BALKANMINE 2009

3rd BALKAN MINING CONGRESS
3. BALKAN MADENCİLİK KONGRESİ

October 1-3, 2009
İzmir-TURKEY

This Congress is supported by TÜBİTAK (The Scientific and Technological Research Council of Turkey)

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UCTEA
The Chamber of Mining Engineers of Turkey

Published by Gurup Matbaacılık, Ankara, Turkey
Phone: +90 (312) 384 73 44   Fax: +90 (312) 384 73 46

Puplication No. : 160
ISBN : 978-9944-89-782-2

Adress: Selanik Cad. 19/3 06650 - Kızılay, Ankara - TURKEY
Phone : +90 (312) 425 10 80   Faks: +90 (312) 417 52 90
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SUNUŞ

Odamız, gerek bilimsel ve teknik bilginin paylaşılması, gerekse ulusal ve evrensel meslek ilkeleri ve sorumlulukları temelinde uluslararası dayanışma amacıyla, diğer ülkelerin meslek örgütleriyle ve üniversiteleriyle iletişim içerisinde bulunmayı önemsemektedir.

Bu çerçevede söz konusu örgütlenmeler ile iletişime geçilmesi hususunda çalışmalar başlatılmıştır. Bu doğrultuda birincisi 2005 yılında Sofya'da, ikincisi 2007 yılında Belgrat'ta düzenlenen Balkan Madencilik Kongresi'nin üçüncüsü Odamızın ev sahipliğiyle ülkemizde düzenlenmektedir.

Dünyada bilim ve teknoloji alanında çok hızlı bir gelişim ve değişim süreci yaşanmaktadır. Üretilen bilginin her 2-3 yılda ikiye katlandığı ileri sürülmektedir. Bilime ve teknolojiye hakim olan güçler dünyayı da egemenlikleri altına almaktadır. Bu nedenle gelişmiş ülkeler bütçelerinden mühendislik- bilim teknoloji ve eğitim alt yapısına ayırdıkları payı gün geçtikçe arttırmaktadır.

Madencilik sektöründe aramadan uç ürüne kadar her aşamada ileri teknoloji kullanılmalıdır. Üretim ve kaynak performansının iyileştirilmesine ve yeni ürünlerin elde edilmesine yönelik olarak yeni gelişen teknolojilerin kullanımı, bu sektörün ülke kalkınmasına katkısı bakımından son derece önemlidir. Bu nedenle sektörde yüksek teknoloji kullanımı ve üretilmesine yönelik araştırma-geliştirme çalışmalarına öncelik verilmelidir. İleri üretim teknolojilerinin geliştirilmesi ve kullanımı, daha temiz ve daha etkin madencilik süreç ve ürünlerinin temini bakımından önkoşuldur.

Bu Kongre'de sektördeki teknolojik gelişmeler paylaşılırken, ülkemizin madencilik sektörünün tanıtımı da yapılacaktır. Balkan ülkelerindeki maden mühendislerinin ve yerbilimcilerin bir araya geleceği toplantılar da deneyimlerin ve teknik bilginin paylaşımı amaçlanmıştır.

Kongre'nin gerçekleşmesine katkı koyan Yürütme Kurulu Başkanı Bahtiyar ÜNVER başta olmak üzere tüm Yürütme Kurulu üyelerine, Balkan Madencilik Kongresi Koordinasyon Kurulu Üyesi Tevfik GÜYAGÜLER'e ve emeği geçen herkese teşekkür ederiz.

Saygılarımızla

YÖNETİM KURULU

FOREWORD

The 3rd Balkan Mining Congress (BALKANMINE 2009) organized by Balkan Mining Association, BALKANMINE and The Chamber of Mining Engineers of Turkey is held between October 1-3 in İzmir, Turkey. The primary objective of the Congress is to promote operational, economical and scientific information pertaining to all aspects of mining technology, energy and sustainable development.

In conjunction with the Congress, 3rd Mining, Natural Resources and Technology Fair of Turkey, MINEX 2009 is organized at the same location for the exhibition of mining products together with companies offering machinery, equipment, instruments, software and services to mining, processing and energy industries.

