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Skid-Resistance of Circular Cross Section Anti-Sliding Pile

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ABSTRACT

Anti-slide pile is a retaining structure commonly used in large-scale landslide reinforcement. It usually adopts large cross-section rectangle pile by artificial excavation, but the defects of this pile are long work cycle, large excavation disturbances and personnel safety of builders in hole can't get effective guarantee in the rainy season and stratum saturated by water. However, the circle section pile has advantages of applying rotary pile drill into holes, high efficiency pore-forming, small excavation disturbances, and the option of aperture convenient and flexible. The circle section pile has obvious superiority to large cross-section rectangle pile. But the mechanism and design calculation of anti-slide pile group with the space frame structure of circle section has not the existing specification to adopt. This study aims to contrast and discuss the anti-sliding effectiveness between circle and rectangle section anti-pile through experiment.

KEYWORDS: Rectangle section pile; circle section pile; anti-sliding effectiveness

INTRODUCTION

Using anti-slide pile to resist landslide is a kind of effective method to govern landslide or stabilize slope [1, 2, 3]. The Mechanism of anti-sliding pile, which is made up of interaction of anti-sliding pile, sliding body and bedrock, is very simple. The stability and passive resistance of bedrock is used to offset residual sliding force [4, 5]. Anti-slide pile is a kind of flexural member[6-9]. The application and research of flexural member are always focus on rectangular and T section beams.

The research on circular cross section beam flexural member is little, because that the section of beam member is rarely designed to be circle. Mitkina [10] cited a method of evaluating the vertical-load resistance of circular piles with an open end from the results of static probing. Automates circulation of the bearing capacity of a circular pile from static-probe data is developed. Zhao and Zhai [11] choose three typical cross section piles (rectangular, square, circular) to do some study about the mechanism, frictional arch and end bearing arch of three cross-section piles. The form of soil arch with different cross-section and the soil arch zone are under same condition in order to define the best cross-section. The result show that rectangular section pile and square section pile are composed by frictional arch and end bearing arch, while circular section pile is made up by united arch. Finally, rectangular section pile has a more effective retaining effect than square section pile and circular section pile through compared soil arch zone with three type section piles.

Rectangular section pile is widely applied in most of present slope engineering, because the design of the rectangular section pile is more mature. While, in some slope engineering, the use of the circle section anti-slide pile is successful. Such as Ma Zhao line landslide control project, which is designed by Traffic planning and design institute of Yunnan province, achieved good economic and social benefits. The object of this study is to research the ability of anti-sliding of the circle section anti-slide pile. Then, the ability of anti-sliding of circle section pile is compared with that of the rectangular section pile. The experiment will provide rigorous and reliable data support for the research of anti-sliding ability and working mechanism of circle section pile.

EXPERIMENTAL METHOD

The test is conducted in the exterior base of Long Rui high-speed of land transportation meteorological disaster prevention and control technology national engineering laboratory. The material used in test are listed in Table 1.

Table 1: Test materials summary

Types of test materials	Quantity Required	Remarks
sand	about 20m3	Sand should be tested physical properties, including the basic test such as moisture content, density and shear strength.
circle section pile	2	The circle section piles, which are cured for 20d, are prepared advance. Size: diameter is 20cm，pile length is 400cm.
rectangle section pile	2	The rectangle section piles, which are cured for 20d, are prepared advance. Size: diameter is 15.5cm*20cm，pile length is 400cm.
Strainometer, steel rebar meter	120 (actually 108)	Embedded within the piles during the piles are preparing.
earth pressure meter	90 (actually 72)	Measuring the change of soil pressure in front and behind the piles.
dial indicator	9	Measuring the change of displacement of soil surface.
Jack	20t: 5; 10t: 4	Simulate the landslide thrust.
collective line box	2	
Reading device	1	

This experiment was consisted of three groups, the first one is loaded with no piles, the second group is loaded with two rectangle section piles and the third one is loaded with two circle section piles. The rectangle piles and circle piles are arranged in the test tank with equal space.

