PRECISE LEVELLING ACROSS THE LIELUPE AND DAUGAVA RIVERS

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Abstract

In Latvia, Class 1 levelling network crosses major rivers. In the places where the river cannot be crossed over the bridge, the levelling across the river should be done directly.

The paper describes the methodology, the applied instruments and the results of levelling performed across the Lielupe and Daugava rivers.

The levelling across the Daugava River at the creek, where the length of the sight reaches 700 m, was performed simultaneously with two Ni002 levellers. To facilitate the reading of the levelling rod, across the river, a special scale type mark was constructed and fitted on a levelling rod. It was concluded that for the levelling across up to 200-m-wide rivers, levelling rods with 3-mm-wide stripes can be successfully used. The scale type mark makes significantly easier and speeds up the measurements. Under unfavourable weather conditions, measurements performed across the Daugava at the creek were less accurate. There was no explanation for the difference in the elevations measured by the two instruments; therefore, further careful studies of both levellers are needed.

Key words: levelling, levelling rod, leveller, levelling mark, benchmark.

Introduction

Between 1929 and 1939, in the process of creating a precise levelling network of Latvia, levelling across the Daugava River and also other water barriers was performed. During the Soviet times, levelling across wide rivers in the territory of Latvia was not performed because a precise levelling network was not fully levelled. Nowadays, because there are no bridges for river crossing or direct levelling across wide rivers, the implementation of Latvian Class I levelling network project has become very significant. Such locations for levelling lines are the Lielupe creek, the Daugava at the Belarusian border near the Kraslava, and the Daugava creek. The objective of the present research study was to create a device for reading of precise levelling rods, which would facilitate and speed up levelling across wide water barriers, as well as increase the accuracy of measurements. Levelling works from 2000 to 2005 were performed by the State Land Service, and from 2006 to 2010 by the Latvian Geospatial Information Agency.

Materials and Methods

Levelling across the Daugava River near the Belarus border was performed on 1 November 2000. Weather conditions were favourable for levelling: Cloudy with little wind, the air and water temperatures were similar. At the site of the river crossing, on both river sides, temporary benchmarks – screw benchmarks – were installed, which were attached to the Class 1 permanent benchmarks with a double run.

For the levelling, optical level with compensator, a Ni002, and bar code levelling rods with 3-mm - wide stripes, were used. As previous research has shown, the bar code levelling rods with 3-mm-wide stripes can be read with a matching technique, just like in levelling with a normal length of sight. Before levelling, the leveller angle of the sight was set at i=-2.5”. Leveller standings were chosen so that the temporary benchmarks and leveller were located on the tops of parallelogram (Fig. 1).

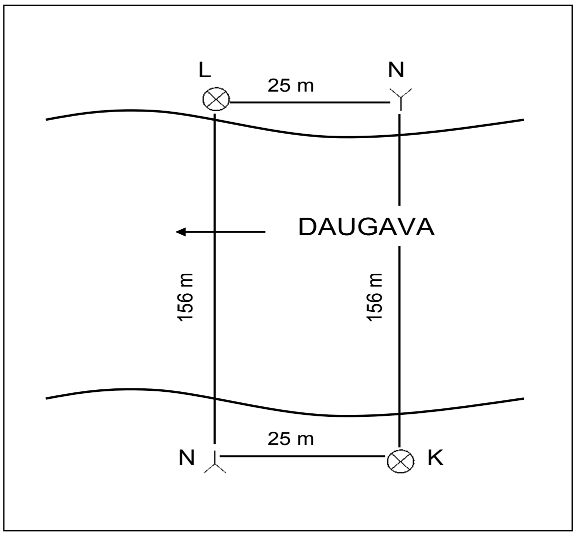

Figure1. The scheme of levelling across the Daugava River near the Belarus border.

Measurements from each coast were performed in four stages. In each stage levelling rods were read similar to those in Class 1 levelling line station to the programme BFFB, FBBF, with the only difference that the far levelling rod (on the opposite coast) was always read 3 times, changing the height of the level.