The papers included in the proceedings volume have been grouped under ten specific themes including, Balkan Mining Industry; Mineral Resources and Mine Geology; Exploitation; Process Engineering; Rock Engineering and Design; Computer Applications in Mining and Processing; Management and Mining Economics; Ventilation and Safety; Mining and Environment; History and Mine Education. The 98 papers included in this volume have been prepared by authors from 14 countries. I am confident to state that papers included in this proceedings volume are testimonials to the vibrant role that mining technology plays in the identification and establishment of routes to sustainable resource development, environmental protection and globalization.

Every successful congress stems from a teamwork approach. We owe gratitude to the members of the Organizing Committee, Balkan Mining Association Coordination Committee, Executive Board of the Chamber of Mining Engineers of Turkey and Chairpersons of the technical sessions. There is no need to mention that this proceedings volume and the BALKANMINE 2009 would not come to reality without contributions of the speakers and authors. Our most genuine appreciation also goes to the delegates for their interest and contributions to the success of the Congress.

We acknowledge with gratitude the financial support provided by TÜBİTAK, The Scientific and Technological Research Council of Turkey. We also owe gratitude to İZFAŞ, İzmir Fair Services Culture and Art Affairs Trade Inc., for their professional effort in the preparation of the Congress venue.

Once again, I thank all of the participants of the BALKANMINE 2009 for their contributions which will become instrumental in the enhancement of our scientific and professional development. I am delighted to reiterate that it is a great pleasure for me to welcome all friends and colleagues to İzmir, to a congress that you will find technically stimulating and socially enjoyable.

Dr. Bahtiyar ÜNVER

for the Organizing Committee

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3rd Balkan Mining Congress, BALKANMINE 2009, 1-3 October, İzmir-TURKEY, © 2009, ISBN 978-9944-89-782-2

Stability Aspects of Excavations in Landslide Zone for a Coal mine "Suvodol" - R.Macedonia

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ABSTRACT: The paper presents some elements of stability aspects and approach used for excavation at the toe of the large landslide which exists on a NE part of coal mine "Suvodol" in R.Macedonia. Its volume is about 30,000,000 m^3. Upper of the main scarp, the earth-fill dam with a length of about 1000 meters exists. As a result of mass movements, about 8,000,000 tonnes of coal is blocked at the toe of the landslide. After a longer time of exposition to the air, the crushed coal is partially involved in a process of self-burning.

Specific combination of natural and man-made elements that control the stability of the area and specific methodology used for an excavation at the toe of sliding mass is shortly explained.

The results from the stability analyses, risks scenarios, some specific comments and recommendations, are summarized in this paper. Some specific comments are also given.

1 INTRODUCTION

The coal mine "Suvodol" is placed on SW part of the Republic of Macedonia.

It is a main source for thermal-electricity plants with coal production of about 6,500,000 tonnes per year.

At NE part of the mine, during 1995 large landslide appeared. The appearance of the landslide caused some difficulties in the normal work of the exploitation systems and it was a potential danger for the upstream earth dam which is spaced about 250 m from the main scarp of the landslide.

In order to adopt the technology of the excavation to such complex conditions, several interrelated steps of investigations and design were applied, starting from the time of occurrence till present moment.

For example, authors of the paper were involved in several phases of landslide investigations, as well as in some design phases. The investigations were complex and with large quantity, in order to prepare data for physical and analytical modeling.

Later, the data are used as a base for stability and dewatering analyses, protection from surface and groundwater's, excavation conditions and so on.

The methodology and results from investigation are explained by Gapkovski *et.al.* (1996a,b); Jovanovski & Gapkovski (1996 and 1997). The design elements are given by Jovanovski *et.al.* (2007a,b) and Panovski *et.al.* (2007).

2 OVERVIEW ON LANDSLIDE ELEMENTS AND CHARACTERISTICS

2.1 History Of Event, Problems And Scale Of Event

The initial phase of landslide activation was at the end of 1995, but several large reactivation phases were also present in 1997 and 1998. Some smaller movements were also present in parts of the landslide continuously.