In the first test group, which is loaded with no piles, 4 earth pressure cells are inbuilt 20cm and 40cm in the front of the default pile location respectively, and 2 earth pressure cells are inbuilt 20cm behind piles, as shown in Fig. 1. That is to say, 24 earth pressure cells in all are inbuilt in the depth of 0.5m, 1.0m, 1.5m and 2.5m of test tank with 6 cells per floor, respectively. While, in the groups of circle section piles and rectangle section piles, 12 earth pressure cells in all are inbuilt in the depth of 0.75m, 1.25m, and 2.0m located on the tensile side and compressive side of each pile. These earth pressure cells are located between each layer of earth pressure cells, as shown in Fig. 2 (the green ones).

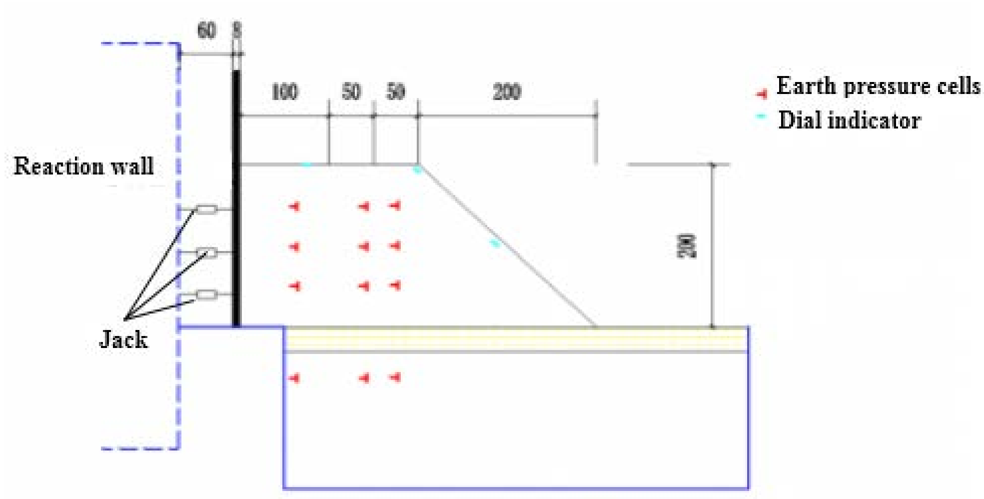


Figure 1: Soil pressure box layout elevation of the first set of no pile driving test (unit: cm).

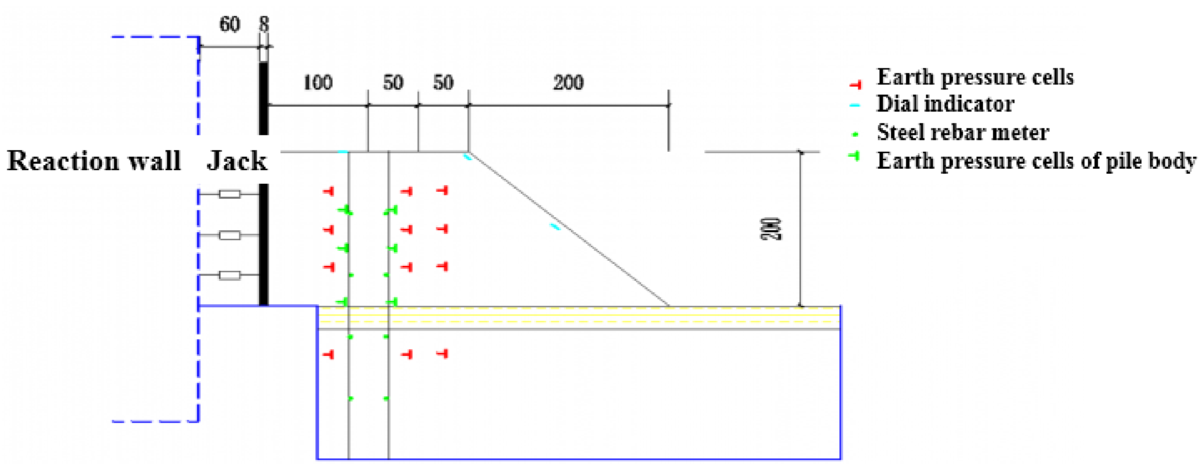


Figure 2: Soil pressure box layout elevation of the second group of rectangle piles and the third group of circle piles (unit: cm).

