Experimental study on physical and mechanical properties of red mud under different compaction degree and water content

Hu Yuzhi[1], Xu Mingming[2] and Li Mingyang[3]
1. Senior engineer
2. Engineer
3. Professor level senior engineer
CHALIECO GAMI, Guiyang, China
Corresponding author: Hu Yu-zhi 37184370@qq.com

Abstract

In order to study the physical and mechanical properties of red mud from Bayer process under conditions of different compaction degrees and water content, samples with 90 % and 95 % compaction degrees were prepared and natural consolidated red mud samples were sampled. The direct consolidation and fast shear test were carried out in the laboratory before and after saturation respectively. Test results show that as the change of dry density from1.13 g/cm^3 to 1.28 g/cm^3, the shear strength index of red mud cohesive force of C increased by 13.4 %. Internal friction Angle of Φ increased 21.7 %, the deformation index of red mud compression modulus of E increased by 99.3 %, and the compressibility of a_v decreased by 55 %. After saturation, the cohesive force of C was decreased by 16.3 %, internal friction Angle of Φ by 22.1 %, the deformation modulus of E of red mud decreased by 41.1% and the compressibility of a_v increased by 77.1%. These results reveal the physical and mechanical properties of red mud from Bayer process under different compaction degree and water content, which has important reference value for the study of practical engineering problems.

Keywords: Red mud from Bayer process, Degree of compaction, Saturated red mud, Shear strength index, Deformation index.

1. General Remarks

Red mud is the tailings discharged from alumina factory. At present, the dry storage technology of red mud has been widely used in alumina production. The compaction degree and water condition of red mud are the main factors affecting the stability of red mud dam. In practical projects, the capacity of red mud storage yard is generally large, and the terrain, climate and other conditions are different. The compactness of red mud is mainly controlled by mechanical rolling and the water-bearing condition is mainly controlled by drying and rainfall drainage. Obviously, it is uneconomical and impractical to control the red mud storage with the same index, so the control index of red mud in the area that affects the stability of dam body should be higher, while the control index of red mud in the area that affects less can be reduced appropriately. The mechanical properties of red mud under different compactness and water conditions are inevitably different, and the study of its variation rule and quantitative analysis is beneficial to the long-term safe operation of red mud storage yard, and provides reference for similar projects.

In recent years, many achievements have been made in the research on the mechanical properties of red mud [1~5]. Tian Yue et al. [1] analyzed the mechanical properties of red mud accumulation starting from the generation of red mud. Liu Zhong-fa et al. [2] analyzed the drying degree and reasons of the red mud accumulation body and discussed its mechanical properties. Li Ming-yang [3] proposed that the moisture content of red mud and the outlying slope of sub-dam are the main factors affecting the slope stability of the red mud storage site in pingguo. Wu Yan-sen et al. [4] summarized the physical and mechanical properties of red mud and the factors affecting the test results through composition analysis and physical and mechanical test research of red mud. Chen

Xue-mei [5] obtained the relationship between the number of crushing times and the compactness and shear strength indexes through the crushing test of red mud filter cake. However, there are few researches on the change rules and quantitative analysis of physical and mechanical properties of red mud under different compactness and water conditions.

This paper aims at a dry red mud storage site in the guizhou province. Through the preparation of different degree of compaction of red mud samples and taking the natural consolidation of red mud samples, respectively for the consolidated quick shear tests study before and after saturated, test method and test data with reference to the related standard [6], and through the comparison of experimental results and analysis, expected to reveal red mud in different degree of compaction and water content under the condition of strength and deformation characteristics and the law along with the variation of parameters and scope.

2. Test Conditions and Plan

2.1. Sample Preparation and Adoption

(1) preparation of samples with a compaction degree of 90 % and 95 %

Step 1: the best moisture content and maximum dry density were 41.6 ± 2 % and 1.25 g/cm^3, respectively, by using the disturbance sample of red mud filter cake taken in the field for compaction test. Then the 90 % compaction degree sample: water content 41.6 ± 2%; rho dry density =1.25 × 0.90 = 1.13 g/cm^3. The 95 % compaction degree sample: water content 41.6 ± 2 %; rho dry density =1.25 × 0.95 = 1.19 g/cm^3.

Step 2: take red mud filter cake, air dry it and grind it [6]. Determine the corresponding air-dried moisture content. Then prepare samples close to the optimal moisture content of the two types of red mud filter cake and determine the actual moisture content after preparation.

Step 3: according to the volume of the sample made and the dry density required, weigh the wet soil quality required for a single sample, and use the method of compaction of sample to complete the preparation of the sample and keep it for test.

(2) Natural consolidation of red mud taken

The samples of natural consolidation of red mud are adopted by ring knife in front of dam at the initial stage of the red mud storage yard, and the natural consolidation time of red mud is more than 6 months.

(3) preparation of saturated samples

Prepared and adopted samples with a compaction degree of 90 % and 95% and natural consolidation, vacuum extraction saturation method [6] was adopted to conduct the saturation of the samples.

2.2. Test Plan

According to the above methods, 12 groups of red mud samples with compaction degree of 90 % and 95 % were prepared, and 12 groups of natural consolidation red mud samples were adopted. Among them, 6 groups of samples are used for direct consolidation and fast shear test, and the other 6 groups are used for consolidation and fast shear test after saturation. In this way, the physical and mechanical parameters of red mud with different compactness and natural

deformation modulus E of red mud decreases somewhat compared with that before saturation, with an average decrease of 41.1 %. After saturation, the compression coefficient a_v of red mud increases somewhat compared with that before saturation, with an average increase of 77.1 %.

(5) This test reveals the physical and mechanical properties of red mud from the Bayer Process under different conditions of compacted degree and water content, and its quantitative results can be used as reference for analogy and parameter prediction of similar projects. For example, in the case that the maximum compactness and water cut conditions cannot be guaranteed in the storage yard under special topography and climate conditions, when the stability of the dam body of the storage yard is reviewed, the variation trend and range of the corresponding mechanical indexes can refer to the results of this paper.

5. References

1. *Yue Tian et al., Mechanical properties of red mud storage. Qingjinshu,1998(02),32 – 34.*
2. Zhong-fa Liu et al., Analysis on the Operation of Dry-process Red Mud Disposal. *Nonferrous metals design*. Vol. 33, No. 1, (2006),83-87.
3. Ming-yang Li, Stability analysis on side slope of the dry red mud disposal site in alumina refinery with bayer process. *Journal of guizhou university of technology (Natural science edition)*. Vol.35, No.4, (2006),38 – 41.
4. Yan-sen Wu et al., Experimental study on physical and mechanical properties of red mud. *Geotechnical engineering world*, Vol.9, No.3, (2006),77 – 78.
5. Xue-mei Chen. Relationships between the compaction passes and the shear strength indices of red mud cakes. Soil eng and foundation. Vol.27, No.4, (2013), 128-130.
6. *GB/T 50123-1999. Standard for soil test method*.