Practical Aspects of the Use BIM Technology for Existing Buildings

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Practical Aspects of the Use BIM Technology for Existing Buildings

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Abstract. In the analysis process enabling the renovation of existing facilities, the use of BIM technology becomes more and more common. It results from the increasingly widespread dissemination of IT solutions, which can be successfully used in situations where it is necessary to implement new concepts of using objects, but also when it is necessary to quickly adapt the structure to different load conditions. At the time of making the decision to implement the reconstruction of buildings, it may turn out that the use of BIM technology to create a full digital model will be one of the better-used investment funds in correlation with the effect of final solutions. In the work, research was undertaken to determine in which types of objects measurable effects can be obtained from the use of new technology. This is extremely important when making the decision about the need to incur additional expenses to perform the necessary macroscopic research and sometimes outlets of the existing structure in a manner adequate to the possibility of later use in the process of creating a numerical model. A different issue is the undoubted usefulness in obtaining new opportunities when used for historic buildings, whose period of use should practically be unlimited. The article will specify the possibilities of using BIM in the processes of building identification and construction structures, as well as the necessary data to be obtained during the preparatory works. Model solutions will be discussed, enabling the use of multi-criteria analysis of the selection of the most optimal solutions during the renovation process. Performing the above work by building a numerical model of the facility allows at each stage of verification by authorized persons inventoried solutions and enables tracking and changes in the situation of identified exceptions in relation to parameters determined at the initial stage. The work will be summarized by the results of the conducted analyzes with an indication of the utilitarian aspects of the completed research.

1. Introduction

The use of BIM technology when designing new buildings becomes an inevitable standard, allowing future users, among other things, to manage the site more effectively during operation. It becomes possible to coordinate the renovation work rationally, perform the works adopting the room to the requirements of future users, including the introduction of new structural elements, which by changing the model allow for the selection of safe solutions. The possibilities of introducing new technology for existing objects built according to traditional solutions are not fully used. Lack of normative solutions that require the use of BIM technology in national regulations lead to restrictions on the creation of numerical models for existing buildings, [1], [2].

In addition to the need to learn new solutions and IT opportunities, one of the main obstacles that limits the process of starting to use BIM technology in already used facilities is undoubtedly the additional costs that will be associated with it. However, when there is a need to carry out inventory

works on the objects correlated with their planned reconstruction, change of technological processes, modernization or local failure, it is possible to plan the execution of works that will be used in the processes of creating facility models based on BIM technology, [3], [4]. This is due to the fact that the scope of work carried out in such cases is so large that the performance of additional work does not significantly extend the task implementation process and the obtained results may prove important in the subsequent operation process. The process of creating models can be accelerated by applying a photometric technique or laser scanning of objects where, after obtaining the image in 3D space, it is possible to quickly map out its geometrical features.

2. Identification of construction solutions

The process of creating a model in BIM technology requires in the first place execution of works enabling identification of the applied structural and material solutions in connection with the deployment of technological installations in its space. It should result in the implementation of works aiming at the unambiguous determination of the type of structure based on the data obtained during the measurement work. It is implemented in relation to foundations, load-bearing walls or columns, ceilings and roofing, and schematically it is shown in figure 1.

