INVENTORY OF AGRICULTURAL BUILDING OBJECTS BASED ON DATA OBTAINED FROM MEASUREMENTS BY LASER SCANNING

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Abstract. Because of their activities, many users of agricultural building objects are interested in improving the state of the objects. However, the planning of repairs requires preparation of documentation of buildings. Often, especially in older buildings, it is not possible to obtain a construction project made many years ago. It is necessary to recreate the missing documents and perform complex measurements. In order to accelerate and facilitate the process modern methods of measurement can be used. One of the possibilities is terrestrial laser scanning (TLS method). The article presents various aspects of preparation and carrying out measurements with special reference to the construction of agricultural facilities.

Keywords: laser scanning, complex measurement, agricultural objects.

Introduction

Farmstead buildings and other facilities needed for agricultural production are in use for decades. Agricultural operations usually create conditions that are unfavourable to buildings and contribute to their accelerated degradation. Another adverse factor is frequently inadequate maintenance of farm buildings, with excessively humid interior atmosphere and high concentrations of substances harmful to building structures. Owners and users often fail to carry out maintenance works regularly, which adds to degradation processes. Farm buildings are typically built from such traditional materials as brick, stone and timber. Stone and brick walls tend to become damp and cracked, while timber structures undergo biological degradation. Many of such constructions need urgent minor or major repairs, which must be planned in compliance with adequate technical documentation. However, in many cases, following long-term use of a building, it is impossible to recover its original documents, in which case laser scanning may be helpful.

Condition of historic buildings associated with agricultural production in Poland

There are over 62 thousand listed buildings, of all categories, situated in Poland [1]. They include places of worship, defence constructions, castles, manors, palaces, but also utility, housing and industrial buildings. Their current status, in terms of property rights, type of use and required repairs, is highly varied. The Report on the Maintenance Condition of Immobile Monuments of History (of 31 December 2004) distinguished 97 palaces (mainly in rural areas), 165 manors (rural and suburban), 517 manorial farms, such as farmhouses and sets of other farm buildings; barns, cowsheds, stables, etc. (compounds), buildings used for agricultural processing and production (compounds), houses occupied by farm workers and villagers (e.g., gardeners, foresters, village doctors), single buildings remaining on sites of former manorial farms, granaries, stores, etc., and 135 farmstead buildings [1]. They are highly interesting and valuable architectural objects, usually located in beautiful surroundings. Most are in private hands, and over 50 % of privately-owned buildings need preservation repairs or general overhauls. Also, more than 50 % of palaces, manors and farmstead buildings are in poor state of repair. The exact data can be found in Table 1.

Listed manors, rural and suburban palaces, as well as manorial farm buildings, owing to their indisputable aesthetic and ambient values, of both the buildings and their setting, tended to be perceived by their owners as attractive estate properties, for example, as suitable for tourist or recreational services. Many such former farmsteads are also used as sites to locate businesses. Sometimes an owner combines agritourism with farming. However, in many cases buildings must be adapted to the type of function envisaged by the owner, for which major and minor repairs are required.

At the moment a decision is made to carry out repairs, a fundamental problem arises. In order to plan repairs of the existing elements of a building, it is mandatory to possess adequate documentation. There are several regulations which stipulate the obligation to elaborate design documentation for building structures.

Table 1

Repairs needed in selected groups of listed buildings in Poland

Selected groups of buildings	Repairs needed in selected groups of buildings					Repairs needed in selected groups of buildings, %			
	Do not need repairs	Small repairs	Preservation repairs	General overhauls	Total	Do not need repairs	Small repairs	Preservation repairs	General overhauls
Palaces[1]	11	27	11	25	74	15	36	15	34
Manors[2]	8	37	32	52	129	6	29	25	40
Farm buildings[3]	14	36	5	26	81	17	44	6	32
Total	33	100	48	103	284	-	-	-	-

[1]no data pertaining to the scope of necessary works for 11 % of these buildings
[2]no data for 9 % of these buildings
[3]no data for 9 % of these buildings
Source: the authors, based on the Report on the Maintenance Condition of Immobile Monuments of History, Kraków 2008

