

The present situation and prospects for safety online-monitoring system of tailings pond

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Abstract: Tailing pond is a major risk source, if happen accident, which would cause enormous losses to life and property of downstream people, however, the safety online-monitoring can effectively prevent the accident happing and reduce the accident loss. This article explains the present development and research situation of safety online-monitoring system for tailings pond, and also analyses shortages in subject-specific development, monitoring theory & technology, management system and operations & maintenance. At same time, according many experiences of safety online monitoring items, the article looks forward to the developing trend of safety online monitoring, and summarize the future development direction and the key point.

Introduction

Chinese is a mining country, according incomplete statistics, it has more than twelve thousand tailing ponds, and the most of which are dangerous or risky ponds [1] (Fig.1), Safety in production of tailing pond is very serious. Tailing pond is a major risk source, if happen accident, which would cause fatal disaster. There are many serious accidents in our country, that caused enormous losses to life and property of people and threatened the environmental security of around region, even influenced the social stability. For example: September in 1962, Huogushan tailing pond of Yunnan tin company limited had happened a dam break accident, which caused 171 peoples died, 92 peoples injured and 13970 peoples disaster, and also 8th September in 2008, tailing pond of Xinta mining company limited in Xiangfen county, Linfen city, Shanxi province had happened a big dam break accident, which caused 277 peoples died, 4 peoples lost, 33 peoples injured, enormous losses to life and property, and bad influence to society [2], therefore, it's necessary to effectively monitor the safety of tailing ponds. For preventing and reducing safety accidents of tailing ponds, government has published many documents to strengthen works of safety in production, and requires tailing ponds of the third class or above must install online monitoring system[3]. Technical regulations for the tailings pond safety monitoring (AQ2030—2010) is published to regulate basic requirement for tailings pond safety monitoring form engineering angles. So far, mining enterprises in country have installed safety online monitoring system of tailings pond one after another, which greatly improve technology and efficiency of safety monitoring and management, and play a direction rote in safety monitoring & early warning and management[4,5]. In the meantime, there are many shortages in subject-specific development, monitoring theory & technology, management system and operations & maintenance, for example, problems of limitations in monitoring methods, system building quality, integrated early warning mechanism and system operations & maintenance etc, all of which seriously impact on normally playing a monitoring and early warming rote in online monitoring of tailings pond. It's necessary to research relevant solutions. This paper explains the present development and research condition of safety online-monitoring system for tailings pond, and also analyses shortages in development. At same time, according many experiences of safety online monitoring items, the article looks forward to the developing trend of safety online monitoring, and summarized the future development direction and the key point.

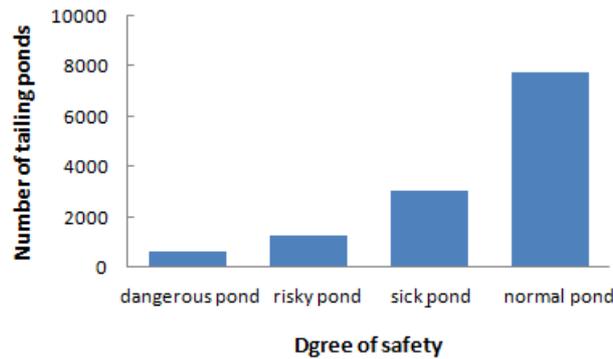


Fig.1 Safety distribution of tailings pond in China

The present development condition

Scholars in home have researched the key technology about safety online monitoring of tailings pond, the key research concentrate on system designing and developing, monitoring technology, data analysis and warning methods etc.

At the point of system designing and developing, YANG Xiaocong [6] designed a safety online monitoring system based a B/C model of tailings pond, which used in many tailings ponds. ZHANG Feiyan [7] designed a wireless monitoring system to monitor tailings dam in GPRS and GSM technology. ZHANG Da [8] developed a three-dimensional safety warning platform based on researching key technology about online monitoring and safety warning.

Hu Jun [9] developed a tailings dam automatic monitoring system based on internet-intranet. LIAO Wenjing [10] build a three-dimensional safety monitoring and warning system concentrating on tailings pond remote monitoring, slope stability analysis, flood regulating & checking and safety warning based on OpenGL and GIS. LEI Ting [11] constructed a wireless warning system based on wireless communication technology and concentrated on rainfall gauge, osmometer and data acquisition equipment. YI Dongfu [12] constructed a remote monitoring index system in systematic point and analytic hierarchy process. ZHOU Yipeng [13] developed a intelligent monitoring system solution based on Agent. ZHAO Jintong [14] designed a online monitoring system of tailings pond in light sensor.