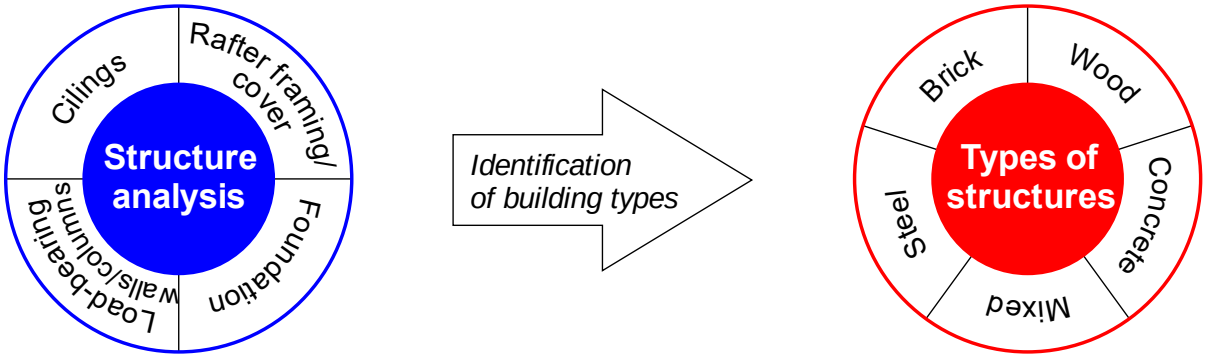

Figure 1. The process of identifying construction solutions

The complexity of works sometimes requires the use of means that are individually adapted to the existing technical solutions, because the complexity of solutions often limits the possibility of applying unified procedures. This is partly due to the fact that in the process of building objects, different material solutions are used, and often one-time, prototype solutions that have not had their repeated applications in other types of objects.

With regard to the objects constructed on the basis of typical, catalogued technical solutions, it will be possible to refer to databases where typical solutions for a specific type of objects will be included and reference of the obtained data with the reference base will be made. Creating and providing databases containing typical solutions is well-aimed and practically useful due to the possibility of data verification based on previously performed works on similar objects. The development of such databases will also facilitate the creation of aging models of materials, where the original data would be obtained during the operation of facilities based on direct research in specific environmental conditions. Completing the databases on the parameters of the analyzed unit structures on a current basis will also support the research processes of subsequent recipients in the future, who will be able to use more information available in the form of comprehensive technical studies. Establishing and running such databases seems to be the next step in the effective use of the opportunities created by the development of IT solutions focused around BIM technology, [5], [6], [7].

3. The process of creating models

The creation and construction of the object model can be accelerated through the use of laser scanning or photogrammetry. Using the above solutions, imaging of external surfaces is obtained, which reflect the external layers of elements. The original structural geometry of the net elements is not obtained

because it is covered with, for example, a layer of plaster, which is taken into consideration at a later stage of the work. All kinds of defects in the form of scratches and cracks will not be properly mapped as a result of the use of laser scanners, which results from their resolution which in the currently manufactured devices is within 0.4-0.5mm for every 10m measurement. Proper mapping of this type of defects is possible based on the use of high resolution photogrammetry, which allows for a correct, detailed analysis of the external surfaces of elements and the application of appropriate defects, defects on the original model. The superficial picture of defects does not always fully reflect the damages occurring on the structural material, hence, after the implementation of the work using digital equipment, it is necessary to carry out opencast work, which is carried out in previously selected locations.

It may happen that completed reconnaissance work in the field of structural solutions turns out to be more complicated than it would appear on the basis of already completed works. This is because of the frequent lack of full technical documentation of facilities and the necessity of full reconstruction of structural solutions. In such a situation there may be significant discrepancies between the already performed identification measurements and the actual state, which may result in incorrect global or local understanding of the structure. In conditions of reliably conducted works of this type, situations should be eliminated by adjusting the amount of outlets to be realized in relation to individual needs resulting from the life of the facility and traces of construction changes and previous repairs. An example of this is the results of opencast works, which showed the use of steel reinforcing and bearing elements in the structure of brickwork, which were not used in primary solutions, figure 2.

Figure 2. Structural reinforcements identified at the outcrops stage

The long service life of historic constructions is not conducive to atypical situations, hence should be particularly carefully implemented in relation to this type of objects.

The macroscopic evaluation process should also allow to determine possible damage in the form of material losses or excessive deformation, scratches, cracks, delamination. The macroscopic evaluation of structural elements is closely related to the assessment of structural solutions of elements in the scope of reinforcement, pre-cuts and types of elements as well as determination of their strength in the current state. For this reason, it is helpful to know the location of places where the load capacity is fully utilized so that the identification of material solutions covers such places. The full assessment should also include evaluation of corrosion processes and degradation caused by biological factors. The result of the research will be a suitably constructed material model that will fully reflect the actual technical parameters of the structure.

4. Analysis of the effectiveness of using BIM technology

The creation of advanced computational models should be the result of work carried out each time using BIM technology, [8], [9]. Advanced models, in addition to meeting the basic requirements regarding ultimate and serviceability limit states, also enable assessment of the appropriate durability

of the structure for the expected period of its use under real environmental conditions. Achieving the above is possible by developing modelling methods so that the durability parameter is one of the main requirements adequate to the type of construction.

