

ASSESSMENT OF ELEVATION DIFFERENCES OF PRECISED LEVELLING BETWEEN DIFFERENT EPOCHS OF MEASUREMENTS

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This article is about first class leveling measurements made in three campaigns in Latvia: from 1929 till 1939 ; from 1967 till 1974 ; from 2000 till 2004 in lines Kolka – Rucava, Riga – Plavinas – Riga and Ainazi – Riga. There are discussed obtained elevations and changed values of them in different epochs. There is also aviable assessment about changes acomplished given.

Introduction. To renew the leveling network in the Republic of Latvia, the 1st order leveling measurements were started in year 2000 (1). In the leveling network of Latvia were used network lines created in 1929–1939, renewed in 1967–1974, with the exception of two lines where leveling was not done before. The planned measuring of the leveling network is proceeding every year. In pursuance of précised leveling there was a chance to compaire elevation changes to results obtained in measurements of leveling epochs done before. Values of elevations are discussed for three periods of made measurements: 1929–1939, 1967–1974 (5) and for measurings made today. That's because measurings made in this time were done in all territory of land and were done with the most aviable precision. There is need to point out that there are not so much benchmarks from the leveling in years from 1929 till 1939 left. That's why the chance of comparing is not so large. However its plenty to give a discretion in changes of elevation differences whats possible are concerned with vertical movement of earth crust in time of 60 yaers.

Janis Bikis was the first who in 20's started to study movement of the earth crust and it's effect on the leveling. He inferred that effect of earth crust movement in Latvia is sensible and it can't be passed over by the organizing of précised leveling measurements.

Research about earth crust vertical movement speed in Baltic area by the analyze of leveling results from 1889 till 1970 was done by O. Jakubovskis. According to O. Jakubvskis developed scheme territory of seacoast of Estonia and territory of seacost of NW Latvia gradually rises. Results accuired in research of O. Jakubovskis matches good with enquirys made by R. Witting (1943), I. Hel (1953), M. Vermer and J. Kakkuri (1988) (4).

This article is a review of the lines Kolka – Rucava, Ainazi – Riga and Rīga – Plavinas – Demene. That's because the lines Ainazi – Riga and Kolka – Rucava oriented to NS direction. Also measurings done before shows that earth crust vertical movement in territory of Latvia mostly proceeds and are more markable in direction NS. The line Riga – Plavinas – Demene was choosed to get a taste about ongoing elevation changes in direction from NW to SE in territory of Latvia. (Fig. 1).

Elevation values choosed for mutual comparing are used with determination to 1mm. Thats because I regard observable vertical movements below 1mm to this length of the line are nonessential. Discussed leveling lines with matched points are with such a length: Kolka – Rucava 256 km; Ainazi – Riga 107 km; Riga – Plavinas – Demene 264 km.

