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Original Contribution

GNSS TECHNOLOGY FOR RESEARCH OF DEFORMATIONS OF HYDROTECHNICAL INSTALLATIONS

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ABSTRACT: *Hydro technical installations are subject to a list of temporary and constant factors, such as Natural, Physical, Tectonic, Anthropogenic and other, which lead to their deformation and destruction. Study, exploration and forecast of deformations, can save us big. In this article has been researched the GNSS capability of obtaining the necessary data for building a model and reading or predicting deformations. GNSS has been used for monitoring structural deformation and deflection for more than a 30 years now. Detailed procedures for field data collection, data analysis and visualisation, generation of reliable analytical model, model updating and prediction for structural operational condition are also recommended.*

KEY WORDS: *Geodetic monitoring; GNSS monitoring, Network adjustmen, Deformation analysis, Hydrotechnical installations, Hydro structures.*

1. Introduction

Hydrotechnical structures, including their technical devices and systems, are used in water management and development of water resources. There are intended for:

- water storage (dams, reservoirs),
- water transfer (ducts, pipelines),

Their contact with water surface is one of the essential characteristics. Such structures, depending on material applied (concrete and steel), are subject to destructive factors and influences similar to that of the majority of other building structures. Therefore, most tests of the said structures are identical to those applied in the building industry or land surveying. However, these methods should be properly adjusted to a hydro-technical object and its operating conditions. In assessing the safety of hydro-technical objects, it is necessary to combine different measuring techniques, calculations and experiences. With technical assessment and modelling of object behaviour, the more comprehensive evaluation should be conducted. It is important to select such technology to obtain the geometric data of a structure. Measurements with surveying instruments may be more or less accurate and characterised by different accuracy levels. The correctness of selected data acquisition methods is a precondition for proper monitoring of the said structures. Regarding hydro-technical objects, several methods of geodetic determination of displacements and deformations are applied – from accurate polygonisation, measurements of angular-linear networks or levelling up to methods of relative measurement, including feeler gauges, inclinometers, strain gauges or clinometers.[1]

In this article we will device and inspect GNSS technology for obtaining the geometric data of a hydrotechnical structure, such as dam wall.

2. Related work

The object of the study is "Shumensko ezero" Dam with the following coordinates 43°14'43.9"N and 26°57'08.6"E. Along the dam's wall there are 20 control points for monitoring of deformations – figure 1.

Fig. 1. Control points along the dam's wall, measured with the rover.

The first task in conducting high-precision geodetic GNSS measurements is to select a suitable receiver. Receivers can use five types of signals to determine coordinates: C/A code, P(Y) code of two frequencies and carrier phase of two frequencies. Millimeter accuracy can only be ensured by measurements of the carrier phase, code measurements can provide accuracy up to a meter [3]. The main disadvantage of single-frequency measurements is the inability to accurately read the ionospheric delay. However, for baselines with a moderate length of up to about 20 km, single-frequency receivers give almost the same results as dual-frequency receivers, as ionospheric refraction is (mainly) excluded when subtracting phase measurements between base points [2].

The selected GNSS equipment is Trimble, model R4 and R8. Their accuracy for Post Processed data is:

POSTPROCESSED KINEMATIC (PPK) GNSS SURVEYING

Horizontal .... 8 mm + 1 ppm RMS

Vertical .... 15 mm + 1 ppm RMS.

REAL TIME KINEMATIC SURVEYING

Single Baseline <30 km

Horizontal .... 8 mm + 1 ppm RMS

Vertical .... 15 mm + 1 ppm RMS

All control points are measured via GNSS – one rover Trimble R4 and a base Trimble R8. The specific period of time, chosen for point observation, forms a session. In RTK mode, each of the points are measured accordingly 30 seconds (according procedure papers) and 60 seconds. Another important parameter in observation session is recording interval [5]. In this study's case the interval is chosen – 1 sec for phase manipulated signals [6]. The base was set on observation monument – figure 2, with number CT110 (see figure 3).

Fig. 2. Observation monument.

All vectors between base and rover were processed with Trimble Business Center. For comparison were used real time GNSS observations, via radio link and a traditional measurement with total station.

