Usage of Laser Scanning Systems at Hydro-technical Structures

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Key words: laser scanning systems, application, hydro-technical structures.

SUMMARY

Laser scanning systems and their applicability in industry surrounding. Application of laser scanners at hydro-technical structures – power plants, navigation locks, dams, turbine houses, etc. Measuring of different structure deformations. Geometry control the crane installed in the main machine hall. Measuring of gate deformations under their operation. Results, achieved accuracy, visualization.

ZUSAMMENFASSUNG

Laserscannersysteme und ihre Applikationsmöglichkeiten in Industriebereich. Applikation der Laserscanner an hydro-technischen Objekten – Wasserkraftwerke, Schleusen, Dämme, Turbinenhäuser, usw. Deformationsmessung verschiedener Konstruktionen.
Geometriekontrolle den in der Hauptmaschinenhall installierten Kranen. Messung von Deformationen der Schleusetoren bei der Füllung und Lehrablauf der Schleuse. Ergebnisse, Genauigkeit und Visualisierung.

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1. INTRODUCTION

Danube creates the natural border (boundary) between Hungary and Slovakia. In 70^{th} was the new hydro-technical system designed, with structures build at territory of both countries. Concerning the negative result of negotiation between Hungary and Slovakia, was build only the system at the Slovak territory. The existing hydro-technical system Gabčíkovo consists of many structures situated along the 40 km long part of the river Danube.

Thank very good co-operation between the Department of Geodesy at TU Munich and the Department of Surveying at SUT Bratislava were realized the measurements of chosen structures of the hydro-technical system of Gabčíkovo. The aim of these measurements, concerning the main topics of the international project "Application of TLS in industry" (Kopáčik, Wunderlich, 2003) is to determine the requirements for the usage of terrestrial laser scanning systems (TLS) in industry surrounding, special in surrounding of hydro-technical structures.

2. HYDRO-TECHNICAL SYSTEM GABČÍKOVO

Main purposes of the Gabčíkovo system are flood control and protection against inundation by internal waters, exploitation of the hydropower potential of the Danube and making possible the peak operation of the hydropower plant Gabčíkovo. Important question is the improvement of navigation conditions between Bratislava and Budapest and removing also other navigation obstacles. Resulting the named activities is improved and stabilized the water management regime in the Danube in the adjacent territory.

The hydro-technical system Gabčíkovo consist of two main components – the hydropower plant Gabčíkovo and the hydropower plant Čunovo, which together create a unified, inseparable operation system (Fig. 1). The system consists of the reservoir, created by peripheral embankment dams with parallel seepage canals. At the left side of the river, the reservoir leads into a bypass canal 25 km long. The headrace canal is created by bilateral dams with asphalt lining, tied to the plastic bottom sealing placed on the terrain. At the 17^{th} km of the canal is the Gabčíkovo power plant with two navigation locks situated. The Čunovo part of the system consists of the longitudinal dividing dam, the by-pass and the central weir, the auxiliary navigation lock, hydropower plant, the inundation weir and the outlet structure into the Mosoni Danube. The main role of the Čunovo complex is to decrease the reservoir area by the part reaching into the Hungarian territory, to replace the function of the primarily designed Dunakiliti weir (should be constructed at the Hungarian territory) and to enable the planned diversion of the Danube waters into the bypass canal.

Fig. 1: Danube river with Gabčíkovo hydro-power system

3. APPLICATION OF TLS IN GABČÍKOVO

The measurement at Gabčíkovo system are planed and realized according the named international project. For the measurement the Leica Cyrax 2500 laser scanner of the Department of Geodesy TU Munich was used. The measured structures were chosen after the detailed discussion and personal visiting of the structures, with the aim to create the different "material" and conditions for measurement and data processing. Three different structures were measured:

- Gates of the navigation locks in Gabčíkovo,
- Turbine of the Čunovo power plant,
- Crane of the main machine hall of the power plant Gabčíkovo.

3.1 Measurement of the Navigation Lock Gates

The gates situated at the down side of the navigation lock have the panel form (Fig. 2). Consist from two parts, which are fastened in two bearing positioned on vertical line. The masses of the panels are 18 m x 22 m x 2 m and were welded from steel plats of thickness 20 mm. The maximum deformation is given by 40 mm in the middle part of gates for the water high 25,0 m in the navigation lock (full stand).
The measurement program consisted from:

- The measurement of gates form,
- The determination of gates deformations (static measurement) at different water high,
- The measuring of gates deformations (dynamic measurement) under operation of the lock.

