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Technological Innovations in Building Management: Assessing the Level of Digitalization

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Abstract
In modern construction projects, the proportion of integrated technologies is constantly increasing, which brings higher demands on their monitoring and management. These technologies generate vast amounts of data that are crucial not only for routine maintenance and ensuring reliable operation but also for addressing unexpected emergency and crisis situations. The digitalization of processes throughout the entire life cycle of a building represents a key step towards more efficient management, operation, and maintenance. An essential role in this process is played by the Building Information Model (BIM) in combination with Computer-Aided Facility Management (CAFM) systems, which enable data integration, simplification of management, and increased overall efficiency. To assess the level of awareness and preparedness in the application of digital tools in building management, a questionnaire survey was conducted among professionals active in the field of facility management. The collected data provide a valuable source of information that can serve as a foundation for further research and the advancement of knowledge in the digitalization of building management and maintenance.

Keywords: Facility management, BIM, digitalization, CAFM

1 Introduction

The chapter provides an overview of basic digital tools such as Building Information Modeling (BIM) and Computer-Aided Facility management (CAFM) systems. It is here that the contribution of these technologies in building management and maintenance needs to be emphasized, especially in terms of effective planning, coordination and decision-making. It is necessary to point out the advantages of digitization in the life cycle of the building and the increase in the value of the given building through modern technologies. However, one should not forget the obstacles or disadvantages that digitization brings with it.

Properly selected building materials, appropriately designed structural solutions, and their optimal combination can significantly reduce the costs of operating and maintaining a building and at the same time extend its overall lifespan **Error! Reference source not found.**.

Currently, the modern approach to the management and maintenance of buildings is increasingly focused on the use of advanced digital tools, such as building information modeling

(BIM), facility management (FM), computer-aided building management (CAFM) or the relatively new blockchain technology **Error! Reference source not found.**. These solutions enable more efficient operation of buildings, cost savings and increasing the quality of services provided. BIM appears to be an extremely breakthrough tool, as it allows the creation and management of digital models containing all key data on the physical and functional properties of the building. Gerrish's research **Error! Reference source not found.** points to the use of BIM in the visualization and management of energy efficiency, which helps to optimize operating costs and improve sustainability. At the same time, it supports cooperation between individual project participants, which is essential for effective management and maintenance of buildings.

1.1 BIM – Building Information Model

The building information model in short, i.e. BIM, is a relatively new issue that has been moving and progressing more and more significantly in recent years. By using BIM, it is possible to use technologies and systems that are based on data analysis more efficiently, and last but not least, it is possible to reduce financial resources for the entire construction work.
The concept of information modeling has been known since 1974, but the name BIM - Building Information Modeling has been used since 2002. The abbreviation "B" - Building primarily does not refer only to the buildings themselves, but includes the entire construction and also the construction process. The abbreviation "I" - Information is therefore information about the construction and the abbreviation "M" - Modeling can also be defined as management, which better describes the entire essence of BIM and thus enables the acquisition of information about the construction and subsequently about its management **Error! Reference source not found.** (Figure 1).

