Hindawi
Journal of Sensors
Volume 2024, Article ID 9760423, 1 page
https://doi.org/10.1155/2024/9760423

Retraction

Retracted: Uncertainty Analysis of Key Influencing Factors on Stability of Tailings Dam Body

Journal of Sensors

Received 23 January 2024; Accepted 23 January 2024; Published 24 January 2024

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Manipulated or compromised peer review

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] S. Qian and K. Hou, "Uncertainty Analysis of Key Influencing Factors on Stability of Tailings Dam Body," *Journal of Sensors*, vol. 2023, Article ID 7521356, 11 pages, 2023.

Hindawi
Journal of Sensors
Volume 2023, Article ID 7521356, 11 pages
https://doi.org/10.1155/2023/7521356

Research Article

Uncertainty Analysis of Key Influencing Factors on Stability of Tailings Dam Body

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Received 23 August 2022; Revised 11 September 2022; Accepted 27 September 2022; Published 20 April 2023

Academic Editor: Sweta Bhattacharya

With the continuous expansion of the mining scale of mineral resources, many tailings are produced. In order to avoid the impact of harmful substances in the tailings on the residents around the tailings pond, it is necessary to explain the stability improvement. The dam safety monitoring system is mainly composed of observation sensors, telemetry data acquisition module, industrial control network, and automatic monitoring system. Through the work of the computer, the dam observation data can be automatically collected, processed, analyzed, and calculated. This paper adopts the automated system that makes preliminary judgments and graded alarms on whether the dam's behavior is normal or not to provide early safety warning reports for monitoring objects. In this paper, combined with a specific example of a tailings reservoir dam body, the comprehensive uncertainty method is used to analyze factors such as the height of the tailings dam, the height of the wetting line, the cohesion of the tailings soil layer, and the internal friction angle, and the stability of the dam body is calculated. The results show that the sensitivity order of the dam stability safety factor K to each factor is as follows: internal friction angle of the tailing silt layer > the height of the wetting line > dam body height > the cohesion of the tailing silt layer. The most dangerous slip surface will jump at the 19-level subdam of the tailings pond. The remediation measures are of great significance for maintaining the ecology around the tailings pond and ensuring the personal safety of residents.

1. Introduction

China is a big mining country, but due to the continuous expansion of mining scale in recent years, the number of tailings discarded every year is increasing. Most of the tailings discarded every year are stored in tailings ponds, and only a small part is reused. With the continuous growth in the number of tailings ponds, there are great potential safety hazards in the process of tailings filling or comprehensive utilization and recovery [1]. If the tailings dam fails, it will not only cause damage to the ecological environment but also lead to casualties. According to incomplete statistics, up to now, only 70% of the total tailings ponds have been treated and utilized in the tailings ponds, and nearly one-third of the tailings ponds have not been treated, which is highly dangerous. Not only that, these tailings ponds are in a very unfavorable situation due to their large storage [2] and old tailings pond facilities. Problems often occur in tailings ponds due to some force majeure. Therefore, the current operating efficiency of tailings ponds in China is low and the disaster risk is very high, which is needed to deal with urgently. Many experts and scholars at home and abroad have conducted in-depth research and discussion on the dam body stability of wet-draining tailings ponds, and their research focuses mainly on three aspects: seepage stability, dam body static stability, and dam body dynamic stability [3]. In the context of strengthening water conservancy construction, improving the safety of hydraulic structures, especially improving the level of dam safety monitoring, and ensuring the safety of reservoirs and dams are the top priorities related to national interests and social stability [4]. The establishment of an automatic monitoring system for dam safety can shorten the data collection cycle, improve the work efficiency of dam observation, and reduce labor intensity [5]. And it can make full use of the reservoir's storage capacity to maximize its benefits in both flood control and water supply. At the same time, it can improve the management level of the reservoir, discover the hidden dangers of the dam in time, and provide a strong guarantee for the safe operation of the reservoir.

The dam safety monitoring system is a huge systematic project and has the characteristics of a large amount of information and a wide range of knowledge [6]. The static stability analysis of the dam body is based on the limit equilibrium theory. The dynamic stability of the dam body mainly considers the influence of the liquefaction of saturated sand, the change of pore water pressure, and the action of irregular waves on the stability of the dam body caused by the tailings dam under vibration conditions [7]. The research on the above three contents have its limitations, because the stability of the dam body is affected by various factors such as the dam body design, the internal friction angle φ of the deposited material, the cohesion, the tailings particle size, and the height of the wetting line, and the changes of each factor have different effects on the stability of the dam body. In engineering practice, it is often necessary to study the influence of the changes of various factors on the stability of the dam body and take preventive measures against the relevant influencing factors. The sensitivity analysis method in the uncertainty analysis method was originally used for financial evaluation. This paper studies and analyzes various factors and parameters that affect the stability of the dam body, selects the uncertain factors, sets their variation range, and analyzes their influence on the stability safety factor K of the tailings pond dam body. The tailings pond is a storage system specially used to store tailings [8]. Accurately evaluating the stability of tailings dams is the premise to prevent tailings pond instability and dam failure, threatening the safety of people's lives and properties, and to provide a basis for tailings pond disaster prevention and control. As we all know, the dam safety monitoring instrument is the eyes and ears of people to understand the operation state of the dam. It must be able to detect the small physical quantity changes of the dam stably and reliably for a long time in the harsh environment. Therefore, in some aspects (such as measurement accuracy and long-term stability), compared with other industrial monitoring industries, its requirements are higher and more difficult. The requirements include the static level, upright and inverted hammer, laser collimation from external observation to piezometer, subsidence meter, inclinometer, soil strain gauge, and earth pressure gauge for internal observation [9]. Its automated telemetry is based on highly reliable sensors. In recent years, with the increase of large-scale dam buildings and the application of high technology, dam safety monitoring is developing in the direction of integration, automation, digitization, and intelligence.