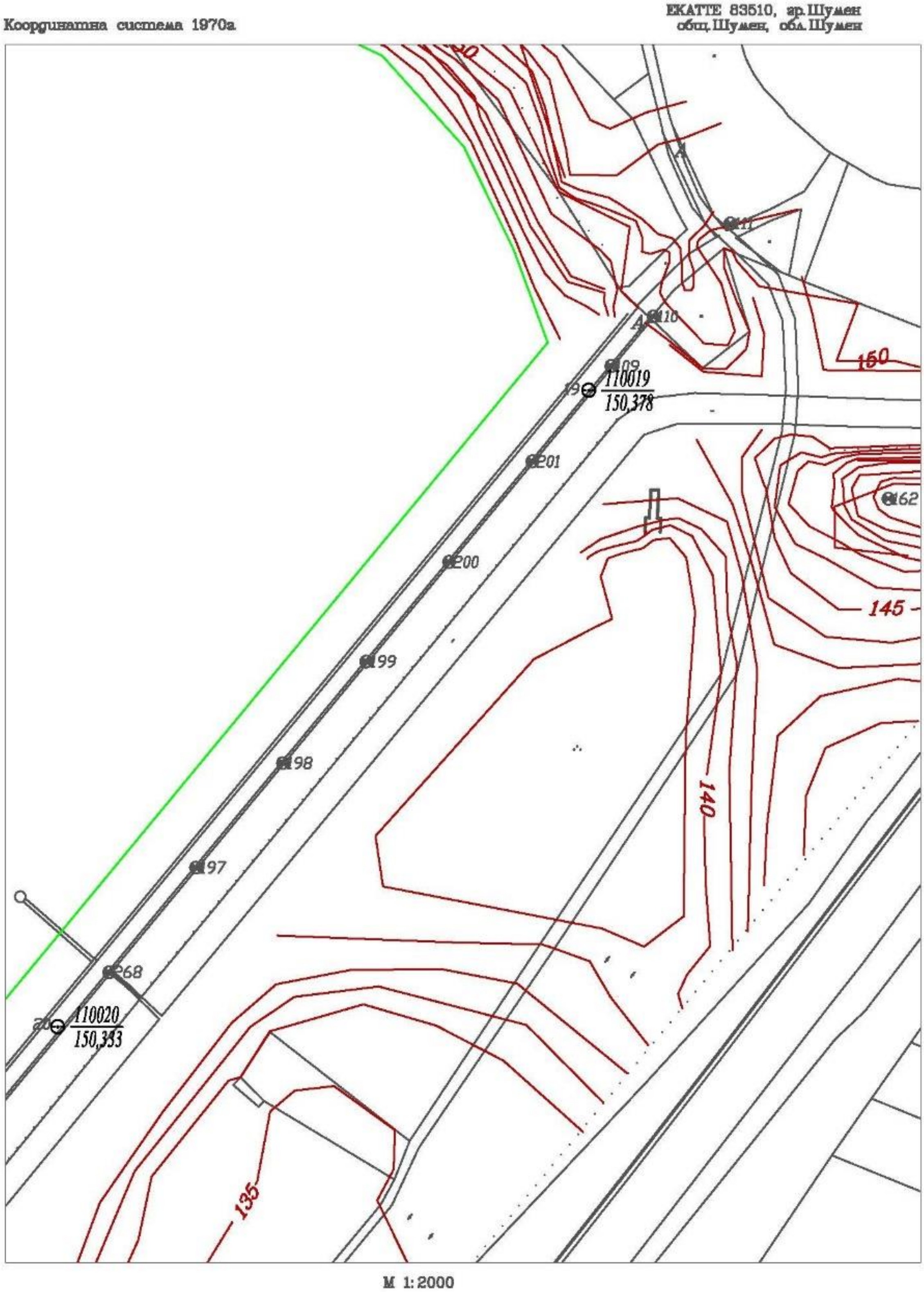

Fig. 3. Scheme of the control points along the dam’s wall

3. Experiment

After completing the surveys via the above mentioned methods, all data was processed separately and interpreted in tables. For better understanding of the results, graphical interpretation was used of the data via horizontal hodographs (see figure 4). The graphic is based on three years of studying deformations with classical methods. It stacks six independent measurements, each over period of six months. For the last period of the study, GNSS was used to compare results and study the accuracy of the acquired data.

