ISSN 2076-2429 (print)
ISSN 2223-3814 (online)

UDC 004.9:69(477)

A. Chumachenko
Odessa Polytechnic National University, 1 Shevchenko Ave., Odesa, Ukraine, 65044; e-mail: 10487490@stud.op.edu.ua

PECULIARITIES OF BIM TECHNOLOGY INTEGRATION IN CONSTRUCTION INDUSTRY ENTERPRISES OF UKRAINE

А. Чумаченко. **Особливості інтеграції BIM-технологій на підприємствах будівельної галузі України.** У статті розглянуто актуальність інтеграції BIM-технологій у діяльність будівельних підприємств України як стратегічного інструменту цифровізації в умовах післявоєнного відновлення країни. Обґрунтовано, що цифрове інформаційне моделювання забезпечує комплексне оновлення підходів до управління проєктами, сприяє підвищенню ефективності рішень, прозорості взаємодії між учасниками та зменшенню витрат при реалізації будівельного процесу. Проаналізовано етапи еволюції категорії «Building Information Modeling» у міжнародній практиці та визначено його значення для трансформації управлінських і проєктних процесів у будівництві. Уточнено сучасні підходи до визначення сутності поняття «BIM» і уточнено його основні характеристики. Окреслено ключові проблеми та бар'єри, які гальмують масштабне впровадження BIM у будівельній галузі, зокрема: нестачу інвестиційних ресурсів, дефіцит кваліфікованих фахівців, низький рівень уніфікації стандартів та інституційної підтримки. Запропоновано алгоритм імплементації BIM-технологій на рівні підприємства, що враховує технічні, організаційні та економічні чинники, а також передбачає апробацію на пілотних проєктах, розвиток інфраструктури цифрових платформ та формування нормативно-правового середовища. Проведено аналіз потенціалу використання BIM у процесах реконструкції та модернізації пошкоджених об'єктів інфраструктури, що фінансуються за рахунок міжнародної допомоги, зокрема у межах програм підтримки Світового банку та ЄС. Доведено, що впровадження BIM-технологій сприятиме підвищенню конкурентоздатності українського будівельного сектору у контексті його адаптації до світових стандартів цифрового управління. Обґрунтовано перспективність подальших досліджень у напрямі синергії BIM та інструментів штучного інтелекту, що дозволить автоматизувати процеси, мінімізувати помилки та підвищити якість управлінських рішень у будівництві.
Ключові слова: будівельні підприємства, BIM-технології, цифровізація будівництва, інноваційна технологія, повоєнне відновлення, будівельний проєкт, інвестиції

A. Chumachenko. **Peculiarities of BIM Technology Integration in Construction Industry Enterprises of Ukraine.** The article examines the relevance of integrating BIM technologies into the operations of Ukrainian construction enterprises as a strategic tool for digitalisation amid the country's post-war recovery. It is substantiated that digital information modelling provides a comprehensive renewal of project management approaches, contributes to more effective decision-making, improves transparency in stakeholder interaction, and facilitates cost optimisation throughout the construction process. The evolution of the "Building Information Modelling" concept in international practice is analysed, and its role in transforming managerial and design-related activities in construction is outlined. Modern approaches to defining the essence of BIM are clarified, along with its core characteristics. Key problems and barriers hindering the large-scale implementation of BIM in the construction sector are identified, including insufficient investment resources, shortage of qualified professionals, low standardisation, and weak institutional support. An enterprise-level BIM implementation algorithm is proposed, accounting for technical, organisational, and economic factors. The approach also includes piloting on selected projects, developing digital platform infrastructure, and building a regulatory and legal framework. The article explores the potential of applying BIM in the reconstruction and modernisation of damaged infrastructure facilities funded by international aid, particularly under World Bank and EU support programmes. It is demonstrated that the adoption of BIM technologies will strengthen the competitiveness of Ukraine's construction sector as it aligns with global digital governance standards. The study also highlights the promising research direction of integrating BIM with artificial intelligence tools, which can support process automation, reduce errors, and improve the quality of managerial decisions in construction.
Keywords: construction enterprises, BIM technologies, digitalisation of construction, innovative technology, post-war recovery, construction project, investments

1. Introduction

The relevance of studying the integration of BIM technologies in the construction industry of Ukraine is growing in the context of developing and implementing a strategy for the post-war economic recovery. As demonstrated by the best cases of international practice [1, 2, 3], the use of 3D modelling has a positive impact on the quality and speed of infrastructure projects. The European experience confirms the growing role of BIM technologies in projects for the reconstruction and renovation of existing buildings [4], which is in line with the general global trend of expanding their scope. After all, investments in BIM technologies allow for a qualitative update of approaches to design, construction, and operational processes throughout the entire life cycle of a construction project. However, when assessing the specifics and trends in the digitalisation of the construction industry in Ukraine, it is worth noting that innovative technologies in this area are implemented mainly on a piecemeal basis, without a clearly structured system. Despite the existing challenges and the use of outdated approaches by most organisations and enterprises, the transformation process has already begun and continues to

DOI: 10.15276/opu.1.71.2025.20

gain momentum. This statement is also true in the context of the need to ensure the competitiveness of Ukrainian construction companies in the European and global markets, which requires analysing the preconditions and developing an algorithm for integrating BIM technologies into the activities of the sector. In assessing the current institutional support for the implementation of BIM in Ukraine, it should be noted that despite a certain lagging behind the world level, it can be expected that BIM design will soon become an organic component of the construction sector.

2. Literature review and problem statement

The topic of implementing BIM technologies in project activities is a topical issue given the slow pace of innovative renewal in the construction industry in Ukraine. Thus, this issue requires the study of a number of scientific publications by both Ukrainian and foreign authors, from the point of view of the need to clarify the best cases of digitalisation of construction companies.

The benefits of implementing BIM technologies by construction companies have been studied in a wide range of scientific papers. Publication [5] reveals the practical issue of increasing the return on investment in the construction business through the integration of BIM technology, which has a direct impact on increasing the productivity of a set of processes within the project life cycle. In the same context, we can consider [6], which focuses on an improved supplier selection process for the procurement of construction materials, which allows for a new approach to the search and ranking of counterparties when using BIM technology. The authors of [7], using the scientific method of expert assessments, identify the security factor as a qualifying advantage in the implementation of projects using BIM technologies.