The safety supervision of dams has also gradually developed from manual inspections to intelligent, networked, and efficient directions. This requires the use of high-precision and high-stability sensors as the eyes and antennae of the intelligent monitoring system to monitor the dam in a wide range, continuously and in real time [10]. The dam safety monitoring mainly has the functions of checking the design, improving the construction, and evaluating the safety status of the dam, and monitoring the safety of the dam is the top priority. The significance of dam safety monitoring is mainly for people to accurately grasp the behavior of dams, better utilize engineering benefits, save engineering investment, and prevent major accidents. In this paper, a variety of observation sensors are used to monitor the tailings dam body in real time as shown in Table 1. By analyzing the factors related to the stability of the dam body, the functions such as rapid early warning can be realized to reduce the occurrence of hazards. In the field of dam safety monitoring, high-precision, high-stability, and high-reliability magnetostrictive liquid level sensors have been used in many aspects due to their unique working principles. In this paper, the displacement, cracks, and seepage of the dam are accurately monitored through the measurement of sensors, so as to better evaluate the safety status of the dam and avoid the occurrence of major accidents.

Table 1: The related work.

No.	Content
1	The dam safety monitoring
2	Factors affecting the stability of tailings dam body
3	Network of dam safety monitoring

2. Materials and Methods

2.1. Sensor Layout of Tailings Pond. A tailings pond is a valley-type tailings pond. The designed total storage capacity of the tailings pond is $230 \times 104\,m^3$, the total dam height is 57 m, and the design level is the fourth-class pond. The amount of pulp discharged from the concentrator is 193.3 m^3/h, and the mine is drawn evenly in front of the tailings dam, and the distance between the draw openings is 6 m. The characteristics of tailings dam body and slurry are shown in Table 2. The surface water system in the reservoir area is distributed in a network, and the groundwater is directly recharged by atmospheric precipitation, and the recharge area is basically the same as that of the flowing area. The geomorphological conditions in the area are not conducive to the enrichment of groundwater. The main aquifer is limestone aquifer with low water content and simple hydrogeological conditions [11]. The rock stratum has complex structures, many faults, widely distributed joints, and the rock is very broken, which belongs to the medium-complex type of engineering geological conditions. The reservoir area has no adverse geological phenomena such as landslides, debris flows, and piping, the bank slope is stable, and the soil and water conservation is good.

The sensor layout is generally set on the straight section of the catchment ditch. The upstream and downstream ditch bottoms and slopes need to be protected by masonry to prevent water leakage. Special concrete or masonry water

Table 2: The characteristics of tailings dam.

Initial dam				
Dam bottom elevation	Dam height	Dam crest elevation	Dam crest width	Downstream slope ratio
611 m	19 m	830 m	3.2 m	1 : 2.2
Late accumulation dam				
Final dam height	Number of dams	Current dam height	Subdam height	Downstream slope ratio
668 m	20	656 m	1.6 m	1 : 2.8
Slurry composition	Slurry volume	Pulp concentration	The average particle size	Tailings dry bulk density
60%	192 m^3/h	8%	0.07	1.9 t/m^3

diversion channels can be built. The water depth below the weir is designed to be lower than the mouth of the weir, resulting in free overflow at the mouth of the weir. In order to obtain accurate observation results, the weir wall should be perpendicular to the diversion channel and the direction of incoming water and be upright [12]. The weir plate is made of stainless steel, the surface should be flat and smooth, and the weir mouth is made at an angle of 45° from the downstream edge. The water gauge of the weir should be set upstream of the weir mouth, and the distance from the weir mouth should be 3 to 5 times the water head above the weir. The scale of the water gauge is changed to 0.1 mn. In order to stabilize the water flow upstream of the weir, a flow stabilization device can be installed upstream of the water gauge.

2.2. Structure of Tailings Dam Body

2.2.1. Initial Dam. The initial dam of the tailings pond was built on a slate foundation and was a rockfill permeable dam. The height of the dam is 40.5 m, the width of the dam crest is 4.0 m, the length of the dam crest is 115 m, the width of the dam bottom is 157.50 m, the downstream slope ratio is 1 : 2.0, and the upstream slope ratio is 1 : 1.7. The 2.0 m wide horse road is set at an elevation of 1156.5 m downstream, and there is a 0.7-1.0 m thick of sand and gravel filter layer upstream.

2.2.2. Late Accumulation Dam. The later accumulation dam is composed of various types of tailings. The upstream method is used to build the subdams step by step. The tailings discharge pipe is set at the top of the dam to disperse the ore, and the tailings are deposited in stages to form a sedimentary beach. In the later stage, the height of each stage of the accumulation dam is 3.0 m, the width of the step is 8.0-11.0 m, and the width of the top is 3.5 m.

2.3. Dam Safety Monitoring. The dam safety monitoring system is big data, which composed of a data acquisition and monitoring module, an expert analysis and prediction module, a risk analysis and evaluation module, and an early warning and forecast module, it can realize all-weather uninterrupted real-time online monitoring [13]. The effective monitoring of the dam body, surrounding banks and related facilities by the system, can provide operation data for the operation status of the dam and complete the stability analysis of the dam body and the dam slope. And through the analysis of monitoring data, the evaluation results of the health status of the reservoir area are given, and the early warning and forecast of abnormal conditions are issued. The data results and their analysis results can be used as data support and decision-making basis for the daily management and emergency management of the reservoir area, thereby effectively improving the management level of the reservoir area. According to the analysis of business requirements, it is determined that the architecture of the dam safety monitoring system consists of five parts: acquisition layer, communication layer, network layer, data layer, and application layer. The system architecture is shown in Figure 1.

The safety factor of tailings comes from the monitoring data of sensors, including parameters such as wetting line and cohesion. The collected data is processed and evaluated, and an early warning result is finally obtained.

