ANALYSIS OF THE STABILITY FINAL SLOPES AT DRMNO OPENCAST MINE IN RELATION TO DEWATERING VARIANT

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Čebašek Vladimir, Šubaranović Tomislav, Pavlović Natalija

Faculty of Mining and Geology, University of Belgrade, Belgrade, Serbia
tomislav.subaranovic@rgf.bg.ac.rs

Abstract: *The Drmno opencast mine, located near the Danube and Mlava rivers, relies on the selection of an appropriate dewatering method. The stability of the final slopes of the mine is influenced by this choice. In this paper, the final slope stability of the Drmno opencast mine is analyzed using two characteristic profiles and three types of dewatering.*

Key words: STABILITY, FINAL SLOPES, DEWATERING

INTRODUCTION

The Drmno coal deposit is hydrogeologically very complex, with a large presence of water in the roof deposits. The northern border of the reservoir is formed by the Danube River, while the Mlava River forms the western border. In the vicinity of river beds, the thickness of alluvial gravel ranges from 0.5 to 30 metres. The level of ground water in the alluvium of these rivers is at a depth of 2 to 3 metres from the surface of the terrain and is in direct hydraulic connection with the level of ground water in gravelly-sandy sediments. The main source of recharge of the Drmnska ground water are the surface waters of the Mlava and Danube rivers.

Protection of the Drmno surface mine from underground water will consist of drainage wells, gravity pipelines, a waterproof screen, floor and drainage channels, water collectors and pumping stations. Modeling of the impact of underground water during slope stability analyses was performed based on calculations and analyses of the effects of the designed drainage system according to the surface mine drainage variants. Drainage variant 1 includes the use of drainage wells and surface water drainage facilities. Variant 2 dewatering includes the application of a watertight screen wedged into the 2nd coal seam (or dusty sediments where there is no 2nd coal seam), drainage wells and surface water drainage facilities. Variant 3 dewatering includes the application

of a watertight screen wedged into the 3rd coal seam (or dusty sediments where there is no 3rd coal seam), drainage wells and surface water drainage facilities. Surface water drainage facilities are the same for all three drainage variants. Based on the analysis of available data, the calculation values of the parameters of the physical and mechanical properties of the quasi-homogeneous zones in the Drmno deposit were selected. The values of the parameters of the physical and mechanical properties of the quasi-homogeneous zones were adopted by statistical calculations for a reliabilty level of 95% and are shown in Table 1.

Table 1, Adopted values of parameters of physical and mechanical properties for calculations of the stability of the final slopes Open Pit Mine Drmno

Quasi-homogeneous zone		Volumetric weight in (kN/m^3)	Cohesion c (kN/m^2)	Angle of inner friction φ (°)	Filtration coefficient k_f (m/s)
Quaternary	Loess	19,17	20,54	22,41	$2,7*10^{-5}$
	Sand	18,30	4,50	24,45	$4,5*10^{-5}$
	Gravel	16,20	1,30	31,54	$5*10^{-4}$
	Siltstone	18,30	10,68	22,60	$1*10^{-7}$
	Clay	18,30	24,14	17,52	$2,38*10^{-6}$
Neogene	Siltstone	18,30	10,68	22,60	$1*10^{-7}$
	Sand	18,30	4,50	24,45	$4,5*10^{-5}$
	Coal	14,90	246,00	24,60	$1*10^{-9}$
	Floor	18,30	24,14	17,52	$1,5*10^{-6}$

ANALYSIS OF THE STABILITY OF THE FINAL SLOPES

The stability analysis of the final slopes of the Drmno surface mine was performed using the method of A. W. Bishop (a group of limit equilibrium calculation methods for a cylindrical sliding plane) using the Slide2 software package version 9,016 of Rocscience Inc. The analysis of the stability of the final slopes was carried out on two characteristic profiles (profiles R2 and R3) for all three variants of drainage of the Drmno surface mine (Figure 1).

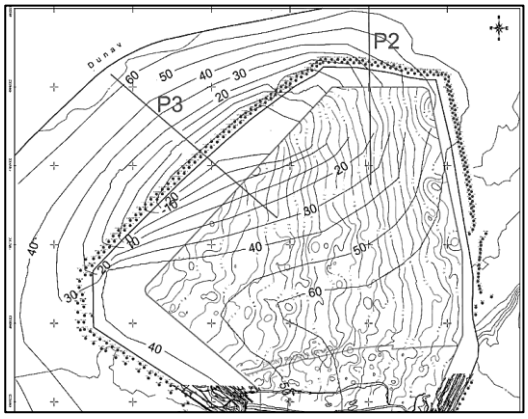

Figure 1, Location of geomechanical profiles

On the above-mentioned profiles, the final slope of the surface mine is made up of floor clayey materials, coal, roof sandy clays, dust, sand, gravel and loess.

