Direct shear test on the interface between concrete and bedrock of dam foundation of a reservoir

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Abstract. The weak failure surface of the dam body and the bedrock cementation surface is one of the key points of dam safety research at home and abroad. The direct shear strength of the contact surface between the dam foundation concrete and the bedrock is used as the current research on whether the dam will "slip" along the contact surface. Based on this, many different methods are used at home and abroad to determine the direct shear strength. In this paper, through the excavation of the dam foundation rock and on-site rock structure samples, 5 sets of 25-point in-situ direct shear tests on the interface between concrete and bedrock were carried out on the medium-thick-thick feldspar quartz sandstone of the main rock mass of the dam foundation to determine the dam foundation. Mechanical parameters of rock mass. Based on the results of field experiments, some reference opinions for field direct shear tests and direct shear strength selection in engineering design are put forward, which also provide a basis for subsequent numerical simulation calculations.

1. Introduction

In order to ensure the safety of the dam, important content in the design of the building is the anti-sliding stability analysis. Its purpose is to calculate the safety performance of the dam body along the dam foundation or along the deep weak structural surface of the foundation. The direct shear strength parameter on the cement surface of the dam body concrete and the bedrock is an important parameter for the dam foundation anti-sliding stability analysis. The selection of its value plays a very important role in the safety of the dam body. In the design stage of the dam, the direct shear strength parameters are related to the safety and stability analysis of the dam and how to select the engineering economic section; during the operation period of the dam, how to select the direct shear strength parameters to more accurately analyze and grasp the stability of the dam. Security situation. Currently, there are two main methods for selecting direct shear strength parameters: comprehensive experience analogy method and in-situ direct shear test method. The former has some subjective problems, and the in-situ direct shear test is also called the on-site direct shear test. In engineering practice, it is a main method to determine the direct shear strength parameters of the contact surface between the dam and the bedrock, and it is also a direct and reliable method. [1] This article analyzes and discusses the example of a reservoir project.
2. **Theoretical analysis**

The purpose of the direct shear test is mainly to determine the mechanical parameters of the dam foundation rock mass. The direct shear test horizontal push method calculates the normal stress and shear stress under different normal phase loads according to the following formula:

\[ \sigma = \frac{P}{A} \quad (1) \]

\[ \tau = \frac{Q}{A} \quad (2) \]

According to the shear stress and shear displacement of each specimen after the test, the relation curve between shear stress \( \tau \) and shear displacement \( \mu_s \) and normal displacement \( \mu_n \) is drawn. According to the relation curve, the peak value and the shear resistance under different normal phase loads are determined. Peak shear resistance.

Based on the same set of experimental data, draw the relationship curve between shear stress \( \tau \) and normal stress \( \sigma \) according to the corresponding force and its corresponding peak and shear peak values, and determine the corresponding shear strength of the interface between concrete and bedrock according to the Coulomb expression. Parameters and shear strength parameters.

3. **Test principle and process**

Select representative test dam sections at the dam foundation for manual sample preparation. The poured concrete has a square shape and is naturally cured for 28 days.

After the concrete strength reaches the design strength, under the condition of applying different phase loads to the five-point specimens of the same dam, the shear load is applied to the specimens by the horizontal push method. Record the corresponding force, normal phase displacement, shear stress and corresponding shear displacement, determine the shear peak value and shear peak value under different normal phase loads, so as to draw the shear stress ~ normal stress curve, and draw the simulation according to the principle of least squares. The curve is combined, the fitting equation is obtained, and the corresponding shear strength parameters and shear strength parameters of the interface between concrete and bedrock are determined according to the Coulomb expression.

