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STABILITY OF THE DAM ”PREVOJ ŠAŠKA“ OF THE FLOTATION TAILING DUMP ‘VALJA FUNDATA“ IN MAJDANPEK[**]

Abstract

The existing dam "Prevoj Šaška" is located on the active flotation tailing dump "Valja Fundata" in Majdanpek. Since there is no valid documentation for the current maximum height of dam K+538 m, and disposal of tailings into this landfill is continued, the stability of dam has been carried out. Stability is calculated with the software SLIDE v6.0.

Keywords: *dam "Prevoj Šaška", stability analysis, software SLIDE v6.0*

INTRODUCTION

From the beginning of the work of the Copper Mine in Majdanpek, the flotation tailings are deposited in two tailing dumps, out of which one is the main and the other auxiliary, that is, accidental. The tailing dump "Valja Fundata" is the main tailing dump. This tailing dump has been formed in the valley of the Valja Fundata stream, which starts right in front of the Copper Flotation Plant in Majdanpek. In order to enable the use of the valley Valja Fundata for deposit of flotation tailings and formation an accumulation reservoir lake for the return of technological water back to the flotation process, it was necessary to adequately close all karst channels in order to prevent the leakage of tailings and water, where it was allowed the leachate water to flow smoothly into the Veliki Pek River.

The beginning of formation the tailing dump “Valja Fundata” dates back to 1961. The tailings were discharged in part of a limestone massif directly from the canal, since the system for separation the bulky tailings was not in a function, which, as a general consequence, has an anisotropic character - sludge and bulky tailings together. The proximity and position of the cleaned water collector, combined with a large drainage surface, compared to the initial precipitation lake, prevented mowing away of the clear water from the limestone massif. This was directly influenced by the surface ore parts that, due to the presence of large quantities of clay material under water, occupy a small drop, almost horizontal.

The dam "Prevoj Šaška" was built up to the level K+538 m, length of 460 m, width of 180 m basically and the width of crest is 12 m. It has a drainage system at the level K+518 m, which is in function, and at the level K+524 m, which is fore

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seen for future overtops. In the central profile of the dam, two piezometers were placed as well as five piezometers on the natural terrain toward the accidental tailing dump "Šaški Potok". It is the only dam on this tailing dump that is in contact with water, although in recent years the water has been rejected from the dam by formation a beach of the unclassified tailings, width of 80 - 100 m. In this sector, there is also a floating pump station that has not been moved in time, and therefore the water level has increased to ensure the normal operation of the pump station.

This paper presents a stability checking of the dam "Prevoj Šaška" for the current operating conditions, as well as in case of further operation for the next 2 m at each 0.5 m of the water level increase from the current level. The aim of this checking is to determine the maximum water level in which the stability of the dam "Prevoj Šaška" and safe operation of the "Valja Fundata" landfill are ensured.

BASIS FOR THE STABILITY CHECKING

The stability checking analysis of the dam "Prevoj Šaška" of the flotation tailing dump "Valja Fundata" in Majdanpek was carried out on a profile placed through the piezometers in the dam body. The geodetic state of the dam was recorded in October 2018 by the Geodetic Department of the RBB. The water levels were taken in September 2018. The position of profile is given in Figure 1.

