BIM technologies in the inspection of buildings and structures

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Abstract. The objective of the research is to investigate the issue of the increase in the efficiency of inspection of buildings and structures with the use of BIM technologies and laser scanning with the subsequent creation of information model of the facility at all the stages of its life cycle. Some examples of the executed inspections of buildings and structures are reviewed. The author set the purpose to develop some practical recommendations on the use of BIM technologies during the inspection of buildings, structures and engineering systems. Such recommendations are presented in the article. The results of approbation of the given technique of carrying out inspection of buildings and structures confirmed its efficiency and high precision. The BIM models of buildings, structures and engineering systems, received within the inspection, can be used during all the stages of the facility life cycle. It is especially relevant for the maintenance stage and reconstruction.

1 Introduction

Information technologies became an important part of life and professional activity of human long ago and did it thoroughly. Their application allows solving a wide range of difficult technical tasks, including those connected with the organization and management of construction during all the stages of the facility life cycle. Such technologies include Big Data, CAD/CAM systems, BMS (Building Management Systems), ERP (Enterprise resource planning), and certainly BIM (Building Information Modeling) [1].

BIM technologies became the trend of the last years; BIM also faces some obstacles during its introduction in construction community and as any product it has some advantages and disadvantages [2-3]. However, some positive moments in relation to BIM are also observed. According to the order of the Head of state, the Government of the Russian Federation has to provide the transition to the control system of the facilities life cycle by the means of the implementation of BIM technologies for the purpose of modernization of the construction industry and improvement of quality of construction [4].

The creation and application of BIM model of the existing buildings gives the chance of control and management of the systems of the facility; that in turn allows providing the necessary parameters of safety and standard operational indicators of the building and also reducing the economic damage, which appears as the result of sudden accidents.

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The process of inspection of technically difficult facilities (tunnels, bridge structures), objects of cultural heritage, engineering systems and their complexes is very difficult and long in time, the application of standard methods of inspection of buildings and structures in such cases demands great economic and personnel expenses. Besides, examination is often conducted on the facilities under maintenance, which activity is impossible to be stopped, thus, the work happens in the environment, characterised with high-risk for life and health of the experts.

2 Methods and Procedure

During the research, such general scientific methods as analysis, comparison, observation, generalization were applied. More than 10 facilities gave the practical material for the research, which was carried out within the short deadlines.

The procedure of works supposed the application of such methods as laser scanning along with drone shooting, for the purpose of receiving a cloud of points, and further 3D models of the surveyed buildings and structures [6-8].

Laser scanning is the modern method of shooting, allowing obtaining the most complete and reliable space-and-geometrical information about the subjects of the explored area quickly. The cloud of points of reflections of high density from any subjects in the shooting corridor is as the result formed. During the work "the cloud of points" is painted in the colors of the photo, that facilitates the visualization of the facility.

The high-precision three-dimensional models of the area, the relief, technogenic subjects, received as the result make the basis for geographic-and-information systems.

The benefits of the method of laser scanning are the following:

1. Rather low cost. The cost of the field and cameral works is lower, than when using classical technologies approximately by 3 - 5 times.
2. Speed of the conducting works. The cumulative speed of shooting and data handling, received by laser scanning, several times quicker, then in case of the usual geodesy and aerial photography.
3. Detail and informational content of data.
4. Accuracy. Accuracy of laser scanning is comparable with the accuracy of land geodesy and much higher than the accuracy of classical aerial photography.
5. Uniqueness of the method.
6. Flexibility. Reliable receiving of the true relief even under dense vegetation, and the possibility of carrying out shooting of any relief of any complexity.
7. Universality.
8. Processing automation.

The principles of system and object-oriented analysis, probabilistic and expert methods were used during the research. Methods of mathematical modeling of the processes of measurements and statistical analysis were used for the assessment of accuracy of results of laser scanning.

Works were performed in the following sequence:

Field works:

1. Measurement works (selectively).
2. Laser scanning with the use of the scanning system of Leica C10 (all the facilities).
3. Shooting with the use of the DJI Phantom drone (all the facilities).
4. Driving of holes, soil sampling.
5. Determination of durability of materials of designs by the nondestructive methods.

