TECHNICAL TRANSACTIONS | CZASOPISMO TECHNICZNE
CIVIL ENGINEERING | BUDOWNICTWO
1-B/2016

DOI: 10.4467/2353737XCT.16.059.5408

ŁUKASZ ŁUKASZEWSKI*

APPLICATION OF SCANNING MEASURMENTS TO DOCUMENT THE BEHAVIOR STATES OF VARIOUS ENGINEERING AND BUILDING CONSTRUCTION COMPONENTS

ZASTOSOWANIE POMIARÓW SKANINGOWYCH DO DOKUMENTOWANIA STANÓW ZACHOWANIA RÓŻNYCH ELEMENTÓW KONSTRUKCYJNYCH I OBIEKTÓW BUDOWLANYCH

A b s t r a c t

Laser scanning is currently a very fast developing field of science. By creating it for the purpose of geodetic, the possibility of using it in other branches of science was quickly observed. Development of measuring devices and the increase of accuracy and simplicity in performing measurements enabled finding a wider audience and extend its use. In the article the author presents the results of experimental studies aimed at identifying the use of scanning triangulation in the research which allows a comparison of behavior states of selected structural elements before and after their deformation. The study was performed using triangulation scanner that uses a white light. The results were compared in the corresponding computer program that allows the analysis of point clouds and to create models from TIN grids.

Keywords: *analysis of behavior state, artifact, cloud points, deformation, laser scanning, TIN grids*

S t r e s z c z e n i e

Skaning laserowy jest aktualnie bardzo szybko rozwijającą się dziedziną nauki. Tworząc go na potrzeby geodezyjne, szybko zaobserwowano możliwość zastosowania w innych gałęziach nauki. Rozwój urządzeń pomiarowych oraz zwiększenie dokładności pomiarów i prostota w wykonywaniu pomiarów umożliwiły znalezienie szerszego grona odbiorców i rozszerzenia jego przeznaczenia. W artykule autor przedstawia wyniki badań doświadczalnych, mających na celu wskazanie zastosowania skaningu triangulacyjnego w badaniach umożliwiających porównanie stanów zachowania wybranych elementów konstrukcyjnych przed i po ich deformacji. Badania wykonano przy pomocy skanera triangulacyjnego wykorzystującego białe światło. Wyniki badań porównano w odpowiednim programie komputerowym umożliwiającym analizę chmury punktów i tworzenia modelów z siatek TIN.

Słowa kluczowe: *analiza stanów zachowania, artefakt, chmura punktów, deformacja, skaning laserowy, siatka TIN*

* M.Sc. Eng. Łukasz Łukaszewski, Institute of Building Materials and Structures, Faculty of Civil Engineering, Cracow University of Technology.

1. Introduction

The analysis of strain measurements in structural elements and building structures is of great importance not only in terms of their quality, performance, operation, but also the consumption which is vital for the life of the item or object by way of its use and destination (installation, use). It is therefore very important currently to apply the laser scanning, which is derived from geodesy. It has been observed that there is a possibility of measuring its properties also in the other fields of science. With a wide range of product measuring we can easily explore various interesting objects, buildings, structures and areas.

Through the development of measuring systems, we can study objects at a distance of 0.05 m to 4000 m for terrestrial geodetic scanners and perform readings with an accuracy of 0.02 mm between subsequent points for triangulation scanners. The opportunity of recording a vast number of points with high accuracy in a relatively short period of time is used in the monitoring of deformation in order to analyze the structural stability of the building structure and the structure of the element. Laser scanners provide, through high density of the points, a better representation of the deformation that occurs over time [1].

In comparison with the conventional precision measurement techniques used for monitoring the deformation, such as total stations or contact sensors, the accuracy of the laser scanner seems better for measuring small objects [2]. The main disadvantage of these conventional techniques is the fact that they only offer a single point measurement, and therefore they require prior knowledge of the critical zones. Moreover, modeling using a digital 3D image, can be used to facilitate a detailed study, artifacts without direct contact with delicate surfaces. Software compatible with these devices offers innovative analysis tools, ranging from the ability to zoom in, examine and measure small surface details or to detect traces of destruction left by other elements. The opportunity to study the results from a distance in a visual and mathematical way, allows us to better understand the tested object. The author of the article focuses on presenting examples of the scanner to document the conservation status of tested objects and describes one of the conducted tests.