In [8], the key vector of research on BIM technologies is to clarify the role of information modelling at the design stage. In contrast, in publications [9, 10], the focus is shifted to the use of BIM technologies for the reconstruction of buildings and structures, which reflects the current task of implementing measures within the framework of the post-war recovery strategy in Ukraine when working with infrastructure and residential facilities that need to be rebuilt. The authors of [11] focus on the need to carefully study the pool of possible risks when integrating BIM technologies into the activities of construction companies and improve, first of all, the institutional and regulatory environment for further digitalisation of processes. Scientists [12, 13] emphasise the key role of the state in creating favourable conditions for innovative renewal of the construction sector, which correlates with the experience of developed economic systems in this regard.

Although a number of publications have been devoted to the issue of finding a universal methodology for assessing the rationality of using BIM technology in construction projects, the general algorithm for implementing the innovation in practice needs to be improved. For example, the methodology proposed by the authors of [14] allows for a comprehensive assessment of the technical and economic feasibility of a project, taking into account the latest advances in BIM technologies. Work [15], for its part, details the qualifying factors for the implementation of an information system and maximising the benefits at an enterprise. Since the algorithm must necessarily include a stage of monitoring and controlling the effectiveness of digitalisation of construction processes, it is appropriate to consider [16] in terms of the formation of standards and regulations for construction design organisations and design units in the processes of information modelling.

The scientific community is also interested in the conceptual vision of the category “BIM technologies”, however, a thorough review of the evolution of the concept [17-19] indicated the need to develop a new approach using the existing theoretical framework.

The study proposes an innovative analytical approach to assessing the readiness of construction companies to implement building information modelling (BIM), highlighting its importance as a tool for transforming the industry in the face of modern challenges. The originality of the study lies in the focus on the peculiarities of applying BIM technologies in the activities of domestic construction companies in the context of implementing strategies for post-war recovery and infrastructure reconstruction.

3. The purpose and objectives of the study

The purpose of the research article is to develop an algorithm for integrating BIM technologies into the activities of construction companies based on an analysis of the prerequisites, a study of the specific features and problems of integration of innovative technology by the Ukrainian construction business in the context of the need to implement the post-war reconstruction of the country.

The realisation of this goal requires a step-by-step solution to the following research tasks:

ISSN 2076-2429 (print)
ISSN 2223-3814 (online)

– to systematise the main scientific approaches to the interpretation of the Building Information Modelling (BIM) category and to identify its key essential characteristics, taking into account the peculiarities of the formation and spread of BIM technologies in the world practice;

– analyse the prerequisites for the integration of BIM technologies in the construction sector in the context of both Ukrainian and foreign experience;

– to consider the potential, challenges and investment prospects for the integration of BIM into the activities of construction companies in the framework of post-war reconstruction.

4. Research materials and methods

The methodological framework of the article covers a range of the following scientific methods:

– methods of analysis and synthesis were used to study the essential content of the Building Information Modelling (BIM) category, systematise theoretical approaches and identify the main characteristics of the innovation system under consideration. The use of the methods of analysis and synthesis allowed to form conclusions about the evolution of the BIM concept from a theoretical model of the future to an applied tool that is actively used in the global construction environment by various market participants;

– the method of critical analysis and synthesis allowed to focus on conceptual shortcomings and gaps in practical approaches to the implementation of BIM technologies in Ukrainian construction companies and to formulate a number of reasonable conclusions;

– the graphical method allowed to visually structure scientific approaches to the definition of "Building Information Modelling" and illustrate the benefits of implementing BIM technologies in the construction industry of Ukraine;

– an algorithmic approach was used to clarify the sequence of stages of integration of BIM technologies into the activities of a construction company to formalise digitalisation processes and introduce tools to monitor their implementation.

Taken together, the methods used made it possible to carry out a comprehensive study of BIM technology as a strategic tool for digitalising the construction industry in Ukraine in the context of post-war recovery and improving the domestic market in accordance with international standards.

The research materials include scientific publications of domestic and foreign authors on the issues of studying the place of BIM technologies in the processes of digitalisation of the construction sector, analytical studies of the current state and prospects for expanding the use of BIM technologies in the construction industry, the regulatory framework in terms of consideration of the Concept for the introduction of building information modelling technologies (BIM technologies) in Ukraine and approval of the action plan for its implementation, as well as the analytical report of the World Bank Group.

5. Peculiarities of integration of BIM technologies in the construction industry of Ukraine

5.1. Study of BIM technology as a tool for ensuring the digitalisation of the construction industry

The rapid development of digital technologies, in particular in the field of information systems, has been a current trend over the past few decades, which has contributed to the emergence of an innovative way of organising project activities in construction based on the concept of digital information modelling, which involves the creation of a complete electronic information model of a construction project that integrates all the necessary data about it – Building Information Modelling (BIM). This innovation is the result of a response to rapid changes in the external environment that must be taken into account at the design and construction stage of a facility, which requires consolidation of all information flows within a single digital platform. The existing traditional tools were ineffective for managing and processing the dynamically changing array of data that is a characteristic feature of design work. The model of an information-oriented approach to the creation of a construction project provides for the holistic coverage of all types of related data, both technical and economic benchmarks of the project and the functional and structural engineering part within an integrated virtual structure, where a clear correlation between all components is defined. Thus, the qualifying factor for the effectiveness of BIM technology tools is the compliance of the information used for digital modelling with the criterion of data reliability, transparency, and reliability.

In [17], a classification of scientific publications covering the world experience of BIM technology development is made, which separates the stage of BIM technology emergence from the 60s of the twentieth century to 2020, as well as the stage of their active implementation and distribution in the activities of construction companies from 2020 to the present.

The first mention of the need to develop specialised design software was made by Douglas C. Engelbart (1962), who emphasised the gradual growth of data that needs to be organised within the framework of an investment project and coordinated between key stakeholders [18].

