Digitizing Heritage: A BIM-Based Approach to Preserving the “Prishtina District Energy Facility's Chimney Stack”

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Abstract In the realm of architectural conservation and the digital transformation of the construction industry, Building Information Modeling (BIM) plays a pivotal role in preserving historical landmarks. This paper delves into the practical application of BIM for the revitalization of architectural heritage, focusing on the renowned Chimney Stack at the Prishtina District Energy Facility in Kosovo. Through an in-depth case study, this research explores how BIM facilitates the digitization of existing structures, shedding light on its manifold benefits, challenges, and limitations. Utilizing archival data, qualitative analysis, and a systematic BIM-based digitization process, this study demonstrates how BIM enhances efficiency, safety, sustainability, and maintenance in heritage preservation. The paper emphasizes the importance of accurate data, standardization, interoperability, cost considerations, and specialized training. This paper serves as a comprehensive resource for understanding the practical implications of BIM in the digitization of historical structures, emphasizing its significance in heritage conservation within the architectural and construction domain.

Keywords: Building Information Modeling (BIM), digitalization, existing buildings, benefits, challenges, analytic model, structural analysis model

1. Introduction

The construction industry has traditionally relied on 2D drawings and paper-based documents to design and construct buildings. However, with the advent of new technologies, including Building Information Modeling (BIM), the industry is gradually shifting towards digitalization. BIM is a digital representation of a building that allows for collaboration between different stakeholders, including architects, engineers, contractors, and owners, throughout the entire lifecycle of the project. BIM enables the creation and management of a comprehensive database that includes detailed information about the building’s components, materials, and systems.

As the benefits of BIM become more widely recognized, there is a growing trend towards the digitization of existing buildings. Digitizing existing buildings using BIM provides maintenance, renovation, and other future projects. The digital model can be used to simulate the performance of the building, optimize energy efficiency, and identify potential issues before they arise. The case study presented in this research paper focuses on the digitization of the Chimney stack at the Prishtina District Energy Facility. This iconic structure was constructed in the seventies, and its preservation is of cultural and historical significance. The digitization of the building using BIM will enable its efficient operation and preservation, while also providing a valuable resource for future maintenance and renovation projects.

1.2. Objectives and research questions

The main objective of this research is to explore the use of Building Information Modeling (BIM) concept for the digitization of existing buildings, using Chimney stack at the Prishtina District Energy Facility as a case study.

The specific research questions that will be addressed in this study include:

1. How can archival data be used to create a comprehensive digital model of an existing building using BIM?
2. What are the benefits of using BIM for the digitization of existing buildings?
3. What are the challenges and limitations of using BIM for the digitization of existing buildings?

1.3. Methodology and scope of the research

This research will use a case study approach to explore the use of Building Information Modeling (BIM) concept for the digitization of existing buildings, focusing on the Chimney stack at the Prishtina District Energy Facility. The case study will involve the collection of archival data from TermoKOS, which will be used to create a comprehensive digital model of the Chimney stack using BIM.

The research will utilize qualitative method, including literature review, and analysis of the data collected from the digital model. The research will also explore the benefits, challenges, and limitations of using BIM for the digitization of existing buildings, and will consider the implications of digitization for future maintenance and renovation projects.

The scope of this research is limited to the use of BIM for the digitization of existing buildings, with a focus on the Chimney stack at the Prishtina District Energy Facility.

2. Literature Review

2.1. Overview of existing literature on BIM and digitalization of existing buildings

The construction industry has seen a rise in the adoption of Building Information Modeling (BIM) in recent years.. BIM enables the creation and management of digital models of buildings, allowing for better collaboration and coordination among project stakeholders [1]. While BIM has primarily been used for new construction projects, there is a growing recognition of the benefits of using BIM for the digitalization of existing buildings [2].

Numerous studies have demonstrated the benefits of BIM –based digitalization for existing buildings. Improved collaboration, coordination, and communication among stakeholders are some of the advantages, resulting in more efficient and cost-effective projects [2,3,4,5,6]. The use of BIM also creates a digital twin of an existing building that can be used for future maintenance and renovation projects, improving accuracy and reducing costs [7]. Moreover, BIM-based digitalization can enhance the management of existing buildings throughout their lifecycle, including maintenance, repair, renovation, and demolition [6].

2.2. Key concepts and definitions

BIM is a process that involves creating and managing digital models of buildings, which can be used for design, construction, and operations [1]. The concept of digitalization of existing buildings refers to the process of creating digital models of existing buildings using BIM [2]. According to Volk et al.[2], digitalization of existing buildings involves the collection of data from various sources, such as laser scanning, photogrammetry and historical records, to generate a 3D model that accurately represents the physical and functional characteristics of the building. The resulting digital model can be used for various purposes, such as maintenance, renovation, and energy management [2,6].

