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Integration of information modelling to improve the performance of capital construction objects: modern approach and perspectives

The paper deals with the integration of information modelling to improve the performance of buildings, basic concepts of the life cycle of buildings, modern approaches to building management and performance improvement at various stages of the life cycle. In modern conditions, information modelling technology (IMT) becomes the main tool to improve the performance of objects. Building performance parameters (BPP) — characteristics of the building, showing the evaluation of the object functioning in accordance with the established/set criteria. Modern approaches to the introduction of information modelling in operational processes are considered, such as: the use of digital twins, digital passportization, implementation of software solutions. The prospects of applying IMT for more accurate planning of preventive works, operative detection and elimination of faults, which leads to significant cost reduction at the operation stage, are also discussed in detail. It is important to specify that construction is improving and becoming fast every year, this leads to an increase in the number of commissioned real estate objects. The main reason for this rapid rate of growth is due to the integration of IMT into the life cycle stages of construction projects. The other side, which is negative and needs significant and deep elaboration and fresh ideas, is the enormously high costs during the operational phase, which is problematic to predict in most cases. Deficiencies in previous phases are activated and become more pronounced in the operational phase. IMT is an important process in all phases of the life cycle, in the operational phase the value of this technology lies in the data that carries up-to-date information about the project and in the increased level of integration of work with it.

Keywords: *information modelling technology, digital twin, building performance, life cycle of construction object, real estate management*

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INTRODUCTION

Modern construction is a complex process requiring thorough consideration of all construction elements. Therefore, integrating various technologies to ensure efficient building operation is a particularly important component. Building Information Modelling (BIM) is a modern method used for construction, equipping, and managing the life cycle of buildings. This approach considers the construction project as an integrated complex that includes infrastructure elements, technological systems, and the construction object itself [1].

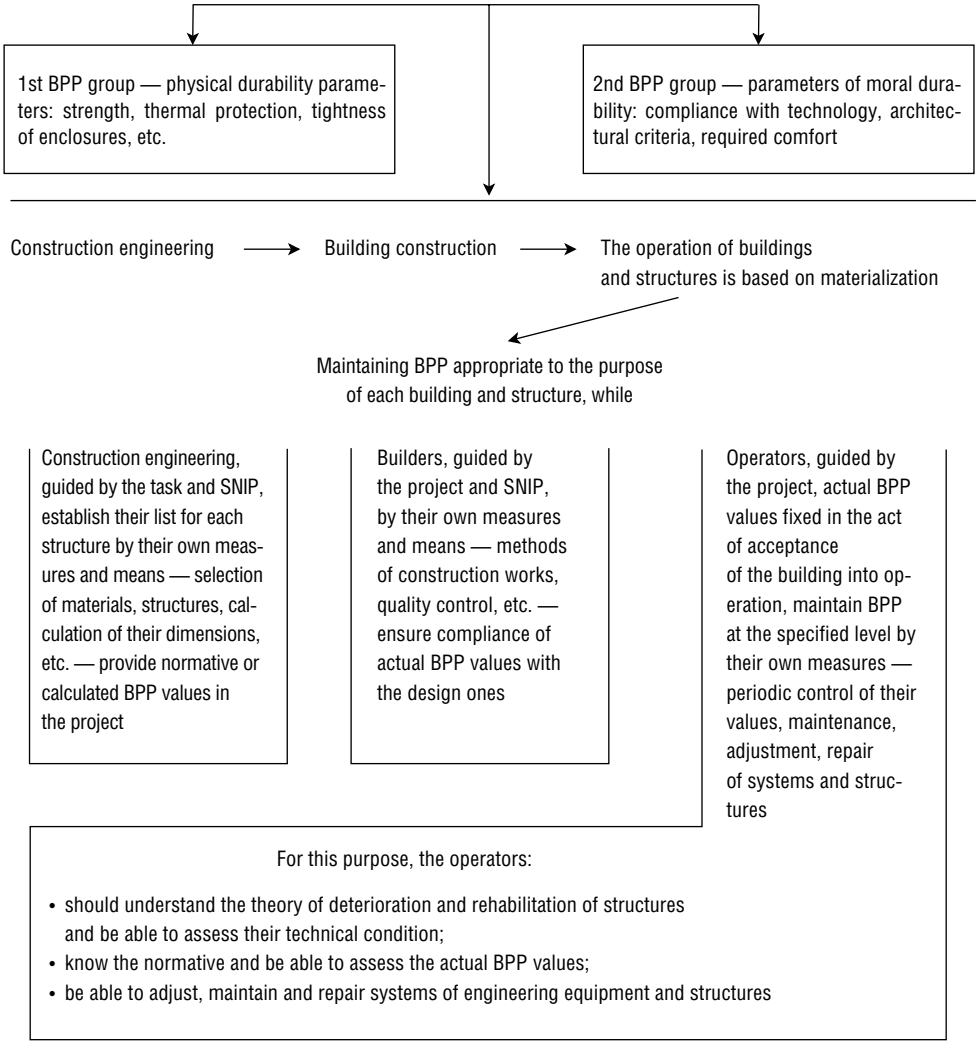
Information models provide opportunities for managing construction schedules, risks, and cost estimates. BIM technology enables visualization of any building system and element in a three-dimensional format, planning and calculating their arrangement, and analyzing the operational characteristics of designed structures to help select the most rational solution. These methods allow for minimizing corrections and remarks, reducing work execution time, and significantly cutting costs at both the construction stage and during the building's subsequent operation. The integration of BIM technology helps lower the total cost estimate of designed buildings and structures, substantially reducing operating expenses and optimizing utility costs for property owners.