2.4. Analysis of Factors Affecting the Stability of Tailings Dam Body. According to Coulomb's law, the shear strength of sand can be known.

$$\tau = \sigma * \tan \varphi. \quad (1)$$

The shear strength of cohesive soil is as follows:

$$\tau = c + \sigma * \tan \varphi. \quad (2)$$

τ is the shear strength of the soil c is the cohesion of soil. φ is the angle of internal friction of soil. φ is the normal stress on the shear slip surface [14]. The internal friction is mainly caused by the surface friction between soil particles and the occlusal force between soil particles. The cohesion is mainly formed by the water film among soil particles subjected to the electric molecular attraction between adjacent soil particles and the cementation of compounds in the soil [15].

The grinding fineness of this tailings pond is less than 200 mesh (sieve size is 0.075 mm), and the mass of particles accounts for 60% of the total mass. It is tail silt, and the one deposited in the lower part is tail silt. The internal friction angle φ of tailing silt, which is generally between 28° and 36°. The void ratio is smaller, and the φ is larger. The cohesion c of tailing silt and tailing silt is generally small, about 10 kPa or less. For the dam body composed of cohesive soil, the dam body stability safety factor K is the ratio of the

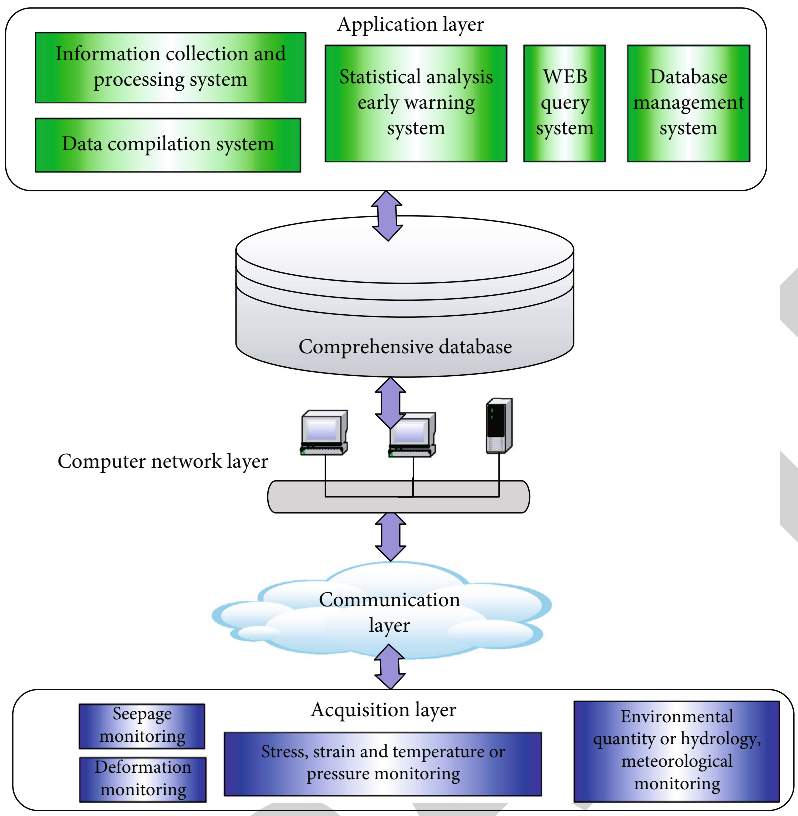


Figure 1: System architecture diagram.

stabilizing moment (equation (3)) to the sliding moment (equation (4)).

$$M_r = \mathrm{R} * \left(\tan \varphi * \sum_{i=1}^{N} W_i * \cos a_i + c * \sum_{i=1}^{N} l_i \right), \tag{3}$$

$$M_s = \mathrm{R} * \left(\sum_{i=1}^{N} W_i * \sin a_i + r * D \right), \tag{4}$$

$$K = \frac{\mathrm{M}_r}{M_s} \Big). \tag{5}$$

In the formula, α_i is the angle between the normal and the vertical line of the sliding surface of soil strip i. l_i is the arc length of the sliding surface of the strip i. c and φ are the cohesion and internal friction angle on the sliding surface. W_i is the soil bar weight, and the buoyancy of water should be considered for the part below the wetting line, and the buoyancy weight should be used. K is the resultant hydrodynamic force acting on the sliding soil body below the wetting line. r is the force arm of the dynamic hydration force D to the center O of the sliding surface. R is the sliding circle radius [16]. The stability of the dam body is affected by many factors, which are related to the particle composition, density, water content, mineral hydrophilicity, mineral colloid characteristics, water seepage state, thixotropy of cohesive soil, water level, and height of the dam body, and some factors are still related to each other and cannot be accurately determined. For the convenience of research and quantitative analysis, the single factor that can be measured experimentally is selected for analysis.

2.4.1. The Height H of the Accumulation Dam. The height of the accumulation dam increases year by year with the operation of the tailings pond, which is a variable. From equations (3)–(5), it can be seen that the safety factor K has nothing to do with the height H of the accumulation dam, which makes it easy to ignore the influence of the height of the accumulation dam. However, if there is a hard rock layer below the dam body and the burial is shallow, the arc surface of the slip crack can only be tangent to the hard rock layer, and the most dangerous slip surface is affected by the height factor H of the accumulation dam.