2.3. Advantages and challenges of BIM-based digitalization for existing buildings

Building Information Modeling (BIM) has proven to be valuable tool for the digitalization of existing buildings. This section will discuss the advantages and challenges of BIM-based digitalization.

2.3.1. Advantages

One of the key advantages of BIM-based digitalization for existing buildings is the improved accuracy of information. BIM models allow for the capture and storage of detailed data about the building's components, such as its structure, systems, and materials. This information can be used to identify potential problems, plan maintenance and renovation activities, and optimize the building's performance [2,6].

Another advantage is enhanced visualization, which allows stakeholders to see the building in 3D and understand how different components interact. This can help to identify design issues and make better decisions during the planning and construction process [8].

Better communication among stakeholders is also a benefit of BIM-based digitalization. BIM models can be easily shared among different teams, including architects, engineers, contractors, and building owners. This can improve collaboration, reduce errors, and result in more efficient processes [2,6]. In addition, the use of BIM can improve the efficiency of maintenance and renovation activities, resulting in cost and time saving [8]. BIM-based digitalization also allows for enhanced decision-making and increased accuracy of a built documentation [4,5].

2.3.2. Challenges

Despite the advantages, there are also several challenges associated with BIM-based digitalization for existing buildings. One challenge is the need for specialized skills and equipment. Building teams must be trained in BIM technology and have access to the necessary software and hardware [9,10].

Another challenge is data compatibility issues. Existing buildings may have outdated or incomplete data, making it difficult to create accurate BIM models [5]. Different software programs may also have compatibility issues, leading to errors and inconsistencies [11]. The high cost of implementing BIM in existing buildings is also a challenge. BIM requires a significant investment in technology, training and time. For some building owners, the cost may outweigh the potential benefits [6,10]. Finally, the complexity of the modeling process is a challenge, BIM-based digitalization requires expertise in both BIM and building engineering. This can lead to a shortage of qualified professionals, making it difficult to complete projects on time and within budget [6,9,11].

3. Methodology

3.1. Research design and data collection methods

For this study, a qualitative approach using a case study research design was employed to explore the advantages and challenges of BIM-based digitalization for existing buildings. The study aimed to gain a comprehensive understanding of the process of digitizing existing buildings using BIM technology. To achieve this, archival data from TermoKOS was analyzed to create a 3D digital model of the Chimney stack in Prishtina, Kosovo. The BIM model enabled the visualization of the building's structural elements in detail.

3.2. Case study selection criteria and description

The case study of the Chimney stack in Prishtina, built in seventies and of historical and cultural significance, was selected for analysis in this study. The selection of the case study was based on the criterion that it pertained to the BIM-based digitalization of an existing building, and that the building itself was an iconic structure. The 3D digital model created through BIM was intended for use in future maintenance and renovation projects.

The archival data collected from TermoKOS was used to create the 3D digital model of the Chimney stack using BIM technology. Figure 1, in this study depict the current state of the Chimney stack in Prishtina. The figure below provide a visual representation of how the chimney stack appears in its present condition.

3.2.1. Technical description of a case study

For the needs of the Residential Enterprise in Prishtina, the main project of a reinforced concrete chimney has been designed to serve as part of the city's heating system. Considering that the location of the chimney was situated in a highly frequented urban area of Prishtina, the investor requested that this chimney have a different shape that would distinguish it from other objects in the area where it was planned to be erected. This was the reason why the designers chose to give it the shape of an eight-sided symmetrical star, based on a 25cm thick wall. Along its height, the chimney is staggered with a silhouette of two trapezoids symmetrically positioned to the axis/platform, which is located in the middle of the chimney's height, at a height of 40 meters from the base. The top of the chimney ends in a stylized and highly refined structure, which is interwoven along its perimeter from a height of +80m to +81.40m. Such a structure is located on the border between a cylindrical and a flared structure, thereby increasing its resistance to lateral forces (wind) and especially to the effect of possible ground shaking (earthquakes). The chimney was made of reinforced concrete using sliding formwork. At its top, signaling was installed with the help of lights to signal it during the night. This reinforced concrete structure has existed for 45 years and has become an icon of the Kosovo's capital Prishtina.

