PROTECTION AND SANATION OF AN AREA AFTER SURFACE EXPLOITATION OF COAL IN VICINITY OF URBANE ZONES

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Summary

To perform sanation of an area which appeared as the consequence of the surface exploitation of mineral raw materials is both a legal obligation and a normal act towards one’s country, mankind and the nature itself.

Reshaping of devastated surfaces in vicinity of urbane zones is subject to additional criteria under urbane or space plans.

In the proposal for the sanation of the surface pit “Vihovići” of the coal mine Mostar, which crater is only 500m distant in air line from the town core, there were required a few additional criteria corresponding to devastated area and to the urbane zone.

Various solutions have formed a rational proposal which is presented in this work.

Note: In the text the following abbreviations are used:

RMU - brown coal mine
P.K. - surface pit
K - quota
ha - hectares (10000m²)

INTRODUCTION

Disorder of natural balance caused by surface exploitation of mineral raw materials requires, already in the phase of making project, creating of prerequisites for the sanation of the state which will appear as a consequence of mining works.

A future shape and purpose of the devastated area, as well as physical-mechanical characteristics of the accompanying layers and mineral raw materials largely influence the choice of technological process aimed at achieving conditions for newly shaped space.
The choice of final shape and its future purpose make a very complex problem influenced by a number of factors:
- type of a deposit
- kind of the exploited mineral raw material
- physical-mechanical characteristics of accompanying layers and mineral raw materials
- deposit location
- climatic conditions
- geological and hydrogeological characteristics of immediate and wider region
- macro and micro urbane solutions.

When making a proposal for the solution of sanation (technical and biological recultivation) of the surface pits situated in the immediate vicinity of urbane zones or in the very urbane zones, the settlements of space is subject to additional criteria specific for each particular urbane environment. Newly reshaped space should be maximally integrated into general town-planning of a particular environment and so obtained space should be used to a maximum degree.

The RMU Mostar, surface pit “VIHOVIĆI” is a classical example of an object situated in an urbane zone where, during exploitation, future destination of the space has not been determined, and consequently its shape which could be acceptable under criteria given for urbane zones. In the course of thirty years of exploitation, 43ha of area were devastated, 16000000m³ of solid mass discarded and 3500000t of coal exploited, and that only 500m of air line far from the centre of the town. (Fig. 1)

Investigations have been made with the scope of sanifying the resulted state and a rational shape and purpose of the future sanified space has been proposed under the most rigorous mining norms and urbane demands.

Fig. 1 Present look of the surface pit “VIHOVIĆI”
SPECIFIC ASPECTS IN RESSHAPING DEVASTATED SPACES IN URBANE ZONES

Inclinations of final slopes

In the project solutions and in the exploitations it should be tried to reduce the relationship between overburden layer and mineral raw materials to the least possible measure. Therefore, inclinations of the final pit slopes and the waste heaps are brought into a state of balance with the safety factors of $F_s = 1.3 - 1.6$. Such consideration with regard to the objects in urbane zones is subject to additional criteria which will exclude the possibility of slipping and of local rock-slides, even if extra stabilization measures are to be undertaken.

Possible directions for the settlement of devastated spaces

When considering possibilities of sanation and shaping of the new space, the ultimate scope and the purpose of an object should be known. Each urbane zone is a specific one and it requires additional pondering.

When performing mining works it is indispensable to know the future purpose of the mine for being able to adapt technical solutions and to choose adequate equipment.

By investigations the destination of the ground should be determined:

- for rural economy:
  - orchards
  - forests, plantations,
  - vegetable growing

- for sport and recreation:
  - public gardens (parks)
  - sporting-recreation pathways
  - swimming pool (pit crater)
  - playgrounds

- for building:
  - individual housing building
  - industrial objects

Such orientations will make it possible that mining technology, works out required inclinations of final slopes, of terrace slopes and horizontal plateaus during exploitation and ensures necessary carrying capacity of the ground and its shape which shall be integrated into natural medium of a certain environment.
Choice of an optimal solution

By variant propositions and by modelling, an optimal technical solution may be chosen which will respect specific conditions of a certain environment.