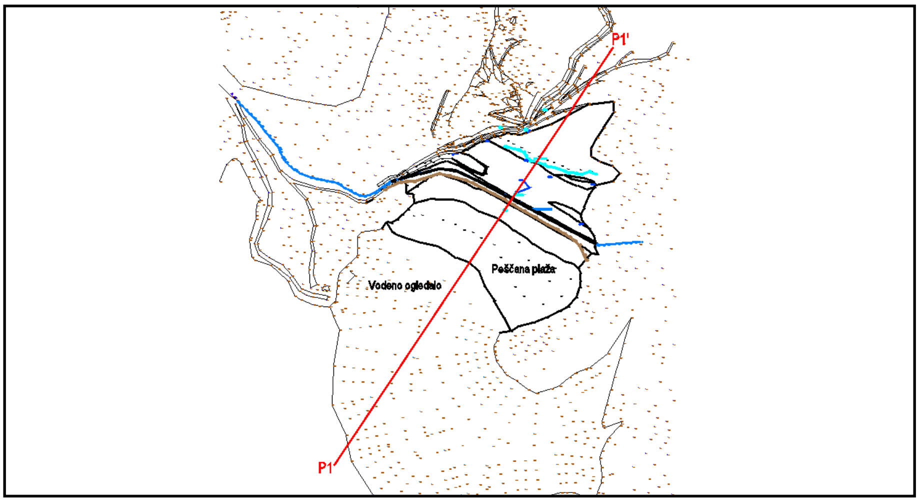

Figure 1 *Position of the analyzed dam profile*

At the location “Prevoj Šaška“, one probe drill hole B-3 with a total depth of 31 m and description was made in the flotation tailings. During drilling, 14 samples were taken from the B-3 drill hole and the tests of grain-size distribution, humidity, bulk mass, water permeability coefficient and direct shear were made on all samples. [1, 2]

Since it was not established whether the cyclonized sand or unclassified pulp composition and at what depths were not found in a drill hole, and arrangement of the cyclonized sand benches during the dam construction is not known, then only on the basis of differences in the results of the above mentioned laboratory tests, the following can be determined:

- The grain size distribution indicates that the grain size of 0.075 mm ranges from 15% to 40%, indicating that the unclassified pulp was embedded, or the cyclone operation was variable.
- The water permeability coefficients range from $1.18x10^{-6}$ m/s to $5.4x10^{-6}$ m/s, which can be the result of changes in the grain size distribution.
- The shear resistance tests range from the angle of friction φ = 24° and cohesion C = 0 to φ = 26° and cohesion C = 6 kPa.
- The bulk density in dry state (compaction) ranges from 1.590 g/cm^3 to 1.857 g/cm^3; the bulk density in wet state from 1.711 g/cm^3 to 2.265 g/cm^3.
- The humidity of samples ranged from 3.3% to 10.5% to 10 m depth, and below that depth from 15% to 27.5%

No shear resistance tests were carried out for the rock mass, while the value of φ= 40°C and C = 60 kPa with bulk density of 2.4 g/cm^3 based on the test from the previous years was adopted for the project of overtop the dam "Pustinjac", but these data were not important for the dam stability since the rock is at a great depth, which is also the case for the dam “Prevoj Šaška“.

According to the presented results, it can be expected that the lowest values correspond to the unclassified pulp, and most the the cyclonic sand. The unclassified pulp was probably used because the amount of overflow is insufficient to follow a dam formation with cyclonized sand, and to achieve the required beach slope of about 1:10, as was the cases with the project of overtop the dam "Pustinjac".

Stability checking [3-11] was done by the SLIDE v6.0 program of ROCSCIENCE. With SLIDE, the stability checking is carried out in the conditions of limit balance. The checking was made according to the Janubu method. For the stability checking, the calculation parameters are given in Table 1.

Table 1 *Calculation parameters for stability checking*

Working environment	Cohesion, kN/m^2	Angle of internal friction, °	Bulk density, kN/m^3
Material in a dam	0	24	15.6
Base	60	40	23.5

The impact of groundwater on stability was modeled with a piezometer line on the analytical profile. Position of the piezometer line for the current condition was determined based on the level of water mirror and measured water levels in the piezometers. The piezometric water level was also defined at every 0.5 m increase in the water level to a height of 2 m.

STABILITY CHECKING

Stability checking was carried out in the static conditions and dynamic conditions for occasional earthquake occurrence with the seismic coefficient, which for the Majdanpek area is K_s = 0.13 for an earthquake of 8° MKS and return period of 475 years. The results of stability checking for the current state and increased water level are shown in Figures 2 - 11 and Table 2.