Basic characteristics:

- Designer: "Vatrostalna" Zenica;
- Constructor: ING Velibor Mutavdzic

- Geometry:
  Height 80 + 1.4m;
  Outer diameter at the base 8.20 - level 0.00;
  Outer diameter at + 40m level-7.10m;
  Outer diameter at the top 8.20m – level 80.00m;
  Walls thickness (sides) – 25 cm;

- Materials:
  Reinforced concrete of MB 300 grade-910m^3;
  Steel for reinforcement JUS CK 6020 CO 200-111830 kg;

Figure 1. Chimney stack in Prishtina

3.3. Data analysis techniques

Content analysis was employed to analyze the archival data collected from TermoKOS for this study. The archival data analysis and creation of a BIM model allowed for insights into the process of digitizing existing buildings using BIM technology. During the process of digitizing and reviewing the structure, we followed these steps:

1. *Document collection:* The first step was to collect all the documents, drawings, and other important data that have been part of the archive at the "TermoKOS" enterprise.

2. *Document scanning:* The documentation was scanned from physical format to digital PDF format.

3. *PDF insertion into Autodesk Revit software:* The digital documentation was inserted into the BIM software, where the modeling process began by overlaying the inserted documents.

4. *3D modeling:* The next step was to create a 3D model of the object using data from the existing documentation. This included creating a digital representation of the object with all its features, such as the foundation, walls, type of material, etc.

5. *Creation of an analytical model:* Based on the physical digital model, an analytical model was generated in Autodesk Revit software, which was processed and made ready for export to Autodesk Robot Structural Analysis Professional software for more detailed analysis of the structure.

Through a systematic digitization process based on the BIM concept, we were able to produce a comprehensive set of digital outputs, including a PDF format, a physical BIM model, and two analytical models. While the primary focus of our study pertains to the structural elements of the chimney stack "Tymtari i Termokosit" BIM Structure Model, we also made sure to incorporate data from other relevant disciplines. This approach is expected to foster interdisciplinary research and promote a more holistic understanding of the structure.

