

## High slope waste dumps – a proven possibility

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*This paper is an overview of dumping operations on High Slope Waste Dump at Veliki Krivelj open pit copper mine, RTB Bor, Serbia. The High Slope Waste Dump in Bor is the highest single slope waste dump in the world with the slope height of 405 m. The paper gives the basics and limitations of the designed dumping technology, the redesigned technology, gives an overview of the 13 year long operation and gathered experiences and addresses the main issues of dumping operations in high slope conditions as well as the present condition of the High Slope Waste Dump.*

**Key words:** Waste dump; high slope; slope stability; gathered experience

### 1. Introduction

Open pit Veliki Krivelj is a copper mine located some 5 km north of Bor, East Serbia. It operates as a part of RTB Bor-Group, one of the largest, if not the largest, copper extraction and processing companies in the region.

The ore reserves are estimated to 350 M tons of low grade ore with the average copper grade of 0.24 – 0.34 %. The mining operations at Veliki Krivelj started with overburden removal in 1979 and the first tons of copper ore were extracted in 1982. According to the Main mine design from 1978 [1], the designed open pit productivity was 8M tons of wet ore. After the revision of the final pit shell and the analysis of the final pit depth a study was made showing that it is possible to achieve the annual productivity of 12 M [2] tons of ore with the final pit depth (pit floor) set at elevation of K-100 m. The latest redesign (2010 [3]) is setting the annual productivity to 10.6 M tons of ore. Unfortunately, this productivity is not yet achieved due to various factors (one of them being mineral processing facilities throughput of 8 M tons but presently the processing facilities are expanding their capacities).

Overburden/waste was hauled and disposed to two active haul truck dumps, Todorov Potok and Saraka Potok. During the period of Serbian economic crisis in the early nineties, chronic shortage of fuel and parts, inability of quality maintenance of the loading and hauling fleets and the mine's desire to survive and sustain copper production resulted in formation of the inner dump in order to reduce the hauling lengths. Unfortunately, that maneuver trapped significant amounts of ore.

With an ambition to achieve the designed annual productivity of 10.6 and eventually 12 M tons of ore and with active waste dumps being almost filled and the need to remove the waste from the inner dump, a solution for waste disposal was urgently needed. The solution for waste dump location was found in the cavity of the closed open pit Bor located 3 km south of Veliki Krivelj. The Bor open pit was closed in the early nineties after 60 years of mining operations and represented obvious and ideal solution because of two reasons

1. The volume of the cavity of nearly 240 M m<sup>3</sup> can provide necessary space for disposal of 225 M m<sup>3</sup> of waste rock from Veliki Krivelj without the need for additional area degradation
2. Upon the completion of dumping operation the cavity will be filled and reclamation of degraded area can be done more easily.

Waste haulage and dumping system was designed in 1994-1995 [4,5], construction operations begun in 1996 and it became operational during 1998. Considering the terrain configuration, the length of haulage roads, the lack of hauling trucks at the time and the costs of haulage the only possible choice was combined haulage system. The designed system considers truck haulage within the pits outline, crusher, belt conveyor to the dumping location and a boom spreader at the end (Fig. 1). The trucks haul waste to the cone crusher located in the south slope of the pit. The south slope was chosen for the crusher location because it is the final slope of the pit and is closest to the dumping location. According to the original design foundations for two cone crushers were built but only one crusher was installed back in the nineties. The other crusher was installed, tested and became operational during the first six months of 2011. Crushed material is fed to the main belt conveyor and transported to the dumping location. The 2.8 km long main belt

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conveyor has installed power of 4 MW (1 MW in the main drive station and 3 booster stations along the conveyor route with 1 MW each). The material from the main belt conveyor is fed to a dump belt conveyor at the dump conveyor turning station. The dump conveyor feeds the boom spreader. Boom spreader dumps the waste material into the cavity of the Bor open pit forming a single slope dump with maximal slope height of 400 m. The designed productivity of the disposal system is 4 700 t of waste per hour. With 6 effective working hours per shift, three shifts per day and 300 working days per year the maximum productivity (considering two operational crushers) of the system is 25 000 000 t/year.

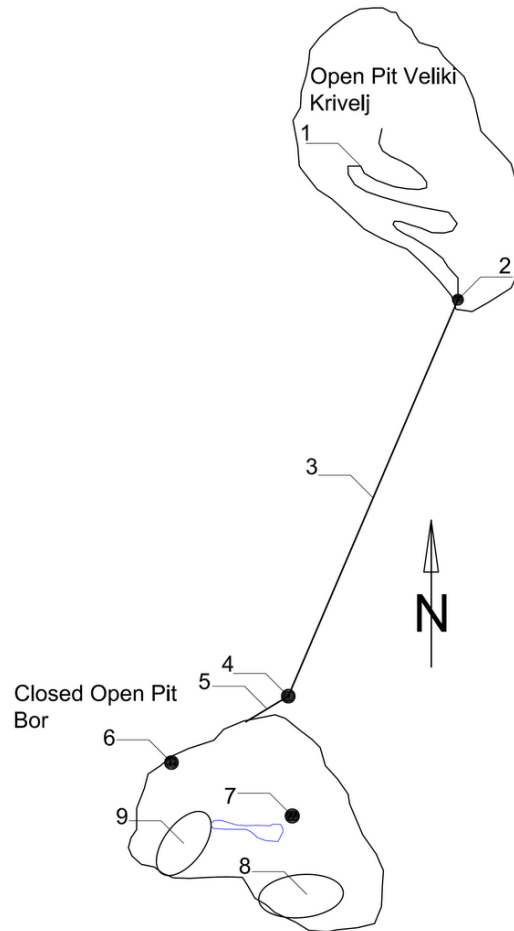


Fig. 1. The elements of the dumping system with objects of concern; 1) haul truck route, 2) cone crusher, 3) main belt conveyor, 4) turning station for the dump conveyor, 5) dump conveyor and boom spreader, 6) ventilation shaft VO-4, 7) ventilation ramp P2A, 8) metallurgical slag dump, 9) landslide zone.