At the point of monitoring technology, online monitoring concentrates on researching monitoring technology and method about tailings pond parameters and communicating & defending technology. ZHU Yufeng[15] monitors operating condition and dam displacement of tailings pond in GPS and remote sensing image. ZHANG Jifeng[16]、HU Jun[17] monitor the beach length in image recognition method. YUAN Ziqing [18] advices a new method using in online monitoring for beach length—seepage inversion method, which arranges some osmometers in beach width to get the phreatic line, and then, by structuring the coordinate system of pond length to dam height, it calculates the beach width by calculating the equation set of phreatic line and water. SU Jun [19] monitors displacement and saturation line of tailings dam in fiber grating sensor. LI Daoming[20] automatic monitors dry beach index (elevation, length and slope) in laser measurement technology. WU Huanliang[21] monitors displacement of tailings dam in Beidou high-precision positioning. ZHAO Zhijun[22] brings the Zigbee wireless technology into safety monitoring of tailings dam. XU Tongle[23] advices a method transferring monitoring data in fiber and GPRS technology for ensuring the reliability of system transferring. OU Yangwei[24] probes into the lightning protection designing of tailings online monitoring system, and advices a new technology in biological bacterium resistance reduction, which can effectively reduce the grounding resistance.

At the point of data analysis and warning method, based on system of district warning index, XIE Xuyang [25] constructs a district warning model in method of Support Vector Machine. ZENG Qunwei [26] uses the saturation line and flood storage capacity as an index of tailings pond automatic monitoring. Utilizing comprehensive evaluation related theory of water reservoir dams and according to the implementation of tailings pond monitoring, HAN Zhilei[27] constructs a monitoring behavior

comprehensive evaluation system of tailings pond, and also constructs a statistical regression model of saturation line in statistical regression theory, that analyses the influence of saturation line depth [28]. LIN Xuesong [29] calculates the warning value of saturation line, dry beach and safety factor by digital simulation method, and judges warning by contract the safety factor with regulation factor. CHEN Zhihua[30] constructs displacement forecasting mathematical model of tailings pond using the saturation line and water as external factors of displacement analysis. LI Lang[31] constructs mathematical model to forecast displacement of tailings dam in grey system theory based on monitoring data. XIE Zhenhua[32] constructs a RBF neural network model for analyzing the monitoring data.

Researching on tailings pond online monitoring system and technology, it finds that all online monitoring system accept the multilevel B/C construction of sensor + monitoring station + server (Fig. 2). Besides, no matter how about the actual situations, monitoring system almost has the same monitoring index, and the monitoring technology is single (Tab.1). At the same time, it can find that people increasingly pay attention to safety online monitoring of tailings pond, and more and more people gradually bring the modern advanced calculating, communicating, sensing and data analyzing technology into the safety online monitoring of tailings pond for achieving the scientization and intellectualization of tailings pond safety online monitoring.

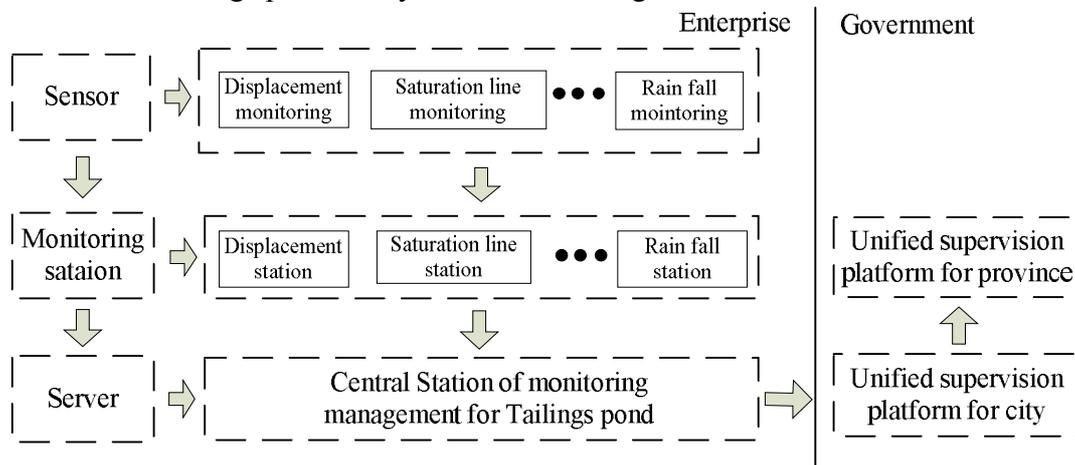


Fig.2 The frequent system construction of safety online-monitoring for tailings pond
 Tab.1 The frequent standards and technology or equipment table of safety online-monitoring for tailings pond

