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APPLICATION THE SOFTWARE PACKAGES GEMCOM AND MINEX FOR DESIGN THE WASTE LANDFILL – AN EXAMPLE OF CONSTRUCTION THE CASSETTE III PHASE 3 OF ASH AND SLAG LANDFILL OF THE THERMAL POWER PLANT GACKO[**]

Abstract

The world mining companies for design of mining facilities and with the aim of rational and cost-effective solutions use the modern computer programs. Among the leading programs in this field are Gemcom and Minex. These software packages are not designed for design of landfills, but with certain knowledge and skills can also be used for this purposes with great success.

This paper describes the design phase of 3 cassettes III ash and slag landfills of the Mine and Power Plant "Gacko", using the above software. Construction of ash and slag landfill was made using the 3D model in the program Gemcom 6.2, and calculation the amounts of material for preparation works and landfill capacity were calculated in the program Minex 5.2, in accordance with the applicable standards and legislation for these kinds of material. It is important to note that the positive experience gained in designing of ash landfill can be successfully applied also to the other waste materials, such as primarily materials incurred by hydrometallurgical processes of recycling the flotation tailings and disposed overburden material.

Keywords: *ash and slag landfill, construction, computer programs Gemcom and Minex*

INTRODUCTION

The aim of the normal operation of the Thermal Power plant "Gacko" requires an extension of the existing ash and slag landfill. As in the Republic of Serbian the standards are not adopted for construction of these types of facilities, the same will be constructed in accordance with the EU LANDFILL DIRECTIVE 1999/31/EC as well as the standard of the Republic of Serbia RS U.C5.020. This standard establishes the conditions for design of embankments and earth dams. In developing the new field of landfill, it must comply with the applicable Mining Act and Regulations on the contents of long-term programs and mining projects of the Republic of Serbian. The space for disposal according to the existing project documentation is not intended for mining activities and existing landfill it will be a single unit with the existing landfill [2,6,7]. Ash and slag landfill is shown in Figure 1.

Prior to disposal of ash and slag in the phase 3 of cassettes III, it is necessary to carry out the preparatory works on renovation the substrate. Preliminary works include the following:

- Preparation of plateau for drainage system;

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- Formation of waste dump from open pit;
- Preparation of circumferential embankment;
- Setting up a layer of marl and then setting up a protection foil.

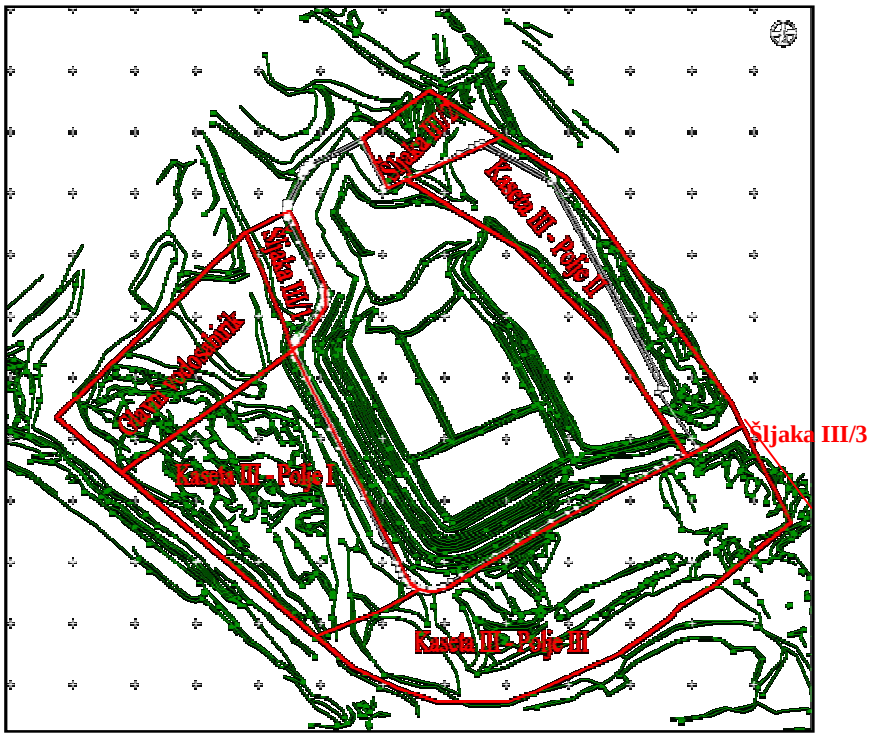

Figure 1 *Space provided for ash and slag landfill*

Initial situation for formation of landfill dumps is the formed landfill on cassettes I and II, phase 1 and 2 cassettes III to the final elevation K + 940 m, and the prepared surface of phase 3 cassette III.

PREPARATORY WORKS

Making of plateau for a drainage system includes excavation of material along the north side of the phase 3. Elevation of excavation on the western side of the plateau is K + 901.5m. Elevation of excavation at the border of cassettes 1 and 2 is K +902.0 m, and the final elevation of the plateau on the eastern side of the K +907.0 m. The width of plateau is 30 m and the length of plateau is 360 m. Along the entire length of the plateau a channel will be made, depth of 2 m. Material will be excavated by hydraulic excavator and directly deposited along the southern side of plateau in the space of phase 3 where a tailing dump will be formed. Total amount of material to be excavated in making of the plateau and the channel is 88 357 m^3.