Measurements on one coast were completed with reading to the levelling rod on the opposite coast. Without changing the focus of binoculars, the leveller was taken to the opposite coast, where the measurements began by observing the far levelling rod (on the opposite coast).

Levelling across the Lielupe at the creek was performed on 27 November 2009. In the levelling across the Lielupe at the creek, the same level and rods were used, as well as measurements were performed by the same methodology as in the levelling across the Daugava River in the year 2000. The weather was overcast, with a very strong catchy wind in the river direction. Points were established with screw benchmarks. Elevation from each cost was determined in six stages. The levelling scheme is shown in Figure 2.

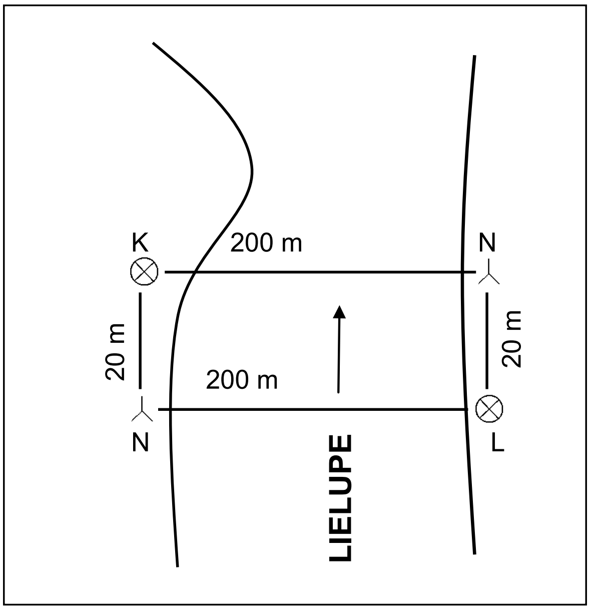

Figure 2.The scheme of levelling across the Lielupe River.

Levelling across the Daugava at the creek was performed on 7 July 2010. Weather conditions were not favourable for levelling: Sunny, almost no wind, a significant air and water temperature difference was observed, in the morning from the left coast the sight was towards the sun. Due to various organizational reasons, it was not possible to choose more appropriate weather conditions.

To simultaneously carry out measurements on both coasts, two levellers, Ni002 and bar code levelling rods with 1.6-mm- wide stripes, were used. For a temporary benchmark on the left coast, 10-cm-long pins with a spherical head were driven into the concrete, on the right coast, and 10-mm-diameter ball bearings were reinforced into concrete slabs.

Since the width of the Daugava at the creek is almost 700 m, the levelling rods could not be read in the usual way. In such cases, for reading the levelling rod across the river, a special mark with one or two wide stripes (Инструкция по нивелированию…, 2003) or a white circle on a black background (Latvijas PSR precīzā nivelēšana, 1941) is usually used, which, following the observer's instructions, is moved and secured on levelling rods so that the binoculars' horizontal stripe coincides with the mark line axis or centre of the circle. The mark position on the levelling rod is determined by a levelling rod scale reading to the marks' index. Since such reading of levelling rods is related to a significant amount of time and is not very big (around 0.5 mm), the authors designed and produced such a mark for the reading of levelling rods, which in the measuring process would not be needed to move on the levelling rod, but the reading of the levelling rod could be obtained by a matching technique using the instrument's micrometer. Instead of the mark with one or two wide stripes, a scale consisting of a 1x2 cm rectangle (similar to rods bars) was constructed on the metal plate. To ensure a 5-mm distance between the stripe axes, stripes were placed in multiple columns obtaining the mark in the scale form. For the mark axis verticality control, a spherical level was fitted (Fig. 3).

