that projects comply with standards and regulatory requirements.

BIM technology has already gained considerable popularity worldwide. It is widely used in the construction industry. It is also gaining popularity in Ukraine. However, it needs to be further developed and disseminated. Some design organisations and construction companies are already implementing BIM technology in their operations. However, in general, this approach is not yet standard in the Ukrainian construction industry.

It is expected that with the emergence of new projects and experience with this technology, the adoption of BIM technology in Ukraine will be gradual. Training professionals to use BIM technology and developing national standards and regulations for its use is important for construction companies and organisations. In general, BIM technology has great potential for the development of the construction industry in Ukraine. It can improve the quality and efficiency of construction and reduce the likelihood of problems and errors.

BIM is an information modelling of a construction object that involves collecting and processing all the information about the building with all its interconnections and dependencies, when the building is considered as a single object [7, p. 142].

It should be noted that the term BIM (Building Information Modelling or Building Information Model) was first proposed in 1992 in the work of Sander van Nederven and Fritz Tolman from the Netherlands. Since around 2002, the concept of the Building Information Model has been actively developed by leading software developers and incorporated into their terminology, thanks to the efforts of many authors and supporters of a new approach to design. Subsequently, thanks to the activities of companies such as Graphisoft and Autodesk, the abbreviation BIM has been widely used by specialists in the field of computer-aided design all over the world [16, p. 197].

It is important to note that when analysing the definitions of BIM, it can be concluded that there is a need to distinguish more clearly what type of object is being referred to. For example, some definitions refer directly to the building model (Building Information Model), the building lifecycle process (Building Information Modelling) and the entire investment and construction process system (Building Information Management). We believe that the clearest division of BIM definitions into the three areas mentioned above is given in the Building SMART International report [22], and certain aspects of differentiation are also presented in more recent studies.

Building Information Model (BIM) is a digital description of the physical and functional properties of a building, which is a source of knowledge and various data about the object and is fully accessible to participants in the investment process. It forms the basis for decision-making in the construction process, from the concept development to the demolition of the building [13, p. 107]. BIM makes it possible to combine data from different sources and provide a wide range of information about the building, including coordinates, quantities of materials, characteristics of structural elements, data on electrical and mechanical systems, as well as other necessary information. This enables those involved in building to manage the project more effectively, identify conflicts and risks, and reduce errors and unnecessary costs. Even after construction is complete, BIM can serve as a source of knowledge about the building. It can be useful for managing the building, making repairs and upgrades, and providing information for operating and maintaining the building throughout its lifecycle.

Building Information Modelling (BIM) is a creative process for the creation and use of data about a building, its design, construction and operation throughout its entire life cycle. BIM uses 3D models of a building that contain not only geometric information, but also data on materials, equipment, structures, work schedules, prices, deadlines and other details. This allows everyone involved in construction, including architects, engineers, contractors and others, to collaborate in a single digital environment. BIM reduces the risks associated with design and construction errors, speeds up workflows and improves communication and collaboration between project participants. It also reduces the cost of building and operating a building. BIM also reduces the cost of maintaining and repairing a building by providing access to complete and up-to-date information about it [19, p.172].

Building Information Management (BIM) is a system for organising and controlling the investment and construction process by using the parameters of a digital building model to organise the information exchanged throughout the investment cycle. Certain effects result from: centralised data exchange, visual communication based on three-dimensional objects, early identification of opportunities, use of sustainable, interdisciplinary and interactive design, control during and on site, regular updating of documentation (design changes, during construction and during operation).

These effects result from the use of modern technologies and approaches in the construction industry. Let's take a closer look at each of these effects in turn:

1. *Centralised data exchange:* This means that a central system is used to store and exchange all project data and information. This provides real-time access to up-to-date information for all project participants, including architects, engineers, developers and consultants. This facilitates better coordination and communication between all parties involved. It also reduces the potential for errors and allows a quicker response to any changes or problems.
2. *Visual communication based on three-dimensional objects:* All project participants can better understand and communicate with each other through the use of three-dimensional models and visualisations. This ensures clearer and more precise communication, improves perception and contributes to a more accurate understanding of the project as a whole.
3. *Early identification of opportunities:* Potential problems or shortcomings in the project can be identified at an early stage through the use of analytical tools and models. This reduces the risk and cost of correcting mistakes in the future, as problems can be identified and resolved more quickly.
4. *Use of sustainable, interdisciplinary and interactive design:* Sustainability, energy efficiency

and environmental considerations can be taken into account at the design stage through modern design approaches. Furthermore, working with different disciplines (architecture, engineering, energy, etc.) allows for better interaction and optimises the project.

