INVESTIGATION OF USING TOTAL STATION WITH ATR SYSTEM IN MONITORING OF DISPLACEMENTS

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1. ABSTRACT

New total stations equipped with ATR (Automatic Target Recognition) system help in automatic move of the telescope of the instrument during monitoring measurements. The accuracy effects of using ATR system in precise measurements were controlled in laboratory and field conditions for standard prism and cube corner reflector. This paper will present the results of testing and the conclusions from the monitoring measurements carried out on typical objects using instrument Leica TDA 5005.

2. THE PRISM REFLECTORS AND CORRECTION OF DISTANCE AND ANGELS OBSERVATIONS

Control measurements of changes in object's geometry are necessary to ensure the safety of an object and its surroundings.
The geodetic monitoring should satisfy high accuracy, reliability and frequency requirements. New total station equipped with ATR (Automatic Target Recognition) system automatically moves the telescope to the center of the prism.

I am going to present the results of monitoring measurements using total stations Leica TDA 5005 during investigations on hydrotechnical objects Wiory (dam) and Zar (the crest of the upper, artificial reservoir of the Pumped-Storage Power Station).

The accuracy effects of using ATR system in precise measurements were controlled in laboratory and field conditions for standard and 1,5” corner cube reflector.

The ATR enables the instrument to search the reflector within the field of view by itself. The system trasmits a laser beam and receives the reflected light. In order to minimize the time of measurement, the telescope is not moved to the centre of the prism reflector (closer than 5 mm).

Fig. 1. The instrument TDA5005 with precise prism and corner cube reflectors

The ATR measures the offsets between the crosshair and prism centre and corrects the value of Hz and V angels.
The accuracy is comparable to manual settings during repeated measurements to a precise reflector, correctly aligned to the telescope of the instrument (learning the theodolite).
The orientation of glass reflector has an influence on results of measurements of distance and angels. Figure 2 shows this situation.

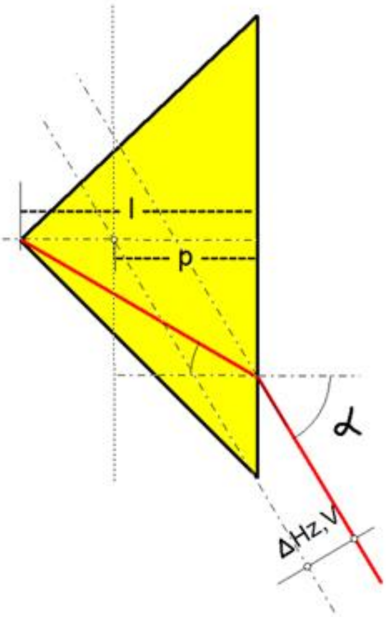

Fig. 2. The trace of the measurement beam in prism reflector

According to the figure it is possible to write following formulas:

- $\Delta d = l(n-\sqrt{(n^2-\sin^2\alpha)}+p(1-\cos\alpha)$,

and

- $\Delta Hz, \Delta V = \sin\alpha[l - l\cos\alpha/(n^2-\sin^2\alpha)-l+p]$

The second formula allows to determine the error of direction HZ,V in general case. The influence of missalignment of prism reflector can be significant, even several millimeters.

This rule does not apply to measurements performed with use of corner cube reflector

3. THE TEST OF INFLUENCE ALIGNING THE TOTAL-STATION TO THE CENTRE OF REFLECTOR

The quality of measurements depends on the reflector alignment and instrument (distancer) alignment. The tests were carried out for an object distance of 8, 42, 289 meters using 1,5" corner cube reflector.

