

# Calculation of object deformation category considering date of its construction

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**Abstract.** The paper presents the problems related to the two-way communication between the numerical map and programs predicting the deformation of the mining area. The issues of creating and editing of exploitation parcels based on the numerical model of the deposit have been described. The method of automatic assigning of deformation categories to objects, including the date of its construction, has been described. The possibilities of the Geolisp program in the scope of visualizing the results of prognostic calculations, searching for facilities meeting certain criteria, reporting, colouring buildings according to the deformation category, etc. were listed. The possibility of using free and open GIS class software for collecting data on construction objects located in the mining area was mentioned.

## 1. Introduction

As a result of underground mining activity, deformations of the mining area arise which cause damage to the facilities located on the surface. This problem applies to a large area of the Upper Silesian Coal Basin. By taking appropriate preventive measures in mining and in construction, it is possible to reduce the negative impact of mining operations on buildings and structures located on the surface. However, in order to ensure the greatest possible protection and usability of both existing and designed buildings, it is necessary to know the expected impacts of mineral extraction on the surface.

The calculation of the deformation prognosis is possible using the EDN program, by J. Białek [1]. The results of these calculations, obtained in the form of text databases, can be combined with a digital map using the GEOLISP [2] system. Thanks to this, it is possible to: make a topology of buildings, detect and colour the buildings whose category of resistance is lower than the category of influence or to generate a list of these buildings. Both of these programs have been used for many years on underground mining in Poland, the new feature is the possibility of automatic deformation category assignment of the object, taking into account the date of its construction.

## 2. GEOLISP software

The vast majority of hard coal mines in Poland use Geolisp software in their work – a system for creating and servicing digital mining maps [3]. This is the original program of Marian Poniewiera, whose aim is to automate the most frequent works in the field of preparation of mining maps. It is dedicated in particular to the: surveying / geological, ventilation and production preparation departments.

The Geolisp system works in a CAD environment, such as AutoCAD, BricsCAD or GstarCAD. The software is divided into a number of modules. In addition to mining and surveying, the software

includes algorithms useful for open pit mines, tools for drawing up spatial development plans as well as algorithms generating railway maps and graphs.

When creating the Geolisp system, the author assumed that the digital map is a database with software. Analysis, technical documentation and the construction of a numerical deposit model are possible. For the majority of mines, coefficients of transformation between local and national coordinate systems have been developed.

### 3. Management of exploitation data files in CAD system

Programs for forecasting calculations require data on exploitation plots saved in the form of a text file. The algorithms embedded in the Geolisp system, allow import, creation and edition this file directly from digital map level. In the next paper, currently being prepared for print, the author shows that the results of calculations based on data obtained from the deposit model may differ by up to several percent from data developed manually, and even a small difference causes a significant change in the boundary line between deformation categories. In addition, only after making the deposit model of all seams, we can be sure that used seam floor elevation, does not contain a gross error.

The recommended algorithm for creating exploitation data is:

- Creation of a geometric model of the deposit, including faults and other disturbances.
- Longwall topology implementation in order to avoid errors, e.g. overlapping.
- Projection of the parcel's shape to the floor seam. The longwalls should be defined with many vertexes, in order to secure proper alignment to the seam floor.
- Downloading remaining data from a digital map, spreadsheet or other database [4].

#### 3.1. Data creation based on digital deposit model

In the Geolisp system, nPrc command downloads data from the digital map. nPrc command:

- selects the seam name of the longwall,
- calculates the thickness and elevation of the floor based on embedded in the digital map thickness blocks and elevation data points, or based on thickness and floor TIN surfaces
- picks longwall length based on mining progress record (date),
- picks longwall starting line (based on the first recorded date),
- picks the subsidence factor, based on hatch.

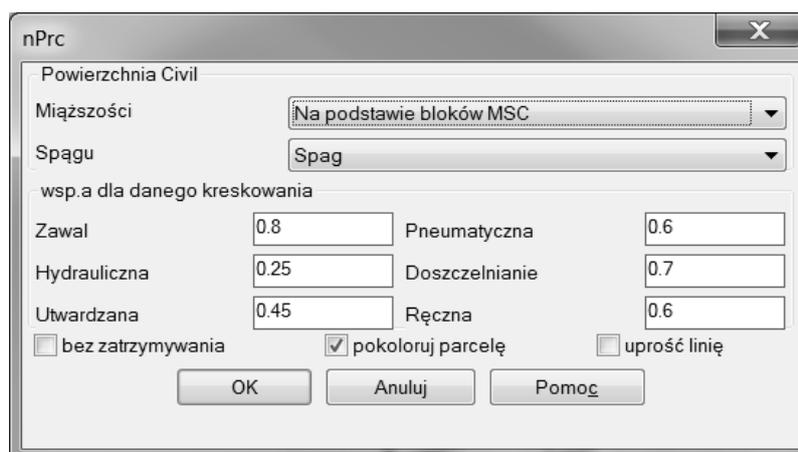


Figure 1. Creation of new exploitation parcel based on digital map.

#### 3.2. Exploitation data import

Another application - cPrc allows to load to the AutoCAD drawing, files containing parcels data, saved in the format used by the software developed by prof. J. Białek. In the EDN program, the average depth and dip angle can be given instead of the elevation of the vertexes of the parcel. If the

file "Nadklad" (cPkt command) is previously loaded into the drawing, the cPrc program will automatically convert the depths into elevations.

