TECHNICAL SOLUTION FOR DRAINAGE CARPET FOR TAILING DUMP TORANICA - KRIVA PALANKA, MACEDONIA

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Abstract: *Mine Toranica - Kriva Palanka for exploitation of lead and zinc, has taken certain activities to improve and qualify the tailing dump for further exploitation, as well as activities for environmental protection from the flotation tailing dump.*

The drainage carpet and the gabion wall with height of 5 m (previewed for constructing in next phase) will constitute a whole which will collect the filtrate and spring water from the sand dam through drainage carpet and through polypropylene pipes, thus the waters will be redirected from the flotation tailing dump, therefore the sand dam stability will be improved and will prevent the infiltration of higher amounts of infiltrate water in the subsoil and the side channels in the valley of the river Kriva Reka.

The drainage carpet is designed by one main leg that is parallel to the collector with length of approximately 50 m and two legs, left one (with length of app. 28 m) and right one (wit length of app. 15 m). The drainage carpet is approximately in shape of flipped letter "Y".

The drainage carpet is designed in the way that firstly on the bottom 300 gr/m^2 geotextile with thickness of 3,00 mm is placed, then above this layer rough geo-membrane HDPE with thickness of 2,00 mm, and above the geo-membrane again geotextile 300 gr/m^2 with thickness of 3,00 mm. Above the geotextile filter layer that contains 3 layers with fractions 4÷60 mm (2 layers) and 1÷8 mm (one layer). This filter material should be covered with the above mentioned geotextile 300 gr/m^2 with thickness of 3,00 mm.

The positive impacts of this project will have long-term environmental effect, to prevent possible instability of sand waves and extended lifetime of safe exploitation of hydro tailing dump.

Key Words: *mineral raw materials, flotation tailing, drainage, environmental protection*

1. INTRODUCTION

Applying the technological process for preparation of mineral raw materials in the mine of lead and zinc "Toranica"-Kriva Palanka two main products are obtained:

- concentrate of lead and zinc and
- flotation tailing.

The economically justifiable product (concentrate) has further use, while the flotation tailing is suspended at special arranged space – flotation tailing dump.

The position of the tailing dump is 4 km downstream along the valley of Kriva Reka, between the profile "Varoshani" and the profile "Cepen kamen" located near the place where the river Toranica flows into the river Kriva Reka. The transport of the flotation tailing as pulp to the flotation dump is performed with resistant acid-abrasive thick-wall PVC pipes with diameter of ø 315 mm. On the upstream side the dump is enclosed with filled retention dam, in the same time the water from Kriva Reka is redirected in drain deviation tunnel and on the downstream side the dump (sand dam) is constructed from sand that is obtained with hydro cyclone separator of the pulps.

Considering that the flotation tailing material to the previewed place for dumping (flotation tailing) arrives as pulp (suspension from water, solid particles and deposits), the area in the dump represents place for deposition of the solid particles and of sludge and for water purification from the pulp.

The separated amount with sand fractions serves for construction of retaining body of the tailing dump on the downstream side so called sand dam, and the flotation sludge i.e. the suspension of small particles is collected in the area of the dump where it is performed their deposition, while the purified water through collector is conducted from the dump and redirected in the river Kriva Reka.

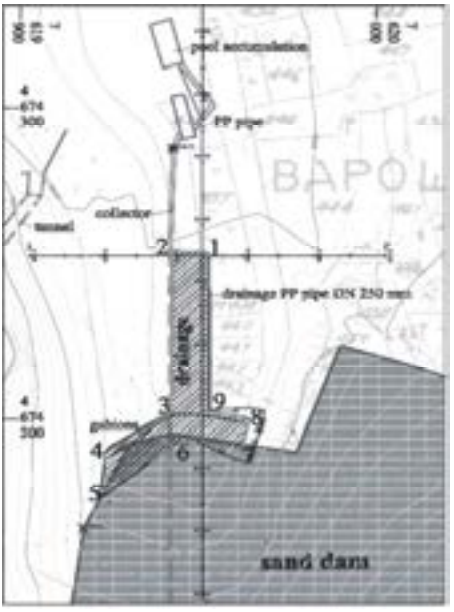
Due to the fact that in the next period the strategy of the mine Toranica is to enlarge the scope of exploitation from 280.500 tones per year to 400.000 tons per year, indicates that the technological process will manifest appearance of certain amounts of the flotation tailing, thus the need for bigger accumulative space for disposal of the flotation tailing will be required.