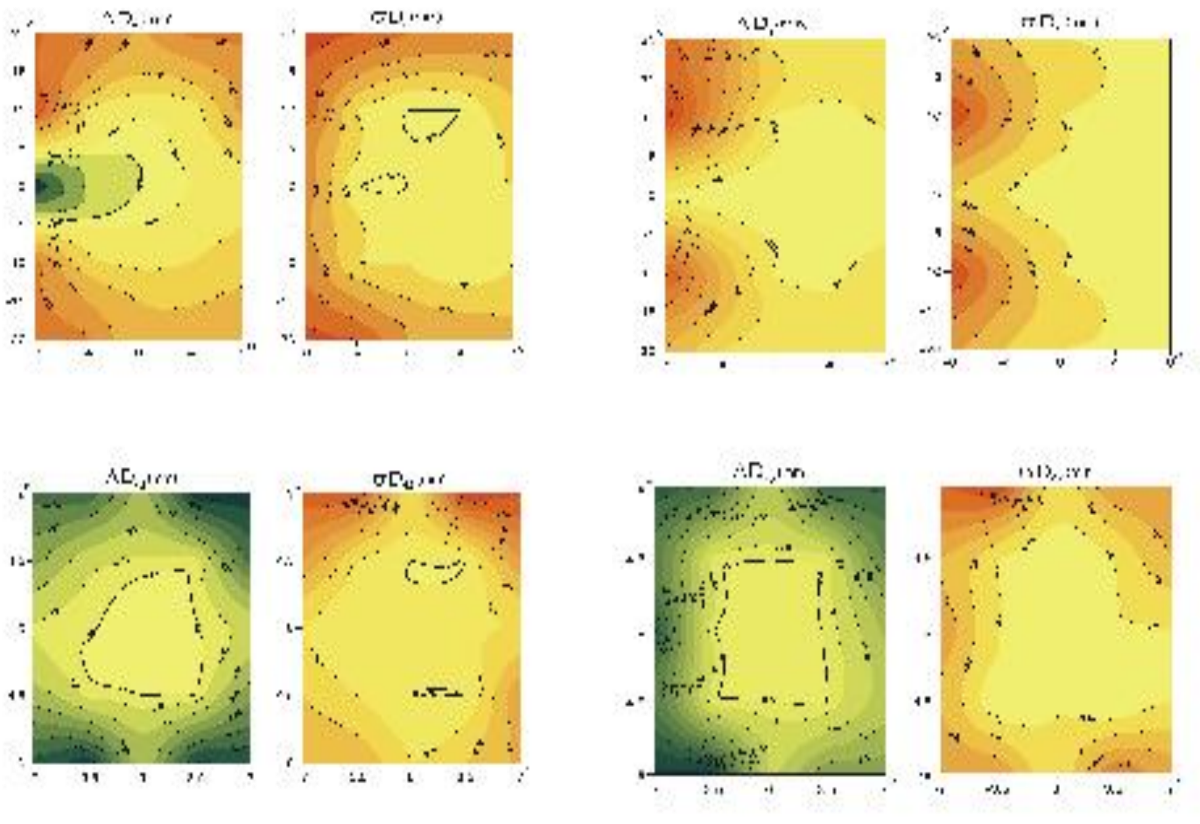

Fig. 3. Changes of results of measurements for different aligning the total station for distance 8 and 42 m

The field and laboratory tests using CCR have shown that differences of measured distances are less than 0.2 mm in range of ±4' from the centre of reflector.
Test measurements using the telescope aperture AP 31 (pictures on the right) allowed to notice decrease of distance deviation. It is most important for measurements of short distances.

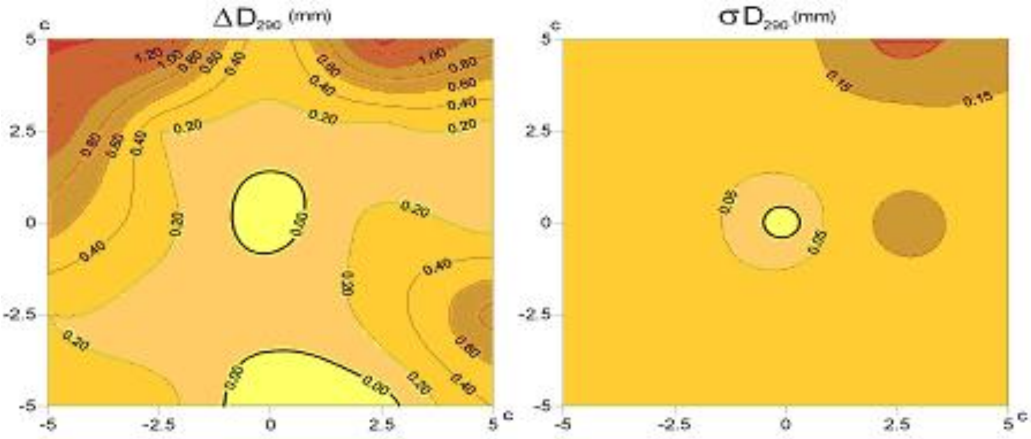

Fig. 4.Changes of results of measurements for different aligning the total station for distance of 289 meter

