Status of the precise levelling database at the University of Warmia and Mazury in Olsztyn

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Abstract

The first levelling campaign in Poland was carried out between 1926 and 1937. The second was done between 1953 and 1955, and the third between 1974 and 1979. The results of the first two campaigns were published in a traditional way as printed catalogues. The results of the third campaign are available in numerical form. The main aim of the paper is to describe the efforts in converting the available levelling data into a database. The result of the work was collecting of all the available data in Access database.

Introduction

Temporal changes of the shape of the earth's surface affect geodetic observations in various ways. Most periodic variations are of tidal origin and can be filtered out from the original observed data. Secular variations are mainly associated with tectonic effects, which affect the precise levelling, and they are very difficult to eliminate and determine. On the other hand secular variations are very interesting phenomena from geophysical point of view.

Geometric levelling is one of the most accurate measuring techniques for the determination of heights differences. By comparing repeated measurements, relative vertical movements can be determined. In the last years various approaches have been proposed by geodesists to model vertical crustal movements. Different methods have their own advantages and disadvantages and can be adapted to different situations.

Poland has extensive records of precise levelling networks, which consist of the three primary levellings. More information can be found in WYRZYKOWSKI (1988), LYSZKOWICZ et al. (1994). The fourth levelling campaign in Poland has almost been finished (LYSZKOWICZ et al.,2001). Data from the first and second campaigns are not available digitally. Therefore, at the beginning of 2002 the Department of Surveying, University of Warmia and Mazury made tremendous efforts to collect, and convert all the available data into one levelling database. In this paper, the design process of a relational database to store precise levelling data is presented. The database structure and the relations among files have been established. Moreover, a communication module to link the database to scientific language has been created.

Description of the original data

The source data of the first levelling campaign are stored in one book *Katalog* (1939), which comprises more than three hundred pages. The main part of the catalogue contains the list of adjusted heights of the benchmarks (see fig.1). On each page of the catalogue, the information has been sorted according to the line number. For each line the following information is given:

- successive bench mark number
- type of bench mark
- distance between two neighbouring bench marks
- distance from the first bench mark
- description of the bench mark and adjusted heights

Linia 8 i 9

L. p.	Rodzaj reperu	Niwelowana odległość między reperami km	OPIS POŁOŻENIA REPERU: Km szosy, kolei	OPIS POŁOŻENIA REPERU: Nazwa miejscowości i budynku (obiektu), na którym umieszczony jest reper	Wysokość nad poziomem morza w Amsterdamie m
			Linia 8: NOWA KA CZMA — KOŚCIERZYNA. pomiar 1936 r. (szosą).		
			szosa: Tczew—Nowa Karczma—Kościerzyna		
	B	0.92	46.15	**Nowa Karczma,** dom Anny Arenzowej przy przecięciu się szosy: Tczew—Kościerzyna z szosami do Egertowa i do Gdańska, w ścianie szczytowej od strony szosy do Egertowa.	**199.176**
2	BK	2.00	47.07	Kamień niwelacyjny, reper niemiecki Nr 8426.	**196.164**
3	BK	1.43	49.07	Kamień niwelacyjny, reper niemiecki Nr 8427.	**191.718**
4	B	0.57	50.50	**Lubań,** strażnica drogowa, w ścianie od strony szosy; reper niemiecki.	**185.857**
5	BK		51.07	Kamień niwelacyjny, reper niemiecki Nr 8428.	**185.644**

Figure 1. Example of adjusted heights (last column) for line number 1, from Reda to Wielka Wieœ.

The results of the second campaign are stored in about 250 volumes *Katalog* (1960). Each volume contains the levelling data from the map in scale 1:100 000. Figure 2 shows levelling data from the N-33-144 map in the international nomenclature. On each page the information has been sorted according to the line number. For each line the following information is given

- name or number of bench mark (col.1)
- type of bench mark (col. 1,2)
- distance from the first bench mark (col. 4)
- description of the bench mark (col. 5)
- adjusted heights (col.6)

Contrary to the *Katalog 1939*, where only primary levelling lines are given, *Katalog 1960* contains information about all levelling lines existing on the territory covered by the maps in scale 1:100 000.