## 2. Dumping technology

### 2.1 Basics and limitations

The basic idea for the dumping technology was to dispose waste from the main dumping platform directly into the cavity of the old open pit. In that way a dump would be formed with the single slope with the crest of the slope at the level of the main platform and the toe of the slope on the floor of the pit. The main dumping platform is at elevation of K+435 m and at the beginning of the dumping operations the floor of the pit was at elevation of K+30 m. These, at one moment, gave the maximum dump height of 405 m.

At the time when application of this solution was considered and waste haulage and disposal system was in design there was no knowledge of existence of similar dump in the world. Up to date and up to the knowledge of the authors, there is still no similar case worldwide.

Considering the lack of knowledge at the time and the lack of data on disposed material behavior in the high slope conditions the dumping technology was designed as a phase operation. The first phase of dumping operations was waste disposal from the main platform level down and filling of the Bor pit cavity. The second phase was waste disposal from the main dumping platform up to the final dump top at elevation of K+450 m. In addition, the first phase is divided into two stages with the first stage being

experimental. The idea was to reach the maximal slope height as soon as possible and collect necessary data for the following stage and phase. Additional reason for the experimental phase was legal. The Serbian ministry of mining would not give permission for the dumping operations if there was no experimental phase since no similar object existed at the time. The other reason for the phase development of the waste dump was the existence of active objects within the Bor open pit outline which needed to be protected against covering with disposed waste. The objects of concern were ventilation shaft VO-4, ventilation ramp P2A, the metallurgical slag dump and the landslide in the South-West slope of the Bor pit (Fig. 1).

Ventilation shaft VO-4 is located in the north slope of the Bor pit at elevation of K+375 m and it is the main ventilation shaft for the underground copper mine Jama located beneath the Bor pit area. The VO-4 shaft was operational at the time of dump design and will remain operational in the future (Fig. 1 pos. 6).

Ventilation ramp P2A was located in the east slope of the Bor pit at elevation of K+121 m and provided air for the ventilation of the P2A orebody of the Jama mine. The P2A orebody was operational at the time of dump design but mining operations in this orebody were abandoned so there is no need for further protection (Fig.1 pos. 7).

The metallurgical slag dump is located in the S-E slope of the pit. It is the dump for the disposal of metallurgical slag from the local copper smelter (Fig. 1 pos. 8).

The S-W slope of the Bor pit is located above the Tilva Ros orebody of the Jama mine (Fig.1 pos 9). Application of the modified Swedish sublevel caving method in this orebody resulted in instability of the overlying pit slope. The slope was subjected to landslides endangering the nearby structures (including residential). The basic idea during dump design was to lead the development of the dump in such way and dynamics to rest the toe of the dump slope against the sliding pit slope in a shortest time. The governing idea was that the mass of the dump will suppress the sliding zone and increase its stability. At the beginning of the 2006 due to unfortunate factors a massive amount of water and mud from the Bor pit floor penetrated and flooded the underground galleries of the Tilva Ros orebody killing one person and injuring several. After that event, all mining operations in Tilva Ros were permanently abandoned. During this year all of the residents of the affected structures were relocated so there is no need for additional stabilization of the slope.

