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MAINTENANCE METHODOLOGY IN THE FACILITY MANAGEMENT SYSTEM AS A BASIS FOR BIM TECHNOLOGY

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ORIGINAL SCIENTIFIC ARTICLE

ABSTRACT

Currently, we need to ensure sustainability in the construction industry. The main tool that could ensure this is BIM Technology. It is this technology that can be a decisive basis for planning the maintenance of building structures because its content includes complex parameters of building structures. In practice, planned maintenance of buildings is carried out based on tracked data of facility managers. Streamlining their work by using spatial and topological relationships and by identifying the problem of building maintenance is offered by BIM technology. Using the proposed methodology, selected life cycle costs can be determined in a simple and fast way, i.e., also future maintenance costs, already during the building design phase. The goal of the paper is to propose a methodology that can become an effective tool in deciding on the material solution of building structures.

Key words: *Technology; Methodology; Facility Management*

1 INTRODUCTION

According to the content analysis of the existing literature shows that current research tends to focus on BIM-based technologies integration to enhance facility management (FM) practice, rather than resolving the issues regarding facilities information management, which is considered as the backbone for successful FM practice. Moreover, the main concept behind extending BIM implementation to the Operations and Maintenance phase is to utilise the benefits of BIM capabilities as a data conduit that can solve the interoperability issue between the various FM systems. Although the research trends and patterns reveal that there is a continuously growing interest in facilities information management using BIM, and a steep rise in the number of publications during the last years on identification of information requirements and integration of different information sources, nevertheless, a seamless **information exchange process between BIM and FM systems does not yet exist**. A successful implementation of BIM in FM requires a seamless information exchange between the different BIM-FM systems. Once the information is transferred and shared between the different BIM-FM systems seamlessly, any other solution can be possible. [1]

A study underway in New Zealand points out that the adoption of BIM in FM practices is slow. Results show that the high cost of BIM implementation in FM practices, **unfamiliarity with BIM, and lack of BIM expertise** among the FM practitioners require the utmost attention. Thus, the following recommendations can be made with consideration to the barriers identified and prioritized. If this collaborative methodology was more widely utilized during the operation phase it is likely the software

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would be more affordable and easier to access. It would be great to see a more diverse range of software providers which could potentially pave the way for a more competitive and fairly priced market. If the software was priced within reason this would help sway many potential users that are put off based on cost alone. BIM for FM training needs to be more easily accessible. Most training for BIM is aimed at design and construction and training specific to BIM FM is only available via online correspondence which increases the cost of training based on supply and demand principles. Thus, local providers need to offer FM training in order to decrease cost and increase popularity among professionals. [2]

Ger Maas, in ongoing research, points to the need to extend the use of BIM technology beyond design and implementation phases, and to consider its use for FM, as well as for building maintenance as part of FM. According to the author, research on the implementation of FM technology stagnates compared to research for the design and construction phases of buildings. At present, maintenance costs are rarely considered at the design stage when they can be influenced by design documentation. Therefore, as a next step for the FM, the author proposes: "to consider the maintenance proposal already in pre-project preparation." [3]

The building is constructed using building structures that have different technical lifetime that make their future maintenance conditional. The technical lifetime of building structures depends on the choice of material design of building structures in the design phase, where the material affects the future maintenance of building structures, quality of regular maintenance, location, climatic conditions, quality of implementation: technological discipline of production and incorporation into the structure.

Most of the building maintenance is now carried out as so-called induced maintenance. Such a maintenance task can result in a three to fourfold increase in costs as with the same repair if it were carried out using a maintenance plan. This practice is ineffective. The maintenance task that is induced by maintenance focuses mostly on the repair of existing symptoms, not on the cause of the failure, thus increasing the frequency and the cost of repair and maintenance. Consequently, it is necessary to focus on preventive (planned) maintenance. Maintaining and recording reliable information about the condition of the building and its structures is essential for quality maintenance planning. The optimal functioning of the building is conditional on the application of facility management, which has an impact on the efficiency of building construction maintenance.