In 1992, the publication [19] became a defining event in the discussion and popularisation of the idea of integrating digital object modelling into the activities of construction companies. The use of BIM technologies in related industries has become widespread since 2002. Since then, under the influence of active promotion of the Building Information Modelling idea by scientists and practitioners, leaders in the segment of digital solutions and software development have integrated this model into their systems, including it in the basic concepts of industry terminology.

Thus, the concept of the BIM model was spread through the development of architectural design software by industry leaders at that time, namely: Graphisoft and Autodesk [10].

Currently, according to a report by Allied Market Research published in November 2023, the key players in the building information modelling market are: Aveva Group Plc, Hexagon AB, Trimble Inc, Autodesk Inc, Beck Technology Ltd, Pentagon Solution Ltd, Nemetschek SE, Bentley Systems Inc, Dassault Systems Asite Solutions Ltd [20]. The key software products for BIM objects are tailored to the needs of creating and implementing projects in the field of civil infrastructure, building structure calculations and engineering, asset management and other services based on BIM/BIM services. The required software product is selected based on the company's internal goals, specifics of operation and priorities. There is no standardised option for all types of organisations using BIM technologies.

According to Pan, Yue & Mario, Chelse [21], the issue of combining Building Information Modeling and artificial intelligence technologies is relevant today, as it will allow for an active transition from traditional, paper-based document management to digital management platforms in the short term, which will allow the construction industry to respond more effectively to the challenges of digital transformation and process automation. According to experts, this will help provide accurate, up-to-date data for continuous monitoring and adjustment of the project process.

Thus, in recent years, the BIM concept has evolved from a theoretical model of the future into an applied tool that is actively used in the global construction environment by various market participants: architects, engineers, builders and contractors, developers, manufacturers of building materials and equipment, facility managers, specialised government institutions and other specialists, in particular in the field of urban planning and territorial planning.

To clarify the content of the BIM (Building Information Modelling) category in current scientific publications, it is appropriate to systematise theoretical approaches to its definition based on several fundamental levels of consideration of the issue, which can be clearly seen in Fig. 1.

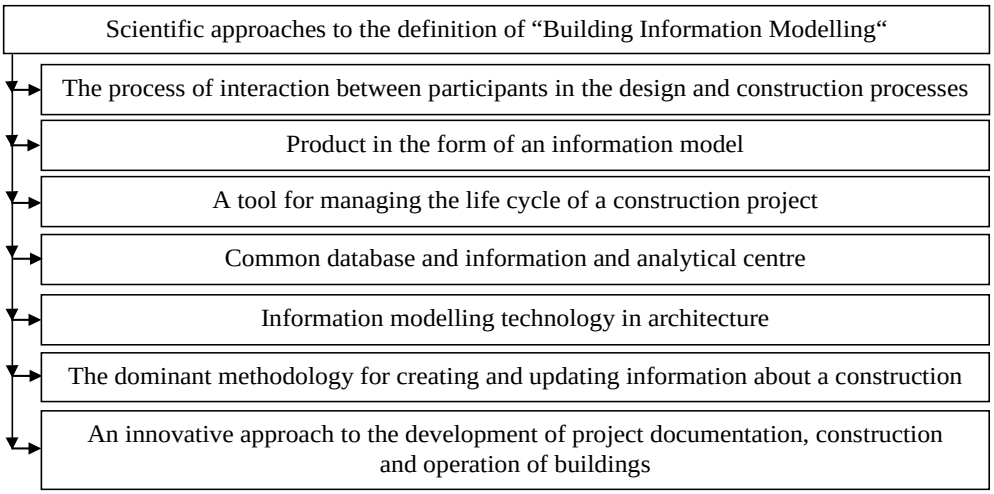

Fig. 1. Scientific approaches to the definition of "Building Information Modelling".
Source: Compiled by the author according to [7; 8; 10; 11; 13; 14; 15; 21; 22]

An analysis of scientific publications has revealed that the modern scientific and professional community still lacks a single, established interpretation of the BIM concept, which is due to the plurality of theoretical approaches to its essential features and specifics of use. However, it can be noted

ISSN 2076-2429 (print)
ISSN 2223-3814 (online)

that almost every scientific publication focuses on the innovative, high-tech and complex nature of the Building Information Modelling category.

Some experts interpret it as the final design model, others as an integrated process of planning and creating a construction project, while another part of the profession does not recognise this concept as a separate category and questions the feasibility and cost-effectiveness of using BIM for all possible projects, emphasising exceptions to the rule. If we focus on the essential characteristics, it is a digital model of a building that contains all relevant information in a consistent manner. Any change in one parameter automatically leads to an update of the data on related elements.

In our opinion, Building Information Modelling (BIM) is a complex innovative system of interrelated processes in the field of architectural and construction design, construction, reconstruction, renovation, revitalization and facility management, based on the creation of a comprehensive digitalised model that acts as a single information and analytical database and a tool for coordinating the actions of all participants in the design, construction and operational processes throughout the entire life cycle of a building: from the idea and engineering design documentation to construction, operation and further modernization of the facility.

The integration of BIM technologies at the micro level of the economic system requires the creation of a high-quality basis for the digitalisation of construction processes at all stages of the construction project life cycle, namely:

1. Development and implementation of a unified architecture for managing the life cycle of a construction project based on the use of a digital BIM model of a building in real time. This concept, prior to the development of project documentation, construction of buildings, equipment with engineering systems, use, renovation and reconstruction of structures, represents the life cycle of a construction project, which ensures the integration of architectural, technological, economic and other accompanying information flows into a single information model, taking into account their interdependencies and functional correlations.

2. Application of up-to-date approaches to managing the processes of developing project documentation and planning construction projects, using innovative network methods that have proven to be effective in accordance with the available practical examples from foreign construction digitalisation practices. Among the widely used network methods, it is advisable to mention the Critical Path Method (CPM), the Potentially Critical Path Method (CCPM), the Plan Evaluation and Review Technique (PERT), and the Priority Diagramming Method for Determining Task Dependencies (PDM). The testing of these network methods creates a basis for optimising resources, managing project duration, prioritising tasks, etc.

3. The modern practice of digital management in the design and construction sector requires a transition to the use of a universal digital model as a means of communication and coordination of the actions of process participants at all stages of the project implementation. It is extremely important to provide a data presentation format that is transparent, accessible and understandable to all participants in multidisciplinary interaction within the project. Thus, the key to achieving efficiency is the unification of the data presentation format and the consistency of information flows for timely updating of the digital electronic model for the purpose of appropriate process analysis.