For the overviewed location there is a Additional mine design for exceeding in which technical

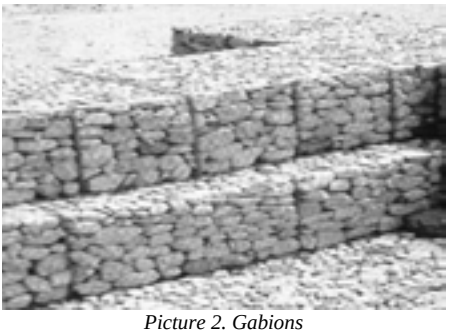
solution as Main design is analyzed and elaborated, thus according to the new occurred conditions and the change of the site activities it is performed alignment of the technical solution with the Annex of the Main design for drainage carpet at the sand dam in the toe zone, in order to accept the filtrate and ground waters.
The drainage carpet has environmental impact, because with its implementation it is solved the process of capturing of the filtrate and spring water in the toe of the dam, hence the stability of the sand dam will be improved, i.e. it will have positive impact on the environment.

2. TECHNICAL CHARACTERISTICS OF THE DRAINAGE CARPET

Flotation tailing dump – "Toranica", in its so far exploitation is functioning without a drainage carpet, but with further exceeding of the hydro tailing dump to elevation of 990 mHB, it is necessary a drainage system that will serve for reception of the discharged water from the (cycloned) sand to be constructed, than for reception of the spring water from the toe of the sand dam, as well as ensuring of geo-mechanical stability of the sand dam of the hydro tailing dump.
Characteristic for the hydro tailing dump is that during the exceeding in relation with the variant of downstream movement from the sand dam toe up to 85 m, as a part of the first phase is the construction of the drainage carpet.
The drainage carpet is designed by one main leg that is parallel to the collector with length of approximately 50 m and two legs, left one (with length of app. 28 m) and right one (wit length of app. 15 m). The drainage carpet is approximately in shape of flipped letter "Y" (picture 1).
The main and the right leg are completely designed in excavation, while one part of the left leg is above earth while the other part is in excavation. The left leg is positioned higher because of the pass of drainage pipe above the collector. In one part of the left leg, it is designed that gabions in length of 12 m with height of 1 m should be positioned. For this purpose the utilization of gabions with dimensions of 2x1x1 with 8÷10 cm shafts, and electroplate with thickness of 2,70 mm can be good practice, as a filling of the gabions 100÷200 mm hard fractions (picture 2) can be used.



Picture 1. Position of drainage carpet

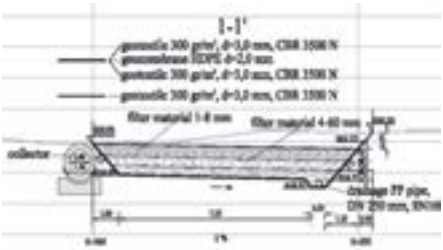

Picture 2. Gabions

The drainage carpet is designed and built in the toe of the existing sand dam including parts of the following cadastre parcels: CP no. 437, 439, 440, 441, 442 and 443.
The location for drainage carpet and contoured with 9 characteristic points and coordinates of these points are presented in table no. 1

Table 1. Coordinates of characteristic points for drainage carpet

point	Y	X
1.	7 619 952,510	4 674 253,772
2.	7 619 942,510	4 674 253,772
3.	7 619 942,434	4 674 203,176
4.	7 619 923,534	4 674 189,128
5.	7 619 923,247	4 674 176,455
6.	7 619 946,457	4 674 193,706
7.	7 619 962,037	4 674 190,618
8.	7 619 964,370	4 674 200,345
9.	7 619 952,510	4 674 202,701

Pictire 3 displays one characteristic cross-section of the drainage carpet.



Picture 3. Cross section view

According to the construction practice, at the beginning is necessary geodetic survey and contour outlining of the terrain to be done, then removal of trees, roots bushes from the terrain (picture 4) and then excavation of material from the predicted location for drainage, loading and transportation of material on distance up to 50 m.

Picture 4. Field for drainage carpet

For positioning of drainage it is necessary to make excavation of material of approximately 1.120,00 m^3 most of the part of the surroundings and a smaller part of the flotation dump.

The drainage carpet is designed in the way that firstly on the bottom 300 gr/m^2 of geotextile with thickness of 3,00 mm, is placed , then above this layer, rough geo-membrane HDPE with thickness of 2,00 mm, and above the geo-membrane again geotextile 300 gr/m^2 with thickness of 3,00 mm is placed.

In order to clad the geomembrane with geotextile around 2.600,00 m^2 of geotextile will be necessary with the following characteristics:

- weight ≥ 300 gr/m^2 (DIN EN 9864);
- thickness during 2 kPa (DIN EN 9863-1) ≥ 3,0 mm;
- ultimative strength of stretching (DIN EN 10319) in length alignment ≥ 12,0 kN/m and in cross section alignment ≥ 25,0 kN/m;
- Elongation during nominal strength of stretching (DIN EN 10319) in length alignment 100 % (±30 %) and in cross section alignment 80 % (±30 %);
- CBR resistance of penetration (DIN EN ISO 12236) ≥ 3500 N;
- Characteristics of the opening O_{90} (DIN EN ISO 12956) ~0,10 mm;
- index of water permeability on flat surface ~60 x 10^{-3} m/s (DIN EN ISO 11058).