The final model is obtained as a result of actions taken consciously at the stage of identification work, in particular by, among others:

- use of 3D scanning devices to identify the geometry of objects,
- use of high resolution photogrammetry to identify any surface defects;
- implementation of outlets allowing for determination of actual material parameters and data regarding their technical condition;
- determination of the strength of the elements in correlation with the current level of damage and defects;
- global assessment of the structural safety status;
- compliance with the requirements regarding the fulfilment of serviceability limit states.

At each stage of building the model, it is possible to correct the data already introduced, which facilitates the process of obtaining solutions based on successively obtained research results.

The model building process in relation to existing objects significantly accelerates the use of 3D scanners, which in combination with point cloud computing software allow to generate real systems in formats recognized by computing software. The degree of complexity and time-consuming work is conditioned by the availability of scanning devices and their resolution. The mapping of geometric parameters of the structure enables their subsequent correction with the results of opencast works and structural defects found. The complexity of the work is also dependent on the software and IT solutions used where the most advanced implementations allow users to fully modify the model based on the necessary technical parameters and perform calculations practically for all possible types of construction solutions.

Limitations on the effective use of BIM technology may result, among others, from technical conditions resulting from:

- analysis of objects whose structure has been damaged or overexploited to the extent that their further use is excluded;
- lack of adequate research equipment allowing for the execution of works identifying the necessary technical parameters;
- incorrect recognition of structural structures of facilities based on completed preliminary work;
- incorrect determination of material parameters, including defects and damages.

5. The variety of construction types in the analysis processes

Adapting adequate research procedures to the analyzed types of structural systems is an indispensable technical problem when applying a number of unified procedures with conditions resulting from the expected final parameters. Another set of activities is undertaken in the construction of a reinforced concrete object model and another in the case of steel. Preparation of appropriate procedures and preparation of proceedings will allow for the unification of activities in the area of all facilities, which should be supplemented with additional works resulting from the fact of finding different solutions in relation to the conducted research works. Due to the lack of formal conditions in this area, all kinds of works were carried out by the author according to individually developed and adapted needs so that the final effect in the form of a computational model would be possible. As an example, the processes of excavation implementation in relation to reinforced concrete structures may be used to identify the thickness of the lagging and the reinforcement method which no longer exist in the identification of masonry structures. For this reason, the level of advancement of data obtained at the stage of works should always be preceded by the analysis of the necessary parameters, which should be set to allow for a global analysis of structural solutions in correlation with the existing loads in individual cases.

The technical problem is complicated in the situation of uneven wear of structural elements when it is necessary to determine the degree of damage, depleting the structure which results from local negative impacts, [10,11]. Making decisions based on limited research results will result in the construction of a model that does not reflect the actual technical parameters of the facility.

6. Results and discussions

Spatial models built on the basis of BIM technological solutions obtained through conducting advanced research works enable the analysis of real structural systems verified during preparatory works, [12], [13]. The current technological changes related to this result in the need to develop new databases in which solutions for the construction systems will be collected. The development of the numerical model in such conditions will require the implementation of works in a faster, more effective way and with lower financial expenditures in individual cases. The usefulness of BIM technology for existing buildings is indisputable and its limited use is usually due to the lack of adequate resources for this purpose.

The analyzes carried out indicate the need to develop numerical models that could be adopted to analyze the durability of building materials, especially in buildings used for a long time, which are undoubtedly historic objects, [14], [15] constituting national heritage.

7. Conclusions

The process of modelling existing objects using BIM technology processes requires a series of additional works identifying structural and material systems. Creating calculation models, which can also take into account defects established at the macroscopic stage, greatly facilitates further analysis and enables correct interpretation of existing threats in the construction. The cost of the works carried out at the first stage will be compensated in the later period of operation of the facilities through, among others, optimization of renovation works.

The use of numerical procedures in the search for solutions using techniques [16], [17] allows for effective design of new solutions and analysis for optimal variants. This is undoubtedly one of the arguments that contributes to the further development of BIM technology in search of new aspects of design, research and material solutions.

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