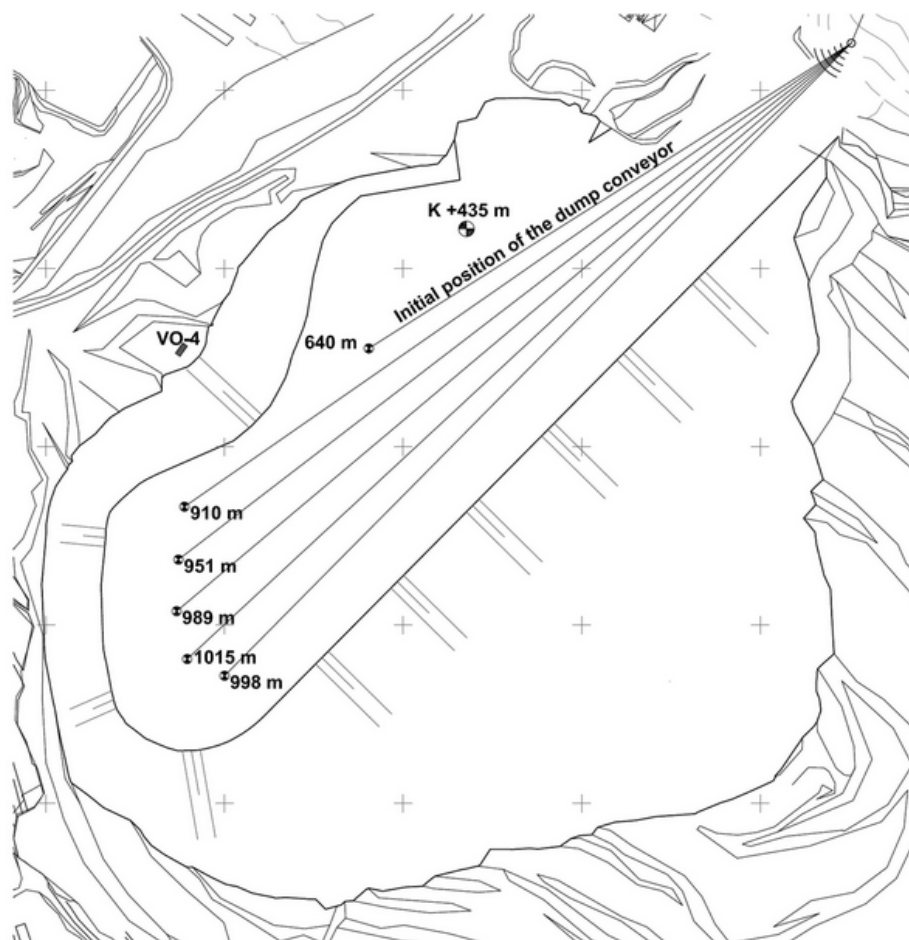


Fig. 2. Plan view of the dump at the end of Stage 1 of the Phase 1 with initial position of the dump conveyor and radial steps.

## 2.2 Phase 1 of the dumping operations

As said, the first phase of dumping operation has two stages. The first stage of dumping operations was considered as experimental and had two basic goals: gathering data on the behavior of dumped waste in the conditions of high slopes and fulfillment of the described limitations. In order to achieve that it was necessary to form the initial dumping platform at elevation of K+435m providing space for the turning station and the route of the dump conveyor. The initial platform is located in the N-E slope of the Bor pit and the designed starting route for the dump conveyor is in the North slope of the pit in the direction of VO-4 shaft (Fig. 2). The 300 t boom spreader with 30 m reach boom (spreader 1) is in the straddle position above the dump conveyor and can travel along the conveyor. The construction of the spreader (Fig. 3) lifts the belt from the dump conveyor and feeds material to the boom. In addition to that, the construction of the turning station of the dump conveyor allows storage of up to 200 m of belt which allows the extension of the conveyor without a setback in disposal dynamics. Considering the lack of knowledge at the time, despite the stability calculations [4] that showed that minimal safe distance from the slope crest was 35 m the designers were cautious and adopted the safe distance of 90 m. With this length of the safe distance the boom spreader could never reach the crest of the slope and dispose the material directly into the cavity of the pit. Because of that the basic technology considered the application of a pair of bulldozers for additional dozing of the disposed material. The boom spreader, at maximal reach of 30 m, disposes the material to the main dumping platform and forms the 12 m high piles. The piles are formed in a semicircle around the spreader (to the left, right and in front). The first bulldozer pushes the material towards the edge of the dump in the length of 30 m and returns. The second bulldozer then takes the material and pushes it for additional 30 m and over the edge (Fig. 4). When the width of the dump in the direction of the pit and in front of the boom spreader reaches 90 m the dump belt conveyor is extended, the boom spreader advances a step and the procedure repeats. The characteristics of the stage 1 of the first phase are material disposal below the main level, the early reach of the maximal dump height and frontal advance of the dump. The end of the stage 1 and thus the experimental stage is the moment when the dump reaches the designed outline in the N-W slope of the pit (Fig. 5).

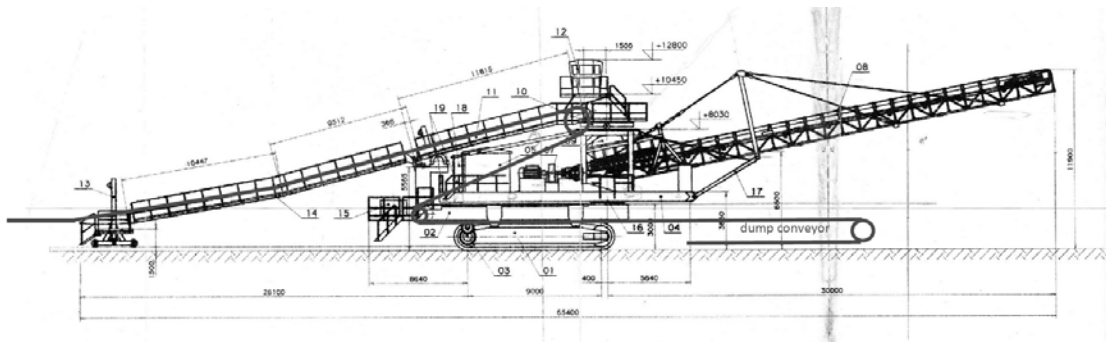


Fig. 3. The construction of the boom spreader with the belt lifting system.