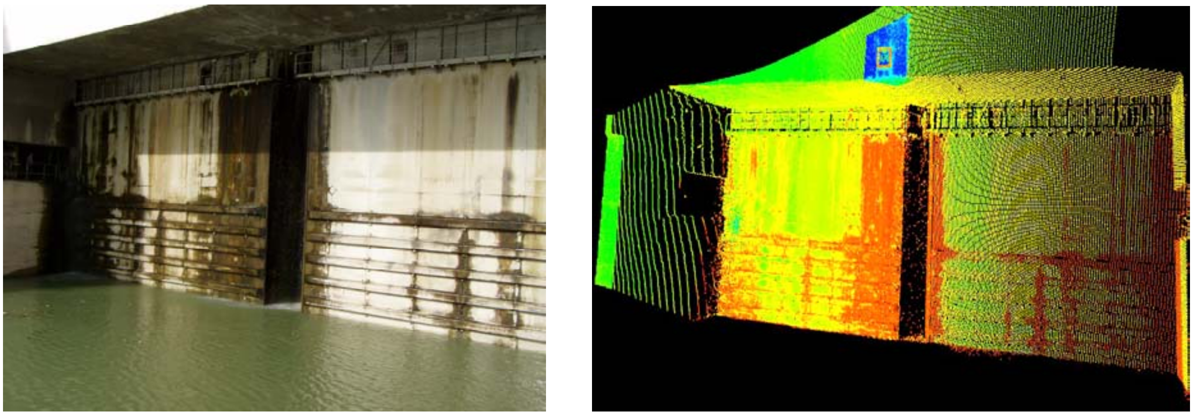

Fig. 2: Photo and point cloud of the gates

During the measurement of the gate form is the TLS under typical conditions. The material and color of gates is typical too, only the water flood created parts makes same problems. These caused the small growing of the measurement accuracy and color changes at the gate surface (red colored parts of the point cloud - Fig. 2).

Fig. 3: TLS station during the gate measurement

For the determination of gates deformations were used parallel with the TLS Cyrax 2500 the total station Leica TC1800, too. Both of the instruments were positioned outside the lock in the existing “windows” of the concrete walls (Fig.3). The measurement was realized for the different water high in the lock:

- 0.0 m,
- 4.4 m,
- 9.4 m,
- 13.0 m,
- 19.3 m,

about the water level outside the lock.

The measuring time by using TLS was 150 sec, by 100 mm x 100 mm point density. The full surface TLS measurement was controlled by the measurement of 6 points positioned in 2 horizontal sections. Differences between the TLS and TC 1800 determined deformations are smaller then 3.0 mm.

New task and situation are given for the TLS, where the TLS is used for determination of dynamic deformations. If the lock is in operation the water level is changed from 0.0 m to 19.3 m in about 20 minutes. For this task was used the 80 mm x 80 mm point density and continual measurement process (Schäfer, 2004). To minimize the time needed for one measurement cycle, the central part of gates (vertical trail of ca 2,0 m) was chosen. The measurement time was 30 sec/cycle. The accuracy of cyclic (dynamic) measurement can be given by 15 mm.

3.2 Measurement of the Turbine in Čunovo

The measurement of the turbine in Čunovo was realized during their reparation. The horizontally positioned cylinder form turbine house was open, which enable the measurement from different stations. The diameter of the turbine is 3,708 m, the turbine house 3,710 m. For data processing must be used procedures for surface creating with continual changed curvature (B-spline, etc.). Additional software will be used for data processing and for the visualization.

The TLS measurement was realized from three stations. Point clouds of different scans were mounted using edges of the turbine case (Fig. 4). The point density of 25 mm x 25 mm was used, with the time of about 120 second/scan.

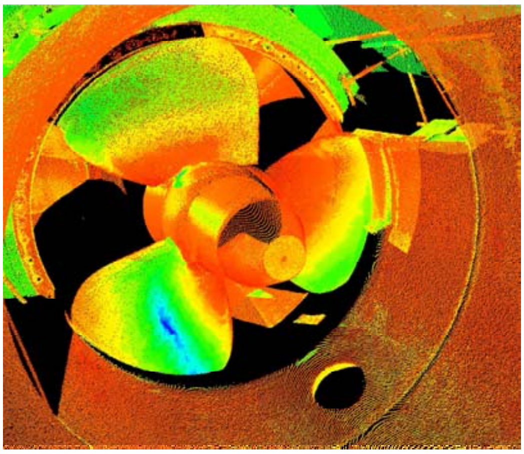

Fig. 4: Photo and point cloud of the turbine

3.3 Measurement of the Crane

In the main machine hall are positioned 8 Kaplan-turbines, each of them with 90 MW installed power. The vertical positioned turbines have a diameter of the runner 9.0 m. The measured bridge crane is 300 m long and is positioned on steel pillars in 6.0 m high above the machine hall deck, with the crane rails gauge 17.8 m. For the measurement was chosen the first 78.0 m long part only. After the full scenario scans were more particular scan used. The TLS was positioned at crane service foot-bridge, which is situated both-side of the rails. Therefore were made the registration of two full scenario scans, with different point density for the target area. To made the particular scans (Fig. 5), the TLS was installed on the crane bridge and with this together positioned in the required crane sections. The point density of these scans was chosen at 25 mm x 25 mm, with the time of 90 sec/scan.

