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APPLICATION OF GPS FOR EXPLOITATION OF GRAVEL-SAND FROM WATER

Summary. Due to a raising usage of building materials, there is a dynamic progress of exploitation of building raw materials. Geodetic surveying of the exploited deposit can use several methods. GPS technology is one of the alternatives that determines both position and depth of a point at the same time.

APLIKACJA GPS DLA EKSPLOATACJI ŻWIRU I PIASKU Z WODY

Streszczenie. Bezustanna potrzeba materiałów budowlanych powoduje dynamiczny rozwój w eksploatacji tworzyw budowlanych. Przy geodezyjnym mierzeniu eksploatowanego łożyska używa kilka metod. Technologia GPS jest alternatywą, która ustala pozycję i głębokość punktu w jednym momencie.

1. Preface

Due to a raising usage of building materials, there is a dynamic progress of exploitation of building raw materials. To gain maximum profits from the exploitation and by observance of current legislature, norms and safety rules, the management of the mining organization tries to find new possibilities to make the most of the exploitation, to affect the progression of exploitation and the usage of exploitation machines. With such requirements also the demands on mine surveying works (done on both mines and quarries) rise.

On the basis of these needs I would like to point out the possibilities of using GPS technology and sonars for mine surveying profession at water flooded gravel-sand deposits, that are exploited in several cuts. My piece of knowledge comes from practical surveying.

Deposits of raw materials are divided into:

1. Deposits of coherent raw materials
2. Deposits of incoherent raw materials

Ad 1) Deposits of coherent raw materials are blasted by blasting operations and they are exploited in etage way in stone quarries, lime or other quarry operations. Also in block way for rough or noble stonework.

For mapping the methods of classical geodesy are used without serious problems, we use, i.e. theodolites, tachymeters, electro-optical rangefinders and recently also GPS devices. The mapping itself is not in a large extent affected by bad surrounding conditions and its quality depends mainly on preciseness and experience of surveyor.

Ad 2) Deposits of incoherent raw materials can be exploited in a dry way or in exploitation from water. When these raw materials are exploited in a dry way, it is the exploitation of gravel-sands and sands in wall localities where the exploitation is done by universal shovel excavator. Conversely, exploited from water are mainly deposits that lie below groundwater level, including exploitation from rivers and sea shelves.

Such exploitation is done in two ways. At first by machines that are placed on the bank, such as shovel excavator. At second there are dredgers that can be bucket-wheeled, grapple, shovel, sucking or hydro-pneumatic. From these machines the exploited material is transported by boats, belt conveyors or pipelines to the bank to other processing [1].

2. Possibilities of mapping of hidden topographical surface

By mapping in flooded quarries the measured surface cannot be seen and so it is a hidden topographical surface. This surface is created in working cycle of individual exploitation machines and so its course largely depends on the way of raw material disintegration. Using dredger excavator there arise quite coherent surfaces of ground. Conversely, using grapple dredger a very irregular surface of ground is created there due to disarranged movement of exploiting machine on the water level. By mapping of such surfaces it is necessary to choose proper density of measured points for a correct display of these surfaces. With respect to both required accuracy of ground course and economy of surveying.

For surveying of hidden topographical surface at irregular and not large deposits the method of cuts can be used. On the banks of water basin the piles are dug in, a wire is stretched between them so that the vertical plains between them are parallel and distant in regular intervals. Along the wire a boat moves in particular cuts. At larger water basins a theodolite or electro-optical rangefinder can be used for incorporating, instead of the wire. For surveying of large deposits it is possible to use not only the method of cuts but also the area net of measured points. Mapping is divided into two parts, i.e. determination of depth beneath the point and determination of position of the point on the water level.

Modified levelling rods, plumb lines or weight-bearing steel bands can be used for surveying of shallow depths. Another possibility of depth surveying is the method that works on a basis of differences of hydrostatical pressure of water in different depths. But due to a bad accuracy this method is not used much at present [2]. Nowadays in most cases we use a measurement by means of sonar that works on the basis of ultrasound. The advantages are high speed and simplicity of measurement, option of automatic record and satisfactory accuracy for measurement of both shallow and deep depths.

For determination of point position mainly electro-optical rangefinders are used. Methods using classical procedures have some problems that are connected with the estimation of satisfactory density of points at sustainable costs. With small density of net, undetected hollows or knolls can misrepresent the course of the hidden topographical surface. These mistakes will then affect the structure of cuts and the calculation of cubatures.

The advantages of classical procedures are their simplicity and general knowledge. Conversely, their disadvantages are time consumption of surveying, necessity of higher number of workers and also ambiguity of determination of point position towards measured depth (reading of depth is done in different moment than determination of position).

Fig. 1. Sonar Fishfinder 100 Blue
Rys. 1. Sonar Fishfinder 100 Blue

Another alternative to determine the position is the method using GPS technology that is still more popular nowadays. With the present technical possibilities and the accuracy, this method enables both elimination of ambiguity of position and depth of measured point (determination of position and reading of depth are done automatically at the same time), and improvement of effectiveness with increasing number of measured points.