Economic criteria reduce technical solutions and make them rational. Influences of the basic soil, physical-mechanical characteristics of discarded masses, hydrogeology as well as immediate surrounding of an object, play also a decisive role and reduceing variants into real frames, economicaaly payable.

SETTLEMENT OF THE SPACE RESULTED FROM THE EXPLOITATION OF COAL SHOWN IN THE EXAMPLE OF THE MINE MOSTAR, SURFACE PIT “VIHOVIĆI”

Basic hydrogeological and geomechanical parameters of a deposit

Specific aspect of the coal deposit RMU Mostar is characterized by a fact that in the basic cretaceous mountain neogene strata developed with exploitatiable veins of coal.

Coal beds lie directly beside the town or in the town through which the Neretva river flows having a direct connection with the P.K. “Vihovici”, through the Neretva run or through the crevices of the cretaceous strata, so that water level of the river influences the level of the underground waters in the object. The regime of the water level is greatly influenced by underground waters from the karst region and which through old mining works flow into the crater of the pit.

Due to such a position of the surface pit, the exploitation of coal in it could be performed only during the summer months. Pumping of the water was started at the affluent of underground waters from 30m$^3$min$^{-1}$ (in the winter period the inflow of underground and surface water makes 150m$^3$min$^{-1}$).

Relatively good geomechanical characteristics of the overburden layer make it possible to carry out stable final slopes, as it follows:

for the pit crater
- the height of terraces $H \leq 15$ m
- inclination of the working slopes $\alpha \leq 75^\circ$
- inclination of the final slopes $\beta \leq 25^\circ$ by direction N-NW
  $\beta \leq 28^\circ$ by direction N-NE
  $\beta \leq 55^\circ$ by direction S-SE
- the width of the working surfaces $B \leq 10$ m.

for the waste-heap
- the height of terraces $H \leq 15$ m
- inclinations of the working slopes $\alpha \leq 30^\circ$
- inclinations of the final slopes $\beta \leq 30^\circ$
- the width of the working surface $B \leq 10$ m.

On the basis of these technological parameters which are the prerequisite for shaping the waste-heap and the pit crater, sanaation and reshaping of devastated area was started.
Defining specified-purpose zone with newly shaped areas

In collaboration with the town planners and following the town's requirements, it has been proposed that devastated spaces should be sanified and brought to the level demanded for the following purposes (taking into account natural characteristics of the rock masses and rational technical solutions; Fig. 2):

- Areas above K60 shall be shaped in a way to enable economic activities as it follows:
  - to shape flat areas on the K 135 and 120 for growing plantation orchards (area of 16ha),
  - terraced planes and slopes between K120 and 60 to be shaped in a way to enable development of green zone, indispensable for the town with Mediterranean climate (area of 12ha),
  - on the self-grown soil at the K85 to perform levelling of the ground for the requirements of trade-industrial zone (area of 10ha).

- The pit crater at the K60.47 to be shaped as a sporting-recreation zone with corresponding objects and pathways. Under the K47 (level of the Neretva run) to shape the lake with free flowing water as a swimming place (swimming place; 7ha and out of this surface the lake occupies 4.5ha) with a possibility of transforming it into an economic pisciculture.

Fig. 2 The proposal of newly shaped areas
controlled way, drained into the lake.

In the sport-fish recreation zone, surface waters shall be collected and then, in a possible or continuous manner, the lake will be drained.

So that maintains flow into the sport-fish recreation zone will be avoided, and any waters from the economic and green zones shall be drained (diverted) into the main canals.