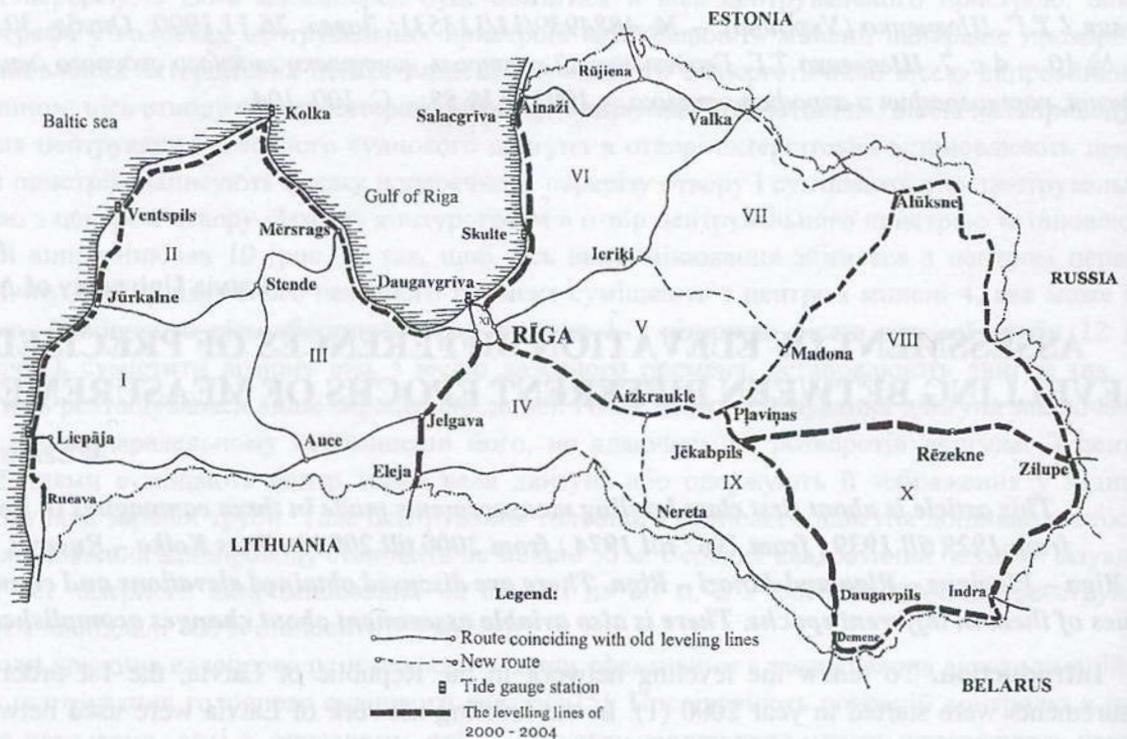


Fig. 1. First order leveling scheme

Materials and methodology of research. The first considerable leveling in line Kolka – Rucava was done already in 19th century. In 1881–1892 the tsarist Russian army headquarter geodesists did the leveling in line Kuldīga-Liepāja-Rucava-Palanga. The marks have remained in Liepāja, Nīca and Rucava.

In 1919 and 1920 German civil engineer Kupfer did the technical leveling in line Ventspils-Pāvilosta-Liepāja. There are some mural benchmarks remained in Ventspils and Jūrkalne.

Precise leveling of the territory of Latvia was done in 1931 by the technical department of Land surveying of Ministry of Agriculture. In Kolka was created special group of ground benchmarks which was composed from three ground benchmarks with serial numbers 10, 11 and 12. Benchmarks were forged of granite and installed in 2,20 meter deep pits, top – part of benchmark is in 1,10 meter deep (6).

Poligonometrical and leveling networks were created in 1956 and 1969 by Design Institute of Latvian cities to perform survey of territory of Ventspils and Liepāja in scale 1:2000 and also to perform geodesic measurements.

In 1968 company of Geodesic Works of Minsk nr. 5 in places of earlier created points aimed to precise altitude marks, repeated I class leveling and II class leveling in line Kolka – Liepāja but in 1974 did III and IV class leveling to develop maps scale 1:10000. The line was connected to points of I and II class leveling on this line.

In 2002 and 2003 were performed preparation works by appraisal of existing marks and also by selecting of places for new creating marks. In places, where the distance between benchmarks exceeded 2 km, there were established new ground or wall geodetic benchmarks. At total additionally there were 62 ground and 11 wall benchmarks established. Ground benchmark installation described in Fig. 2. Obviously the biggest part of new created benchmarks compose ground benchmarks because in territory of Baltic seacoast in this place there are to less of fundamental buildings in which walls there would be possible to create mural benchmarks. I class levelings were done in 2004 by the specialist of State Land Service of Latvia.

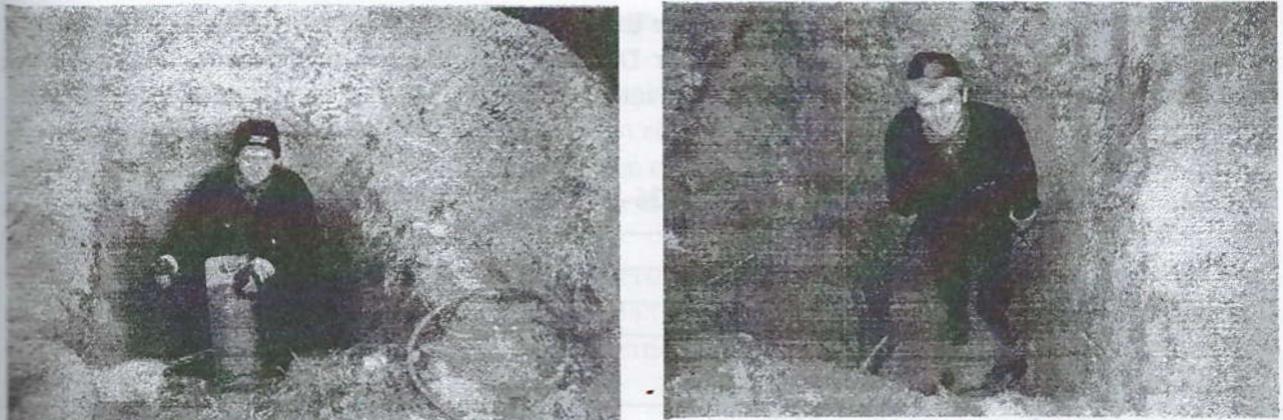


Fig. 2. Ground benchmark installation

In line Riga – Plavinas – Demene leveling done before from 1881 till 1892. Leveling line fixed with wall benchmarks and precision done satisfys average quadratical error of $\pm 2,6$ mm. There is no benchmarks left from this time of measurements because they were built in railroad station buildings and bridges. In 1936 and 1937 department of land surveying of Ministry of agricultur did précised leveling, it was a part of all-embrasing levelings of all territory of Latvia. In 1948 and 1949 Nord West aerogeodesic enterprise did II class leveling in line Riga – Jekabpils. In 1963 Geology Institute of Latvia in company with geodesy department of Latvian Agricultur academy did II class leveling near Plavinas. Mission of this was to fix the changes possible caused by upbuilding of Hydropower station on Daugava river near Aizkraukle. In 1968 and 1969 enterprise of geodesy Nr. 7 (Moscow) did I class leveling. I class leveling by the specialists of State Land Service of the Republic of Latvia was done in 2001 and 2004.

