Concept of Sustainable Development of the Construction Sector Based on BIM-Technology

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Abstract. The paper explores the relevance and defines the role of BIM technology fitting into the general concept of sustainable construction development. Summing up the analysis of scientific publications, the authors note that at the current stage of BIM technology development there is no common idea of its staged progression. Further, the authors suggest the overall IBM evolution model in the construction sector showing the individual stages. Because sustainable construction development is inconceivable without environmental aspect, a special role in the new model is given to environmental monitoring: first, at each stage of construction modeling, second, as a suggested new model stage identified as 7D, where all environmental support information will be accumulated subsequently to become the basis for optimizing the environmental parameters of construction and operation of a building or facility. The authors further suggest considering reconstruction of a structural system not as a conventional lifetime stage in the overall BIM model, but as a new lifecycle of a previously operated system with all stages characteristic of new construction. The paper underlines that the new understanding of the BIM concept makes it an integral part of the construction process and a strategy of successfully arranging construction operations.

1. Introduction

Relevance of the paper is explained by the diversity of the existing approaches to the assurance of sustainable development and environmental safety of construction operations, and the need to understand and identify the role of BIM technology in construction.

The issues of modeling construction systems throughout the lifecycle stages using BIM (Building Information Modeling) technologies are considered by many foreign scientists, including [1–3], as well as their Russian counterparts (of special interest are the papers [4–6]) as a basis for creating the sustainable development concept as applied to construction operations. This frame of reference is substantiated by a reduction of physical construction waste [1], improvement of environmental and economic components of construction, which eventually come to resolve a number of social tasks [2] with unlimited technical capabilities of BIM [3]. The papers [4, 5] place the sustainable development...
in the construction industry in the context of “green” construction, i.e. “management of the lifecycles of construction objects; methodology for ensuring safety, energy efficiency, and energy saving; environmental certification, theory and methodology of the use of BIM technologies” [4]. The scientific publication [6] holds that “construction is a “horizontal” industry, which maintains extensive interaction with many other sectors.”, and BIM technologies in such a sector assume a paramount importance. In many papers, BIM technologies are viewed as a process, type of database, software or even a 3D model [7], and described as “the state-of-the-art information technologies, which allow creating a multidimensional multi-parametric model of a construction object containing all information on the same.” [8]. The study below elaborates on how closely the statements given in the papers [7, 8] correspond to the modern-day state of affairs.

That said, it is worth noting that at the current stage of progress of the construction sector, high-technology information resources, among which are BIM technologies, are expected to become a strategy for successful operation for construction organizations.

2. Problem setting, tasks, research methods

The problem setting and goal of this research are connected with the suggested new approach to understanding the role of BIM technology in assuring the sustainable development and environmental safety of construction.

Tasks:
1. Explore the theoretic background of the sustainable development and environmental safety concepts as applicable to construction operations.
2. Study and analyze the scientific publications viewing the progress of BIM technology and its interconnection with sustainable development and environmental safety in construction.
3. Identify the definitive role of BIM technology in the sustainable development and environmental safety concepts in the context of construction operations.

The key research methods are the analysis and synthesis of information contained in the topical scientific publications, and its compilation in the new approach to understanding the BIM technology.

3. Mein text

3.1. Theoretical relevance of the topic

It is known that the sustainable development problems are approached by scientists in the context of environmental safety of construction operations [1, 9, 10]. At the same time, it is important to note that these two notions cannot be considered synonymic, for “according to the sustainable development concept as applied to construction operations, erection of buildings and facilities is aimed at the acquiring of capital by the humankind for the sake of its wellbeing; reconstruction, restoration, overhaul and maintenance of buildings and facilities are aimed at preserving the capital acquired. These two components have a socioeconomic nature. But without resolving multiple global and local environmental problems, especially the problem of adverse human impact on the environment, the preservation of the environmental niche carved out by the humankind is impossible, since the preservation of human capital first of all means the preservation of humans themselves on the level on which they were originally created, i.e. without mutations.” [11]. The principal provisions of this paper are developed on the basis of the publication [12]. Previously, various approaches were identified in the paper [13] (author: Abramyan S.G.) to assure the sustainable development of construction, in particular, by the assurance of its environmental safety. The point was made that the basis of sustainable development of the construction sector is the “structural environmentalization of construction process flows, environmental monitoring etc.”, but the paper did not touch upon any BIM technology issues. However, another paper [14] not only highlighted the importance of BIM technology in terms of environmental support of construction operations, but also stressed the need for its integration with GIS technology despite certain ongoing problems associated with BIM introduction into the global construction practice [15, 16]. It is the evolution of BIM technology that
has made it possible to achieve the highest performance in the field of environmental safety [17-19]. The possibility of integrating these two most powerful business information systems is extensively explored in [20] as well as the need for adopting modern GIS technologies for monitoring and forecasting emergencies [21]. The formation and general concept of BIM technology, its enormous potential fostering the sustainable development of construction are considered in the scientific publication [22]. The author of the paper notes that “the general BIM concept has turned into “philosophy” that helps avoid many problems during engineering and construction.” However, despite the huge potential of BIM technology, it has not until now properly affirmed its status based on construction practice. This means the theoretic aspects of this technology significantly outperform its practical application.

