

Radmilo Rajković, Daniel Kržanović*, Miomir Mikić*, Milenko Jovanović**

SELECTION OF THE MOST FAVORABLE VARIANT FOR OVERTOP THE ASH AND SLAG LANDFILL "MALJEVAC" - PLJEVLJA TO THE PEAK ELEVATION K + 832 m**

Abstract

The existing landfill at the site "Maljevac" is still active and it should provide the additional space for ash and slag disposal and continue the exploitation period as long as possible. For these purposes, in the licensed GEMS and Minex software, the variant solutions of the dump overtop to the peak elevation K + 832 m were developed in the licensed GEMS and Minex software to see the all possibilities of the "Maljevac" site. Out of the four offered variant solutions, an optimal variant was selected giving the largest disposal space and the least unit costs of exploitation.

Keywords: ash and slag landfill "Maljevac" - Pljevlja, construction, GEMS and Minex software, variant solutions

INTRODUCTION

In order to provide the sufficient space ash and slag disposal from the Pljevlja Thermal Power Plant Pljevlja as a by product, in 1982 a dam "Maljevac" was built in the Paleški stream, at a distance of about 7 km from Pljevlja. The ash and slag landfill for the Thermal Power Plant Pljevlja was formed by the construction of the "Maljevac" earth dam. In the first phase, a basic dam was constructed, with a dam crest of 790.5 m (27.5 m high), and in the second phase, the dykes - stairs were successively constructed to the peak elevation of 813.2 m. Further overtop of the embankment which limits downstream the cassette I to the peak elevation K+826 m. The space of the active cassette II is an oblique dyke of an approximate height of about K+832 m,

which represents the final angle of ash and slag disposal at the Maljevac landfill in all analyzed variants.

The transport system of slag and ash from the thermal power plant is solved hydraulically, wherein the mixture of water and ash through the pipeline leading to the landfill where ash is deposited. Through the overflow structure, water is taken from the surface of landfill, i.e. the horizontal precipitation channel, gravitationally drains to the excavator digger, and in this way forms a closed recirculation system of technological water at the landfill. Below the landfill, there is a reinforced concrete collector, wall thickness of 60 cm, and through it the water of the Paleški stream are led. The collector consists of the main and secondary one. The

* Mining and Metallurgy Institute Bor, radmilo.rajkovic@irmbor.co.rs

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length of the main collector, after extension, during implementation of the project of stabilization the dam "Maljevac", is 1460 m, and the secondary one is 600 m.

During 2014, stabilization of the dam "Maljevac" was carried out by construction a stabilizing ballast. The works have provided the given conditions of static and dynamic stability. The existing landfill at the site "Maljevac" is still active and it needs to cover the disposal of ash and slag from the TPP until the beginning of opening the landfill on a new location.

CONSTRUCTION OF THE OVERTOP

The overtop of the ash and slag landfill "Maljevac" is projected to the peak elevation K+832 m. In the construction of new cassettes, in order to prevent the pollution of the Paleski stream, a watertight clay layer of 1.0 m thickness is placed on the bottom. The filling is done in all cassettes up to the peak elevation K+832 m, after which, there are closure and recycling of the landfill in accordance with the applicable regulations. A waterproof layer is placed up to the peak elevation K+833 m, and a reclamation layer is placed up to the peak elevation of K+834 m.

In the Maljevac landfill, the ash and slag from the thermal power plant are deposited in the currently active cassette II at the Maljevac landfill. The dyke of cassette II has already been built up to the peak elevation K+832 m in some places, while in some places the height of dyke is around K+830 m. The overtop of the cassette II practically represents a correction of dyke up to the peak elevation K+832 m in the places where it has not been reached, so that the newly formed dyke has a 6 m wide crest at the peak elevation K+832 m, with an inclination of inside and outside slopes of 1:2. Upon completion of the works on correction the

peripheral embankment, the ash and slag disposal will continue to the peak elevation K+832 m.

The cassette III overtop was done for three possible cases [1].

The first case: overtop of the cassette III covers the space up to the existing path around the cassette III. Along the access road around the cassette III, a circumferential embankment of 5 m waterproof material will be made, the width of the dike crest will be 6 m and the slope of the inner and outer slopes of 1:2. Correction of the existing dyke towards the cassette I will also be done in the places where it is needed. Geometric elements for the overtop according to this variant are: general angle of the overtop slope 1:3; floor height 5 m; angle of floor slope 1:2; width of the final floor level is 5 m.