One of the main problems (risks) was to solve problem with possible extension of the sliding process retrogressively to the upstream earth-fill dam direction.

This was solved using of techniques of dewatering on the space between dam and main landslide scarp with vertical and horizontal systems. The main idea was to decrease hydrostatic and hydrodynamic forces and to reduce groundwater inflow to the landslide zone. Other aspects were to define newly created conditions and to see possibility of excavate the blocked coal at the toe of landslide. In order to illustrate the scale of the event, the main elements of the landslide are given in Table 1.

Table 1. Main landslide elements.

Landslide element	*Value*
Length (m)	About 1700
Wide (m)	Min 650
	Max 880
Area (m^2)	About 1,050,000
Volume (m^3)	About 30,000,000
Depth to sliding zone (m)	Min 14
	Max 55

In Figure 1, we present map with relative subsidence and uprising of the field, after the phase of main activation.

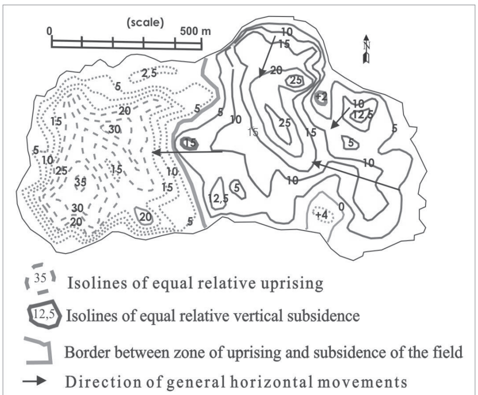

Figure 1. Map with relative subsidence and uprising of the field.

The map is prepared using elevations of the ground before and after main sliding process.

In Figure 2, we present the map with thickness of sliding mass.

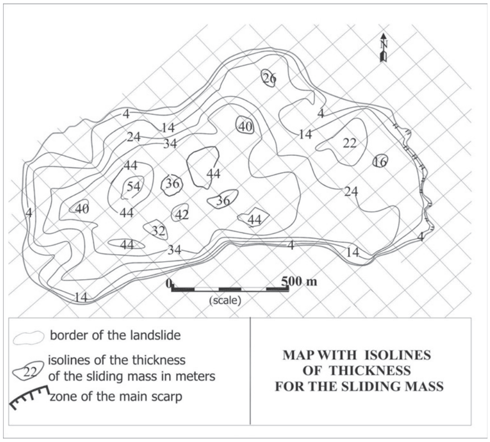

Figure 2. Map with thickness contour lines of sliding mass (in meters).

In this case, groundwater conditions have the greatest influence on the stability. The presence of the aquifer zone under pressure and gas influences is defined for all area bellow the disturbed coal layer.

An important and very restrictive additional factor was a process of self-burning, which happened because of coal direct exposition on the fresh air.

Results from the investigations, indicates that the sliding surfaces are very deep, usually along coal-like clay and silts with high plasticity. One of the main characteristics is also the great heterogeneity of the lithological composition.

A lot of secondary scarps and zone of "secondary toe" were also defined. Artesian effects are directly observed during drilling. Huge quantity of sand was transported from drilling bottom to the ground surface, because of high artesian pressures and hydraulic gradients.

Shortly, the problem is too complex and unique, that every technical action is always connected with numerous restrictions and risks, which is shortly explained in this article. To illustrate better the scale of the process, landslide elements in horizontal view are given Figure 3.

