The TLS Method as an Element of the Building Management System

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Abstract. 3D terrestrial laser scanning (TLS) is a modern measurement technique which enables to obtain a large amount of data in short time. The gathered data is very detailed, thus the scope of its use is vast. Therefore, scanners other measurement devices which results in considerable acceleration of stock-taking work. This approach enables to prepare a documentation of a building or to make an assessment of its technical condition using only a 3D cloud of points. Additionally, flexibility of data and advanced computer programmes make it possible to use such data in many sectors, not only in the building trade. The paper presents how to use the data obtained from 3D laser scanner measurements in the management of construction objects. The aim of the presented research was to develop a scheme of systemic approach to the management of used building objects.

1. Introduction

The construction objects are exploited by decades. During this time, they gradually degrade. Buildings are subject to different destructive processes depended upon numerous external factors as well as passing time. Their constant influence makes taking preventive measures necessary. Factors affecting condition of a building can be divided in several groups. The first group is atmospheric factors for example rain- and snowfalls, wind, solar radiation as well as the changes in temperature and air humidity. The next is external factors which result in changes of subgrade, e.g. vibrations and shaking as well as proximal building activities [1,2].

Another group constitutes factors connected to living organisms such as mushrooms and insects. In the case of this first they infect mainly wall plates, ends of rafters, beams whereas the second do damage to wood elements drilling small holes [1,2].

A considerable threat for building constructions is imposed by crisis circumstances [3], e.g.:

a. Destructive influence of natural elements: hurricanes, fires, floods,

b. Technical failures understood as building catastrophes,

c. Human activities: conducting military operations, acts of terrorism, or vandalism.

Unfortunately, each of the above-mentioned factors may influence on the increase of occurrence of another. For example, the increase of humidity may result in development of fungi, mildew or harmful
organism’s infection. In turn, deterioration of ground conditions influences the increase of cracks, which require repairs. The consequences of a bad planning or completion of work will result in additional damage to e.g. foundations of a building.

According to the applicable rules of owners and users of buildings, they should perform certain actions and procedures designed to keep buildings in good condition, ensuring above all safety. Planning renovation and maintenance works requires knowledge of technical documentation and details related to the facility, its technical condition and changes in the structure.

The method of terrestrial laser scanning (TLS) allows to make a complex measurement of buildings resulting in a dimensional image of the existing physical object. A cloud of points is obtained in the digital form in which each point has coordinates X, Y, Z in the local system of coordinates of a scanner (it can be transferred to any geodetic system) and the fourth coordinate I – describing the intensity of reflection of a laser beam from a measured object. This technology was appreciated by many specialists – it enables preparation of multi-discipline works [4,5,6] such as threats of tunnels collapse, examination and archiving of archaeological findings both underground and mural or stock-taking of untypical and unique natural findings such as e.g. calcite caves.

In civil engineering practice, it can be used for supervising dislocation of an individual part of a construction, control of construction safety and creating a stock-taking documentation of architectural-building constructions. Considering the universality of the method, it can be assumed that laser scanning (TLS) can be successfully used as a tool to collect complete information about buildings during many years of exploitation.

2. Research methodology

Research conducted by the authors showed various problems related to the management of used building objects. The study involved an analysis of source materials provided by the property managers. These were the technical documents of the buildings. Information about problems was obtained through questionnaires. People who took part in the research, answering a lot of questions, presented problems related to the maintenance of buildings in a good technical condition. The information obtained has been grouped into problem files:

a. planning repairs is the lack of complete technical documentation.

b. no information about changes introduced in the structures used.

c. in many cases, information about damage is missing.

The proposed method of collecting data on objects allowed to develop the basis for creating a complete database on a construction object. The method of proceeding is presented in the diagram in Figure 1. The diagram is supplemented with information opening after clicking the appropriate window in the presented diagram.

3. Results and discussions (description of the proposed systemic approach)

The developed support system shown in Figure 1 includes three basic elements. The first (gray colour) shows the stages related to planning and performing control and maintenance activities. The second one (blue colour), connected by horizontal arrows with the first element of the scheme, is support for actions through technical and photographic documentation, expert opinions, etc. The third element (red colour) is the proposed support of traditional activities with documents and information obtained from the TLS measurement. Figure 2 shows the stages of reproduction of technical documentation based on data obtained from TLS measurement. Figure 3 shows graphical information illustrating the technical condition of the object. While the third element (Fig. 4) is an example of monitoring cracks of the wall. There are visible data regarding the crack parameters, which gives the opportunity to compare these data from different time periods. Element 4 is an as-built measurement that allows you to complete the database, which can be the starting point for planning subsequent activities.
Figure 1. Scheme of object management system based on measurements with a laser scanning 3D
Figure 2. Database No. 1 (stages of restoring the documentation of the facility)

Figure 3. Database No. 2 (scratches and damage to the masonry structure)

Figure 4. Database 3 (damage monitoring)
4. Conclusions
Stage of exploitation of building object is the longest in the whole life cycle of the facility. Concerned about their safe use, it is the responsibility of managers to make regular inspections, maintenance and repair work. Practice shows that often the complete documentation necessary for the proper operation of buildings is missing.

The research process carried out in this work shows that the TLS method can support the process of managing construction objects. In addition to many other advantages of this method, it facilitates gathering information about hard-to-reach items, and allows you to develop 3D models of objects. What's more, the tests carried out confirm that the measurements using the scanner give very accurate results. Data obtained using the TLS method are information saved in electronic form, which gives many possibilities for their processing and using.

The combination of traditional methods of creating a database with the method based on measurements with a laser scanner suggested in the work allows for the use of a variety of data and can be very useful in practice.

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