Stress Analysis of Double Row Anti-slide Pile

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Abstract. Double row pile as a retaining structure in slope reinforcement and foundation pit support engineering and many other neighborhoods, it has a wide application. But due to the complexity and difference of the soil around the pile, the interaction mechanism between pile and soil is not clear. Calculated with different models and assumptions of double row pile internal force has big difference. On the basic of the former research, this paper improves the basic assumption. Analysis of the soil stress between the double row pile under the improvement basic assumption, and further analysis of the characteristic of the double row pile stress. It guides the practical application in engineering.

1. Background

The landslide is a large area of soil along a sliding surface slither which caused by the loose soil landslide by gravity, pour water pressure and vibration and other factors. It is a natural disasters phenomenon. It caused a serious security risk to people's life and property safety. It has enormous energy and destructive power. As a common retaining structure of double row piles are widely used in slope engineering. Put the double row piles into the landslide. It can improve the force mechanism of the soil landslide. Then it enhances the soil strength, and makes above the slide surface of the slope and sliding surface below the soil forming an entirety. The thrust of landslide soil above the sliding surface transfers to the below sliding surface to stability of foundation [1]. Compared with the traditional measures of landslide, anti-slide pile has the advantages of anti sliding ability, flexible layout, and convenient construction, wide use, safe and reliable.

The stress of double row piles is a space force, so the calculation is very complicated. The commonly used calculation models have some limitations, such as inter pile soil static earth pressure model, before and after the row soil pressure distribution model, Lang Jintu pressure or Coulomb's earth pressure theory. These can not accurately analyze the stress of the double row piles [2,3]. In this paper, analysis of the soil between the pile which in the double raw pile, and then stress analysis of the double raw pile. It applied in practical engineering provide theoretical support.

2. Stress Analysis of the Soil between the Double Raw Pile

(1) Stress analysis of the soil between the double raw pile

The analysis method of rigid plastic body model is used to analyze the inter pile soil stress in this paper. This method does not consider the effect of cohesive soil particles. This paper will improve and prefect this method under this basis. It mainly studies on the soil rupture angle between the piles and pile spacing effect. It ignores friction between pile and soil in the process of analysis. The stress model is shown in Figure 1:

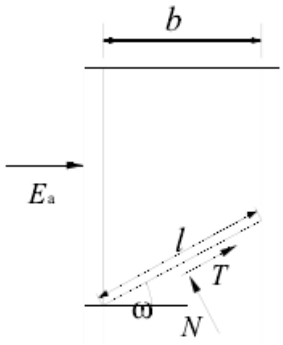

Figure 1 The stress analysis diagram of soil between the pile

In this figure, w is rupture angle. Ea is soil pressure. T is friction. γ is weight of soil. b is clear distance between the piles. N is positive and negative slope force.

The limit equilibrium theory can be used to calculate the rupture plane along the skirting impose a fixed point of view. The soil pressure is linear distribution in the vertical direction. After the interaction of the double raw pile, the soil destruction is limited by before and after pile. Spacing of double-row piles makes the foot of inclined crack along the front row not in accordance with a fixed angle. The rupture of the shear angle is not a fixed value. It changes with the value of the pile row distance. Mutative rupture angle also affects the changing of side soil pressure of pile.

(2) Analysis of the front raw pile side soil pressure

The soil between piles under its own gravity to lose stability and provide landslide thrust. The landslide thrust only in front of the anti slide pile, so the soil between the piles approximation that the front row pile resistance, sliding bed support force and friction interaction is to maintain a stable. While the front piles by the soil between the piles of gilding thrust and the rear pile transfer should be both composition. According to this assumption, it can be calculated in front of pile lateral soil thrust load decline degree distribution. The soil mechanics theory shows that the distribution of earth pressure may be assumed as linear distribution. It is assumed that the pile top and pile bottom load intensity respectively of q_1 and q_2. The force form as shown in Figure 2:

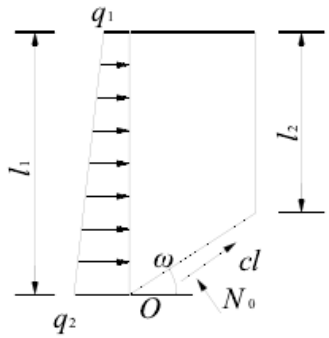

Fig.2 Distribution of lateral earth pressure

The limit equilibrium condition can work out q_1 and q_2, and obtain the distribution form of earth pressure.

(3) The influence of pile spacing on the rupture angle

We can see from calculation the limit equilibrium theory of boundary conditions. When the pile spacing changed, the maximum slip angle is changed. The change trends as shown in Figure 3.

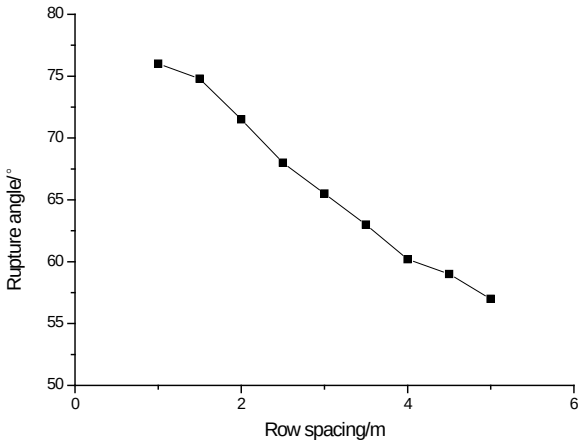

Figure 3 pile spacing and rupture angle curve

From Figure 3, we can see that with the increase of pile spacing, rupture angle will decrease gradually until it becomes a fixed value.