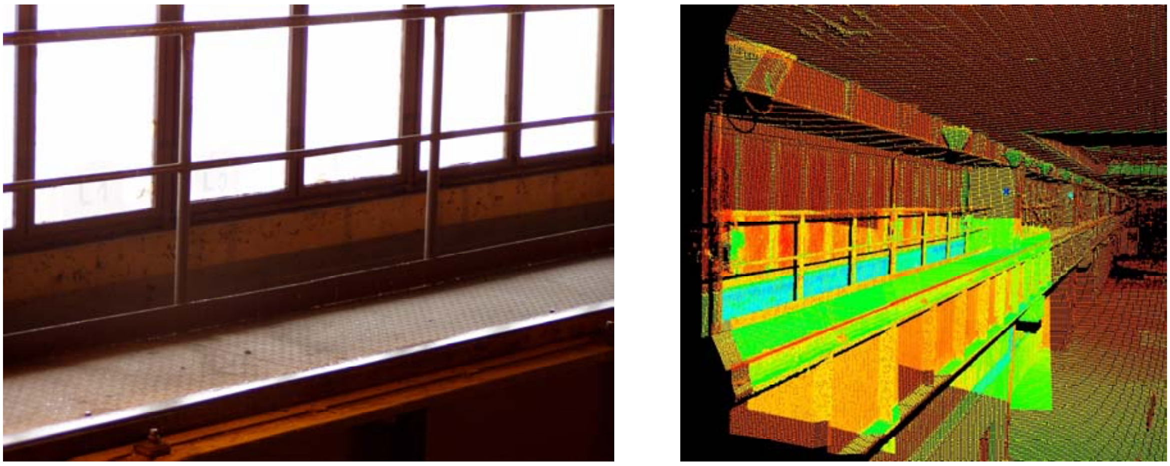

Fig. 5: Photo and particular scan of the crane rail

Geometrical frame of the situation was defined by the structure of points, marked by targets on steel pillars. These were measured by Leica TC 1800 from two stations, where were chosen at the stable part of the crane structure. The accuracy of these points is 1.5 mm. According the first results can be the accuracy of rail position given by 2-3 mm.

4. CONLUSIONS

TLS representing the modern tehnology with high density of measured points, high efficiency and accuracy. The combination of the advancement of clasical polar and photogrammetric method in TLS enable the surveyor to applicate in your work new operating principles. The fully automatic measuring porcess is operated at beginning only, by determination of small number of parameters (point density, volume of measured section, etc.). Results achieved during the in paper described projects enable to formalise the conclusions:

- TLS are acceptable in the surrounding of hydro-technical structures,
- The application of TLS for deformation measurement of navigation lock gates (general lock structures) is desirable and possible for dynamic deformations too,
- The usage of TLS for crane measurement was tested with good results, should be discussed the methodology, where the crane bridge is in different positions during the measurement (according the existing standards requirements should be the crane bridge in the stop position),
- The application of TLS for turbine form (geometry) determination is very effective.

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BIOGRAPHICAL NOTES

Univ.-Prof. Dr. habil. Alojz Kopáčik

Study Geodesy and Cartography SUT Bratislava 1977-82. Doctor study at the Department of Surveying the SUT Bratislava in 1982-85. Senior lecturer at the Department of Surveying – lectures and seminars from Geodesy for CE, Geodesy for Water Managers and Construction Engineers, the Underground and Mine Surveying and Engineering Surveying, Measurement systems in engineering surveying and Surveying for Civil Engineering (the study program in English). From 1990 - 1992 lectures and seminars at the TU Vienna from Geodesy and Engineering surveying.

Chairman and member of State Exam and Diploma Commissions at TU Brno, Uni Žilina and at the SUT Bratislava and the Slovak Chamber of Surveyors and Cartographers. Member of the European project EEGCES, WG1. Delegate national of the Com.2 (Education) of the FIG. Member of the board of Geodetski list (Croatia) and the WG's of FIG and IAG, which activity is oriented to implementation of laser technology in geodesy.

Research in the filed of application TLS and dynamic measurements in real-time, the integrated solutions by increasing the level of automated quantification in measurement.

Standardisation, chairman of the TC 89 - Geodesy and cartography (Slovakia), author of 4 ISO standard translations to the Slovak system of standards (STN).

Univ.-Prof. Dr. habil. Thomas A. Wunderlich

Study Geodesy and Cartography TU Vienna 1974-79. Doctor study at the Department of Geodesy of TU Vienna in 1980-83. Humboldt Sholarship at the Uni Hannover 1987-88. Habilitation at Uni Hannover 1992, TU Vienna 1993. Professorship at TU Vienna 1997-99. Professor of Geodesy at TU Munich from 2000.

Research activity in the field of high precision control measurement (Tunnels, Deformation of buildings and mechanical engineering structures). Deformations analysis. High determination. Terrestrial laser scanning. Navigation (sensors, Kalman-Filter, Map-Matching). Position determination by GSM (location based service).

Chairmen of FIG WG6.2 "Engineering Surveys for Industry and Research. Member of German Geodetic Commission, Austrian Association of Geodesy and GIS, German Association of Surveying, German Union for Location and Navigation, Royal Institute for Navigation, Institute of Navigation (USA).

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