OPTIMAL PHYSICAL MODEL FOR SELECTION OF SUPPORTING CONSTRUCTION AT THE CONSTRUCTION OF HORIZONTAL UNDERGROUND MINING FACILITIES

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The stabilization strategy of excavation field couture implies a choice of supporting methods and type of supporting material as well as the determination of the most optimal period for support installation. The optimum model reduces geomorphologic changes at the surface due to construction of underground mining facilities. Physical-mechanical characteristics of the working environment and the definition of an optimal model are challenge for scientific research, projecting, mining practice and economics, and have a very important task in making a substantial changes in a very short period of time, which must meet the requirements of modern technology within exploitation of coal deposits through the goals as follows:
- achieving a high level of coal production both in certain mines, as well as at individual face and face line;
- achieving of a higher degree of production concentration at maximum application of mechanized work as well as its maximum improving;
- introduction of new technologies for mining of small mining fields and huge coal reserves at the protective pillars left under facilities, urban and agricultural areas;
- protection of the human environment from separation scraps, electric-ach from thermal power plants, slags from the ironworks as well as part of their anew lodgment into the excavated mining facilities.

In order to properly address the further development of underground exploitation, it is necessary to have perception and define more precisely the general and specific exploitation conditions in the coal deposits and then to determine the direction of development of the exploitation technology on the basis of the results achieved so far. Due to the large differences in geological age and intensive tectonic, the exploitation conditions in our mines are significantly different from exploitation conditions in other mines in the world.

The conditions of exploitation in our country are harder and different from one deposit to another, and often between the individual excavation fields in the same deposit.

Very common occurrence in the brown coal and lignite deposits in our county is intensive tectonics, which divides excavation fields into so called "excavation blocks" of smaller dimensions.

Key words: *stabilization, meuble, polyurethanes, epoxy resin, arched roof, monitoring, geotechnique, geomorphology*

INTRODUCTION

The stabilization of the underground mine facilities is in the immediate function to the ground surface settlement. Selection of material for supporting depends on specific mine-geological and technological conditions that domineer in a specific working environment in underground facility.

- Type of rock,
- Physical parameters of the rock,
- Hydrogeological characteristics,
- Intensity and other elements of underground pressure,
- Purpose of facility.

ENGINEERING-GEOLOGICAL CONDITIONS

The geographic position of "Đurđevik" coal basin is an integral part of Banovići coal basin. It has an area of about 13 km^2 and is located about 4 km east of the central Banovići basin.

Đurđevik basin stretches northwest-southeast with a length of about 5.5 km and a variable width of 1.5-3.0 km. It is located on a triangle between the Gostelja River, to the east, to Oskova River, to the north, and to the Djedinske Mountains, to the southwest. The boundary between the floor of coal seam and the coal seam itself is not clearly defined in most cases. Some of the parties are soft, shaly and clumpy. The upper parties are stratified and consisted of unclean clay, marl, limestone. Deeper part within the floor of coal seam is consisted of fine-grained and medium-sized sandstones and plate-like marl. One brown coal seam is developed within Đurđevik basin, and it has high heat/caloric value. The thickness of the coal seam is variable and it moves 15-25 m in the northwest part to 9-11 m in the southeastern part. The general slope is of the southwest direction with varying falling angles of 12 to 30°.

Immediate roof of the coal seam is consisted of a Miocene pack of rocks, which are mostly marl-structured, clearly separated from the coal seam. The firm calcareous marl is located directly above the coal, and it is quite solid and compact with the calcite venations that tightly connect cut pieces.

The main roof is also marly, and within it there are solid, gray and spotted marl with the dark colored marls, sometimes, poorly clay. In almost whole Đurđevik basin it is characteristic the middle roof with the speckles of ribbon-like marl where the dark and bright shade of marl are being changing.

Physical-mechanical characteristics of prospecting for the determination of the optimal model

Sampling of the coal and rocks of the accompanying deposits was carried out in the form of blocks, which were cut into probation samples in the Institute’s laboratory. The data represent the average geomechanical values of the basic rocks that form the "Đurđevik" basin. In 1985 the geomechanical examinations were performed at the geomechanics institute IRJ in Tuzla. Represented in the table 1., 2.,i 3.