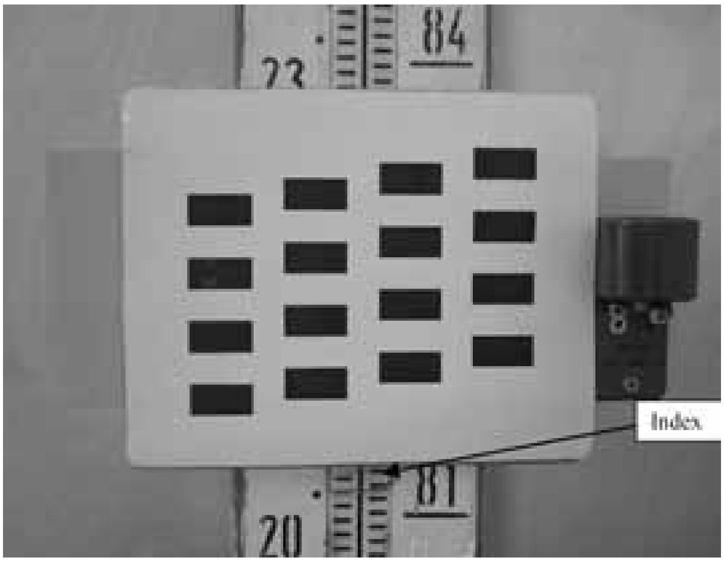

Figure 3. Levelling rod with a mark.

A mark plate was attached to the device which was strengthened on the levelling rod, and for position fixing on the rod the index scale for the levelling rod reading was created. The levelling scheme is shown in Figure 4.

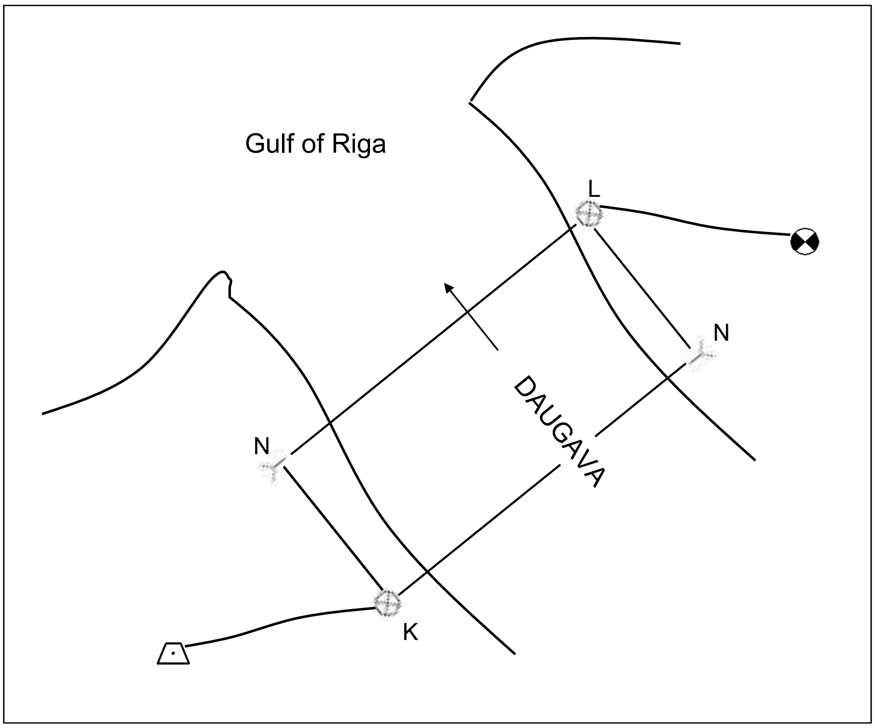

Figure 4.The scheme of levelling across the Daugava at the creek.

Results and Discussion

Before leveling, the leveler angle of sight was set i=-2.5” After completing levelling measurements across the Daugava River near the Belarus border, the angle of the sight was set again at i=-2.7”. Therefore, for the measurement period the average angle of the sight could be extended to i=-2.6”.