Formation of the landfill includes planning the existing material on the site of phase 3 and waste disposal from the open pit. Plateaus are formed at the levels E900/914, E915/924, E925/934 and E935/940. Gradients of level slopes are 1: 3, and minimum final width of level planes is 20 m. After placing a layer of marl, height of 1 m, at

levels E900/914, E915/924 and E925/934, the initial levels for formation of ash landfill will be K+915 m, K+925 m and K+935 m. The amount of existing material and material from plateau and channels in the embankment is 211 090 m^3. After completion of works on planning the existing material, and material disposed after making the plateau and channel for disposal of waste from the open pit, the area of 89 017 m^3 remains.

Development of circumferential embankment includes delivery of marl from the marl landfill, planning of marl into layers, thickness of 30 cm, and compaction of marl. The average transport route for transport of marl is 600 m. Circumferential embankment will be built on the northeast part of phase 3 of cassettes III. The lowest elevation of the crown of this embankment is K + 923m. The width of embankment crown is 8m, and the edges are made with slope of 1: 2. The required amount of marl from the marl landfill in compacted state is 16 057 m^3.

After making the circumferential embankment, a layer of marl is placed on the surface of the phase 3 of cassette III. Development of this layer includes delivery marl from the marl landfill, planning of marl into layers, thickness of 25 cm and compaction of marl. The average transport route for transport of marl is 850 m. The required amount of marl from the marl landfill in compacted state is 191 766 m^3.

The spatial position of all phases, defined based on the 3D model [4,5,10] was conducted in the program Gemcom 6.2 [1,3,8] (license No. GCL01124), Figures 2 and 3.

Calculation the amount of material was made on the basis of the 3D model in Minex5.2 [9] (license No. Aa024765), by Triangle Volumes tool that calculates the volume between two surfaces that intersect, Figure 4.

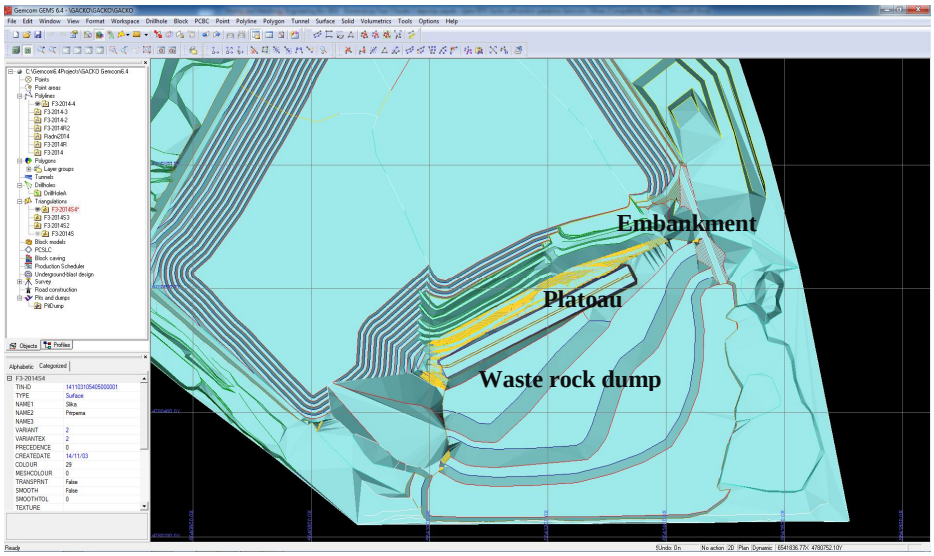

Figure 2 *2D view of the phase 3 of cassette III upon completion the preparatory works in the program Gemcom 6.2*

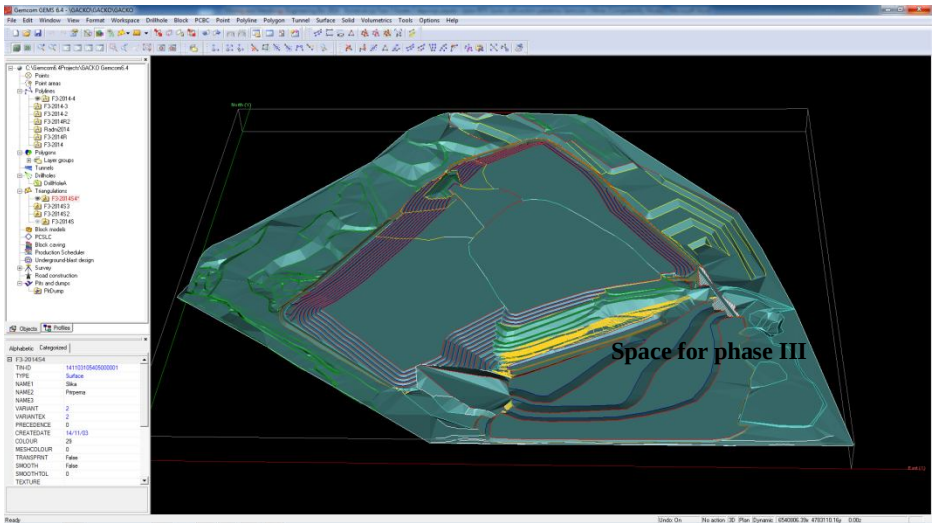

Figure 3 *3D model of phase 3 of cassette III upon completion the preparatory works in the program Gemcom 6.2*

