GEOTEXTILE BARRIERS IN THE TAILING DUMP INWASH TECHNOLOGY IN PERMAFROST REGION

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ABSTRACT

The object of research of the present work is the tailing dump “Lebyazhie”, located on the territory of Norilsk industrial region (north of Siberia). The exploitation of the disposal area has begun since 1983 with the purpose of warehousing of tails from concentrating mill and organization of system of turnaround water supply. Today the problem of its capacity increasing is very important. One of the ways of increase in capacity of the tailing dump is replacement of a slurry collecting slag prism by the filter screen from a geotextiles. It allows increasing usable tailing dump volume approximately by 8-10 %, and lowering the metallurgical slag input and labour coefficient. The given method was tested and has shown its efficiency.

Keywords: Tailing dump, geotextile sleeve, slurry collecting slag prism

INTRODUCTION

High level of industrialization of northern regions of Russia causes significant geocryological problems in the soil. Only in Siberia in the areas of large mining and metallurgical enterprises dozens of million cubic meters of different deposits have been accumulating for a long time in the tailing dumps.

The construction of new tailing dumps is connected with the huge material and labour expenses. Over the last 10 years none of new tailing dump was built on the territory of the Russian Federation. Therefore at present we face a burning issue of increasing the useful capacity of existing storage devices during their operation.

Object of research of the present work is the tailing dump “Lebyazhie”, located on the territory of Norilsk industrial region.

The exploitation of the disposal area has begun since 1983 with the purpose of warehousing of tails from concentrating mill and organization of system of turnaround water supply

The disposal area provides sedimentation, clarification and natural stabilization of ionic structure of turnaround water acting with tails. The clearing of water from firm phase is done with the help of gravitation method.

The main objective of this paper is to develop special techniques of increasing of the capacity of the tailing dump and its operation period and make in-situ investigations of these techniques.

CASE HISTORY

The climatic characteristics of Norilsk industrial region are:

- average annual temperature of the air is -9.4 ^{0}C;
- the maximum temperature of the air is +32 ^{0}C and the minimum temperature is -56 ^{0}C;
- the maximum speed of wind is 40 m/sec;
- winds with speed above 15 m/sec are observed during 90 days;
- the strong winds and snowfalls are observed up to 130 days a year;
- average amount of precipitations is 564.5 mm per year.

The basic hydraulic engineering structures of the tailing dump “Lebyazhie” include:

- pool for reception of pulp and storage of tails

- local tailing dam;
- system of pipelines for transportation of pulp
- system of pipelines for turnaround water supply with coastal and floating pump stations
- spillway system

The constructive characteristics of dam are:

1. the disposal area - 4.02 sq.kms
2. the length of the tailing dam - 8.1 kms
   - the tailing dam is carried out as a persistent drainage prism from metallurgical slag: the width of a prism - 8 m, the length of a prism - 8500 m
4. the capacity of disposal area - 16.7 mln. m^3
5. the settlement term of operation - 20 years
6. the height of dam - 39.3 m;
7. the inclination of a top drain level - 1: 50
8. the inclination of a bottom slope - 1: 4
9. the maximal depth of pool – 4.7 m
10. the average depth of pool – 2.5 m.

The basis of the pool and the dam is layered by artificial, alluvial and moraine soils with gravel and pebble with sand, sandy loam and loam additions of 5-60 m capacity being in a frozen state. The underlaying layer is heterogenous rock. The exploitation period of the tailing dump was planned for twenty years.

Since 1992 in connection with the changes in technological processes of concentrating mill, reduction of volumes of processing of ores and complexities in transportation of tails, the northern part of a tailing dam practically was not raised, that has resulted in considerable reduction of capacity of pool. The decision about tailing dam filling by old (stale) tails was accepted in 1997 for the rapid rise.

As a result of mutual research-and-production investigations the technology of controlled inwashing of the levee was designed. It includes the following operations (Lolaev & Butygin 2005):

- the construction of the retaining prism of metallurgical slag. The metal distributing slurry pipeline is laid on it;
- the construction of ring slag fill in the beach zone at the specific distance from the axis of the distributing slurry pipeline. It retains the solid particles in the beach zone and simultaneously it illuminates the water coming into the pool.

The scheme of the levee inwash is shown in Fig. 1.