As a result of the program's operation, the contours of the parcels, created with a 3D polyline and texts with the name of the longwall will be inserted into the drawing.

### 3.3. Editing and saving parcels to the EDN format

Each parcel has descriptive data attached, which can be edited using the ePrc command. In the dialog box that appears after selecting the parcel, descriptive data can be entered, such as: name of the seam and longwall, average depth, subsidence factor, seam thickness, number of vertexes, start date, number of entry gates, azimuth and dip angle.

The ePrc program also allows to enter descriptive data to parcels drawn in the AutoCAD with a ordinary polyline. After selecting the parcel, appropriate data in the dialog box needs to be entered (the data of the previously edited parcel are pre - entered as default). In the EDN OPN program, the order and direction of plot contours is important - they should be drawn in the counterclockwise direction, beginning and ending on longwall face line. The location of the text describing the parcel is a form of checking the correctness of its creation - the description should be located on the longwall start line. The ePrc program gives the possibility to change the order of coordinates (when the description is on the wrong side) and to reverse the order of coordinates (when the description is outside of the parcel).

PODAJ DANE O PARCELACH			
Nr kolejny	12	ILOŚĆ WIERZCHOŁKÓW	5
NAZWA POKLADU	713-1	DATA ROZRUCHU	118.0101
NAZWA SCIANY	16-w	ILOŚĆ WYBIEGÓW	3
ŚREDNIA GLEBOKOŚĆ	0	AZYMUT	
WSP. OSIADANIA	0.45	KĄT UPADU	
GRUBOŚĆ POKLADU	2900		

Buttons: WYBIEGI, WSPÓLZEDNE, OK, Anuluj

**Figure 2.** Parcel description preview.

Data describing parcels and created in the AutoCAD drawing (loaded with the cPrc command or edited with the ePrc command) can be saved to the exploitation file in the format used by prof. J. Białek using the wPrc command. Parcel report can be also created which will contain area, tonnage, average quality parameters, etc.

## 4. Creating buildings database

The line constituting the outline of the building on the map should have additional data attached, such as: address, number of storeys, construction year (construction date can be included in the calculation of the building category), cubature, resistance category, impact category or type of the building. These data can be supplemented in several ways: manually by pointing one by one each building on the map, importing data from an Excel database or using a relational database such as Quantum GIS.

### 4.1. Manual attributes make-up

Data about buildings can be completed manually for each building on the map by means of the KatBud command. The program dialog box is shown in figure 3. Some attributes, such as the city,

emblem or category of terrain, can be completed automatically; the remaining ones must be entered manually.

**Figure 3.** Building attributes.

#### 4.2. Data import from the spreadsheet

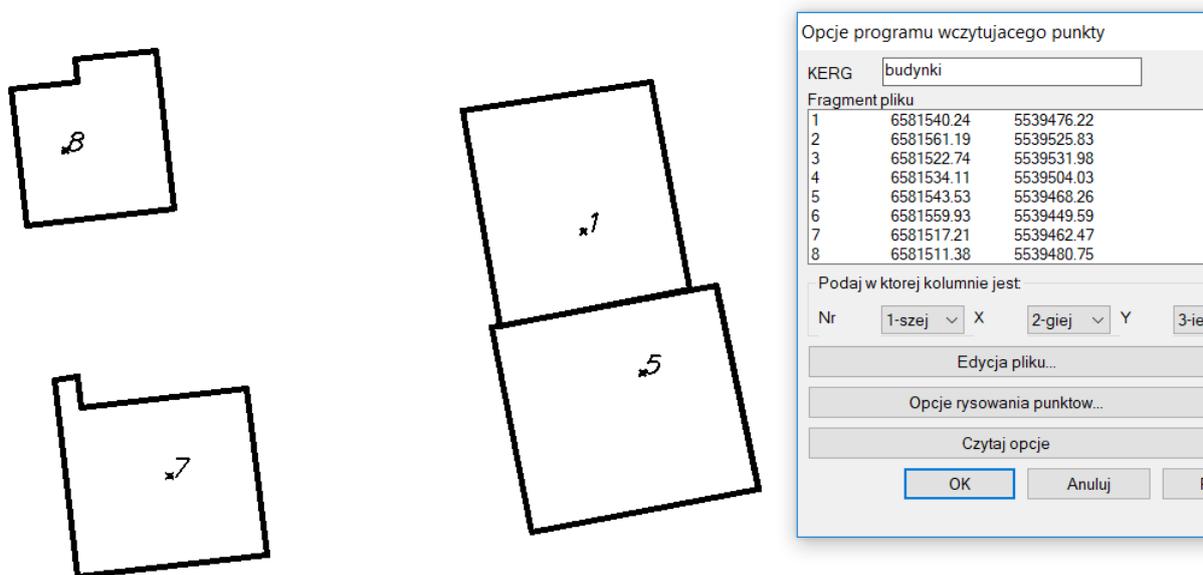
There are several ways to link data on the map with data stored in a spreadsheet. The easiest way would be if there is unique ID number on the map and on the spreadsheet. The pkt2Bud command discussed in this paragraph can be used when report created in the spreadsheet for each building contains coordinates of the point inside the building. The next paragraph 4.3 describes the situation when city, street and number is given.

In this case, the spreadsheet should start with coordinates, the remaining data describing the building can be arranged in any way (the order of the columns does not matter). A part of an exemplary report, based on which buildings will be completed on the map, is shown in figure 4.