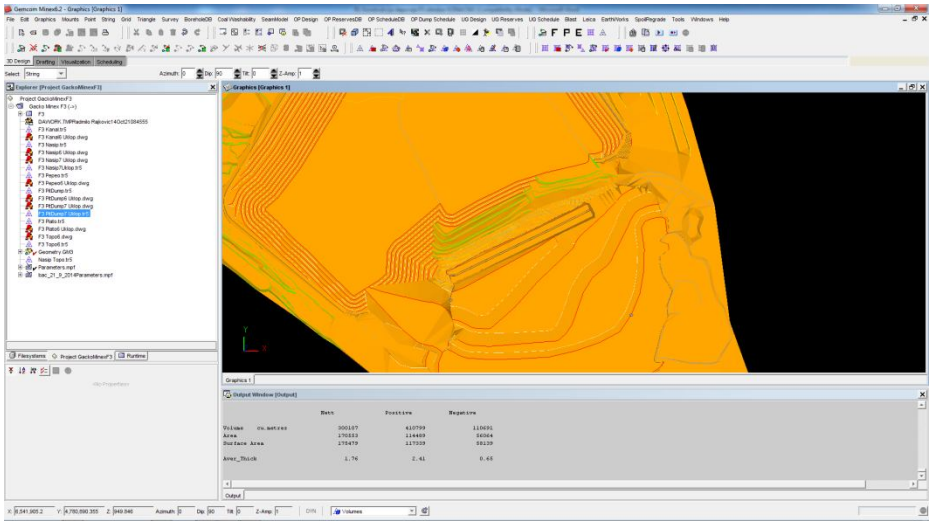

Figure 4 *Calculation the amounts in the program Minex 5.2*

CONSTRUCTION OF LANDFILL

The ash and slag landfill was constructed in the program Gemcom 6.2 by tool Pit Dump Design [8]. Structural elements of the landfill in the program Gemcom 6.2 are shown in Figure 5. The final view of the landfill is shown in Figures 6 and 7.

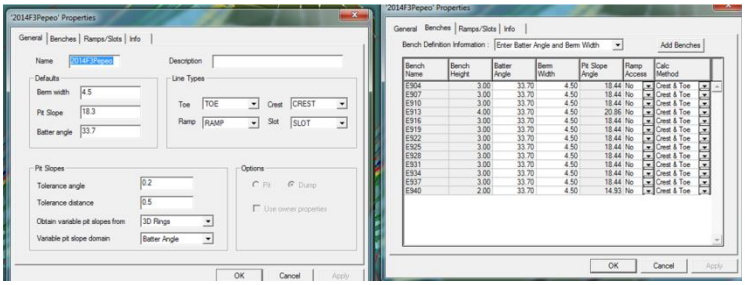

Figure 5 *Starting parameters for Pit Dump Design in the program Gemcom 6.2*

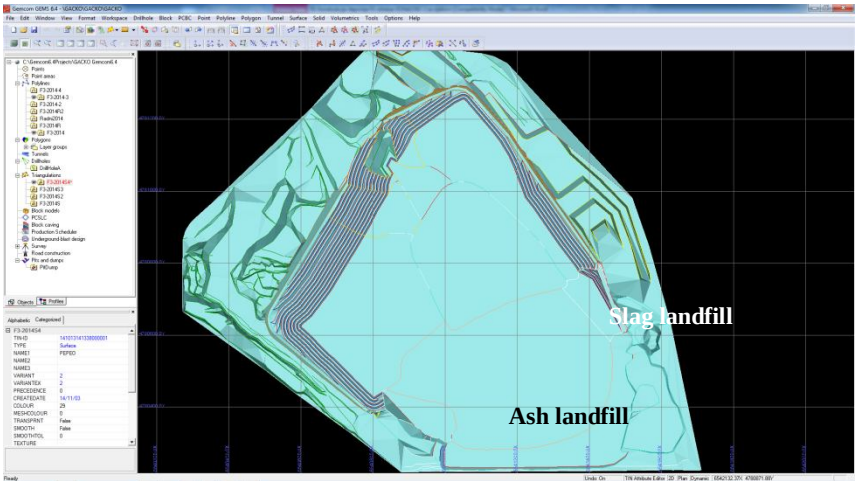

Figure 6 *2D view of the phase 3 of cassette III upon completion the depositing of ash and slag in the program Gemcom 6.2*

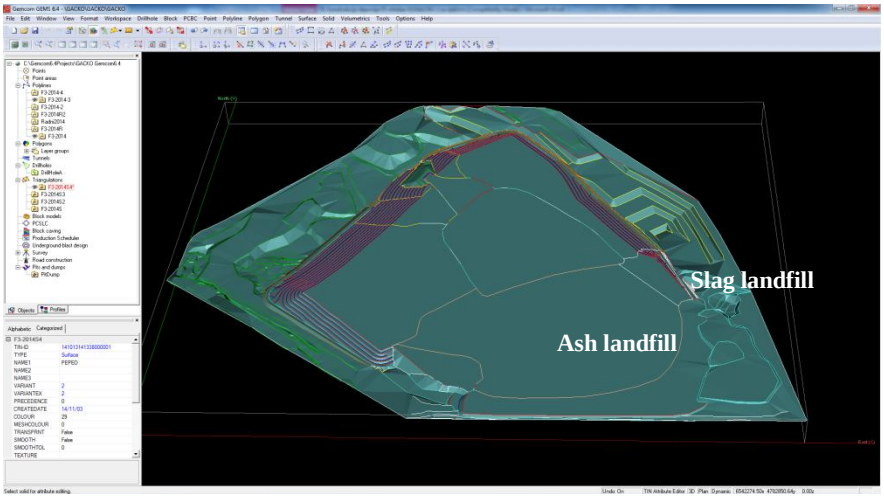

Figure 7 *3D view of the phase 3 of cassette III upon completion the depositing of ash and slag in the program Gemcom 6.2*

Calculation the amount of ash and slag in the phase 3 of cassette III on the ash and slag landfill in program Minex 5.2 is shown in Table 1.