4. THE TEST OF THE INFLUENCE OF CCR ALIGNMENT TO THE SIGHT OF THE ATR SYSTEM

The tests were carried out for an object distance of 8, 42 meters using 1,5” CCR. The presented graph shows differences and standard deviations of values: HZ, V, D according to different missalignments of CCR.
The horizontal and vertical value of missalignment is accordingly up to ±15° and ±30°.
The test allowed to determine the influence of changes of reflector aligning on results of precise measurements (fig 5, 6). The upper pictures refer to measurements done with use of the telescope aperture AP 31.

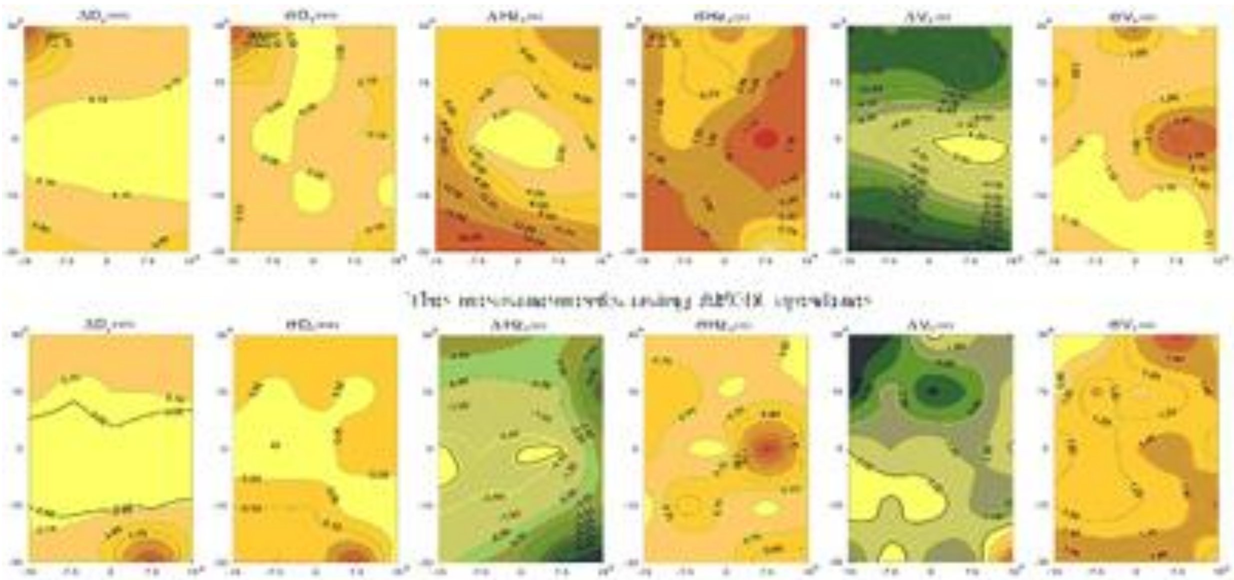

Fig. 5. Differences of value of observations for distance 8 m

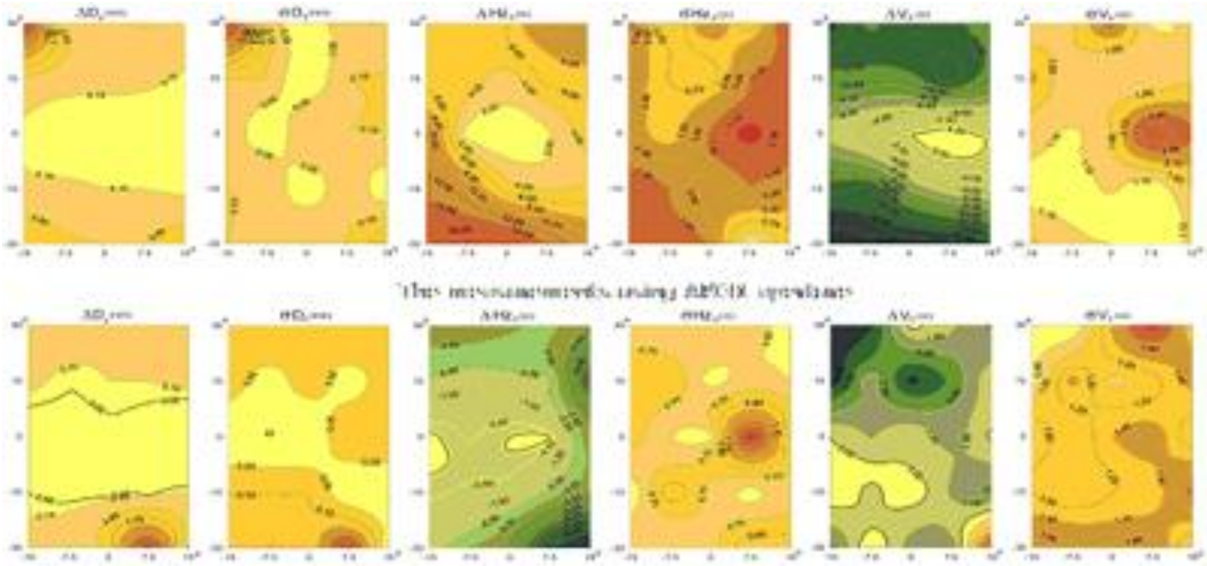

Fig. 6. Differences of value of observations for distance 42 m

5. THE FIELD TEST ON REAL OBJECTS ŻAR AND WIÓRY

In order to verify the highly accurate measuring system of TDA 5005 we have measured the control network of the upper reservoir - Żar and control network of Wióry dam.
In distance measurements we use: triple-prism GDR1, CCR and certificated reflective tape.

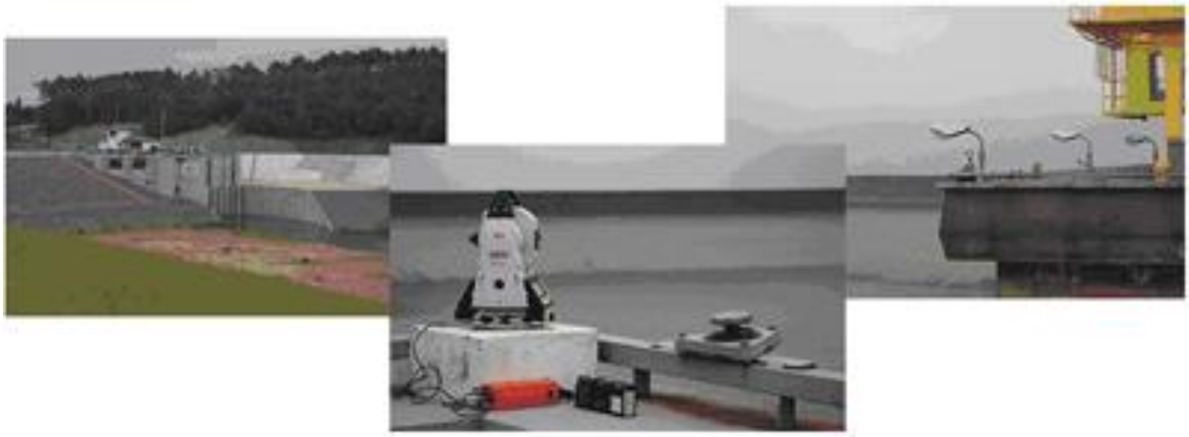

Fig. 7. Measurements on the real objects

We used the "monitoring" program for controlling position of selected points for 24 hours every 30 minutes with a help of ATR system. Results of our experiment confirmed the high accuracy of observations and their objectivity by automation of monitoring measurements.
This system is particularly helpful at night. The accuracy of night measurements is the same as in good conditions during a day.

5. CONCLUDING REMARKS

The analysis of the measurements shows that there are many advantages of using ATR system in monitoring measurements. This system helps to attain objectivity in engineering surveys.

Most attention was dedicate to experiences with CCR. The investigation of influence of the alignment of CCR has shown:

- **it must be taken into account that the accuracy of our measurements is reduced by alignment of prism reflector,**
- **the accuracy of measurements is reduced if alignment of CCR is more than ±10°**
- **change the value of distances can be even several millimeters,**
- **the collimation error of ATR system should be controlled,**
- **the CCR is the reflector especially good for precise measurements of medium distances.**

The field test on real objects has shown that the accuracy of an automatic measurement with the ATR is as good as a manual one.