

Analysis of Soil Pressure in Indoor Model Test of H-Typed Prestressed Concrete Bank Protection Pile

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Abstract. In order to explore the distribution of soil pressure on the side of the pile and the bending moment of the pile body during the excavation and pile loading stages of the H-shaped prestressed concrete piles, three groups of indoor scaled model tests with prestressed rectangular piles and with or without prestressed H-shaped piles were carried out, and the test results shows that the lateral earth pressure on both sides of the sheet pile has the same trend as the static earth pressure calculation value when it is not excavated, but the measured earth pressure at different depths is always lower than the static earth pressure calculation value; in the excavation stage, the H-shaped prestressed pile lateral soil pressure on the side of the pile excavation is less than that of the rectangular sheet pile and the unprestressed H-typed pile.

Keywords. H-shaped, prestressed, model tests, soil pressure

1. Introduction

The pretensioned H-type prestressed concrete bank protection pile is a newly developed concrete sheet pile component specially used for the protection of rivers and lakes and coastal dikes. It has high flood control capacity, takes into account ecological and environmental protection functions, and has good landscape effects and relatively low cost.

The distribution and magnitude of the earth pressure of the retaining and revetment structure is an important parameter for the research and design of the retaining and revetment structure, and it has a direct impact on the load transfer and acceptance deformation mechanism. Terzaghi [1] pointed out through a model test as early as 1932 that the classical earth pressure is correct only when the horizontal displacement of the soil reaches a certain value. Wang Xinquan [2] conducted field tests on a bank protection project of the Changhu Shen Channel, and the results showed that the earth pressure on both sides of the rectangular sheet pile showed a "wave-shaped" change trend, and the distribution of earth pressure on the waterfront side and the shore side was different. Roughly linear distribution, the latter increases first, then decreases, and then increases. Cai Zhengyin [3] introduced in detail the development history of the theory of earth pressure on sheet pile structures, and found that there is a "bucket" effect of soil pressure between the front wall of the blind sheet pile structure and the

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blind pile, which is related to the distance between wall piles and structural rigidity. , And there is an optimal wall pile spacing. Zhang Feng [4] carried out sheet pile support experiments, focusing on the analysis of the influence of foundation pit excavation depth and load combination on sheet pile lateral soil pressure, ground settlement behind the pile, and anchor cable tension. Huang Xuefeng [5,6] conducted dynamic field tests on the deep foundation pit supporting structure of a railway station renovation project, and the measured earth pressure was less than the value calculated by the Rankine earth pressure theory in soil mechanics. Further back analysis Earth pressure, optimize the design of supporting piles. Zhang Zhengxuan [7] carried out a full-scale flexural and shear resistance test on the pre-tensioned prestressed steel stranded ultra-high-strength concrete H-shaped pile (section size shown in figure 1), and the results showed that the H-shaped pile has a relatively equal mid-span deflection. The pile width and pipe piles are significantly improved. The H-shaped pile has a certain degree of ductility before failure, and has brittle failure characteristics when it fails; after the specimen is loaded to failure, the steel strands are not broken.

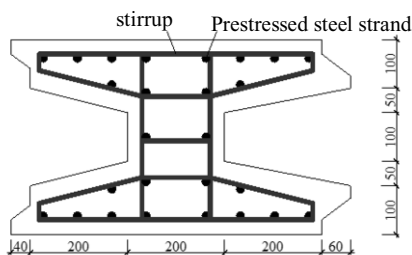


Figure 1. H-shaped cross section of prestressed super high-strength concrete.

2. Indoor Model Test

2.1. Test Model Box

The design and production of the model box should be based on the principle of not affecting the actual stress state of the rock mass and the load transfer of the pile body, and comprehensively consider the influence of the boundary conditions and facilitate the observation of the deformation of the soil. Therefore, the test mode×width×height), the thickness is 10 mm, and the periphery is reinforced with a metal frame. 1 box adopts plexiglass. Processed. The size of the box is 1200 mm×470mm×1050mm (length).

2.2. Model sheet pile

The model sheet piles are made of plexiglass. The length of the panels after splicing is determined by the width of the model box and the gaps left on both sides. After splicing, it is about 450mm. Figure 1 is simplified in consideration of the difficulty of processing, as shown in figure 2; the rectangular model sheet pile is shown in figure 3. The groove at the edge (the groove depth is 2mm) is used to place the steel strands. The

prestress of the steel strands is implemented by hanging a certain mass of weights and anchoring them with anchors.