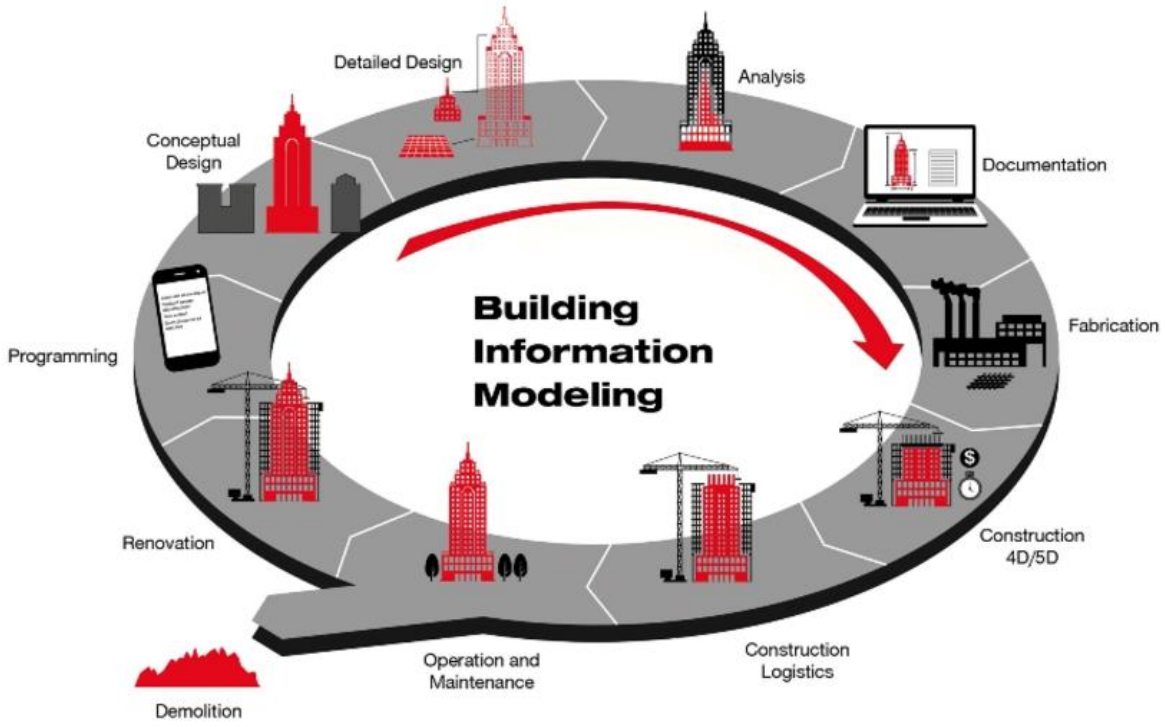

Figure 1: The role of building information modeling **Error! Reference source not found.**

The BIM model can be used not only in earthworks, but in the entire engineering construction. This model can be imagined as a database of information, which represents complex data from the design of the construction object to its actual removal. All participants in the construction process contribute to the information database. In order to achieve the maximum use of BIM, it is necessary that none of the participants refuse to use the model and that they constantly contribute their data, otherwise the efficiency of using the information model is significantly reduced. Thanks to this technology, the construction industry acquires a completely new dimension in the planning, implementation and use of the construction work. The entire model is thus stored on a digital storage, where every construction participant can update information about the construction object. Thus, the 3D model lives with the object and thus provides data and analysis during the construction and use of the construction work. The introduction of information modeling of constructions represents the digitization of the construction sector, it is necessary that more and more participants start to deal with this digitization, since the use of digital processes, automation and qualification of workers significantly contributes to the future, whether from economic or social development **Error! Reference source not found.**.

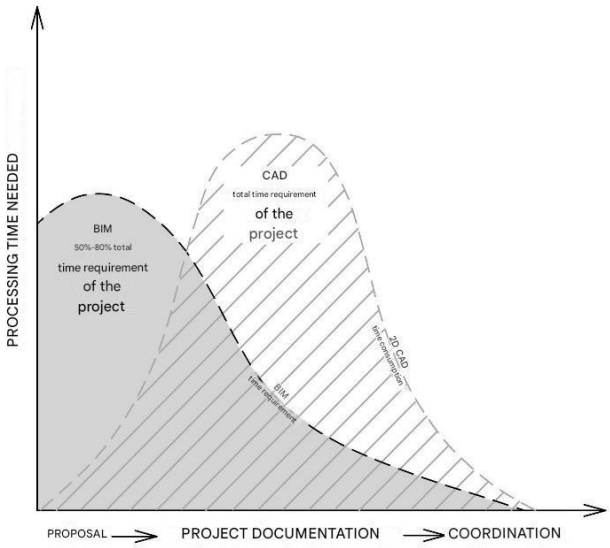

Figure 2: CAD vs. BIM **Error! Reference source not found.**; source: Author

From the above graph (Figure 2), it follows that designing using BIM modeling is less time-consuming, since with the help of a BIM software solution it is possible to automate work operations that often take too long. However, the use of software solutions that offer model creation is up to the individual construction participants.

