Review of Activities on Levelling Works in the Republic of Croatia 1999 – 2000

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Summary

In the period from 1999-2000 the systematic levelling work activities were continued in the Republic of Croatia referring to the national height system. With the colleagues from Hungary the third previously planned connection of fundamental state levelling networks has been established along with two already existing connections. This connection should contribute to the higher quality connecting of national height system of the Republic of Croatia with UELN. Apart from that the works on the revision of levelling control networks have been continued, as well as on their including into frame of fundamental state levelling network II.NVT. The proposal of the new national height system HRGVS71 is being right now in the legal procedure of adopting it as officially valid.

1. Connecting of Levelling Networks of the Republic of Croatia and the Republic Hungary

The successful international collaboration of the Republic of Croatia and the Republic Hungary in the work on mutual connecting of state levelling networks of the highest order geometric levelling resulted in 1997 in connections on two locations. These are border places Gorican (Letenye) and Terezino Polje (Barcs) at the outermost western and central part of the interstate border. The results of these works, levelling and gravimetric, were processed through calculations, analysed, mutually exchanged, verified, published (KLAK et al. 1999) and delivered to the official data centre for processing the UELN data (BKG, Leipzig).

Together with those two connections the third one was also planned and was supposed to be carried out at the outermost eastern part of the interstate border, at the territory of Croatian Danube Area, in the place Udvar. Due to various organisation and other circumstances, this third connection was successfully realised in 1999 instead of 1998 (KLAK et al. 2000). In September simultaneous levelling measurements were made by Croatian and Hungarian experts at the border crossing in the place Udvar, and consequently, the Croatian experts completed the survey of the levelling line No. 82 connecting Udvar with the fundamental levelling network of the Republic of Croatia, i.e. with the II.NVT, Fig. 1. All three above mentioned connections, levelling lines No. 74, 75 and 82, are presented on Fig. 2.

Along with the levelling measurements, the indispensable gravimetric measurements were also made. Modern instruments and equipment have been used based on the digital level Leica NA3003. Measuring data processing is just being done, and numerical results will be delivered to the official data centre for processing the UELN data after exchanging and verifying them with Hungarian colleagues.

It is quite realistic to expect that this third connection of fundamental levelling networks of the Republic of Croatia and the Republic Hungary will contribute to the higher quality with respect to including the II.NVT into UELN, and also to the improvement of the geometric configuration firmness of the network UELN in the south-eastern part of the European continent. In this respect one should point out that the II.NVT on the territory of the Republic of Croatia is already successfully connected with UELN even without this third phase, and official results of the processing made by the official data centre for processing the UELN data have been delivered to the State Geodetic Administration of the Republic of Croatia (SACHER et al. 1999).

One can come to the conclusion that due to the extraordinary good collaboration between Croatian and Hungarian experts, as well as between competent state institutions, the task of connecting the fundamental levelling networks of the two states was successfully accomplished in the field, and will be completely and finally finished in the course of this year. Complete data of connecting referring to all three connections will be adequately published.

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Fig. 1. Levelling network of the II.NVT at the territory of the Republic of Croatia.



Fig. 2. Connection of fundamental levelling networks of the Republic of Croatia and the Republic Hungary

2. Continuation of Systematic Works on Levelling Networks Revision

As it has already been presented in National Reports on levelling works in the height system of the Republic of Croatia that were already demonstrated at previous EUREF symposiums in Bad Neuenahr-Ahrweiler and in Prague (Klak et al. 1999, Klak et al. 199a), the works on the revision of geometric levelling state networks of all orders were continued. The task of the revision is to define the up-to-date situation with respect to how much the bench marks of these networks have been preserved, i.e. ruined, then to compile new documentation for practical use and to adjust these networks by integrating them into the fundamental state levelling network of II.NVT. The above mentioned works have been continuously carried out since 1992 and are now almost completed. At the moment, the revision of the levelling networks is being carried out on the remaining, very small part of the territory of the Republic of Croatia, in the area encompassed by the VII and XI levelling figure and on Croatian islands at the Adriatic Sea. These works are planned to be completed till the end of this year.

The level of bench mark perseverance in state levelling networks of all orders of accuracy (levelling of high accuracy, precise levelling, city levelling, technical levelling of increased accuracy and technical levelling) is clearly illustrated by the data given in the table 1.

Levelling figures	IINVT ¹		PN ²		TNPT ³		TN^4		GN^5	
	total	found	total	found	total	found	total	found	total	found
I.	634	414	1324	700	762	308	477	153	1125	545
II.	219	173	525	265	334	146	135	59	1396	663
III.	492	335	1195	521	947	367	1401	443	800	353
IV.	145	106	596	203	293	83	333	97	73	22
V.	338	255	912	428	353	87	133	46	200	102
VI, XIV, XV, XVI.	688	521	990	538	166	104	288	96	695	366
VIII.	443	305	836	328	348	120	688	364	932	483
IX.	225	170	236	107	247	67	15	8	263	115
XII.	124	86	178	65	188	50	-	-	-	-
Total	3308	2365	6792	3155	2783	1332	3470	1266	5484	2649
Total %	100%	71%	100%	46%	100%	37%	100%	36%	100%	48%

Table 1. Data about the perseverance of height system bench marks of the Republic of Croatia

¹ NVT – levelling of high accuracy, ² PN – precise levelling, ³ TNPT – technical levelling of increased accuracy, ⁴TN – technical levelling, ⁵ GN – city levelling

It should be pointed out that the results of benchmark perseverance refer to the levelling networks established mostly in the period from 1945 to 1973. It can also be seen that the benchmarks have been pretty destroyed in all levelling networks. It was caused partly by insufficiently updated maintenance of height basis in the period of seventies and eighties, but also because of the war destruction during the Homeland War at the beginning of the nineties.