Table 1 *The amount of ash of the phase 3 of cassette III to the elevation K+940 m in the program Minex 5.2*

Size	Value
Volume, m^3	2 789 621
Area, m^2	187 600
Thickness, m	14.9

Calculation of masses on the ash landfill in the phase 3 of cassette III by levels was performed in the program Minex 5.2 based on differences in volumes of the upper and lower surfaces above the corresponding elevation. The results of this calculation are shown in Table 2.

Table 2 *The amount of ash of the phase 3 of cassette III by levels in the program Minex 5.2*

Cont.	V, m^3	Top.	V, m^3	Level	Ash, m^3
8 472 301		5 506 608			
7 865 958	606 343	4 901 547	605 061	901/899	1 186
7 259 615	606 343	4 317 057	584 490	904/901	20 214
6 653 272	606 343	3 748 774	568 283	907/904	35 206
6 046 929	606 343	3 194 321	554 453	910/907	47 998
5 440 586	606 343	2 657 127	537 194	913/910	63 963
4 834 243	606 343	2 149 500	507 627	916/913	91 312
4 227 900	606 343	1 686 413	463 087	919/916	132 512
3 621 557	606 343	1 253 076	433 337	922/919	160 031
3 015 213	606 344	855 936	397 140	925/922	193 514
2 408 995	606 218	565 296	290 640	928/925	291 910
1 803 572	605 423	319 853	245 443	931/928	332 982
1 199 649	603 923	122 472	197 381	934/931	376 051
598 253	601 396	20 301	102 171	937/934	461 783
0	598 253	0	20 301	940/937	534 606
					2 721 866

In calculation the total amounts of ash and slag, there is, generally for the entire landfill and by levels, a slight differences, shown in Table 3. These differences are negligible compared to the total amounts of material in a landfill.

Table 3 *Differences in the amount of ash of the phase 3 cassette III by levels and total in the program Minex5.2*

Location	Whole volume	Volume by levels	Difference	%
Phase 3	2 789 621	2 721 866	67 755	2.49

The amount of ash in the phase 3 of cassette III is 220 692 m^3. The ash is situated in the northeastern part of phase 3 of cassette III in order to minimize the transport relations for supply of ash, Figures 6 and 7.

CONCLUSION

In the world, design of mining facilities is performed with the help of modern software packages, what has become the established standard for quickly and efficiently solving of this problem. Among these computer programs are Gemcom 6.2 and Minex 5.2, which are applied in the Mining and Metallurgy Institute Bor. The construction is done according to the researched and tested technical parameters according to the prescribed standards and legal acts in this field.

The important factor in the use of computer programs is much shorter time and better quality of project development in relation to the classic design, which in today's market conditions is of great importance in obtaining the jobs and favorable conclusion of financial contracts.

3D model generally represents an excellent aid for process design in geology and mining. This is primarily related to the initial design phase, which involves the need of designers to gain an impression on geographic features of the terrain and without directly entering on the location as well as design the geomodel of deposit, construction of open pits and waste dumps and dynamics of implementation the mining works.

Construction of new and modern landfills for permanent disposal of waste in accordance with the latest technical solutions, domestic and EU legislation on landfills, is still in its infancy in Serbia. In Serbia, the issue of disposal of hazardous waste is still pending because there is no built a landfill for hazardous waste, nor its construction is expected soon. Serbia exported its hazardous waste and deposit it in the neighboring countries for what a significant foreign exchange are spent. The newly-gained experiences in designing of ash landfill in the Thermo Power Plant Gacko, using the modern software package Gemcom 6.2 and Minex 5.2, can be successfully applied to the design of landfills for waste disposal that will arise after recycling and valorization of useful components from deposited open pit overburden and flotation tailings in Bor.

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PRIMENA SOFTVERSKIH PAKETA GEMCOM I MINEX ZA PROJEKTOVANJE DEPONIJE OTPADA - PRIMER KONSTRUKCIJE KASETE III FAZE 3 DEPONIJE PEPELA I ŠLJAKE TE GACKO[**]

Izvod

Svetske rudarske kompanije za projektovanje rudarskih objekata, a u cilju racionalnih i ekonomičnih rešenja, koriste savremene računarske programe. Među vodećim programima iz ove oblasti su Gemcom i Minex. Ovi softverski paketi nisu dizajnirani za projektovanje deponija, ali se uz određena znanja i veštine sa velikim uspehom mogu koristiti i za ove namene.

U radu je prikazana konstrukcija faze 3, kasete III deponije pepela i šljake Rudnika i Termo-elektrane "Gacko", korišćenjem navedenih softvera. Konstrukcija deponije pepela i šljake urađena je 3D modelom u programu Gemcom 6.2, a obračun količina materijala za pripremne radove i kapacitet deponije proračunati su u programu Minex 5.2, saglasno važećim standardima i zakonskom regulativom za ove vrste materijala. Ono što je bitno napomenuti je da se pozitivna iskustva stečena u projektovanju deponije pepela mogu sa uspehom primeniti i na druge otpadne materijale, kao što su pre svega mate-rijali nastali hidrometalurškim postupcima reciklaže flotacijske jalovine i odložene kopovske raskrivke.