GPS device Topcon HiPer+ and sonar Fishfinder 100 Blue (fig. 1) were used in this method. Sensor of the sonar was placed closely below water level by the side of the boat. GPS device was fastened at tow-boat above placing of sensor. It was necessary to determine the height of GPS device above the sensor of sonar before the start of surveying. This value was then taken into the surveying as a height of point. Separate devices were connected by cables. Such connection enabled simultaneous reading of point position and depth of ground below the point, and so the ambiguities of surveying were removed. Coordinates gained from GPS device were recorded in the internal memory of controller. The depth of the ground gained from sonar was recorded in the notes of these points.

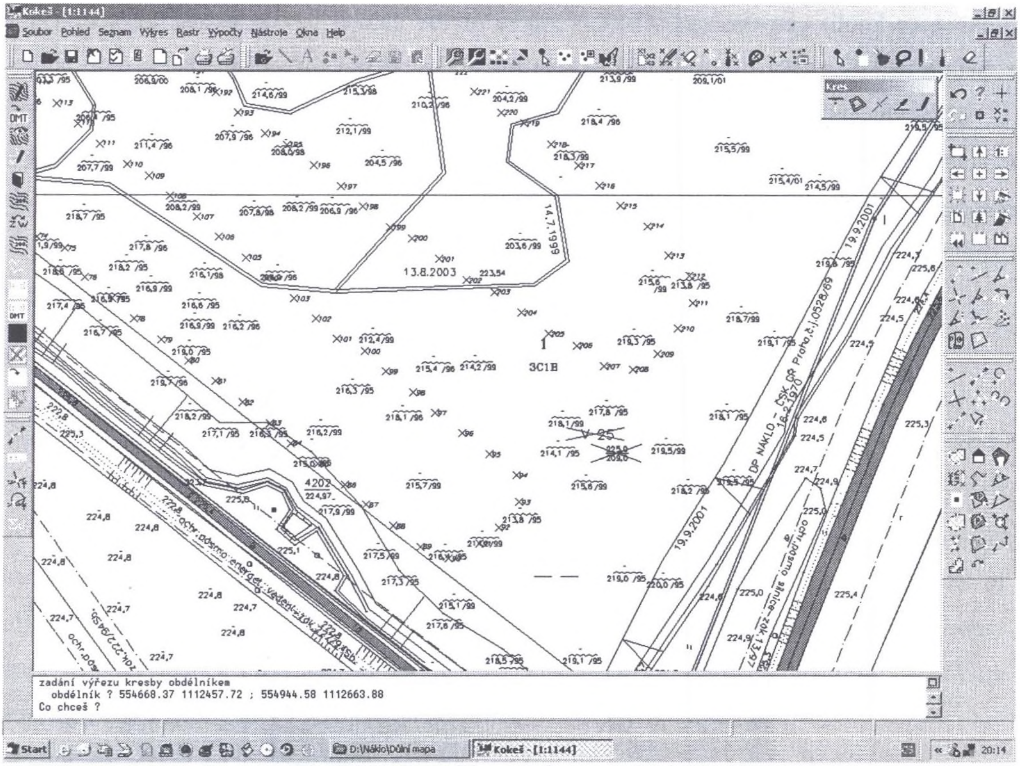

Fig. 2. Cut out of the net of measured points
Rys. 2. Wycinek sieci wymierzonych punktów

After surveying and recording of the point its position is displayed on the controller, and that enables us to create the nets of points more easily and to orient while the boat is sailing on a large water level. If we have the coordinates of the lake's margin in the controller, we can also localize unmapped parts of the deposit. And so during the surveying we already gain 100 % coverage of the locality. Thanks to this procedure we can avoid subsequent problems with data processing in computer. Most of the localities have good observation conditions where there is almost no loss of the satellite signals, and so it is possible to automate the reading of the points by using kinematic method.

During surveying there can be set the step of reading of points coordinates in GPS device by time or length interval. Size of these intervals depends on requested density of measured points and also on measuring range and on store size for recording of measured data. Length interval is usually chosen within the range of several meters, size of time interval must be revised on the basis of the moving speed of measuring tow-boat or boat. Using the length step seems to be more elegant. The distances between measured points are not affected by speed fluctuation of the boat in this case.

3. Processing of measured data

On the basis if such surveying we gain a net of points (fig. 2). Using software application, a digital model of ground (DMG) of hidden topographical surface of gravel-pit can be created from these points. This DMG can be projected into a prepared digital model of terrain (DMT) from the geological prospecting that precedes the exploitation [3, 4, 5]. From this intersection we gain the information about actual course of exploitation of the deposit (fig. 3). We can see places where the mineral is unexploited (grey places above the intersection plane) or conversely places that were exploited below the lower plane given from geological prospecting (black places below the intersection plane).

