Impact of the Target Configuration to the Precision of Total Station Measurement

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Abstract

Measurement in the industry requires higher precision than measurement in civil engineering. However, both types of work use total stations as the main tool for the measurement. The right total station is chosen according to the needed accuracy in measurement of distance and horizontal and vertical angle. Final precision is influenced by other factors such as type of reflector, turn deviation and recline deviation from the line of sight, precision in aiming, measured point configuration, atmospheric conditions during measurement, etc.

This article is focused on the testing of four total stations and aiming at three types of reflector at the distance of ten and fifty meters. The reflector was turned and reclined from the line of sight which changes the final coordinates of the measured point.

Key words: industrial surveying, turned target, reclined target

1 INTRODUCTION

Spatial polar method is currently one of the most frequently used method in industrial surveying. This fact is a result of a development of total stations and improving their accuracy, especially the accuracy of electro-optical range-finders. The stated method is used for ship, trains, cars, machines manufacturing, installation of foundational boards of new machines, their manufacturing, reconstructions, or maintaining in services. The spatial polar method is irreplaceable mainly for measuring more extensive objects.

In industrial surveying the required accuracy is somewhere below a level of one millimeter. That is why it is needed to pay attention to anything that could possibly influence the accuracy of the measured or set point. For the industrial measuring it is necessary to chose the most suitable total station and a prism. The measurement accuracy can be, however, influenced by a turning or recline of a prism.

This article describes testing and the results of the influence of turning and recline of a prism with the use of four total stations: Leica TDA5005, Leica TCRP 1201+, Leica TS30, and Trimble S8 2 DR Plus (further only Trimble S8), - in combination with three prism GPH1P (precise prism), Mini GMP101 (mini prism), and GRZ101 (360° mini prism).

2 TEST MEASUREMENTS

The surveying took part in the surveying hall in the Institute of Geodesy and Mine Surveying, VŠB - TU in Ostrava. A massive metal tripod for placing the total station was screwed to the floor. There were signs on the floor for 10 m and 50 m far from the tripod and the tripod with spike for a prism was positioned above each of them. There was fixed an especially made component with horizontal and vertical scale to the tripod of the spike. This component made possible to set the prism to the needed position of turning or recline. The setting of the prism was, nevertheless, not combined, that means, it was not aimed at the turning and at the same time reclined prism. Each prism was attached an arrow providing the possible setting of the prism to the required position. The scales of both protractors went in 5°.

There were always taken measurements of air pressure, temperature, and humidity of the surroundings for defining physical corrections of the measured values right in the total station. All equipments and machines used for testing surveying had to temper for long enough time not to effect the surveying results in a negative way. The total stations tempered switched on as even this fact influences the accuracy of measured values, as states (Hánek, 2012).

The testing itself was made in sets of five measurements. The prism was positioned in a 10 m distance, set on 0° turning of the line of sight and 0° recline, with the measurement taken in one position of the telescope. It was then turned to the position of 5°, 10°, 15°, 20°, 30°, 45° in a positive as well as negative direction (Fig. 1). There were taken 70 measurements for one total station and one prism. This way of measurement was possible for GPH1P and Mini GMP101 prisms. The GRZ101 prism was set for measurements with the 30° level of the turning from 0° to 360° again in series after five measurements. There were taken 65 measurements.

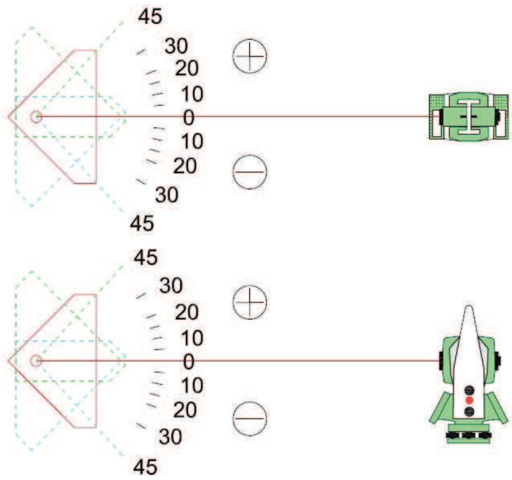

Figure 1 Turning and reclination of the target

After such a series of measurement the prism was again set on 0° turning and 0° recline. The testing was made in series of five measurements with the difference the prism was reclined to the horizontal level. The level of angle recline was the same like with the tuning of the line of sight. The positive recline angle means the prism was reclined downwards, negative upwards (Fig. 1). There were again taken 70 measurements for one total station and one prism. The only exception is GRZ101 (mini 360°) prism, which cannot be due to its construction reclined but only turned.

