

GEODETIC WORKS IN EXPLOITATION FIELDS IN THE WIDER CITY AREA OF ORAHOVICA, CROATIA

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Summary: Exploitation of natural stone is very complex in a view of legal and technical matter, and in both, geodesy has a great role. Geodetic works are necessary before, during and after quarry exploitation. Geodetic works are required for production of geological maps in cooperation with geologists, staking out of testing fields and exploitation fields, resolving of ownership issues, obtaining of legal permits and concession rights, production of mining, road and building projects, monitoring of exploitation fields, maintenance of facilities and, in the end, different tasks during restoration of quarries in ecologically acceptable state. In this work, above mentioned geodetic works are presented on an example of quarries situated near the City of Orahovica in the Republic of Croatia.

Keywords: Exploitation field, natural stone, quarry, City of Orahovica

1. INTRODUCTION

As geodesy finds its application in many branches of industry, so it does in mining during exploitation of natural stone in quarries. Geodetic works are necessary before, during and after quarry exploitation. Geodetic works are required for production of geological maps in cooperation with geologists, staking out of testing fields and exploitation fields, resolving of ownership issues, obtaining of legal permits and concession rights, production of mining, road and building projects, monitoring of exploitation fields, maintenance of facilities and, in the end, different tasks during restoration of quarries in ecologically acceptable state.

In the wider area of City of Orahovica are four quarries: Brenzberg-Točak, Žervanjska, Oršulica-kosa and Hercegovac, which are managed by Radlovac d.d. It is a firm that is

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engaged in the production of a technical stone from the diabase (eruptive rock) and dolomite (sedimentary rock). In this paper geodetic works for the needs of abovementioned quarries are described.

2. EXPLOITATION OF NATURAL STONE

Exploitation implies exploitation of natural resources, means of transport, people and nations. Exploitation field is an area within which exploitation is allowed, and it is determined by the polygon of ownership and/or concession. Within its boundaries it covers surface excavation pit, access roads, floors, area for raw materials processing plant, tailings and other auxiliary facilities. Boundaries of the excavation pits are most often defined on the basis of the approved exploitation boundaries and other legal and professional restrictions, which causes striving for maximum economic gain of raw materials from given boundaries [1]. There are two types of exploitation: surface and underground. When it comes to modern mining, surface exploitation is safer and more economic than the underground.

Process of exploitation consists of several technological phases [2]: removing and disposing of barren soil layer, drilling and mining of deep wells in diabase, embarkment of mined raw materials into conveying bunkers for grinding and classing, technical restoration and biological recultivation of quarries.

3. EXPLOITATION FIELDS IN THE WIDER CITY AREA OF ORAHOVICA, CROATIA

Natural stone is exploited in four exploitation fields in the wider area of City of Orahovica in Croatia. Those are quarries Brenzberg-Točak, Žervanjska, Oršulica-kosa and Hercegovac (Figure 1). In the fields Hercegovac and Oršulica-kosa dolomite stone is exploited, and in the fields Brenzberg-Točak and Žervanjska diabase rock is exploited. The land within the exploitation fields is partly owned by the concession holder Radlovac d.d., and partly is in the given easement on the land of the owner of the Republic of Croatia, and for the further exploitation, property and legal issues must be resolved. Aggravating circumstance for these exploitation fields is that they are settled in Nature Park Papuk, and further expansion of their boundaries is not possible, moreover, it is forbidden.

The exploitation field of dolomite stone Hercegovac has 28 hectares, and exploitation of it is in its final phase, so the terrain damaged by mining works must be remediated. The idea is to repurpose it into touristic and recreational park, mainly for local population. The exploitation field of the diabase stone Brenzberg-Točak has 42 hectares. After exploitation will be over, this quarry will probably serve as flood control lake for the Radlovac creek. The exploitation field of the diabase stone Žervanjska has 34 hectares, and it has been proven that this field has the biggest reserves of the highest quality diabase stone in the country. The exploitation will continue after fifteen years pause due to inadequate mining. The exploitation field of the dolomite stone Oršulica-kosa has 39 hectares, and it has the most proven reserves of the dolomite stone. The exploitation started in 2003, after almost fifteen years of obtaining necessary documents and permits.