ANALYSIS OF THE STABILITY OF THE FINAL SLOPES IN RELATION TO DRAINAGE VARIANT 1

Analysis of the stability of the final slopes of the Drmno surface mine in relation to Drainage Variant 1 was performed on the characteristic profiles R2 and R3 (Figure 2).

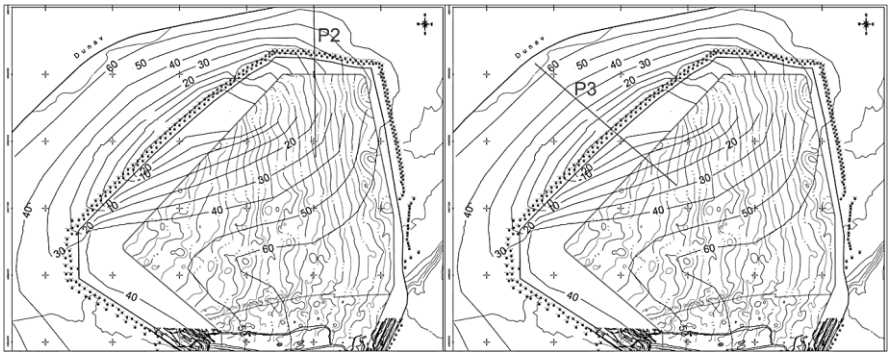

Figure 2, Layout of the surface mine with profiles and NPV (Variant 1 of drainage)

The influence of groundwater in the body of the slope was determined on the basis of the groundwater level map (Figure 2), while the layout of the profile is shown in Figure 3.

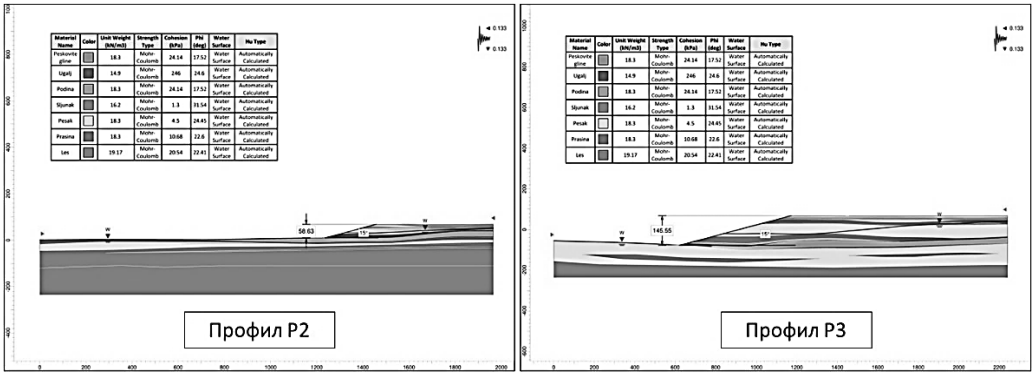

Figure 3, Layout of final slopes on profiles R2 and R3 (Variant 1 drainage)

Table 2 gives an overview of the results of the analysis of the stability of the final slopes on profiles R2 and R3 for Variant 1 drainage is given. A detailed presentation of the results of the stability analysis is shown in Figure 4.

According to the results shown in Table 2 and Figure 4, for the analyzed condition of final slopes of $k_s = 0$, the safety factor according to profile R2 is 1,541, while according to profile R3 it is 1,424. Based on the previous analysis, it can be concluded that the final slopes on profiles R2 and R3 for Drainage Variant 1 are stable.

Table 2, Overview of the geometry of the final slopes on profiles R2 and R3 when applying drainage Variant 1

Profile	Slope height H (m)	Angle of inclination of the slope α (°)	Safety factor F_s	
			$k_s = 0$	$k_s = 0.133$
P2	58.63	15	1.541	1.033
P3	145.55	15	1.424	1.098