1.2 Facility management

Facility management itself dates back to the second half of the last century. The cradle of facility management is the United States of America, where a certain group of designers and at the same time operators of construction objects concluded that the function of construction objects can change during the life cycle in the phase of use. This system brings order and proper organization of individual processes to the company's management **Error! Reference source not found.**.

Facility management – it is a modern method that manages the support activities of the entire organization. The word " Facility " in translation means a building in which there is a facility as well as services that are provided with a certain goal. The word "management" in translation means management or management. Each building object is realized with the knowledge that its purpose is already defined, and it is created for different entities or organizations. Activities that take place in organizations are different; these activities can be defined as **Error! Reference source not found.**.

- primary – main activities (processes)
- secondary – supporting activities (processes)

Primary – main activity means the goal for which the organization was created. Core business is classified among the main activities, it can be defined as a dominant process carried out by

an individual or a group of individuals or an organization that aims to fulfill a basic function, such as making a profit from a certain activity in the company **Error! Reference source not found.**.
Secondary - supporting activities are all other activities that take place in the building. However, these supporting activities create conditions for the main activity. Supporting activities include , for example: facility operation, facility maintenance, quality management, real estate administration or asset management **Error! Reference source not found.**.

1.3 FM Software support for building management and maintenance

Software support in technical management represents a number of software solutions. Due to the amount of information that occurs in the field of facility management, these software solutions are an essential part of every larger company. Software programs that are used to manage support processes are denoted by the abbreviation CAFM (Computer Aided facility management). These software solutions are primarily based on the connection of a graphic environment such as drawings, graphs with alphanumeric information. An important aspect is that all software solutions that only offer individual services cannot be considered CAFM systems **Error! Reference source not found.**.

The CAFM system is primarily intended for top management, which creates strategic plans with the aim of cost optimization. This top management tries to reduce the costs of operating the building and increase the quality of the services provided **Error! Reference source not found.**. Nowadays, almost every major company has a large part of its data in electronic form. Qualitative parameters of software solutions in the field of CAFM can be expressed by how the software is ready to process the given data, open it and then transform it and send it to the interested participants. These software solutions usually contain the following data **Error! Reference source not found.**.

- property passportization, which contains a graphic representation of the data
- management and maintenance of property or buildings
- property inventory
- registration of real estate, assets
- management of rental relations and warehouse management
- property records from an accounting and tax point of view
- documentation and contracts with lessors, suppliers
- records of fire protection, training
- records of revisions, ongoing inspections and service inspections
- overview of cost items for energy, cleaning, water consumption

It is necessary to add that, in addition to the parameters considered above, it is necessary to monitor whether the software is transparent, clear and whether its control is not too complicated. An important factor in choosing suitable software for the organization is also the purchase price

of the entire software, whether the license is unlimited or the entry price is paid monthly, quarterly or annually. Also, whether the purchase of the given software is connected to the purchase of other hardware items, such as the purchase of a new computer or tablet. Because of these aspects, it is necessary to pay sufficient attention when choosing a given software solution. Therefore, it is advisable to monitor what software is available on the market, what are their price parameters, what items the software offers, how many participants the software is available to, and last but not least, how it is possible to communicate within the software or how communication with other software takes place. If the choice of software is underestimated, this aspect can lead to ineffective management and costs can increase many times. Facility management is also constantly evolving, and software solutions are also evolving along with it . New software is coming to the market or software solutions already in use are being optimized and developed. Therefore, it is necessary that every participant who is involved, either in the software or outside it, contributes and evaluates the overall operation of the organization or building **Error! Reference source not found.**.