2.4.2. The Shear Strength Index of the Dam Sedimentary Layer. When the tailings are deposited, the coarse sand that is easy to settle settles and consolidates in front of the dam, and the silt settles sequentially in the clarification zone according to the particle size [17]. When the specific gravity, mass concentration, and particle size of the tailings entering the wet tailings pond do not change much, the tailings slurry volume, dry beach length, and clarification length are stable, and the tailings sand layer and the tailings soil layer are deposited in layers. Boundaries can be identified by engineering drilling. The particle characteristics of tailings, mineral hydrophilicity, mineral colloid characteristics, and thixotropy of cohesive soil are comprehensively reflected in two factors, internal friction angle φ and cohesion c, whose changes affect the dam body

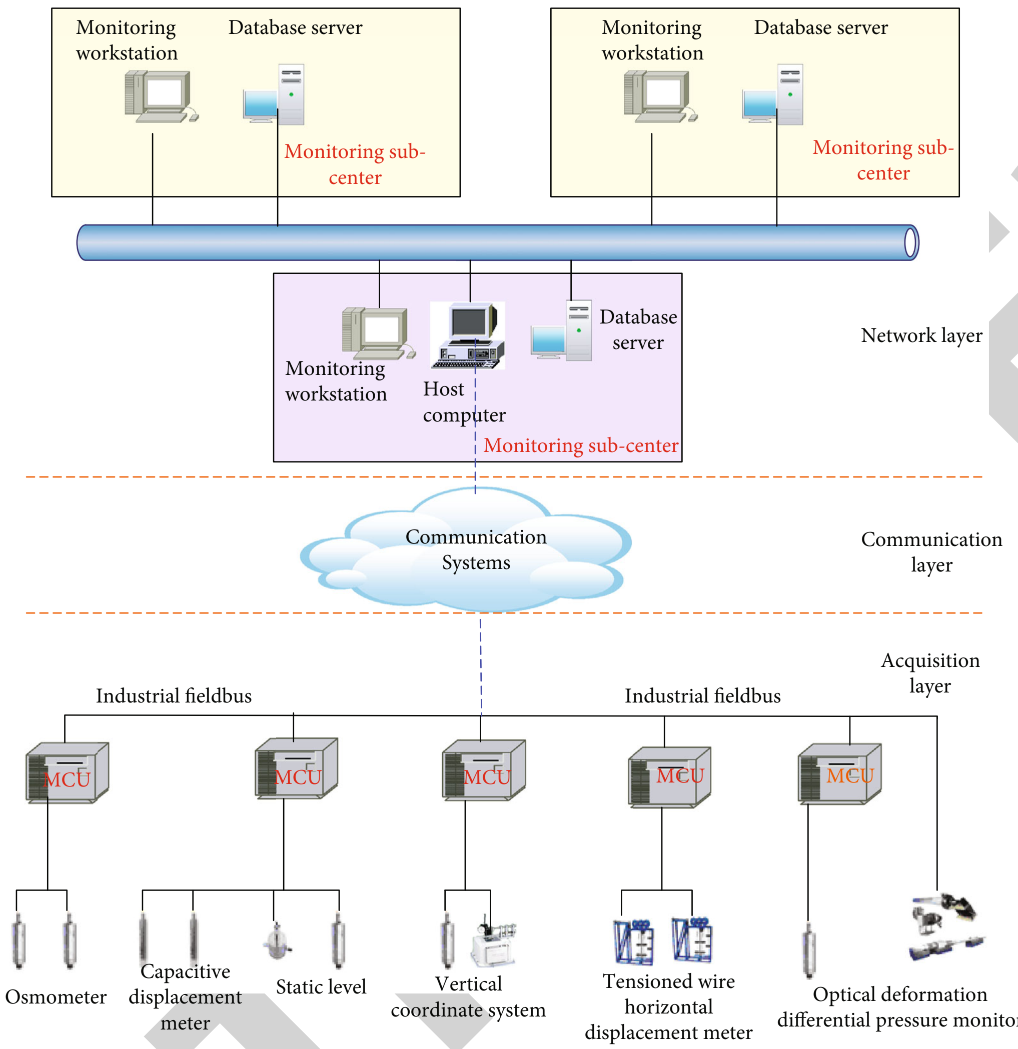


FIGURE 2: Network of dam safety monitoring system.

stability safety factor K. Because the tailing silt layer is deposited in the lower part and all below the infiltration line, it is the most prone to slipping surface. Therefore, the underwater internal friction angle and underwater cohesion of the tailing silt layer are studied in this paper.

2.4.3. The Height of the Wetting Line. The height of the wetting line is a variable, and the heights of the dry bulk and saturated sections of the soil strip have an impact on the stability of the dam body when calculated by the circular arc method. The growth of water content in the dam body will reduce the shear strength of the dam body, which is manifested as follows: first, the water flow takes away fine particles, which play a lubricating role between the coarser particles and reduce the internal friction force. The second is the thickening of the water film on the surface of the clay particles, which reduces the cohesion of the soil.

3. Result Analysis

3.1. System Composition. The dam safety monitoring system consists of an information acquisition system, a communication system, a network system, a comprehensive database system, and an application software system, including automatic acquisition or manual observation of sensors embedded in the dam body or installed (dam deformation, seepage, stress and strain, temperature, rainfall, water level, temperature and earthquake, etc.), measurement and control unit (MCU) host computer, monitoring center, and monitoring subcenter, and the system composition is shown in Figure 2. The system structure adopts a distributed architecture, and the data acquisition work is distributed to the measurement and control units close to more sensors to complete, and then the measured data is transmitted to the host computer. The measurement and control unit of each observation site of the system is a multifunctional intelligent instrument, which can control and measure various types of sensors.

The system selects sensors to mainly sense various physical quantities such as dam deformation, seepage, pressure, strain, temperature, environmental quantity, hydrology, and meteorology and inputs analog quantity, digital quantity, pulse quantity, state quantity, and other signals to the measurement and control unit. The measurement and control unit performs actual measurement, calculation, and

Table 3: Basic parameters of model calculation.