B	C	D	E	F	G	H	I	J	K	L	M
Współrzędne w układzie Rejon/ nr inwentarza		Właściciel/	Użytkownik	Adres			Rodzaj obiektu	Kubatura (m3)	Liczba	Rok budov	Kategoria
X	Y			Miejscowość	Ulica	Nr					
m	m										
6581540	5539476.22	'26/51-98	Gil Edward	Brzeszcze	Śląska	98	garaż	311	1,5	1999	4
6581561	5539525.83	'26/11-90	Konwicka Marzena	Brzeszcze	Śląska	90	mieszkalny	732	2	1964	4
6581523	5539531.98	'26/12-94	Polak Wanda	Brzeszcze	Śląska	94	mieszkalny	576	2	1970	4
6581534	5539504.03	'26/13-96	Piłka Bożydar	Brzeszcze	Śląska	96	mieszkalny	682	2	1993	4
6581544	5539468.26	'26/14-100	Kot Wiesława	Brzeszcze	Śląska	100	mieszkalny	990	2,5	1979	4
6581560	5539440.50	'26/15-102	Isak Janusz	Brzeszcze	Śląska	102	mieszkalny	1172	2	1060	2

**Figure 4.** Part of the building report.

The work should start by creating a text file containing the X Y Numbers, which will then be loaded into the drawing using the cPkt command. As a result, points were inserted into the drawing, as presented in figure 5.



**Figure 5.** Points inserted into the drawing using the cPkt command.

Then, pkt2Bud command, assigns identifiers to the building outlines. Report with building data, in which only the ID column was completed (figure 6) was created. The report was created using the KatBudWs command, which is described in detail in section 6.

	A	B	C	D	E	F	G	H	I	J	K	L
1	Raport wszystkich budynków (tylko posiadające kategorię odporności)											
2	ID	Miasto	Nazwa ulic	Nr domu	Właściciel	Rodzaj obi	Kubatura	Kondygnac	Rok budov	Kat.odpori	Kat. teren	Kat.dyna
3		3										
4		4										

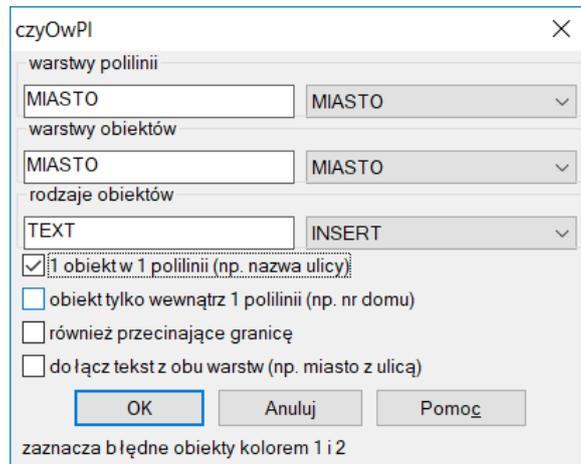
**Figure 6.** Building report created by KatBudWs command.

The report created in the above-described manner was supplemented with the possessed data and saved under the same name. Next, the data in the drawing was replaced by data from the report. The kbImport command was used for this purpose. The correctness of the program operation can be checked using the KatBud command - if the data has been correctly imported, it will be visible in the program dialog window (as in figure 3).

#### 4.3. Linking of buildings on the map with a database

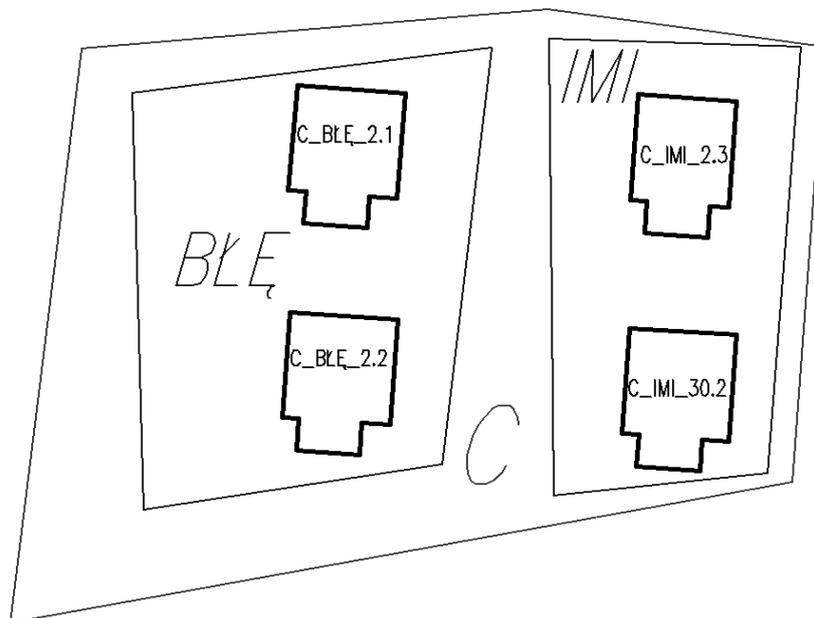
AutoCAD allows linking of existing buildings shown on the map with a database created, i.e., in MS Access. To be able to perform this operation, each building on the map and recorded in the database must have an identifier in the form of, i.e., City-Street-No. The identifiers on the map can be generated automatically if map is prepared properly. For example, if the identifier is to look like suggested above, each building must have the address number, and must be assigned to a specific city and street. For this purpose, it is necessary to outline the city border with a closed polyline, so that the buildings are inside the contour. Additionally, inside this polyline, a description such as used in the identifier in the database should be inserted (eg C - Chełm Śląski). The contour and description should be placed on a separate layer, eg "Miasto". Assigning buildings to streets needs to be done in the same way.