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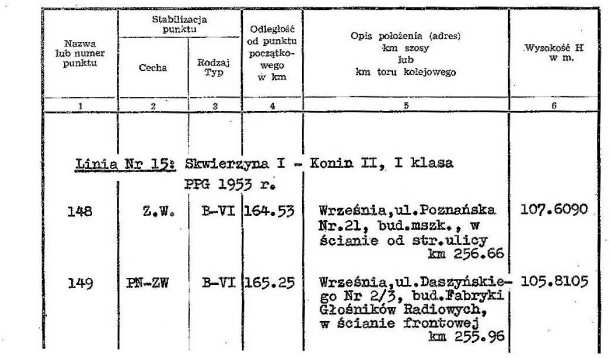
The results of the third levelling campaign are available in a digital form. The 371 lines are stored in 371 files. Each file contains information shown in fig 3.



Nazwa lub numer punktu	Stabilizacja punktu: Cecha	Stabilizacja punktu: Rodzaj Typ	Odległość od punktu początkowego w km	Opis położenia (adres) km szosy lub km toru kolejowego	Wysokość H w m.
1	2	3	4	5	6
Linia Nr 15: Skwierzyna I – Konin II, I klasa PPG 1953 r.					
148	Z.W.	B-VI	164.53	Września, ul. Poznańska Nr. 21, bud. mszk., w ścianie od str. ulicy km 256.66	107.6090
149	PN-ZW	B-VI	165.25	Września, ul. Daszyńskiego Nr 2/3, bud. Fabryki Głośników Radiowych, w ścianie frontowej km 255.96	105.8105

Figure 2. Example of adjusted heights (last column) for line number 15, from Skwierzyna to Konin..

Lp	Nr punktu	[R]	Przew.popr.	PN I	PN II	Wysokosc	Sr.bl.wys.
	Rodzaj	Typ	Kod stab.	Glowica	Grupa	Wsp. X, Wsp. Y	
Opis polozenia punktu							
1	31340032	0.00	0.00000	0	0	20.4037	8.400
	F	III	703	AB 2306	A	6097300.0, 3502600.0	
SLUPSK,UL.NOWOBRAMSKA,F.P.W.NA PL.PRZED KOSCIOLEM							
2	31340077	0.62	-2.77415	-1	-5	17.6296	0.000
	B	VI	910	B.C.	A	6097750.0, 3502300.0	
SLUPSK,UL.STASZICA 1,BUD.MSZK.							
3	31340078	0.81	0.97048	0	2	18.6000	0.000
	B	VI	880	HP	B	6097900.0, 3502400.0	
SLUPSK,UL.KOPERNIKA NR 31,BUD.SZPITALA							

Figure 3. Example of file 0001, containing line from Slupsk to Ustka.

For each line the following information is given;

- number of bench mark
- distance from the first bench mark
- corrected height difference
- normal correction, first part
- normal correction, second part
- adjusted height
- standard deviation of adjusted height
- type of bench mark
- coordinates X and Y in 1965 system
- description of the localisation of bench mark

The creation of the relation database

General description

The relation database developed in early 1970s provides a user-friendly organisation because it stores information as tables called relations. A relational database consists of one or more relations. Developing of the levelling database has been done according to the well known rules given in literature and they generally rely on:

- analysis,
- designing,
- implementation.

The first and the most important stage was analysis. First, it consisted in analysing the traditional data resources and determining the needs of potential data base users. The second step was design data base structure. Based on the results of the initial analysis, database was designed. Once the data base structure had been designed, our problem was to handle a large amount of data. The manager of this database needs to be fast and guarantee the maintenance of the integrity of the data. The manager selected was Access: because

- is easy in use
- gives simple modification of source data
- gives rapid access to information
- easily can be enlarge

In the last step, taking into the consideration the resulting data base model the applications of the system are being created in selected software environment, in our case – Access. The support for the database system and users' application was a personal computer with Windows operative system, because it is one of the most popular systems in the world.