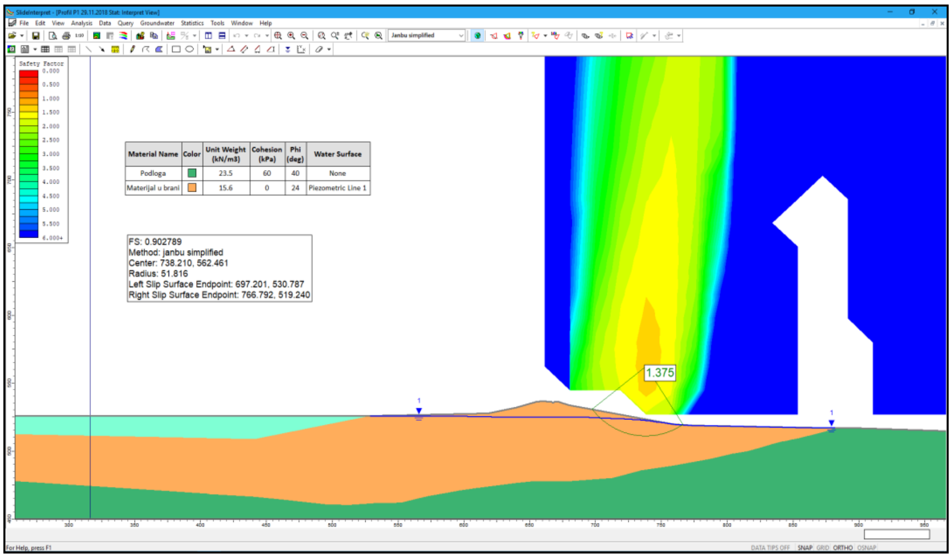

Figure 2 *Static safety coefficients by the Janub method for the existing state*

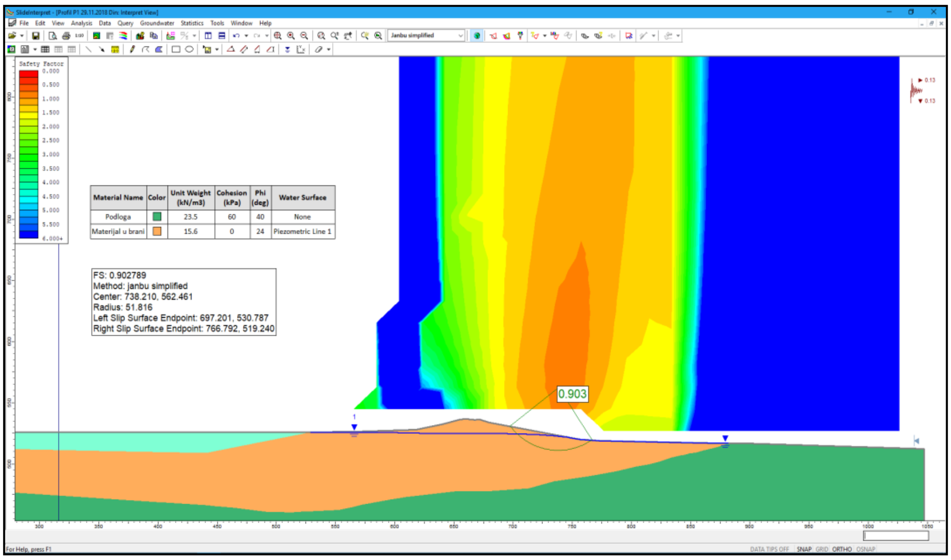

Figure 3 *Dynamic safety coefficients by the Janub method for the existing state*

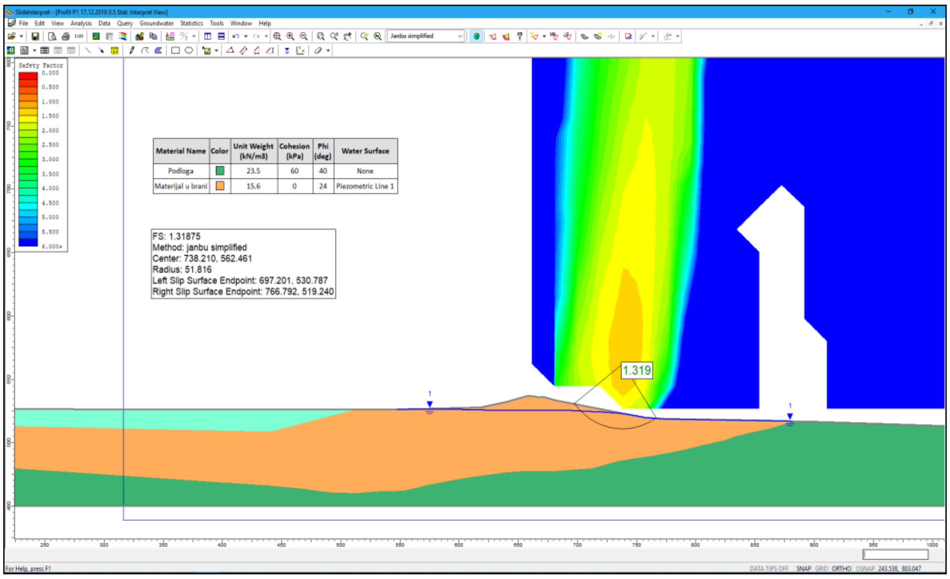

Figure 4 *Static safety coefficients by the Janub method with the increased water level 0.5 m*