Next, it needs to be checked if each of the polylines on the "Miasto" layer corresponds exactly to single text on that layer. This verification can be performed with the help of the CzyOwPl command, using the settings as in figure 7.



**Figure 7.** The command to control if one description is assigned to one polyline.

If there are no errors, texts need to be combined in a way allowing to create an ID. To do this, command CzyOwPI needs to be run twice, with the option: include text from both layers (eg city with street), first connecting the street with the number (polyline layer - street, object layers - number, object types - text) and then city with number (polyline layer - city, object layers - number, types of objects - text). As a result, a correct identifier will be created and inserted on the layer number. Figure 8 shows a fragment of the map prepared in the way described above.



**Figure 8.** Buildings assigned to the city C (Chelm Śląski), streets BŁĘ (Błękitna) and I (Imielińska) together with the created identifiers.

The next step is to open the AutoCAD task window (MapWspace command). This command is used to create, display and publish maps and manage them. After switching to the map explorer tab, data source needs to be attached to the map – i.e Access database file. Afterwards link template needs to be identified. As the key column, select the column number of the registration sheet, whose data

will correspond to the created identifiers. Figure 9 shows the part of the database (column A is the key column) and the dialog box define the connection template.

	A	B	C	D	E	F
1	Numer arkusza ewidencyjnego	Miejscowość	Ulica	Numer	Rodzaj obiektu	Rok sp. Właściciel
2	C_BŁĘ_2.1	CHEŁM ŚL.	BŁĘDÓW	2	bud. mieszkalny	2016 PASTWA MARIA
3	C_BŁĘ_2.2	CHEŁM ŚL.	BŁĘDÓW	2	bud. gospodarczy	2016 PASTWA MARIA
4	C_BŁĘ_2.3	CHEŁM ŚL.	BŁĘDÓW	2	bud. garażowy	2016 PASTWA MARIA
5	C_BŁĘ_2.4	CHEŁM ŚL.	BŁĘDÓW	2	bud. garażowy	2016 PASTWA MARIA
6	C_BŁĘ_30.1	CHEŁM ŚL.	BŁĘDÓW	30	bud. mieszkalny	2016 KOLBA BEATA
7	C_BŁĘ_30.2	CHEŁM ŚL.	BŁĘDÓW	30	bud. garażowy	2016 KOLBA BEATA
8	C_BŁĘ_30A.1	CHEŁM ŚL.	BŁĘDÓW	30A	bud. mieszkalny	2016 STOLECKI TOMASZ
9	C_BŁĘ_30A.2	CHEŁM ŚL.	BŁĘDÓW	30A	bud. gospodarczo-garażowy	2016 STOLECKI TOMASZ

**Figure 9.** Defining the connection template between the drawing and the MS Access database.

In the drawing there are texts that correspond to the information in the table (identifiers). They were used to create data connections. As the type of binding, “closed texts” were selected - texts lying inside a closed polyline. The “connection option is required” must be selected too - the connection will be created only where the text corresponds to the value of the key field of an existing record. The connection was created, now if a building on the map is selected, the corresponding row in the database will open and vice versa - by selecting a row in the table, the building will be highlighted.

#### 4.4. Search of objects that meet certain criteria

In the GEOLISP system, it is possible to search for buildings that meet specific criteria. The kbSzu command allows not only searching for objects with specific features, eg two-storey buildings, located in the town of Brzeszcze, whose resistance category is 4, but also describing buildings in accordance with the established criteria. Figure 10 shows the search results for buildings with 4<sup>th</sup> resistance category.