4. Introducing the use of licensed digital tools and software into the design and management of facilities allows for the creation of an interactive information environment that provides continuous access to data, prompt resolution of production tasks, and transparent decision-making by all participants. This approach will also reduce administrative and technical costs, as well as promote the development of the related information sector, which is formed at the intersection of technological demand and market innovations.

5. The development and implementation of a high-quality digital tool in the form of a single integrated information system for the construction segment is an important step in ensuring its sustainable development, modernising infrastructure, and intensifying the process of attracting foreign capital by adapting to international standards for the design and management of construction projects.

6. Like any other innovation, digital modelling requires financial investment and transformation of the organisational structure of the project process. Construction companies are faced with the task of investing both in the purchase of new licensed software and in the training of personnel involved in working with the BIM model. Both the psychology of construction project executors and design technology need to be transformed.

Analysing the process of integrating BIM technologies into the activities of construction companies, the following algorithm can be used (Fig. 2).

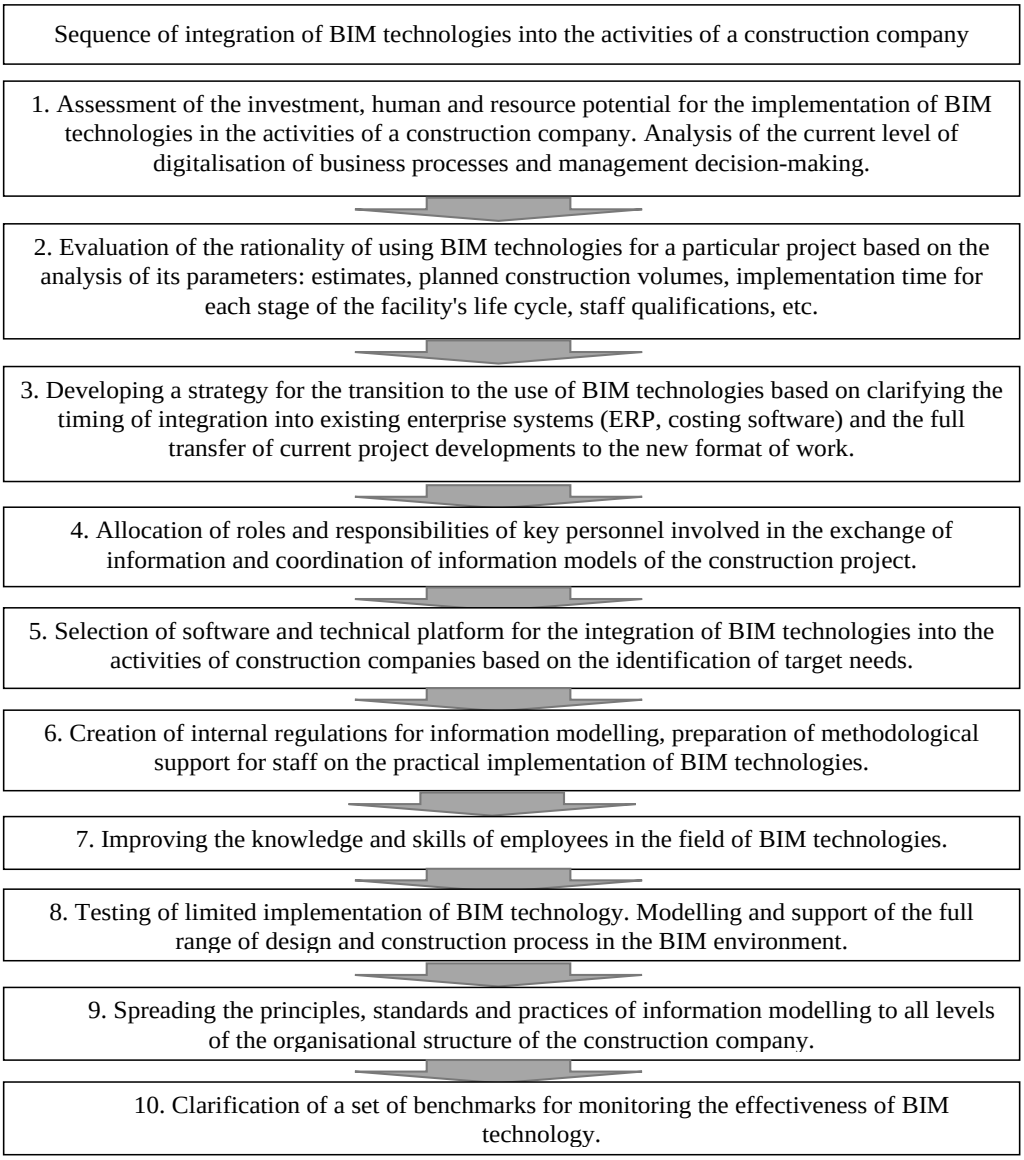

Fig. 2. Sequence of integration of BIM technologies into the activities of a construction company

In our opinion, the starting point for using BIM technology in the activities of a construction company is to assess, first of all, the investment, human and resource potential, since its implementation is a capital-intensive process. Insufficient investment potential will create risks for fragmented application of BIM technology. It should be noted that the introduction of BIM technologies requires a systematic approach that involves transforming the methodology of design activities, restructuring organisational mechanisms and revising the professional thinking of the designer, rather than just replacing software and updating technical equipment.

According to a number of scholars [14], it is appropriate to evaluate each individual project for the need to use BIM technologies, as there are certain exceptions to the general rules that indicate the irrationality and inefficiency of such actions. In particular, projects with a low funding limit, short implementation timeframes, insufficient staff competence, and the prevalence of unified architectural and construction schemes with standardised design and engineering solutions are inappropriate for consideration for the implementation of BIM technologies.

A necessary step in the digitalisation of construction processes is also the development of a strategy for the transition to the use of BIM technologies based on the clarification of the timing of integration into existing enterprise systems (ERP, estimating software) and the full transfer of current project developments to the new format of work.