2. Examples of laser scanner applications

2.1. Analysis of deformations in the brick arch

Thanks to a trial modeling of a brick arch in the laboratory, movements could be analyzed so as to reproduce the real conditions in the arch. Researchers have used laser scanning to monitor the tested object.

Comparative measurement with a total station has provided researchers with an accurate measurement of deformations with an indication of the global trend of these deformations and showed the possible critical zones.

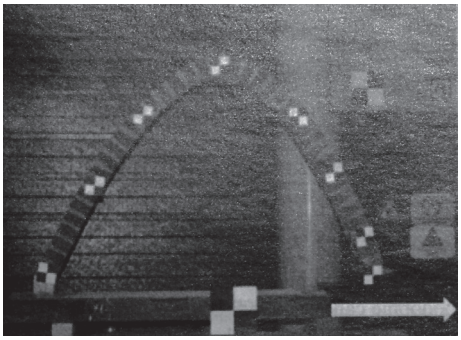

Fig. 1. Image of a brick arch model with paper targets [2]

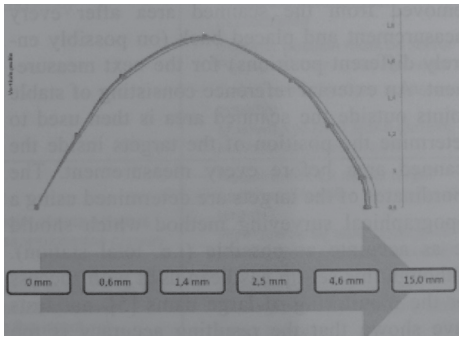

Fig. 2. The diagram of further deformations applied in the arch [2]

2.2. The application when reconstructing the construction defects

Another example of the laser scanner application is an inventory of an iron bridge in Coalbrookdale, which in 1986 was inscribed on the UNESCO list. The aim of the measurement was to enable the analysis of the entire bridge - existing structure in such a way that the object was maintained in the process of strengthening the components and eliminating the defects of the original appearance.

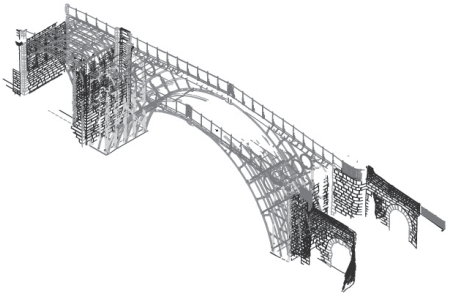

Fig. 3. Image of inventoried object [3]

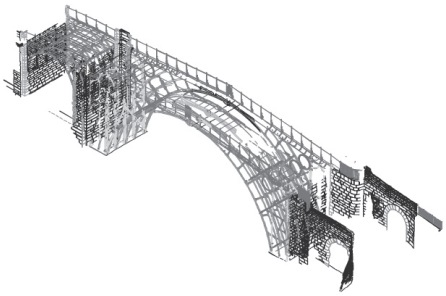

Fig. 4. Photograph of defects reconstruction and applied reinforcement on a performed earlier measurement [3]

2.3. The application of scanning for testing artifacts

The UNESCO Convention from 2001 established a rule that in order to protect underwater cultural heritage in situ protection should be treated as a prime one. However, with regard to organic artifact in situ protection is not compatible with security rules and the use of their possessions. The long bureaucratic way and costly conservation and restoration procedures

Fig. 5. Photograph of artifact measurement [4]