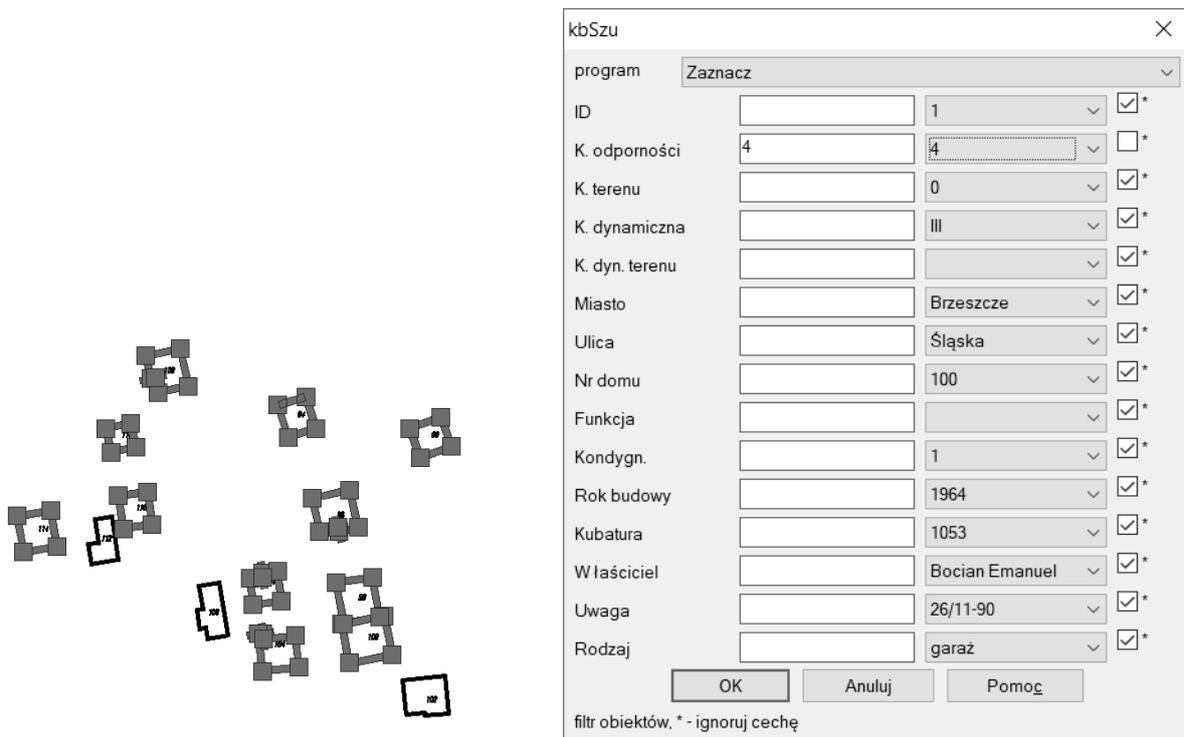


Figure 10. Selecting buildings with 4<sup>th</sup> resistance category.

## 5. How to assign terrain deformation category to the buildings based on calculations performed by an external program

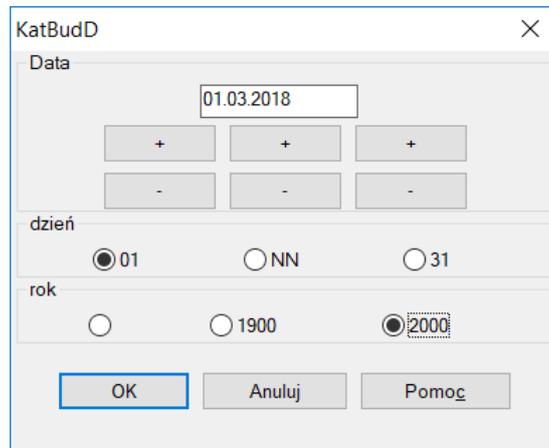
Having the parcel file created in point 3, we make calculations of the land deformation category, e.g. in the EDN program. Then we can assign these calculations to objects on the map, database or reports. Currently, we have two ways to perform these calculations, which are described in the following subsections.

### 5.1. Performing calculations disregarding a building construction date

Creating any map in the EDN program, a text file is automatically created in the form of a grid of squares, where in each vertex the value of the calculated parameter is presented, e.g. the category of deformations. The points recorded in this file can be loaded into the AutoCAD drawing using the Czyn-Grd command. Then, with the Kat2Bud command, the field "terrain category" of building attributes is automatically filled based on the nearest points. This method does not take into account the date of construction of buildings, thus we use it in the case when there was no mining activity in the analyzed area. The use of the described method of calculation for buildings built after the period of mining activity impact will cause that they will have an overstated category.

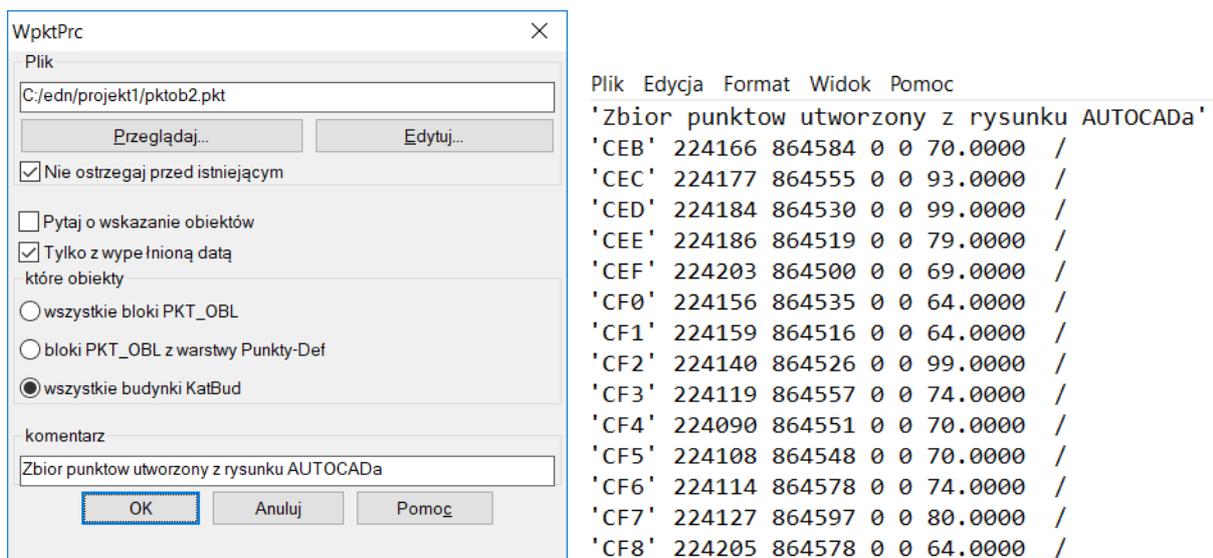
### 5.2. Performing calculations taking into account the construction date of buildings

The date of construction of the buildings shown on the drawing can be entered in several ways which were described in chapter 4. An additional method is to add the date with the help of the KatBudD command (the correct date format is dd.mm.yyyy). It is possible to specify only the year of construction. After selecting the contour of the building, a dialog window will pop-up as shown in figure 11, in which correct date must be entered.