Cameral works:

1. Stitching of a cloud of points by the means of Autodesk ReCap.
2. Development of information model of the subject by the means of Autodesk Revit.

3. Drawing up sheets and maps of the defects revealed.
4. Testing calculations of bearing structures.
5. Processing of the results of the field works and drawing up the technical report.

3 Results

In spite of the fact that BIM technologies has been already adopted for many participants of the construction industry, the most buildings and structures under maintenance have no BIM model.

Within this work, we studied the opportunity to gain the increase in the efficiency of inspection of buildings and structures due to the use of BIM technologies, laser scanning and a fotogrammetry, creation and further use of information model during all the subsequent stages of the facilities life cycle (design, reconstruction, operation, dismantling). Demonstration of the possibility of the further use of BIM model during maintenance and reconstruction.

In practice, it is often necessary to come up against a situation of total or partial absence of project and executive documentation; that considerably increases the inspection terms. In such cases, the application of laser scanning and BIM technologies is the most successful decision for the creation of exact and correct information model of the surveyed facility. The facilities, where the use of BIM technologies along with laser scanning during the inspection will be the most relevant, include:

- industrial territories with many diverse objects (both according to constructive and space-planning decisions and on functional purpose);
- subjects of cultural heritage, facilities with many difficult architectural details demanding their restoration;
- engineering systems and networks, both civil buildings, and industrial facilities (oil refineries, chemical productions, etc.);
- complex building of the territory (multipurpose housing estates, administrative and office complexes).

One of examples of the successful decision and receiving BIM model is presented in Figures 1-4. Various stages of conducting works on inspection of a complex of the facilities, located on the site of 1.23 hectares with the existing building mainly consisting of offices and office buildings and also buildings of auxiliary appointment (warehouse) are presented.

Fig. 1. Photos of a subject to inspection by the DJI Phantom drone, foreshortening 1-2


Fig. 2. Photos of a subject to inspection by the DJI Phantom drone, foreshortening 3-4

Shooting with the use of the DJI Phantom drone (for all the facilities) gave the results presented in the figures 1-2.

Then, during the cameral works, stitching of a cloud of points by the means of Autodesk ReCap was carried out (figures 3-4).

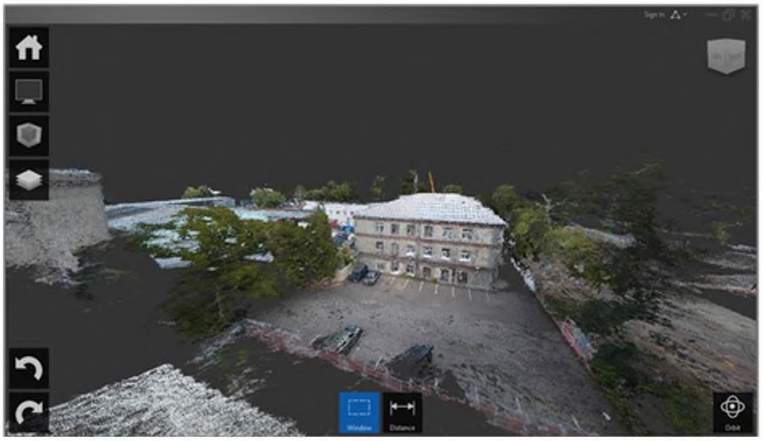


Fig. 3. A cloud of points of the surveyed facility in Autodesk ReCap, foreshortening 1

