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Study on the Effect of Occlusion Rate on the Deformation of Non-Vegetarian Occlusal Piles

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Abstract

In order to investigate the force characteristics of the occlusal pile, this paper takes the underground garage support project of Nanchang Bayi Square as the research background and studies the bending moment of the occlusal pile after the excavation process of the foundation pit through the model test. The test results show that the bending moment of the pile increases and then decreases with the increase of soil depth under horizontal load, and the bending moment reaches the maximum near the excavation surface of the foundation pit; the test results can provide a reference for the design of occluded pile body in practical engineering.

Keywords

Occlusion Pile, Plain Pile, Model Test, Deformation Characteristics

1. Introduction

In recent years, underground space has been developed rapidly, and the excavation depth of foundation pits has become deeper and deeper, and foundation pit support technology has become a key issue in foundation pit construction [1]. Due to the many advantages of the occlusion pile containment structure [2] [3], it has been widely used in foundation pit projects. Soil pressure is the main load of the occlusal pile containment structure, and the complexity of engineering geology makes the soil pressure acting on the occlusal pile containment pile complex. The pile deformation calculated according to the traditional earth pressure calculation method differs greatly from the actual situation, and the law of pile deformation cannot be accurately derived. Many scholars have studied the pile

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deformation of occluded piles under earth pressure, such as Dan Li [4] who analyzed the variation law of shear force, bending moment and displacement of the support structure by MIDAS/GTS simulation software; Yifei Zeng [5] simulated the excavation process of foundation pit precipitation by using Midas GTS NX finite element software, and compared the calculation results with the monitoring data of foundation pit construction site, The detailed analysis of the support structure force deformation law. Ji Yao Bo [6] analyzed the reason for soil pressure fluctuation with time and studied the relationship between soil pressure and pile displacement based on the actual measurement data of Huayuan Station of Tianjin Metro. Li Dong [7] carried out a study on the force analysis and structural optimization of occluded pile structure, and established the calculation and analysis method of force calculation of deep foundation pit curved occluded pile support structure under complex geological conditions, which provides technical support for the application of large size support engineering.

In order to study the internal force distribution and change law of cantilevered circular occlusal pile, this paper obtains the change law of occlusion rate (the ratio of occlusion between adjacent piles and pile diameter, the same below) on the bending moment of non-vegetarian occlusal pile through indoor model test. The research results can provide an auxiliary reference for the design of occluded piles in similar projects.

2. Experimental Overview

2.1. Model Box

In order to meet the test requirements, the model box baffle is designed and processed into two equal parts, which can slide between each other, see **Figure 1** below; the horizontal load is loaded along the length direction, and the hydraulic jack applies the horizontal load to the soil by pushing the movable baffle; during the test, the load is only loaded on the upper soil in order to simulate the rock-embedded effect of the pile in the field conditions.

Figure 1. Physical drawing of the model box.

2.2. Model Pile Preparation

The model experiment uses a similar geometric model with a pile length scaling ratio of 1/30, and three common engineering occlusion rates are selected to study their effects on the pile deformation of occluded piles. The detailed design dimension parameters of the model pile are shown in Table 1.

2.3. Soil Selection, Filling and Pile Emplacement

In this experiment, the pile length of the model pile is 900 mm, the lower part of 225 mm is designed as (gravel) embedded section, and the upper part of 675 mm is designed as (sand) excavated section, *i.e.* the top of the pile body is kept flush with the upper surface of the sand. In order to simulate the effect of retaining structure, "L" type retaining wall was poured symmetrically before filling the upper layer of sand, and 40 cm wide opening was reserved at the connection of retaining wall on both sides, and the pile body was buried here as the supporting pile, as shown in Figure 2.

Table 1. Model pile size parameters.