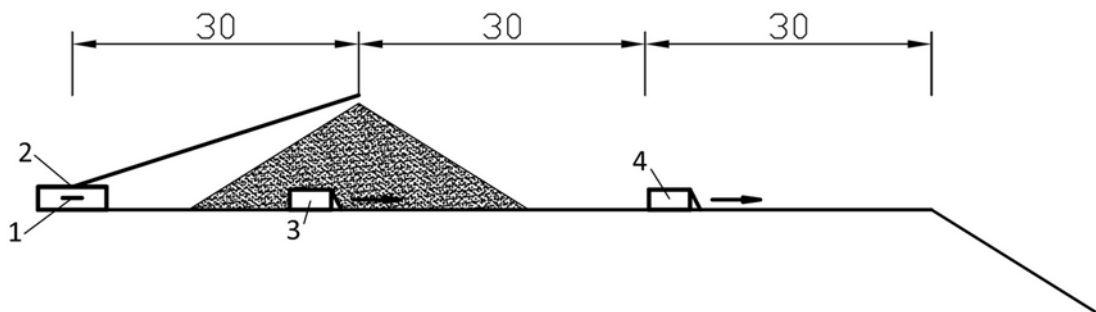


Fig. 4. Dumping technology-original design; 1) dump conveyor, 2) boom spreader, 3) bulldozer 1, 4) bulldozer 2.

The stage 2 of the phase 1 follows the stage 1. The data on the behavior of the disposed material and the dump it self should provide necessary intelligence for the selection and construction of the new boom spreader (spreader 2) and its use. The basics of the second stage are the application of the boom spreader with

the longer boom which, in combination with lowered safe distance should allow the disposal of the material directly into the pit. The bulldozer application is minimized to leveling operations on the top of the dump.

At the end of the stage 1 the boom spreader returns to the starting position at the turning station of the dump belt conveyor. The dump conveyor then makes a radial step in the direction of the pit cavity (counterclockwise). The boom spreader then travels along the dump conveyor and disposes the material into the cavity of the pit. When the dump reaches the level of K+435 m along the route of the dump conveyor at the maximal reach of the spreader a new radial step follows and the procedure repeats with eventual extensions or contraction of the dump conveyor. The stage 2 of the phase 1 finishes when the belt conveyor reaches its final position, and when the dump reaches its final outline in the East slope of the pit (Fig. 5). The characteristics of the stage 2 are material disposal below the main level, constant lowering of the dump height (since maximal height is reached early in the stage 1) and radial advance of the dump.

### 2.3 Phase 2 of the dumping operations

The phase 2 is the finalization faze of the dumping operations. The material is disposed above the main platform at K+435 m to form the final dump outline wit the dump top at elevation of K+450 m. The technology is virtually the same as in the stage 2. The boom spreader travels along the dump conveyor and disposes the material upwards. The starting position of the dump conveyor is its final position from the stage 2 of the phase 1. The dump conveyor performs radial steps around the turning station (but now clockwise) and advances until it reaches its final position in the N-W slope of the pit ending phase 2 and dumping operations (Fig. 6).

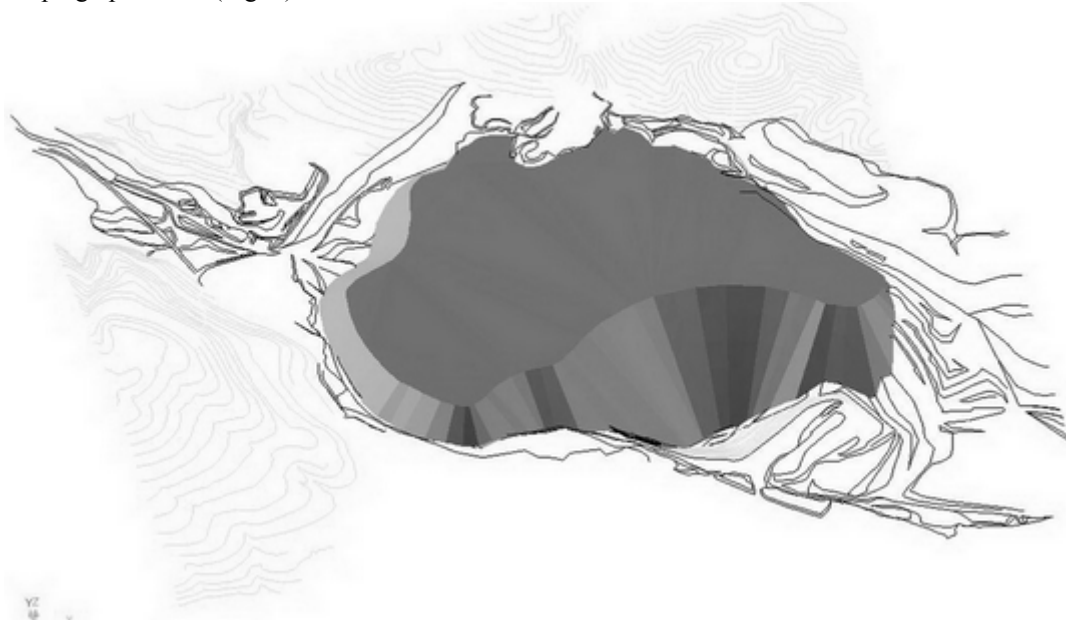


Fig. 5. 3D view of the dump at the end of Phase 1.