In order to form impermeable layer, rough geomembrane HDPE around 1.300,00 m^2 with the following characteristic, is to be used:

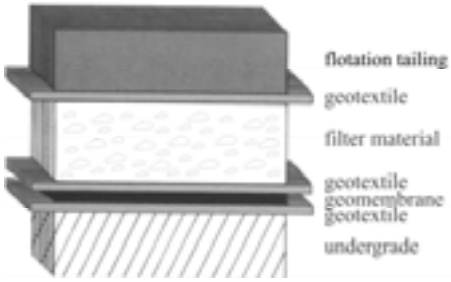
- thickness 2,00 mm;
- strength of stretching ≥ 16,0 N/mm^2 (ISO 527);
- dilatation during suspension ≥ 400 % (ISO 527);
- resistance penetration 534 N (DIN 16 726);
- water absorption ≤ 0,1 % (ISO 62);
- resistance discharge to the change of mechanical properties ≤ 20 % (OENORM S 2073).

Above the geotextile filter layer that contains 3 layers is placed:

- first layer 30 cm with granulated filter material with fractions 4÷60 mm, above which light consolidation should be performed;
- second layer 30 cm with granulated filter material with fractions 4÷60 mm, above which light consolidation should be performed; and
- third layer 40 cm with granulated filter material with fractions 1÷8 mm, above which light consolidation should be performed.

This filter material should be covered with the above mentioned geotextile 300 gr/m^2 with thickness of 3,00 mm. For coverage of the filter material 1.100 m^2 of geotextile is needed.

Picture 5 shows the drainage layers.



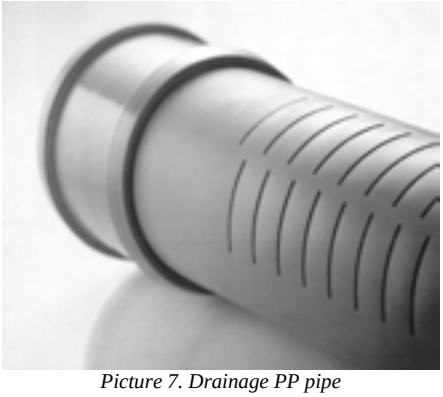
Picture 5. Preview of drainage layers

The roll of the geo-membrane is not to allow passage of spring water in the subsoil as water impermeable barrier, retaining the water and then lead the water out of the tailing dump with drainage pipes. The role of the geotextile that is placed around the geo-membrane is to protect the rough geo-membrane from damage, from subsoil as well as from the filter material, while the role of the geotextile placed above the filter layer, is to prevent bigger penetration of smaller fractions from the flotation tailing dump.

Picture 6 illustrates a situation of similar profile with the profile of the designed drainage carpet for flotation dump for mine Toranica, where the geotextile placed on the bottom of the subsoil can be seen, over which the rough geo-membrane is placed.

Picture 6. Lining of bottom drainage layers

For draining of the drained waters of the flotation dump, system of drainage polypropylene (PP) pipes (picture 7), DN 250 mm, SN16 with 5 mm slot, in total length of around 100 m has to be placed. The propylene is a high class raw material that has proved its high quality in many years in complicated areas of the industry.



Picture 7. Drainage PP pipe

The propylene has the following properties:
- mechanical - ideal balance between the tightness and the impact resistance;
- thermical - implementable in low temperatures (up to - 20 °C) as well as in high temperatures (in short terms up to 90 °C);
- chemical and corrosion - resistant;
- ecological - fully safe, it can provide the material cycle with nutrients.

PP - polypropylene pipes are chosen because of their chemical resistance, easy bend ability and flexibility in reactions of static and dynamic loads. They are more elastic from the surrounding land. Easy bend able pipes refuse the pressure and insignificantly reshape, with what they avoid the damage pressures therefore cracks cannot appear. With the abovementioned, a long and continuously functioning is implemented, that can be seen in picture 8, where, the action of hard band able pipes is compared to the easy band able pipes.

Disadvantages of hard pliable pipes

Advantages of easily pliable pipes

Picture 8. Disadvantages of hard pliable and advantages of easily pliable pipes

Excavation in width of 0,5 m and depth 0,25 m for installation of drainage pipes is predicted in the lowest parts of the long alignment profiles. For protection of penetration of small fractions from the overburden through the openings of the drainage pipes, it is necessary for these pipes, to be folded with geotextile (picture 9). The geotextile plays the role of straining of the water and prevention of penetration of small fractions from the flotation overburden. For flexible folding of 100 m drainage PP pipes it is needed around 100 m^2 geotextile. The above mentioned geotextile with weight of 300 gr/m^2 and thickness of 3,00 mm will be used.