Monitoring index	Monitoring technology or equipment
Surface displacement	GPS, intellectual total station, hydrostatic leveling
Internal displacement	Fixed clinometers, settlement meter
Saturation line	Osmometer, water level gauge
Dry beach length	Camera, laser ranger, ultrasonic & radar levelmeter
Beach crest height	Laser ranger, ultrasonic & radar levelmeter
Pool level	Osmometer, water level gauge
Rain fall	Tipping bucket and capacitance rain gauge
Seepage flow	Measuring weir, ultrasonic levelmeter
Seepage pressure	Pore pressure gauge

Deficiency of development of online monitoring

From the above present situation of on line monitoring, we can see that there is a large number of on line monitoring systems about tailings pond and researchers have achieved good results in online monitoring related key technologies. But it still has the following disadvantages when looking at the current development of the whole tailings pond on line monitoring.

(1) Single existing monitoring techniques, low level of technological innovation and not enough data representation and accuracy. These phenomena are more obvious in displacement and invasive monitoring. The current dam displacement and invasive monitoring are almost point but not line and area monitoring. These monitoring has not enough representativeness to reflect the security status of tailings dam accurately and comprehensively. So it is quite necessary to develop large scale, large dimension and more representative new research about monitoring techniques and methods.

(2) The current tailings on line monitoring technology almost all use hydroelectric dam technology. Due to the differences in the engineering properties of the tailings dam, most data lack of accuracy. It is urgent to research and development new tailings dam engineering characteristics monitoring technology and sensors. For example, the method to monitor tailings moisture content in the bag and the inter story displacement of the mold bag tailings dams; How to monitor displacement of centre line method tailings dam et al.

(3) Fundamental theoretic research about the tailings pond on line monitoring system is not enough and lack of depth. The current on line monitoring technology has more applied research but software development, system integration degree and intelligence are still relatively lacking. Automatic safety comprehensive analysis and early warning function of the software is weak. Comprehensive warning method and early warning threshold value research about the tailings pond on line monitoring are very scarce. The current monitoring data in tailings rainfall, infiltration line and displacement can represent only one measuring point. It is difficult to solve the problem of comprehensive analysis in the whole tailings dam with multi parameter and measuring point data then timely evaluate the safety and early warning. In addition, due to the national norms and technical standards have not clearly define the monitoring indicators and its warning thresholds set, so the current setting of monitoring parameters early warning value lack of basis and guidance.

(4) There are no clear on line monitoring management system and construction standard in mining companies and the occupational specification[33]. So it can't guarantee the normalization of on line monitoring design, construction and acceptance. This situation directly impact the security of system construction and play of system security warning function.

(5) Mine enterprise lack of internal security needs of tailings pond on line monitoring, system operation and maintenance are inadequate, operational stability and continuity is time to be improved nor data integration and analysis deficiency. Tailings pond on line monitoring is mandatory under national administrative means to implement. So its system construction and internal demand for using are deficiency. Through investigations, many companies lack awareness of security risks. They still regard on line monitoring system as cope with administrative licensing examination and government departments and don't maintain the system effectively, the management system is also very imperfect. Although many scholars have done some analysis which were mostly simple and lack of timely data compilation and analysis, thus the state of tailings dam safety can't be accurate and timely evaluated[34]. These deficiencies made on line monitoring can't play roles on safety early warning and process guidance in the true sense.

(6) There is none national unity tailings pond on line monitoring platform, information sharing and integrated regulatory are inefficiency, regulatory platform overlap seriously which makes a waste of resources. Currently, each province independently regulates the construction and operation of tailings pond as well as on line monitoring system in their respective regions. So there is unbalanced regulatory standards, the standards are not uniform etc. are inevitable. These is not conducive to higher management and decision making. Also, because many provinces and cities have established a province innings different data interfaces tailings pond on line monitoring unified management platform. So the

platforms are seriously overlapping, resulting in a great waste of resources and information sharing between platforms in lower level.