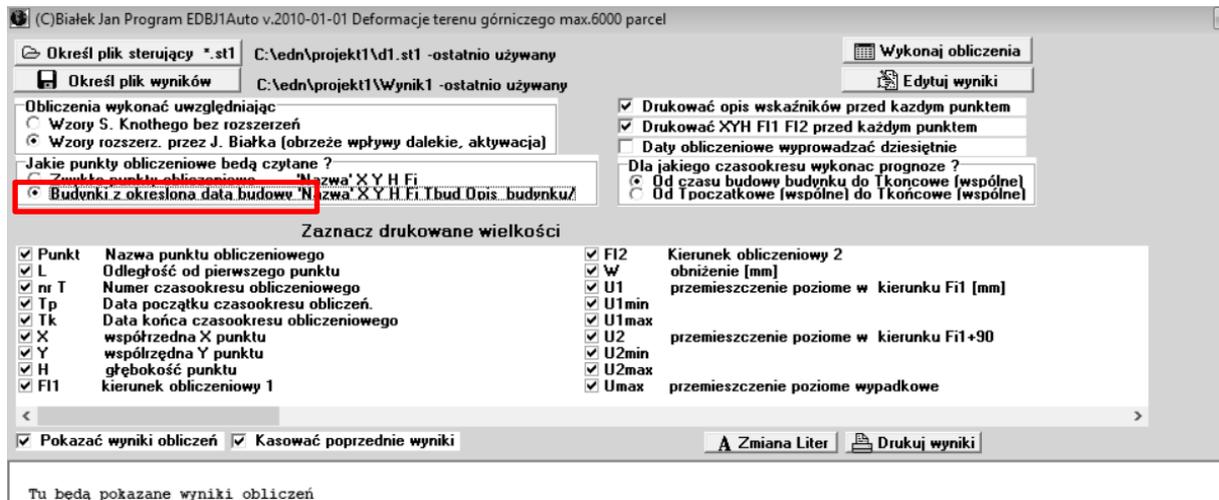
**Figure 11.** Adding construction dates to buildings using the KatBudD command.

Next, building data needs to be exported to EDN format file in the using the WpktPrc command. In the program dialog box, select the objects – “*all KatBud buildings*” and select the option “*with entered date only*”. As a result of the program calculations, the user receives a text file containing data as shown in figure 12.



**Figure 12.** The WpktPrc dialog box with a part of the file created with this program.

The next step is to calculate the category for each of calculation points in the EDN program. In the EDN1a program, a forecast should be made in the form of table 2. The option “Buildings with a specific construction date” must be selected (as in figure 13).



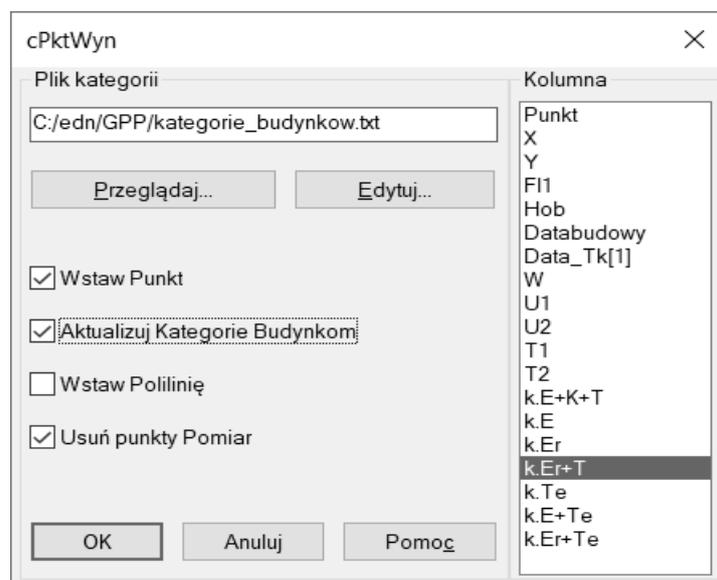
**Figure 13.** Settings in the EDN1a program.

As a result of the EDN1a program activity, a file is created. Figure 14 shows part of such file. It contains the building identifier and the parameters calculated for it.

Punkt	X	Y	FI1	Hob	Databudowy	Data_Tk[1]	W	U1	U2	T1
28	505.00	351.00	0	0	70.1201	120.0401	-1228	-20	-21	0.30
2A	354.00	272.00	0	0	70.1201	120.0401	-1166	42	73	-0.45
2F	620.00	414.00	0	0	70.1201	120.0401	-1206	-52	-33	0.85
30	606.00	420.00	0	0	70.1201	120.0401	-1215	-43	-46	0.69

**Figure 14.** A part of a file with the results of the calculation of EDN points.

To import the calculation results into a drawing, use the CpktWyn command (figure 15). The program reads the results of computation of calculation points, calculated by the EDN program. Depending on the selected option, points will be inserted into the drawing, building attributes will be updated or a 3D polyline will be created from which the chart can be made.