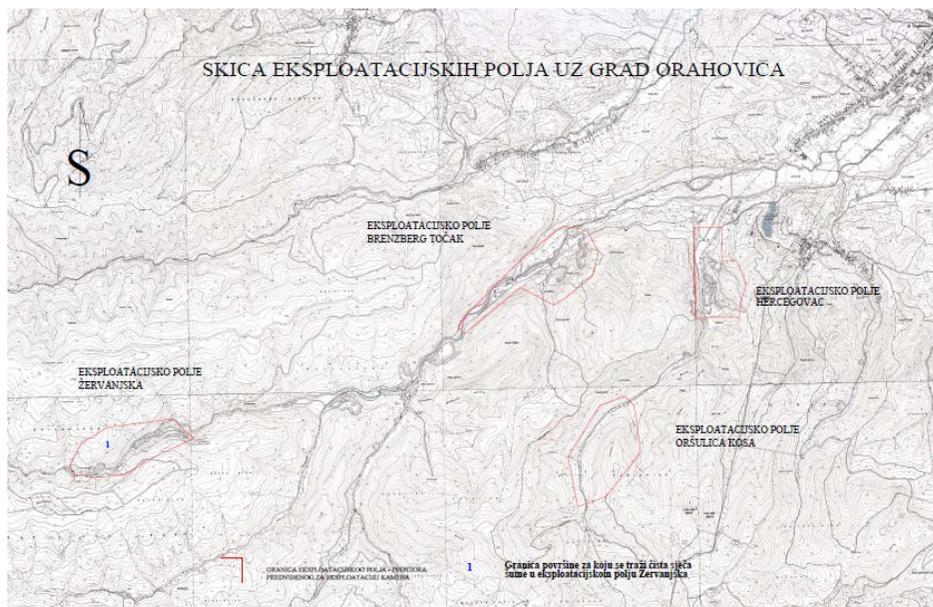


Figure 1. Map of exploitation fields in wider area of City of Orahovica

4. GEODETIC NETWORK FOR MINING

Each point is determined with its own coordinates. The goal of the geodetic survey is to obtain maximum faithful horizontal and vertical image of the terrain. Prior to any geodetic works and determining the position of the object in the space, it is necessary to establish a geodetic basis, i.e. a network of geodetic points. In specific cases, special purpose geodetic networks are established. The goal of their establishment is that they cover the working area. During the establishment of geodetic basis, we can differ geodetic points by the method of coordinates determination: trigonometric, GNSS, nodal, polygonal (traverse), levelling (benchmarks), gravimetric and astro-geodetic [3]. All surveys of surface and underground mining facilities are related to state survey. The connection of the mining survey to the state geodetic basis is necessary because of the orientation of the mining facilities in the space [4]. All surveys that allow safe operation with humans or in underground spaces within mines and quarries must be recorded, oriented and located in space and connected to a surface geodetic basis. With this aim, geodetic points are stabilized around exploitation field. These points serve as a basis for all future measurements within mining facilities. Within the quarries, most often, existing trigonometric network is filled with traverse points. Geodetic network in quarry is a type of special purpose geodetic network. In quarries it is impossible to fill out every default condition like in general geodetic networks because of presence of heavy machinery, frequent mining and insufficient education of quarry employees concerning geodetic points, which are unintentionally destroyed on regular basis. The points are set to be stabilized at the highest point of the quarry (Figure 2, left), near the quarry or at

less accessible places to prevent their destruction. After stabilization, points are marked with markers, heavy stones or rods (Figure 2, right). But even then, it they are often destroyed. As an alternative, when setting up a network, several points were marked on the terrain to make sure that at least two of the stabilized points would remain usable. The rules of clear sightline between two points and its length are often neglected, which is contrary to the rules of the geodesic profession, but this is done for practical reasons and the measurements are always within the required accuracy for mining purposes. The mining profession most often has a demand for coordinates of accuracy in meters, so it is unnecessary to display more precise data. Geodesist can display more detailed data, but because of rough work during exploitation it would be unnecessary and uneconomical.



Figure 1. Stabilization and marking of geodetic point in quarry

5. GEODETIC WORKS FOR OBTAINING LEGAL REGULATIONS FOR QUARRIES

Geodesy is needed during setting mining idea and its practical realization on the field. Geodetic works must be conducted according to mining regulations for natural stone exploitation. First task for geodesist in mining is production of geological maps in cooperation with miners and geologists. In Croatia in force is Basic Geological Map in scale 1:100 000, mapped on a topographic map in scale 1:25 000.