1.4 BIM and CAFM implementation process: opportunities and obstacles

The information model of the building, which is prepared for the given construction work, represents a set of complete data about the building, which can be used in the management and maintenance of buildings. Currently, the handover of the building is taking place by handing over the documentation of the actual state of the building, where all changes and adjustments compared to the original project documentation are recorded, it can also be done after the implementation focus of the building, if of course it is necessary and the external dimensions of the building have changed. Also, when handing over the building, the necessary protocols, audit reports, tests and many other documents are handed over, which are necessary for the approval of the building. At the moment when this information is submitted, this data is current and valid, however, with the passage of time, this data may change significantly or even some of the data may be lost. This obstacle should be solved by the BIM model of the building, where building managers will always have an up-to-date model and up-to-date data available. Of course, this model must be constantly worked on and must be constantly updated and supplemented with new data **Error! Reference source not found.**. The BIM model is capable of containing information that can reflect the current state. This information can be, for example, information about suppliers, warranty periods or even technical reports of individual devices or elements. This information is beneficial for the building administrator, who can respond in a timely manner to the maintenance or revision of the given technological devices or elements located in the building. If the given construction work is made using the BIM model, it is possible to save 3-5% of maintenance, management and energy costs, which can be a significant financial saving during the life cycle in the use phase **Error! Reference source not found.**. In information modeling of buildings, it is also important to what level of detail the given construction work is modeled. The level of detail can be made to the level shown in the image below (Figure 3).

Figure 3: BIM model of the Visionary administrative building and detail of the model **Error! Reference source not found.**

2 Methods

Currently, there are several approaches to building management and maintenance, with digitalization significantly contributing to simplifying these processes, increasing transparency and more effective monitoring of technical and operational parameters. In order to objectively assess the current level of digitalization in the operational phase of buildings, a questionnaire survey was conducted focusing on the use of digital tools (especially BIM, CAFM and other FM technologies) in practice. The target population included entities actively operating in the design, construction and management of buildings sector – designers, construction contractors, public administration workers, education experts and property managers. The sample was compiled through targeted electronic outreach of more than 1,200 potential respondents. This procedure was chosen due to the availability of contacts and the existence of connections to professional networks. The return rate exceeded 7%, which represents 87 completed questionnaires. Such a return is common in research in the professional FM segment and allows for the approximate identification of trends and barriers to digitalization. For the purposes of this work, only respondents who are directly involved in property management were further analyzed. Out of a total of 87 evaluated questionnaires, 58 respondents stated that they are actively involved in building management and maintenance. This subgroup represents the core of the research and allows for a relevant insight into the real limits and potential of digitalization in the operational phase of a building.

2.1 Results

The majority of respondents, more than 41%, were aged between 36 and 50 years. The second most represented group were respondents aged 51–60 years (23%), followed by those aged 61 and older (19.5%). The smallest group consisted of respondents aged 26–35 years, representing

16.1%. Nearly three-quarters of participants were from the Slovak Republic, while more than 25% were from the Czech Republic. This distribution is illustrated in the graph shown below. In the subsequent questions, the survey focused on the types of buildings that respondents primarily deal with. Almost 80% indicated their professional focus is on civil engineering structures. Another section of the survey addressed the use of software tools, specifically asking respondents whether they use Building Information Modeling (BIM) technology and, if so, for how long. Nearly 53% of respondents stated that they do not use BIM technology and do not plan to adopt it. This result is likewise confirmed in the graph presented below (Figure 4).