Table 1. Physical-mechanical parameters of the marl at the roof

Specific Gravity **γ(kN/m^3)**	Resistance to uniaxial pressure **σ_p(kN/m^2)**	Tensile strength **σ_z(kN/^{m2})**	Parameters of shearing resistance	
			Cohesion **C (kN/m^2)**	Internal friction angle **φ(°)**
23,25	61200	3830	4217	34,96

23,15	58700	3680	4123	24,99
22,66	72350	3720	4028	36
22,56	60890	3510	4300	27
23,15	45960	3930	3986	29
23,25	63700	3870	4215	33
22,95	61100	3620	3872	31
23,64	62300	3910	3926	27,97
23,44	59600	4010	4220	25,22
23,12	61400	3780	-	-
Medium parameter values				
γ(kN/m^3)	σ_p(kN/m^2)	**σ_z(kN/m2)**	C (kN/m^2)	φ(°)
23,12	60720	3786	4098	29,9

Table 2. Deformability parameters of marl at the roof

Bulk modulus **E** **(kN/m^{2}xl0^4)**	Deformation modulus **D** (kN/m^2**x 10^4)**	Poisson coefficient **ν**
605,0	409,6	0,22
558,0	368,0	0,21
742,0	557,0	0,23
520,0	458,6	0,19
650,0	410,0	0,18
600,0	591,2	0,25
760,0	410,5	0,22
605,0	420,2	0,23
592,0	425,0	0,22
610,0	325,2	0,22
Medium parameter values		
E (kN/m^{2}x IO4) 624,2	**D (kN/m^2 x 10^4) 437,53**	**ν 0,22**

Table 3. Physical-mechanic parameters of marl limestone at the bottom

Specific Gravity γ(kN/m^3)	Resistance to uniaxial pressure σ_p(kN/m^2)	Cohesion C(kN/m^2)	Internal friction angle φ(°)
23,20	42000	5750	31,30
24,28	43650	5250	39,20
24,80	59700	6930	33,00
25,14	62000	7500	37,00
24,90	49380	5660	31,60
23,70	41120	4270	39,40
24,18	45260	4950	37,20
24,10	43200	4790	35,30
23,15	41150	7120	33,00
23,20	53250	4950	39,20
Medium parameter values			
γ(kN/m^3) 24,06	Ϭp(kN/m^2) 48071	C(kN/m^2) 5717	φ(°) 35,62

ANALYSIS OF THE WORKING ENVIRONMENT

Stability includes a working environment which constitutes the useful raw material with the accompanying rocks from the roof and floor, which processed with empirical and practical methods.

Mine "Đurđevik“

An average weighted coal quality for Đurđevik deposit, which defined by immediate and elemental analysis of coal and chemical analyze of the ashes. After analysis of coal on the basis of previous research of the working environment, it has been organized preparation of the meuble samples for the laboratory testing of compression strength at the Mining-geology-civil engineering Faculty (RGGF) Tuzla for location of Đurđevik coal mine. It has been applied EU experiences as well as valid legislative and safety protocols.

DETERMINATION COMPRESSIVE STRENGTH

The sample was prepared at in-situ conditions *locality: Đurđevik Coal Mine*

Figures 1. and 2. Preparation of the samples in the mine GDN1, suspension flex BASF MEYCO

Cubes for experiment were formed by the practical application, which is presented at the figures.

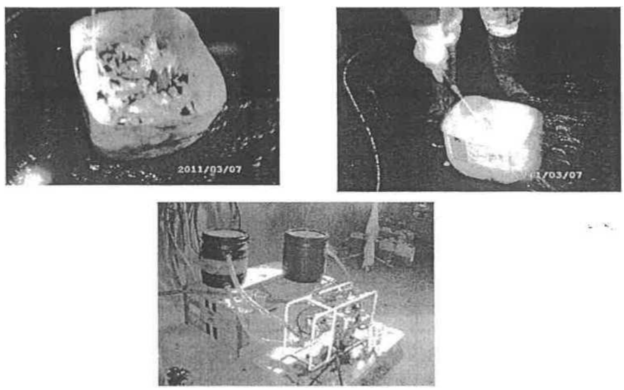

Figure 3. Determination of a compression strenght at four samples

The research results previously analyzed empirically and given through time dimension, presented in table 4.

Table 4. Tabulation of research results

SAMPLE	*U - 1*			
Test No.	*1*	*2*	*3*	*4*
DIMENSION	*100x100*	*100x100*	*100x100*	*100x100*
COMPRESSION STRENGTH **бp** *(MP a)*	*8,72*	*9,04*	*8,63*	*8,88*
TYPE	*The pieces of marl in suspension*			

PRACTICAL MODEL

Stabilization system is based on inserting a silicate compound in the borehole through IBO-IBO anchor with the aim to combine interstices at the rock massif in the area of anchor, as well as creation of a new reassignment of pressure around facility. The aim of injecting a mixture of PU (Polyurethane) under pressure is to combine the incoherent working environment, and create a stable environment. On a selected locality, it has been performed a test of stabilization of meuble material and filling empty space at the roof and side parts of the underground facility (supply corridor).