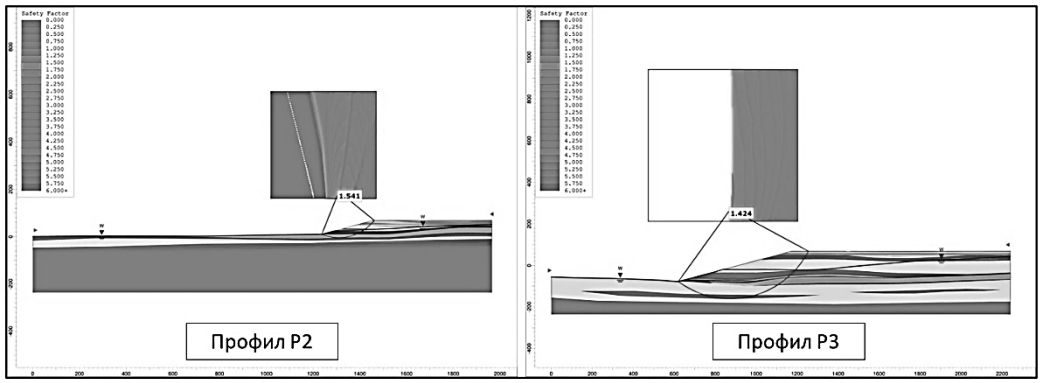

Figure 4, Results of the analysis of the stability of the final slopes on profiles R2 and R3 when applying drainage Variant 1

ANALYSIS OF THE STABILITY OF THE FINAL SLOPES
IN RELATION TO DRAINAGE VARIANT 2

Analysis of the stability of the final slopes of the Drmno surface mine in relation to Drainage Variant 2 was performed on the characteristic profiles R2 and R3 (Figure 5).

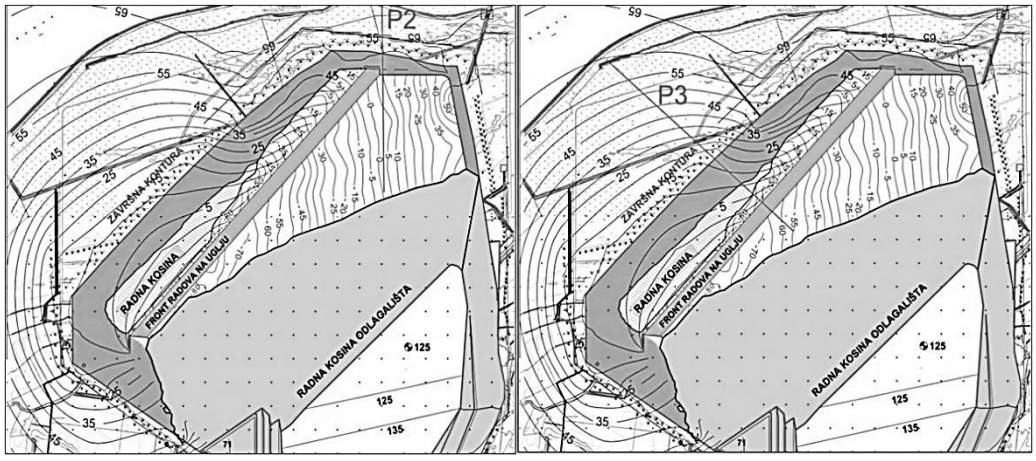

Figure 5, Layout of the surface mine with profiles and NPV (Drainage Variant 2)

The influence of groundwater in the body of the slope was determined based on the groundwater level map (Figure 5), while the appearance of the profile is shown in Figure 6.

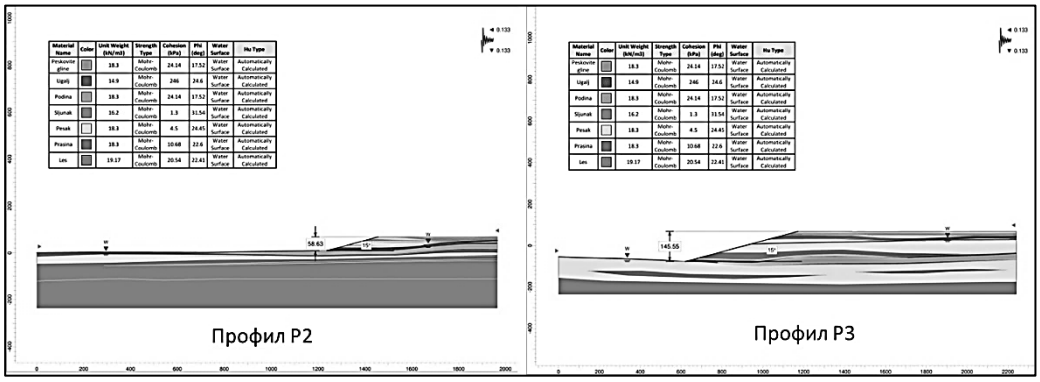

Figure 6, Appearance of final slopes on profiles R2 and R3 (Drainage Variant 2)

In Table 3, an overview of the results of the analysis of the stability of the final slopes on profiles R2 and R3 for Drainage Variant 2 is given. A detailed presentation of the results of the stability analysis is shown in Figure 7.

