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THE OPPORTUNITIES OF BIM TECHNOLOGIES IN DIGITALIZATION OF CULTURAL HERITAGE OBJECTS

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Annotation

This research explores the possibilities of preserving cultural heritage objects and integrating them into modern architectural design. The use of BIM technologies serves for the digital modeling of monuments, monitoring their condition, and systematically managing restoration processes. The study emphasizes that modeling national decorative elements and ornaments within a BIM environment helps to reflect not only their geometric structure but also their functional characteristics. The research findings indicate that BIM technologies enable the systematic archiving of information about cultural heritage sites and facilitate their reuse in future projects.

Keywords

BIM, Discrete, Parameter, Catalog, Digital classification.

Introduction. Cultural heritage is the historical, cultural, and spiritual wealth of a nation, playing an important role in understanding national identity and passing it on to future generations.

Among the world's renowned civilizations, Uzbekistan stands out with its exquisite applied decorative art and rich history of unique architecture. Every year, thousands of tourists from various countries visit Uzbekistan to explore and study its national cultural treasures [1].

In our country, extensive measures are being implemented to identify, register, preserve, promote, and monitor tangible cultural heritage objects, as well as to maintain the state register, electronic catalog, passport, and state cadastre, designate protected areas, and ensure state control in this field.

The Development Strategy of New Uzbekistan for 2022–2026 outlines important tasks such as "Establishing continuous monitoring of immovable tangible cultural heritage objects, enhancing the use of modern technologies in this area, and fostering international cooperation in the restoration of cultural heritage sites" [2].

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Around the world, numerous scientific studies and practical projects are being tested using new technologies to reconstruct historical buildings and structures, assess their preservation levels, and optimize restoration processes. One of the most widely adopted approaches in design is Building Information Modeling (BIM) technology, which is among the globally recognized and applied methodologies [3].

The integration of BIM technologies aligns with the current legislation and regulatory documents of the Republic of Uzbekistan, as well as with scientific advancements and leading international practices in the design, construction, and operation of buildings [4].

Studies on the use of BIM in global markets highlight specific adaptations based on regional construction practices and technological infrastructures, emphasizing its flexibility as a methodology and framework [5].

Today, the potential of digital modeling technologies in the preservation and restoration of cultural heritage objects is remarkably high.

Simply put, the process of creating a digital model of cultural heritage sites can be considered a new approach to documenting monuments.

Digital transformation is a natural stage in the development of any modern state, enabling the adaptation of the economy to new realities and global standards, while ensuring the sustainability of the country's economic prosperity [6].

Main Part. BIM technologies offer a wide range of opportunities when working with historical monuments. The informational model serves not only as a storage place and tool for data about the monument but also as a crucial means for researching this information. It also acts as an efficient platform for information exchange. This model is closely connected with monitoring the condition of the object and its operational processes. In other words, the informational model of an architectural monument is not just a simple virtual copy, but an "intelligent container" containing interlinked data related to this object, serving virtually unlimited purposes [7].