Maintenance of buildings in the concept of facility management represents a complex of services aimed at ensuring the smooth running of buildings and their technologies. It's a continuous process. Building maintenance is: "part of the technical building management that ensures the maintenance of building structures and the maintenance of the technical installations installed in the building. Wear and change of functionality is compensated just by the maintenance of building structures of buildings, which leads to the maintenance of the desired properties of buildings. [4]

2 POSSIBILITIES OF INVOLVING THE PROPOSED METHODOLOGY IN BIM TECHNOLOGY

BIM ("Building information modeling") Building information modeling is a technology that involves the creation and management of digital information on the physical and functional characteristics of a building. Building Information Modeling is a modern technology that creates and manages construction projects. It is based on virtual building models. The resulting building information models become the sources of collective knowledge to support building decision-making from the pre-design phase, during the design and implementation phase, during the building operational phase and possible disposal, i.e.,

throughout the building's life cycle. It facilitates the exchange of information during the design, construction, and operational phases of the building. [5]

The designed methodology serves for participants of the investment process to select a suitable, economically efficient material solution of the building construction. During the project preparation, the designer has the possibility to influence future operating costs by selecting the material solution of the building structures. The designer should select the optimal material solution from the variety of material solutions, based on the economic demands of the building operational phase, and thus evaluate the cost of future maintenance of the building structure and heating during the design. This information can be recorded using BIM technology.

BIM technology allows you to efficiently create Bill of Materials (BOM) reports. This increases the quality and speed of the calculation of investment costs.

In the design process, investment costs are a priority for the investor, but it is not possible to accurately determine the future operating costs of building structures, and a lump sum of cost is an inaccurate method. If maintenance processes are more accurately planned, this will result in more accurate maintenance costs.

The basis of the planned maintenance is the Building Maintenance Manual. The facility manager should work together with the investor and the implementer during the design phase to create a Manual for individual variants of building construction material solutions. For the selected option, the Manual will be elaborated during the construction of the building, as well as a Process Sheet and Key Performance Indicators.

The software solution for BIM technology gives the possibility to input various parameters for the building material solution, such as:

- Thermo-technical parameters
- Acoustic parameters
- Fire resistance
- Labor intensity of construction
- Investment costs

According to the methodology, developed indicators of the critical life-cycle costs of a building could be included among the already existing parameters that can currently be included in the model. The parameters would be displayed for each variant of the structural design of the building structure.

With as-build documentation, the builder will hand over the building Maintenance Manual for the selected building material variant to the investor, which will be inserted into the BIM model.

During the operational phase, the manager has the opportunity to record information about the implementation of building maintenance, tests, measurements and controls using BIM technology, allowing him to create time-space maintenance analyses. The analysis can then be used by the designer during renovations or when designing a new building. Facility manager continuously evaluates and optimizes individual maintenance processes. The evaluation can be a basis for the preparation of the Manual for individual types of buildings.

3 PROPOSAL OF A METHODOLOGY FOR THE MAINTENANCE OF BUILDING STRUCTURES IN THE FM SYSTEM

Maintenance of buildings in the concept of facility management represents a complex of services aimed at ensuring the smooth running of buildings and their technologies. It's a continuous process. Building maintenance is: "part of the technical building management that ensures the maintenance of building structures and the maintenance of the technical installations installed in the building." Wear and change of functionality is compensated just by the maintenance of building structures of buildings, which leads to the maintenance of the desired properties of buildings. [4]

The designed methodology of building maintenance consists of several successive activities. These activities influence each other and lead to the evaluation and selection of a suitable and economically advantageous material solution of building structures. In the design phase, when selecting a building construction material solution (V_{SEL}), it is important to identify costs that are indicators of economic life-cycle efficiency and subsequently become an effective tool in the decision-making process. Operating costs were selected for the designed methodology, which account for the highest percentage over the life cycle and are directly related to the structural design of building structures, heating costs and maintenance costs.