According to statistics from experts within the Expert Council and the Working Group under the Ministry of Construction of the Russian Federation regarding BIM integration in industrial and civil construction, construction companies primarily use BIM at the design stage (up to 80 % of total BIM adoption), approximately five times less at the construction stage (around 15 %), and the lowest utilization occurs at the operation stage (about 5 %) [2].

Financial expenditures of up to 80 % of the total estimated cost are associated with management and the operational stage of the building's life cycle. Given this data, limiting the integration and use of BIM at various stages of the building's life cycle is unwise. By designing and implementing a digital model — a "digital twin" of the building [3] — object management and operation become more efficient. Additionally, there is a significant increase in the service life of engineering systems, communications, and the building as a whole, leading to reduced expenses and an improved quality of life for the property owner(s) [4].

The experience of using BIM abroad [5, 6] clearly demonstrates and recommends the development and updating of reconstruction, renovation, and maintenance processes for buildings and structures. However, in Russia, the application of BIM in this area has received little attention, even though it is crucial for building operation practices.

The operation and repair phase of buildings is a costly and critical stage in the entire building life cycle. As previously mentioned, this accounts for up to 80 % of the total life cycle cost. Therefore, during the operation stage, BIM offers significant opportunities for integration and application. The building information model can always provide up-to-date information on the condition of structural elements, engineering systems, etc. This enables the development of a precise schedule and plan for maintenance work, cost estimates, identification



Performance parameters of buildings and structures

of necessary contractors, and oversight of completed work. These parameters can be useful for both management companies and property owners engaged in rental business.

The relevance of this topic lies in the fact that Russia currently has a vast housing stock [7, 8], and large-scale projects for comprehensive territorial development are actively being implemented in place of industrial zones. The already developed housing stock, which is owned by both the state and private individuals, requires constant maintenance and capital repairs. New construction also demands electronic passporting to ensure precise control, execution of repair works, and elimination of defects that arise during the building's construction phase. This method will enhance efficiency and reduce building operation costs.

Let us consider the groups of operational qualities of buildings. There is a set of indicators that must be considered during the design and construction of a building. These criteria are divided into two groups [9]:

Group 1: Parameters related to the physical durability of the building, such as moisture resistance, thermal insulation, structural strength, and wear resistance.

Group 2: Parameters related to the moral longevity of the building, such as compliance with modern trends in design, planning, and architectural solutions, as well as the use of new engineering equipment and methods.

All quantitatively measurable qualities are represented in numerical form, while the rest are evaluated subjectively. These operational quality parameters (OQP) are taken into account at various stages of construction, starting from building design (fig.).