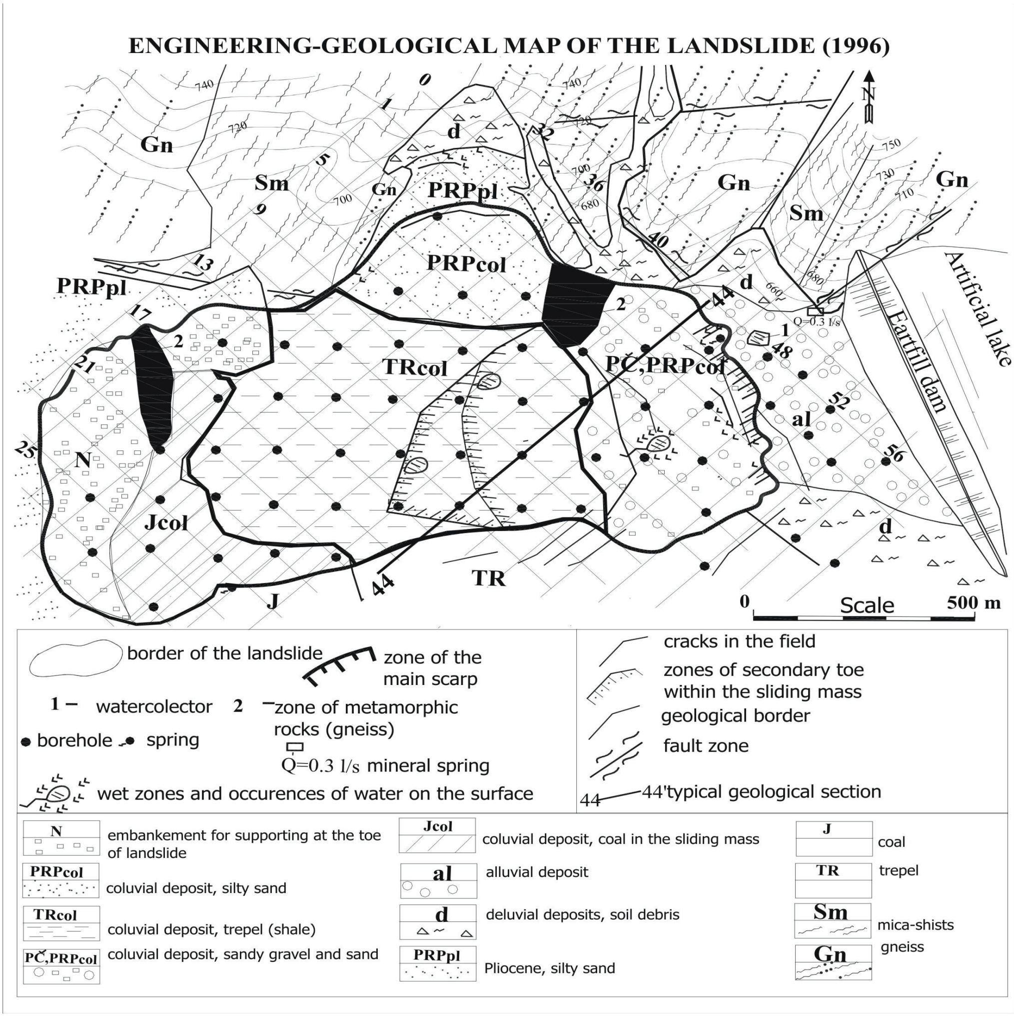

Figure 3. Engineering-geological map of landslide zone and surrounding.

2.2 Geotechnical Parameters

The most important characteristics for the main sediments are: the high plasticity and water content of coal like clay and silts, high value of uniformity coefficient, low shear strength of coal-like clay and silts with high plasticity, and high decreasing of shear – strength properties of main group of sediments after sliding process.

The typical range of physical properties is given in Figure 4.

The range of values for shear strength is given in Figure 5. The cases before and after sliding are presented.

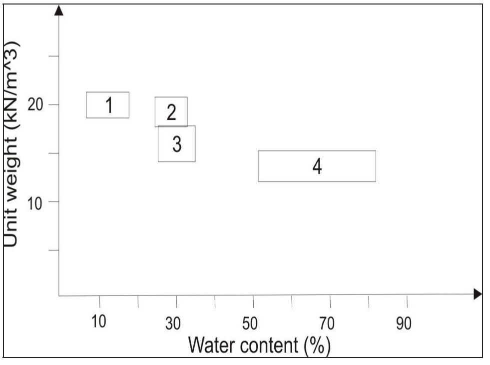

Figure 4. Range of water content and unit weight for quarterian sandy clay (1), silt (2), coal-like clay (3) and trepel (4).

