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Determination of spacing between anchored piles in row for deep foundation pit

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Abstract. *Based on the pile - anchor structure soil between piles,the unified strength theory is introdued in the strength analysis of soil arching between the piles, and parabolic soil arching computational model is uniformly distributed loads ,which are given to meet the soil between piles arch static equilibrium conditions and intensity of conditions , pile spacing formula. Compared with calculations based on the pile spacing of the Mohr-Coulomb strength criterion , the proposed method can consider the contribution of the intermediate principal stress on the strength of the soil arch , the results are more in line with the actual characters of the supporting structure .*
Keywords: *Deep foundation pit; Soil arching effect; Anchored piles in row; Unified strength theory*

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I. Introduction

Pile anchor retaining structure because of its supporting effect, adaptable and simple in construction,supported a very wide range of applications in deep foundation excavation. In engineering practice, how to choose a reasonable support pile spacing is a key issue of the foundation pit supporting structure design. The pile spacing was too large may cause the supporting effect of failure,and if too small will easy to unnecessary waste. Generally from the technical and economic point of view, it should guarantee the condition of the pit walls safe as far as possible choose a large pile spacing to reduce the number of supporting piles, which will bring considerable economic benefits. As we all know, is far from the anchored pile retaining structure design theory lags behind the demand for engineering practice. For the determination of reasonable pile spacing is still stuck in the experience of stage, there is no strict theoretical formula to follow. Does not take into account the beneficial effects of soil arching effect between piles in the pile spacing, the value is too conservative. In recent years, existing experts and scholars based on their assumptions, considered the static equilibrium conditions of soil arching between piles and intensity conditions, gives the calculation method of the cantilever support pile spacing, and were assumed to the plane strain model, the Mohr-Coulomb strength criterion, failed to consider the contribution to the strength of the intermediate principal stress on soil arching. This assumption was clearly breaks with the actual uneven force of the supporting piles. Anchor retaining structure of pile spacing to determine the pit pile of fresh reports. In this paper, based on the existing support pile spacing study, considered the soil arching between the piles, and the introduction of the unified strength theory was given the strength of the soil arch pit pile anchor retaining structure of pile spacing[1].

Soil Arching Effect

The use of non-continuous support piles deep foundation pile - anchor projects, due to the excavation of the pit, making the pile of soil to produce the trend of moving to the pit, while the pile of soil mass behind by the displacement of the constrained role of the pile ordeformed very little, so the relative displacement between the two will cause the play of the shear strength of the soil pile and pile soil mass, in the soil to form a "wedge tight" the role of, which producearching effect of soil between piles.

At present, there are two views of the arching effect of soil between piles. A soil arch is located adjacent to two of the medial arch foot pile side friction to balance the pile soil pressure , common in slope engineering support piles; another was supporting piles directly as a soil arch arch feet, the soil in the pile after the gradual compaction within a certain range, the formation of a triangular compression region, soil arch destruction mainly to the arch of the foot to squeeze the strength of the dense triangle . Deep foundation pile - anchor structure, the pile spacing is relatively small, the form of arch foot for the second case. Therefore, the rational spacing between starting from the latter, supporting piles rational spacing between the formula is derived based on the static equilibrium conditions and the strength of the soil arch conditions, round support retaining pile[2].

Unified Strength Theory.

Theory and practice show that, in the main stress for the soil yield damage is an objective reality. Mao-Hong Yu unified strength theory , the unit cell of the twin shear stress as a physical model, fully taken into account the influence of intermediate principal stress in the yield or failure of different materials under different stress conditions, for a variety of engineering materials is a uniform, a new strength theory. Rock and Soil Mechanics and Engineering, the general provisions of the compressive stress is positive, tensile stress is negative, the unified strength theory can be expressed as the following form:For a beam structure, given by the mechanics of materials straight beam bending the relationship between the static:

$$\left.\begin{aligned} F &= \alpha\sigma_1 - \frac{b\sigma_2+\sigma_3}{1+b} = \sigma_t, \sigma_2 \le \frac{\sigma_3+\alpha\sigma_1}{1+\alpha} \\ F' &= \frac{\alpha}{1+b}(b\sigma_2+\sigma_1) - \sigma_3 = \sigma_t, \sigma_2 \ge \frac{\sigma_3+\alpha\sigma_1}{1+\alpha} \end{aligned}\right\} \quad (1)$$

In those,b is the unification of strength parameters,value is $0 \le b \le 1$, $\sigma_t = \frac{2c\cos\varphi}{1+\sin\varphi}$ is ultimate tensile strength, $\alpha = \frac{\sigma_t}{\sigma_c} = \frac{1-\sin\varphi}{1+\sin\varphi}$ is material compressive and tensile strength, c , φ are the rock and soil cohesion and angle of internal friction.