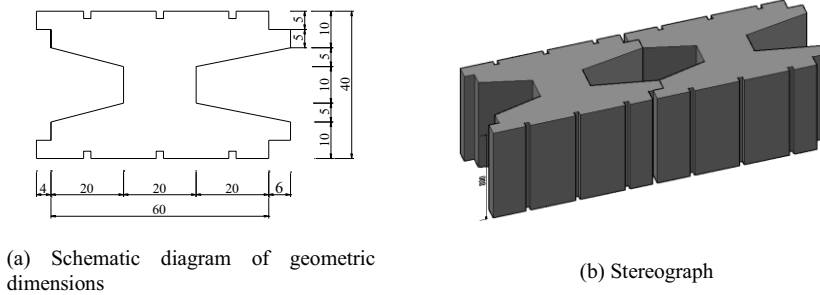


Figure 2. Schematic diagram of H-type model sheet pile (unit: mm)

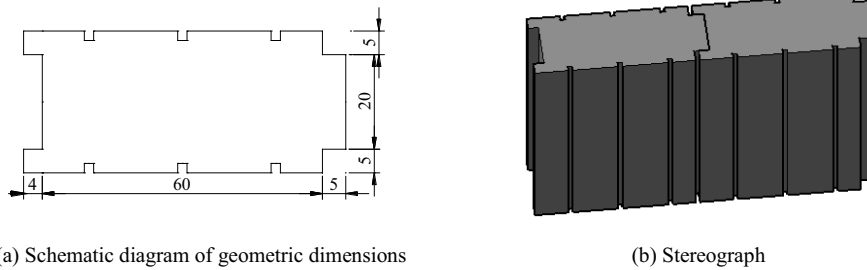


Figure 3. Schematic diagram of rectangular model sheet pile (unit: mm).

2.3. Test soil

Air-dried fine sand is used as the soil for indoor test, which is convenient for test operation. Its weight is $17.9 \text{ kN} \cdot \text{m}^3$, and through direct shear test, it has a cohesive force of 0.1 kPa and an internal friction angle of 27.4° .

2.4. Test plan

Carry out 3 groups of model tests, the test plan is shown in table 1. The layout of the monitoring equipment is shown in figure 4.

Table 1. Test plan.

Test number	Sectional form	Section size(mm ²)	Sectional area(mm ²)	Embedding depth(mm)	Pile length(mm)	Prestress	Test soil
1	rectangle	30×60	1916.00	350	800	prestress	sand
2	H-typed	40×60	1920.32	350	800	prestress	sand
3	H-typed	40×60	1920.32	350	800	no prestress	sand

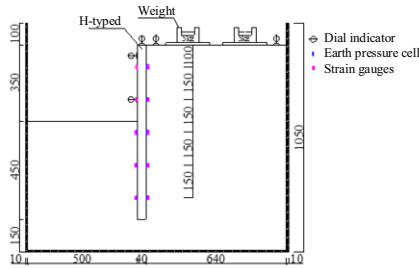


Figure 4. Cross-section of monitoring equipment buried (unit: mm).



Figure 5. Layout of earth pressure cell and strain gauge.

3. Analysis of Pile Side Soil Pressure

The earth pressure measuring points of the rectangular piles are arranged on the middle piles, with 3 layers in front of the piles and 5 layers behind the piles, each with an interval of 15cm. The results of earth pressure measurement are shown in figure 6.

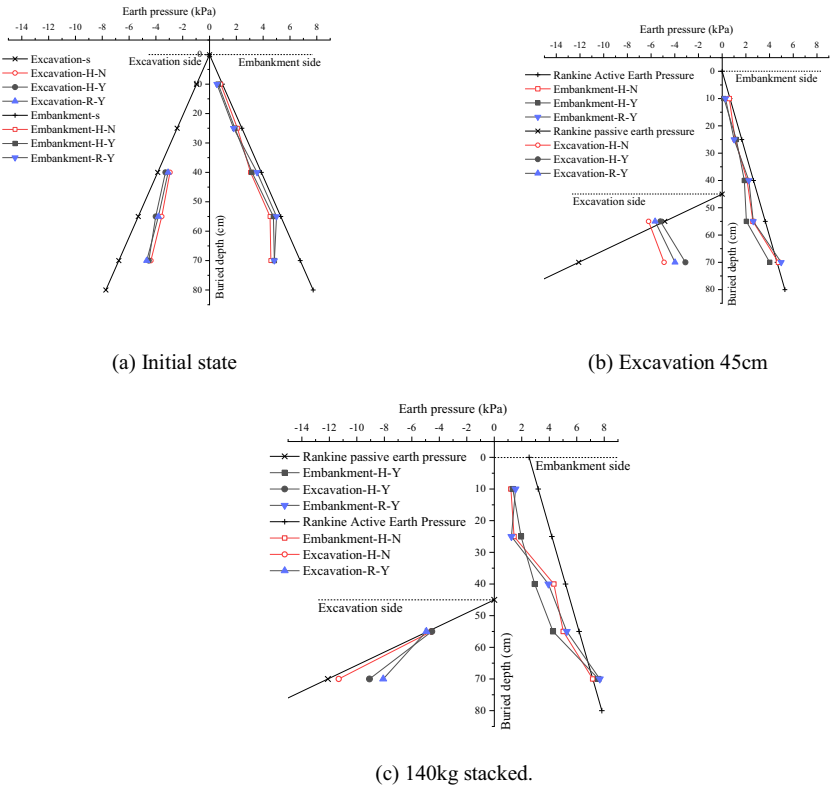


Figure 6. Test results of lateral earth pressure of H-shaped pile (sand soil).