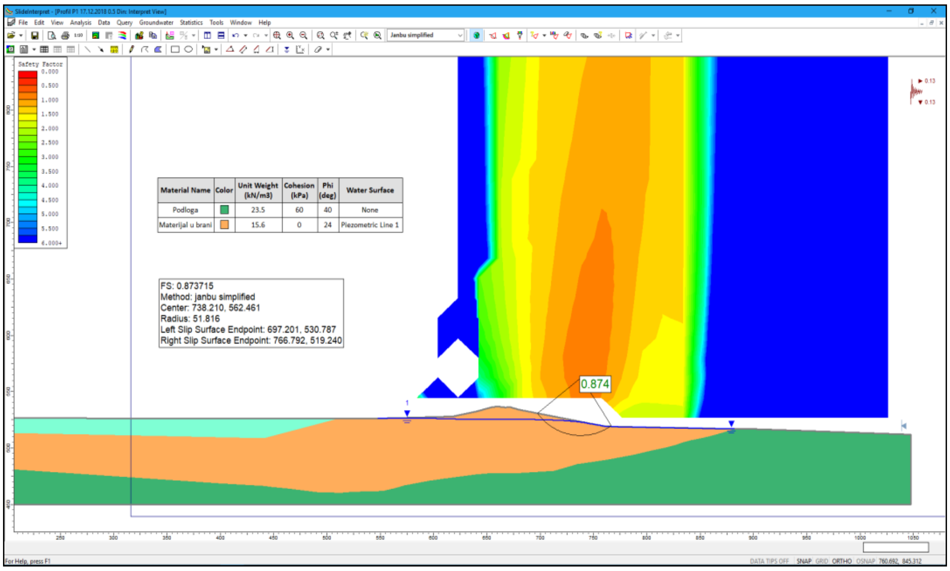

Figure 5 *Dynamic safety coefficients by the Janub method with the increased water level 0.5 m*

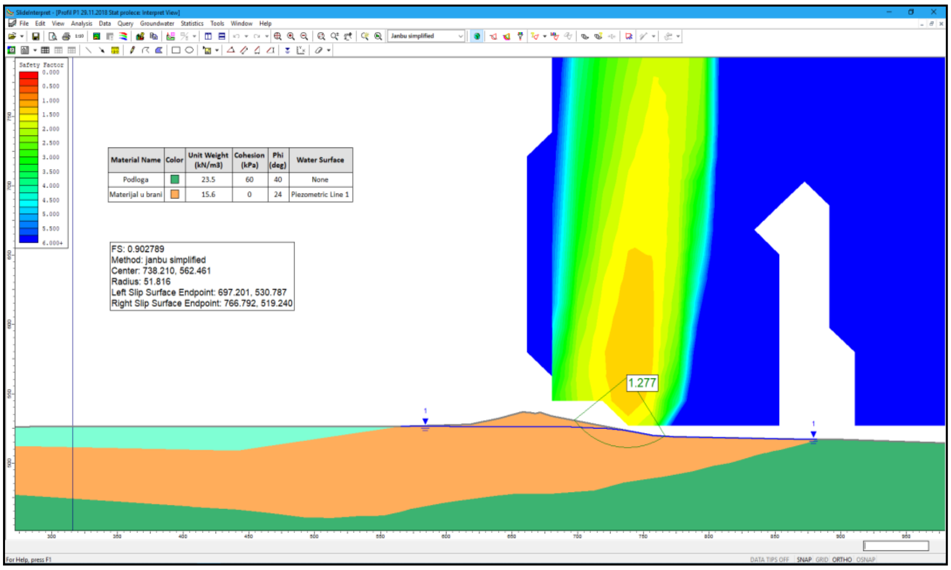

Figure 6 *Static safety coefficients by the Janub method with the increased water level 1.0 m*