Item	Dry weight	Saturated weight	Cohesion	Internal friction angle	Underwater cohesion	Underwater internal friction angle
Tailings sand	17.7	19.8	7.6	34	7	32
Tailing silt	17.7	26.1	9.6	27.9	8.4	26.2
Initial dam	24	28.2	52	59	51	59
Bedrock	22	24	0	41	0	40

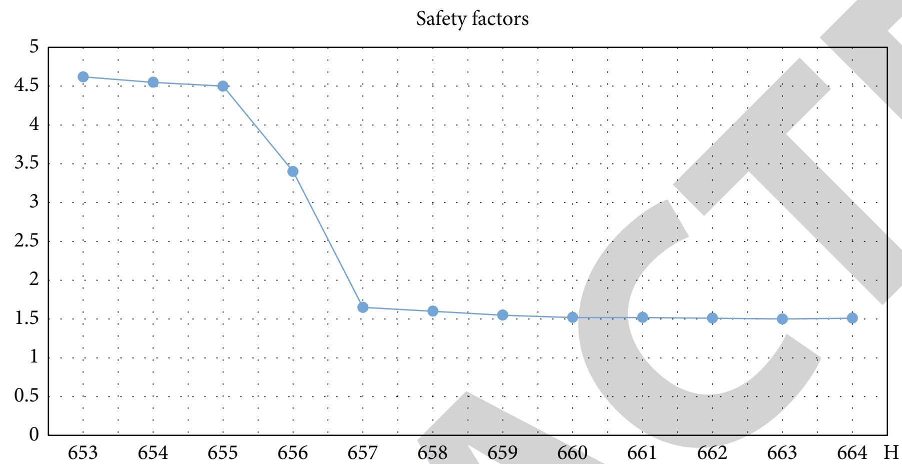


Figure 3: Sensitivity analysis of dam height of subdam.

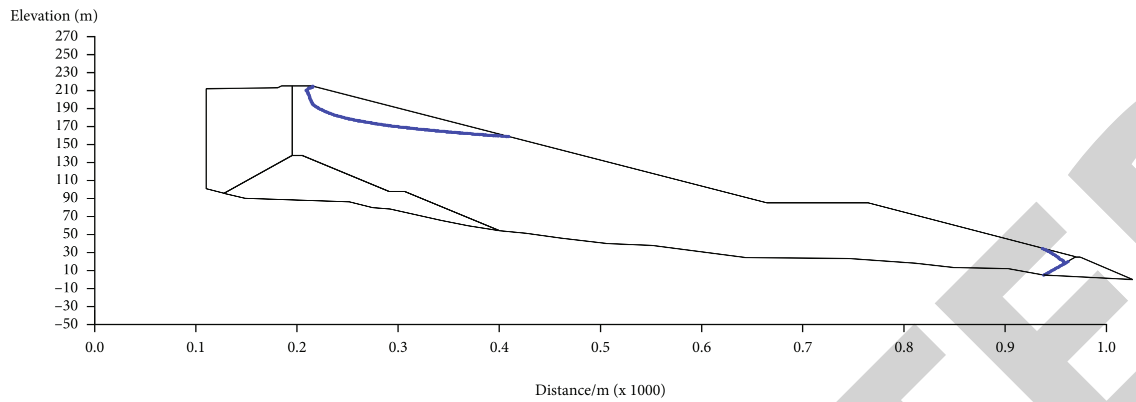
storage according to the determined observation parameters, plans, and sequences and has self-checking, automatic diagnosis functions, and manual observation interfaces. According to the determined recording conditions, the observation results and error information are communicated with the designated monitoring center or other measurement and control units [18] Different measurement modules or boards can be selected to realize the signal acquisition of various types of sensors. The communication system adopts wired or wireless mode according to the site situation. And two communication modes can be used as backup channels for each other, and a communication system with dual channels as backup for each other can be established. The business application system is mainly a dam safety management software system; it can perform functions such as data reception, processing, storage, analysis, and early warning in the monitoring center and subcenter. The integrated database system can establish a unified data platform, unified data format, and standardize data standards for hydrological information and can effectively carry out data sharing and data analysis, providing a reliable foundation for business application systems. Interfaces can also be provided for data access to other related systems.

3.2. Stability Calculation Model of Tailings Dam Body. A mathematical model is established by taking the section of the central axis of the dam body, using the principle of the limit equilibrium method, and using the Swedish circular arc strip method to calculate the stability of the tailings pond dam body. This model also inputs the shape characteristic information of initial dam and accumulation dam (see Table 2). The bedrock inclination angle is 7°, and the subdam is of grade 20, corresponding to a dam height of 658 m. The boundary line between the silt layer and the silt layer in the engineering detection is 22.4 m vertical depth below the slope. The average value of the infiltration line is 8 m, and the minimum length of the dry beach is 50 m, and a geometric model is established. The basic parameters of tailings sand, tailing silt, initial dam, and bedrock are shown in Table 3. For the level 4 tailings dam, the effective stress method is used for the hydraulic force, and the earthquake influence is not considered. In this paper, the geotechnical slope stability software is used to calculate the stability of complex soil slopes, and the width of the strip is 1 m. The arc stability calculation adopts automatic search for the most dangerous slip surface. The safety factor K of the dam body stability is 1.68, and the calculation result is as follows:

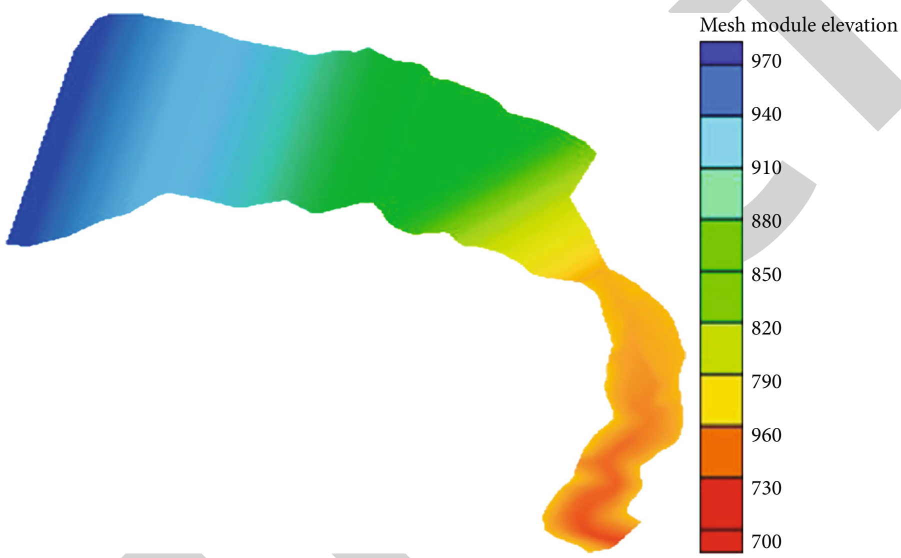
Four key influencing factors are selected, namely the dam height H, the wetting line height h, the underwater cohesion c of the tailing silt, and the underwater internal friction angle φ of the tailing silt, and the degree of their influence on the stability of the dam body is analyzed. Each factor varies by −15%, −10%, −5%, 5%, 10%, and 15%, respectively.

3.3. Sensitivity Analysis

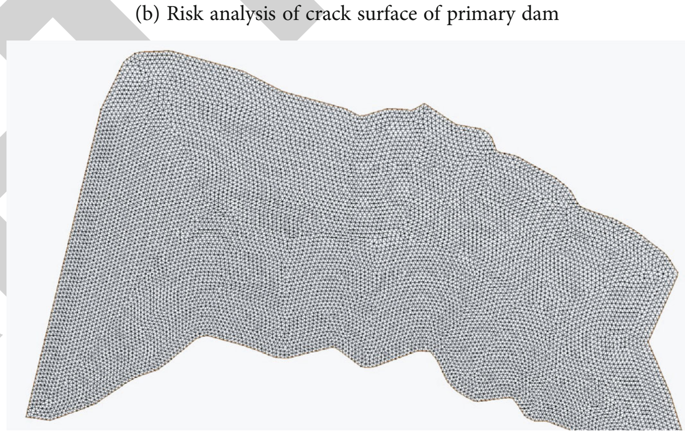
3.3.1. Subdam Height. Figure 3 shows the influence of the height change of the subdam on the safety factor of the dam body stability. As the height of the subdam increases, the dam body stability safety factor K shows a downward trend. When the normal subdam increases by 2 m, the safety factor decreases by about 0.014.



(a) 2D graphics of tail dam



(b) Risk analysis of crack surface of primary dam



(c) Accumulation on sediment movement dam

Figure 4: Analysis of the risk of slippage of the tail dam crack.

For this dam body, when the level of subdams number is 18 (dam height + 655 m), the most dangerous slip crack arc surface appears on the initial dam (see Figure 2(a)), but the level of subdams number is 19 (when the dam height is +656.5 m, and the dam height is increased by 1.5 m), and the most dangerous slip crack arc surface appears on the accumulation dam, the position jumps (see Figure 4), and the safety factor K also changes greatly.

The location of dangerous slip surface is a round toe or a round slope. It mainly depends on the depth of the hard layer, and the most prone to slip surface is always tangent to the top surface of the hard layer. For this dam body, this paper believes that the position abrupt change of the most

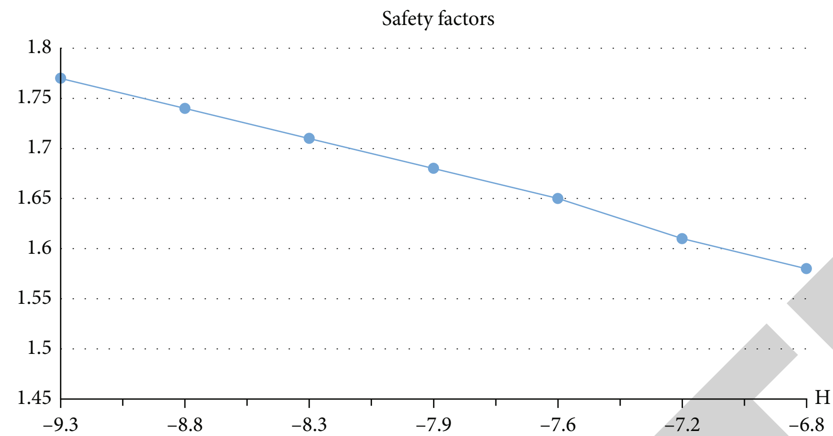


Figure 5: Sensitivity analysis of infiltrated line height.

dangerous slip crack arc surface with the dam height is related to the initial dam structure, the dip angle of the bedrock, and the characteristics of tailings deposition. In the initial stage of the dam, the dam was built with block stone concrete, filled with gravel, and the foundation was firm, which was equivalent to the retaining wall structure [19]. Part of the accumulation dam near the initial dam is subject to greater water pressure, and active earth pressure is applied to the initial dam [16], reaching the limit equilibrium state. When the subdam exceeds the critical height, the overall stability of the upper accumulation dam depends on the cohesion c of the tailings sediment layer and the internal friction angle φ.

3.3.2. Wetting Line Height. The dam body stability safety factor K changes inversely with the height of the wetting line, as shown in Figure 5. It can be seen from Figure 3 that the height of the infiltration line is higher, and the safety factor K of the dam body stability is smaller.

3.3.3. Cohesion. Figure 6 shows the influence of the change of the underwater cohesion of the tailing silt layer in the accumulation dam on the safety factor K of the stability of the dam body. It can be seen from Figure 6 that the influence of cohesion is small.

3.3.4. Internal Friction Angle. The variation of the underwater internal friction angle of the tailings in the accumulation dam has a great influence on the safety factor K of the dam body stability (Figure 5). It can be seen from Figure 7 that with the growth of the internal friction angle, the dam body stability safety factor K increases, and the dam body stability safety factor K is more sensitive to the change of the internal friction angle of the tailing silt layer.