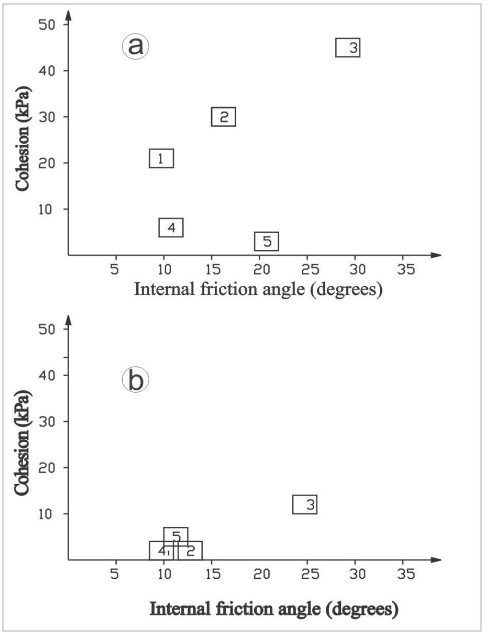

Figure 5. Range of internal friction angle and cohesion for quarterian sediments (1), trepel (2), coal (3), coal-like clay (4) and sandy silts (5) before (a) and after sliding (b).

It can be noted that, the shear strength after sliding is reduced to residual shear strength parameters, which is taken into the consideration in stability analyses.

3 POSSIBLE RISKS SCENARIOS CONNECTED WITH STABILITY

It is a well known fact, that the landslides are occurrences where time-dependent behavior can be very important.

A special problem for management team at coal mine was negative influences on the environment because of gas production during self-burning. This leads to constant loosing of the coal mass and decreasing of mechanical properties of the exposed coal.

All this is at the most critical zone which is not favorable from stability aspect. Covering of the zone of self-burning will lead to final closure of this zone. This is very unfavorable for future exploitation in so-called bottom coal series (which lies below main coal layer). Having in mind such restrictions, an adequate design analyses are prepared in order to find best-possible solution for this not typical mining case. In general, two scenarios are possible (Fig.6 and Fig. 7).

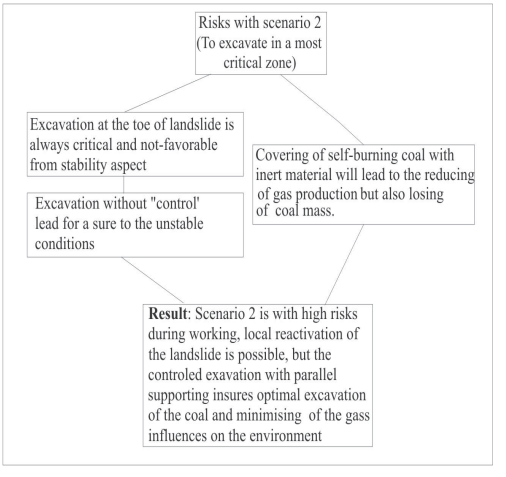

Figure 6. Scenario 1 (Do nothing).

We want to note, that in decision making, we used also methodology of so-called interaction matrix method firstly introduced by Hudson 1993.

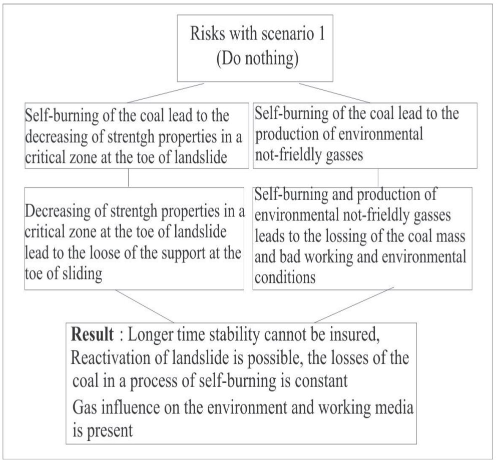

Figure 7. Risk scenario 2.