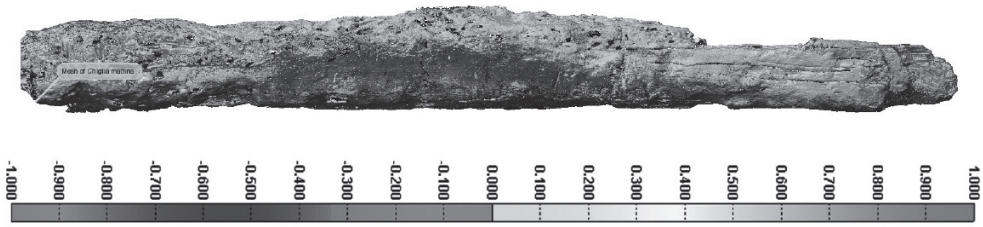

Fig. 6. Determination of color between dimensions made in the morning and in the afternoon [4]

a) b) c)

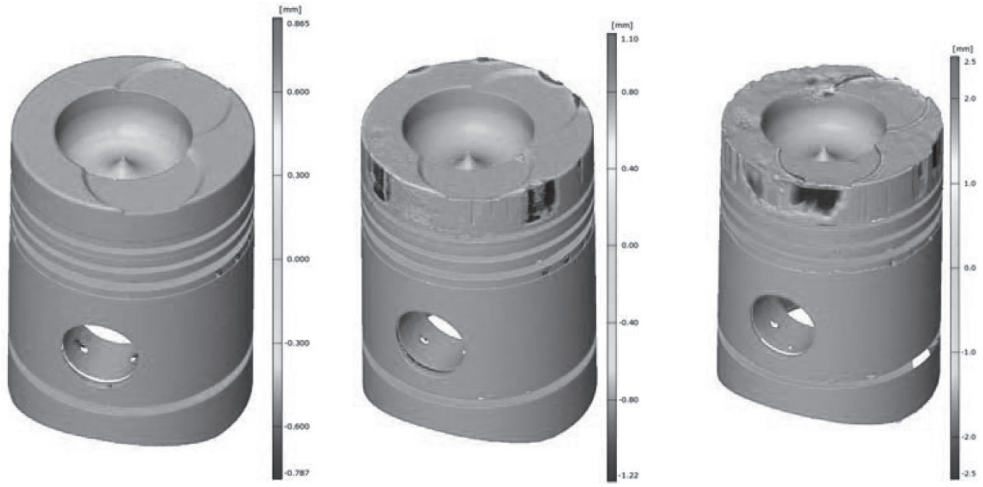

Fig. 7. Engine pistons SW-680: a) the new engine; b) a piston with a damaged side surface; c) a piston with a damaged surface and burns of a piston top [6]

forced scientists to find an alternative solution to the physical reconstruction of submarine monuments. Thanks to the use of digital technology, testing artifacts without any direct contact with sensitive surfaces offers an innovative analytical tool [4, 5].

2.3. The application of the scanner in the analysis of pistons damage

Another study is focusing on the use of triangulation scanner to examine pistons damage that is their tops and the side surface between the top and the first seal ring. Distortions of the tested elements could not be accurately presented by the flat images and measurements of the damages depth were very difficult to measure and were inaccurate. Only after using the scanner the accuracy and transparency were achieved

3. Research on a sample

The author subjected an aluminum profile to mechanical deformation. Using a triangulation scanner he assessed the behavior state of the sample before and after the deformation. After completing the readings in both trials, spatial deformations were presented. They were caused by deformation of a cloud of points with respect to a reference sample.