The measurement of earth pressure in this model test starts from the initial static state. After the soil sample is put into the model tank, it is allowed to stand for a few days, and the reading when the earth pressure box becomes stable is regarded as the static earth pressure. However, due to the actual test In terms of control, it is impossible to achieve absolute stillness, so the earth pressure value at this time is only close to the measured static earth pressure value.

When not excavated, the sheet pile is in a balanced state in the fill. In the initial state, the lateral earth pressure on both sides of the sheet pile has the same trend as the theoretical calculation value of the static earth pressure, but the measured earth pressure at different depths is always less than Calculated value of earth pressure at rest. For example, at the measuring point depth $H=70\text{cm}$, the calculated value of the static earth pressure is 6.76kPa , and the measured value of the unstressed H-type sheet pile is 4.37kPa (excavation side), and the measured value is about 35% smaller than the theoretical calculated value. Because the method of K_0 is based on the empirical formula, there is a certain deviation from the actual project. The calculated value of K_0 is 0.54, and the empirical value used in most projects is 0.35~0.45. At the depth of the measuring point $H=65\text{cm}$, if $K_0=0.35$ is calculated, The calculated value of the static earth pressure is 4.39kPa , which is very close to the measured value; and the size of the model box is limited. The stress state of the soil in the box is affected by the boundary conditions around the box wall and the semi-infinite space. The stress state is different, and the stress under the same conditions is less than the theoretical value. At the same time, there are some errors in the test process, which come from the angle of the contact surface between the micro earth pressure cell and the fill, the tightness of the contact, and the accuracy of the sensor.

During the excavation stage, the soil pressure distribution on the side of the prestressed rectangular sheet pile, the unstressed H-type pile and the prestressed H-type pile shows similar regularities: 1) On the excavation side, the sheet pile is mainly affected by passive soil pressure. When the excavation is 45cm , the measured value of lateral earth pressure at a distance of 10cm from the excavation surface is slightly greater than the value of Rankine passive earth pressure, and the measured value at a distance of 25cm from the excavation surface is less than the value of Rankine passive earth pressure, which has not reached the limit status. The lateral soil pressure coefficients at the excavation side of the prestressed rectangular sheet pile, the unstressed H-type pile and the prestressed H-type pile at a distance of 10 cm from the excavation surface are 3.16, 3.47, and 2.91, respectively, and those at a distance of 25 cm from the excavation surface The earth pressure coefficients are 0.89, 1.09, 0.92 respectively. The lateral earth pressure coefficient at the bottom of the excavation side of the sheet pile is smaller than that near the excavation surface, which is consistent with the displacement characteristics of the sheet pile body. The bottom displacement of the sheet pile is small, and the displacement near the excavation surface Larger, the passive earth pressure is positively correlated with the pile displacement, so the lateral earth pressure coefficient at the bottom of the excavation side is smaller than that near the excavation surface. 2) On the side of the embankment, the sheet piles are mainly affected by the active earth pressure. Except for the measurement points of the rectangular sheet piles close to the bottom of the pile, the lateral earth pressures are all less than the Rankine active earth pressure value, which has not reached the limit state. When the excavation is 45cm , the lateral earth pressure coefficients at the excavation side of the prestressed rectangular sheet pile, the unstressed H-type pile and the prestressed H-type pile at 25cm from the excavation surface are 0.22, 0.25, 0.27,

respectively, and the distance from the excavation The coefficients of earth pressure at 55cm of the surface are 0.40, 0.38, and 0.32 respectively. It can be found that as the depth of burial increases, the displacement of the pile body decreases, and the coefficient of active earth pressure gradually increases, and the lateral earth pressure near the bottom of the sheet pile approaches the static soil. Pressure value.

In the surcharge stage, the lateral soil pressure of the prestressed H-type pile is similar to that of the prestressed rectangular sheet pile. On the excavation side, compared to the passive earth pressure after 45cm of excavation, after 140kg is piled up, the soil basically shows a passive earth pressure state, and the zero point of earth pressure is not much different under the two working conditions. 20~25cm below the surface.

4. Conclusion

When not excavated, the lateral earth pressure on both sides of the sheet pile has the same trend as the calculated value of static earth pressure, but the measured earth pressure at different depths is always lower than the calculated value of static earth pressure. During the excavation stage, the soil pressure distribution on the side of the prestressed rectangular sheet pile, the unprestressed H-type pile and the prestressed H-type pile shows similar regularities-the measured value at the excavation side is less than the Rankine passive earth pressure value , Has not reached the limit state; on the bank side, the sheet pile is mainly affected by the active earth pressure. Except for the measuring point of the rectangular sheet pile close to the bottom of the pile, the lateral earth pressure is less than the Rankine active earth pressure value, which has not reached the limit state.

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