Prospects for the online monitoring

Nowadays, because of the guidance of the state policies and regulations, domestic mining enterprises safety consciousness increases ceaselessly and they also pay more attention to the safety management of the tailings dam. Along with the rapid development of computer, communication, electronic information as well as sensor technology, more and more safety monitoring technology, method and equipment is applied in the tailings dam safety online monitoring and management, thus online monitoring of tailings is equipped with more advanced hardware and its analysis and early warning is more timely and reliable. Meanwhile, it should not be neglected that the current online monitoring is lack of software, imbalance development and the fundamental research is not insufficient. Based on the cases of Shibahe tailing dam, Zhangdou tailing dam, Dapingzhang tailing dam, Laoyaling tailing dam, Jiashigou tailing dam, Xiaodae online monitoring tailing dam, The author think that the main direction and content of tailing dam online monitoring in the future should be as follows:

(1) Study on the new mode of tailings online monitoring and management system. Change the existed old mode “Sensor + Monitoring station + Server”, applied advanced networking and cloud service technology, establish new mode of tailing dam safety online monitoring “Networking sensor + Cloud service + Terminal” (Figure 3). Study on the establishment of a national unified supervision of tailings online monitoring platform, and develop the corresponding software system, organization and management system.

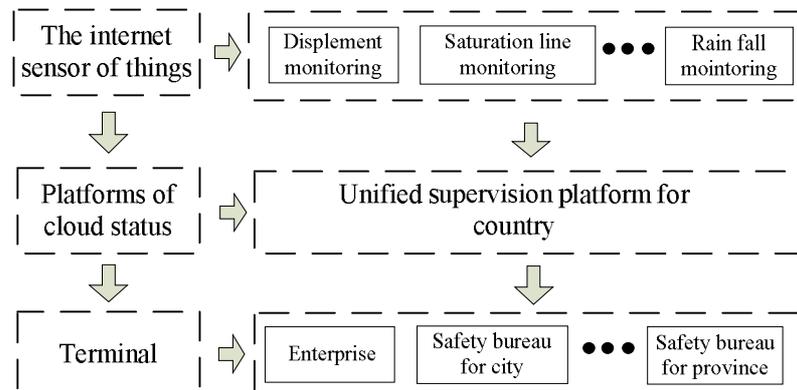


Fig.3 Construction of online monitoring for tails pond based on “Internet of things+ cloud status+ terminal”

(2) Study on the tailing online monitoring theory and technology. Study on safety monitoring method and optimization of tailings, such as displacement and invasive method of optimal layout for line monitoring points. Study on method of early - warning indicators of online monitoring tailing; Study on comprehensive early - warning method and model of the multi parameter, multi measuring point, and developed the corresponding early warning system. Research on change regulation of each tailing monitoring indicators and establish the corresponding mathematical statistical analysis model. Online monitoring data processing method of tailings reservoir. Applied advanced electronic and sensing technology R & D to tailings reservoir. Study on low cost, high reliability, high integration, intelligent online monitoring system. Research on large scale, multidimensional tailings dam internal hidden danger monitoring technology. Research on system protection technology research of ground tailings.

(3) Research on regulations and laws online monitoring of tailings. Formulate the code for design of online monitoring system of tailing reservoir, in order to clearly define the online monitoring system requirements and construction standards. Study on acceptance specifications of tailings pond on-line monitoring system construction; Clarify online monitoring system to ensure the quality of construction

requirements, ensure the reliability of the system from the design stage, implementing stage to final acceptance of construction stage. Establish the corresponding operation rules for the tailings of online monitoring system.

Conclusion

The author reviewed the research and development status of domestic tailings online monitoring system, analysis the development of this subject, the monitoring theory, technology, management systems and the existing problems in operations. The conclusion can be drawn the as followings:

(1) In recent year, the tailings online monitoring has made great development and progress in system design and development, safety monitoring technology and methods. From the current research results, we can conclude that implementation of the advanced hardware technology and the methodology could be the inevitable trend of tailings dam safety online monitoring in China.

(2) Based on large amounts of analysis and several online monitoring cases, the author summarized the main direction of the future research on tailings safe online monitoring and revealed the research tendency of online monitoring field of tailings, which played a positive role in promoting China's tailings dam safety online monitoring research and development.

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