Development of Tailings Pond Flood Routing Simulation System Based on LabVIEW

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Abstract—Flood routing is an important work for tailings ponds to flood control. Although the flood routing method is relatively mature, the manual calculation and parameter selection still remain a major challenge for field engineers. In this study, a program, developed by LabVIEW, is introduced to improve the tailings ponds flood routing calculation. The developed program provides two flood generation calculation methods and four kinds of flood discharge model, which can be applied to any tailings pond and achieves flood routing fast and accurately. An application of Dexing 4# tailings pond is conducted to verify the function of program. The result indicates that the program shows good performance on calculation speed and accuracy.

1. Introduction
Tailings ponds are important production facilities to store metal and nonmetal mines wastes generated by mining operation, which contains many toxic and polluting substances\cite{1}. In recent few decades, mining activities have intensified and produced large amount of tailings ponds. It is estimated that there are more than 7000 tailings ponds in China\cite{2}. The safety of tailings ponds is not only related to the smooth progress of mine production, but also affects the public live and property\cite{3}. Therefore, the safety assessment of tailings pond is priority research area.

Although tailings dams and water storage dams are similar in appearance, a number of characteristics make tailings ponds more vulnerable than water storage dams\cite{4}. From 2001 to 2020, a total of 88 tailings ponds accidents had been reported on China, including 69 dam break accidents. One of the main factors to cause tailings dam break is flood overtopping, which causes more than 30 percent of dam break accidents. Therefore, the flood storage capacity and flood drainage capacity have become leading factors to determine the safety of tailings ponds. Ministry of Emergency Management of the People’s Republic of China requires that tailings ponds in operation must have flood routing calculation before flood season and make sure the tailings ponds have adequate flood control capacity. The flood routing calculation has become a key work in tailings pond safety management.

However, flood routing is a complex work which is usually fulfilled by professional staff. The mining enterprises would be unable to handle this task. Meanwhile, the traditional method of flood routing calculation costs a lot of manual work. In order to overcome the drawbacks of the manual flood routing calculation, a program developed by LabVIEW is introduced and implemented in this paper. The flood generation and discharge can be completely presented in the program. To demonstrate its applicability, the developed program is applied to a case study in Dexing 4# tailings pond.
2. Calculation method and program design

2.1. Calculation method

The flood routing calculation has two parts: flood calculation and discharge calculation. The flood calculation can be used to determine the process of flood, including peak flow and the flood volume. The purpose of discharge calculation is to determine the drainage capacity of flood discharge system. Then the water balance equation, shown as formula (1), is adopted to calculate the change of water in tailings pond. Finally, the highest flood level can be obtained by the water level-storage capacity curve[5].

\[
\frac{1}{2}(Q_s + Q_t)\Delta t - \frac{1}{2}(q_s + q_t)\Delta t = V_z - V_s
\]  (1)

where, \( Q_s \) and \( Q_t \) are the amounts of water that flow into the tailings pond, \( q_s \) and \( q_t \) are the amounts of water that drained out of the tailings pond, and \( V_s \) and \( V_z \) denote the amount of water stored in the tailings pond at the beginning and end of the period, \( \Delta t \) stands for any period of time, respectively.

The program, introduced in this paper, contains two methods to simulate the process of flood generation, which are five points probable method and instantaneous unit hydrography method. To ensure safety, the larger result of these two methods is chosen as the proposed flood generation and adopted to routing calculation. Then, the developed program provides 4 kinds of flood drainage calculation models including underground inclined channel(UIC), frame type of drainage well(FTDW), windows type of drainage well(WTDW) and physical model(PM). UIC, FTDW and WTDW are empirical calculation model, PM is the test result established by similarity model. The proper model can be chosen based on the actual situation of flood discharge system. The water storage capacity of each water level can be measured by the topographic map, then the relation curve of water level-storage capacity can be fitted. In this program, the water balance equation is solved by iterative calculation. By setting a small unit of water level, \( \Delta H \), the water volume of each water level can be obtained. When iterating to the difference of water volume is less than \( \varepsilon V \), a time step finished. In this program, \( \Delta H \) and \( \varepsilon V \) are set up manually, which are \( 10^{-6} \) and 50, respectively. Finally, the flood routing curve is determined and the flood prevention capacity of tailings pond obtained. The process of calculation is shown in Fig. 1.

![Fig. 1 Process of flood routing calculation](image)

2.2. Program Design and development

In this paper, the flood routing program is development by LabVIEW platform. The program contains 6 blocks that provide data input interface and demonstrate flood generation curve, flood discharge curve, water level-storage capacity curve and flood routing curve, respectively. The highest water level also
can be obtained by this program, then the flood prevention ability of tailings pond is determined. The program is shown as follow.

3. Case study

3.1. Field conditions
The case demonstrated in this paper is the Dexing 4# tailings pond, which is the largest tailings ponds in Asia. By analysing topographical map, the geographic conditions are determined. Flood parameters are retrieved in local hydrological data. The form of constructed flood drainage system is underground inclined channel, and a physical model test of drainage capacity is conducted by field engineers. The relation curve of water level-storage capacity has been obtained by topographical map. The present water level is 256m and the top of dry beach is 260m.

3.2. Result and discussion
The flood parameters are inputted to program, then results of five points probable model and instantaneous unit hydrograph model are obtained. After analysing and comparing, the result of five points probable model is higher than result of instantaneous unit hydrograph model. Therefore, the result of five points probable model is conducted to flood generation of this flood routing calculation, shown as Fig. 3.

According to the present water level and and the top of dry beach, the curve of water level-storage capacity is fitted. Flood discharge curve based on PM is also determined, shown as in Fig.4.
Fig. 4. Flood generation of five points portable model

Fig. 5 is the flood routing curve solved by water balance equation. It can be seen that the highest water level is 257.22m. Compared with the result of manual work given by field engineers, which is 257.21m, the error is only 0.01m.

Fig. 5 Flood generation of five points portable model

4. Conclusion
In this study, a program for tailings pond flood routing, developed by LabVIEW, is introduced. The program contains two methods to fulfill flood calculation and four kinds of drainage calculation, which can be applied to different types of drainage systems. The program can greatly improve tailings pond flood routing calculation efficiency, compared with manual work. To verify its availability, the flood routing calculation of Dexing 4# tailings pond is tested by this program. Result indicates the program performs obvious effects of fastly and accurately calculation.

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