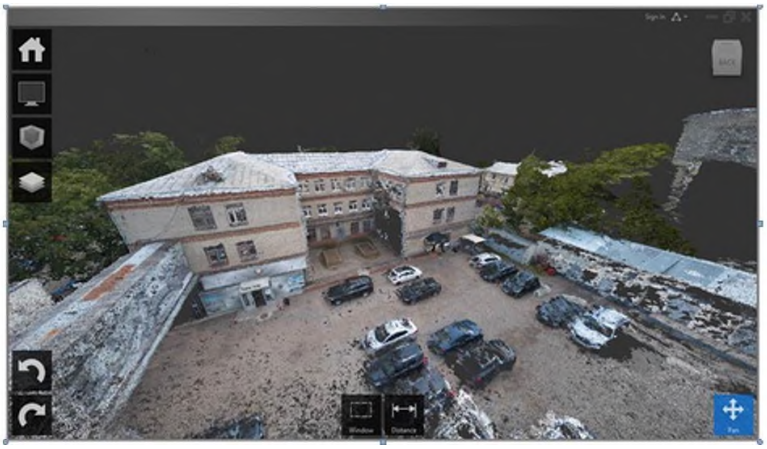
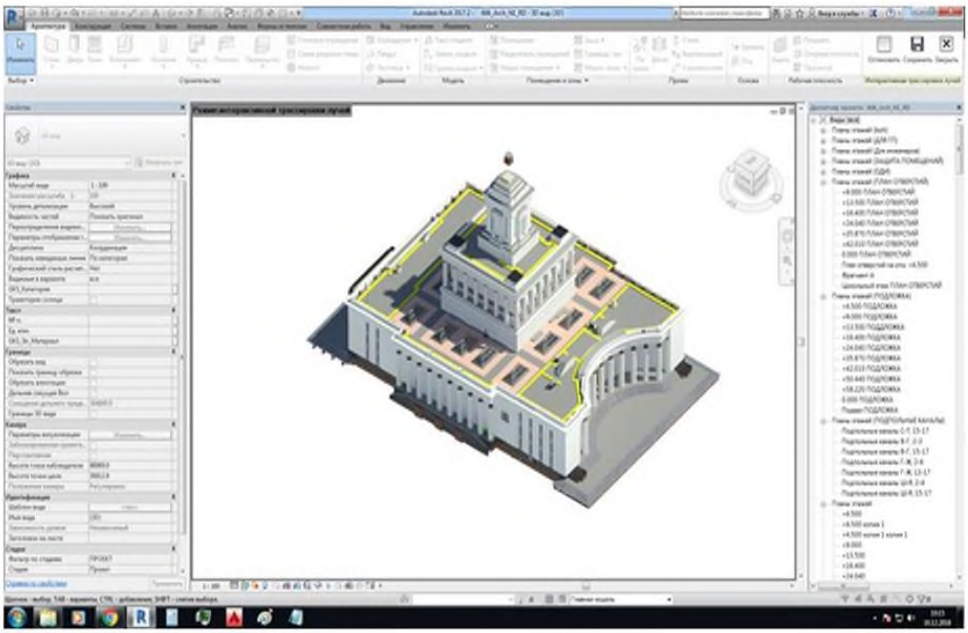


Fig. 4. A cloud of points of the surveyed facility in Autodesk ReCap, foreshortening 2

The use of two ways of receiving a cloud of points (laser scanning and fotogrammetry) allows to conclude that the final BIM model is accurate and correct enough (Figure 5),

according to the shootings received in both ways. At the same time, the application of fotogrammetry, including the DJI Phantom drone and ON Fugro is the option, which is economically more available. It is presented in the Figure 5, and the developed BIM model is presented using the example of the subject of cultural heritage, the VDNH Central Pavilion 1, Moscow.



Fig, 5. BIM model of the VDNH Central Pavilion 1, Moscow

The offered technique of inspection of buildings and structures is approved successfully for many city facilities of Moscow and Moscow region for the purpose of determination of technical condition of building and structures and assessment of the impact of new construction (reconstruction) on surrounding building [10-11]. As a result of the performed works, exact BIM models are received, the set of 2D-drawings, sheets of works volumes, repair lists were developed.

The results of approbation of the given technique of carrying out inspection of buildings and structures confirmed its efficiency and high precision. The BIM models of buildings, structures and engineering systems, received within the inspection, can be used during all the stages of the facility life cycle. It is especially relevant for the maintenance stage and reconstruction.

4 Conclusions

Thus, it is possible to conclude that the use of BIM technologies along with laser scanning and fotogrammetry has considerable advantages in comparison with the standard methods of inspection of buildings and structures, specifically, the accuracy of measurement works increases, their labour input decreases, the possibility of the use of BIM model at further stages of the facility life cycle appears. That, in turn, gives the positive economic effect for the operational stage and the subsequent inspections of a facility.

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