Each of the above mentioned total station measured above mentioned prisms that were turned and reclined in stated level and distance of 10 m, and the whole procedure was repeated in a distance of 50 m. There was used ATR function for aiming; all total stations are equipped with this function.

3 DATA PROCESSING AND PRECISSION ANALYSIS

Every single measurement was divided into separate components, such as horizontal direction Hz, zenith angle ξ and inclined length d_s. Every component was then evaluated separately to make more obvious how one component changes the values of the remaining two.

This testing procedure tested all measured data to find whether the series of measurements include extreme values that could negatively influence arithmetic average. Regarding the fact the value of the standard deviation is not known in advance, known are only the measured data, it was chosen Pearson's (also known as Grubbson's) test, according to (Švábensky).

Tasting was taken in 10 m and 50 m distance. The distance of 10 m represents in industrial geodesy measuring of detailed points, and a distance of 50 m represents focus on orientation. Turning and recline of the prism influence in both the cases accuracy of the measured point.

The main studied component of the turned prism is the horizontal direction Hz. The main studied component of the reclined prism is the zenith angle ξ. Due to the limited length of the article there are not included lengthy tables with the resulting values. There are used diagrams for the presentation of the results, and the final summary is included in the conclusion of this article. The influence of all measured quantities is in short introduced in the conclusion of this article with the use of prism coordinates with a zero turning/ reclining and a turned/ reclined prism. The center of the coordinate system is in a point of zero turning/ reclining, and the orientation of coordinate axis shows Figure 2.

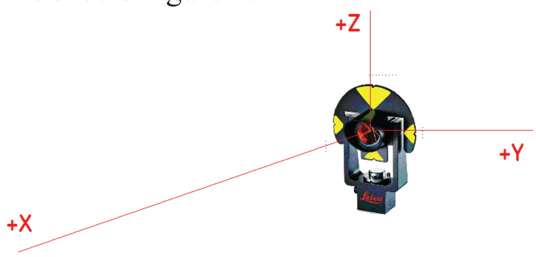

Figure 2 System of coordinates

The results gaind when turning the Mini GMP101 prism shows Figure 3 and 4, there can be compared values of 10 m and 50 m distance. The results gaind with the use of GPH1P prism are similar.