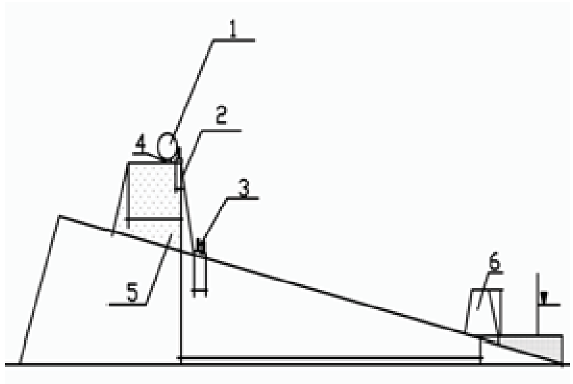

Fig. 1 The scheme of the levee inwash
1. distributive slurry pipeline; 2. geotextile anti-filtration screen; 3. load; 4. a slag prism; 5. a retaining prism of a dam; 6 . slurry collecting slag prism

Functions of a slurry collecting prism in operation of an inwash are the following:

- placing of prism on various distances from distributive slurry pipeline allows regulating intensity of an inwash;
- slurry collecting prism promotes more intensive consolidation of hydraulic fill tails and increase of stability of a dam;
- it allows operating of bottom contour formation in pond zone that is rather an important factor that provides winter storing of tails under ice;
- it promotes more intensive frost penetration in an inwash massif that raises its static and filtration stability and in that way provides environmental safety of the tailing dump;
- it carries out reinforcing a body of a levee function.

The inwash is made by sections of 800-1000m in width, after formation of a layer of tails with the capacity of ≈0,5 m, hydraulic fill section is left for "rest" (10-15 days). The given way of an inwash already for the first years (1997-1998) has provided an advance growth of a dam..

This measure has allowed to increase the height of a dam and to increase capacity of the disposal area for next 10 years. Today the top of the dam is about 70 m (Lolaev et al. 2004).

Now, in connection with planned substantial growth of an exits of tails there was a new problem emerged – the increase in the capacity of the "Lebyazhie" tailing dump and its service time. Therefore optimization of the inwash technology of the tailing dump was carried out in view of this important condition.

From 2006 the tailing dump has the second tailing pond. The second pond is under the construction. The top of the dam of the second pond is about 50 meters now. Thus the tailing dump "Lebyazhie" is the cascade type of dumps with difference in grades of the tops of dams about 20 meters. Planned level of the top of the dam is 90 meters.

The constructive characteristics of the second tailing pond and dam are:

1. the disposal area - 2.4 sq.kms
2. the length of the tailing dam - 4.3 kms
   - the tailing dam is carried out as a persistent drainage prism from metallurgical slag: the width of a prism - 8 m, the length of a prism - 4313 m
3. the capacity of disposal area - 16.7 mln. m^3
4. the settlement term of operation - 20 years
5. the height of dam – 19-20 m;
6. the inclination of a top drain level - 1:50-1:100
7. the inclination of a bottom slope - 1:4-1:5
8. the maximal depth of pool – 5.2 m
9. the average depth of pool – 2.9 m.

The developed technology of the dam inwash takes into consideration the height of a dam inwashed for one cycle and as a whole for a year, the width of front of an inwash, the quantity of the inwashed tails, operations schedule etc. The beach sectoring for the determination of the volume of the inwashed tails is presented in Fig. 2.

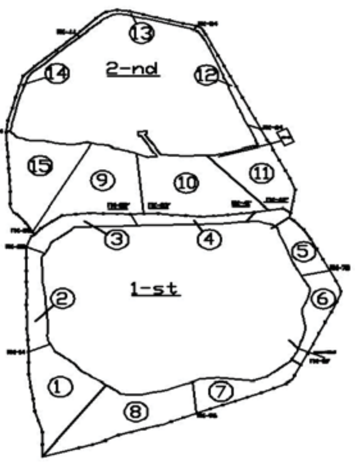

Fig. 2 The beach sectoring

The creation of an additional field considered as the geometrical way of increasing of the tailing dump volume. But it is possible to do it by technological ways too (Lolaev et al., 2011).

We will consider the results of approbation of increase in capacity of the tailing dump by replacement of a slurry collecting prism by the filter screen from a geotextiles

TEST RESULTS AND DISCUSSIONS

The technology given has been applied over 10 years and has shown its efficiency. However, the construction of slurry collecting prism from slag demands great costs for the material of the prism, has a great labour input and machine input. In addition, this construction reduces the payload volume of the tailing dump due to the volume occupied by the slag dam.

One of the methods of increasing capacity is to replace the slurry collecting prism of the tailing dump, backfilled with traditional materials (slag, clay, etc.) by a screen from nonwoven geotextiles.

The use of screens from membrane constructions is known at building of lightly constructed hydraulic facilities.(Sergeev et al. 1971, Zatvornitsky 1975, Chanson 1998)

However, the in-situ experiment conducted on the "Lebyazhie" tailing dump has shown, that the use of screen is inefficient because of its being unsteady at strong wind loads.

In this connection the replacement of slurry collecting prism from slag by the sleeve from nonwoven geotextiles filled with tails was proposed.

The laboratory and in-situ experiments were conducted to approve the possibility of application of the given method.