The second case: overtop the cassette III covers the space up to the peak elevation K+832 m. Before the cassette III overtop, a circumferential embankment will be made in the northern and southern part of the cassette III, and corrections of the existing dyke to the cassette I, so that the newly formed dyke has a 6 m wide crest at the peak elevation K+832 m, with an inclination of inside and outside slope of 1:2 for the southern dyke, while the northern dyke will have the same inner slope, but due to the stability, the inclination of the outer slope will be 1:2.5. The new cassette IV on the west side of the landfill is added, with the formation of one dyke with the same geometry.

The third case: overtop the cassette III covers the space up to the peak elevation K+832 m, together with the space of the new IV cassette, without the construction of a central dyke. Before the cassette III overtop, the circumferential embankment in the northern part of the cassette III will be made, corrections of the existing dyke towards the cassette I will be made, and the peripheral dyke will be constructed in

the southeastern part of the space, so that the newly formed embankment has a 6 m wide crest at the peak elevation K+832 m, with an inclination of the internal and external slopes of 1:2. Upon completion of the works on the construction and correction of the peripheral embankment, the ash and slag disposal is made to the peak elevation K+832 m. The northern dyke that connects the cassette I dyke and the paleo-relief will have an internal slope of 1:2, while the external will be 1:2.5.

The new cassette IV on the west side of the landfill is added, with the formation of one dyke. Also, this cassette is filled up to the peak elevation K+832 m. Geometric elements are the same as for other dyke. Upon completion of the works on the construction and correction of the peripheral embankment, the ash and slag disposal is made to the peak elevation K+832 m.

The cassette I overtop will be realized when the favorable conditions for its construction are achieved, i.e. when sufficient dynamic stability of the main dam is achieved. In the first phase, its surface is covered with a waterproof material of 1 m thickness, in order to prevent further infiltration of atmospheric and technological water from the surface of landfill to the lower parts of the landfill, which is aimed to reduce the influence of groundwater on the cassette stability as well as the pollution of the Paleški stream. Then, all necessary measures are implemented in order to achieve a satisfactory stability coefficient in the case of a peak elevation up to K+832 m. If the required stability is achieved, the cassette I is extended to the peak elevation K+832 m with formation the circumferential embankment of the same characteristics as for the other cassettes and space filling with ash. In the event that the required stability is not achieved, the closure is reached, i.e., rehabilitation of the cassette I [1].

Construction of the ash and slag dumps of the Maljevac Thermal Power

Plant Pljevlja to the K + 832 m was done in the licensed software Gemcom, and calculation the quantities in the licensed Minex software [4 - 9].

VARIANT SOLUTIONS OF THE OVERTOP

By development the variant solutions of the overtop of the existing landfill Maljevac, it was possible to consider the possible variants of ash and slag disposal of the Thermal Power Plant Pljevlja in order to find an optimal variant for the continued use of the landfill in the next period.

The considered variant solutions take into account all restrictions that directly affect the realization of the expansion and elevation the existing landfill, such as: Urbanistic technical conditions, Detailed spatial plan, relocation of the existing transmission line, land expropriation, stability of the existing dam and assessment the stability of designed overtop to the peak elevation K+832 m, as well as the condition of the existing collector for deviation of the Paleški stream under the landfill body. In addition to these factual constraints, the legal constraints must also be taken into account which strictly define the way of forming the new cassettes, drainage of leachate and atmospheric water and way of closure - rehabilitation of the landfill, i.e. all restrictions that reduce the negative impacts of landfill on the environment [2, 3, 10].

Based on the construction of cassettes of the Maljevac landfill, it is possible to provide several variant solutions for the overtop. The following variants of the landfill overtop were analyzed according to the construction phases:

1. Variant 1: cassette II – cassette III to a road
2. +– cassette I;
3. Variant 2: cassette II – cassette III to isohypse K+832 m – cassette I

4. Variant 3: cassette II – cassette III to isohypse K+832 m – cassette IV – cassette I
5. Variant 4: cassette II – unique cassette III and IV to isohypse K+832 m – cassette I

Figures 1 - 4 show the 3D model [4 - 9] of the final contours of the landfill for all 4 variants. Comparative calculation of the amount of deposited material and service life of exploitation according to the variant solutions is shown in Table 1.