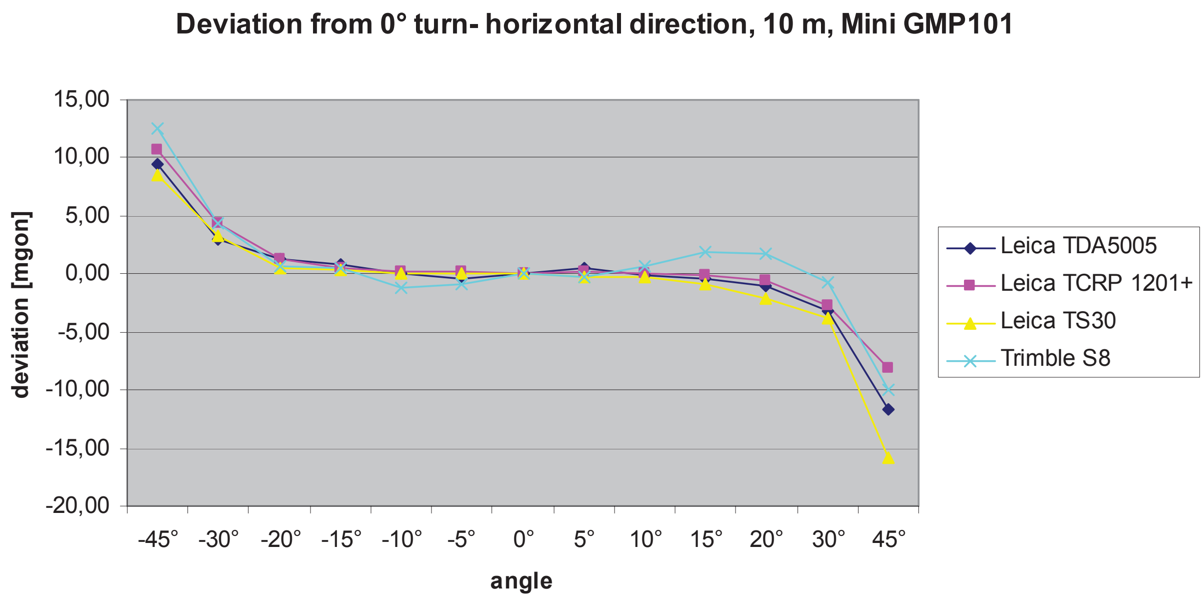

Figure 3 Comparison of values with the turn of Mini GMP101 prism, 10 m

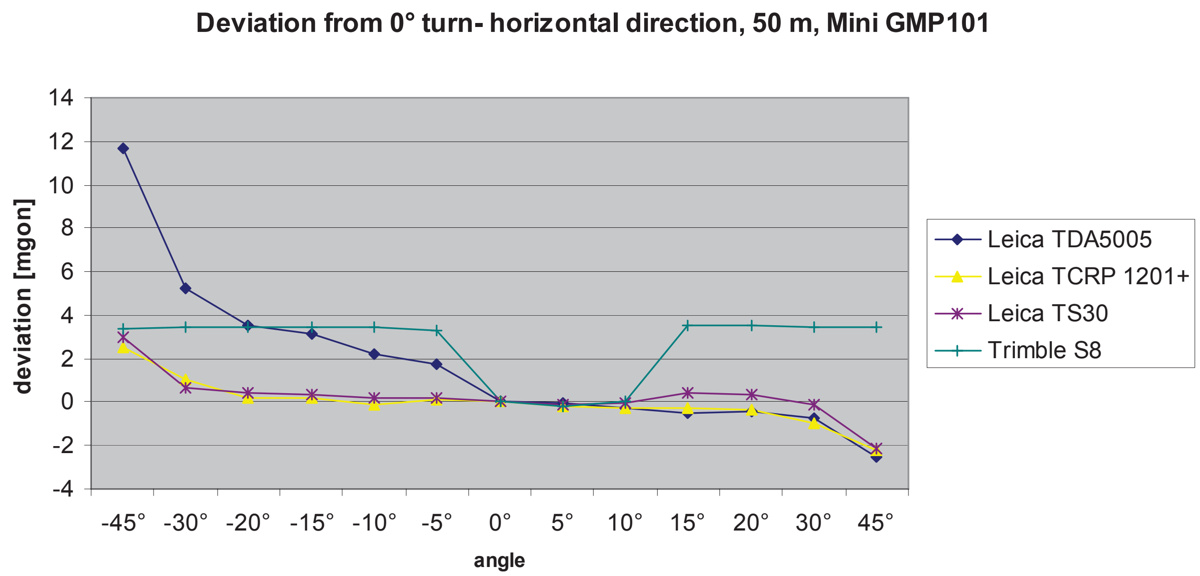

Figure 4 Comparison of values with the turn of Mini GMP101 prism, 50m

The results of the use of the prism mini 360° (GRZ101) show the Figure 5. The results of the horizontal direction measurement significantly differ, as it is given by the construction of a prism as such and a place of reflection of a transmitted beam.

The results of reclined prism GPH1P are shown in Figure 6 and 7. There is again a possibility of comparison of received values of each total station for the distance of 10 m and 50 m. The values for prism Mini GMP101 are similar.