The water from the compound region should be drained through a system of main canals. The purpose of newly shaped areas on painted surfaces determines carrying out the protection from surface waters by sport-fish systems for economic and sport-fish recreation.
A direct connection between the pit crater (K47) and the Neretva river ensures a continuous outflow of water from the lake. Minimal inflow of underground waters from the basic mountains, through the old underground mining works, in the amount of $6\text{m}^3\text{min}^{-1}$ ensures free water flowing in the lake. Since the bottom of the lake will be built in three levels (K40; K25; K10) a deep circulation, which secures purity and quality of the water, will be possible. As there is a possibility of abrupt raising of the Neretva river level, above K47, water-impenetrable doors should be placed in the Neretva run to prevent direct pouring out the water into the lake.

System of road communications

Formation of the economic and sporting-recreation zones set apart requires construction of separate systems of road communications. (Fig. 2)

Approach to the economic zone is provided by the communication at the margin of sanified spaces from the North -East and South-West parts, wide 6 m, and by direct access to the plateaus K135 and K120. Maintenance and the passage to the green zone is provided by the access roads to the terraces K120, 105, 90 and 75.

By a separate communication, directly connected to the town’s infrastructure, the access to the sporting-recreation plateau K60 is possible as well as to the circular connection around the lake K60.

Protection of the terrace slopes and final slopes of the pit crater

Specific purpose of the newly shaped spaces demands the undertaking of additional measures of protection, in particular with regard to the terrace slopes.

The terrace slopes with the inclination of $30^\circ$ at the inner waste-heaps, fulfil geomechanic conditions of stability with the safety factor $F_s=1.9$. The protection from erosion influences ought to be performed by means of the “counter” inclinations of the terraces (minimally 1%) and with a biological protection using vegetation with deep roots.

The sporting-recreation zone under the K60, which will be full during summer with picknickers, sportsmen and people who seek recreation, requires additional measures of protection on the terrace slopes inclined for $75^\circ$ and 15m high.

Wire-hurdle (net) of $25\times25\text{mm}$ will cover terrace slopes on the area of 130000m$^2$. For achieving necessary stability the wire net will be fixed with anchors in the length of 1-1.5 m, with distances of 2.5m (Fig. 4). Thus the rock-slide would be prevented and the safety of sporting-recreation zone users would be increased.
Esthetic impression and visual function of the newly shaped space

Since the newly shaped space is situated near the town, an esthetic impression, i.e. visual function of the sanitary areas has been into consideration as an additional criterium in the sanitation.

When making shape of the plateaus and the waste-heap terraces, it has been tried to lean them on the margin slopes of the mountains which surround the P.K. "Vihovici", with mild passing into horizontal planes. Final slopes of the waste-heap have been alleviated from the allowed inclinations of 30° to the inclinations of 22° to prevent any sort of local moving of masses which might make the environment ugly.

All the peripheral points of terraces and plateaus are rounded with mild passings.

Final slopes under the K60 of the allowed inclinations of 55° are alleviated to the inclination of 45°, where terrace slopes are additionally protected with the wire net which will not spoil the esthetic impression as they are placed under the surrounding ground (K75). Brims of the pit crater are rounded without pointed out parts.

The space above the K60 is biologically recultivated, by planting the vegetation and it will represent the ground which is fully integrated into the Mediterraneand (Karst) environment of the town of Mostar.
CONCLUSION

A changed outlook of the scenery is the consequence of the mining exploitation activities. The change of the scenery outlook does not mean automatically a permanently devastated environment. The sanation of the area both in the course of the exploitation and after the same is finished, should be drawn through investigations which are subject to a number of criteria and restrictions.

The vicinity of a urbane milieu demands, when carrying on the work on technical and biological recultivation, the enlarging of the extent of investigations with the scope to integrate the sanified space completely into the environment, and to have newly obtained area as useful and improved spaces so much needed in the urbane medium.

Technical (geromehanical) parameters of the working medium which present the basis of every surface exploitations (inclinations of slopes, width of terraces, stability, carrying capacity) should be additionally corrected and adapted to new demands.

The example of the P.K. ”Vihovići” is a characteristic on, due to the requirements put in front of the investigators. It shows the extent of the criteria which should have been taken into account when making the proposal for the newly shaped space and the rational usage of the sanified zones.

LITERATURE