Serial number		meat pile			Vegetarian pile		Bite rate
		Pile diameter/(mm)	Pile length/(mm)	Reinforcement rate/(%)	Pile diamete/(mm)	Pile length/(mm)	
Meat and vegetable bite pile	1#	120	900	1.73	120	900	1/5
	2#	120	900	1.73	120	900	1/4
	3#	120	900	1.73	120	900	1/3

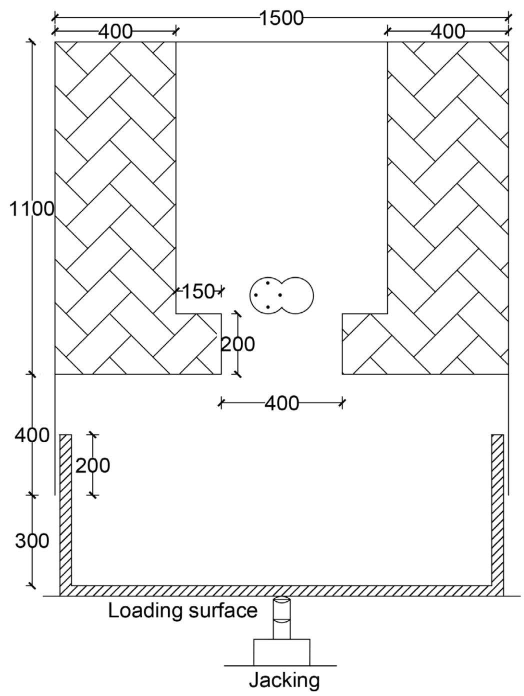


Figure 2. Plan layout of meat and vegetable occlusion pile.

2.4. Measurement Point Arrangement

This test requires the measurement of pile strain in order to accurately measure the pile deformation; therefore, the strain gauges were chosen to be attached to the adjacent soil side of the occluded pile, and the strain gauges of the non-vegetarian occluded pile were arranged as shown in Figure 3.

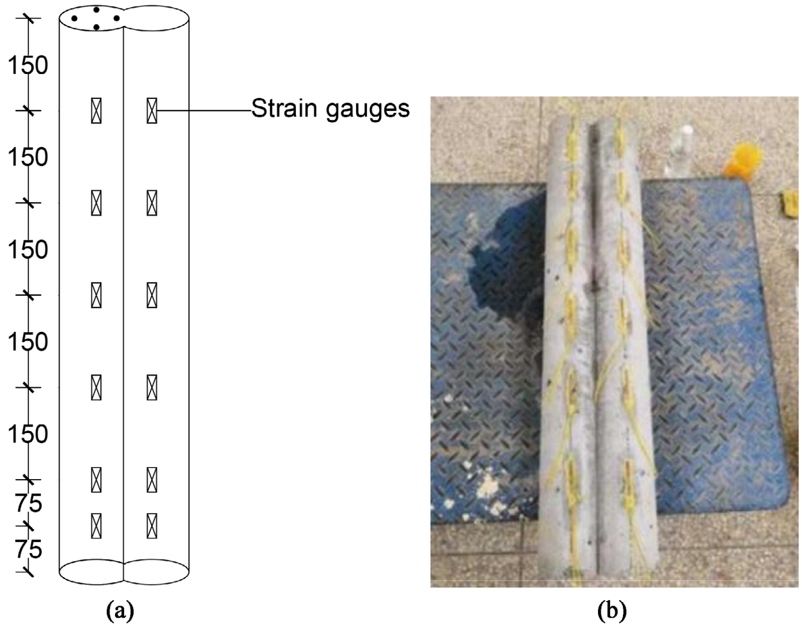
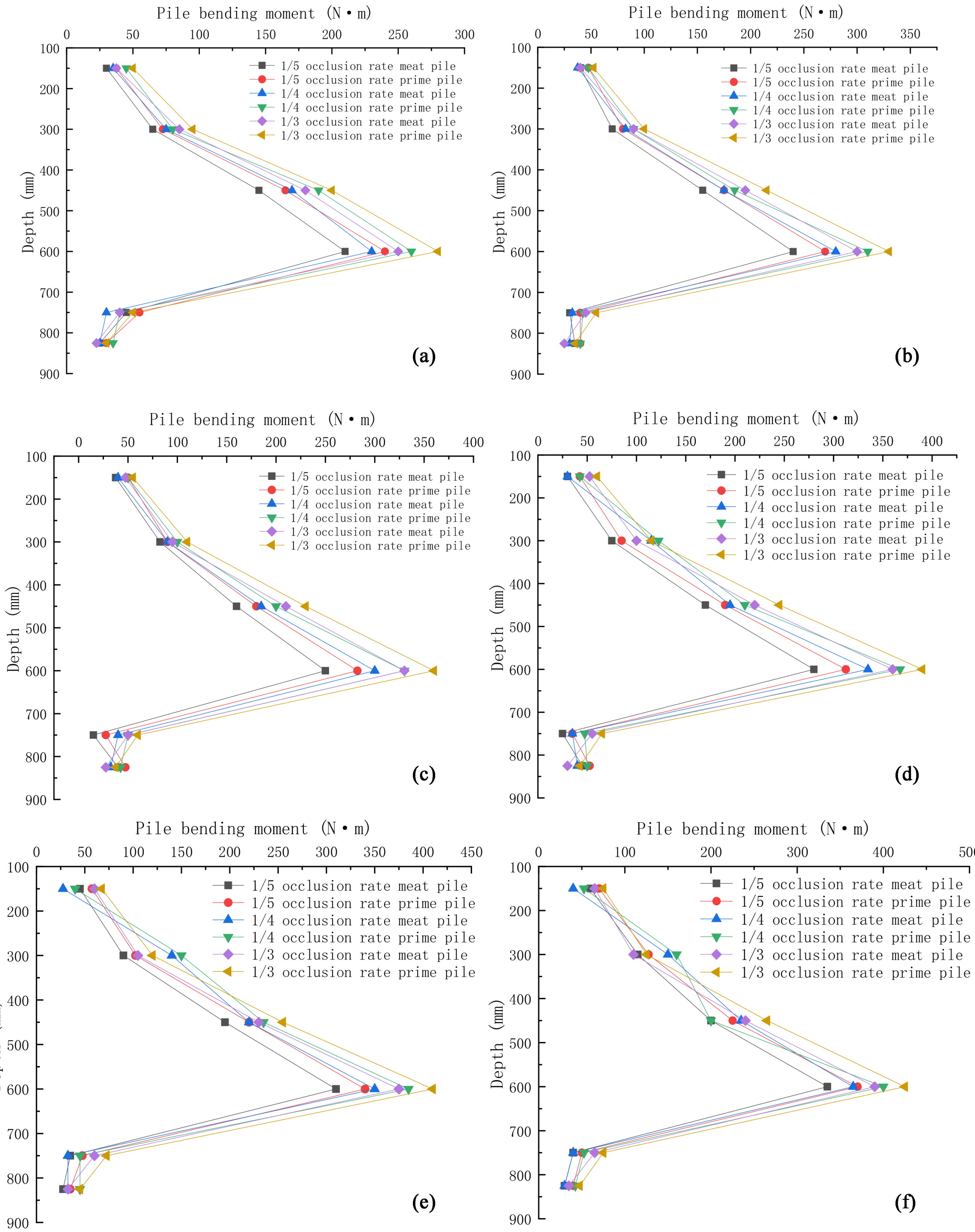