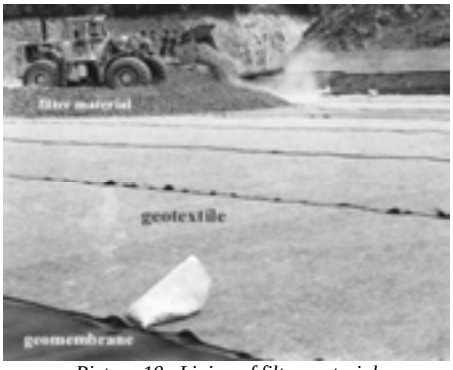
Picture 9. Lining of drainage pipes with geotextile

At the exit of the drainage to the sedimentation pool, a pipeline with length of approximately 65m is designed, with full polypropylene (PP) pipes, DN 250 mm, SN16 with drain gradient of approximately 1 %.

In order to install the pipes, at first it is necessary to perform mechanical and manual excavation for ground trench in trapeze shape, with bottom width

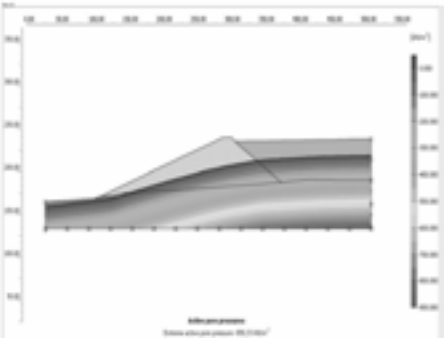
of 0,5 m and inclination of 1:1. For this trench, excavation of around 30 m^3 material has to be performed. The performance of the base of the trench bottom is with gravel mixture with grain size of 4÷8 mm in layer of 10 cm with consolidation.
After installation of polypropylene pipes, backfill of the trench with excavation material should be performed. Significant number of fittings will be needed for lining of the drainage and filled PP pipes such as:
- Splitter 90° DN 250/250;
- Quarter bend 90° DN 250;
- One-eight bend 45° DN 250;
- Closing cap DN 250.

Two one-eight bends 45° will be necessary for lining of the left leg drainage system of the drainage carpet, as well as 90° splitter for connection to the drainage pipe of the main leg. While the drainage pipe of the right leg will be connected to the drainage pipe of the main leg with quarter bend 90°. At the beginning of drainage pipes that are from the left and the right leg, closing caps will be placed. One, one-eight bend 45° will be necessary for direction of the full polypropylene pipe to the sedimentation pool.
After setting the lower layers (geotextile - geo membrane - geotextile) and placing drainage tubes polypropylene (PP) pipes filter material (Fig. 10) is placed, as described earlier: 2 lower layers of 30 cm with fractions from 4÷60mm and the upper layer of 40 cm with fractions of 1÷8 mm. It is necessary for these layers to make the compression easier. Then filter layer is covered with a geo textile.



Picture 10. Lining of filter material

It should be emphasized that it is important the things to be happening in sequence, to meet the regulations and standards for conducting of such type of work, particularly in the following stages are planned freeboard and extension of the tailing dump to be carried out and thus the extension of drainage carpet after new projected toe.
It is necessary to continuously monitor the level of groundwater in the sand dam, for which purpose there are placed more piezometers.
On the basis of available bases and data a model of a sand dam is prepared, in which geomechanical and hydro geological parameters and carried out analysis of filtration are included. On Picture 11 is shown the dam condition with pore pressure with performed drainage.


Picture 11. Analysis of pore pressure

The performance of drainage carpet in toe of sand dam of hydro tailing dump Toranica is shown on picture 12 and 13.


Picture 12. Construction of drainage carpet


Picture 13. Construction of drainage carpet

On Picture 14 is shown the drainage carpet in final situation, as in Picture 15 is shown drainage carpet in function (exploitation).

Picture 14. Drainage carpet in the final situation

Picture 15. Drainage carpet in exploitation

3. CONCLUSION

Considering the importance of tailing dump Toranica managed by DPTU Indo Metals and minerals Ltd import-export Skopje, for the city of Kriva Palanka and Republic of Macedonia, the expert team for the design of drainage carpet included knowledge acquired during the construction of a large number of domestic and international projects taking into account all the environmental impacts of planned technical solution.

Drainage carpet of tailing dump Toranica is designed and constructed in the second half of 2010.

Materials embedded in the drainage carpet are predicted in accordance with technical regulations, taking into account the burdens of flotation tailing.

The positive impacts of this project will have long-term environmental effect, to prevent possible instability of sand waves and extended lifetime of safe exploitation of tailing dump.

4. LITERATURE

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