5. *Control during and on site:* Better control of the construction process, both remotely and on site, through the use of modern technologies such as drones, sensors and monitoring systems. This helps to improve the quality of work, reduce risks and improve project efficiency.
6. *Regular updating of documentation:* Keeping the design documentation up to date allows all changes and modifications made during designing, building or operating the facility to be taken into account. This ensures that you always have the latest and most accurate information about the project and how it's progressing. In general, by harnessing these effects, the quality, efficiency and sustainability of construction projects can be improved, risks and costs can be reduced and collaboration between all project stakeholders can be improved.

To summarise, Building Information Management (BIM) is an integrated project management system in the construction industry that uses digital models to organise, analyse and share information throughout the entire lifecycle of a building. BIM enables the creation and collection of data related to the project, construction and operation. This helps to improve efficiency and communication between all project stakeholders [23, p. 3].

Building Information Modelling (BIM) is a new approach to construction that involves the collection and comprehensive processing of all information about a building during the design phase. Using specialist software, all architectural, design, technological, financial and other information about the building is collected into a single three-dimensional model. This model is linked to an information database. An important feature of this approach is the design of the building as a single, integral object, with automatic changes being possible in the event of a change in any parameter. Building information modelling makes it possible to reduce the number of errors and the cost of construction. It also improves the efficiency of production and the quality of construction [20, p. 41].

It is important to note that the traditional approach to design is based on two-dimensional models-plans, drawings and paper documents. In contrast, BIM technologies add new dimensions - construction plans, time and cost, which can be presented in any convenient form using an information model of the object in virtual reality. By enabling more detailed and coordinated planning of all aspects of a project, the introduction of BIM can significantly improve the efficiency of design and construction.

The historical constant in developing BIM technologies is unique. Under the influence of the digital revolution, there has been a transition to Construction 4.0, known as Intelligent Construction. This provides integrated management of the construction project chain. Intelligent construction enables predicting, controlling and planning all business processes for construction projects. Intelligent construction is based on 4 key digital technologies: 3D printing, the Internet of Things, virtual reality and big data, which significantly improve safety, labour efficiency and reduce costs during the construction process. According to experts, using digital technologies in construction projects can reduce construction costs by 5-10% and operating costs by 10–20% [12, p. 36].

Obviously, positive experience of implementing Industry 4.0 in EU countries and some Ukrainian enterprises is important. The analysis shows that the following factors were successful: approval of the national Industry 4.0 development programme by the government, attraction of more innovative and market-oriented financial instruments (e.g. business loans and tax benefits, provision of specialised financial instruments), creation of large multilateral platforms for discussing initiatives aimed at increasing the capacity and implementation of digital transformation programmes in the respective industries of companies Taking these recommendations into account, implementing such initiatives may be appropriate when implementing Ukrainian innovation projects [11, p. 5]. Implementing BIM is one of the most relevant initiatives.

Experience shows that where there is government support, the development of BIM is most active. For example, the United States was a pioneer in the use of BIM in government projects, leading to the creation of a specific regulatory framework in support of BIM and the adoption of this technology in the construction industry. Today, if developers do not use information modelling, they cannot win government contracts. In China, after a government decision to adopt BIM, a complex water sports stadium, the Water Cube, was built using new technologies. It was used during the 2008 Olympics. Since 2016, in the UK, the Netherlands, Finland, Denmark and other countries, implementing government contracts requires using BIM technology [9, p. 50].

The main principle of BIM is the cooperation of different stakeholders at different stages of the object's life cycle. This enables the implementation, receipt and updating of information to support and reflect the role of each user [17, p. 55]. The value of BIM is that it enables collaboration and information sharing at every stage of the building's lifecycle between different project participants - architects, engineers, contractors, clients and others. This can include designing, building, operating and maintaining. The benefits of using BIM include increased design efficiency, easier coordination between different disciplines, improved quality of construction solutions, reduced risks and errors, and increased ease of operating and maintaining the building. In addition, BIM enables the capture of building performance data and its use to support decisions on how to maintain, repair, modernise and refurbish. This helps to improve the productivity of the construction process, extend the life of the building and reduce the overall costs over the life cycle of the facility.

BIM has two main advantages over CAD:

1. BIM models and control objects are not just graphical objects, they are information which can be used for automated drawing and reporting, project analytics, scheduling, plant operations, and so on. This provides the construction team with an unlimited number of possibilities to make the best decision based on all the data available to them.
2. BIM supports distributed teams so that people, tools and tasks can use this information effectively and collaboratively throughout the life cycle of the building. This avoids redundancy, re-entry and loss of data, errors in its transfer and conversion [2, p. 152].