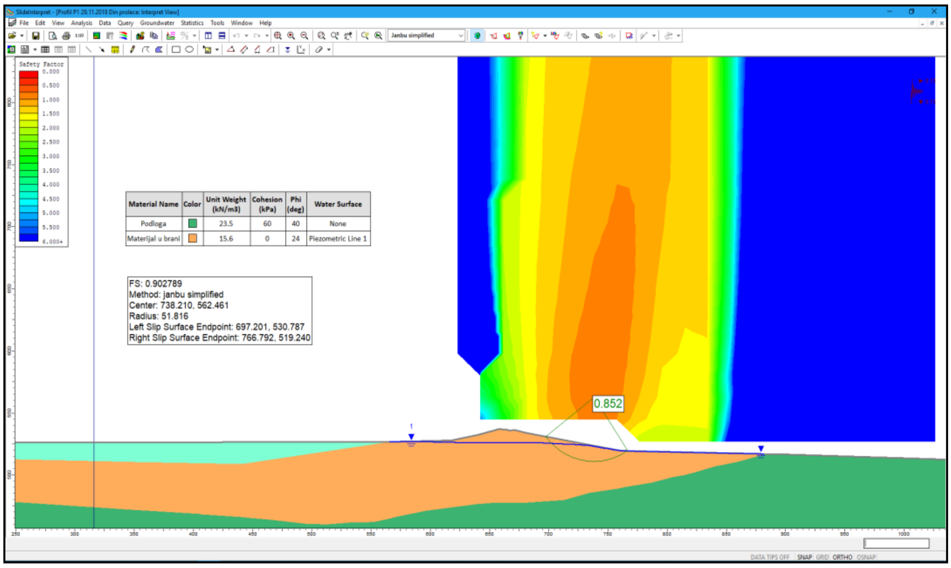

Figure 7 *Dynamic safety coefficients by the Janub method with the increased water level 1.0 m*

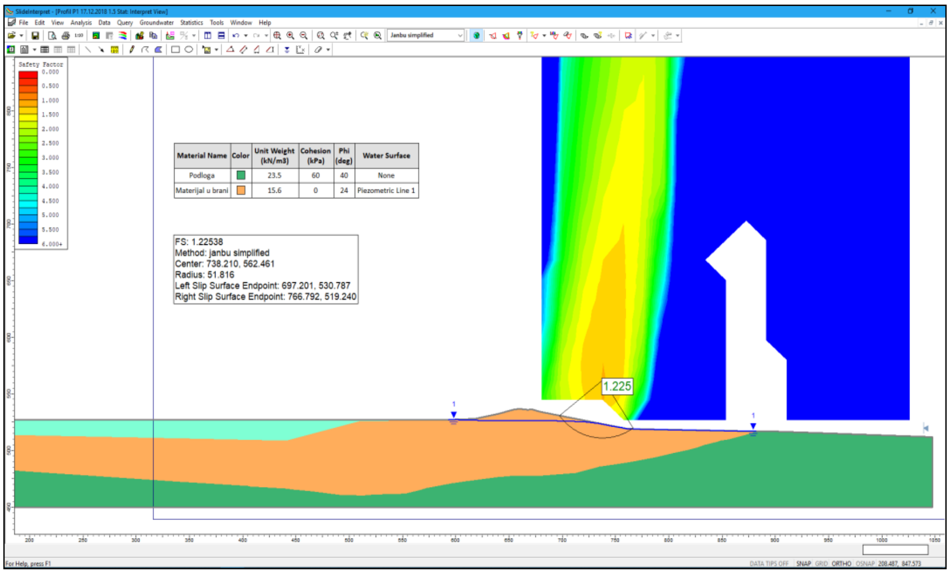

Figure 8 *Static safety coefficients by the Janub method with the increased water level 1.5 m*