Furthermore, arrangements of tension meter, dial indicator and jack are shown in Figs 1 and 2.

Experiment Process: The first group—no pile test

After the preparation work, the first group of test will be start. The whole test process is roughly divided into the following steps :(1) Fill with soils and earth pressure cells; (2) Set the slip band; (3) Set up the dial indicator and jack; (3) Using a jack to load, record the data; and other processes are shown in Fig. 3.

(a) (b)

Figure 3: The test process. (a) Set up dial indicators; (b) load completed.

In the process of loading, soil slope surface appears larger crack and convex as the displacement of soil increasing gradually. Meanwhile, integral sliding phenomenon in soil mass is appeared, as shown in Fig. 3. Thus, authors concluded that the soil has been destroyed and lost the ability to continue bearing thrust.

Experiment Process: The second group—rectangle pile test

After the first group test, the clay is cleaned up to the outside of the test tank. The rectangle piles are handled to the location of the reservation slot. Then, concrete is applied to fix the piles. After the completion of the maintenance, the test tank is filled with soil.

The displacement of pile body is large enough as the jack thrust load increasing gradually. Finally, jack thrust is hard to continue to increase. On the basis of similarity theory, the test is not possible to get the limit state for the piles on this condition. Moreover, data collection has accorded with the test requirements. So, the test came to an end. The test processes are listed in Fig. 4.

(a) (b)

Figure 4: The test processes: (a) before loading; (b) fractures on pile body.

Experiment Process: The second group—rectangle pile test

The circle pile test retains most of details of the rectangle pile test. The ultimate load displacement is also basically same as the test of rectangle pile.

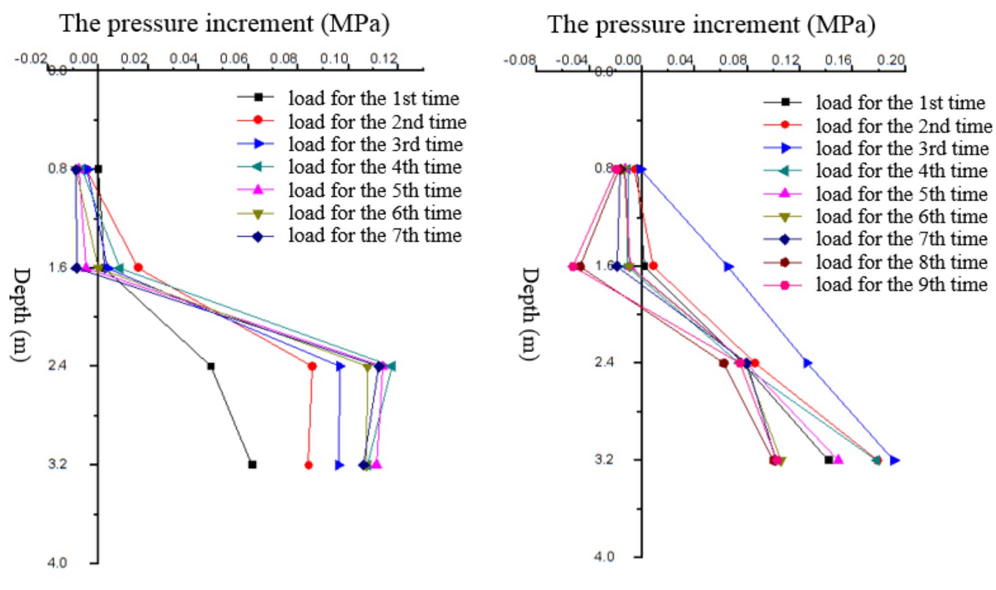
Although loading conditions of these two tests are almost same, the results are different from each other. Firstly, there is no damage on the cap of circle piles; secondly, concrete of pressure zone of piles is crushed; finally, the distribution of fracture on circle piles is more uniform and closely than that on the rectangle piles, as shown in Fig. 5.