The analysis of the traditional data base

The analysis of the existing material proves that the consecutive levelling campaigns were carried out and the results were processed in different ways. The material is not coherent. The confusing variety of data from the campaigns indicates a need for creating independent modules for each campaign. However, the modules need to be related to each other.

Relating the data to each other should be done through the common benchmarks from the campaigns. Such relation will enable to select the identical points obtained from three independent campaigns. The relation should also be carried out through the common lines from the consecutive campaigns, which will enable to compare the benchmark heights measured in different epochs.

The analysis of the prospective users' needs

The data base comprising three levelling epochs needs to contain all available data and enable searching through it according to specified criteria so as to one can carry out simple analyses.

The functional aspect is the priority. Apart from the analyses carried out in the database proper the should be a possibility of transferring the data automatically into different software environments.

The system should enable to obtain the heights of the benchmarks from different campaigns in one vertical reference frame. It is necessary to create the possibility of obtaining section and line height differences in different epochs. The data can be used in statistical analyses and in land uplift research. One may assume that the needs outlined in the initial stage will probably be supplemented by new requirements occurring as the database is being developed and used.

The database will have to be modernised and developed as data from the old and current campaigns is being gathered.

Design database structure

The database should contain heights of benchmarks, section and line height differences and height differences of levelling loops. Each of these objects needs to have attributes ascribed.

As these objects differ in the quality and number of attributes from one campaign to another, they can not be placed into one table and should be presented for each campaign separately. The defined objects should be related to each other in a way that would reflect the relationships between sections and benchmarks, sections and lines, or loops and lines. The following is presented on the figure 4.

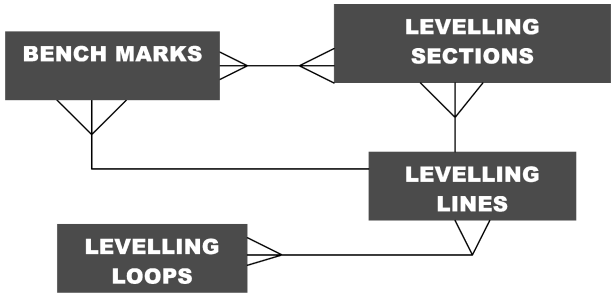


Figure 4. Relational base model for levelling observations from different campaigns.

The creation of levelling data base in Access

The designed model needs to be put into practice. Currently, work on the transmission of the data stored in traditional fashion into digital form was finished. It was done through scanning the data and saving it in digital form. Then converted data were carefully checked with original data. We must confess that it was very time consuming part of the work. Checked and corrected data was provisionally saved in Excel sheets, each line in a separate sheet.