After an area of mining interest is found it is necessary to prove existence of reserves of raw material. Before any of mining and exploitation works, it is necessary to obtain different legal permits. It is not possible to exploit natural stone without proven reserves of raw material. Reserves are initially proven with field testing by drilling the ground and taking the samples or by electromagnetic testing. In this phase geodesist are mapping drilling points and then producing detailed geological maps of area of exploitation interest. After initial proofing of reserves of raw material, a request for change of county and city or municipality spatial plan by drawing in an exploration area is sent. When that request is approved, mining company gets a permit for thorough exploration of reserves of raw material on a strictly determined area. Geodesist again must produce a geological map with exploration drilling points. Based on that map and other exploration data, geologist decide what area will be the best for exploitation. That area is called exploitation field and it is usually much smaller than overall exploration area. After the reserves are finally proven, location permit for exploitation field is requested. When location permit is given, geodetic work is to stake out and permanently

mark borders of the exploitation field in the field. Exploitation field also must be plotted into the county and city or municipality spatial plan, after which mining project and environmental studies are being produced.

With mining project, methods and technology of mining, embarkment, transport and processing of raw materials from deposits are defined. According to Republic of Croatia regulations, in highest order projects – main mining projects, methods of exploration, calculation of raw material supplies, calculation of exploitation volume, ventilation and drainage methods, recultivation methods and protection measures are given and described [4]. With mining project all phases of exploitation, including the final phase known as the final slope, are given.

Environmental impact studies deal with the impact of exploitation on the flora and fauna in exploitation area. The impact on surface and underground waters, the impact of noise on the nearest inhabited site, the impact of dust and the impact of mechanization are considered. For the needs of environmental impact studies, geodetic task is to produce 3D relief models for simulation of noise influence on nearest neighborhood settlements. It can take several years from the production of mining project and environmental studies to their approval. In that time span, laws and regulations may change, and it is possible that new projects, studies and permits are needed. With approval of exploitation field, ownership and/or easement of land parcels which are affected with exploitation must be regulated. Usually, parcels in question are owned by the state, and praxis is a request for long-term easement on that land for the needs of exploitation of raw materials. Exploitation is not possible if property and legal relations are not resolved.

Upon completion of the property and legal issues, license for exploitation is requested, that is, a Decision for performing of mining works, which defines, along with exploitation field polygon, amount of concession fee and fee for space occupation for exploitation of raw materials. With the application for the exploitation license, proof of solved property and legal issues, permit for exploitation field, location permit, decision on confirmed reserves, and building permit for mining facilities and objects are enclosed. The concession contract is concluded for a maximum of 40 years and 5 years for restoration. Throughout the time of the concession, holders are obliged to have a position plan of the exploitation field, a cadastral plan with the boundaries of the exploitation field, the geological map and, if necessary, other plans.

6. LEGAL ISSUES BEFORE AND DURING EXPLOITATION

In previous chapter the whole procedure from preparatory works to the end of exploitation and the restoration is described. During that procedure some problems may emerge. In the Figure 3 an example of correctly performed legal regulations is presented. Land parcels 1205/11 and 1342/2 represent boundaries of exploitation field. Only for land parcel 1205/16 easement is registered in the ground book for the period of 5 years on the exploitation field Oršulica-kosa in favor of Radlovac d.d. It is needed to point out that the shape of the exploitation field doesn't depend on ownership, but on the proofing on reserves of raw materials. Land parcels are created, and easements are established according to phases listed in mining project because it is not profitable to establish easement on the whole exploitation field. One of the problems is building inside of the exploitation field. To get a building permit, subject area must be in a building zone

according to spatial plan. Objects built for the needs of exploitation field are usually for production purpose, so administration often disagrees on a building permit request because exploitation field is in an exploitation zone according to spatial plane and no production facility can be built in that zone. That problem is solved by entering a production zone inside of exploitation zone by changing the spatial plan.



Figure 2. Representation of easement right on the exploitation field Oršulica-kosa [5]

Second biggest problem is a dissent between cadastral and actual state in the field, which is noticeable on borders of cadastral municipalities, in inhabited and forest areas. In Figure 4 is shown disagreement of cadastral plan with the actual state in the field. In the cadastral municipality in the north-west parcels of quarry Žeravanjska match to actual state in the field, but in the south-east cadastral municipality, a parcel, which is also a part of the quarry, is shifted for approximately 283 meters to the north-east.