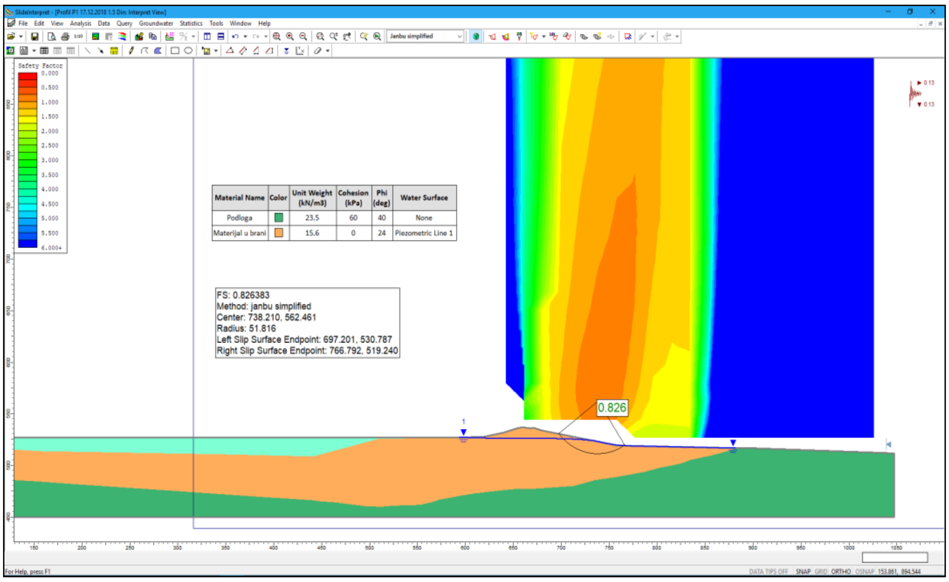

Figure 9 *Dynamic safety coefficients by the Janub method with the increased water level 1.5 m*

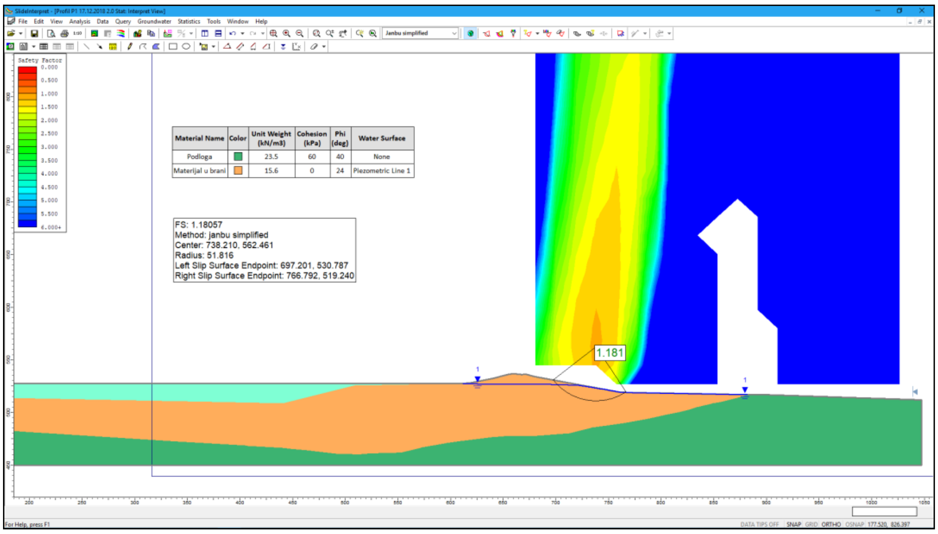

Figure 10 *Static safety coefficients by the Janub method with the increased water level 2.0 m*

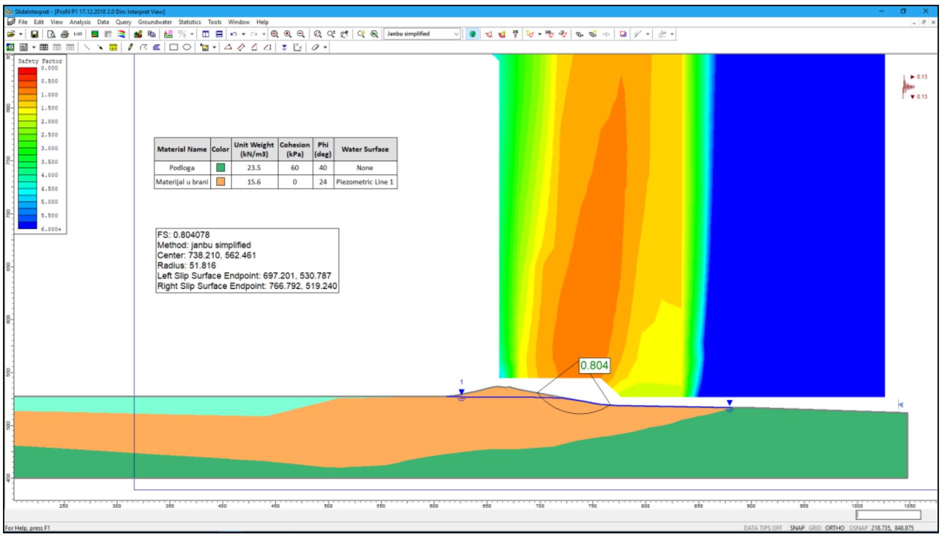

Figure 11 *Dynamic safety coefficients by the Janub method with the increased water level 2.0 m*