Ključne reči: *deponija pepela i šljake, konstrukcija, računarski programi Gemcom i Minex*

UVOD

U cilju normalnog rada termoelektrane "Gacko", potrebno je proširenje postojeće deponije pepela i šljake. Kako u Republici Srpskoj nisu donešeni standardi za izgradnju ovakve vrste objekata, isti će biti izgrađen saglasno Direktivi EU O Deponijama 1999/31/EC kao i standardu Republike Srbije RS U.C5.020. Ovim standardom se utvrđuju uslovi za projektovanje nasipa i nasutih brana. Pri izradi novog polja deponije, mora se pridržavati i važećeg Zakona o rudarstvu i Pravilnika o sadržini dugoročnih programa i rudarskih projekata Republike Srpske. Prostor predviđen za odlaganje prema postojećoj projektnoj dokumentaciji nije predviđen za rudarske aktivnosti i sa postojećom deponijom će predstavljati jednu celinu [2, 6, 7]. Deponija pepela i šljake prikazana je na slici 1.

Pre odlaganja pepela i šljake u fazu 3 kasete III potrebno je izvršiti pripremne radove na uređenju podloge. Pripremni radovi obuhvataju sledeće:

- Izradu platoa za drenažni sistem;

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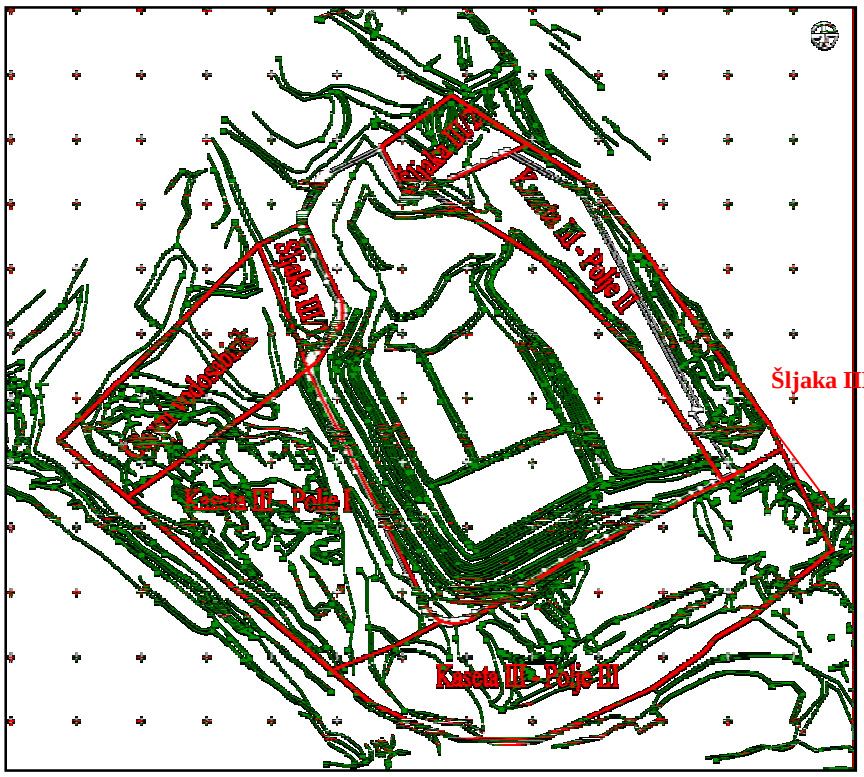
[**] *Ovaj rad je jednim delom proistekao iz projekta TR37001 „Uticaj rudarskog otpada iz RTB Bor na zagadjenje vodotokova, sa predlogom mera i postupaka za smanjenje štetnog dejstva na životnu sredinu“, koji je finansiran sredstvima Ministarstva prosvete, nauke i tehnološkog razvoja Republike Srbije*

- Formiranje odlagališta jalovine sa kopa;
- Izradu obodnog nasipa;
- Postavljanje sloja laporca nakon čega se postavlja zaštitna folija.



Sl. 1. *Prostor predviđen za deponiju pepela i šljake*

Početna situacija za formiranje deponije je formirana deponija na kasetama I i II, faze 1 i 2 kasete III do završne kote K+940 m, i pripremljena podloga faze 3 kasete III.

PRIPREMNI RADOVI

Izrada platoa za drenažni sistem obuhvata iskop materijala duž severne strane faze 3. Kota iskopa na zapadnoj strani platoa je K+901,5 m. Kota iskopa na granici kaseta 1 i 2 je K +902,0 m, a završna kota platoa na istočnoj strani je K +907,0 m. Širina platoa je 30 m a dužina platoa 360 m. Po celoj dužini platoa biće izrađen kanal dubine 2 m. Materijal će se otkopavati hidrauličnim bagerom i direktno odlagati duž južne strane platoa u prostoru faze 3 na kome će se formirati odlagalište jalovine. Ukupna količina materijala koji se otkopava pri izradi platoa i kanala iznosi 88.357 m^3.