(a) (b)

Figure 5: The test processes: (a) before loading; (b) fractures on pile body.

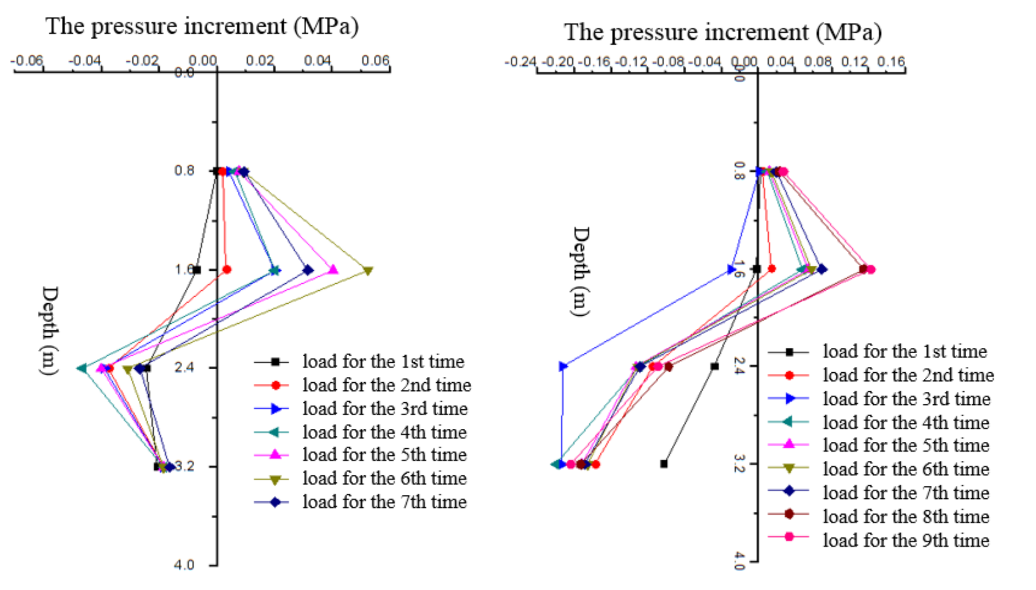
DATA ANALYSIS

The original data of tests is prepared and calculated. The curves of tests are plotted in Figs 6, 7, 8 and 9. Because of the restriction of site conditions, the original data missed partially. So, part of the figure contents are not complete.



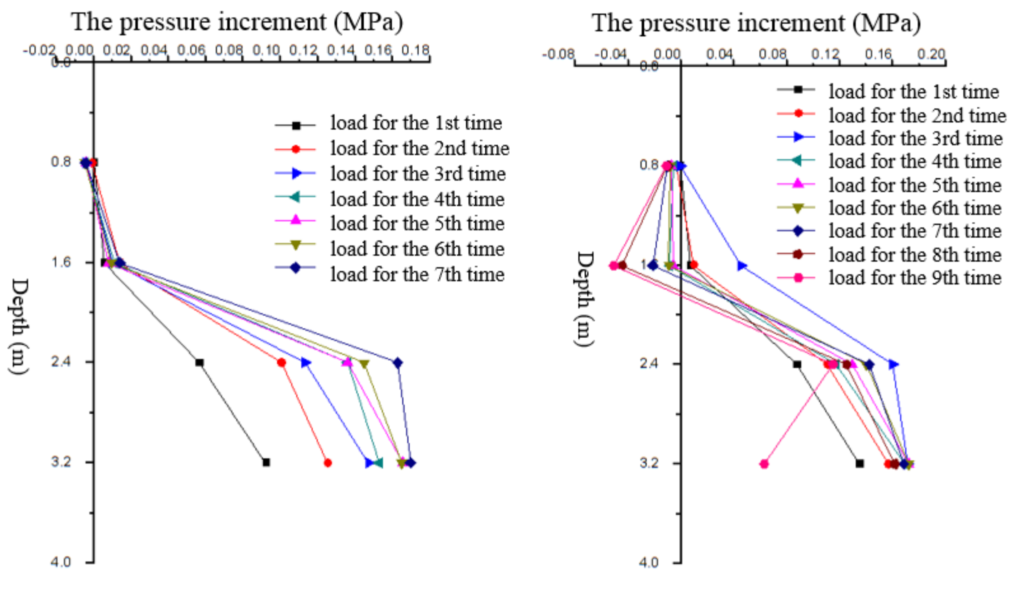
(a) (b)

Figure 6: stress in the tensile region of pile 1# (a) rectangle pile; (b) circle pile.