A significant problem is that some buildings do not meet the original project specifications once construction is complete. The discrepancy between planned and actual indicators can be substantial, resulting in significant financial costs to the owner. This phenomenon can be referred to as a "gap"; if the gap is large, adjustments to certain construction elements may be required, changes may have to be made or, in extreme cases, the building may not be allowed to operate. In addition, the transition from traditional methods to new technologies is often challenging. For example, the integration of BIM may be resisted by property managers or owners due to insufficient knowledge of the technology. It is therefore crucial to promote the widespread adoption of BIM at various stages of the lifecycle, possibly through Russian government regulations. To date, Government Decree No. 2357, which comes into force on 1 July 2024, already mandates the implementation of BIM in the construction sector [10].

The prospects for integrating information modelling to improve the performance of civil buildings lie in several aspects:

- Digital Twins. The widespread use of digital twins will enhance both analytical and economic capabilities of BIM in different life cycle stages. With digital twins, property owners and managers can reconstruct every parameter and element from the real environment into the digital model. Designers can conduct digital simulations and analyze expected results before making adjustments to project documentation that could impact the physical and actual building in the future [11, 12];
- Electronic Passporting. The electronic passport of real estate objects is an automated platform for storing and processing technical documentation data. This system organizes technical information and provides tools for working with parametric data. It includes an interactive building model that allows for more accurate and comprehensive visualization of object characteristics. The software suite contains functions for generating reports on the current technical condition of the building and assessing risks of emergency situations. The electronic passport system also stores catalogs of project, operational, and technical documentation and ensures compliance with maintenance recommendations through various monitoring methods aimed at addressing deficiencies [13, 14];
- Virtual Reality. Today, BIM is considered one of the foundations of digital transformation in the construction industry. The combination of BIM and VR presents tremendous opportunities at the design, construction, and operational stages.

A key advantage of this integration is improved interaction with property owners or management companies. Owners can immerse themselves in a virtual environment and actively participate in the design and subsequent operation process. Builders can easily oversee work processes and identify critical issues requiring special attention. This practical involvement provides more informed feedback and adjustments that reflect owners' preferences, construction oversight, and more. Moreover, this technological fusion increases project efficiency by enabling the creation of virtual models that help detect potential problems before construction begins, preventing costly mistakes [15].

CONCLUSION

The rapid growth of new construction, territorial development programs, and the renewal of existing urban fabric are highly relevant and promising topics that require detailed elaboration and the implementation of various technologies and methods to address current challenges. The integration of BIM for improving building operational qualities is a crucial segment that will resolve a wide range of problems at different stages of the building life cycle.

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Интеграция информационного моделирования для улучшения эксплуатационных качеств объектов капитального строительства: современный подход и перспективы

В статье рассмотрены вопросы интеграции информационного моделирования для улучшения эксплуатационных качеств зданий, базовые понятия жизненного цикла зданий, современные подходы к управлению зданием и повышению эксплуатационных качеств на различных этапах ЖЦ. В современных условиях технология информационного моделирования (ТИМ) становится главным инструментом, который позволяет улучшить эксплуатационные характеристики объектов. Параметры эксплуатационных качеств здания (ПЭК) — характеристики здания, показывавшие оценку функционирования объекта в соответствии с установленными/заданными критериями. Рассмотрены современные подходы к внедрению информационного моделирования в эксплуатационные процессы, такие как: использование цифровых двойников, электронная паспортизация, внедрение программных решений. Также подробно обсуждаются перспективы применения ТИМ для более точного планирования профилактических работ, оперативного выявления и устранения неисправностей,

что приводит к значительному снижению затрат на этапе эксплуатации. Важно уточнить, что строительство с каждым годом совершенствуется и становится быстрым, это приводит к увеличению числа вводимых в эксплуатацию объектов недвижимости. Главной причиной такого быстрого темпа роста обусловлена интеграция ТИМ в этапы жизненного цикла объектов строительства. Другая сторона, которая является негативной и нуждается в значительной и глубокой проработке, а также в свежих идеях — это колоссально высокие затраты на этапе эксплуатации, которые проблематично предсказать в большинстве случаев. Недоработки на предыдущих этапах активизируются и проявляются более ярко на этапе эксплуатации. ТИМ является важным процессом на всех этапах ЖЦ, на этапе эксплуатации ценность данной технологии заключается в данных, которые несут в себе актуальную информацию о проекте, и в повышенном уровне интеграции работы с ними.

Ключевые слова: *технология информационного моделирования, цифровой двойник, эксплуатационные качества здания, жизненный цикл объекта строительства, управление недвижимостью*

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