(4) Analysis of thrust transmission between double row piles

Analysis of the after pile additional stress on before pile, considered the active pressure produced by the weight of the soil between the pile. The soil between piles under the gravity slid failure. The force has to meet the balance equation. So analysis of the additional stress should be not considered the sliding surface shear stress and normal stress [4]. In this paper, in order to facilitate the calculation, residual soil pressure after pile is triangle. The lower part of the load is $q_{3.}$ Set length of front-row cantilever piles to z. Splitting angle to ω. The stress form shown in Figure 4.

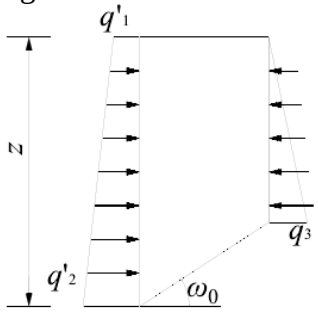

Figure 4 Double row piles between thrust transmission diagrams

Referring to the above analysis method, the limit equilibrium condition and horizontal force equal conditions can be worked out. q_3 is the solution set load $q'_{1,}q'_{2.}$ In summary, the force of the front row pile is a trapezoid. The upper and lower load respectively can be expressed as $q_{A=}q_1+q'_1$ and $q_B=q_2+q'_{2.}$ The $_{q1}$ and q_2 are earth pressure load collection degree, through the above method can be worked out the real solutions,q'_1,q'_2 can be expressed as a function of expression with $q_{3.}$The force of back pile for landslide thrust and residual soil pressure difference, so after row of piles stress has relationship with q_3(unknown).

(5) To calculate the displacement of soil between piles

The analysis before and after the double row piles soil pressure distribution from above mention, the mechanical analysis model is shown in Figure 5.

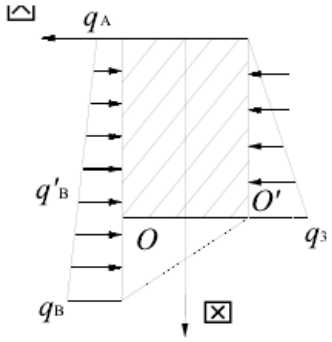

Figure 5 the inter pile soil stress analysis diagram

O and O' figure as a reference point. Set front row pile and pile bottom load intensity distribution to q_A, q_B. The back row pile bottom load intensity is q_3. O load set point of reference at the q'_B. The q'_B which can be prorated according to the load determined set of top and bottom. According to the material mechanics found: linear OO' above the soil due to the horizontal forces only by piles. Bending stress and bending moment about the shear stress and shear-related cross-section. The y direction stress is not associated with x. As shown in the shaded area in Figure 5. The assumed stress component function form:

$$\sigma_y = xf(y) + f1(y) \quad (1)$$

And then follow the semi-inverse method can be derived from the stress function. The last major study boundary conditions and minor boundary conditions. Combined solution of equations can be derived from the displacement between piles.

3. Analysis and Calculation of Stress of Double Row Pile

When calculating elastic pile, the unit balance conditions and force calculation formula of foundation pile can obtain the differential equation of the deflection. Then use a look-up table method for solving the pile internal force [5]. T he double row pile anchor only by the bending moment and shear force at the sliding surface. The analysis method can be calculated according to the single pile. The common calculation methods are foundation coefficient method. Depending on the horizontal foundation coefficient of resistance, it is divided into"m", "k" and"c" law. For rigid anti slide pile, it can analyze the desirable pile. It calculated angle and displacement of the sliding surface under the static equilibrium method. It can calculate the internal force of sliding surface of arbitrary depth of pile. Figure 6 shows the differential unit laterally loaded pile analysis.

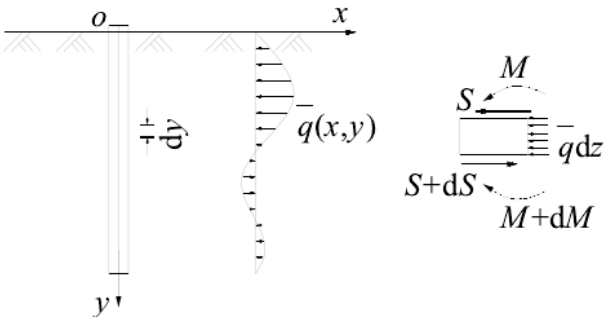

Figure 6 the differential unit laterally loaded pile analysis.

Let pile section shear is S. Ultimate flexural modulus of EI. Pile side soil resistance function expression of p(x, y). x is the horizontal direction. Vertical direction is y direction. Taking the pile with arbitrary cross section micro element analysis by horizontal unit stress balance equation list:

$$(S+dS)-S-p(x, y)\,dx=0 \quad (2)$$

And the relationship between the shear and moment is substituted into the above equation:

$$\frac{dS}{dx}=\frac{d^2M}{dx^2}=p(x,y) \quad (3)$$

The formula (3) can be obtained by substituting moment Differential Equations pile curve is:

$$EI\frac{d^4y}{dx^4}+p(x,y)=0 \quad (4)$$

Solving the above equation can be calculated force double piles.

4. Conclusion

In this paper, the structural model of the double-row piles divided into three parts, front and rear posts and beams. To get the landslide thrust and the rear of the front pile resistance based on analysis of soil between piles. Then it can use elastic mechanics method to solve the displacement between pile soils. Once the landslide thrust and Winkler foundation model various parameters be confirmed. You can take advantage of the relative displacement of the two selected reference points to establish coordinated displacement equation, and to calculate the internal forces and displacements double pile. In the whole process of elastic deformation, considering the influence of beam bending stiffness and beam and pile rigid connection. Connecting beam structure without anti-slide pile is simple statically indeterminate structure. In the case of the known pile landslide thrust expressions, you can use simple displacement deformation compatibility to calculate internal forces and displacements of each point.

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