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The discussion about the safety management of the mine tailings pond near the mine stope

Lv Shuran[a,*],Lv Shujin[b]

[a]*Safety and Environment Institute of Capital University of Economics and Business,Beijing,100070,China*
[b]*Mathematic and Computer Department of Baoding University,Baoding,071000,China*

Abstract

In our country, lots of ultra poor iron ore resources have been developed. Due to the low profits of mining ultra poor resources, the enterprise built mine tailings pond near the stope to save cost, witch is usually at the upstream of the stope with the distance from 100 to 400 meters. This kind of mine waste reservoirs also have another name—the tailings pond at the top of the head, they take a certain proportion in our cauntry. Different from general tailings ponds, this kind of tailings ponds is frequently effected by the stope blasting vibration, it can not be ignored of the security implications of stope blasting vibration to tailings pond. So the discuss key of this text is the specific environment characteristics of this kind of mine waste reservoir. In practice, the security management to this kind of tailings pond is very worth to be reserched and discussed.

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1. Introduction

Tailings pond which a concentration plant uses to store tailings or other industry wastes is not only a critical and essential facility to the development of the mining, but also an important component of the mine, however tailings ponds which contain high potential energy are the dangerous source of mud-rock flow. There are lots of serious accidents in the world before, which bring great loss of people's life and

* Corresponding author. Email: lsr22088@163.com

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properties. The security problems due to tailings ponds have drowed great attention of our party and government, especially the "9.8"serious accident in Xiangfen town of Shanxi province,which caused 277 dead, the direct economic losses of 96,192,100 Yuan and the extremely adverse social impact[1].

According to statistics[2], in all 12655 tailings ponds of our country, some are located at the upstream of the mine stope and close to it very much—commonly known as the tailings pond at the top of the head, "head pond" for short. Such tailings ponds are usually in a distance from 100 to 300m and take a certain proportion in all tailings ponds nationwide. According to data[3], only in Hebei province, there are 547 "head pond" which take 8.74% in all tailings ponds in our nation.

Such ponds are not the same as general tailings ponds because the unique environmental trait they suffered—the blast vibration of the mine stope. Therefore, the security managements toward such ponds are different from general tailings ponds. Recently, there are few reports on interrelated research about how to run security management on this kind of ponds, so it is worthy and significant to study the management of these ponds.

2. The tailings ponds close to mine stope and their environmental traits

2.1. Relationship between location of tailings pond and mine stope

In *Safety Technical Regulations for the Tailing Pond* and other technical regulations, standards, fundamental rules are defined on selecting sites for tailings pond, but the specific limiting conditions are not given. For example, "the pond site shall near the concentration plant, may as well locate downstream of the concentration plant", but the distance between the tailings pond and mine stope are not mentioned, so are the specific conditions and regulations when tailings pond is built on upstream.

Selecting a site of tailings pond properly is very important for constructions and safe running of a tailings pond. In designing a tailings pond, several pond sites are usually selected, and one is confirmed considering both technology and economic. However, it is not that simple to choose a pond site to meet all selecting fundamental conditions. As a result, in order to saving costs, enterprises built tailings pond near the mine stope, even at the upstream close to the mine stope which we call "head pond".

2.2. The traits of the tailings pond that close to mine stope

Totally speaking, there are some traits of the tailings pond that close to mine stope below:

（1）Tailings pond locates near the outdoor stope, and some at the upstream of the stope, tailings pond accidents will have a direct threat to the stope security.

（2）Tailings pond is very close to stope and frequent blasting vibration of the mine stope will have obvious influence on tailings pond.

（3）Parts of drainage system in tailings pond is imperfect. The dam body of tailings pond has a higher water level, and the embankment is not standard and the slope is very steep.

（4）With the exploiting of the mine, the stope is much lower and the tailings pond is much higher. Since the amplifying effect during the propagation of the earthquake wave, the influence that the blasting vibration of the stope on tailings pond is more and more obvious, as well as the increasing threat to the stope caused by tailings pond.

3. The influence caused by blasting vibration on tailings pond

In *Safety Technical regulations for the Tailing Pond* and other technical regulations, standards, there are clear requirements toward anti-seismic ability of tailings pond. Those tailings pond in level 5 tailing

is confined to those where earthquake intensity is 6 degrees and 6 degrees below, when the dam slope is less than 1:4, tailing silty clay and weak damaged, steady calculation are not needed, in addition to the original tailing mine clay. Those tailings pond above level 4, when areas whose earthquake intensity is above 6 degrees, should be considered the influences of natural earthquake. But there are no relevant demands about blasting vibration of stope and also no relevant criterions found in *Safety Regulations for Blasting*.