In developing the methodology, the following conditions were defined

- The building will be realized in an environment with standard weather conditions
- During the construction of the building, all technological regulations will be observed
- The necessary quality of the realized construction is ensured

Developing the methodology

- After specifying the requirements from the investor, the designer decides on the material solution of the building construction. The designer develops a set of M possible solutions. Mi = {V1, V2, V3, ... Vn}
- For each variant of the M solution set, the budget manager will prepare a budget for the building construction. The budget determines the investment costs for the construction of the building: CINV.
- The MEP designer will elaborate documents for the energy performance of buildings for all solution options to determine the heating costs: COPh.
- Facility manager in cooperation with the designer, according to data and experience, develops facility management documents, namely the Building Maintenance Manual together with Process sheet of maintenance for all solution options. It defines individual maintenance activities of building structures with their periodicity. Maintenance costs: COPm is determined by budgeting according to applicable building materials and works price lists or by collaboration with companies providing Facility Management services or directly with companies providing specific maintenance activities.

The main task of facility management is to optimize the support processes, so also maintenance of building structures. Facility managers have tracked maintenance activities for various variants of building construction solutions.

After n-years, the future value of current money depends on the present value and the method of interest rate. For all variants, the same interest rate is used in the methodology and therefore the values obtained by calculation are comparable with each other. The calculated individual selected life cycle costs for a

set of possible M variants are compiled into an evaluation table (Table 1). Individual costs are a decisive means in deciding the participants of the investment process on the choice of material solution of the building structure from the economic point of view.

The selected costs can be determined according to the methodology for any year during the building operation phase. The prerequisite for selecting the optimal variant of the V_{SEL} material solution is that:

$$LCC\ V_{SEL} \overset{!}{=} min \tag{1}$$

Tab. 1 Design of the scoreboard with an overview of the various costs

Cost [€]		V_1(year X)	V_2(year X)	.....	V_n(year X)
Investment costs	**$CINV_i$**	-	-	-	-
Heating costs	**COP_{hi}**	-	-	-	-
Maintenance costs	**COP_{mi}**	-	-	-	-
Life cycle costs	**LCC_i**	-	-	-	-

The methodology was incorporated for three variants of external wall on the administrative building. V1 was considered as a masonry wall made of ceramic blocks, V2 was considered as a reinforced concrete wall with insulation, V3 was considered as an all-glass facade. The cost indicators [€/m2] are determined by dividing the costs by the areas of structure S. Life cycle cost indicators were processed for the 30th and 80th year (Table 2-3).

Tab. 2 Overview of lcc cost indicators per m^2 in terms of 30-year level

Cost indicators [€/m^2]		V_1(30)	V_2(30)	V_3(30)
Investment costs	**$cinv_i$**	184,36	163,01	400,00
Heating costs	**cop_{hi}**	221,63	189,63	253,91
Maintenance costs	**cop_{mi}**	120,54	300,01	553,55
Life cycle costs	**lcc_i**	526,53	652,66	1 207,46

Tab. 3 Overview of lcc cost indicators per m2 in terms of 80-year level

Cost indicators [€/m^2]		V_1(80)	V_2(80)	V_3(80)
Investment costs	**$cinv_i$**	184,36	163,01	400,00
Heating costs	**cop_{hi}**	3 651,72	3 124,50	4 183,57
Maintenance costs	**cop_{mi}**	1 216,56	1 517,01	9 120,60
Life cycle costs	**lcc_i**	5 052,65	4 804,52	13 704,17

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4 CONCLUSION

The proposed methodology points to the possibility of using support facilities for facility management and their integration with BIM technology. The BIM technology model can contain all the necessary information that the facility manager should use to plan and optimize building maintenance for the longest possible lifetime of buildings and trouble-free operation. The main result of BIM should be the management of the building and its structures throughout its life cycle, with the support of digital technologies. In fact, most BIM systems focus only on the design phase, not the building use phase. Building managers are also interested in BIM technology but are not aware of its application in practice. The proposed methodology is used in the decision-making process in the selection of the material solution of building construction. It is comprehensible to all participants in the investment process. The data obtained by the design methodology would determine the input data for solving the issue of maintenance using BIM technology. With the help of indicators of selected costs of the building life cycle, it becomes an undemanding tool according to which the selection of the optimal material solution in the design phase can increase the efficiency of the future maintenance of building structures.

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