Experimental study on sedimentation characteristics of fine tailings

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Abstract: The experimental results of sedimentation characteristics of fine-grained tailing at home and abroad are summarized. For fine-grained tailing dam, the particle size of tailing, the discharge concentration of tailing and pore water pressure has significant effects on the sedimentation characteristics of fine-grained tailing dam. Different particle size of tailing will lead to a different structure of tailing deposition, which directly affects the sedimentation characteristics and stability of tailing. The increase of discharge concentration and pore water pressure will also lead to adverse results of tailing sedimentation characteristics.

1. Introduction
The tailings pond project is a huge complex project that is always related to the safety of people's lives and property. As early as 1995, the fine dam tailings were identified as one of the important directions for the development of tailings technology. The material of the dam body forming the fine tailings accumulation dam is also extremely special. The material of the dam will be affected by many aspects such as the form of discharge, sedimentary structure and dam construction. In the past few decades, the tailings pond in China has been adopted. The upstream dam is different from the permanent dam adopted by countries such as Canada. The research on sedimentary characteristics in China is obviously more than that in foreign countries, but most of the current research results are seepage and stability analysis of tailings dam. Sexuality is dominant, and the study on the sedimentary characteristics of fine-grained tailings is slightly insufficient. So far, no complete research methods and theoretical systems have been formed.

2. Definition of fine-grained tailings
Introduction to China's Colored Tailings Reservoir define fine-grained tailings as:

◆ average particle size cp≤0.03mm
◆ -0.019mm content is generally >50%
◆ +0.074mm content<10%
◆ +0.037mm content≤30%

The specified tailings can be determined by the particle size composition and plasticity index of the table below in Chinese national standard “Technical code for geotechnical engineering of tailings embankment” (GB50547-2010).

Table 1 Category, name and classification criteria of specified tailings.
### Classification criteria

| Category          | Name            | Classification criteria                                      |
|-------------------|-----------------|-------------------------------------------------------------|
| Sand tailings     | Tail gravel     | Particles with a particle size greater than 2 mm account for 25% to 50% of the total mass |
|                   | Tail coarse sand| Particles with a particle size greater than 0.5 mm exceed 50% of the total mass |
|                   | Tail sand       | Particles with a particle size greater than 0.25 mm exceed 50% of the total mass |
|                   | Tail fine sand  | Particles with a particle size greater than 0.075 mm exceed 85% of the total mass |
|                   | Tail silt       | Particles with a particle size greater than 0.075 mm exceed 50% of the total mass |
| Powder tailings   | Tail silt       | The particle size of particles larger than 0.075mm does not exceed 50% of the total mass, and the plasticity index is not more than 10 |
| Viscous tailings  | Tail silty clay | Plasticity index greater than 10, and less than or equal to 17 |
|                   | Tail clay       | Plasticity index greater than 17 |

With the gradual improvement of the production technology level in China, the particle size of the tailings produced will be more and more fine. The deposition characteristics of fine-grained tailings is one of the technical problems that need to be solved urgently.

### 3 Study on sedimentary characteristics of fine tailings

The tailings pond section deuteration method is a commonly used survey and dam test method. However, due to the unique complexity of the tailings project, the sedimentary characteristics of the tailings particles are also highly complicated. Therefore, the tailings pond section deuteration method is applied. Studying sedimentary properties of fine tailings has certain limitations. In order to accurately obtain the sedimentary laws in the tailings pond, numerous scientific research workers at home and abroad have been conducted a large number of numerical simulation calculations, field tests and laboratory tests. The following are mainly studied from the three aspects of tailings particle size. Tailings discharge concentration and pore water pressure to study its deposition law and its influence on sedimentation characteristics.

#### 3.1 Effect of Particle Size on Deposition Characteristics of Tailings

The particle size of tailings is one of the most influential factors in the current research. In recent years, domestic and foreign scholars have tried to use different test methods to prove the relationship between tailings particle size and tailings deposition characteristics, and then to control the stability of the tailings pond. The key is to control the particle size of the tailings.

As early as 2004, Xu Hongda [1] and others passed the static sedimentation test of tailings containing ultra fine grain group, which proved that the sedimentation of tailings particles is from coarse to fine and then sinks with time, and the higher the concentration, the fine particles in the slurry. The larger the flocculation structure formed, the coarser particles will also be trapped in the floc to form a network structure. Subsequently, Yi Liping [2] proposed that the deposition of tailings particles is affected by their own gravity. Last year, Zhao Huaiang [3] used indoor screening test and constant water flow theory to further study the sedimentary characteristics of tailings particles. It is found that the sedimentary law on the dry beach surface is generally rough and thin, and can be generalized as “thick”. The process of change-slow refinement-refinement; the particle size of the dam body is
generally coarse and fine, and there are interlayers, interbeds, and staggered layers at different depths; separation speed of tailings particles. It is smaller as the particle size of the tailings increases.