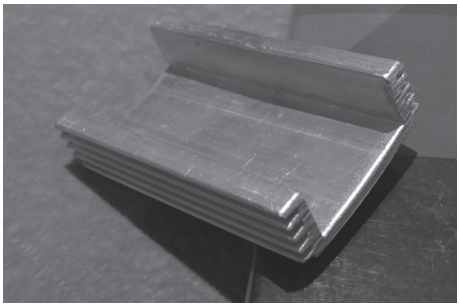

Fig. 8. Photograph of the tested object

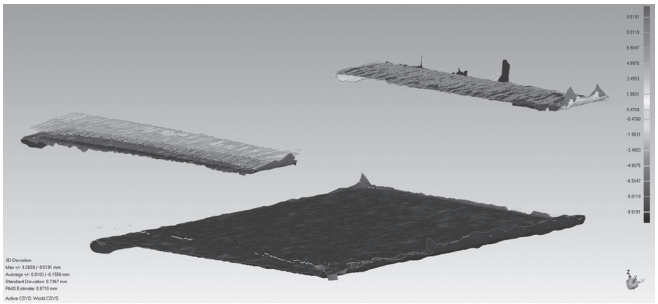

Fig. 9. The spatial screening of deformations

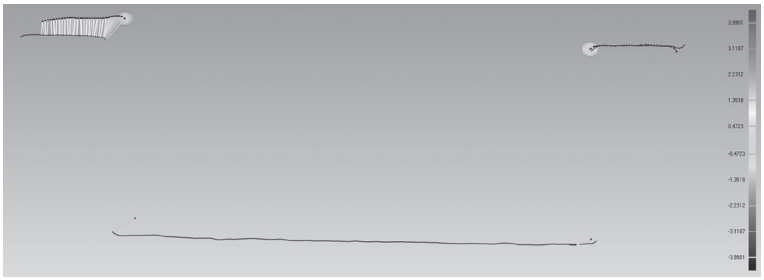

Fig. 10. The cross-section of the tested sample deformations

4. Conclusions

To summarize some examples of using a laser scanner to the research, the following conclusions result from the process of scanning and analysis of the object states:

– The speed of the scanning process and a very large amount of data at the subsequent stages allow the researchers to analyze the test subjects more accurately and design construction elements flawlessly.
– At any time during exploitation of an object or construction, scanning measurement enables us to compare and analyze the state of the object in relation to the reference measurement.
– The accuracy and versatility of the use of traditional techniques, measurement systems used to monitor deformation of the tested object is much smaller than the measurement of a laser scanner [2], which is used to test integrated building management systems "BIMS" and in application development GIS programs, using the method of "BISM MACHINE" for playback studied spherical surface parts of buildings with accuracy 1 μ = 0.0001 mm [7].

When carrying out the tests with a laser scanner we should pay attention to accuracy and the conditions under which it is carried out in an area where we do not have stable conditions.

The test results have convinced the author that in further studies it is necessary to deal with the analysis of assessing the accuracy of spatial models created from point clouds with the help of the laser scanner.

References

[1] Scheremans L., Van Genechten B., *The use of 3D-laser scanning in assessing the safety of mansory vaults-A case study on the church of Saint-Jacobs*, Optics and Lasers in Engineering 47, 2009, 329–335.
[2] Van Genechten B., *Skanowanie laserem dla dokumentacji dziedzictwa kulturowego*, Stowarzyszenie Konserwatorów Zabytków: XIII Konferencja Naukowo-Techniczna REMO 2009, Dolnośląskie Wydawnictwo Edukacyjne, 727–737.

[3] Bedford J., Papworth H., *Measured and Drawn. Techniques and practice for the metric survey of historic buildings (second edition)*, English Heritage 2009, 43–50.
[4] Bandiera A., Alfonso C., Auriemma R., Di Bartolo M., *Monitoring and conservation of archeological wooden elements from ship wrecks using 3D digital imaging*, Proceedings of 2013 Digital Heritage International Congress (DigitalHeritage), Mareille, France, Vol. 1, 113–118.
[5] Sedina J., Pavelka K., Reznicek J., Matouskova E., Faltyonova M., *Combining laser scanning and IBM technology i cultural heritage*, 15th International Multidisciplinary Scientific GeoConferences SGEM 2015, Book 2, Vol. 1, 61–69.
[6] Karczewski M., Koliński K., Walentynowicz J., *Wykorzystanie skanera 3D do analizowania uszkodzeń silników spalinowych*, Zeszyty Naukowe Akademii Marynarki Wojennej, ROK LII, No. 1 (184), 2011, 59–66.
[7] Kereković D., Wróbel Z., Buntak K., *Building integrated management system-BIMS the developed research and application of "BIS MACHINE" method*, TEKA Kom. Arch. Urb. Stud. Krajobr., OL PAN, IVa, 2008, 260–270.