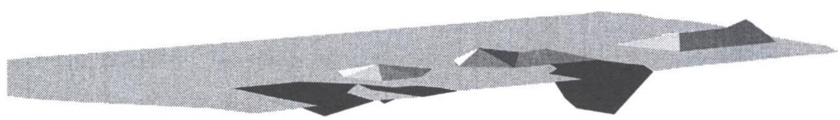

Fig. 3. 3D model of intersection of DMG and DMT
Rys. 3. 3D model skrzyżowania DMG i DTM

Individual cross-cuts can be also created from the net of measured points (fig. 4). On the figure of the cross-cut there are displayed the course of surveyed ground (dark grey) and the ground of deposit in given profile (light grey).

Fig. 4. Cross-cut
Rys. 4. Poprzeczne przecięcie

Subsequently this information affects planning of future progress of exploitation. Quality of these results depends not only on accuracy of surveying and density of measured points but also on quality of elaborated geological prospecting [6]. Even though the deposits are usually sedimentary and their course is almost horizontal, quality and carefully elaborated geological prospecting before the exploitation would ease subsequent decision steps and calculations. For easier orientation it is also possible to project measured data into the base map of quarry (fig. 5).

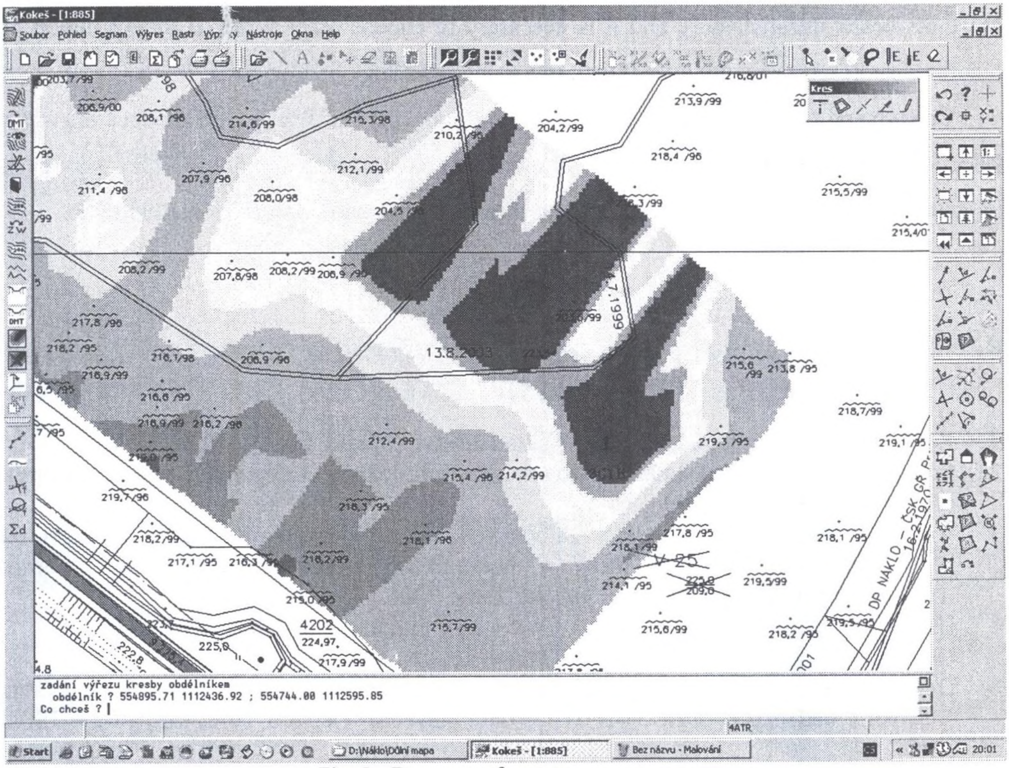

Fig. 5. Base map of quarry
Rys. 5. Mapa podstawowa kamieniołomu

With a change of position of grapple dredger there is a new work for GPS devices. With their help we lead the exploitation machine to a new place of exploitation. During the whole exploitation cycle we do a controlling surveying again using GPS and sonar.

The information resulting from intersections of DMT can be also successfully used for the application of effective progresses of exploitation of gravel-sand, e.g. calculation of cubatures, steps of movement etc. [3].

4. Conclusions

Thanks to falling prices of GPS devices their using for mapping of gravel-sand deposits becomes more common. In some exceptional cases when there are large deposits and the accuracy of position estimation is satisfactory within several meters, it is possible to use GPS device that is delivered by producer together with sonar (e.g. Garmin GPSmap 178C Sounder and GPS17-N). Though in such cases it is necessary to realize that the height accuracy of these devices is unsatisfactory and it is necessary to choose other ways of determination of height of sonar sensor on the water level, e.g. using levelling.

Consequent on what was written above, the popularity of using GPS devices on water flooded gravel-sand deposits will have an increasing character in the future. They may even become the main mine surveying devices on localities with good observation conditions.

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