According to the results of different experiments by the above scholars, the sedimentation of tailings particles is mainly due to the fact that their gravity gradually sinks from time to time. Taylor, Michael J. [4] takes a tailings pond with coarse-grain tailings and fine-grain tailings as an example, by controlling a single variable. The way of depositing fine-grain tailings below the water storage area after W, the key to monitor the stability of the dam is to control the compatibility of coarse particles and fine-grain tailings in the tailings deposition process.

3.2 Effect of Emission Concentration on Deposition Characteristics of Tailings

However, the particle size of tailings is not the only key influencing factor of sedimentary characteristics. Yu Shaowei [5] and so on by comparing the slope of the dam in the tailings pond, the height of the sub-item, the ore-bearing ore, the tailings concentration, the particle size, After various influencing factors such as the form of ore discharge and the ore discharge flow of each discharge pipe, it is considered that the key factors affecting the sedimentation law of the tailings are the slope of the piled dam, the height of the sub-item and the form of discharge. Yan Xuejun [6] et al. also suggested that the concentration, flow rate, flow rate, and location of the discharge point should be considered in the design of the tailings pond.

Li Fulan [7] and other experiments have analyzed the average particle size of the tailings of the flotation process tailings and carbon slurry process, the average slope and the size data of the median diameter d50 of different beach length L. High concentrations and low flow rates will result in poor tailings sorting properties. Liang Bing [8] studied the influence of the slurry discharge speed on the tailings deposition law in the tailings reservoir through the self-developed water separation sorting particle size analyzer. The slope of the sedimentation beach decreases with the increase of the slurry discharge speed, and the sedimentation slope in the sedimentation tank is almost unaffected by the discharge speed. The concentration of the pulp plays a decisive role in the sedimentation rate. In short, the greater the concentration of the slurry, the slower the sedimentation rate of the ore.

According to the above experimental research results, the higher the tailings discharge concentration, the more difficult it is to sort, resulting in the unstable instability of the tailings deposit structure. Minkyung Kwak, David F. James, Katherine A. Klein [9] and other indoor simulation test models with the sink to replace the tailings reservoir boundary, the shear strength test of the dam structure formed by different concentrations of tailings deposits, the test results prove the tail. There is a monotonous increase between the concentration of the ore and the shear strength of the sedimentary slope formed.

3.3 Effect of pore water pressure on sedimentation characteristics of tailings

The pore water pressure is mostly caused by two conditions, one is the seepage field formed by the water's own weight, and the other is caused by the change in the total stress acting on the soil unit. In short, when the skeleton of the soil cannot achieve the transition of the new void ratio in a short time, an additional pore water pressure field that may disappear with time, that is, pore water pressure, is generated. Zandarin Maria, Oldecop Luciano A, Rodriguez Robertot [10] and others have studied that under the same operating conditions, the pore water pressure will be different due to the structure of the dam obtained after tailings deposition. Especially under the operating conditions of floods, the pore water pressure will suddenly increase, causing the sink line to rise and the tailings dam to be unstable.

The study of the distribution law of pore water pressure has also been the difficulty and focus of research. Tian Limei [11] et al. used the indoor sedimentation test and the permeability test to obtain the geological model of the tailings reservoir generalization, and then used the triaxial test to summarize the stress relationship of different layers of tailings. Based on the measured saturated water content, residual water content, saturated permeability coefficient and the gradation curve of each tailings, the soil-water characteristic curve and seepage model were obtained by Fredlund-Xing model. The
mathematical model of flow-solid coupling of upstream tailings reservoir is established, and the stress field and seepage field of the tailings pond are analyzed. Finally, the distribution law of pore pressure is obtained.

4 Conclusion
It is of great significance to study the sedimentary characteristics of fine tailings for the stability and time of formation of tailings. However, due to the different tailings reservoirs formed by different conditions such as dam construction, it is not possible to accurately understand the sedimentary characteristics of tailings by simply generalizing the tailings section. As far as the current research results are concerned, although different researchers use their own test methods to obtain different test conclusions, the overall situation is relatively one-sided. Therefore, research on the sedimentation characteristics of fine tailings is still a long way to be done. The author believes that the following aspects can be improved and strengthened:

① Nowadays, the research on the sedimentary characteristics of tailings is mostly based on a certain damming process or setting, which has limitations. However, the actual operation of the tailings pond is not developed in a single situation, so it is necessary to build one. A complete set of experimental systems and theoretical systems that fully embody the complex tailings project in China for reference and learning by future researchers and workers.

② The existing numerical simulation studies on the sedimentary characteristics of tailings are mostly operated under ideal conditions, and the conclusions obtained cannot be fully applied. The establishment of the fine-grain tailings deposition model should be more diversified to promote The accuracy and practicability of numerical simulation of fine tailings.

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