In line Ainazi – Riga I class leveling was done in 1933, 1969 and 2001.

Results and discussion. To make analyze there were included 5 leveling marks with condition to be leveled in every leveling campaign. Distance between first and last benchmark is 256,5 km. Comparing of elevation changes was done in direction Kolka – Rucava and started from special ground benchmark nr.12. Further values of elevation were summarized for every campaign of measuring (Table 1).

How it's visible in the table shown bellow, to the given distance between start and end points there is tendency elevation to decrease. The difference is 53 mm and in time of 65 years its considerable amplitude. Difference between elevation in 1931 and 1968 was 24mm and in period till 2001 29 mm.

Table 1

Difference of elevation amplitudes 1931 – 2004 in line Kolka – Rucava

Place	Point Nr	Distance, km	Height differences		
			1931	1968	2004
Kolka	12				
		20,48	2,444	2,439	2,457
Mazirbe	1026				
		72,19	0,074	0,037	-0,012
Ventspils	0228				
		135,83	0,834	0,846	0,835
Liepaja	331				
		28,00	-1,473	-1,467	-1,454
Rucava	0170				
		256,50	1,879	1,855	1,826

There were geodesic 5 marks included in line Riga – Plavinas – Demene to assess elevation changes. From Riga to Daugavpils the line is set up near Daugava river. Near to this river in little depth are dolomite rocks and in several places they comes on surface. (Table 2)

Table 2

Difference of elevation amplitudes 1936–2004 in line Riga – Plavinas – Demene

Place	Point Nr	Distance, km	Height differences		
			'36-'37	'68-'69	2001; 2004
Rīga	0296				
		41,64	28,947	28,934	28,942
Kegums	0245				
		43,66	42,432	42,445	42,483
Plavinas	0278				
		54,31	7,086	7,061	7,059
Jekabpils	0483				
		123,90	40,400	40,364	40,361
Demene	314				
		263,51	118,865	118,804	118,845

There were 4 geodesic marks in line Ainaži – Riga included to assess elevation changes. Length overall of the line 106,8 km. In this line elevation overall from 1933 till 2001 is changed for 50mm. Its interesting that in period from 1933 till 1969 elevation value changed just for 6mm. Such a tendency also visible in sectors where the elevation changes at most in period from 1969 till 2001 Table 3.

Table 3

Difference of elevation amplitudes 1933 – 2001 in line Ainaži – Riga

Place	Point Nr	Distance, km	Height differences		
			1933	1969	2001
Ainaži	1015				
		67,31	15,829	15,822	15,775
Skulte	0829				
		30,45	-12,769	-12,770	-12,759
Bergi	0393				
		9,00	-0,054	-0,052	-0,060
Riga	0319				
		106,76	3,006	3,000	2,956

Looking on observed results can conclude that difference of elevation changes between different epochs of measurements by executing of precized leveling exists. As it provided was these changes at most visible are in lines Kolka – Rucava and Ainaži – Riga. Interesting that in line Ainaži – Riga the largest changes happened from 1969 till 2001. There can be an opinion offered that these changes arised in effect of local vertical movement. But than these changes would have be seen just in separate places. So the values changes in every sector of the line with tendency to decrease it can be considered this effect cause movement of the earth crust. Also in line Kolka – Rucava speed of elevation values changes is faster in period from 1968 till 2004. The largest elevation volume in this line visible from Kolka to Ventspils. This tendency is visible in results obtained in all three campaigns (2).

In the line Riga – Plavinas – Jekabpils elevation value in all period of time from measurements made in 30's till 68, 69 decreases and again till measurements made today rises. There is also such a tendency in separate section visible. Thats possible its concerned to upbuilding of two hydropower stations and dam onrush near by Riga and Plavinas. In the same time there are very small elevation changes visible in line Jekabpils – Demene.

Conclusions. 1. Differences of elevation changes in different epochs repeatedly verify tendency of the earth crust vertical movement in Latvia.

2. Changes accomplished in reviewed lines globally agree with ICE4G model (Peltier, 1998).

3. In process of research of levelling elevation changes there must be conditions carefully analyzed who effect them (local and global effect interaction on concrete geodesic point).

4. Speed of earth crust vertical movement in all territory of Latvia will be able to calculate after finishing of I class levelling.

5. After levelling in Baltic States will be repeated, leveling networks should be connected and included in levelling network system which covers Baltic sea. That would give a chance in connection with other geodesic methods more detailed recognize vertical movement of the earth crust and could give a prognoses about oncoming process in future.

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