Table 1 Comparative overview of disposal capacities at the landfill for the variant solutions

CASSETTE	Variant 1	Variant 2	Variant 3	Variant 4
II (m ³)	453,483.00	453,483.00	453,483.00	453,483.00
III (m ³)	136,782.00	2,532,031.00	2,532,031.00	4,995,721.00
IV (m ³)			2,463,358.00	
I (m ³)	906,797.00	908,475.00	906,797.00	906,797.00
Total ash, (m ³)	2,728,103.00	3,893,989.00	6,355,669.00	6,356,001.00
Service life, (years)	4.5	6.4	10.5	10.5

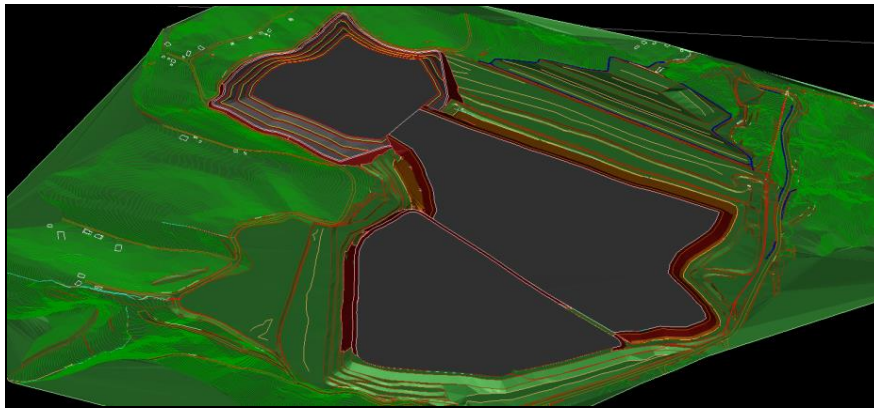


Figure 1 3D model of the final landfill view by the Variant 1

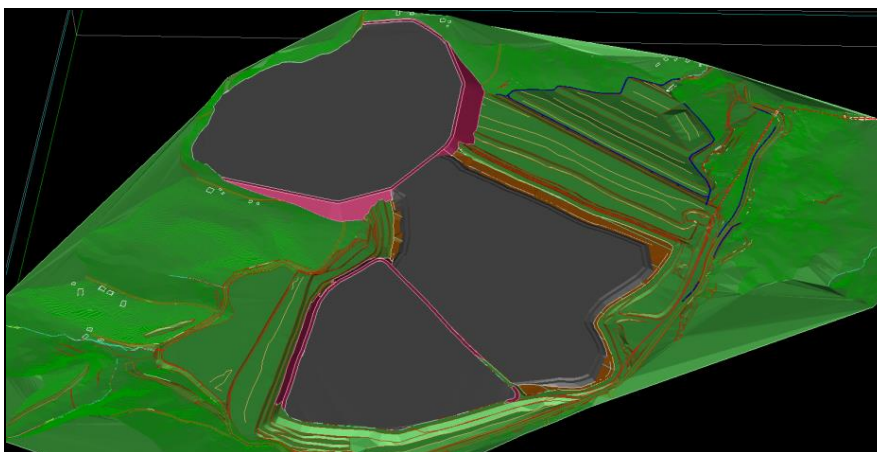


Figure 2 3D model of the final landfill view by the Variant 2

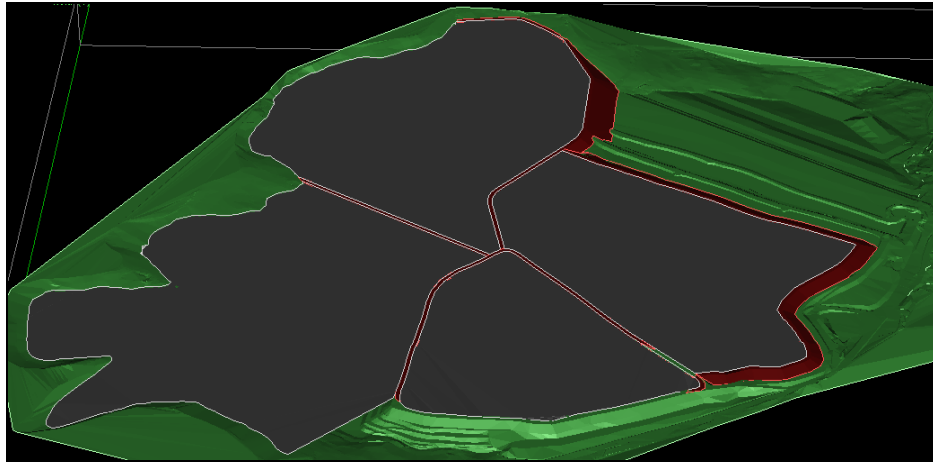


Figure 3 3D model of the final landfill view by the Variant 3

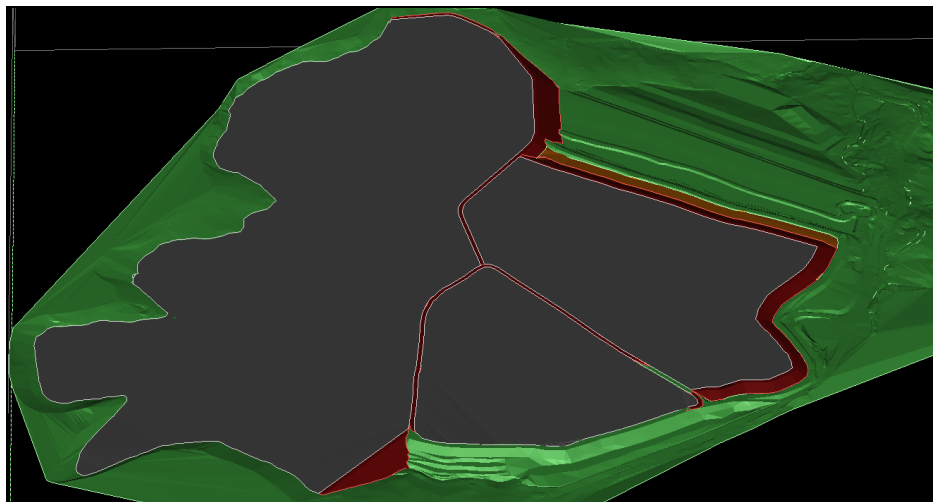


Figure 4 3D model of the final landfill view by the Variant 4

SELECTION OF THE MOST FAVORABLE VARIANT FOR OVERTOP

In selection the most favorable variant solution for overtop of the landfill, the all limitations, specified in the previous chapter, have been taken into account, and

the main selection criteria are the unit costs of disposal and service life of exploitation at the landfill. Table 2 gives a comparative overview of these criteria.

Table 2 Comparative overview of the unit costs of disposal at the landfill for the variant solutions

Cassette	Variant 1	Variant 2	Variant 3	Variant 4
Service life, (years)	4.5	6.4	10.5	10.5
Investments per cubic of deposited ash, (€/m ³)	1.86	1.98	1.66	1.59
Investments per cubic of deposited ash for expropriation, (€/m ³)	0.92	1.05	0.98	0.98
Investments per cubic of deposited ash for reclamation, (€/m ³)	1.24	1.21	1.05	1.05
Total investments per cubic of deposited ash, (€/m ³)	4.02	4.24	3.69	3.62

On the basis of the all applied technical, economic, social and environmental considerations of selected variant, and adhering to the basic criteria of evaluation, ie. providing as much as possible volume of the ash disposal area, with achievement of as long as possible the period of exploitation of the landfill, and as little as possible the unit costs of exploitation, and in accordance with the given Urbanistic technical conditions, the Variant 4 was selected as the final technical solution for the landfill overtop.