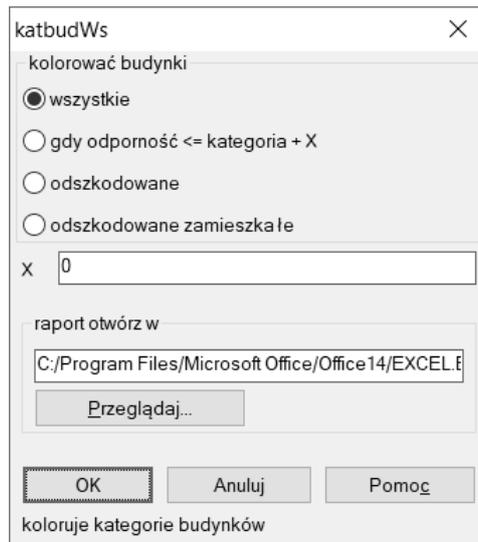


**Figure 15.** Imports of deformation categories to the buildings.

## 6. Colouring buildings, creating a report, generating isolines

In the Geolisp system, there is the KatBudWs program (figure 16), which allows you to colour buildings according to their resistance category. It is possible to colour:

- all buildings in the drawing (if the buildings does not have a specific resistance category, the program will change their colour to green),
- buildings whose resistance is less than or equal to the impact category of mining operation. + X; X is a number added to the impact category (eg. X = -2 allows to search for buildings whose resistance is 2 units less than the impact).



**Figure 16.** The KatBudWs program dialog window.

In addition, the program creates a report “a list of buildings and technical infrastructure with a category of resistance equal or lower than the category of mining area within the range of impacts of planned exploitation, including dynamic resistance to mining bumps”. The report is consistent with the formula 11 of the Regulation [5]. This report is one of the attachments to the Mining Operation Plan.

	A	B	C	D	E	F	G	H	I	J	K	L
1	Raport wszystkich budynków (tylko posiadające kategorię odporności)											
2	ID	Miasto	Nazwa ulic	Nr domu	Właściciel	Rodzaj obiektu	Kubatura	Kondygnac	Rok budov	Kat.odpori	Kat. teren	Kat.dyn
3	3	Brzeszcze	Śląska	98	Gil Edward	garaż	311	1.5	1999	4	0	III
4	4	Brzeszcze	Śląska	90	Konwicka Marzena	mieszkalny	732	2	1964	4	0	III
5	1	Brzeszcze	Śląska	94	Polak Wanda	mieszkalny	576	2	1970	4	0	III
6	5	Brzeszcze	Śląska	96	Piłka Bożydar	mieszkalny	682	2	1993	4	0	III
7	6	Brzeszcze	Śląska	100	Kot Wiesława	mieszkalny	990	2.5	1979	4	0	III
8	8	Brzeszcze	Śląska	102	Jasek Janusz	mieszkalny	1173	3	1969	3	0	III
9	7	Brzeszcze	Śląska	104	Zawada Paweł	mieszkalny	887	2	1964	4	0	III
10	9	Brzeszcze	Śląska	104	Wcisek Joanna	gospodarczy	424	1	1964	4	0	III

**Figure 17.** A part of the report created by the KatBudWs command.

Deformation isolines in CAD can be created in two ways. First - the Czy-tPlt command reads the content displayed in the EDN program. This method is simpler, but all objects are located one layer and distance between isolines can't be changed thus the Czyt-Grd program described in section 5.1 is recommended. The Czyt-Grd command creates a TIN surface, which can then be visualized with the OP command (isolines, colorings, etc.) and what is more important, calculations can be performed e.g. it allows to generate a graph of subsidence along a stream or create a predicted surface map (the most

convenient way is to create a volume surface, containing subsidence and actual terrain data). It is worth to note that in EDBJ2licz program (which calculates deformation maps) grid size can be selected - the smaller the grid, the more accurate the calculation, but the described programs will run slower.

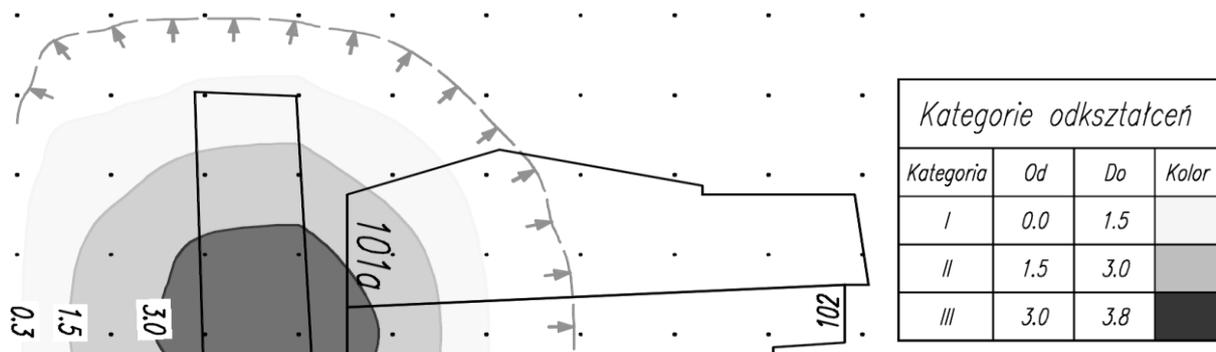


Figure 18. A part of the depression category map, created with the Czyt-grd command.