ISSN 2076-2429 (print)
ISSN 2223-3814 (online)

In the context of the distribution of roles and responsibilities of key personnel involved in the exchange of information and coordination of information models of a construction project, attention should be paid to the importance of ensuring that they have the same level of digital skills. If the team is expanded, the organisational structure should include a BIM manager whose focus will be on:

a) compliance with the rules and standards of working with the information model of the construction object;

b) setting the programme parameters and modelling the information model;

c) control over the activities of employees working with the information model of the construction object;

d) allocation of areas of staff responsibility in the design process;

e) checking the information model for errors, identifying conflicts between its elements, as well as eliminating logical and structural inconsistencies that may adversely affect the accuracy of project documentation and the efficiency of the construction process.

The defined set of tasks requires the BIM manager to have a high level of digital literacy, a deep understanding of the principles and approaches to information modelling, and the ability to ensure control over the correct integration of heterogeneous information flows within a single digital model of a construction project.

The next step is to select software and a technical platform for the integration of BIM technologies into the activities of construction companies based on the identification of target needs. According to the report [23], Autodesk, Inc. is the most widely used among the key market participants that create platforms for the implementation of BIM technologies. The Autodesk Revit technical platform is used for a wide range of tasks that can be performed in design, coordination and cost estimation. It supports work with architectural, structural, and engineering elements to help architects, engineers, and designer complete tasks efficiently. It can be integrated with Robot, Navisworks, ReCap, AutoCAD and 3ds Max.

The success of using BIM technologies in a construction company depends on the orderliness of internal information modelling regulations that systematise uniform standards for working with digital models, including data structuring standards, levels of detail and formats for exchanging information flows. After all, the issues of formalisation and regulation require special attention when working with a digital model by specialists who work in parallel on all structural parts of the project [16].

In our opinion, it is imperative to test BIM technology on the basis of a selected construction project as a pilot project in order to identify weaknesses and clarify areas for improving both internal standards and the practice of digitalising business processes.

The development of a set of benchmarks for monitoring the effectiveness of BIM technology allows for an objective assessment of the effectiveness of information modelling in the dynamics, comparing the expected and actual results and adjusting the directions of further scaling of the construction entity’s activities.

5.3. Integration of BIM into post-war recovery: potential, challenges and investment prospects

Under martial law, BIM technologies are transforming from a tool for innovation to a necessary component of a strategy for the rapid, reasonable and controlled restoration of destroyed infrastructure. According to the World Bank Group [24], as of December 2024, the total cost of reconstruction in Ukraine reached USD 524 billion, which should be used in the next two years. These funds are to be used over the next 10 years to address a set of priorities: rebuilding housing, healthcare, education, etc. Thus, it is now undisputed that large-scale economic damage has been caused to the civil and industrial infrastructure of the state, which raises the extremely important issue of assessing the economic feasibility of reconstructing these facilities in the near future. In this regard, the problem of the feasibility and priority of restoring damaged civilian and industrial facilities as a result of Russian military aggression is becoming more urgent. Expert assessments point to the impossibility of reconstructing some facilities due to the critical level of damage. At the same time, a significant number of facilities can be rebuilt with grant support or targeted funding from international partners, including European financial institutions. Achieving these goals will require attracting financing from foreign investors while ensuring the necessary level of trust in Ukrainian construction companies. The desire of foreign investors to minimise risks and increase the level of predictability of project implementation in the Ukrainian market necessitates the use of modern digital tools to meet high standards of management efficiency. As there is a possibility that foreign investors will engage their own project teams, high-tech solutions and qualified personnel, ignoring the internal potential of the Ukrainian construction

segment. In this context, the integration of BIM technologies is a tool for strengthening the competitiveness of Ukrainian companies, forming the basis for a long-term strategic partnership with international investors. Thus, the Ukrainian construction market needs to adapt to global digitalisation standards and continuous innovative technology upgrades to prevent domestic companies from being forced out of the market. This is an urgent requirement of the time, due to the mandatory use of BIM technologies in a significant number of EU member states for the implementation of projects financed from budgetary funds. A significant advantage of integrating BIM technologies into the process of assessing the technical condition of existing structures with various types of damage is the ability to strengthen control over the quality of restoration work and guarantee the operational stability of structures in the long term [9].

When assessing the scale of the global information modelling market, it is appropriate to note its significant development potential, which is measured by a compound annual growth rate of 16% starting from 2023 in the forecast period until 2032, according to Allied Market Research [20].

The size of the global building information modelling market was estimated at USD 7.9 billion in 2012. USD in 2022, and, according to experts, will reach USD 34.2 billion USD by 2032.

Among the qualifying factors that will contribute to the further scaling of the technology in the Ukrainian market, it is worth noting the government's commitment to the use of building information modelling (BIM), which is enshrined in the Concept for the Implementation of Building Information Modelling (BIM) Technologies in Ukraine [25]. Indeed, the introduction of BIM technologies in the activities of companies in the construction segment has a number of advantages for all key stakeholders, which are systematised in Fig. 3.