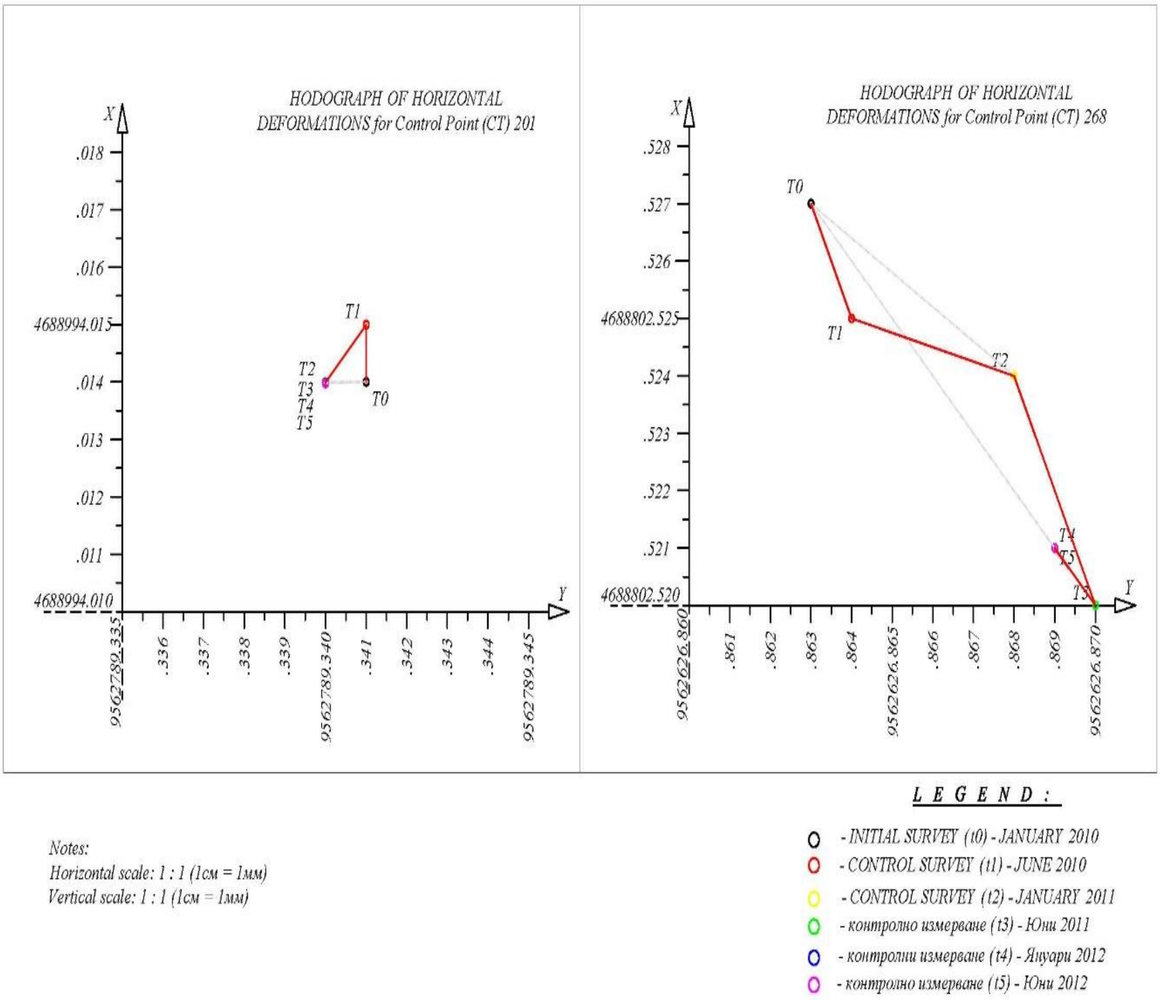

Fig. 4. Horizontal hodograph for CT200 and CT 268

4. Results

The results compare classical methods and Post Processed GNSS measurements, which were back upped by RTK measurements for the same control points, that confirms the results of post processing.