Table 2 *Summary overview of the stability coefficient*

Profile P – P'	**F_s static**	**F_s dynamic**
Existing state	1.375	0.903
Water level +0.5 m	1.319	0.874
Water level +1.0 m	1.277	0.852
Water level +1.5 m	1.225	0.826
Water level +2.0 m	1.181	0.804

By comparison the obtained safety coefficients of the flotation tailing dump dam with the allowed minimum coefficient, prescribed technical conditions for design of earth dams and hydro technical embankments - SRPS U.C5.020, which for the earth dams above 15 m is minimum F_s = 1.50 in case of the constant static load, or F_s = 1.00 in case of the occasional dynamic load for the earthquake occurrence, it can be concluded that the obtained safety coefficients for static and dynamic loads are below the prescribed values.

Figure 12 shows the linear dependence of change the safety coefficient for the static and dynamic loads from the water level.

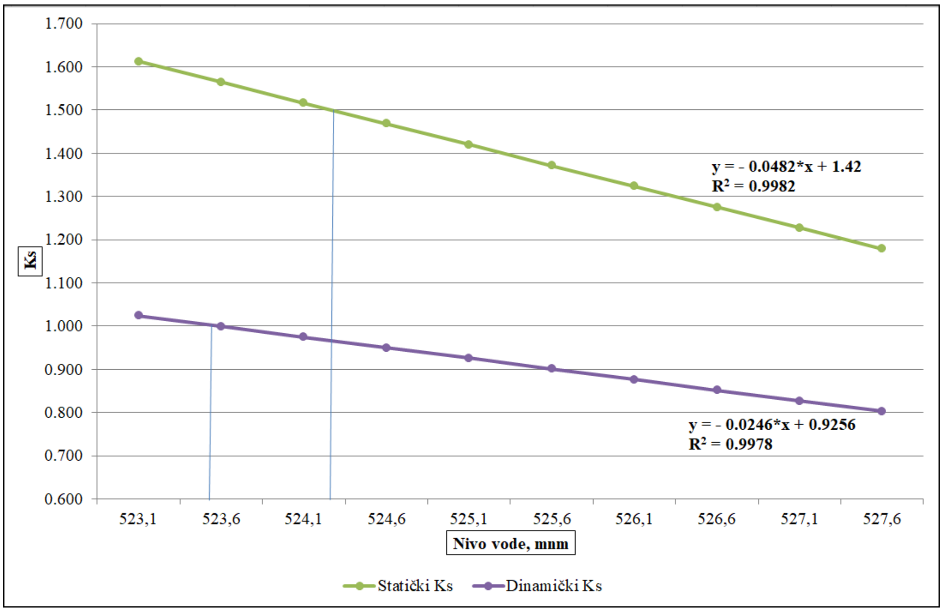

Figure 12 *Dependence diagram of changing the value of safety coefficients from the water level*

CONCLUSION

For deposition the flotation tailing of RBM, in addition to the existing tailing dumps, there is no alternative without large investments. Due to these reasons, a technical – technological solution should be provided for maximum use of their spatial capabilities.

Observation should be carried out in order to prevent a possible damage by timely detection a phenomena and occurrences that adversely affect the stability, as well as to establish a program of works for partial remediation and repair, ongoing maintenance and general rehabilitation of the dam.

The maximum level of water mirror in the tailing dump should not be above the K+23.3 m. This entails the removal of water mirror from the dam crest and displacement of the pump station from the existing location.

For monitoring of the influx water through the dam body, it is necessary to select the characteristic profiles on which the piezometers are placed in a straight line of the embankment. With such arrangement of piezometers, a precise position of the influx level line is reached. With previously performed laboratory tests and with the results of other observations and measu-rements, a complete set of measured values is obtained on the basis of which the dam stability will be calculated.

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