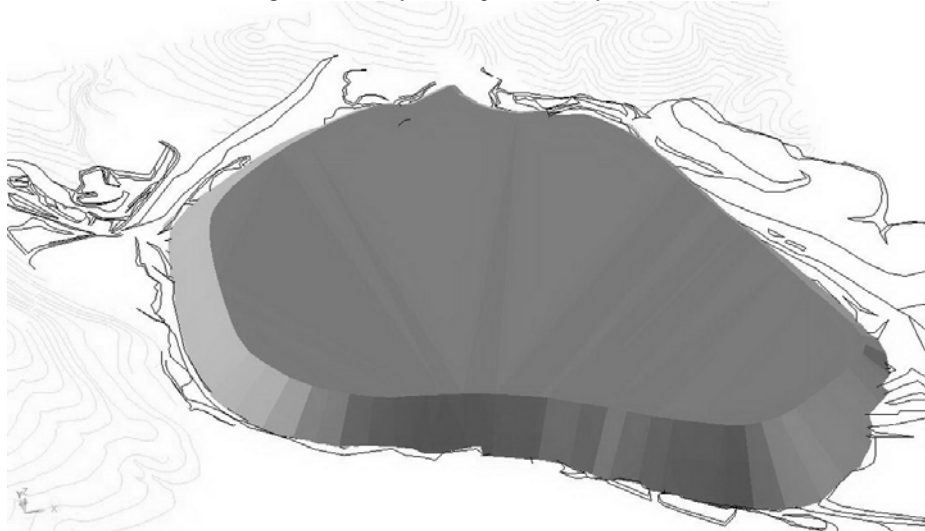


Fig. 6. 3D view of the dump at the end of Phase 2.

### 3. Experiences gathered during 13 years of operation

#### 3.1 Achieved productivity

The system became operational during 1998 and with only one of two primary cone crushers installed its productivity was, from the very beginning, decreased to 50 % (2 350 instead of 4 700 t/h). In addition, nineties were extremely unfortunate for Serbia and its industry. Economic crisis, shortage of fuel and spare parts reduced the hauling fleet to only a couple of operational haul trucks. With the need to sustain copper production the overburden removal operations were at a minimum and all mining operations and available machinery were concentrated to ore extraction. After the democratic changes at the beginning of the 21<sup>st</sup> century the new government was not sure what to do with the RTB-Bor so the stagnation (even fall) of the Serbian copper giant continued. All this influenced the productivity of the waste disposal system. The total and annual amounts of the disposed material are given in Table 1 and the percentage of productivity utilization over the years is given graphically in Fig. 7.

Tab. 1. Data on achieved productivity.

No	Year	Disposed waste [t]	Available productivity [t]	Utilization of available [%]	productivity full [%]
1	1998	1 400 810	12 500 000	11.2	5.6
2	1999	1 141 391	12 500 000	9.1	4.6
3	2000	2 080 052	12 500 000	16.6	8.3
4	2001	1 773 557	12 500 000	14.2	7.1
5	2002	2 755 112	12 500 000	22.0	11.0
6	2003	807 680	12 500 000	6.5	3.2
7	2004	104 567	12 500 000	0.8	0.4
8	2005	285 440	12 500 000	2.3	1.1
9	2006	1 449 612	12 500 000	11.6	5.8
10	2007	731 220	12 500 000	5.8	2.9
11	2008	1 995 994	12 500 000	16.0	8.0
12	2009	3 986 119	12 500 000	31.9	15.9
13	2010	3 784 392	12 500 000	30.3	15.1
14	2011 (Jan-Aug)	3 516 583	8 333 333	42.2	21.1
TOTAL		25 812 529	170 833 333	15.1	7.6

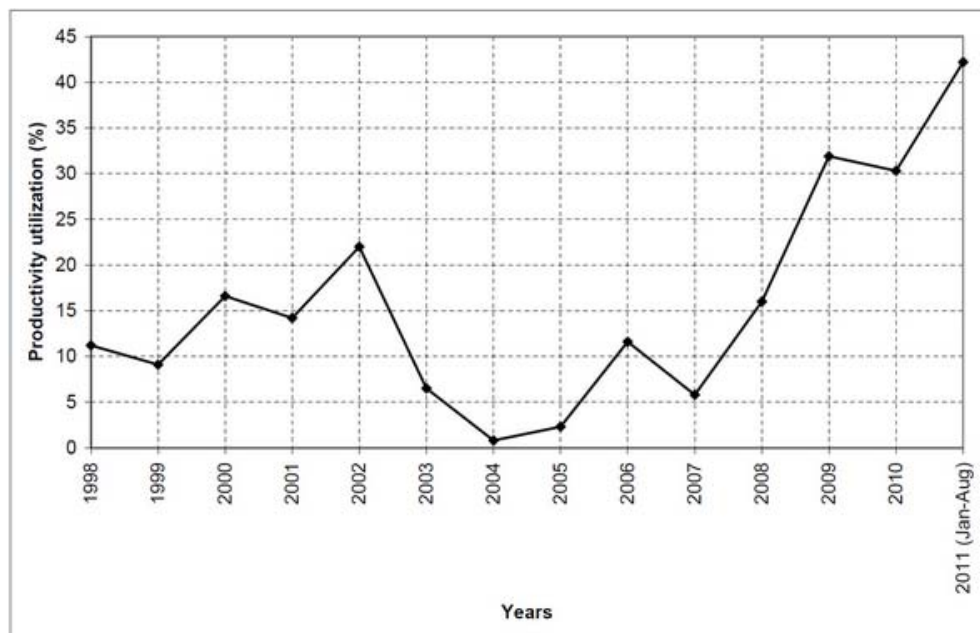


Fig. 7. Annual utilization of the dumping system productivity.