	A	B	C	D	E	F	G
1	IDLinii	NrPunktu	Rodzaj	Odległość	Położenie	Adres	H
2	1	1	T	1,58	—	Reda, kościół parafialny, w ścianie bocznej.	14,9
3	1	2	B	1,95	1,29	Ciechocino, szkoła powszechna, w ścianie bocznej.	12,87
4	1	3	NK	2,05	3,2	Kamień niwelacyjny.	64,12
5	1	4	B		5,16	Rekowo, oberża Augustyna Kryza, w ścianie od strony	64,27
6	1	5	T	1,96	5,16	Rekowo, oberża Augustyna Kryza, w ścianie od strony	65,34
7	1	6	B	2	7,1	Sławutówko Małe, dom Gustawa Beelowa, w ścianie	31,25
8	1	7	B	2,17	1,7	szosa: Sławutówko Małe — Żelistrzewo I Kamień n	37,73
9	1	8	B	0,1	5,19	Stacja kolejowa Żelistrzewo, budynek mieszkalny kole	30,93
10	1	9	B	1,13	5,15	Żelistrzewo, dom Leona Abrahama, w ścianie od stro	30,76
11	1	10	B	0,94	4,01	Przepust kamienny.	18,9
12	1	11	B	3,04	3,1	Błądzikowo, budynek gospodarczy Billowa, w ścianie	20,84
13	1	12	B	1,59	0,3	Stacja kolejowa Puck, budynek stacyjny, w ścianie	15,95
14	1	13	B	0,03	—	Puck, dom Pawła Zientz'a naprzeciw kościoła katolicki	7,558
15	1	14	T	1,37	—	Puck, ul. Morska, kościół katolicki, w ścianie bocznej,	9,438
16	1	15	B	1,14	0,07	Most drewniany, w przyczółku betonowym od strony	3,04
17	1	16	B	2,37	1,09	Most kolejowy, w przyczółku od strony Gnieżdżewa; re	2,049
18	1	17	B	0,95	3,48	Gnieżdżewo, dom J. Bobera, w ścianie od strony szos	8,149
19	1	18	B	1,64	4,41	Stacja kolejowa Swarzewo, budynek stacyjny, w ścian	21,56
20	1	19	B	1,9	5,84	Swarzewo, kościół katolicki, w ścinIE BocżneJ	27,41
21	1	20	B	1,81	7,4	Wielka Wieś, dom Franciszka Ga^Kcianie bocznej, od	28,66
22	1	21	B			Wielka Wieś/szkoła powszechnaJ^Sille 1 'od- strony-sz	15,63
23	1	22	B		-	Wielka Wieś, szkoła powszechna, w ścianie bocznej 3	15,6
24	1	23	T		—	Wielka Wieś, szkoła powszechna, w ścianie od strony	16,88

Figure 5. Example of Access table Kampania1 with converted levelling data from Katalog 1939.

Next Excel tables with levelling data were transferred into three Access tables. Each levelling campaign was placed in a separate Access table. First table (see fig.5) called Katalog1 keeps data from the first campaign (1926-1937), table Katalog2 keeps data from the second campaign (1953-1955) and table Katalog3 comprises data from the third campaign (1974-1982).

The created in such a way levelling database enables searching through the existing benchmarks in three independent tables. One searches the catalogues entering the dialogue window where one chooses benchmark from a particular campaign is given below.

There were created additionally three more Access tables called; Linie1, Linie2 and Linie3 containing data of each campaign sorted according the line number.

The designed in such a way levelling database enables searching through the existing benchmarks in three independent catalogues from the levelling campaigns. One searches the catalogues entering the dialogue window where one chooses benchmark from a particular campaign.

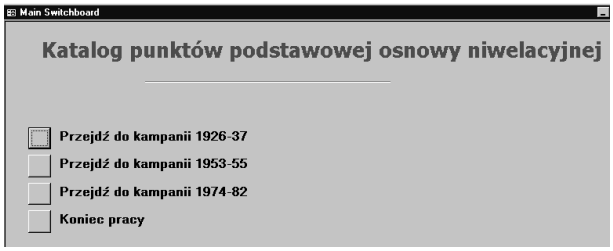


Figure 6. The dialogue window giving access to bench marks from consecutive campaigns.

Levelling database has two types of relations, one-to-one and one-to-many. All existing in database relations are shown on fig.7.