Figure 3. Example of a dissent between cadastral and actual state [5]

For the solution of problems like this one, there is a need for a cooperation between geodesist, owners of the land, in this case Republic of Croatia and its representative Croatian forests and concessionaires when producing Geodetic project to record the actual position of individual already recorded cadastral parcels.

7. GEODETIC WORKS IN EXPLOITATION FIELDS

Practically all types of raw material demand certain level of refinement or processing to be economically viable [4]. Accordingly, it is necessary to construct the plants so that the raw material can be processed (Figure 5). Often in the quarries, facilities are mobile, so it can be moved as near as possible to freshly mined materials. Geodetic task is to survey freshly mined area and produce actual state map, so the position of the facility can be planned. After the position of facility, mobile or fixed, is determined, geodesist stake out in the field planned position of the facility.

Explosives are a requisite when we talk about mining. For safe keeping of explosive, the storage must be built in the hole in the ground. During design and construction, geodesists are determining heights of the storage for explosive.

Every exploitation field needs electricity and water for normal functioning. Also, every exploitation field must be connected to a road. Geodesists must produce special purpose maps for design and construction of utility lines and access roads. Furthermore, after design is done, geodesist produce necessary documents, projects and reports for easement and building, stake out designed objects and monitor their construction, and in the end, they survey and produce final state map.



Figure 4. Facility in a quarry owned by Radlovac d.d. [6]

One of the main geodetic tasks is to take survey of exploitation fields periodically every six months. As a result of conducted surveys, situation maps are produced on which current exploitation polygon, ownership or easement boundaries, slopes and floors are shown. On a basis of that situation map, a mining inspector issues a decision on the legality of the exploitation for past period. In the Figure 6 is given an example of Situation Maps of Oršulica-kosa exploitation field, in two epochs, April and December 2016. By comparing two maps from different epochs it is possible to see progress of the exploitation of the diabase stone.

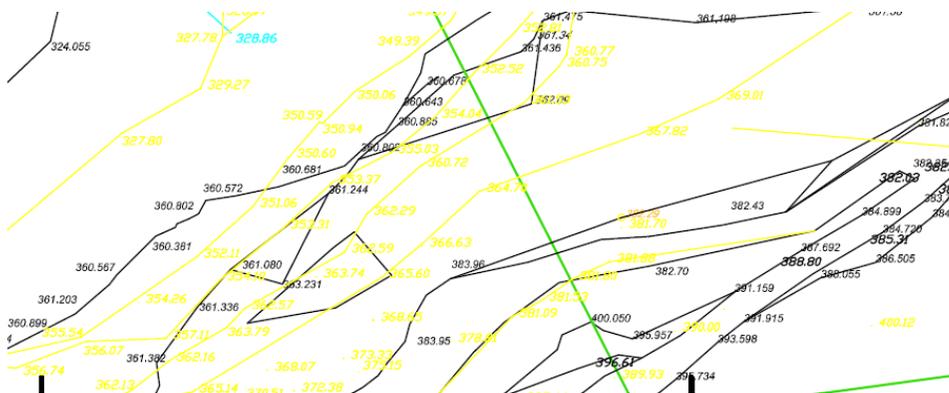


Figure 5. Situation Map (epoch April 2016 – yellow, epoch December 2016 – black) [6]

Fees for exploited raw materials is no more calculated from the volume calculated from survey conducted by geodesist, but it is calculated from the mass weighed on the exit of exploitation field.

8. CONVERSION OF QUARRIES

The Mining Act stipulates that anyone taking the stone must return the space to an environmentally acceptable space. Restoration involves restoring the original lives of the devastated area where mining activities were carried out. Geodetic works are also represented during realization of urban planning solutions. Previously, conversion implied the afforestation of the nature of the disturbed environment. Today, it is performed so that it is converted for tourist purposes. Technical remediation implies that the final slopes were performed according to the main mining project. The exploitation area is always trying to restore as much as possible the original look that is visually fit into the existing harmony.

An example of the conversion is given within the quarry Hercegovac, which is currently in restoration phase. The project was created according to the elements defined by the Mining Act and in accordance with the spatial plans of the county and the city. According to the project task, the conceptual project for the rehabilitation of quarries includes [7]:

- recovery, repair, stabilization and recultivation of space,
- construction of access roads, pedestrian and bicycle trails, with parking space and connection with Orahovac Lake and Ružica town,
- project of two viewpoints with food service on the eastern edge of the quarry, at the highest points,
- exploiting the tailings in forming of the architectural solutions,
- converting the excavation area into a tourist-recreational lake,
- physical separation of the industrial road towards Oršulica-kosa from the tourist part in the length of about 360 m,
- restoration of the medieval building into one of the complex's new buildings.