Control point number	GNSS measurement with Post-Proccesing			Trigonometric Measurements with total station			Differences		
	X (m)	Y (m)	Normal Height (m)	X (m)	Y (m)	Normal Height (m)			
1	2	3	4	5	6	7	8	9	10
№	X (m)	Y (m)	H (m)	X (m)	Y (m)	H (m)	dX (m)	dY (m)	RMS
ct1	4688322.508	9562217.993	150.718	4688322.509	9562218.006	150.7319	0.001	0.013	0.014
ct2	4688355.077	9562245.825	150.623	4688355.088	9562245.827	150.6359	0.011	0.002	0.013
ct3	4688388.450	9562274.439	150.565	4688388.458	9562274.445	150.5786	0.008	0.006	0.014
ct4	4688418.245	9562299.683	150.744	4688418.251	9562299.692	150.7592	0.006	0.009	0.015
ct5	4688456.722	9562332.607	150.650	4688456.729	9562332.625	150.6751	0.007	0.018	0.025
ct6	4688495.401	9562365.651	150.565	4688495.407	9562365.662	150.5822	0.006	0.011	0.017
ct7	4688533.684	9562398.310	150.594	4688533.706	9562398.333	150.6386	0.022	0.023	0.045
ct8	4688572.919	9562431.813	150.639	4688572.925	9562431.831	150.6628	0.006	0.018	0.024
ct9	4688611.455	9562464.647	150.421	4688611.464	9562464.665	150.448	0.009	0.018	0.027
ct10	4688649.887	9562497.269	150.616	4688649.899	9562497.272	150.6312	0.012	0.003	0.015
ct11	4688687.978	9562529.762	150.591	4688687.990	9562529.772	150.6132	0.012	0.010	0.022
ct12	4688725.019	9562561.271	150.555	4688725.035	9562561.278	150.5783	0.016	0.007	0.023
ct13	4688763.859	9562594.345	150.587	4688763.877	9562594.351	150.6109	0.018	0.006	0.024
ct14	4688802.332	9562627.031	150.624	4688802.352	9562627.035	150.6484	0.020	0.004	0.024
ct15	4688841.381	9562660.434	150.646	4688841.396	9562660.449	150.6755	0.015	0.015	0.030
ct16	4688880.497	9562693.900	150.647	4688880.520	9562693.912	150.6824	0.023	0.012	0.035
ct17	4688918.416	9562726.043	150.663	4688918.432	9562726.045	150.6809	0.016	0.002	0.018
ct18	4688955.656	9562757.877	150.620	4688955.658	9562757.889	150.6341	0.002	0.012	0.014
ct19	4688993.176	9562789.990	150.575	4688993.185	9562790.008	150.6024	0.009	0.018	0.027
ct20	4689028.922	9562820.446	150.576	4689028.935	9562820.454	150.597	0.013	0.008	0.021

5. Conclusion

It is apparent from the examinations made that GNSS can be used to capture and trace detailed points related to objects in open areas. For capturing points from the contours of buildings and property boundaries in populated areas where there are obstacles and the multi-wayness factor for satellite signals is realised, the use of GNSS in RTK mode is difficult [4]. For research of deformations of hydrotechnical installations GNSS technology is not yet proven itself for accuracy less than 8 mm + 1 ppm RMS in horizontal and 15 mm + 1 ppm RMS in vertical planes and if those accuracy does meet technical specification for the job – GNSS can be used.

References:

[1] Maria Mrówczyńska , Jacek Sztubecki, Małgorzata Sztubecka and Izabela Skrzypczak. “The use of classical methods and neural networks in deformation studies of hydrotechnical objects”. Open Geosciences 2020; 12: 718–725, ISBN-2391-5447.

[2] Yanchev, K., “Selection of appropriate geodetic equipment for reception of gnss signals when conducting high-precision measurements”, Journal

scientific and applied research, licensed в EBSCO, USA. Volume 18, 2020, pp. 72-76, ISSN: 1314–6289.

[3] Yanchev, K., Kirilova, K., Modern Research of the Krupnik Geodynamic Polygon, Journal of Geodesy, cartography, land management, Vol. 1 - 2’2020, pp. 44-50, ISSN 0324-1610.

[4] Stoykov, Ev., 2019. Methodology for surveying and tracing of objects by using GNSS. Annual of Faculty of Technical Sciences. Vol. IX E, Shumen, University press Konstantin Preslavsky University of Shumen, pp. 21 - 24, ISSN: 1311-834X.

[5] Stoykov, Ev., 2018. Measurement methodology for creation of a working geodetic base using GNSS in RTK mode, MATTEX 2018: Conference proceeding, Vol. 2. Part 2. Shumen, pp. 75-80, ISSN: 1314-3921.

[6] Pl. Yanakiev, Bedzheva M., Computer laboratory for automated synthesis of phase manipulated signals. International scientific conference UNITECH, 16-17 November 2018 – Gabrovo, pp. II-11 – II-15.