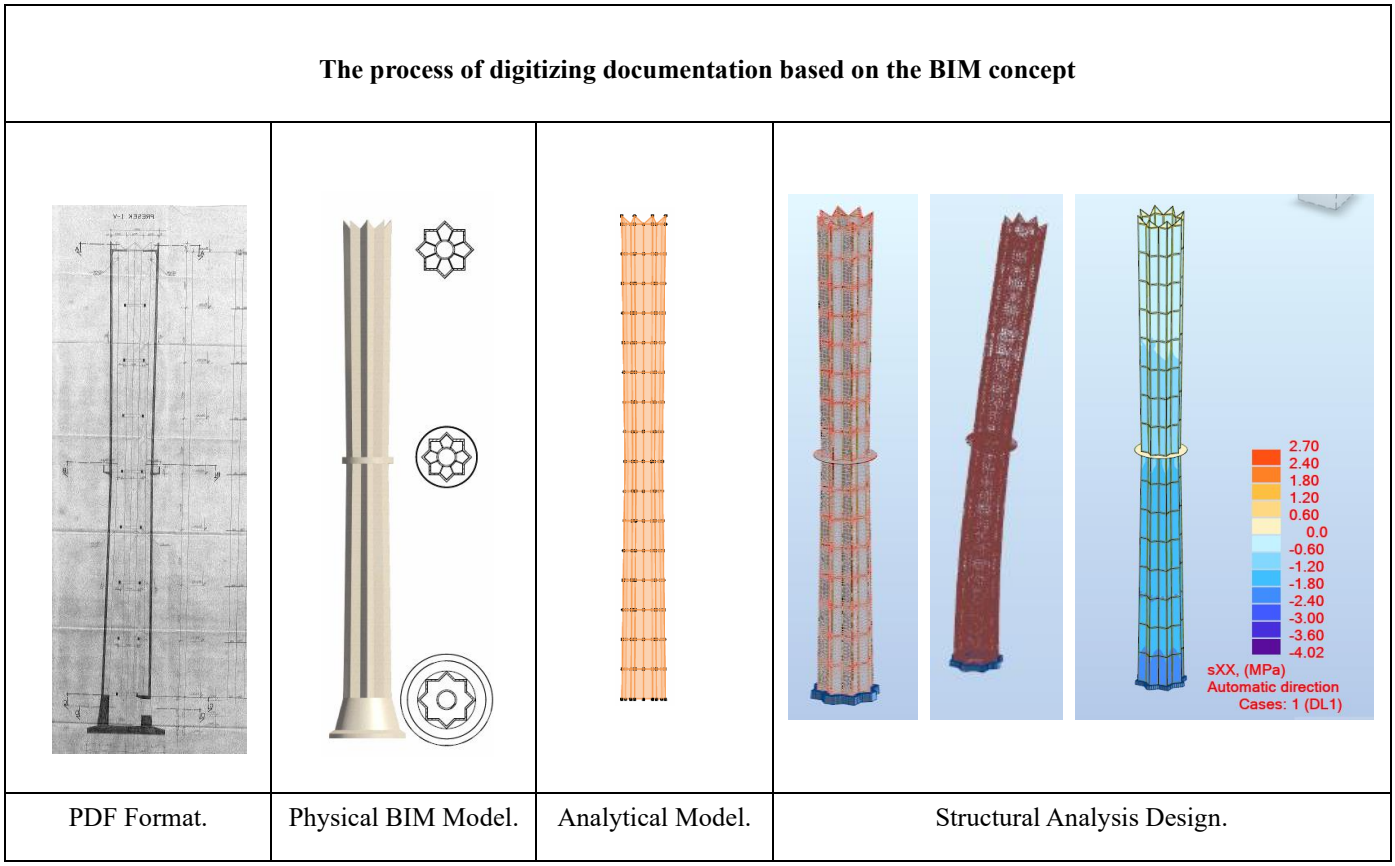

Figure 4. The process of digitizing documentation based on the BIM concept

4. Results and Analysis

4.1. Findings from the case study

The case study conducted on the chimney stack in Prishtina, Kosovo revealed that the use of BIM in the digitalization of existing buildings can be a useful tool for improving efficiency, safety, sustainability, and maintenance. The study showed that by creating a detailed digital model of the existing structure, potential problems and defects can be identified, leading to reduced maintenance costs and improved safety. Additionally, the digitization process revealed new investment and utilization opportunities for the structure, which would not have been possible without the use of BIM.

4.2. Analysis of digitalization process and outcomes

The analysis of the digitalization process for the chimney stack in Prishtina revealed that archival data is a fundamental and necessary source for creating digital models for existing buildings. However, the accuracy of the data can be a challenge, as there is often a lack of existing data or the data is outdated. The time and effort required for scanning the building and collecting data is also a significant challenge. The lack of standardization and interoperability between software and the high cost of BIM software are other challenges. Despite these challenges, the use of BIM in digitizing existing buildings can result in several benefits, including improved efficiency, safety, and sustainability, as discussed below.

4.3. Evaluation of the effectiveness of BIM-based digitalization for existing buildings

The evaluation of the effectiveness of BIM-based digitalization for existing buildings revealed that BIM can contribute to improving efficiency, safety, sustainability and, maintenance. The detailed examination of the building through the creation of a BIM model can help identify potential problems and defects, leading to reduced maintenance costs and improved safety. BIM can also identify areas of the building that require reconstruction or repair, leading to increased sustainability and reduced need for further repairs. However, there are challenges and limitations to using BIM for the digitization of existing buildings. The accuracy of data is a significant challenge, and the time and effort required for scanning the building and collecting data can be significant. The lack of standardization and interoperability between software and the high cost of BIM software are also challenges. Moreover, the complexity of BIM software and the need for specialized training for using it can be limiting factors.

In conclusion, the use of BIM for digitizing existing buildings can lead to improved performance, reduced maintenance costs, and reduced risk of degradation. However, overcoming the challenges and limitations associated with the use of BIM for the digitalization of existing buildings is crucial to realizing its potential benefits.

5. Discussion

5.1. Interpretation and discussion of the results

The findings of this study demonstrate that digitalization of existing buildings through BIM can provide numerous benefits. By utilizing archival data and creating detailed digital models of buildings, BIM can help identify potential problems and defects, improve efficiency, reduce maintenance costs, enhance safety, increase sustainability, perceive new investment opportunities, and facilitate the decision-making process for future renovation or retrofitting projects. Additionally, our study highlights that the BIM-based digitalization process can also provide new insights into the building's historical and cultural significance that were not previously documented.
However, there are also several challenges and limitations that need to be addressed. Firstly, the accurate data is crucial for BIM-based digitalization, which may require additional time and effort for scanning and verifying the data. Secondly, the lack of standardization and interoperability among different BIM software can create challenges in integrating different data sources. Thirdly, the high cost of BIM software and its complexity may limit its accessibility to smaller firms and organizations. Fourthly, specialized training is required to operate the BIM software, which may require additional resources and time.