Formiranje odlagališta obuhvata planiranje postojećeg materijala na lokaciji faze 3 i deponovanje jalovine sa kopa. Platoi se formiraju na etažama E900/914, E915/924, E925/934 i E935/940. Nagibi etažnih kosina su 1:3, a minimalna završna širina etažnih ravni iznosi 20 m. Nakon postavljanja sloja laporca visine 1 m na etažama E900/914, E915/924 i E925/934, početni nivoi etaža za formiranje deponije pepela biće K +915 m, K +925 m i K +935 m. Količina postojećeg

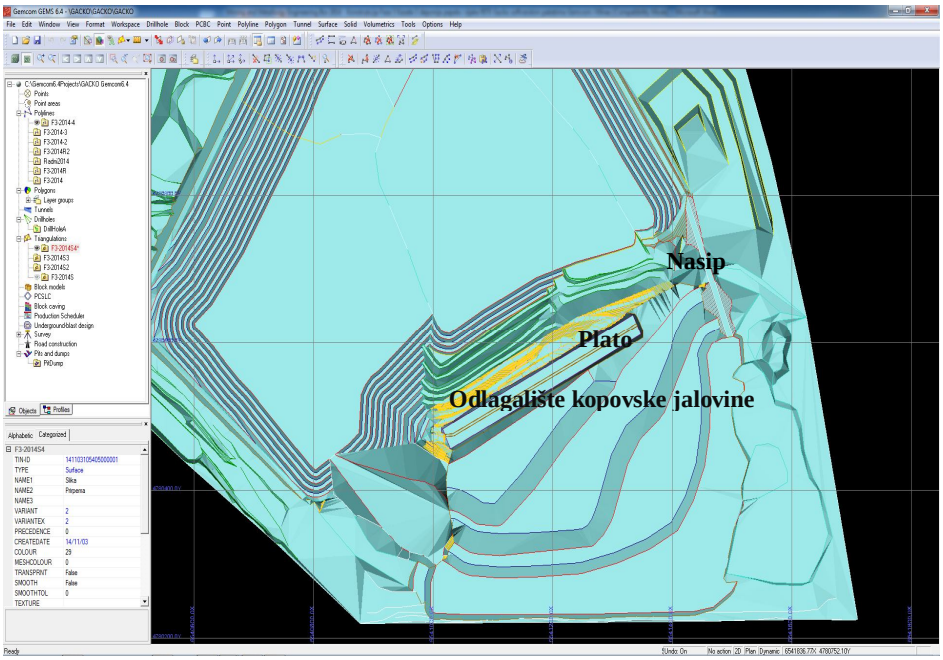
materijala i materijala iz platoa i kanala, u nasipu iznosi 211.090 m^3. Nakon završetka radova na planiranju postojećeg materijala i materijala odloženog nakon izrade platoa i kanala, za odlaganje jalovine sa kopa ostaje prostor od 89.017 m^3.

Izrada obodnog nasipa obuhvata dopremu laporca sa deponije laporca, planiranje laporca u slojevima debljine 30 cm i sabijanje laporca. Prosečna transportna relacija za transport laporca iznosi 600 m. Obodni nasip će se izgraditi na severo-istočnom delu faze 3 kasete III. Najniža kota krune ovog nasipa iznosi K+923 m. Širina krune nasipa iznosi 8 m, a ivice se rade sa nagibom 1:2. Potrebna količina laporca sa odlagališta laporca u zbijenom stanju iznosi 16.057 m^3.

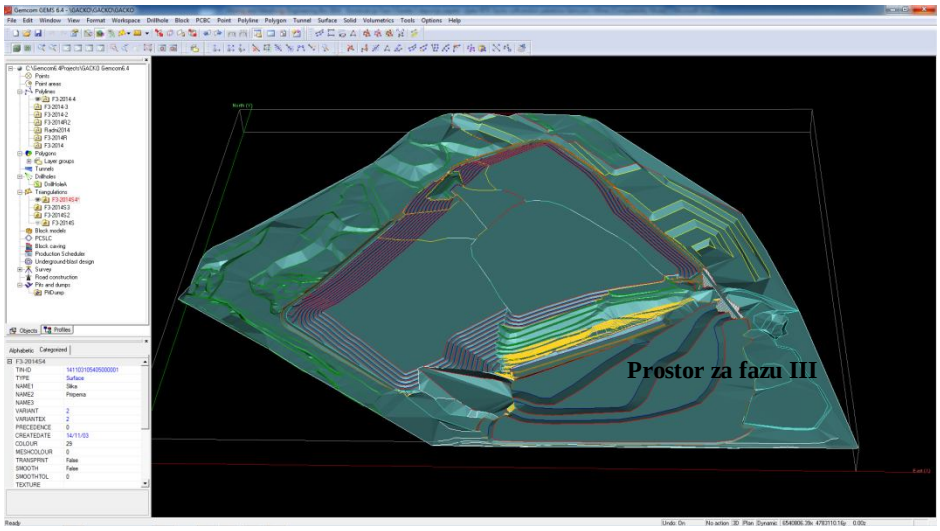
Nakon izrade obodnog nasipa postavlja se sloj laporca na podlogu faze 3 kasete III. Izrada ovog sloja obuhvata dopremu laporca sa deponije laporca, planiranje laporca u slojevima debljine 25 cm i sabijanje laporca. Prosečna transportna relacija za transport laporca iznosi 850 m. Potrebna količina laporca sa odlagališta laporca u zbijenom stanju iznosi 191.766 m^3.

Prostorni položaj svih faza definisan je na osnovu 3D modela [4,5,10] urađenog u programu Gemcom 6.2 [1,3,8] (licenca br. GCL01124), slike 2 i 3 .