The use of BIM (Building Information Modelling) by users has both short-term and long-term benefits. These are confirmed by modern research [18; 21; 24–26] and practice. Minimising errors in documentation is one of the main short-term benefits of using BIM. A further benefit in the short term is the possibility of using BIM as a marketing tool. Reduced staff turnover is also cited as a short-term benefit of BIM use. Long-term benefits are seen as reduced contract claims and reduced construction costs. A major benefit of using BIM is also seen as longer-term client relationships.

For initial planning and feasibility studies, the use of Building Information Modelling can also be effective. A conceptual building model can include cost information that will help the developer to determine whether a building of a given size, level of quality and set of requirements can be constructed within a given budget and time frame. In addition, the BIM model allows the design to become realistic to visualise at all stages of the project. BIM Level 4C network schedules are a powerful tool for phasing, coordinating and communicating information about planned work between those involved in the project. It should be noted that the processes involved in this phase, and in the project management process in general, require a favourable and supportive environment. In particular, they require the approval of the responsible management [8, p. 148].

Costs are reduced and labour productivity increased because all materials and components are automatically identified and calculated, and can be ordered via an electronic form and delivered to the site as required. The 3D model provides an easy-to-understand visualisation of the workspace, while the network diagram allows a simplified understanding of the various requirements throughout the project lifecycle. Stakeholders directly responsible for the execution of construction activities will find this particularly useful. From a single, fully integrated dashboard, BIM can link manufacturer data, construction data and communications.

We agree with O. M. Polinkevich [15] that a key aspect of any innovative visualisation system is to facilitate interactive updates in real time. The benefits of using such technology are negated by inefficiency in performing updates. Inconsistent updates can cause team members to lose focus and make it difficult to monitor and use the project. In the future, it is expected that data visualisation tools will provide seamless updates in real time and will be powerful enough to enable effective interaction between team members. Everyone involved in the process will be working in a single environment. Changes to one component will result in changes to all other interdependent components, without the need for additional time to coordinate them.

BIM technology goes beyond standard CAD systems. It enables the creation of three-dimensional models, known as 3D models, as well as models defined as 4D, 5D, 6D and even 7D. In concrete terms, BIM technology from 4D to 7D can be described as follows 4D – a virtual model of a building with construction plans and the ability to control the construction process simultaneously with the visualisation of the building at a selected time; 5D – the creation of opportunities for more accurate preparation of cost estimates, minimisation of errors and cost control during the construction phase; 6D – compliance with the principles of sustainable development in the construction process [6, p. 177]. This technology makes it possible to evaluate the future building from the point of view of energy saving and the use of solar energy as early as the design phase. The entire life cycle of a building facility, from design to decommissioning, can be managed using 7D modelling based on Facility Management. The integration of many levels of design allows you to analyse things that until recently seemed outside the scope of design.

Even at the lowest level of BIM 3D, current applications have many more features than standard CAD systems, which are usually limited to defining the geometry and materials of the elements being designed. BIM 3D systems provide a parameterised description of geometric and material properties. They also offer the possibility of using the latest technologies available for the production and processing of building elements, such as CNC machining or laser cutting. A significant advantage of BIM 3D systems is also the ability to generate photorealistic images through the use of appropriate software that is integrated with the central BIM system [1, p. 16]. "Higher" 3D systems offer the possibility of incorporating and taking into account parameters such as time, cost and other indicators aimed at sustainable development and management of the facility. BIM 4D is expected to combine geometric and material information with time parameters that will assist in the planning and scheduling of the construction project.

BIM 5D, together with the parameters specific to BIM 4D, allows you to define cost parameters that are important for modelling, estimating and analysing the costs that are or may be incurred throughout the lifecycle of a facility. BIM 5D therefore enables cost to be modelled, currently one of the most important factors determining the market for building investment. As for BIM 6D, it enables the calculation of a building's energy efficiency and energy consumption, as well as complex calculations of the entire building (taking into account its location) and all its elements at the same time. In addition, thanks to BIM 6D and 7D, we are able to collect and use a wide range of information about the object in a central system, which allows us to make efficient use of the building during its operation. The most important functionality of the BIM 6D and 7D system is its use in the field of facility management [16, p. 198].

In an automated system, the project management model is built on the basis of three elements: structure of project activities; structure of resources; matrix of resource allocation to project activities [5, p. 100].

The structure of project works is a list of stages and works of the project, hierarchical organisation of works, interrelations between them and the estimated time of executing. Based on these parameters, the software automatically (independently) creates a project schedule. It determines the start and end dates of individual activities and the entire project, as well as time reserves. Unlike manual planning, automated planning in Project Management Systems is characterised by the fact that we usually don't tie activities to specific dates, but only determine their structure, interconnection and duration. This allows the system to use various project optimisation algorithms and to track changes in the project schedule as it is being implemented.