Figure 3. Arrangement of strain gauges of meat and vegetable occlusion piles. (a) Side view of strain gauge arrangement of meat and vegetable occlusion pile; (b) Physical diagram of the strain gauge arrangement of the meat and vegetable occlusion pile

3. Experimental Results and Their Analysis

By collecting the strain values of the pile under different levels of horizontal loads, the bending moment values at each section of the pile were calculated and the characteristic curves of the pile moment distribution were plotted as shown in Figure 4 below.

From the above figure, it can be seen that the pile bending moment of each occlusal pile gradually increases with the increase of horizontal load. When the horizontal load is 30 kN, the bending moments of the meat pile near the excavation surface are 250 N-m, 230 N-m and 210 N-m for the meat pile with 1/3, 1/4 and 1/5 occlusion rates, respectively, and the bending moments of the vegetarian pile near the excavation surface are 280 N-m, 260 N-m and 240 N-m; while when the horizontal load is 72 kN, the bending moments of the meat pile near the excavation surface are 420 N-m, 395 N-m for the meat pile with 1/3, 1/4 and 1/5 occlusion rates, respectively. The bending moments of the meat pile near the excavation surface are 420 N-m, 395 N-m and 370 N-m, and the bending moments of the vegetal pile near the excavation surface are 455 N-m, 437.5 N-m and 410 N-m. The analysis data shows that the bending moments of the occluded pile increase with the increase of the occlusion rate as the horizontal load increases. Under the same horizontal load, the bending moment of the meat pile is smaller than that of the plain pile, and the deformation of the meat pile is smaller, which is mainly due to the fact that the meat pile contains vertical