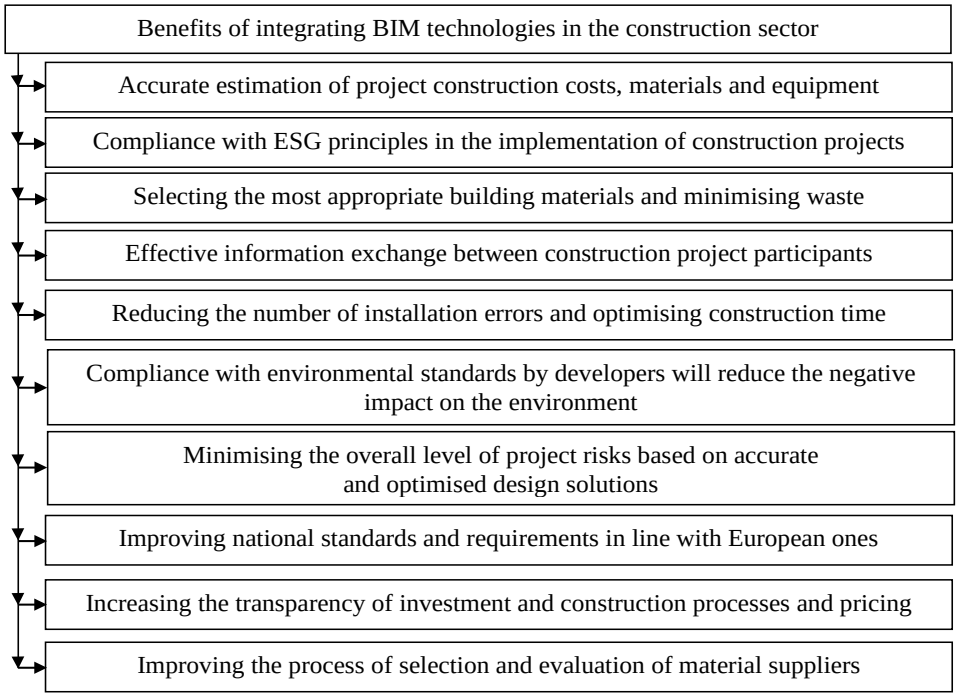

Fig. 3. Benefits of integrating BIM technologies in the construction sector

The considered set of advantages of integrating BIM technologies in the construction sector contributes to both increasing the competitiveness of Ukrainian construction market participants and increasing the investment attractiveness of the construction sector as a whole through innovative approaches to project management and implementation.

6. Analysis of research results

The presented work focuses on the consideration of BIM technology as one of the qualifying factors for the systemic restoration and reconstruction of residential buildings and urban infrastructure affected by the war. The originality and scientific novelty of the proposed algorithm for the integration of BIM technologies lies in a multi-level, systematic and adaptive approach that takes into account both technical and organisational, human and economic factors of innovative updating of processes in a construction company. The study of the specifics of the integration of BIM technologies at the micro level of the economic system takes into account the creation of a qualitative basis for the digitalisation

ISSN 2076-2429 (print)
ISSN 2223-3814 (online)

of construction processes at all stages of the life cycle of a construction project, which determines both the theoretical validity and practical value of the work. Thus, the research focuses on the conceptualisation of the principles of implementing BIM technologies in the Ukrainian construction sector, which is becoming increasingly relevant in the context of the need to ensure post-war recovery and reconstruction of both infrastructure and housing.

Conclusions

Building Information Modelling is a strategically important technology that provides comprehensive digitalisation of processes in the construction sector – from the conceptual design stage to operational support. A study of the specifics of its implementation in the activities of Ukrainian construction companies has led to several important conclusions.

1. There has been a gradual evolution of the BIM concept from a theoretical model of the future to an applied tool that is actively used in the global construction environment by various market participants. The paper further develops the definition of the category “Building Information Modelling” as a complex innovative system of interrelated processes in the field of architectural and construction design, construction, reconstruction, renovation, revitalization and facility management, based on the creation of a comprehensive digitalized model that acts as a single information and analytical database and a tool for coordinating the actions of all participants in the design, construction and operational processes throughout the entire life cycle of a building: from the idea and engineering to the construction of the building. The key essential characteristics of the category “Building Information Modelling” include its innovative, high-tech and complex nature.

2. A study of the world’s best practices confirms that among the pool of innovative digital technologies currently being implemented in the construction sector, one of the most effective is building information modelling, which creates a holistic and comprehensive view of the construction object. The integration of BIM technologies into the construction sector at the micro level of the economic system, among the key prerequisites, involves the formation of a comprehensive organisational and technological framework, which includes the creation of a unified digital architecture for managing the life cycle of a construction project, the introduction of effective network planning methods, the unification of data presentation and exchange formats, the use of licensed software, the formation of an interactive information environment, and the development of integrated information systems capable of Among the general prerequisites identified on the basis of best foreign practices, special attention should be paid to staffing for digitalisation, financing of transformation processes and rethinking the methodology of project activities, which is critical for the sustainable functioning of a modern construction company in the digital economy.

3. The scientific novelty of the results obtained is the development and substantiation of an algorithm for integrating BIM technology into the activities of a construction company, taking into account the specifics of the company’s internal resources, the level of digital literacy of personnel, strategic management goals, and technical and organisational prerequisites for the implementation of innovative digital solutions. The algorithm provides for the possibility of testing innovative approaches on pilot projects and provides a basis for further scaling BIM solutions throughout the organisation. Among the main challenges of integrating BIM technology into the activities of construction companies are the adaptation of Ukrainian business to global digitalisation standards and the continuous innovative updating of technologies.

A promising vector for further research in this area is the development of BIM technologies based on the integration of artificial intelligence tools, which will improve the quality of construction project management through automation and process acceleration.

Література

1. Kalajian K., Ahmed S., Waleed M. A. Youssef. BIM in infrastructure projects. *International Journal of BIM and Engineering Science.* 2023. Vol. 6. № 2. P. 74–87. DOI: https://doi.org/10.54216/IJBES.060205.
2. Abd Alnoor B. BIM model for railway intermediate station: transportation perspective. International *Journal of BIM and Engineering Science.* 2022. Vol. 4. № 2. P. 33–48. DOI: https://doi.org/10.54216/IJBES.040202.
3. Building Information Modeling (BIM) applicatiion for an existing road infrastructure / Vignali V., Acerra E., Lantieri C., Di Vincenzo F., Piacentini G., Pancaldi S. *Automation in Construction*. 2021. Vol. 128. URL: https://sci-hub.se/downloads/2021-06-19/fc/vignali2021.pdf.