The selected variant has the unit operating costs of 3.62 €/m³ of deposited ash and slag, and a space of 6,356,000 m³ is provided which ensures the service life of the landfill for a total of 10.5 years, taking into account the all necessary ecological standards.

CONCLUSION

By development the variant solutions of the overtop of the existing landfill Maljevac, it was possible to consider the possible variants of ash and slag disposal of the Thermal Power Plant Pljevlja in order to find an optimal variant for the

continued use of the landfill in the next period. The considered variant solutions take into account all restrictions that directly affect the realization of the expansion and elevation the existing landfill. In addition to these constraints, the legal constraints were also taken into consideration which strictly define the way of forming the new cassettes, drainage of leachate and atmospheric water and way of closure - rehabilitation of the landfill.

The use of cassette I for ash disposal would be as the next logical phase of ash disposal in the present disposal conditions, after the completion of exploitation the cassette II, as its height is about K+825 m. However, the stability calculation for the cassette I to the peak elevation K+832 m does not provide a sufficient stability coefficient, due to the saturation of landfill body with water in the zone upstream from the primary dam, and collector zone of the Paleški potok, therefore it was decided that this cassette would be the last stage of overtop - in all variants. This data has affected that some of the planned variants are immediately eliminated.

Four variants of the landfill overtop were considered using the modern soft-

ware for mining design, which is now the standard in this field. For each variant, its configuration in space, the method of cassette formation, volume of ash and slag storage space, method of closure and rehabilitation, drainage of leachate and atmospheric water were given. As a result, the evaluation of unit costs of the landfill exploitation per m³ of deposited material was obtained, and the most favorable variant for the continuation of disposal at the site "Maljevac" was selected.

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