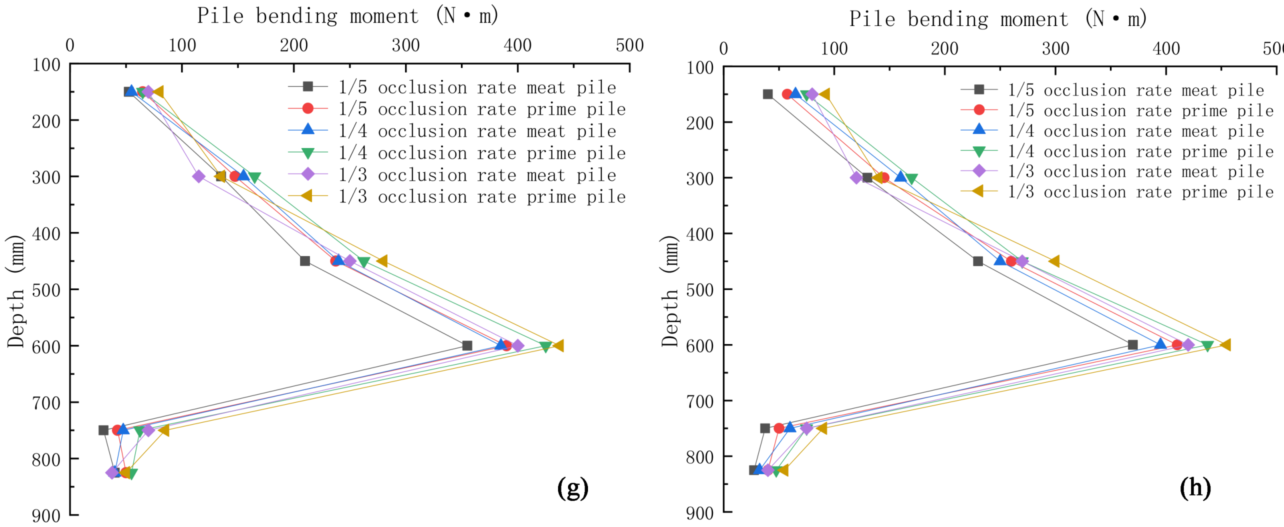


Figure 4. Bending moment-depth curve of non-vegetable occluded pile under each level of horizontal load. (a) Bending moment-depth curve of non-vegetable pile under 30 kN load; (b) Bending moment-depth curve of occluded non-vegetable occluded pile under 36 kN load; (c) Bending moment-depth curve of non-vegetable pile under 42 kN load; (d) Bending moment-depth curve of occluded non-vegetable occluded pile under 48 kN load; (e) Bending moment-depth curve of non-vegetable pile under 54 kN load; (f) Bending moment-depth curve of occluded non-vegetable occluded pile under 60 kN load; (g) Bending moment-depth curve of non-vegetable pile under 66 kN load; (h) Bending moment-depth curve of occluded non-vegetable occluded pile under 72 kN load.

longitudinal reinforcement and horizontal circular hoop reinforcement, which improves the strength of the pile itself. By comparing three different occlusion rates of 1/5, 1/4 and 1/3 occlusion piles, it can be found that the deformation of the meat and vegetation occlusion piles with 1/5 occlusion rate is smaller. This is mainly because under the same horizontal load, the lower the occlusion rate the larger the self-weight and load bearing area of the occlusal pile. With the increase of horizontal load, the bending moment ratio of meat pile and vegetal pile gradually increases, which means that the force role of meat pile increases with the increase of horizontal load, but the vegetal pile does not only stop the water in the occlusal pile enclosure structure, but also plays a considerable force role.

4. Conclusions

1) With the increase of horizontal load, the pile moment of each occluded pile gradually increases, and the pile moment of occluded pile increases with the increase of occlusion rate.

2) Under the same horizontal load, the bending moment of meat pile is smaller than the bending moment of plain pile, and the deformation of meat pile is smaller.

3) In the occlusion pile enclosure structure, the force effect assumed by the non-vegetarian pile increases with the increase of horizontal load, but the force contribution of the vegetarian pile cannot be ignored.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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