4. An analysis for the adoption of Building Information Modelling (BIM) across the EU27 for Public Sector. European Innovation Council and SMEs Executive Agency (EISMEA). 2024. URL: https://build-up.ec.europa.eu/en/resources-and-tools/publications/analysis-adoption-bim-across-eu.
5. Sompolgrunk A., Banihashemi S., Mohandes S.R. Building information modelling (BIM) and the return on investment: a systematic analysis. *Construction Innovation*. 2023. Vol. 23. № 1. P. 129–154. DOI: https://doi.org/10.1108/CI-06-2021-0119.
6. BIM-based search and selection of construction material suppliers: a dedicated framework and prototype / Aftab U., Hassan M.U., Ullah F., Nasir A.R., Thaheem M.J. *Construction Innovation*. 2024. DOI: https://doi.org/10.1108/CI-06-2023-0136.
7. The use of building information modelling (BIM) in the management of construction safety: The development towards automation hazard identification and assessment / Zanib K., Muhammad Y., Uzair R., Hafsa K., Abdul K., Kenneth L. *International Journal of Science and Research Archive*. 2024. Vol. 11. P. 830–852.
8. Філіппов О.В., Шумак Л.В. BIM-технології інформаційного моделювання будівель на стадії проектування. Національний та зарубіжний досвід. *Будівельне виробництво.* 2023. №75. С. 39–53.
9. Мещерякова О.М. BIM: ефективний інструмент для реконструкції будівель та споруд. *Сучасні технології та методи розрахунків у будівництві.* 2022. Випуск 18. С. 61–70.
10. Гудима Л.О. BIM-технології в будівництві: сучасні виклики для України. *Бізнес Інформ*. 2024. №2. С. 97–104.
11. Київська К.І., Лузіна Ю.В. Перспективи впровадження BIM-технологій у вітчизняній будівельній галузі. *Управління розвитком складних систем*. 2021. Вип. 46. С. 63–69.
12. Безтелесна Л.І., Паламарчук О.С., Пляшко О.С. Формування системи забезпечення інноваційного розвитку будівельних підприємств в економіці України. *Наукові записки Львівського університету бізнесу та права. Серія економічна. Серія юридична*. 2021. Випуск 28. С. 229–243. URL: http://dx.doi.org/10.5281/zenodo.5589498.
13. Левченко О.В., Антоненко Н.В. BIM як інструмент технологічного розвитку архітектурно-будівельного проєктування та стимул реновації навчальних програм вищих навчальних закладів України до міжнародних стандартів. *Перша всеукраїнська науково-практична конференція «BIM-технології в будівництві: досвід та інновації»*, Харків (18–19 березня 2021). С. 204–207.
14. Андрухов В.М., Потєха А.С., Басістий В.О. Комплексна оцінка доцільності використання BIM технологій для будівельного проекту. *Сучасні технології, матеріали і конструкції в будівництві*. 2024. Том 36, №1. С. 161–165.
15. Theoretical and methodological bases for implementing BIM technologies in construction companies: Essence. Characteristics. Economic Efficiency / Yashchenko O.F., Makatora D.A., Kubanov R.A., Zinych P.L., Prusov D.E. *Бізнес Інформ*. 2024. № 1. P. 167–177.
16. Андрухов В.М., Матвійчук В.В. Основні засади BIM проектування при розробці конструктивних рішень в Autodesk Revit. *Сучасні технології, матеріали і конструкції в будівництв*. 2020. Вип. 28(1). С. 18–26.
17. Borkowski A.S. Evolution of BIM: epistemology, genesis and division into periods. *Journal of Information Technology in Construction (ITcon).* 2023. Vol. 28. P. 646–661. URL: https://www.itcon.org/papers/2023-34-ITcon-Borkowski.pdf.
18. Engelbart D.C. Augmenting Human Intellect. A Conceptual Framework, Contract, No. 3578. 1962. URL: https://www.dougengelbart.org/pubs/papers/scanned/Doug_Engelbart-AugmentingHumanIntellect.pdf.
19. van Nederveen G.A., Tolman F.P. Modelling multiple views on buildings. *Automation in Construction.* 1992. Vol. 1. №. 3. P. 215–224. URL: https://www.sciencedirect.com/science/article/abs/pii/092658059290014B?via%3Dihub.
20. Building Information Modeling market size, share, competitive landscape and trend analysis report, by component, by deployment mode, by building type, by application, by end-user: Global opportunity analysis and industry forecast, 2023-2032. Allied Market Research. 2023. URL: https://www.alliedmarketresearch.com/building-information-modeling-market.
21. Yue P., Chelse M. Integrating BIM and AI for smart construction management: current status and future directions. *Archives of Computational Methods in Engineering*. 2023. Vol. 22. P. 1081–1110. URL: https://link.springer.com/article/10.1007/s11831-022-09830-8.
22. Integrating Building Information Modelling (BIM) into construction: innovations, challenges, and global perspectives. Acta Scientiarum Polonorum / Kurcjusz M., Krysińska K., Kosakiewicz M., Naliwajko M., Jabłońska Z., Radecka K., Grzegorzewska E., Sieczych M., Ferenc-Pupek E., Stefańska A. *Architectura.* 2024. Vol. 23. P. 287–303.

ISSN 2076-2429 (print)
ISSN 2223-3814 (online)

23. BIM in construction market size, share, competitive landscape and trend analysis report, by phase of work, end user, application and deployment model: Global opportunity analysis and industry forecast, 2020-2027. Allied Market Research. 2021. URL: https://www.alliedmarketresearch.com/bim-in-construction-market-A10290.
24. Оновлена оцінка потреб України на відновлення та відбудову. World Bank Group. 2025. URL: https://www.worldbank.org/uk/news/press-release/2025/02/25/updated-ukraine-recovery-and-reconstruction-needs-assessment-released.
25. КМУ, «Про схвалення Концепції впровадження технологій будівельного інформаційного моделювання (BIM-технологій) в Україні та затвердження плану заходів з її реалізації», Офіційний вебпортал парламенту України. URL: https://zakon.rada.gov.ua/laws/show/152-2021-%D1%80#Text.