3.2. Overall model of BIM technology evolution as applied to construction operations

The analysis of all the scientific publications as well as website publications [23-26] allowed creating an abstract model of a stage-wise development of BIM technology (figure 1).

![Figure 1. Model of BIM technology development in construction.](image)

The 3D - 6D stages are traditionally identified in many “constructions” enabled by BIM technology, and also serve to ensure “access for simultaneous work of a multidisciplinary team of specialists and an opportunity to combine their technical solutions within common space” [27]. Each of these stages of the suggested model is briefly summarized below.

3D – traditionally considered as a coordinated model of a future piece of property with visualization, engineering solutions, detailed documentation, and simulated effects of abiotic environmental factors [23]. This stage employs various software products.

4D – based on 3D with optional automation of the optimal construction schedule (drafted as a calendar based construction plan, progress schedule, or cyclogram). However, according to [28], it is this stage where environmental modeling tasks are most efficiently solved with the use of the Plant-4D software package, which is also the most efficient for engineering industrial facilities, especially trunk lines [29]. A very important part at this stage is the use of data gathered with the use of GIS technologies.
5D – based on 4D with optional automation of the cost estimation process before construction and the cost management process during construction” [30]. In figure 1, this stage is shown as the performance of works according to the approved construction estimate.

6D – based on 3D with optional automation of construction system monitoring during its operation and possible modification of the electronic technical file of the construction system. At this stage, the performance and energy efficiency of a building or facility is improved by means of overhaul. If for a number of reasons a construction system is unsuitable for overhaul, the building or facility is considered as subject to demolition.

Erroneously, this stage is deemed to include also reconstruction of a construction system; however, reconstruction improves not only the operational performance, but also the adopted layout solutions, and as often as not alters the functional purpose of a building and facility. This means a construction product, following reconstruction, switches over to a second lifecycle. After reconstruction, the BIM technology model shown in figure 1 resumes its full functionality including all the appropriate stages. Reconstruction involves the use of innovative materials, which were unknown during the period of construction of the same facility and which help dramatically reduce the load exerted on underlying elements. The applicable technologies meet the energy efficiency and environmental safety requirements, i.e. ensure sustainable development of construction operations. All engineering solutions necessary for reconstruction, which fall within the 3D stage, as well as the detailed documentation fundamentally differ from the same stage as part of new construction.

7D – focused on information gathering for overall environmental monitoring comprising various stages of the lifecycle of a respective piece of property. Previously, it was mentioned that the modeling of effects of abiotic environmental factors on a construction system takes place at the 3D stage. The general impact of sunlight, precipitation, wind and other factors on specific construction materials or on property as a whole can be identified during the engineering phase. But the way the wind direction, precipitation intensity, ambient air temperature etc. affect the performance of construction works can only be understood at the 4D stage, and during operation – at the 6D stage. All this information is gathered by various “I” units for further optimization of the work process at all lifecycle stages of a construction product.

Obviously, the functioning of each stage depends on the software products developed to this end. Figure 1 shows the feedback connection between stages 7D and 3D, which implies the use of the information accumulated during environmental monitoring at the 7D stage for new construction and during 3D modeling for reconstruction.

(7+n)D – conventionally assumed to show the dynamics of the suggested model and its further development.

4. Conclusion

The evolutionary progress of BIM technology in the construction field is an irreversible process. The formative role of BIM technology as part of the sustainable development concept is explained by the fact that its use throughout the lifecycle of a construction product allows optimizing the necessary resources and costs, minimizing construction waste, mitigating adverse effects of construction on both the natural and manmade environment (NME) and, conversely, the NME effects on a construction product, thus improving the reliability of its operation. Each stage of construction aided by BIM technology is functionally supported by the specially developed software products, which are approved as efficient tools for resolving engineering, technological, organizational, environmental and economic challenges.

BIM technology should not be viewed merely as a software package or database for three-dimensional engineering of construction projects. As a high-technology information resource (even in its theoretical aspect for the time being), it serves as a strategic base for successful operations of construction organizations.

The currently existing contradictory interpretations and problems with the implementation of BIM technology in the construction industry are of temporary nature, since the barriers hindering the
adopted of BIM technology at all lifecycle stages of a construction product are being removed. The new understanding of BIM technology envisages that it should become an integral part of the construction process, regardless of how it will be called in the near future.

The new approach to understanding BIM technology in the construction industry consists in the assumption that reconstruction of buildings or facilities cannot be considered as one of the lifecycle stages as applicable to construction projects. As part of BIM technology-aided simulation, a piece of property subject to reconstruction is expected to undergo all the stages shown in the above mode; (3D/4D/5D/6D etc.), because reconstruction is the new lifecycle of an existing construction product designed for resolving a number of town-planning, environmental, economic and social tasks.

Summing up, we would like to note that the importance of this paper consists in the new philosophical conception of BIM technology in that it can become the basis for identifying the key points of development of a new lifecycle management model for construction products.

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