Low utilization of productivity over the past years is the result of previously explained problems and the chronic shortage of bulldozers. The designed technology considers application of two bulldozers and the common situation over the years was that there were no available bulldozers for even weeks. When available, bulldozers were not in pair or had inadequate productivity. This practically means that the disposed material was not dozed by bulldozers. Due to the lack of bulldozers the boom spreader was, most of the time, forced to be at a distance of less than 30 m from the slope crest and dispose material directly into the cavity of the pit. Although this was not in accordance with the designed technology and could be considered “grey” in legal terms, it gave significant data on slope stability and confirmed previous (and the newest [6]) stability calculations.

A significant increase in productivity utilization is noticeable in the last years. This increase is the consequence of renewal of the loading and hauling fleet. The drop in productivity utilization in 2010 is the result of the spreader reconstruction which lasted two months. During that time the spreader was not operational. However, the data on available effective working time utilization for the last two years (Tab. 2) show that the system was in operation 50 % or less of the designed effective working time. On several occasions the system was operational more than designed but less than maximum time. The designed effective working time considers 6.5 working hours per shift, 3 shifts and 300 working days per year giving 487 effective hours per month. Maximum time would be 24 hours during 30 days giving 720 h/month. The causes of this low annual/monthly time utilization are not in the system it self. It was designed for the Veliki Krivelj ore productivity of 12 M tons/year and present is 8 Mt. Even with the redesign of the pit and increase in productivity to 10.6 Mt the system will not be fully utilized. Additionally, at present moment Veliki Krivelj forces the fourth pushback. Waste hauling to the dumping system of the High Slope Dump is not cost effective due to long hauling routes so the waste is disposed to a nearby Todorov Potok dump. Amount of waste coming from other locations at Veliki Krivelj is small so there is no need for full utilization of the available time or productivity of the system.

Tab. 2. Effective working time of the dumping system.

Month	Effective working time [h]	
	2010	2011
Jan.	222	596
Feb.	346	444
Mar.	222	307
Apr.	387	546
May	155	380
Jun.	242	243
Jul.	458	161
Aug.	338	28
Sep.	473	-
Oct.	272	-
Nov.	55	-
Dec	393	-
Total	3563	2705

### 3.2 Gathered experiences

At the moment the length of the dump conveyor and the position of the boom spreader are at the 308<sup>th</sup> meter from the turning station. This means that maximum dump height is already reached. Due to dumping operations and occasional minor slides in the slope the pit floor is filled with disposed material and is now at the level of K+116 m giving the present dump height of 319 m. Since the maximal height of the dump was reached early during the stage 1 with pit floor at K+30 m the height of the dump at one moment reached 405 m. The angle of the slope can not be controlled and depends on the angle of repose of the disposed material. However, due to segregation the slope angle is variable with height in the range of 22.6° at the toe up to 40.6° at the crest of the dump slope. Overall angle of the slope is 32°.

Apart from the setbacks in overburden removal operations at Veliki Krivelj and lack of bulldozers at the dump site there were no major problems in the operation of the waste disposal system. The greatest concern over the years was the stability of the slope and the safety of personnel and engaged machinery. The disposed material is subjected to settling, which is normal, and appearance of the tension cracks in the main dumping platform as a result of settling is constant. Minor slides from the slope crest appear periodically as well as the slides in the toe. The slides in the toe are triggered by the fluctuation of the water level of the water

accumulation formed at the floor of the pit. The newest stability calculations with the material cohesion of  $c=3 \text{ kN/m}^2$ , loose density of  $\gamma=18.82 \text{ kN/m}^3$  and the angle of internal friction of  $\varphi=33.7^\circ$  showed that minimal safe distance from the slope crest, with the factor of safety of 1.30 (Serbian regulatory limit [7]) is 35 m. The mass of the spreader of 300 t is neglectable compared to the mass of the disposed material and does not influence the stability of the slope or the safe distance. The safe distance of 35 m is in accordance with the major landslide of the material from the 12 September 2010. At that event  $511\,000 \text{ m}^3$  or  $970\,900 \text{ t}$  of material slid down the slope but the sliding surface reached less than 30 m of the main platform.

However, the designed technology was controversial from the beginning. There were two main objects of controversy. The first was the starting location/route of the dump conveyor in the N-W slope of the pit. This slope of the pit is unstable and is subjected to sliding and VO-4 ventilation shaft is located in it. Being the active object of concern VO-4 governs the development of the dump in such way that the disposed material does not cover the shaft. Because of that, it will be necessary to perform one radial step of the dump conveyor to bypass the shaft. Additionally, the present route and the technology imply that the dump conveyor is constantly extended in the stage 1 of the first phase and that frontal advance of the dump is dominant. The authors of this article, among others, share the opinion that East slope of the pit is much better solution for the starting route of the dump conveyor. There are two basic reasons for that. First, East slope is in healthy andesite rock mass so it is stable. Second, after minor terrain preparations for dump conveyor routing, the initial length of the dump conveyor would be at least 800 m. One reason why this route was not chosen is the location of the ventilation ramp P2A. The other reason was previously explained need for the stabilization of the S-W slope of the pit. With this ramp not in use any more and with mining operations in Tilva Ros orebody abandoned and residents of the affected structures relocated, it is still possible to relocate the dump conveyor and the spreader with a maximal setback in disposal operation of two weeks (considering all the terrain preparations are performed previously).