Table 3, An overview of the geometry of the final slopes on profiles R2 and R3 when applying Drainage Variant 1

Profile	**Slope height H (m)**	**Angle of inclination of the slope α (°)**	**Safety factor F_s**	
			$k_s = 0$	$k_s = 0.133$
P2	58.63	15	1.751	1.298
P3	145.55	15	1.318	1.015

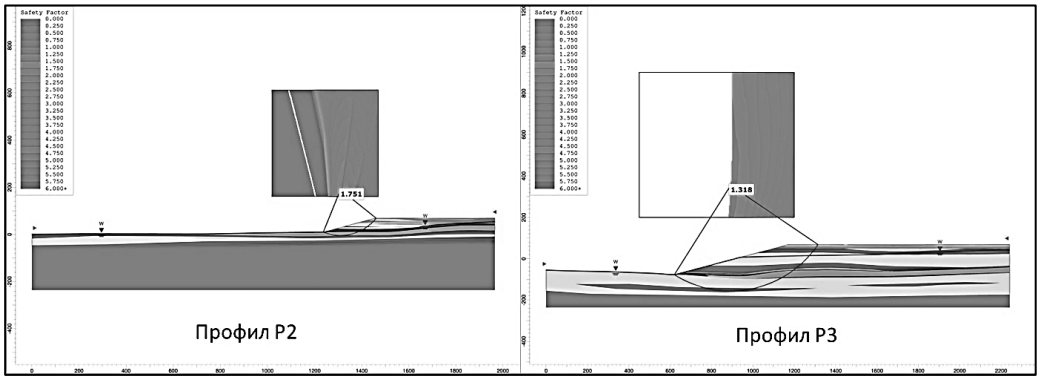

Figure 7, Results of the analysis of the stability of the final slopes on profiles R2 and R3 when applying Drainage Variant 2

According to the results shown in Table 3 and Figure 7, for the analyzed condition of final slopes of ks = 0, the safety factor according to profile R2 is 1,751, while according to profile R3 it is 1,318. Based on the previous analysis, it can be concluded that the final slopes on profiles R2 and R3 for Drainage Variant 2 are stable.

ANALYSIS OF THE STABILITY OF THE FINAL SLOPES IN RELATION TO DRAINAGE VARIANT 3

Analysis of the stability of the final slopes of the Drmno surface mine in relation to Drainage Variant 3 was performed on the characteristic profiles R2 and R3 (Figure 8).

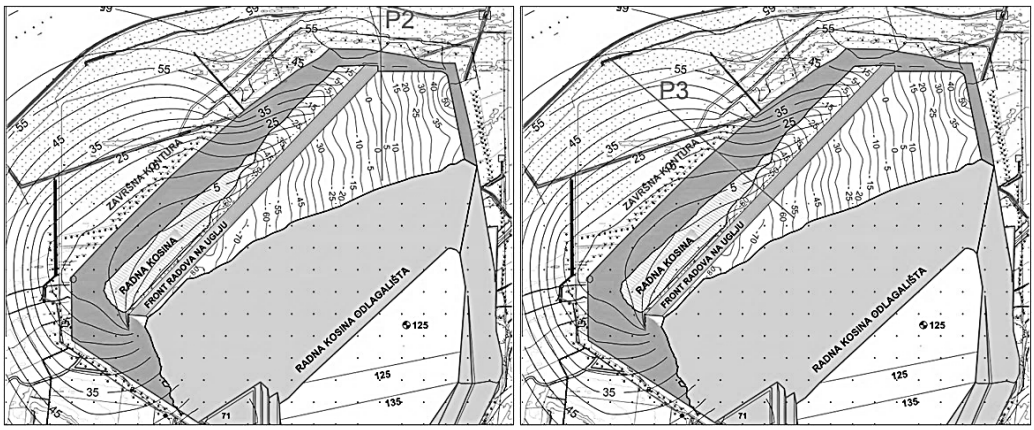

Figure 8, Layout of open pit with profiles and NPV (Drainage Variant 3)

The influence of groundwater in the body of the slope was determined based on the groundwater level map (Figure 8), while the appearance of the profile is shown in Figure 9.