Problems in preparing a plan of repairs

When planning any type of building work, it is required to prepare the documentation that will enable the investor to plan and carry out subsequent stages leading to successful completion of the undertaking. This also holds true for repairs. Depending on the type of work, future use of a building and sources of financing, different requirements are set regarding the preparation of the project. When handling objects which belong to the national heritage, and most of the listed buildings fall into this category, one must comply with the Act of 29 January 2004 – Public Procurement Law [2; 3]. Another situation when the above is mandatory is when the works are to be financed from the EU or public funds, in which case the Act obliges the contracting authority to present a description of the envisaged work with design documentation and technical specification of the execution and acceptance of the work. Obviously, a design of repairs must be prepared according to and in line with the documentation of a building which will undergo repairs. The following article of the Act emphasizes that the value of contracted work is established based on the investor's costs calculation, made at the stage of preparing the design documentation. In compliance with the binding regulations, the documentation should comprise preliminary calculations of the scope of the envisaged building works. In the event when such building works are difficult to assign an exact range and dimension, it is allowed to calculate them according to the measurements taken on the works done. The latter applies to general overhauls, repairs and modernization of buildings. The legal framework also includes the Regulation of the Minister of Infrastructure, of 18 May 2004, on defining methods and basis for preparation of cost estimate, calculation of planned costs of project and construction works [3]. This document, same as the previously cited one, specifies that an investor's costs breakdown must be based on the design documentation of the envisaged work.

Documentation prepared for building repairs should be based on the original building design [2; 3]. Unfortunately, many buildings serving agricultural production functions, especially the ones in private hands or often passed from hands to hands, lack such documentation. In addition, sometimes an owner claims to have the design documentation of the building, but it turns out to be incomplete. A survey questioning about a hundred owners of manors and manorial farm buildings in the Province of Warmia and Mazury (the survey was addressed to those proprietors who intended to carry out some repairs in the buildings they owned) revealed that the majority of the respondents had to face this problem. Over 50 % of the owners had very scanty sets of documents regarding technical designs, while 70 % admitted to having the documentation which was insufficient for commencing the planned repairs. Around 25 % reported that they did not have any documentation whatsoever. Most of the fragmentary sets of documents comprised reports on inventory making, but more often than not they were outdated, drawn many years before and not corresponding to the current state.

Most owners were eager to reproduce the missing information, emphasizing the fact that they were under the pressure of time. An offer to make measurements of buildings with the help of a state-of-the-art laser technique raised much interest. A range of possible applications of TLS measurements is demonstrated through a series of illustrations showing the measurements taken by the authors of this article in August 2014.

Application of laser scanning measurements to reproduction of building documentation

A 3D laser scanner is a teledetection system which employs electromagnetic radiation emitted by the device. It belongs to LIDAR (Light Detection and Ranging) instruments, while a ground laser scanner is referred to as a TSL (Terrestrial Laser Scanning) [4; 5]. Having been set on a levelled, stable tripod, a scanner collects data while rotating around its axis. The principle is to measure the distance and angle between the device and the scanned object, using for this aim a laser beam, which is emitted by the scanner and reflected by the measured object acting like an obstacle. Laser scanning enables the user to acquire data which help visualize buildings and other structures very precisely [5; 6]. Measurements taken both outside and inside buildings can be consolidated, thus providing complete information about the measured object [5; 6], including construction and architectural details (even colours of the walls, etc.). Figure 1 shows an image of the shape of a building obtained by laser scanning.

The model of a building obtained from 3D laser scanning is editable, for example, it can be used to generate floorplans and cross-sections. These can be useful when making a complete survey of a building. Floorplans and cross-sections can be created quickly using the Limit Box function, which generates a hexagonal box with cutting edges [7-9]. They can cut the model of a building at any place, creating a "slice" which can serve as a basis for making vertical or horizontal cross-sections of the building [8-10]. This is possible when we have measured straight and diagonal dimensions, diameters, lengths of arches, any angles, etc.

Fig. 1. **Shape of a scanned building of barn – a cloud of points with a mapped texture**