References

1. Kalajian, K., Ahmed, S., & Waleed, M. A. Youssef. (2023). BIM in infrastructure projects. *International Journal of BIM and Engineering Science*, 6(2), 74–87. DOI: https://doi.org/10.54216/IJBES.060205.
2. Abd Alnoor, B. (2022). BIM model for railway intermediate station: transportation perspective. *International Journal of BIM and Engineering Science*, 4(2), 33–48. DOI: https://doi.org/10.54216/IJBES.040202.
3. Vignali, V., Acerra, E., Lantieri, C., Di Vincenzo, F., Piacentini, G., & Pancaldi, S. (2021). Building Information Modeling (BIM) applicatiion for an existing road infrastructure. *Automation in Construction*, 128. Retrieved from https://sci-hub.se/downloads/2021-06-19/fc/vignali2021.pdf.
4. An analysis for the adoption of Building Information Modelling (BIM) across the EU27 for Public Sector (2024). *European Innovation Council and SMEs Executive Agency (EISMEA)*. Retrieved from https://build-up.ec.europa.eu/en/resources-and-tools/publications/analysis-adoption-bim-across-eu.
5. Sompolgrunk, A., Banihashemi, S., & Mohandes, S.R. (2023), Building information modelling (BIM) and the return on investment: a systematic analysis. *Construction Innovation*, 23(1), 129–154. DOI: https://doi.org/10.1108/CI-06-2021-0119.
6. Aftab, U., Hassan, M.U., Ullah, F., Nasir, A.R., & Thaheem, M.J. (2024). BIM-based search and selection of construction material suppliers: a dedicated framework and prototype. *Construction Innovation*. DOI: https://doi.org/10.1108/CI-06-2023-0136.
7. Zanib, K., Muhammad, Y., Uzair, R., Hafsa, K., Abdul, K., & Kenneth, L. (2024). The use of building information modelling (BIM) in the management of construction safety: The development towards automation hazard identification and assessment. *International Journal of Science and Research Archive*, 11, 830–852.
8. Filippov, O.V., & Shumak, L.V. (2023). BIM-technologies for information modelling of buildings at the design stage. National and foreign experience. *Building production*, №75, 39–53.
9. Meshcheryakova, O.M., & Iasnii, V.P. (2022). BIM: an effective methodology for the reconstruction of buildings and structures. *Modern technologies and calculation methods in construction*, 18, 61–70.
10. Hudyma, L.O. (2024). BIM-Technologies in Construction: Modern Challenges for Ukraine. *Business Inform*, 2, 97–104.
11. Kyivska, K. & Luzina, Y. (2021). Prospects for the implementation of BIM-technologies in the domestic construction industry. *Management of Development of Complex Systems*, 46, 63–69.
12. Beztelesna, L.I., Palamarchuk, O.S., & Plyashko, O.S. (2021). Formation of the system of ensuring innovative development of construction enterprises in the economy of Ukraine. *Scientific notes of Lviv University of Business and Law. Economic series. Legal series*, 28, 229–243. DOI: http://dx.doi.org/10.5281/zenodo.5589498.
13. Levchenko, O.V., & Antonenko, N.V. (2021). BIM as a tool for the technological development of architectural and construction design and an incentive for the renovation of curricula of higher education institutions of Ukraine to international standards. *First All-Ukrainian Scientific and Practical Conference* «*BIM Technologies in Construction: Experience and Innovations*», Kharkiv (18-19 March 2021), 204–207.
14. Andrukhov, V.M., Potekha, A.S., & Basistyi, V.O. (2024). Comprehensive assessment of the feasibility of using BIM technologies for a construction project. *Modern technologies, materials and structures in construction*, 36, 1, 161–165.
15. Yashchenko, O.F., Makatora, D.A., Kubanov, R.A., Zinych, P.L., & Prusov, D.E. (2024). Theoretical and methodological bases for implementing BIM technologies in construction companies: Essence. Characteristics. Economic Efficiency. *Business Inform*, 1, 167–177.

16. Andrukhov, V.M., & Matviychuk, V.V. (2020). Basic principles of BIM design in the development of construction solutions in Autodesk Revit. *Modern technology, materials and design in construction*, 28(1), 18–26.
17. Borkowski, A.S. (2023). Evolution of BIM: epistemology, genesis and division into periods. *Journal of Information Technology in Construction (ITcon)*, 28, 646–661. Retrieved from https://www.itcon.org/papers/2023-34-ITcon-Borkowski.pdf.
18. Engelbart, D.C. (1962). Augmenting Human Intellect. A Conceptual Framework, Contract, No. 3578. Retrieved from https://www.dougengelbart.org/pubs/papers/scanned/Doug_Engelbart-Augmenting HumanIntellect.pdf.
19. van Nederveen, G.A., & Tolman, F.P. (1992). Modelling multiple views on buildings. *Automation in Construction*, 3, 215–224. Retrieved from https://www.sciencedirect.com/science/article/abs/pii/092658059290014B?via%3Dihub.
20. Building Information Modeling market size, share, competitive landscape and trend analysis report, by component, by deployment mode, by building type, by application, by end-user: Global opportunity analysis and industry forecast, 2023-2032. (2023). *Allied Market Research*. Retrieved from https://www.alliedmarketresearch.com/building-information-modeling-market.
21. Yue, P., & Chelse, M. (2023). Integrating BIM and AI for smart construction management: current status and future directions. *Archives of Computational Methods in Engineering*, 22, 1081–1110. Retrieved from https://link.springer.com/article/10.1007/s11831-022-09830-8.
22. Kurcjusz, M., Krysińska, K., Kosakiewicz, M., Naliwajko, M., Jabłońska, Z., Radecka, K., Grzegorzewska, E., Sieczych, M., Ferenc-Pupek, E., & Stefańska, A. (2024). Integrating Building Information Modelling (BIM) into construction: innovations, challenges, and global perspectives. *Acta Scientiarum Polonorum. Architectura*, 23, 287-303.
23. Allied Market Research. (2021). *BIM in construction market size, share, competitive landscape and trend analysis report, by phase of work, end user, application and deployment model: Global opportunity analysis and industry forecast, 2020-2027*. Retrieved from https://www.alliedmarketresearch.com/bim-in-construction-market-A10290.
24. World Bank Group. (2025). *Updated assessment of Ukraine's recovery and reconstruction needs*. Retrieved from https://www.worldbank.org/uk/news/press-release/2025/02/25/updated-ukraine-recovery-and-reconstruction-needs-assessment-released.
25. Cabinet of Ministers of Ukraine. (2021). *On approval of the Concept of implementation of Building Information Modeling (BIM) Technologies in Ukraine and approval of the Action Plan for its implementation*. Official Web Portal of the Parliament of Ukraine. Retrieved from https://zakon.rada.gov.ua/laws/show/152-2021-%D1%80#Text.

Чумаченко Андрій Миколайович; Andriy Chumachenko, ORCID: https://orcid.org/0009-0008-7574-0843

Received April 02, 2025

Accepted May 20, 2025