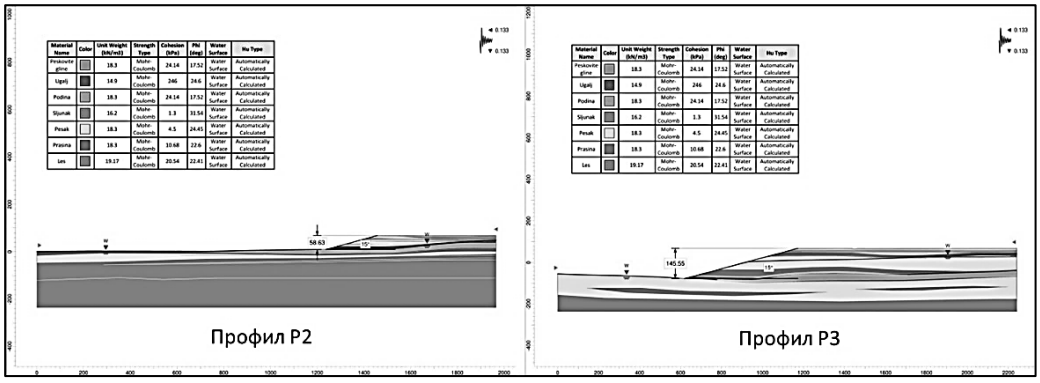

Figure 9, Appearance of final slopes on profiles R2 and R3 (Drainage Variant 3)

In Table 4, an overview of the results of the analysis of the stability of the final slopes on profiles R2 and R3 for Drainage Variant 3 is given. A detailed view of the results of the stability analysis is shown in Figure 10.

Table 4, Overview of the geometry of the final slopes on profiles R2 and R3 when applying Drainage Variant 3

Profile status	Slope height H (m)	Angle of inclination of the slope α (°)	Safety factor F_s	
			$k_s = 0$	$k_s = 0.133$
P2	58.63	15	1.753	1.299
P3	145.55	15	1.329	1.023

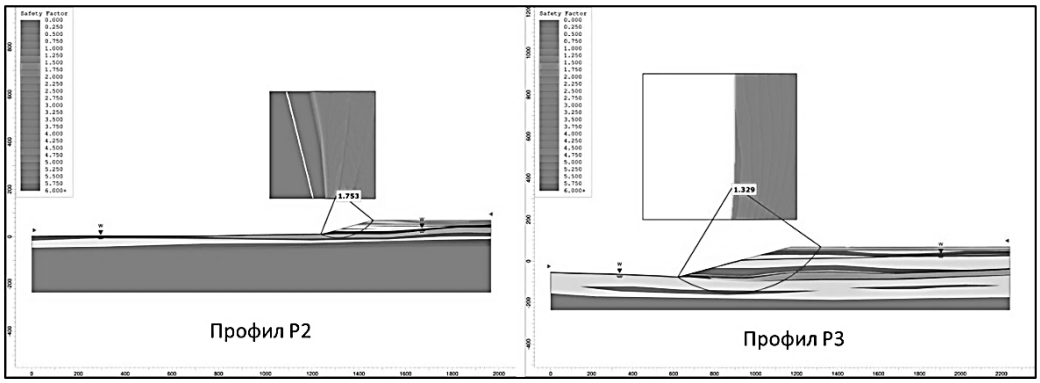

Figure 10, Results of the analysis of the stability of the final slopes on profiles R2 and R3 when applying Drainage Variant 2

According to the results shown in Table 4 and Figure 10, for the analyzed condition of final slopes of ks = 0, the safety factor according to profile R2 is 1,753, while according to profile R3 it is 1.329. Based on the previous analysis, it can be concluded that the final slopes on profiles R2 and R3 for Drainage Variant 3 are stable.

CONCLUSION

The stability analysis of the final slopes of the Drmno surface mine was performed on two characteristic profiles for three types of drainage. Analysis of the stability of the final slopes was performed using the Bishop method, and for these purposes the Slide 2 software package, version 9.023 of Rocscience Inc. was used.

Table 5 shows the results of slope stability analysis on characteristic profiles for all three drainage variants.

Table 5, Presentation of slope geometry with stability analysis results

Profile	Slope height H (m)	Angle of inclination of the slope α (°)	Safety factor F_s		
			Variant 1	Variant 2	Variant 3
			$k_s = 0$	$k_s = 0$	$k_s = 0$
P2	58.63	15	1.541	1.751	1.753
P3	145.55	15	1.424	1.318	1.329

According to the results shown in Table 5, for the analyzed final slope profiles at the Drmno surface mine for all three drainage variants, it can be said that they meet the stability criterion of $Fs \geq 1.30$.

LITERATURE

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