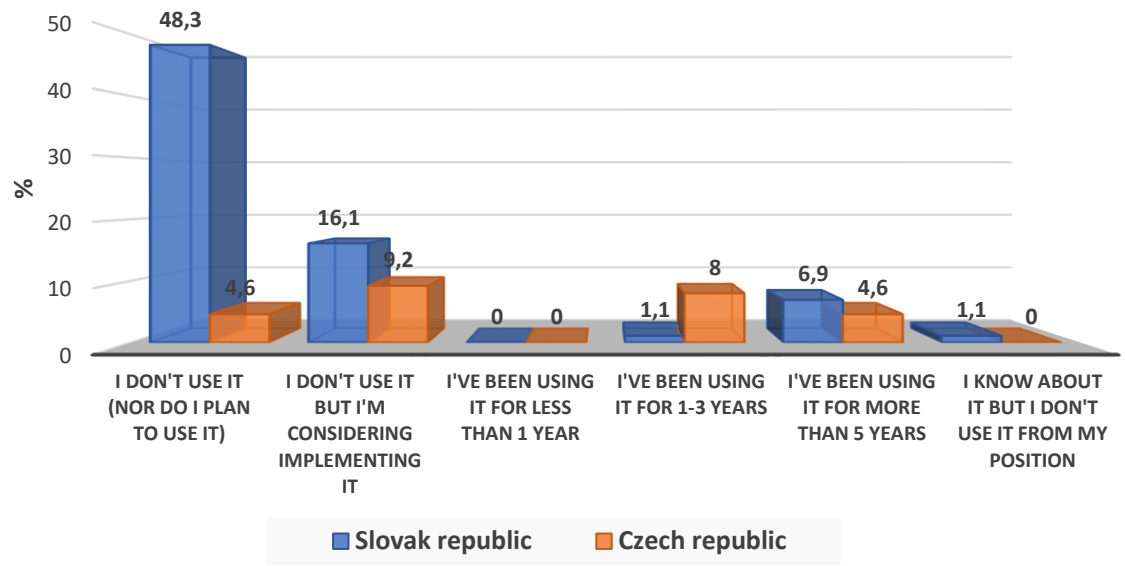

Figure 4: Using BIM technology (source: Author)

The next question in the survey was directed at property managers and focused on whether they use Computer-Aided Facility Management (CAFM) technology (Figure 5). CAFM applications support facility management and building operation through information technologies, enabling the recording of routine maintenance, failures, repairs, and all relevant data necessary to ensure the continuous operability of a building during its use phase. Surprisingly, nearly 45% of respondents indicated that they do not use CAFM technology and do not plan to adopt it in the future.

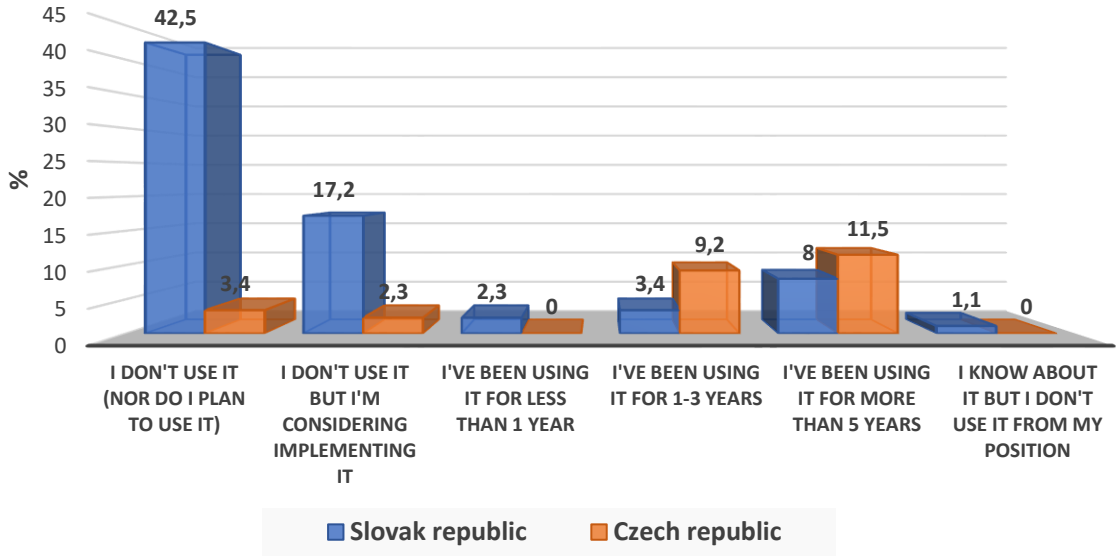

Figure 5: Using CAFM (source: Author)