As said before, for the needs of quarry restoration, geodesist need to produce special purpose maps adequate for planning and design, from which even a 3D model can be produced (Figure 7).

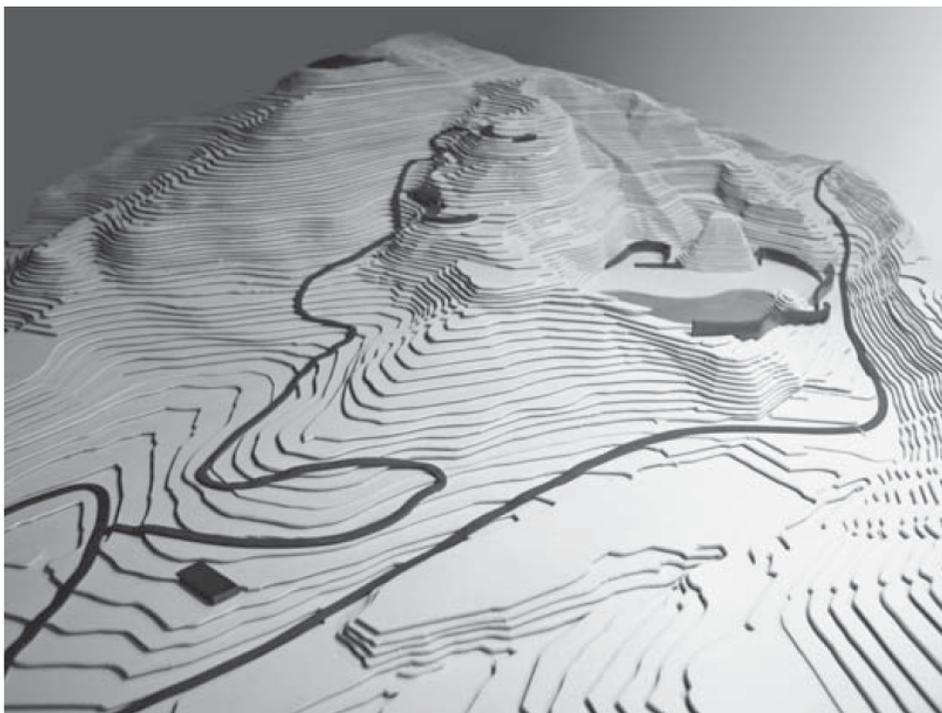


Figure 6. 3D model of the Hercegovac quarry [6]

9. CONCLUSION

The application of geodesy is highly represented in everything that accompanies exploitation of natural stone. Companies that plan to be successful and do business respecting the law and legal regulations must use geodetic services. From geodetic point of view, solution of property and legal issues is foundation of realization of mining project. Geodesist are the ones that will produce geological maps in cooperation with geologists, stake out testing fields and exploitation fields, resolve property and legal issues, obtain legal permits and concession rights, produce mining, road and building projects, monitor exploitation fields, maintenance of facilities and, in the end, carry out different tasks during restoration of quarries in ecologically acceptable state.

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ГЕОДЕТСКИ РАДОВИ НА ЕКСПЛОАТАЦИОНИМ ПОЉИМА У ШИРОЈ ОКОЛИЦА ГРАДА ОРАХОВИЦЕ У ХРВАТСКОЈ

Резиме: *Експлоатација природног камена је врло комплексна у погледу правне и стручне нарави, и у обе геодезија има велику улогу. Геодетски радови су потребни пре, за време, и након експлоатације каменолома. Геодетски радови су потребни за израду геолошких карата у сарадњи с геолозима, ископчавање испитних подручја и експлоатационих поља, решавање власничких односа, прибављање правних дозвола и концесионих права, израда рударских, цестовних и грађевних пројеката, надзор експлоатационих поља, одржавање погона и, на крају, обављање различитих задатака потребних приликом санације каменолома у еколошки прихватљиво стање. У овом раду претходно споменути послови су описани на примеру каменолома у близини града Ораховице у Републици Хрватској.*

Кључне речи: *Експлоатационо поље, природни камен, каменолом, Град Ораховица*