3.1. Blasting vibration and Natural earthquake

Explosive blast breaks the medium around blast hole by releasing the explosive energy, meanwhile shear stress and tensile stress are created on the medium faraway by the blast stress wave, and cranny on medium occurs; the remaining parts of the explosion energy propagate to the ground in the form of wave , causing the vibration of the ground particles and forming the blasting vibration which have similar effects with the natural earthquake on ground and building.

Earthquakes are phenomenon of ground vibration in a certain range caused by seismic wave which created from dramatic breakdown of the local medium in the earth. Earthquake is the rapid vibration of the earth surface. Ground vibration is the most intuitive and common performance of earthquakes.

Blasting earthquakes have similar effects with natural earthquakes that they both release the energy rapidly and propagate to outside in the form of wave which causes vibration of particles of medium and earthquake effect. But the differences between blasting vibration and natural earthquakes are listed below[4]:

（1）The energy and influenced scope of blasting earthquake are smaller. However the number of mine explosion is frequent during the whole mining process, it takes a few years to decades.

（2）Blasting earthquakes usually have shorter duration and take about 0.1～2 seconds while natural earthquakes usually last longer and take about 10～40 seconds.

（3）Blasting earthquakes have a higher frequency than natural earthquakes.

（4）The size and directions of blasting earthquakes source can be controlled contrast with natural earth quakes.

（5）The intensity of blasting vibration can be reduced by changing the amount of explosive, the directions and network technology of the blasting.

As seen above, the two seismic wave parameters may be equal at the same position, but the influence and damages of the building caused by blasting earthquakes are less than by natural earthquakes. Nevertheless, the influence to tailings pond caused by blasting vibration can not be ignored because the dam is mostly the accumulation of fine sand-like material dam which are sensitive materials can be easily liquidated under vibration loading.

3.2 Blasting vibration on the influence of tailings safety

The harm of blasting seismic waves to tailings is that sand body of tsilings dams are made into the phenomenon of liquefaction, which led to collapse of tailings pond, as the blasting particle vibration velocity reaches a certain degree. According to the data presented in our country, cases that tunnel excavation which triggered breakdown of tailings pond case of tailings had happened[5]. The influences of blasting vibration to tailings pond reflect in the following aspects:

（1）liquefaction of tailings sands generated in tailings dam

Vibration liquefaction is a phenomenon that saturated sandy clay in dynamic (such as under the vibration) lost its former strength and turn into a liquid-like state which lead to serious consequences. When moisture permeating water level of tailings dam is high enough, and the blasting vibration

amplitude reaches a certain degree, saturated or half-saturated sand body of tailings dam turns into liquefaction, finally, the dam-collapse risk is brought as the physical stress indexes of the tailings sandy materials are lower enough, especially the cohesion C and internal friction Angle φ, even to zero.

（2）sliding collapse of local dam

When the length of dry beach inside the tailing dam is shorter, more water accumulated in the dam, the phreatic line of dam body is higher, the water in the sand layer of dam is saturated and the damage of seepage is increasing, the saturated sand body liquefied rapidly under the blasting vibration, which lead to lower C, ϕ. Combined with the gravity came from the top of dam, the local part of dam will slide and bulge. As the cranny generated meet the accumulated water inside dam, which aggravate liquefaction causing from slide and bulge, it will result collapse in disasters.

（3）collapse of local dam

If the dry beach of tailings pond is shorter, the water in tailings sands of top dam may be saturated. When blasting seismic wave conducted from the base to the top of dam, the vibration strength at top is greater than in bottom, because the top of dam is higher and the amplification effect in seismic wave exists. When C、 ϕ of the top dam is very low, the top of dam will turn into mortar through liquefaction and flow away, it will overflow after combined with the accumulated water inside dam, larege area dam-break occurs, resulting in accident of tailings pond dam-break.

Overall, the adverse influence to tailings pond caused by blasting vibration do exist, however adverse impact is conditional, mainly depends on the following two aspects:

(1)The length of dry beach of tailings pond is rather small, accumulated water is also rather small, the infiltration water level of tailings pond is ultra-high. Water content of dam is huge, in the state of saturated or half-saturated.

(2)When the intensity of blasting vibration reaches a certain degree, the inside dam start to appear liquefaction phenomenon, the C、 ϕ of tailings pond materials is low enough to bring landslide or bulge. As the generated cranny meet the accumulated water inside dam, the accident of collapsed dam happens.