In the table 2 there are the accuracy criteria given expressed with probable reference measurement errors computed on the basis of hierarchy adjustments of levelling networks made by accuracy orders and individual levelling figures of the network II.NVT. The achieved accuracy of measurement can be estimated as acceptable and in accordance with the technical criteria prescribed in the Republic of Croatia for performing levelling works.

Levelling figure	$\frac{\text{PN}}{mm / \sqrt{km}}$	$\frac{\text{TNPT}}{mm \ / \sqrt{km}}$	$\frac{\text{TN}}{mm \ / \sqrt{km}}$	GN mm/√km
I.	± 1.86	± 1.87	± 3.89	± 2.92
II.	± 4.59	± 3.19	-	± 1.25
III.	± 2.36	± 3.18	± 6.09	± 3.25
IV.	± 2.28	± 6.55	± 6.73	± 2.10
V.	± 2.14	-	-	± 2.31
VI, XIV, XV, XVI.	± 1.85	± 1.47	± 9.56	± 3.79
VIII.	± 2.47	-	± 5.60	± 2.75
IX.	± 1.15	± 2.27	± 6.95	± 4.83
XII.	± 1.15	± 3.96	-	-

Table 2. Measuring accuracy on the basis of adjustment

The completion of the works on field revision of state levelling networks is closely connected with the introduction of new height system of the Republic of Croatia into official use. The detailed data about the concept and characteristics of this system, called HRGVS71, having the levelling network II.NVT as its framework, are explained in (FEIL et al. 1993, KLAK et al. 1999, FEIL and ROŽIĆ 2000). At the moment there is legally foreseen procedure of its introduction into the official usage being carried out, and the bearer of activities is the State Geodetic Administration of the Republic of Croatia in collaboration with the Faculty of Geodesy, University of Zagreb. One can expect that this procedure will be completed till the end of this year.

It should be pointed out that great attention will be paid to the publication of the height system data in the forthcoming period, in classical and digital form, in order to make all works easier that are connected with its practical usage, maintenance, updating, enlargement and if necessary reconstruction.

3. Conclusion

Since all previously presented activities referring to the levelling works in the Republic of Croatia are logically connected with all systematic works carried out from 1992 till today, it is possible to make a conclusion, with already published data (KLAK et al. 1999, KLAK et al. 1999a) that very extensive, complex and significant phase of the new height system establishment of the Republic of Croatia is to be completed before the beginning of the new millennium. In this phase a systematic and comprehensive analysis and revision has been done on the height system inherited from the period when the Republic of Croatia was not independent and sovereign country, all available levelling data of the state levelling networks have been maximally used, new documentation of the height system for practical usage was prepared, the fundamental state levelling network II.NVT was successfully integrated into UELN and connected with the levelling networks of the neighbouring countries, especially the Republic Hungary etc. All above mentioned results have been obtained with our own scientific and professional potentials of the state and through very good collaboration of the State Geodetic Administration and the Republic of Croatia, Faculty of Geodesy at the University of Zagreb, and a smaller number of reputable geodetic firms. The continuation of the systematic levelling works in the Republic of Croatia can be expected in the forthcoming period as well.

References

- FEIL L., KLAK S., ROŽIĆ N. (1993): Nivellement von hoher Genauigkeit auf dem Gebiet der Republik Kroatien. Österreichische Zeitschrift für Vermessungswesen und Photogrammetrie, 1993, Heft 4, 176-182.
- FEILL, ROŽIĆ N (2000): *Proposal of the Official Height Datum* of the Republic of Croatia (in Croatian). Faculty of Geodesy, University of Zagreb, Zagreb.
- KLAK S., FEILL., ROŽIĆN., GOJCETA B. (1999): National Report on Height System. Mitteilungen des Bundesamtes für Kartographie und Geodäsie, Frankfurt am Main, Publication No.7, Volume I, 142-148.
- KLAK S., FEIL L., ROŽIĆ N., GOJCETA B. (1999a): National Report on Height System. EUREF Symposium, Prague, June 2-4, 1999, 146-149.
- KLAK S., FEIL L., ROŽIĆ N. (2000): Connecting the Precise Levelling of the Republic of Croatia and the Republic Hungary – the second part (in Croatian). Faculty of Geodesy, University of Zagreb, Zagreb.
- SACHER M., IHDE J., LANG H. (1999): *Results of the Adjustment* of the United European Levelling Network 1995 (UELN-95/98). Report by the UELN data centre, des Bundesamt für Kartographie und Geodäsie, Leipzig, Germany.