Diagram 1

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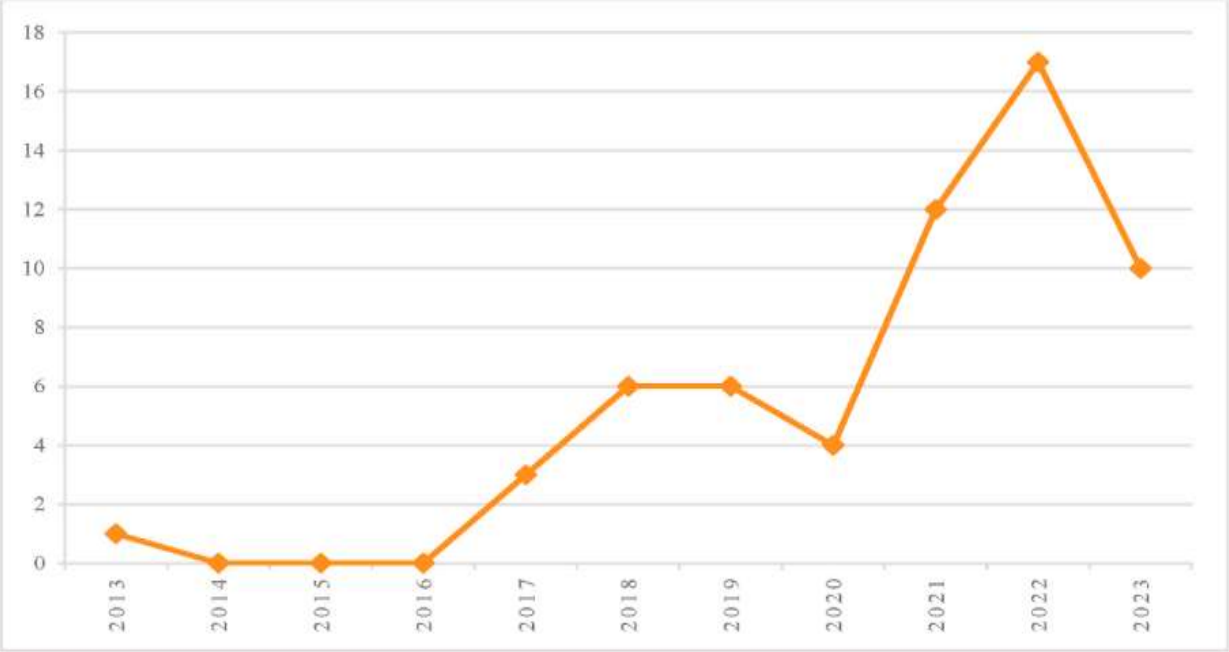

The studies selected using the "PRISMA" method are presented by year.

If we analyze the research conducted by foreign scholars, the study examines scientific articles related to the modeling of cultural heritage objects in the BIM environment from Google Scholar and Scopus databases, selected using the "PRISMA" method. As a result, a total of 59 works related to BIM technology were identified, and a table was formed showing the years of publication (1-diagram) [8]. The vertical column of the table represents the number of articles, while the horizontal column shows the years of publication. The results of the table indicate that the use of BIM technology for modeling historical objects has been increasing over the years, and it provides relevant conclusions about the effectiveness of applying this technology in the digitalization of heritage objects.

In the process of modeling an object in the BIM environment, it is essential to select an appropriate modeling methodology based on the structure of the model elements and strictly follow the sequence of the modeling process.

In each specific case, the sequence of work when creating information models of architectural monuments is determined individually, taking into account rational modeling and construction, from general to specific, in order to prevent software inconsistencies and mismatches [9].

Two different methodologies can be applied for modeling [10]:

- The traditional methodology is mainly used for architectural monuments built from brick and stone. It is very close to conventional modeling and design in BIM software.

- The discrete methodology is used for wooden and other "assemblable" (demountable) structures [11].

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The choice of methodology depends on the history of the architectural monument, its preservation, and operational characteristics in each specific case. The traditional methodology is simpler to implement in BIM software, but the discrete methodology, although more complex, allows for individual monitoring and management of each structural element of the building, which is much more effective in the preservation and reconstruction process of the monument [10].

At the modeling stage, BIM goes beyond geometric representation and focuses on developing smart models that contain semantic data [12].

The application of parametric modeling in BIM systems provides a significant number of possibilities [13], particularly when modeling cultural heritage objects.

Since the models created in the BIM environment are parametric, it is necessary to determine the parameters the model should have before modeling, and a "General Parameters File" is created. The parameters in the file are categorized into different groups. The generated file can be used in the modeling process of almost all objects.

Unique architectural elements of architectural monuments do not have a wide range of dimensions. Therefore, to avoid excessive data in the model uploaded to the file, it is advisable to create library elements that correspond to only one parameter value [14].

It is recommended to collect "single-parameter" element files in electronic catalogs. However, this process should not only be based on structural features (such as windows, balustrades, columns, doors, profiles, etc.) but also according to museum classification. This includes the following [15]:

- **Hronological classification** (based on the period of creation or use of the objects);
- **Geographical classification** (based on the location of creation or existence of the objects);
- **Authorship or name classification** (groups objects related to a specific individual);
- **Thematic classification** (associates objects with the topics of relevant scientific fields);
- **Subject classification** (groups objects based on their function or subject matter).

