Model Test of Soil Squeezing effect of Jacked Pile Sinking in Sand Slope

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Abstract. Jacked pile sinking has many advantages in terms of construction, which is one of the commonly used piling methods. However, the jacked pile sinking has significant squeezing effect against the side slope, resulting in the stability of the slope being affected to a certain extent. This paper attempts to determine by model test the squeezing effect of jacked pile sinking in slope.

1. Introduction
Due to its characteristics, jacked pile sinking is mainly used in building-intensive areas and soft soil areas, and the technology is relatively mature at present. Domestic scholars have made a lot of research on the squeezing effect of jacked pile sinking in slope.

Jiang Yuenan [1] used indoor model test to analyze the jacked pile sinking in stratified soil. Jiang Tong and Li Bo [2] designed their own model test system based on PIV technology, and conducted comparative experimental study on the deformation field of soil around the piles during pile sinking. Rao Pingping and Li Jingpe [3][4] adopted the discrete element method (PFC2D) to study the law of change in soil squeezing displacement field of slope soil during pile sinking with the law of change analyzed for soil squeezing displacement field of spherical hole expansion at different boundary inclination angles. Luo Zhanyou [5] analyzed the difference of displacement field of soil squeezing under large and small strain conditions. Wang et al. [6] studied the composite cement pile foundation under expressway embankment (bank slope) by field test. Yang Qingguang [7] studied the influence of excess pore water pressure on the side of jacked pile.

In this paper, qualitative research is carried out to study the law of soil squeezing of jacked pile sinking in slope. Considering that the site conditions and other influencing factors of prototype test are difficult to control, and a lot of manpower and material resources are needed, while the test condition of indoor model test is an ideal method for qualitative exploration of Engineering laws, which is easy to control, highly operable and of low cost. Therefore, this paper studies the soil squeezing law of jacked pile sinking in slope through indoor model test.

2. Contents and layout of squeezing effect test of single pile on sand slope
In this test, the variation of the radial displacement and the vertical displacement of the slope soil caused by the process of single pile pressing into sandy soil are studied respectively.

In the direction of soil depth, a white sand marking line is set at every 5cm, as shown in figure 1. The four nearest marking lines from top to bottom represent the depth of soil respectively at 5cm, 10cm, 15cm and 20cm. The photographs corresponding to these depths and those taken at the end of piling are
picked out from the photographs obtained by the photographic recording system. These selected photographs constitute a complete set of images describing the piling process.

Based on the complete piling process obtained from the test, the squeezing displacement of a single pile is studied when it is pressed into the soil 5cm, 10cm, 20cm and 60cm in depth respectively. The radial displacement and vertical displacement values of each displacement measuring point then are calculated by Geodog, before the displacement contours and the vector map of the displacement measuring points in the study area are made by surfer software.

Figure 2 is a schematic diagram of the process of single pile being pressed into sandy soil. A semi-formwork pile is pressed into the top of the slope at the location of the diameter distance of the pile. The length of the semi-formwork pile is 70cm, with 60cm pressed in to the soil. The slope angle is 30 degrees and the slope height is 20cm.

3. Analysis of squeezing effect test results of single pile on sand slope

3.1 Radial Squeezing effect of Single Pile on Sand Slope

Figure 3-6 are the contour maps of radial displacement of slope soil when the depth of single pile is $Z=5cm$, $-10cm$, $-20cm$, $-60cm$ respectively.
3.2 Vertical Squeezing effect of Single Pile on Sand Slope

The curves in the analysis maps show that the rule of radial soil squeezing of single pile on sand slope is as follows: 1) The whole soil moves to the right during piling, but different radial displacement happens in different locations. 2) The maximum displacement area of radial displacement increases gradually from $-2.5d<Z<-0.5d$ to $-4.5d<Z<-0.5d$ with the downward pressure of piles every 5cm. 3) The radial displacement of the extruded soil decreases gradually above and below the maximum displacement area in the slope, but it decreases slightly in the maximum displacement area. 4) From the contour distribution of the whole slope, the displacement change is relatively gentle, which indicates that the sand has strong displacement transfer ability. 5) When the pile sinking is completed, the peak value of radial displacement reaches 9.7mm, and the maximum position appears at $(X=1d, Z=-3d)$. 

Figure 5. Radial displacement of slope when pile is pressed in to 20cm ($6.67d$).

Figure 6. Radial displacement of slope when pile is pressed in to 60cm ($20d$).

(Note: The unit indicated on the contour line is mm and d is the diameter of the pile.)
Figure 9. Radial displacement of slope when pile is pressed in to 20 cm (6.67d).

Figure 10. Radial displacement of slope when pile is pressed in to 60 cm (20d).

(Note: The unit indicated on the contour line is mm and d is the diameter of the pile.)

Figure 7-10 is the contour maps of vertical displacement of sand slope caused by single pile pressing. The test results show that: 1) There are two kinds of vertical squeezing effect of piles in slope, one is to make the soil uplift, and the other is to squeeze the soil to make it sink. 2) The soil adjacent to the pile side produces downward displacement under the action of pile side friction and radial compression, and the downward displacement area is within the range of 4d from the pile body. 3) During the process of pile soil squeezing, the uplift area increases gradually, while the subsidence area outside the vicinity of pile body decreases gradually. 4) The maximum uplift area increases from -1d<Z<0 to -5d<Z<0 on the right side of the downward soil squeezing area adjacent to the pile body, and the displacement changes in this area are very small, basically independent of the X direction, which is the same as the radial displacement. The settlement area far away from the pile body gradually enlarges in the X direction with the pile body pressing, and has obvious diffusion trend. Therefore, it can be found that the displacement transfer ability of sand is stronger. 5) The peak displacement of the final uplift is 6.3mm, which is located between -4d<Z<-1D. The uplift displacement in this area is basically the same, independent of the coordinates in the X direction.

3.3 Total displacement of sand slope squeezed by single pile

The total displacement vector diagram of single pile to sand slope is shown in figure 11-14, and the pile-pressing depth corresponding to the total displacement vector diagram is Z=-5cm, -10cm, -20cm, -60cm, respectively.
Figure 13. Total displacement vector diagram of soil squeezing when pile is pressed in to 20cm of soil.

Figure 14. Total displacement vector diagram of soil squeezing when pile is pressed in to 60cm of soil.

As per the graphs, the total displacement of single pile on sand slope soil squeezing is as follows:
1) The maximum total displacement area in the sand slope is located in the upper half of the slope, i.e. 
   -4.5d<Z<-0.5d.
2) The maximum total displacement of sand slope is about 12.5mm.

4. Conclusion
The squeezing effect of single pile in slope shall not be neglected. In this paper, the following are concluded through indoor model test:

(1) Within the maximum total displacement area of sand slope, the closer to the pile edge, the greater the displacement value, but the change range is gentle. At the same time, the sinking area is gradually expanded with the downward pressure of the pile, which shows that the displacement transfer of sand is good.

(2) The squeezing effect of jacked pile sinking in slope is considerably obvious in single pile test. The squeezing effect of pile group in slope will be more significant, and the squeezing effect under different soil conditions will alter greatly, which needs further experimental study.

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