5.2. Comparison with existing literature

The literature review revealed that BIM-based digitalization for existing buildings has gained recognition due to the numerous benefits it provides. These benefits include improved collaboration, coordination, and communication among stakeholders, creation of digital twin for future maintenance and renovation projects, and enhanced management of buildings throughout their lifecycle. Our study's findings are consistent with these existing literature results, demonstrating that digitalization of existing buildings through BIM can lead to improved efficiency, safety, sustainability, investment potential, and historical documentation. However, our study brings new insights into the benefits and challenges of BIM-based digitalization for existing buildings. Our findings emphasize the importance of accurate data for BIM-based digitalization and highlight the potential for BIM to uncover new information about a building's historical and cultural significance. Additionally, our study emphasizes the need to address challenges related to standardization, interoperability, cost, and training to successfully implement BIM-based digitalization for existing buildings.

5.3. Implications and limitations of the research

The findings of this study have several implications for practice. First, the study highlights the importance of utilizing archival data for creating digital models of existing buildings through BIM. Second, it emphasizes the benefits of BIM-based digitalization, such as improved efficiency, safety, sustainability, investment potential, and historical documentation. Third, it highlights the challenges and limitations that need to be addressed for successful implementation of BIM-based digitalization, including the need for accurate data, standardization, interoperability, cost, and training.
One limitation of the study is that it focused only on one case study, which may not be representative of all existing buildings. Additionally, the study did not consider the impact of BIM-based digitalization of different types of building or in different geographical locations. Future research can address these limitations by conducting similar studies in different contexts and with different types of buildings. Overall, this study provides valuable new insights into the benefits and challenges of BIM-based digitalization for existing buildings, highlighting its potential for improving the efficiency, safety, sustainability, investment potential, and historical documentation of existing buildings.

6. Conclusion

6.1. Summary of the main findings and contributions

This research paper presents an investigation into the use of Building Information Modeling (BIM) for the digitization of existing buildings, using the chimney stack at the Prishtina District Energy Facility as a case study. The study outlines a systematic seven-step process that was followed during the digitization and review of the structure.

Initially, all relevant documents, drawings, and data were collected from the archive at "TermoKOS" enterprise. Subsequently, the documentation was scanned into digital PDF format. The digital documentation was then inserted into Autodesk Revit software, and the modeling process began by overlaying the inserted documents. A 3D model of the object was then created using data from the existing documentation, including a digital representation of all features such as the foundation, walls, and materials used.

Moreover, an analytical model was generated based on the physical digital model, using Autodesk Revit software, which was then processed for export to Autodesk Robot Structural Analysis Professional software for more detailed

analysis of the structure. Other relevant disciplines were incorporated into the process, to promote a more comprehensive understanding of the structure.

The research findings suggest that the use of BIM for the digitization of existing buildings can contribute significantly to efficiency, safety, sustainability, and maintenance. The creation of a detailed digital model of the existing structure facilitates the identification of potential problems and defects, resulting in reduced maintenance costs and improved safety. Furthermore, the digitalization process revealed new investment and utilization opportunities for the structure, which would have been unfeasible without the use of BIM.

In conclusion, this research has demonstrated that BIM can be a valuable tool for the digitization of existing buildings. The study has contributed to insights into the use of BIM for the digitalization of existing buildings and has identified areas for future research. Overall, the paper provides a comprehensive understanding of the benefits of BIM in the context of digitizing existing buildings.

6.2. Suggestions for future research

Future research should focus on addressing the challenges and limitations associated with the use of BIM for the digitization of existing buildings. The accuracy of data is a significant challenge, and the time and effort required for scanning the building and collecting data can be significant. The lack of standardization and interoperability between software and the high cost of BIM software are also challenges. Moreover, the complexity of BIM software and the need for specialized training for using it can be limiting factors. Addressing these challenges and limitations will be crucial to realizing the full potential of BIM in digitizing existing buildings.

6.3. Concluding remarks

In conclusion, the digitization of existing buildings using BIM provides owners and facility managers with a comprehensive digital model that can be used for maintenance, renovation, and other future projects. The use of BIM in digitizing existing buildings can lead to improved performance, reduced maintenance costs, and reduced risk of degradation. However, overcoming the challenges and limitations associated with the use of BIM for the digitalization of existing buildings is crucial to realizing its potential benefits. This research has provided insights into the use of BIM for digitalization of existing buildings and has identified areas for future research. The findings of this research can be applied in various fields, including architecture, engineering, and construction, and can contribute to the overall advancement of the construction industry.

7.Declarations

7.1. Data Availability Statement

The data that can be presented are included within article.

7.2.Conflicts of Interest

The authors declare no conflict of interest.

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