The above-mentioned classification is also of great importance for ensuring the logical use of created models in projects, searching for them, and systematically storing the elements of buildings and structures that will be created in the future.

Thus, the information model of an architectural monument also functions as an electronic catalog of its components.

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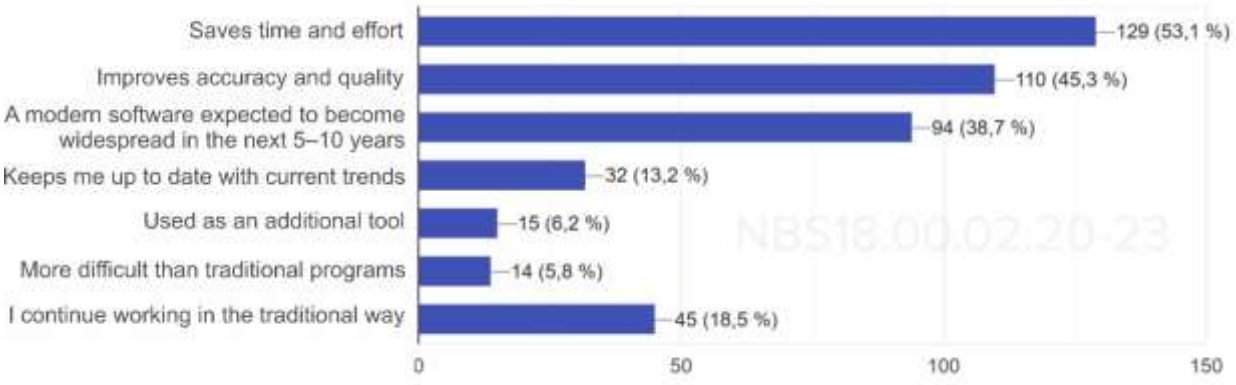
The results of a social survey conducted in September 2023 also confirmed the advantages of this technology. According to the opinions of organizations or specialists who have implemented BIM technologies, working with computer programs in this platform is considered preferable compared to the "old methods." In particular, 53.1% of participants believe it saves time in the design process, while 45.3% report it improves accuracy and quality (2-diagram) [16].

Diagram 2



Advantages of BIM technology over traditional methods

The diagnosis of the deterioration processes and the assessment of the technical condition of monuments are the most important aspects in the preservation of cultural heritage objects. These analyses determine the extent to which engineering intervention is necessary in the existing structural system of ancient buildings. It is known that technical solutions based on superficial diagnostics, relying on incorrect structural operation principles or failing to account for hidden factors, result in a number of errors. In some cases, defects that were initially unnoticed reappear, further develop, and worsen the overall condition of the monument. This has led to significant costs and strengthening works, often causing damage to the original appearance of the object [17].

The application of building information modeling (BIM) technology in museum activities expands the possibilities for working with movable exhibits and takes the research and preservation of cultural heritage objects to a new level [18].

Before creating and integrating a comprehensive digital environment for cultural and architectural heritage, it is crucial to conduct research aimed at determining the methods and procedures for reality-based repositories and data analysis [19].

It should also be noted that this system allows for the integration of all information, creating an accurate model that enables a complete assessment of production tasks and provides insight into all necessary processes and issues in construction, restoration, and reconstruction processes. This also pertains to human safety, which is an inseparable component of the system [16].

Conclusion. The integration of cultural heritage monuments, traditional decorative elements, and national ornaments into modern architectural design not only contributes to the preservation of national heritage but also creates numerous opportunities in restoration and reconstruction processes.

This research examined the factors affecting the systematic operation of the BIM model and its key advantages in the digital design phase. In the BIM environment, the modeling of national elements serves not only to represent their geometry but also to highlight their functional aspects. Specifically, BIM technologies enable systematic archiving of data, which enhances the efficiency of construction processes by allowing the reuse of this information in subsequent projects.

The process of information modeling for cultural heritage monuments requires a clear, systematic operation phase. The findings indicate that BIM not only allows for the creation of precise digital models of objects but also enables the monitoring of their materials, dimensions, condition, and operational processes during the parameterization phase.

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