Regardless of the sudden change of the height of the subdam on the dam body stability safety factor K, the sensitivity of each factor to the dam body stability safety factor K is ranked as follows: internal friction angle of tailing silt soil layer > wetting line height > dam height > tailing silt soil cohesion.

3.3.5. Case Analysis. The flow process of the breach is shown in Figure 8; the maximum flow of the breach is 469 m^3/s, and the flooding duration of the breach is 279 h. In order to simulate the propagation process of the levee-breaking flood in the protected area, the simulation time is 843 h, that is, during the period of $t = 252\,h \sim 877\,h$, the breaking flow is 0. The calculation is based on the two-dimensional shallow water equation, and the method proposed in this paper is used to establish a hydrodynamic model of flood evolution adapted to complex terrain in Figure 8. Take the embankment rupture on the right bank of a river as an example to calculate. The modeling area is 9568 km^2, the grid side length is controlled by 250 m-400 m, the number of grids is 182860, and the average grid area is 0.049 km^2.

Data-based evaluation of tailings dam safety is feasible and can reduce unnecessary investment in engineering construction. The combined analysis method of experiment and two-dimensional numerical model provides a quantitative analysis idea for tailings pond safety assessment, and provides a new research direction for future tailings pond management and safety assessment.

4. Discussion

According to the analysis of the above stability influencing factors, the stability improvement measures of the tailings dam body are expounded. First, the coarse-grained tailings should be selected when building the dam. The safety and stability of the mine is higher. The larger the size of the same tailings material, the larger the internal friction force and the agglomeration angle. Therefore, when building tailings dams, coarse tailings should be selected. In order to concentrate the coarse tailings into the dam body, it is necessary to discharge before the dam, so that the coarse tailings quickly settle in the dam area, and the fine tailings flow into the reservoir of the dam body [20]. A cyclone can also be used to sort the tailings particles, the coarse tailings are intercepted, and the fine tailings are directly discharged into the storage area.

The first point is to pay attention to the slope angle of the side slope of the mine dam when stacking the tailings dam. Therefore, it is necessary to check the inclination angle in

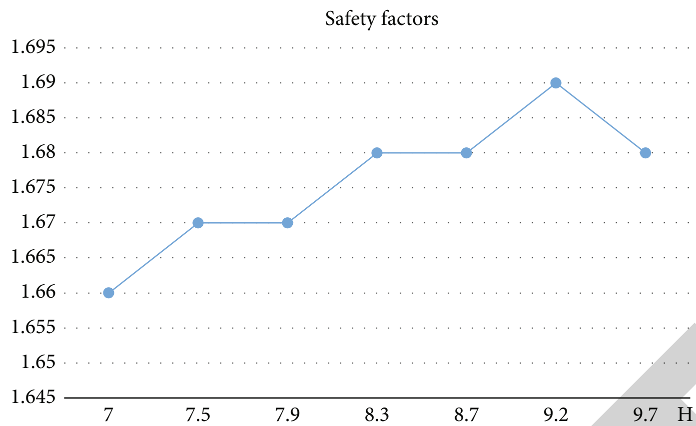


Figure 6: Sensitivity analysis of underwater cohesion of tailing silt.

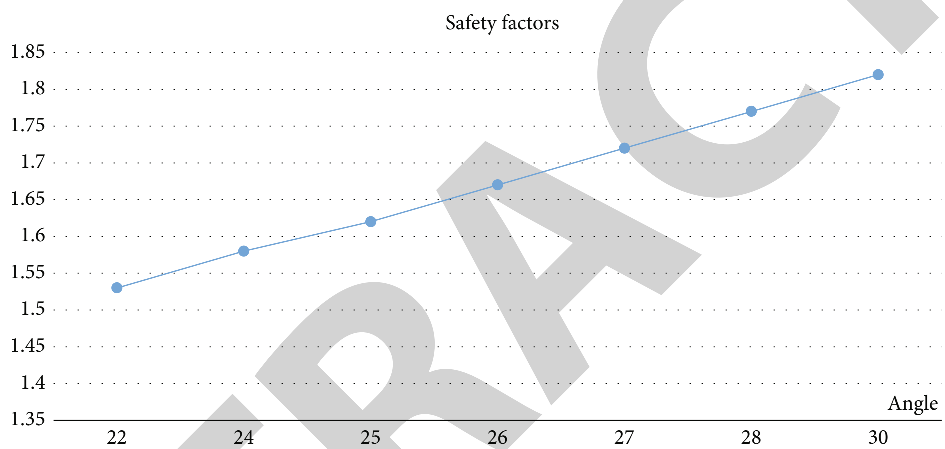


Figure 7: Sensitivity analysis of underwater internal friction angle of tailing silt.

advance and compare it according to the design scheme of the inclination angle. After the comparison, if the slope angle at this time meets the standard requirements, it can be stacked. If it does not meet the requirements, the dam slope angle needs to change in time [21]. If it is greater than the standard value, you can choose to slow down the stacking and reduce the slope angle. If it is lower than the standard value, slope pressing treatment is required to ensure that the inclination of the entire mine dam is within the design range.

The second point is to control the position of the entire mine dam on the river bank, which needs to calculate according to the wettability of the mine dam. First, the wettability determines the height of the entire mine dam, which is crucial to the stability [22]. At this time, the infiltration line exceeds the standard value, and corresponding measures should be taken immediately, that is, the water level around the dam can be reduced, the scope of the infiltration line can be reduced, the surrounding pressure can be reduced, and the length of the dry beach can be increased to ensure the stable position of the infiltration line In addition, if the phenomenon of exceeding the water level occurs, it is necessary to discharge all the seepage water of the mine dam to avoid the collapse of the mine dam.