4. **Direct shear test results and analysis**

According to the shear stress and shear displacement under different normal stresses obtained in each set of direct shear tests, draw the shear strength and deformation relationship curves and the shear strength and deformation relationship curves, and determine the proportional ultimate strength and peak strength from the curves, and according to the normal stress of each point and the corresponding shear strength or shear strength, the relationship curve is drawn according to the least square method, as shown in Figure 1, and the fitting equation is obtained to obtain the corresponding shear strength parameters and shear strength parameters.
Figure 1 Curve of relationship between normal stress and shear stress

According to the requirements of geotechnical parameters, the shear strength parameters between the bottom surface of the concrete dam foundation and the bedrock are taken as the average value of the peak strength parameters. The strength parameter is based on the smaller value of the residual strength parameter and the proportional ultimate strength parameter as the standard value. The fitting equation of peak shear strength, the fitting equation of residual shear strength, and the fitting equation of proportional ultimate strength of each group of tests are shown in the following table 1:

Table 1 Summary of the fitting equations of each test point

| Group | Test dam | Equation type       | Fitting equation | Correlation coefficient |
|-------|----------|---------------------|------------------|-------------------------|
| Group 1 | 3# Dam block | Shear-break resistance | $y = 0.89x + 0.79$ | 0.78                    |
|       |          | Shear resistance     | $y = 0.81x + 0.42$ | 0.86                    |
|       |          | Proportional limit   | $y = 0.83x + 0.66$ | 0.90                    |
| Group 2 | 4# Dam block | Shear-break resistance | $y = 1.19x +1.12$ | 0.98                    |
|       |          | Shear resistance     | $y = 0.73x + 028$ | 0.92                    |
|       |          | Proportional limit   | $y = 1.03x + 0.87$ | 0.96                    |
| Group 3 | 5# Dam block | Shear-break resistance | $y = 1.13x + 0.73$ | 0.77                    |
|       |          | Shear resistance     | $y = 0.75x + 0.32$ | 0.84                    |
|       |          | Proportional limit   | $y = 1.02x + 0.59$ | 0.84                    |
| Group 4 | 5# Dam block | Shear-break resistance | $y = 1.06x + 0.67$ | 0.98                    |
The standard values of the direct shear test strength parameters of the interface between concrete and bedrock are summarized as follows:

Table 2 Summary of strength parameters of field direct shear test results

| Dam block    | Standard value of shear-break strength parameter | Standard value of shear strength parameter |
|--------------|-------------------------------------------------|------------------------------------------|
|              | $f'$, $\varphi'$, $C'$                           | $f$, $\varphi$, $C$                      |
| 3# Dam block | 0.89, 41.7, 0.79                                 | 0.81, 39.1, 0.42                         |
| 4# Dam block | 1.19, 49.9, 1.02                                 | 0.73, 36.0, 0.28                         |
| 5# Dam block | 1.10, 47.7, 0.70                                 | 0.71, 35.5, 0.32                         |
| 6# Dam block | 1.18, 49.6, 0.95                                 | 1.01, 45.3, 0.36                         |

5. Conclusion
The direct shear test of the interface between dam foundation concrete and bedrock is the same as other tests, and there are various influencing factors. Due to the complex geological conditions of the dam foundation rock mass, the difference in rock mass structure, the uneven distribution of lithology, and the different degree of rock mass weathering, etc., all have different degrees of influence on the test results, and the local weak interlayer in the dam foundation affects the dam foundation. The anti-sliding stability of the dam foundation has adverse effects, and the shear area of the direct shear test on the interface between the concrete and the bedrock is very different from the actual situation of the project.[6] Therefore, the direct shear strength parameters of the dam foundation need to be combined with the project. The actual situation and geological conditions of the rock mass will be determined after comprehensive analysis and discussion. Based on the engineering example of a Reservoir, this paper carried out 5 sets of 25 points on-site concrete and bedrock contact surface on the medium-thick-thick feldspar quartz sandstone of the main rock mass of the dam foundation, and obtained the above test results. Based on the results of field experiments, some reference opinions for field direct shear tests and direct shear strength selection in engineering design are put forward, which also provide a basis for subsequent numerical simulation calculations.

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