The most important step in this methodology is to establish the objectives of the project and the analysis. The relevant problems are placed along the leading diagonal of conceptual interaction matrix.

Then, all the interactions are established and the problem structure is developed. Example of relevant interaction scheme is given in Figure 8.

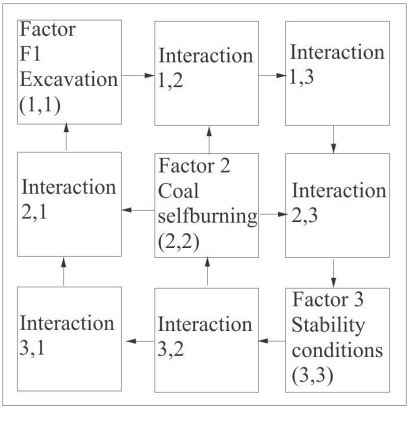

Figure 8. Conceptual matrix of interaction between tree basic factors.

F1 group of factors is related to the technology of excavation such as: applied method, depth of excavation, way of transportation, dewatering concept and so on.

F2 group is related to the characteristics of self-burning process (area of burning, intensity, gas production etc.).

Group of factors F3 is related to the stability of the field, defined with movements of the masses and safety during the working.

All possible interactions in a fist place are defined qualitatively, which is very important step for engineering judgment and decisions. Explanations are given as follows:

Interaction 1, 2 means that elements of the excavation can have an influence on the process of self-burning, because faster and efficient nearby excavation can stop the spreading of burning in wider areas.

Interaction 1, 3 means that the elements of the excavation have a direct influence on the stability conditions, because correctly designed and applied technology of excavation create stable field conditions.

Interaction 2, 3 mean that the process of self-burning during longer time has an influence on the shear strength parameters, and leads to possible unstable conditions (beside other negative influences).

Interaction 3, 2 shows that the stability of the field is governing element which affects possible access to zones of self-burning.

Interaction 3, 1 means that stability of the field affects the way of excavation technology in numerous ways.

Interaction 2, 1 means that the process of self-burning influence the excavation process, because of difficulties in access and on heavy working conditions.

It is obvious that such “simple” matrix shows several complex mutual influences between the environment and the engineering activities, and all of this shall be incorporated in design.

4 STABILITY ASPECTS

4.1 Methodology Of Analyses

An important step in mining practice is to find solution for stability problems in an appropriate way. This is certainly valid for this case.

After detailed analyses, a heavy decision was accepted.

It was decided that it is better to start with excavation with all possible negative consequences, than to allow losing a high quantity of coal in a process of self burning. In fact, this is scenario 2.

In decision making, the fact that the final result, in both scenarios is the same situation - to have instability due to decreasing of the volume of the coal in the toe of the landslide, was a reason to go into acceptable risk.

During the design, the technical solution with so-called methodology of parallel excavation and supporting was analyzed. After that, this technology was applied in a practice.

Detailed stability analyses were the basis for development of strategy for excavation.

The analyses are prepared on some representative profiles using the software package SLIDE 5. This is a known product of Canadian company Rocscience, and allows analyses with known limit equilibrium methods (Bishop, Spencer, Janbu and others).

In calculating, different phases of excavations and scenarios are involved.

For example, in Figure 9a, we illustrate a value of safety factor (Fs=1.04) before any kind of engineering activities.

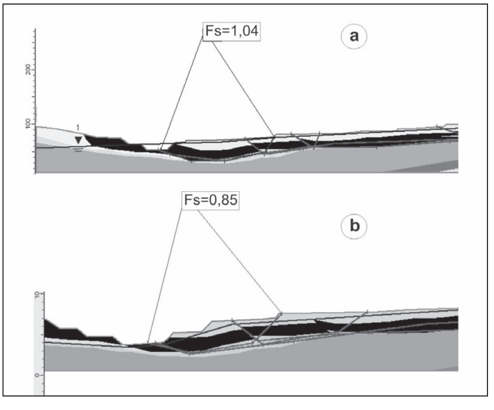

Figure 9. Outputs from stability analyses for initial phases of excavation.