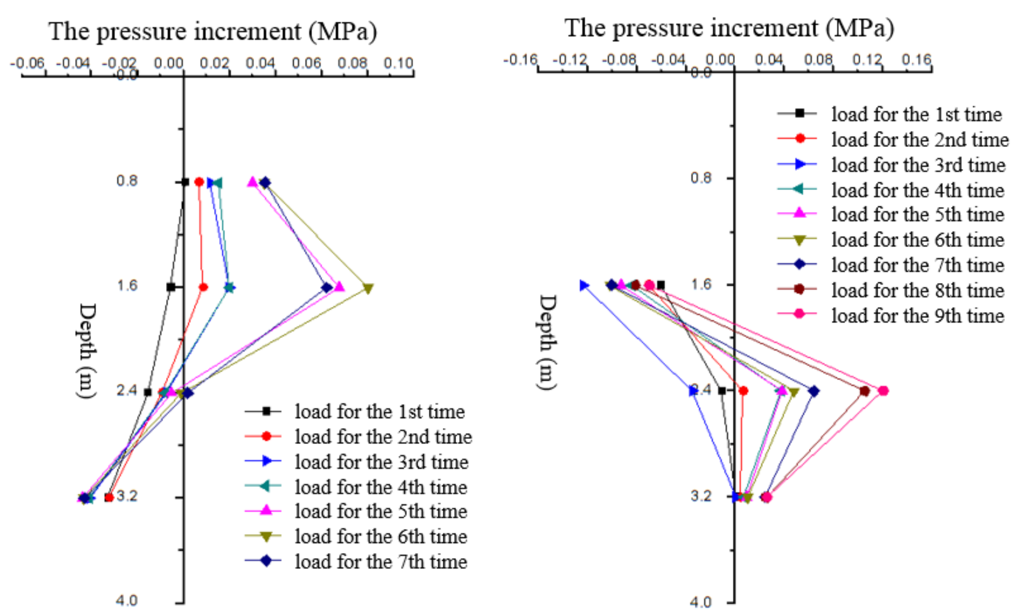
(a) (b)

Figure 7: stress in the compression region of pile 1#(a) rectangle pile; (b) circle pile.



(a) (b)

Figure 8: stress in the tensile region of pile 2#(a) rectangle pile; (b) circle pile.



(a) (b)

Figure 9: stress in compression region of pile 2#(a) rectangle pile; (b) circle pile.

As shown in Figs 6, 7, 8 and 9, the stresses in the tensile region of rectangle piles and circle piles are decreasing with the increase of depth. Conversely, the stresses in the compression region of rectangle piles and circle piles are increasing with the increase of depth. Furthermore, the increase of stresses become flat with the increase of depth. Differences between rectangle piles and circle piles are that the increment of stress of rectangle piles are bigger than that of circle piles. The reason is that stress of the circle pile can be more evenly distributed on the whole pile.

CONCLUSION

In order to reveal the landslide thrust force and deformation character of the pile underground, a contrast experiment research on mechanical performance of piles was made between the rectangle piles and circle piles. Based on practical engineering, this test was carried out by field pile test research. Based upon the data processing and analysis of the test, the conclusions are listed:

(1) there is no damage on the cap of circle piles; (2) concrete of pressure zone of piles is crushed;(3) the distribution of fracture on circle piles is more uniform and closely than that on the rectangle piles; (4) the stresses in the compression region of rectangle piles and circle piles are increasing with the increase of depth; (5) the increase of stresses become flat with the increase of depth; (6) differences between rectangle piles and circle piles are that the increment of stress of rectangle piles are bigger than that of circle piles.

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