The measured elevations were updated by the angle of the sight and curvature of the Earth’s surface. The levelling results are shown in Table 1.

Table 1

Results of levelling across the Daugava River near the Belarus border

Point name	Measured elevation (m)	Correction of		Corrected elevation (m)	Average elevation (m)
		angle of sight (mm)	curvature of the Earth’s surface (mm)		
K					
	+0.8482	–1.7	+1.2	+0.8477	
L					+0.8467
	–0.8452	–1.7	+1.2	–0.8457	
K					

As can be seen, the elevation difference in opposite directions is +2.0 mm, which indicates that the measurement was done sufficiently precisely.

The levelling results across the Lielupe are given in Table 2. The correction of the angle of sight was calculated from average slope angle at i=-4.5”.

Table 2

Results of levelling across the Lielupe River

Temporary benchmark name	Measured elevation (m)	Correction of		Corrected elevation (m)	Average elevation (m)
		angle of sight (mm)	curvature of the Earth's surface (mm)		
K L	+0.1919	–3.9	+2.2	+0.1902	+0.1886
L K	–0.1852	–3.9	+2.2	–0.1869	

As it can be seen, the difference between the elevations in opposite directions is + 3.3 mm. In view of the not very favourable weather conditions, it can be assumed that the elevations are sufficiently precise.

Levelling across the Daugava at the creek was performed in the morning from each coast in 10 stages by the same methodology as in the previous levelling. Before the measurements were started, markings were installed and reinforced on the levelling rods to such height that the sight was about to cross the centre line markings, but the index exactly coincided with the one of the levelling rod strip, thus excluding the levelling rods section's part reading error.

Before the measurements in the afternoon, the positions of the levellers were exchanged. Measurements in the afternoon were also performed in 10 stages. The measured elevations were updated by the angle of sight and curvature of the Earth's surface. The angles of the sight for both levellers were determined before and after the levelling; and for the calculations, the average value was used. The levelling results are given in Table 3.

Table 3

Results of levelling across the river Daugava at the creek

Leveller	Benchmark name	Measured elevation (m)	Correction of		Corrected elevation (m)	Average elevation (m)
			angle of sight (mm)	curvature of the Earth's surface (mm)		
Ni002 Nr.460552 (HES)	K L	–0.6605	+9.2	+31.2	–0.6201	–0.6216
	L K	+0.5828	+9.2	+31.2	+0.6232	
Ni002 Nr.460817 (LLU)	K L	–0.6295	–14.8	+31.2	–0.6131	–0.6066
	L K	+0.5837	–14.8	+31.2	+0.6001	

With one leveller, the elevation difference, measured in opposite directions, is 3.1 mm, whereas with the other 13.0 mm. If such height value differences (because of unfavourable weather conditions) should be allowed, then there is no explanation for average elevation differences, measured by the two instruments. It is possible that external factors have had different effects on the accuracy of each instrument, which should be additionally studied.

Precise levelling across wide water barriers is not a daily routine in the process of creating a national levelling network. For this reason, information about the results is not easily available. Also, in the levelling, described in this paper, a mark for levelling rod reading of a new type was used, which indicates that the measurement results are unique and not comparable with the data obtained by other measurements.

Conclusions

Summarizing the results of levelling across the Lielupe and Daugava Rivers, it can be concluded that:

1. In order to achieve the desired precision in levelling across up to 200-m-wide water flows and water reservoirs, bar-code levelling rods with 3-mm-wide stripes can be successfully used;
2. For levelling across the Daugava, the designed mark for levelling rod reading makes the levelling easier and faster;
3. To achieve higher measurement accuracy, levelling should be performed in most favourable weather conditions, as well as the width of the levelling rod mark stripes should be increased;
4. In the levelling across the river Daugava at the

creek the average elevation difference between the measurements performed by both instruments cannot be explained, and requires additional studies;
5. Levelling across water reservoirs under bad weather conditions is not acceptable.

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