The second object of controversy is the second phase of disposal. During the first phase the maximal height of the dump is 405 m. All the maneuvers of dump conveyor and the spreader on frontal and radial advance are performed until the dump reaches the designed outline with the top platform at elevation of K+435 m. During the Phase 2 all of the maneuvers are performed again for radial advance but in the opposite direction to form additional layer of waste and reach final top of the dump at elevation of K+450 m. What is in question is the necessity and the amount of maneuvers and machinery engagement to form a 15 m thick layer of material. Additional height of 15 m is only 3.7 % increase of the maximal dump height achieved in the Phase 1 and does not significantly influence the stability of the slope. The authors of this article share the common opinion that it was and still is better to form initial starting platform at elevation of K+450 m and exclude the phase 2.

### 3.3 Redesign of dumping technology

As said, with the new investments in the equipment Veliki Krivelj open pit mine will reach its designed annual productivity of 10.6 M tons of ore. The experiences in the operation of the disposal system showed that the designed productivity in waste disposal can not be achieved with only one crusher in operation and with bulldozer application. The disposal system would become a bottleneck for the Veliki Krivelj development. Because of that, even before the end of experimental stage 1, the management of RTB Bor engaged Technical faculty in Bor to redesign the dumping technology. However, one of the requests for the redesign was to stay within the boundaries of the original design considering Phase and stage operation. Consequently, we were not able to address the controversial issues and suggest any changes in that direction. The gathered data allowed us to suggest two major changes in the dumping technology [6]. The first is a decrease in the safe distance from 90 m to 35 m and the second is the reconstruction of the existing boom spreader. The reconstruction of the spreader considers the same basic machine with the longer, 45 m reach boom which, combined with shorter safe distance, would allow the spreader to dispose the material directly into the cavity of the pit and minimize the dozing operations to leveling. According to the suggestions the spreader reconstruction was finished in December 2010 and it became operational during January 2011. After the reconstruction the spreader is 15 tons lighter due to application of light materials (the 45 m boom now weighs 15 tons instead of the 30 t of old one).

The longer boom and shorter safe distance allow increase in frontal advance steps as well as in radial steps. The basic parameters of the redesigned technology are presented in Fig.8.



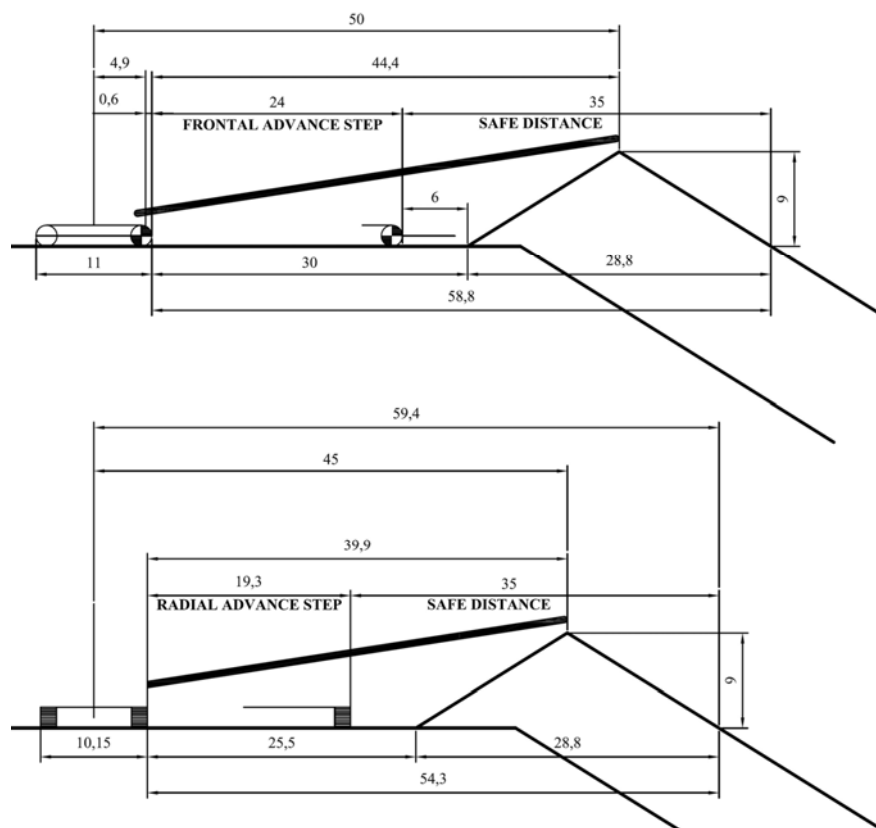


Fig. 8. The basic parameters of redesigned dumping technology.