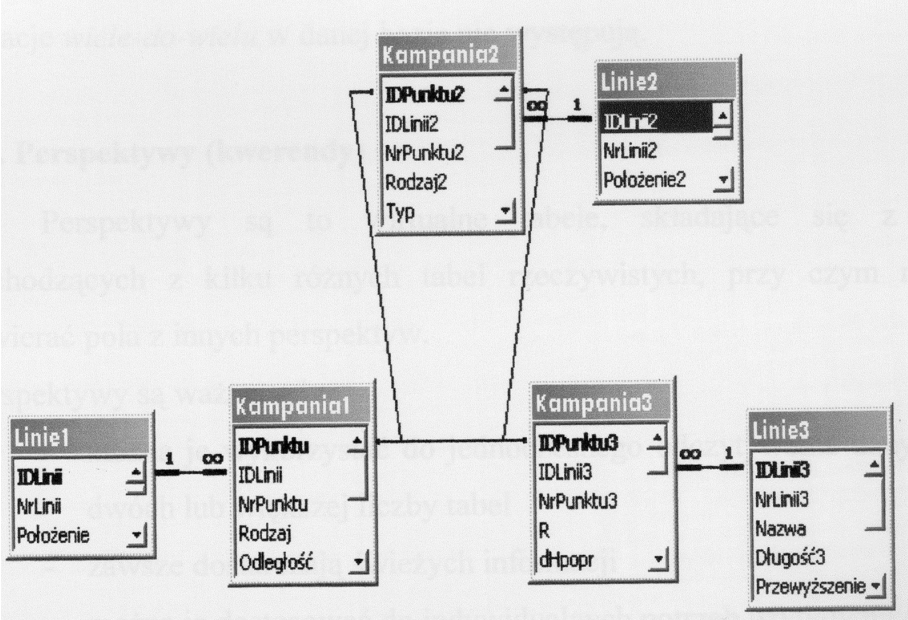


Figure 7. Relations in levelling database

It is seen that between tables Kampania1 - Linie1, Kampania 2 - Linie2, Kampania3 - linie3 there is relation one-to-one. Between tables Kampania1 - Kampania2 - Kampania3 there is relation one-to-many. Relations one-to-one enables e.g. searching common benchmarks in all three campaigns.

User's applications

Search queries are usually virtual tables, which elements comes from different real tables. They enable control, modification and display levelling data. In our case four search queries has been created. The first three (Max,min 1, Max,min 2, Max,min 3) enable us searching the height of initial and last benchmark of the given line, maximum, minimum and average height of the given line from the first, second and third campaign. The last one enable us searching the common points in campaigns. An example of the result of searching using first query is given below.

Forms give us possibility display in easy way tables and searching queries. In our database were created 14 different forms. Form Kampania 1 enable us observe information concerning the first campaign (see fig. 8).

Detail descriptions of all forms can be found in GALKA M. and SUTY J.,2002.

Max,śr,min 1 : Kwerenda wybierająca

IDLinii	Wysokość Mak	Wysokość Min	Wysokość śred	Pierwszy	Ostatni	Różnica
1	65,338	2,049	26,2214	12,867	15,946	-3,079
2	29,396	14,572	22,3637	29,396	14,572	14,824
4	100,568	32,042	66,5002	98,889	32,042	66,847
5	32,252	15,131	23,1918	19,691	15,131	4,56
6	252,298	24,717	157,0731	252,298	24,717	227,581
7	225,774	78,746	167,9210	163,434	98,889	64,545
8	199,176	163,891	181,3849	199,176	163,891	35,285
9	199,176	9	107,4461	29,948	199,176	-169,228

Figure 8. An example of search query (Max, Ńr,min 1)

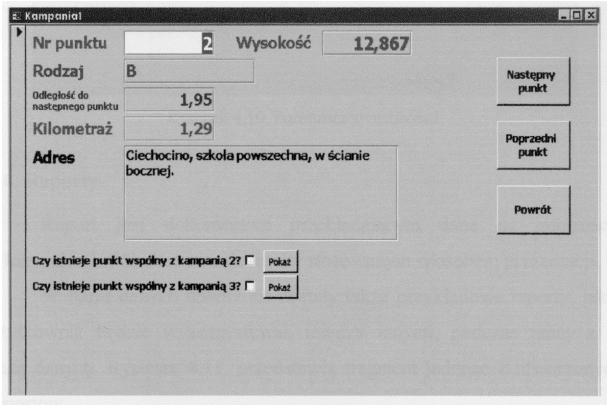


Figure 8. Form Kampania 1, which is based on table Kampania1

Conclusions

First version of levelling database was created in Department of Geodesy, University of Warmia and Mazury in Olsztyn. It comprises all available Polish precise levellings. It enables us undertake works concerning land uplift evaluation and study the propagation of systematic and random errors in levelling network. Further development of database is expected.

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