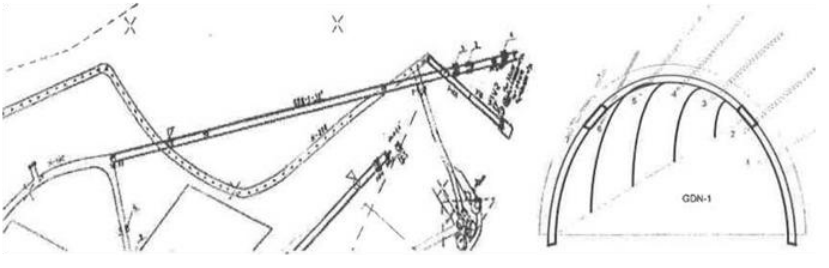

Figure 4. Location of works (GDN 1 -K + 180 main supply corridor)

This method was first applied to the underground mine "Đurđevik“ at the facilities (premises) constructed in the coal seam, with the aim to prevent self-ignition of coal, and sanation of the facilities at the area where the coal heating occurred.

Releasing material from calotte of the facility, partially removes the danger of potential hotbeds of the fire, but also creates the conditions for sanation and reconstruction.

Experimental work has been performed in the facility called GDN-1 (main supply corridor K+180), above the concrete crossings, and according to the elaborate number 45/1.

This method shows the possibilities of application and usage of polyurethane (PU) mixture in the meuble and non-meuble working environment in the underground mine „Đurđevik“ with the usage of geotechnical anchors, as well as accepting of new technologies and methods.

DESCRIPTION OF WORKS

The proper selection of observation of rocks, and the optimal safety ways of supporting, reduces the risk of changing the morphological ground surface above the constructed horizontal underground facilities (premises).

Cleavage, faults, folds and other discontinuities are stabilizing. Proper selection of support is important for retrograde metamorphism as well as ultra-metamorphism.

Results of the research consolidate all factors of metamorphosis as well as provide support in the calotte of underground facility and prevent the influence of the underground pressure on the degradation of the surface. The location to test the effect of injecting has been selected with the reason due it was previously planned the reconstruction of this part of the facility. This part of facility was supported with the steel arch support, additionally secured with wooden planks and net. Position of the wells, direction and length of anchors, has been defined by the expert team who directed all works.

Length of wells was different and depended on the amount of meuble material at the ceiling and sides, while self-drilling anchors penetrated all the way to the solid part (undisturbed) working environment. The aim was that PU resin with anchor combine the crunched part of massive with the rocks.

The number, length and position of the anchors, in this case, will depend on the size of the calotte. Anchors must be so long that they can be safe and deep enough to strengthen the load-bearing rock and so strong to carry the weight of the built mass. The calculations are based on technical characteristic issues by manufacturer DSI/ALWAG dimensioned according to EU regulations.

IBO anchors are successfully used for anchoring in the inferior working environment – unbound sediments, i.e. with different geological conditions. The anchor body is a cold rolled thread, and it is equal to serrated drilling bar and pipe for injection.
Beginning of work, preparation and drilling of „borr-hamer“with the self-drilling anchor.