The third point is to control the position of the wetting line. Because the height of the infiltration line has a great influence on the stability of the dam slope, the highest position of the infiltration line corresponding to different dam heights should be given in the design [23]. The main measures to control the position of the infiltration line of the dam body are as follows: first, the water level reduced in the reservoir, a sufficient dry beach length maintained in front of the dam, and reduce the seepage pressure in the dam body, so as to reduce the position of the infiltration line of the dam body. The second is to take engineering measures for dam body seepage drainage, such as adding dam body seepage drainage facilities to remove seepage water inside the dam in time and reduce the infiltration line in the dam body.

In addition to the above measures, it is necessary to strengthen daily inspections and timely check whether the equipment parameters of the entire tailings pond meet the operating requirements. The first is to check the drainage performance of the tailings pond and dam. Water seepage avoids in tailings ponds, which leads to the collapse of the dam, second, plant green plants on the dam to avoid soil erosion on the surface of the dam. Third, the key indicators of the dam are complete and to avoid data errors. Fourth,

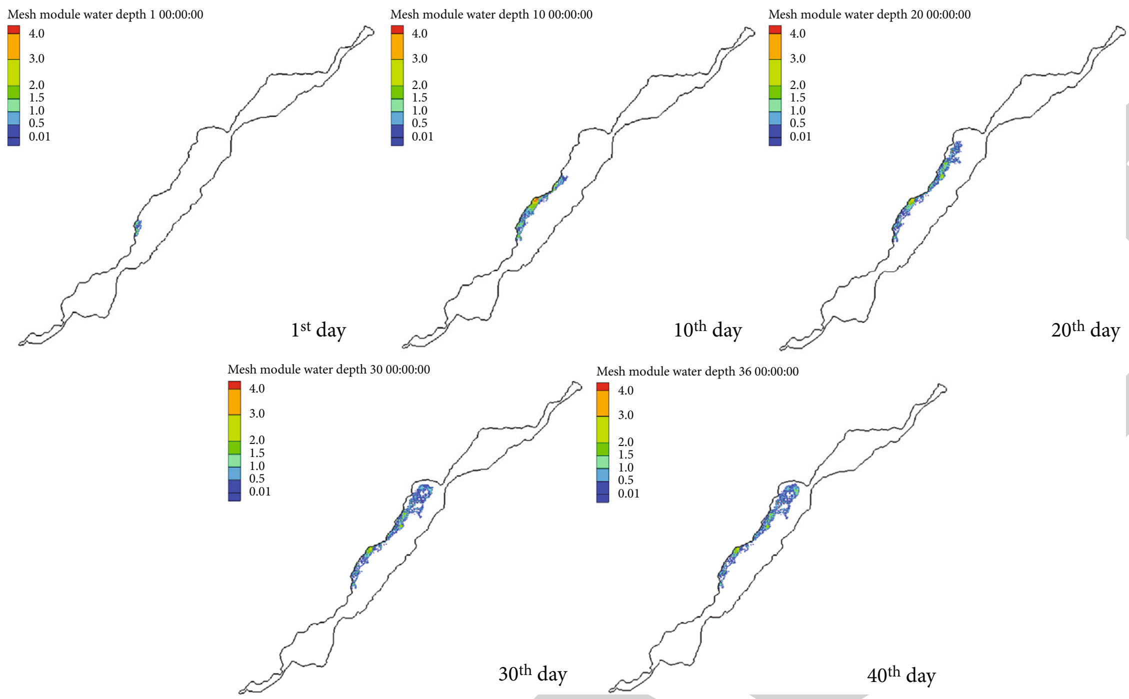


Figure 8: A real-time computing system for flood evolution of tailings.

during the maintenance of the dam, the accumulated tailings should be pretreated to avoid the reaction between the accumulated tailings and the air to produce toxic chemicals, which would endanger the ecological environment around the tailings pond.

In addition, the dam body should have monitored to check regularly and comprehensively whether there are abnormal conditions such as cracks, landslides, and leakage of infiltration lines. When abnormal conditions are found, they should be dealt with in time. When controlling the rising speed of the accumulation dam, prevent the rising speed from being too fast, so that the lower dam body cannot be consolidated in time and the strength is not enough, thus causing the deformation and cracks of the dam body.

5. Conclusion

The dam safety monitoring and management system software is an important part of the reservoir dam safety monitoring system. It has functions such as data acquisition, data processing, data management, data compilation, data analysis, and network management. By using the dam safety monitoring and management system software, reservoir managers and management leaders can keep abreast of the current state of the dam. The tailings dam can basically meet the requirements of the specification when operating under normal conditions. The safety factor calculated by each method is greater than 1.25. However, when the infiltration line exceeds 6.0 m, the dam body cannot meet the specification requirements under the dynamic state. The software of the dam safety monitoring system adopts the B/S structure. Except for the data collection service program that needs to be started on the server, as long as the computer user is connected to the server through the network, it can be accessed through a browser to query monitoring data, graphics, security monitoring information, and evaluation conclusions. Therefore, in order to increase the safety reserve and improve the stability, it is necessary to strengthen the seepage drainage and reduce the height of the dam body infiltration line. (1) Subdam height, wetting line height, internal friction angle of tailing silt layer, and cohesion all affect the safety factor K of dam body stability. The friction angle of the tailing silt layer is deposited in the lower part, and the height reduction of the wetting line is the most effective way to improve the stability. (2) The height of the wetting line and the dam body stability safety factor K change in the opposite direction. The influence of the safety factor K of the body stability is more significant. (3) For this dam body, the most dangerous slip crack arc surface jumps at the height of the 19-level subdam, and the dam body stability safety factor K changes greatly. This paper considers that it is related to the initial dam structure, bedrock inclination, and tailings sedimentary characteristics. Further research is needed in the follow-up, and great attention should be paid to it in engineering practice.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author does not have any possible conflicts of interest.

Acknowledgments

The work was supported by the National Natural Science Foundation of China under Award No. 51964023 and the Yunnan province project Education Fund No. 2021 J0946.

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