(3)The damming methods of tailings dam is not standard, the overall do not rise evenly, accumulation slope is too steep, the anti-sliding stability of tailings dam is lower after the blasting vibration effect.

4. Strategies and measures

4.1 Control of depth of burial of phreatic line

The control of depth of burial of seepage embellish line is the most important point in the safety management of tailings pond close to mine stope. The purpose of controlling seepage embellish line is to prevent seepage damage. The depth of phreatic line is one of the most important parameters which determine the stability of tailings dam, the stability of tailings dam body can be increased by increasing the depth of the phreatic line. In order to improve the stability of dam body, people in engineering usually take measures to lower the phreatic line by adding seepage water and rainfall drop drainage facilities and gain successful experience.

For the permeable dam, the exposed point of phreatic line of tailings pond should be under the top of dambase. Control the depth of burial of phreatic line to stop it from exposing at the dam slope of accumulation dam of tailings, or seepage damage would happen. Seepage damage mainly comes in the forms of piping, with flow soil and rushing. When the seepage or leaking water “run muddy” or the sign of piping in surface of downstream slope appears to flow with soil, measures should be taken immediately to prevent from aggravating seepage damage. Besides increasing the depth of phreatic line, adding inverted filter facilities in dam slope can also be taken, usually choosing gravels and rocks after paving geotextiles.

4.2 Blasting scale grading of stope

Blasting scale grading of stope is that grading different blasting scale according to the different distances between blasting point of stope and tailings pond. The purpose of grading is to control the intensity of blasting vibration in tailings pond and make sure the intensity of blasting vibration is not enough to cause liquefaction phenomenon of saturated sand body in the tailings pond.

The micro blasting vibration will make the sand body closely and increasing the stability of dam body. According to *Safety Regulations for Blasting*, and controlling standards of the soil caves and adobe house, for main frequency 10Hz, the speed of blasting vibration must be controlled between 0.5～1.0 cm/s; for main frequency 10Hz～50Hz, the speed of blasting vibration must be controlled between 0.7～1.2cm/s. Experimental results show that [6] it won't produce adverse effect on dam body in such control level.

With the key point of how to achieve blasting vibration grading, we should monitor and evaluate the blasting vibration according to the facts of mine producing and blasting; we should also classify the blasting scale according to actual monitor results, in order to delimit the different blasting distance and confirm different blasting scales.

4.3 Control of dry beach in tailings pond

Another important measure to safety management of tailings pond that close to stope is to control the length of dry beach and safety ultra-high. Controlling the length of dry beach and safety ultra-high of tailings pond is not only an important index to anti-flood of tailings pond, but also an critical factor in affecting phreatic line water level in tailings pond. In actual production, in order to get clear water, mining enterprises keep high water level running in a very long time at the expense of scarifying the length of dry beach. Due to the high water level inside dam, there is no doubt that the length of dry beach is very short, which can't meet the demands of anti-flood but increase the phreatic line water level of tailings pond.

Therefore, higher requirements should be put forward to the control of dry beach and safety ultra-high of tailings pond that close to stope. It requires the dam run at a low water level, increasing the grade of tailings pond and controlling the length of dry beach and ultra-high during the rainy season, which means the requirement of quality and quantity of return water are meeted, so we should keep the water level of dam as low as possible.When returning water and safety of tailings pond have conflict with requirements of the length of dry beach and ultra-high, the safety of dam body should be made sure.

4.4 Maintenance and monitoring of dam slope

The dam slope should fit the design requirements, but the formation of dam slope, steep or not, is made gradually during the running of tailings pond. If the slope is steeper than designed, the stability of dam body itself will reduce, combined with the blasting vibration which make it worse, collapse of local tailings pond will finally occur.

Therefore, we should pay more attention to the work of maintenance and monitoring of dam slope during the running of tailings pond. We should monitor not only the running indexes and parameters of tailings pond, but also the blasting vibration. Guide the blasting and production of stope by monitoring the blasting vibration.

5. Conclusions

The safety management on tailings pond that close to stope should not only follow the requirements in *Safety Technical Regulations for the Tailing Pond,* but also take two following measures: the one is that using engineering technology to reduce the intensity of blasting vibration by adopting the grade of blasting vibration to microquake; the other is that taking series of technical measures around the water storing of tailings pond and lower the running water level and phreatic line of tailings pond, meanwhile increasing the standardability and reasonableness of the way to maintain the slope and build the dam.

The safety management of tailings pond that close to stope is different from general tailings pond. We should take pointed measures to manage according to the traits which can make the potential danger and risk controlled and accepted.

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