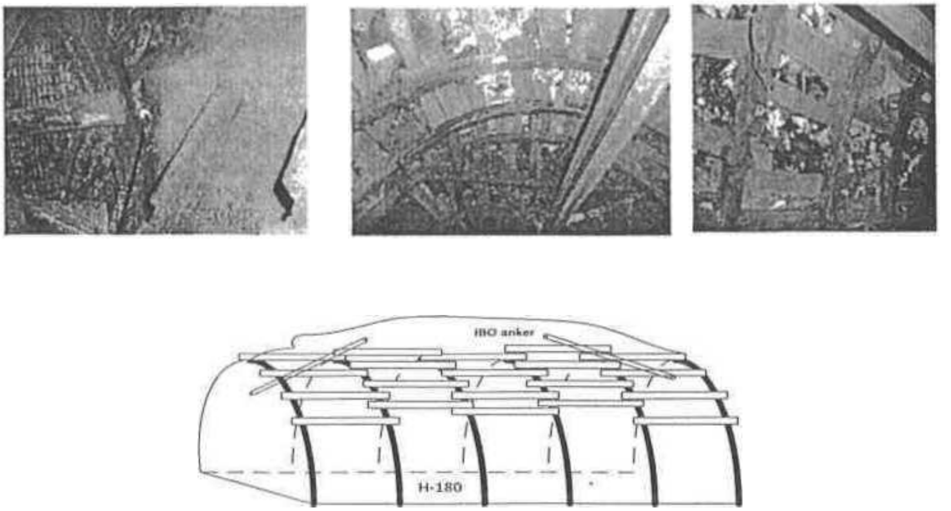

Figure 5,6,7,8. A method of stabilizing, installation of packers, geotechnical anchors and suspensions of Basf/ MEYCO

By detailed calculations of the required number of anchors, anchor capacity, the analysis of each case taking into account the shape, and optionally clamp of the rock block, as well as the friction force between the intersecting planes of the rock, it has been processed condition for the practical production of the model, for the unbound and the bound sediments.

In according to these conditions, it has been decided to conduct testing injection at the chosen location as well as plugging empty space with the aim to prevent self-ignition of the coal as well as sanation of the facility. A method for stabilizing meuble parts of the working environment was conducted by foreign and domestic experts and has shown good results.

Underground mines in Bosnia and Herzegovina with this type of issues should apply this MODEL with the aim to increase safety and efficiency at the exploitation of raw material. Working system has been based on selection of the mass suspension, its injection by the IBO anchor and creating the new pressure condition at the stabilization site. The selected injection mixture solved the problem in a very quality way, and it has been established a diagnoses for handling safety at the ceiling of underground facilities in coal mine „Đurđevik“. The new methodology for mines prevents degradation of the surface and reduces an indirect cost at the mine.

RESULTS OF APPLICATION

Stabilizing has been performed with two-component polyurethane mixtures, selected for the current conditions. It was a quick-attaching mixture from manufacturer BASF/MEYCO, that archived a mechanical strength over 8 (MPa) and more, for in-situ conditions of the meuble ceilings and sides at the underground facility. The reaction was operated with addition of accelerator. Factor of expansion depended on the parameters of the working environment that has to be stabilized. If it were to work on a larger rock meuble ceiling, sides or floor, it is necessary to achieve a larger expansion factor in order to fill the gap between the individual blocks of the rock. If it is a smaller nubanded material the reaction speed should be lower, and the expansion factor is smaller.

It has been recommended a proven model for an experiential choice of construction and support of the underground facilities, with continuous geologic supervision of the lithological structure.

Model: Volumetric physical characteristics of sediments in the form of Geomorphology.

Success of stabilization as well as protecting the underground facilities shows a good result, which confirmed applicability of polyurethane mixtures in the mining where this model was not used before but even they have significant problems.

According to above mentioned stabilization factor, after filling so-called bell-shape, it has been reduced power consumption for 20% at the ventilation, and increases the coefficient of safety for 35%.

DISCUSSION

The introduction of stabilization technology of meuble working environment in the coal mines, with the aim of isolation of facilities, reducing the possibilities of self-ignition of coal, the protecting of facilities is a scientific novelty in the mines which should be given special attention. That is confirmed through the results of research in the coal mine „Đurđevik".

A method for stabilizing an empirical and practical stresses the application of the model and based on simplicity, safety use of constructional hernia is extremely cost-effective for all operating conditions

The silicate mass used to combine the rock material is very good quality. It has good strength and high ignition point. It is according to international standards, and is applicable.

The filling of the cavity at the ceiling of the GDN-1 and the installation of the IBO anchors proved to be a good alternative to the future of the market survival of mines.

Stabilization of the sides at the underground facility GDN-1 in coal mine „Đurđevik" allowed its stabilization as well as prevent demolishing and oxidation.

Within work process it has not found any harmful effects of chemical components to workers nor environment.

This method is extremely flexible and it can find a wide range of applications in mine, especially in:

- Filling an empty spaces in the mine
- Consolidation of the crumbly rock massive
- Sanation of the fire area in the mine
- Isolation of excavated spaces in the mine and solving the problem of

In the long term, from the economic points of view, using this method would result with savings at the maintenance of facilities as well as frequent reconstructions. The range between the arches would additionally increase up to 45%. This application in combination with anchoring would greatly contribute to achieving safety of the underground facilities, and unobtrusive anticipated activities during the exploitation and maintenance of underground facilities in terms of increasing the profile of the facility itself.

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