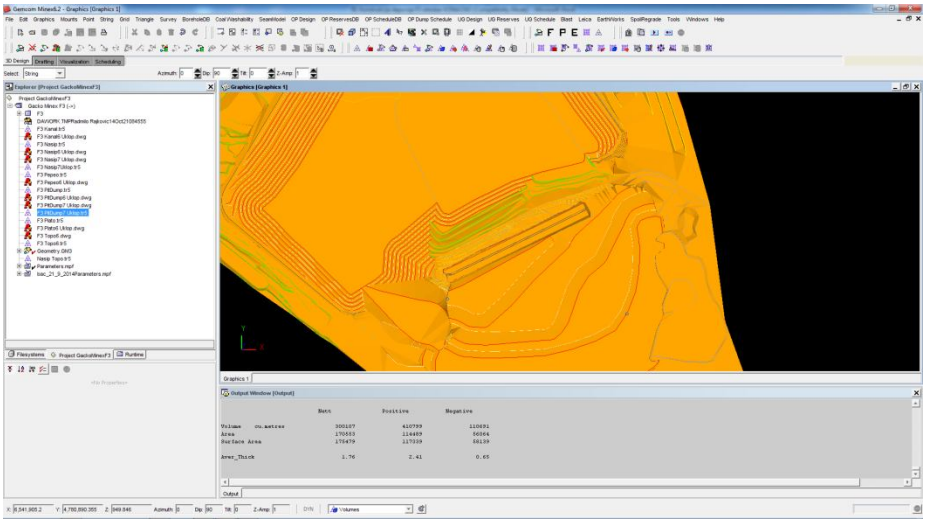
Obračun količina materijala izvršen je na osnovu 3D modela u programu Minex5.2 [9] (licenca br. Aa024765), alatom Triangle Volumes koji računa zapreminu između dve površine koje se seku, slika 4.



Sl. 2. *2D prikaz faze 3 kasete III po završetku pripremnih radova u programu Gemcom 6.2*



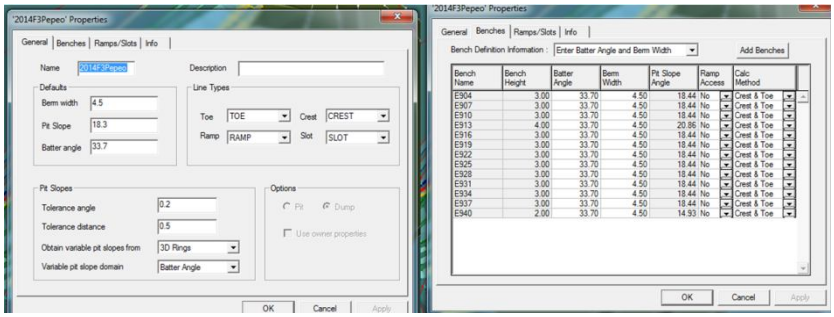
Sl. 3. *3D model faze 3 kasete III po završetku pripremnih radova u programu Gemcom 6.2*



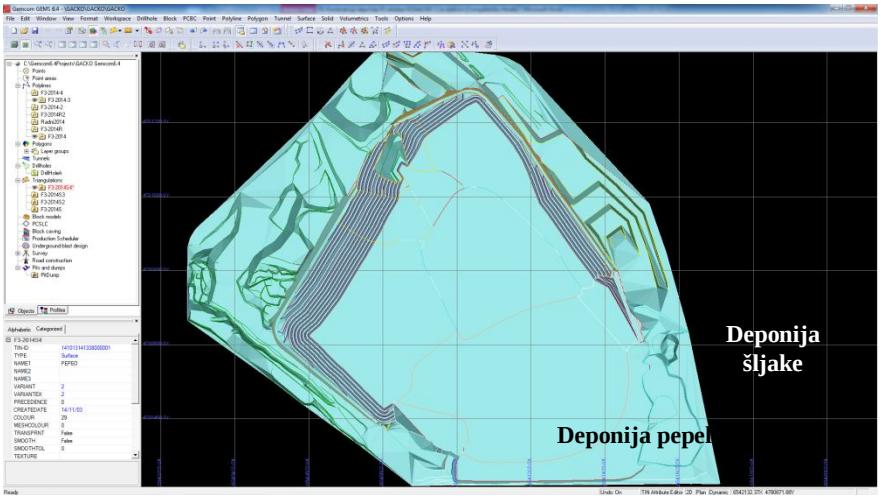
Sl. 4. *Obračun količina u programu Minex 5.2*

KONSTRUKCIJA DEPONIJE

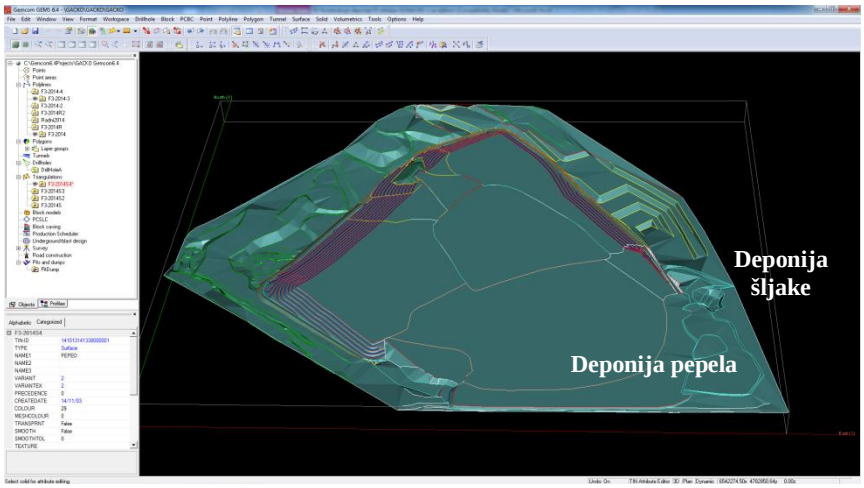
Deponija pepela i šljake konstruisana je u programu Gemcom 6.2 alatom Pit Dump Design. [8] Konstrukcioni elementi deponije u programu Gemcom 6.2 prikazani su na slici 5. Konačni izgled deponije prikazan je na slikama 6 i 7.