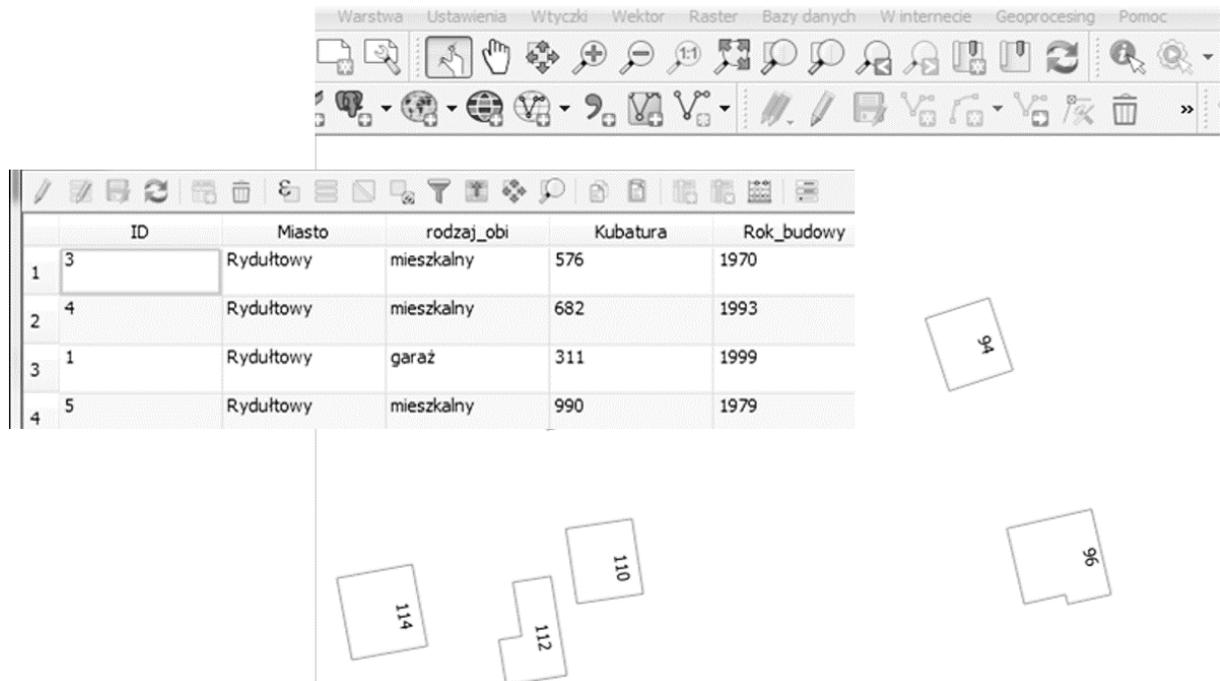
## 7. Supplementing attributes in external GIS software

To complete spatial and descriptive data about buildings, open software such as Quantum GIS [6] can be used. This is convenient, because not everyone in the mine has and is able to use CAD software. QGIS is simple and can be used to build and edit the database, while Geolisp program can be used to prepare reports and assign categories of deformations to the mining area. In order to achieve that, data need to be transferred from one system to another which is described briefly below. The assumption is, that the digital map contains buildings data with assigned attributes (e.g. as described in section 4).

If the map was prepared in a local system, it should be transformed into the state system. This can be done by using the TransK program available in the Geolisp system. TransK performs a conformal transformation between different systems. The Bud2Map command converts Geolisp data to the AutoCAD MAP descriptive table, which allows to export buildings to the shapefile format (the \_MapExport command). Different types of objects (buildings, numbers, streets, etc.) are saved to separate files.

In the Quantum GIS system the work begins with the creation of a new project, defining the coordinate system and loading shapefiles. Each of the files is automatically loaded into a separate layer, for which the display method can be specified: colour visibility or line thickness. Then, missing buildings and their attributes can be completed.

Figure 19 presents the data that is necessary to create a list in accordance with formula 11 of the Regulation [5].



**Figure 19.** Descriptive data for buildings supplemented by the QGIS program.

The data supplemented in the project are automatically saved in the original shapefiles which can be imported to AutoCAD using the `_MapImport` command. Buildings will be inserted into the drawing as ordinary polylines with descriptive data in the form of a data table - they can be viewed in the object's properties window. For data management, the `cShp` command can be used, which allows to describe the object based on the data located in the data table.

The next step is the return transformation - from the state system in which the QGIS program is operating to the local coordinate system (`TransK` command). Then, `Map2Bud` command converts the MAP descriptive data into Geolisp's additional data, which allows to run any further commands listed in this article.

## 8. Summary

The article discusses the problems associated with the creation, visualization, import and export of databases describing mining exploitation. The method of creating of exploitation parcels based on the digital deposit model was presented, which significantly increases the accuracy of calculations of forecasted terrain deformations. An algorithm for assigning descriptive attributes to building objects in both the CAD system and free GIS software has been presented. The paper also describes how to combine and transfer data between different systems. The method of automatic assignment of the deformation categories with regard to the date of building construction has been discussed. The technologies described in the article are presented on the example of Geolisp and EDN software which are popular in mining industry. Nevertheless, they are universal and can be successfully used in any systems.

## References

- [1] Białek J 2003 *Algorytmy i programy komputerowe do prognozowania deformacji terenu górnictwa* (Gliwice: Wydawnictwo Politechniki Śląskiej)
- [2] Poniewiera M 2013 Model terenu górnictwa *Przegląd Górniczy* **8** pp 170-9
- [3] Poniewiera M 2017 Zastosowanie oprogramowania Geolisp do budowy dynamicznego systemu informacji o przestrzeni górniczej *Systemy Wspomagania w Inżynierii Produkcji* **6** pp 213-22

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