Respondents were also asked to indicate in which of the listed phases of the building life cycle they consider BIM to provide the greatest benefit (Figure 6). In general, the life cycle can be divided into the pre-investment phase (initial concept and design), the investment phase (construction and realization), the operational phase (management and maintenance), and the decommissioning phase. The survey results show that participants most frequently perceive the greatest value of BIM in the pre-investment phase (nearly 24% of respondents) and in the operational phase (almost 40% of respondents).

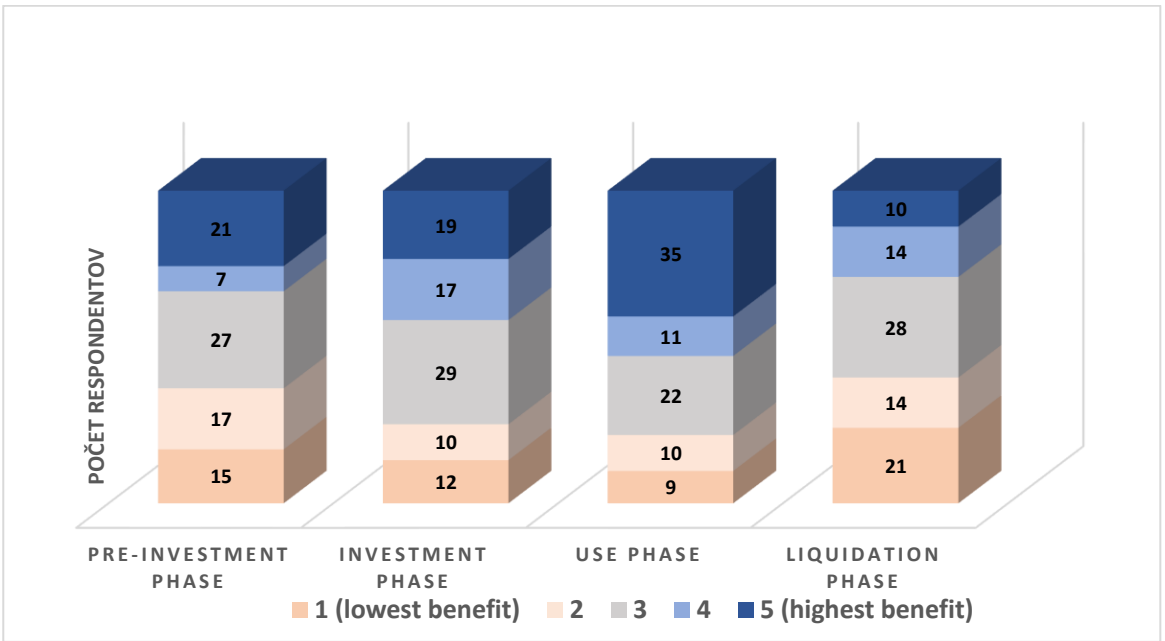

Figure 6: Using BIM in the phases of the construction life cycle (source: Author)