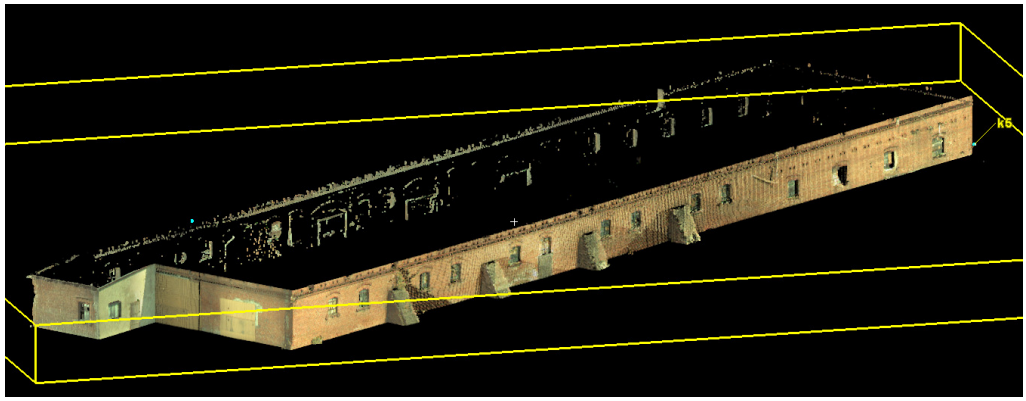

Fig. 2. **First stage of making a ground floor plan**

The subsequent steps leading to the projection of a floorplan in the analyzed farm building are illustrated in Figs 1, 2 and 3. The measurements were taken in August 2014, at a land estate located near Olsztyn, encompassing a palace and several utility buildings.

The data acquired through 3D laser scanning enable the user to make axonometry of a building or even visualization of its external walls. A cloud of points can be used for this purpose. It generates a model of the object once the data from individual stations are aggregated.

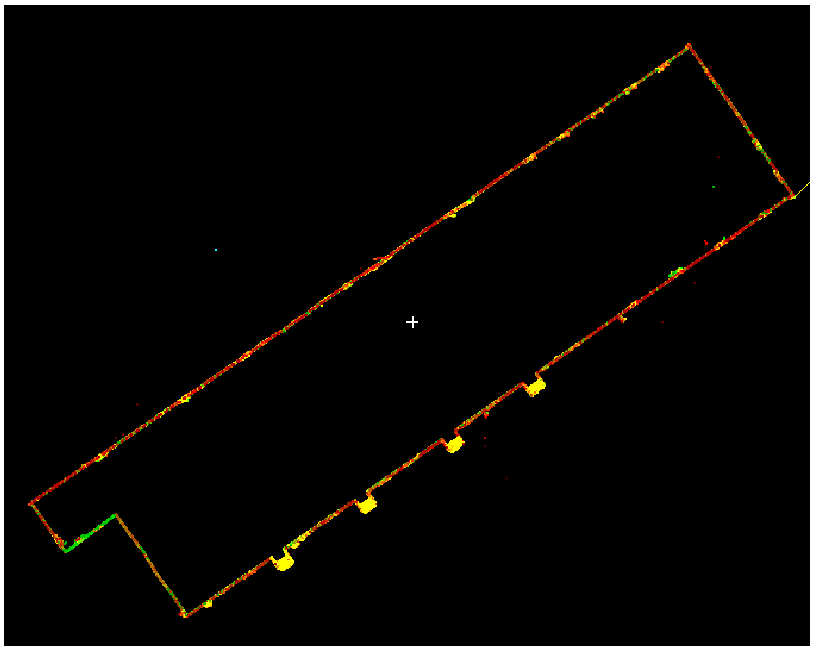

Fig. 3. **Second stage of making a ground floor plan**

Conclusions

3D scanning is the state-of-the-art method based on laser technology, which creates endless opportunities for applications. Its main advantage is the rapid acquisition of huge amounts of data in a very short time, which makes it a much superior solution that any earlier measuring techniques. Terrestrial laser scanners easily find implementations in various branches of economy.

The range of their capabilities means that they can be used in engineering geodesy, in specification of the parameters of buildings and building objects characterized by very complex shapes (e.g., historical buildings), in the research in deviations and deflections of building structures, but also in archeology or forensic science.

Objects scanned with a 3D laser can be quickly analyzed. Furthermore, this technology allows one to make a survey of a construction where the use of classical methods is excluded. This technology will allow us to reproduce quickly the missing documentation which is mandatory to prepare and execute building repairs. Apart from accelerating and improving the process of surveying a building, the application of a laser scanner allows us to create an unlimited database without having to go outdoors. The examples presented in this article pertain to just a few of the possible applications of a 3D laser scanner. However, they fully demonstrate the usefulness of this device for making inventories of buildings which await repairs.

The examples presented in this paper confirm the possibility of using laser scanning in documenting existing buildings. Figures 1,2,3 illustrate the successive stages of the development of floor plans.

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