Sl. 5. *Polazni parametri za Pit Dump Design u programu Gemcom 6.2*



Sl. 6. *2D prikaz zafe 3 kasete III po završetku deponovanja pepela i šljake u programu Gemcom 6.2*



Sl. 7. *3D model zafe 3 kasete III po završetku deponovanja pepela i šljake u programu Gemcom 6.2*

Obračun količine pepela u fazi 3 kasete III na deponiji pepela i šljake u programu Minex 5.2 prikazan u tabeli 1.

Tabela 1. *Količine pepela faze 3kasete III do kote K+940 m u programu Minex 5.2*

Veličina	Vrednost
Zapremina, m^3	2.789.621
Površina, m^2	187.600
Moćnost, m	14,9

Obračun masa na deponiji pepela u fazi 3 kasete III po nivoima izvršen je u programu Minex 5.2 na osnovu razlika u zapreminama gornje i donje površine iznad odgovarajuće elevacije. Rezultati ovog obračuna prikazani su u tabeli 2.

Tabela 2. *Količine pepela faze 3 kasete III po nivoima u programu Minex 5.2*

Cont	V, m^3	Topo	V, m^3	Etaža	Pepeo, m^3
8.472.301		5.506.608			
7.865.958	606.343	4.901.547	605.061	901/899	1.186
7.259.615	606.343	4.317.057	584.490	904/901	20.214
6.653.272	606.343	3.748.774	568.283	907/904	35.206
6.046.929	606.343	3.194.321	554.453	910/907	47.998
5.440.586	606.343	2.657.127	537.194	913/910	63.963
4.834.243	606.343	2.149.500	507.627	916/913	91.312
4.227.900	606.343	1.686.413	463.087	919/916	132.512
3.621.557	606.343	1.253.076	433.337	922/919	160.031
3.015.213	606.344	855.936	397.140	925/922	193.514
2.408.995	606.218	565.296	290.640	928/925	291.910
1.803.572	605.423	319.853	245.443	931/928	332.982
1.199.649	603.923	122.472	197.381	934/931	376.051
598.253	601.396	20.301	102.171	937/934	461.783
0	598.253	0	20.301	940/937	534.606
					2.721.866

Prilikom obračuna ukupnih količina pepela i šljake generalno za celu deponiju i po nivoima dolazi do neznatnih razlika prikazanih u tabeli 3. Ove razlike su zanemarljive u odnosu na ukupne količine materijala u deponiji.

Tabela 3. *Razlike u količini pepela faze 3 kasete III po nivoima i ukupno u programu Minex 5.2*

Lokacija	Cela zapremina	Zapremina po nivoima	Razlika	%
Faza 3	2.789.621	2.721.866	67.755	2.49

Količina pepela u fazi 3 kasete III iznosi 220 692 m^3. Pepeo je smešten na severoistočnom delu faze 3 kasete III u cilju mininiziranja transportnih relacija za dopremu pepela, slike 6 i 7.

ZAKLJUČAK

U svetu se projektovanje rudarskih objekata obavlja uz pomoć savremenih softverskih paketa, a što je postao ustaljeni standard za brzo i kvalitetno rešavanje ove problematike. Među ove računarske programe spadaju Gemcom 6.2 i Minex 5.2, koji se primenjuju u Institutu za rudarstvo i metalurgiju Bor. Konstrukcija se vrši prema istraženim i ispitanim tehničkim parametrima, uz pridržavanje propisanih standarda i zakonskih akta iz ove oblasti.

Važan činilac upotrebe računarskih programa je mnogo kraće vreme i bolji kvalitet izrade projekata u odnosu na klasično projektovanje, što je u današnjim tržišnim uslovima od izuzetnog značaja pri dobijanju poslova i sklapanju povoljnih finansijskih ugovora.

3D model generalno predstavlja izuzetnu pomoć za proces projektovanja u geologiji i rudarstvu. Tu se pre svega misli na početnu fazu projektovanja, koja podrazumeva potrebu projektanata da steknu utisak o geografskim osobinama terena i bez neposrednog izlaska na lokaciju, kao i projektovanje geomodela ležišta, konstrukcije kopova i odlagališta jalovine, i dinamike izvođenja rudarskih radova.

Izgradnja novih i savremenih deponija za trajno zbrinjavanje otpada u skladu sa najnovijim tehničkim rešenjima, domaćom i EU regulativom o deponijama, je u Srbiji tek u začetku. U Srbiji pitanje odlaganja opasnog otpada još uvek nije rešeno, jer ne postoji nijedna izgrađena deponija za odlaganje opasnog otpada, niti se u skorije vreme očekuje njena izgradnja. Srbija izvozi svoj opasan otpad i deponuje ga u zemljama u okruženju, za šta se troše značajna devizna sredstva. Novostečena iskustva u projektovanju deponije pepela u TE Gacko, primenom savremenih softverskih paketa Gemcom 6.2 i Minex 5.2, se sa uspehom mogu primeniti na projektovanje deponija za odlaganje otpada koji će nastati nakon reciklaže i valorizacije korisnih komponenti iz odložene kopovske raskrivke i flotacijske jalovine u Boru.

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