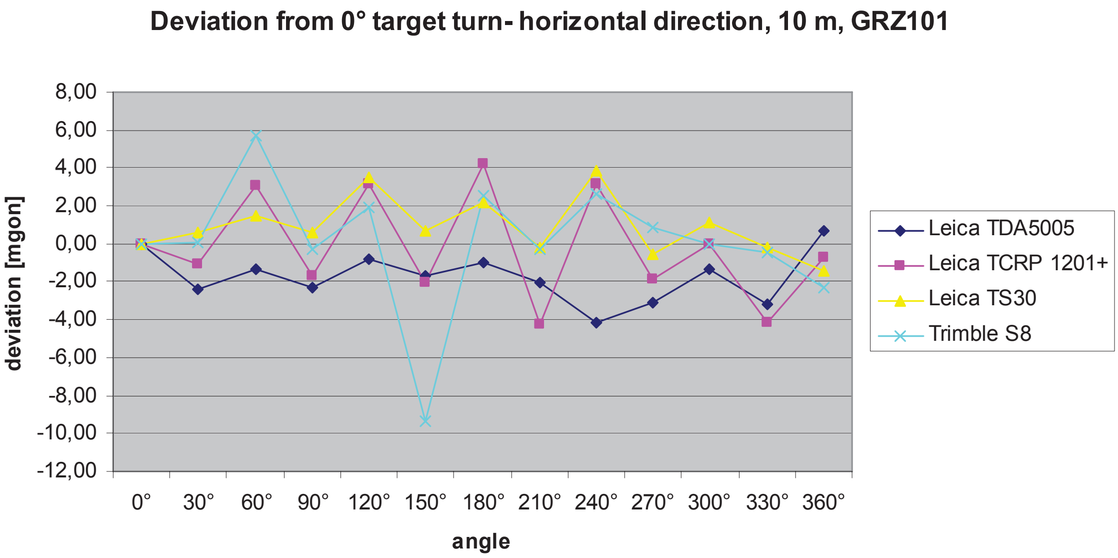

Figure 5 Values measured with the turn of a prism GRZ101

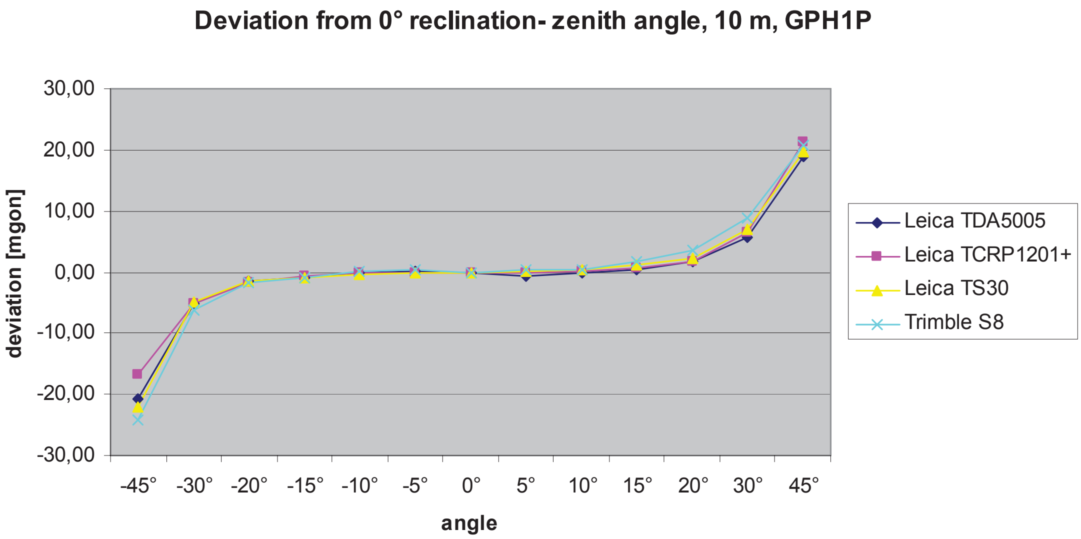

Figure 6 Values measured of a reclined prism GPH1P, 10 m

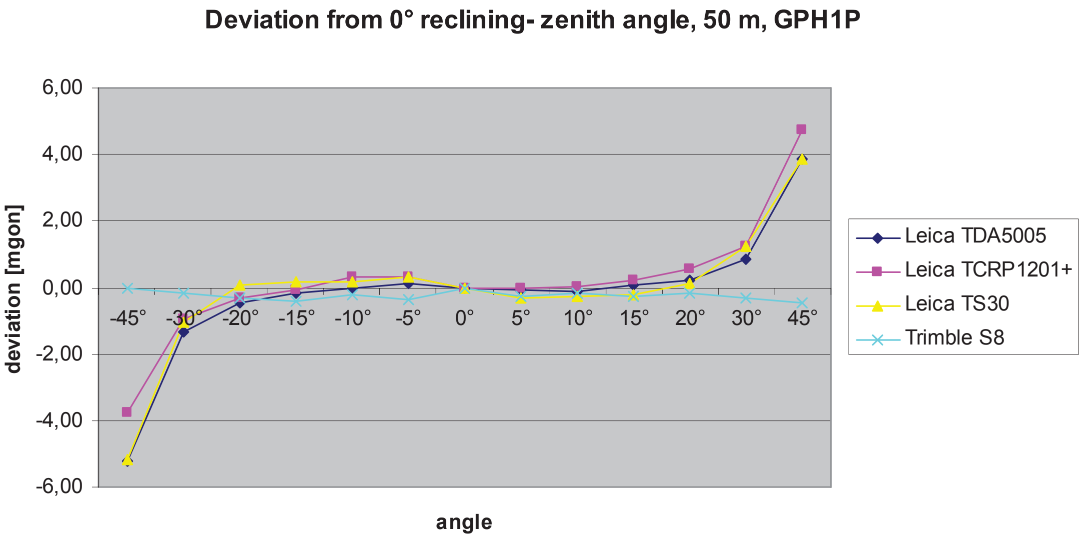

Figure 7 Values measured of a reclined prism GPH1P, 50 m

3 CONCLUSION

The goal of this test was to find out the importance level of the role of a turning and recline of prisms for the industrial surveying.

The presented diagrams clearly show that when turning and recline to 15° in both directions the deviations usually do not get over 0,5 mgon. Regarding the measured distances in industry, this value does not influence the resulting value in a way to exceed the required accuracy (Pospíšilová, 2012). It can then be claimed that the measurement can be used while turning or recline the prism to 15° of the line of sight. The deviation up to 15° can be reached with the GPH1P prism with build-in collimator. We have to pay more attention to the turning towards the line of sight with the Mini GMP101 prism.

The values for GRZ101 (mini 360°) prism changed rapidly, it is the most probably caused by the construction of the prism as it is composed of six corner reflectors. Concerning used machines, all Leica total stations registered similar deviations of the measured values and a similar trend. The Trimble S8 total station showed deviations in some situations independent on distance and a turn of a prism. This might be caused by vibrations of the stative caused by the machine. When comparing values measured in 10 m and 50 m distance, it is obvious the deviation relies on a distance of a total station and a prism. That is why the industrial surveying requires special diligence for short distance measuring.

For evaluating all measured values there will be stated also values measured by TDA5005 in a combination with Mini GMP101 prism and a 10 m distance. When calculating out of measured directions and distance coordinates of points in a coordinate system according to Figure No. 2 then the point with a turn of ±15° would have coordinates of y = ±0,2 mm, x = ±0,1 mm, z = 0,0 mm. With the turn of the prism of +45° the coordinates of the point would be y = -1,8 mm, x = -4,3 mm, z = -0,1 mm. The recline of the prism for ±15° would make the coordinates of the point y = ±0,1 mm, x = ±0,1 mm, z = 0,0 mm. And the recline of the prism for +45° the coordinates would reach values y = 0,3 mm, x = 0,2 mm, z = 1,5 mm.

The overall accuracy of a position of a point is, however, relying on not only precision of a turn or a recline of a prism towards the line of sight but also on an accuracy of a points in a mircro-net, definition of a base location and conditions of a surroundings that cannot be always optimized (Pospíšilová, 2012).

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