In Figure 9b, we illustrate hypothetical value of safety factor. This is a case if we have a case without parallel support of excavated zone when the safety factor is bellow Fs=1.

Figure 10 explains cases of parallel support and decreasing of artesian pressure, when the safety factor has values Fs=0.98 and Fs>1.1 respectively.

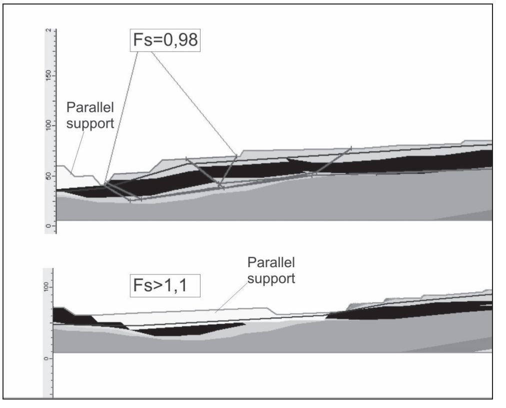

Figure 10. Analyzed cases with parallel excavation and support.

In a practice, this case can be explained as a state of allowable deformations in a term of slow (controlled) sliding, which is expected during initial phases of excavations.

In Figure 11, we give an estimation of influence of self-burning process during a longer time.

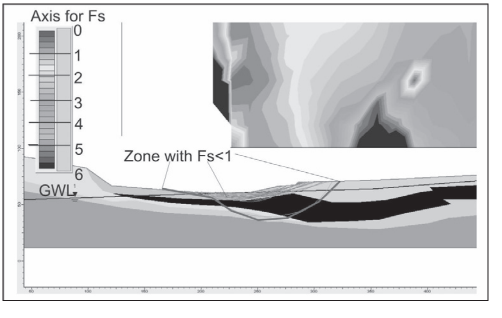

Figure 11. Hypothetical case to predict self burning influence on the stability conditions.

For the case in Figure 11, it was estimated that the upper zones of coal, during longer time will be transformed into coal ash. Minor unit weight and internal friction angle are used in analyses.

Results shows that the "new" sliding surfaces can be expected with values of safety factor Fs<1 (unstable state).

4.2 Presentation of the Executed State

It is a well known fact, that all engineering solutions should be checked directly in a practice.

This was especially important in this unique case, because almost all analyzed cases gives safety factor values that are usually not allowed in the mining practice.

The question is why the designers went into the calculated risk and allow excavations in critical zone are explained in risk scenarios.

The idea was to excavate maximal quantity of the coal from one side, and to stop the process of self-burning, from other side.

Of course, all measures of surface dewatering, visual and geodetically observations for control of possible rapid movements was strictly applied.

The excavation was allowed only with discontinued type of equipment, because it can be evacuated from critical zones in a fast way (if necessary).

We can underline that with such approach, till now, about 3,000,000 tonnes of coal is already excavated from this critical zone.

As it was expected, during excavation phase, some minor mass movements were observed. In every case, some rapid movements don't happen.

5 CONCLUSIONS

The given article is an example, that sometimes, in the practice, it is necessary to deal with unusual cases and to face with high risks.

This must not being not a rule but only the exceptions from the rules.

In every case, this article shows clearly that, it is fundamental for successful design of each engineering activity to get acquainted in detail with the properties and conditions of the working and natural environment.

All approaches in investigating and design shall be completely adapted to the characteristics of the natural environment; it is not possible to define the physical model of the terrain.

The physical model of the terrain must be the base for all numerical and mining analyses.

It is obvious that qualitative aspect of a problem, defined with checking procedure and interaction matrix method, can be useful approach in decision making.

Defined interactions are a good basis for complex analytical and numerical analyses, where the interactions can be defined with all necessary outputs (safety factors, stress-strain conditions, groundwater quantities etc).

Such approach can be adapted for numerous engineering problems, but it is necessary to have a team of specialists in mining, geological and geotechnical engineering, to solve such heavy engineering problems in an appropriate way.

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