The laboratory experiment was conducted on laboratory-scale plant made according to the requirements of the similarity theory criteria.

The equality of Fourier numbers of nature (n-parameters of an object) and model (m- parameters of a model) was taken as conditions of similarity of model and nature

$$Fn = Fm \tag{1}$$

According to (Rozovsky 1969) the correlations of geometric measurements and volumes of nature and model are in dependencies.

$$L_m / L_n = B_m / B_n = H_m / H_n ; \tag{2}$$

And the timing of nature and model are in the ratio:

$$\tau_m / \tau_n = (L_m / L_n)^2 ; \tag{3}$$

where L, B, H- geometric measurements, V – volume, τ –time, indices m and n – indications of model and nature system.

At the known consumption of pulp in full-scale conditions (Q_P^n) and the equality of Froude criteria (Fr) on a model and in the nature, the consumption for the model must make up (Chugaev, 1982):

$$Q_p^m = Q_p^n \left(\frac{1}{100} \right)^{\frac{3}{2}} = 1.0 \times 10^{-5} \times Q_p^n \tag{4}$$

The general view of the laboratory-scale plant is given at Fig. 3.

Fig. 3 General view of the laboratory-scale plant.

The experiment objectives were the following: research of possibility of filling of sleeve from nonwoven geotextiles by hydromechanization method from pulp output of distributive slurry pipeline and the possibility of application in alluvial hydraulic structures of slurry collecting prism done from the sleeve from nonwoven geotextiles, filled by the solid phase of the inwashed pulp.

To achieve the assigned objectives on the desk of the laboratory-scale plant a sleeve from nonwoven geotextiles was rolled, then the pulp was given in sleeve from pulp output and distributing sump. As the experiment has shown the solid phase of the pulp gradually filled the sleeve and the water was filtered outwards. (Fig. 4)

Fig. 4 Sleeve from nonwoven geotextiles filled with tails (in profile)

The sleeve filled with tails was installed on the calculated distance from the pulp outputs. After the pulp feed on the pilot site the solid phase of pulp was stowed on the beach, and the liquid phase was filtered through the sleeve. (Fig. 5)

Fig. 5 Filtration through the sleeve from nonwoven geotextiles.

During the laboratory experiment the following results were given:

1. When filling the sleeve from nonwoven geotextiles the filling of sleeve with solid phase of pulp occurs. The water is filtered through the sleeve.
2. The sleeve from nonwoven geotextiles filled with tails carried out its functions completely: the deposit of the solid phase of pulp took place, and the liquid phase filtered through the screen into the pond of the tailing dump.

The results obtained during the laboratory experiment suggest the possibility of application of sleeve from nonwoven geotextiles filled with tails instead of filling the slurry collecting prism from traditional materials.

However, this result was regarded intermediate and the in-situ experiment was conducted.

To achieve the assigned objectives on the pilot site a sleeve from nonwoven geotextiles was rolled, and then the pulp was given in sleeve from the pulp output of the distributing slurry pipeline. As the experiment has shown the solid phase of the pulp gradually filled the sleeve and the water was filtered outwards. (Fig.6)

Fig. 6 Filling of sleeve from nonwoven geotextiles with tails by hydromechanization method.

The sleeve filled with tails was installed in the line of spreading of pulp and on some distance from distributing slurry pipeline. After the pulp feed on the pilot site the solid phase of pulp was stowed on the beach, and the liquid phase was filtered through the sleeve. (Fig.7)

Fig. 7 Filtration of liquid phase of pulp through the screen from nonwoven geotextiles.

The sleeve filled with tails was installed in the line of spreading of pulp and on some distance from distributing slurry pipeline. After the pulp feed on the pilot site the solid phase of pulp was stowed on the beach, and the liquid phase was filtered through the sleeve. (Fig.7)

During the full-scale experiment the following results were obtained:

1. When filling the sleeve from nonwoven geotextiles the filling of sleeve with solid phase of pulp occurs. The water is filtered through the sleeve.
2. The sleeve from nonwoven geotextiles filled with tails carried out its functions completely: the deposit of the solid phase of pulp took place, and the liquid phase filtered through the screen into the pond of the tailing dump.

CONCLUSIONS

1. The results of laboratory and in-situ tests show that the sleeve from nonwoven geotextiles filled with tails carried out its functions completely: the deposit of the solid phase of pulp took place, and the liquid phase filtered through the screen into the pond
2. Application of geotextile sleeve instead of retaining prisms allows to increase the tailing dump volume up to 8 %
3. The results obtained suggest the possibility of industrial application of sleeve from nonwoven geotextiles filled with tails instead of filling slurry collecting prism from traditional materials. This permits to reduce the labour costs for construction of retaining prism and increase the useful capacity of the tailing dump.

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