The basic parameters of redesigned technology are [6]:

- effective disposal radius 44.4 m
- maximum boom reach (height) 9.0 m
- diameter of the cone of disposed material 28.8 m
- theoretical distance of the spreader crawlers from the slope crest 58.8 m
- maximum frontal advance step 29.0 m
- maximum radial step 19.3 m
- volume of the cone of disposed material 1 982.0 m<sup>3</sup>
- mass of disposed material in the cone 3 766.0 t
- time of cone forming (full productivity of 4,700t/h) 0.8 h

### 3.4 Latest events

During the first six months of 2011 the second crusher was installed and tested and the system now became capable of achieving its full productivity. The crusher No 2 became operational on 6 May 2011 and was in testing during the 15 days during May and June. During tests the crusher No1 was in standard operation regime and the crusher No 2 was periodically switched on and operational during several hours (Tab. 3). As it can be seen in Tab. 3 the maximum load test was performed on May 20 when crushers were in parallel operation during 19 hours. Test showed that the system is capable of achieving full productivity but at the moment only one crusher is operational and the system still works with 50 % of full productivity. The reason for that is the fact that waste from the fourth pushback operation is hauled to other dump and waste from other locations within the open pit is hauled to the crusher and disposed to High Slope Dump. Consequently, at present moment there is no need for both crushers operation. Since there is no need for both crushers to be operational the crusher No 1 is now in overhaul and the newly installed crusher No 2 is operational.

Tab. 3. Time of parallel operation of crushers No1 and No2.

Date (dd.mm.)	Total working time (h:min)	
	Crusher No1	Crusher No2
06.05.	11:30	08:30
10.05.	05:00	03:00
11.05.	01:30	00:50
12.05.	02:00	01:00
13.05.	13:40	01:50
14.05.	03:45	06:00
15.05.	03:00	05:00
17.05.	00:20	02:30
20.05.	19:00	20:30
21.05.	10:30	07:00
22.05.	19:00	19:30
25.05.	17:30	19:00
26.05.	02:00	01:00
08.06.	05:00	07:30
09.06.	02:30	07:00

As said, during the last 13 years of dump operation the slope was stable with only minor slides in the toe and the crest, mostly in the form of surface peeling. There are several cracks in the main platform which are the result of material settling and consolidation and do not influence the stability of the dump. Of course, these cracks are considered as a threat and are under geodetic survey. Unfortunately, despite the fact that we suggested a continuous crack monitoring system in our design such a system is still not installed. Consequently, there are no precise data on crack development apart from geodetic surveys which are conducted on a weakly base or on demand. The greatest stability issue was the mentioned slide from 12 September 2010. Unfortunately, the reason for this slide is not yet defined. Several factors have been investigated namely the diversity of disposed material in type and fragmentation, water saturation after snow melting and the overall conclusion was that the combination of all these factors weakened the bearing capacity of the disposed material resulting in slide.

There were two additional large slides since the beginning of 2011, each with more than 200 000 m<sup>3</sup> of sliding material. There is no pattern in slide appearance (after heavy rain or snow, rapid crack development in the main platform etc) and these slides are still a mystery. What was common for the slides is that they remained within the safe limit of 35 m as designed and that, prior to the slide, during several days, intensive swelling of the slope was noticeable (Fig. 9).



Fig. 9. View of the slope with noticeable swelling.

This swelling indicated that the reason for sliding is failure in the bearing capacity of the material. Due to, to some extent, increased dynamics of waste disposal compared to previous years the disposed material has no time to settle and consolidate before new amount of waste is disposed over. Consequently, the material cannot reach its full stability and bearing capacity and fails under additional load. Being a major safety concern these slides are still an object of investigation. Since the decrease in productivity or dumping dynamics is not an option it is necessary to find a reliable prediction/prognosis model and our further research is developing in that direction. With slope swelling being common denominator for all slides it is our opinion that slope monitoring should be a base for future model. With slope being an active object which changes rapidly due to new material disposal and the need to monitor the slope on a daily basis traditional geodetic survey cannot be applied and could not give satisfactory precise data. Because of that we think of a 3D scanner as of optimal solution. Comparison of a reference 3D surface with the most recent 3D surface/image should give necessary data on the slope movement (displacement vectors and velocities). Fortunately, the sliding process is not rapid and even when it starts there is enough time for preventive retreat of the boom spreader to a safe position. Despite that, prediction model and monitoring system must be designed and implemented as soon as possible.

#### 4. Conclusion

Despite the controversy the dumping technology for waste disposal from Veliki Krivelj open pit into the cavity of the closed open pit Bor proves that **it is possible to form extremely high dumps with a single slope**. The issue of stability is always present but the experiences gathered during the last 14 years show that this dump was stable beyond expectations. The formation of the tension cracks in the main platform is a consequence of material settling and the reasons for the large slides from 2010 and 2011 are still in investigation, especially in the direction of soil bearing capacity. In the light of those events, a program of slope and overall dump sight monitoring is in rapid development.

At present moment all of the necessary actions are taken in order to provide the conditions for achievement of full productivity of the disposal system. The spreader boom is reconstructed, installation of the second crusher is finished and its operation tested, the technology is redesigned and approved and accepted with the Serbian ministry of mining. The internal controversy on the original dumping technology and design still remains and we undoubtedly realize that this type of dump would be highly controversial in many mining districts and most likely would not be issued a permit but we think of these controversies as of spiritus movens of future research.

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