Human resources, equipment, materials and funds are included in the project resource structure. Spreadsheets are used to describe their main characteristics, such as the cost, productivity and quantity of the resources. You can set calendars for the use of some types of resources in the systems.

The resource allocation matrix contains information on which resources are used for each project activity, what type of resources they are and how they are used. The system stores data on the resource requirements of activities, including their characteristics and quantities. The programme automatically recalculates the calendar plan, taking into account the restrictions associated with the resources, after the resources have been assigned to the work.

These three elements together make up a model of project management in an automated system that allows for the effective planning, control and implementation of projects. Therefore, it should be noted that the success of the information system implementation and obtaining the maximum benefits and advantages for the company depends on the effectiveness of cost management throughout the project life [4, p. 20].

BIM technology makes it possible to achieve high speed and quality of design and construction works, as well as significant cost savings. For example, in the construction of the new Museum of Art building in Denver, USA, which is complex in shape and interior design, an information model developed specifically for this facility was used to organise the interaction of subcontractors in the design and construction of the building frame, as well as in the development and installation of networks and communications [16, p. 199].

The overall cost effectiveness of implementing BIM technology is determined by several factors: the overall level of project risk will be reduced due to proven, accurate and optimised design solutions for engineering systems; construction time and costs are expected to be reduced due to fewer installation errors and lower material costs; and the improved quality and efficiency of building use will help reduce the negative impact on the environment.

Proven, accurate and optimised design solutions for engineering systems will reduce the overall level of project risk. The use of a BIM model for maintenance and operations is gaining more attention from building owners. It can reduce costs in the long term. If we think of a building as an iceberg (in the sense that only 1% of the total cost of a building's life cycle is spent on its design, while 70% is spent on its maintenance), BIM has great potential: A small increase in cost at the design stage can reduce future maintenance costs, which account for the majority of all building costs [10, p. 317].

Fewer installation errors and less material consumption are expected to reduce construction time and costs. With the development of software, it is possible to quickly create and quickly test different solutions in order to eliminate errors as quickly as possible. In the world of traditional construction, developers must ensure that the first version of the building is as successful as possible, as the second version means expensive rebuilding [3, p. 599]. BIM technology will help to avoid the need for massive "on-site fixes" that gradually drive costs out of control. BIM will help to analyse, test, modify and reanalyse the building design, perfecting it to achieve the highest quality and most functional model before construction begins.

The negative impact on the environment will be reduced by improving the quality and efficiency of buildings. Environmental standards and pollution are of particular concern to developers today. The calculation of volumes on the basis of a 3D BIM model, rather than on the basis of 2D drawings, will be much more accurate. As a result, architects and contractors will be able to avoid making mistakes when determining the amount of building materials that will be needed. The closer the preliminary estimate is to the final version, the more accurate this estimate will be. Furthermore, this can significantly reduce waste. Accurate calculation has a direct impact on the amount of energy, resources and transport time required to obtain building materials, leading to a significant reduction in carbon emissions. Environmental performance calculation tools can help you analyse the life cycle of a building and calculate the environmental impact of different buildings. They can also help you reduce emissions by choosing different materials or production methods. Prefabricated and modular structures are regaining popularity thanks to advances in BIM. For the domestic construction market, this means the ability to design building components accurately and in detail, which means that an increasing number of components can be manufactured off-site. The use of modular and prefabricated structures can reduce the time required to complete a construction project and increase its efficiency, as prefabricated components can be manufactured in optimal factory conditions, which means that construction companies do not have to deal with constraints such as bad weather or short daylight hours [14, p. 234].

In general, by reducing risks, shortening construction time, cutting costs, improving quality and reducing negative environmental impacts, the introduction of BIM technology can have a positive impact on the economic efficiency of construction projects.

CONCLUSIONS

Thus, a relevant and important direction in the modern construction industry is the introduction of virtual information models in construction companies. The essence of BIM technologies is the creation of digital models of construction objects that combine the geometric, physical and functional characteristics of the building. This allows analysis, visualisation and management of the construction process at all its stages. The ability to communicate and collaborate with everyone involved in a construction project based on a centralised information model is a key feature of BIM technologies. This helps to improve design accuracy, reduce conflicts and errors during the construction phase, and enables virtual simulations and analysis of the effectiveness of solutions. Successfully implementing BIM technologies in a construction company offers the potential for economic efficiency through increased labour productivity, reduced resource and material costs, as well as improved construction quality and safety. It also contributes to the efficiency of construction projects by ensuring compliance with standards and reducing the risk of errors. In addition, using BIM helps to improve the quality of buildings and optimise the use of resources, which can help to reduce negative environmental impacts. In fact, BIM is a significant constant in overall cost effectiveness through this integrated approach to construction project management. ■

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