3 Results and discussion

This survey revealed that, based on the analysis of the examined sample, the overall awareness of digital tools for building management and maintenance remains at a relatively low level. In practice, these tools are only rarely applied. However, certain differences between the Slovak Republic and the Czech Republic can already be observed in terms of their adoption. The responses indicate that in the Czech Republic, CAFM systems are being increasingly implemented, and some companies are even attempting to integrate them with the BIM model of a given building, although such efforts are still in their early stages. With regard to BIM technology, this finding is not particularly surprising, as there are still many challenges and open questions that must be addressed before its broader implementation in building management and maintenance becomes feasible. On the other hand, the results concerning the use of CAFM systems were more unexpected, as these systems can be considered, in many respects, simplified software solutions that nevertheless support timely maintenance, failure prevention, and provide a comprehensive overview that facilitates the work of all stakeholders involved. Another noteworthy outcome of the survey is that nearly 20% of respondents are considering the implementation of either Building Information Modeling (BIM) or a CAFM system. It will be interesting to observe how this trend in the adoption of digital technologies develops in the future. Nevertheless, many challenges and issues remain to be resolved. The most effective approach appears to be the integration of these two technologies, as their combined application can significantly strengthen and streamline building management and maintenance processes.

On the other hand, the deployment of Facility management requires initial investments and actions that can be a challenge for some organizations, for example training staff, purchasing software licenses or setting up data repositories for backing up all data. Although these steps may seem like an added burden, in the long term they represent a significant benefit for the effective management and maintenance of objects.

In the article Krämer **Error! Reference source not found.** defines that tools such as BIM and CAFM must interact in the BIM model, but also later in the phase of operation of the construction work and Facility management as such. The most suitable way for the model to move on without any loss of information. All information can be stored on the Common data environment Data environment (CDE). In the study of Gnanaredman **Error! Reference source not found.**, the right question arises and to what extent the BIM model can satisfy the information needs for the CAFM software solution. The answer may be the study of Wijeratne **Error! Reference source not found.**, who within the study examined how the BIM model can help in the management and maintenance of the given buildings. He carefully examined 33 projects and found that the BIM model brings several advantages. One of the main advantages is that the data is linked to the 3D model, so this model provides the team that manages the building with direct access to the database and allows easy access to the required information. In this way, errors and duplication of work can be avoided, leading to significant savings in time and costs. Also, the given operator will correctly and more simply understand the entire process associated with the given administration and maintenance, which leads to the fact that it is possible to anticipate problems and malfunctions instead of reacting to an already real problem. In this aspect, the question also arises as to how it will be possible to implement AI in administration and maintenance.

The survey results indicate a prevalent low awareness of digital tools such as Computer Aided Building Management (CAFM) systems and Building Information Modeling (BIM) technology in building management and maintenance. Recent literature highlights that although these technologies are not sufficiently used, some countries, such as the Czech Republic, show a more positive trend towards their implementation compared to the Slovak Republic. For example, it is reported that Czech companies are starting to integrate CAFM systems with BIM models, although they are in an early stage **Error! Reference source not found.**. This comparison underlines regional differences in technology adoption that deserve further investigation. The integration of BIM into the operational phase of construction is paramount, as highlighted by Liu **Error! Reference source not found.**, who discuss the need for these tools to work effectively together throughout the building lifecycle. This idea is further supported by other authors, whose analysis shows that BIM facilitates maintenance management and mitigates errors, potentially leading to significant time and cost savings by directly linking data to the 3D model.

4 Conclusion

Facility management provides a wide range of tools and methods that enable more efficient management and maintenance of buildings. To ensure the full functionality of a building, it is essential to optimize processes so that they can flexibly respond to changing conditions of use and purpose. Since the operational phase represents the longest period in the building life cycle, regular inspection of technical systems and the prompt elimination of potential failures or deficiencies play a crucial role in maintaining safety and user comfort. In addition, buildings contain numerous components with shorter life cycles, which require regular upgrading or replacement in order to prevent a decline in quality standards. In this context, increasing emphasis is placed on systematic planning of preventive maintenance, process digitalization, and the use of advanced information technologies. These approaches make it possible to better monitor performance, predict malfunctions, and optimize costs throughout the entire operational phase of a building.

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