The use of commonly used in geotechnical engineering, cohesion and angle of internal friction as basic parameters, the unified strength theory can be expressed as [16]:

$$\left.\begin{aligned} &\sigma_1 - \frac{1-\sin\varphi}{(1+b)(1+\sin\varphi)}(b\sigma_2+\sigma_3) = \frac{2c\cos\varphi}{1+\sin\varphi} \\ &\sigma_2 \le \frac{1}{2}(\sigma_1+\sigma_3) - \frac{\sin\varphi}{2}(\sigma_1-\sigma_3) \end{aligned}\right\} \quad (2a)$$

$$\left.\begin{aligned} &\frac{1}{1+b}(\sigma_1+b\sigma_2) - \frac{1-\sin\varphi}{1+\sin\varphi}\sigma_3 = \frac{2c\cos\varphi}{1+\sin\varphi} \\ &\sigma_2 \ge \frac{1}{2}(\sigma_1+\sigma_3) - \frac{\sin\varphi}{2}(\sigma_1-\sigma_3) \end{aligned}\right\} \quad (2b)$$

Pile Spacing Determining.

Soil arching stress analysis. Pile - anchor structure, when the formation of the soil arching between piles, the soil arching will be the combined effect of the pile soil pressure P and the anchor cable tension T, does not consider the arch before the soil resistance, soil arch suffered load the difference of the pile soil mass pressure and cable tension.

Soil arch is the first strong arch, soil arch must maximize their effectiveness and to form a reasonable arch axis . Based on the foregoing assumptions , the soil arch is symmetrical , it is desirable that the half of its study of the structure , to simplify the calculation model shown in Figure 1 .

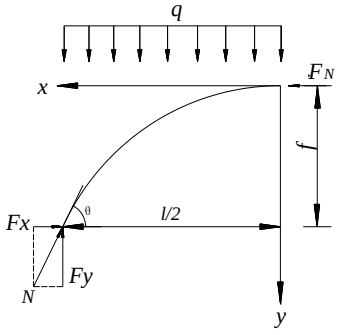

Fig.1 Stress analysis diagram of arch axes

The establishment of the coordinate system, as shown in the arch axis equation :

$$y = 4fx^2/l^2 \quad 0 \le x \le l/2 \quad (3)$$

According to the force and torque balance of the soil arch analysis shows that:

$$F_x = \frac{ql^2}{8f}dz\,; F_y = \frac{ql}{2}dz \quad (4)$$

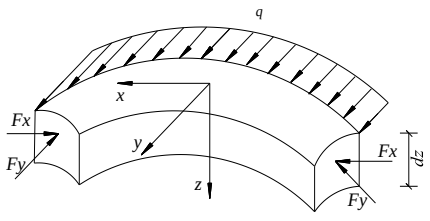

Fig.2 Soil arch unitbody diagram between piles

Arch in soil arching any depth to take a high degree of soil analysis, micro segment of the force shown in Figure 2 . Based on the assumption of one-way pressure conditions and cross-sectional arch , arch foot cross-section of the normal

stress is greater than the cross in place , so the most unfavorable soil arch to arch foot section location .

Existing studies have shown that the pile spacing to set a reasonable , within the local area in the rear with a body , the soil adjacent to both sides of the arch form to squeeze very dense triangular compression zone, arch foot role in the extrusion of the surface of the triangle , assuming that the arch thick internal circular pile square side length of the soil arch arch feet by the force shown in Figure 2.

Reasonable pile spacing Deriving. To ensure that soil arching between adjacent two functioning properly , the soil arching between piles shall meet the static equilibrium conditions . Loaded adjacent soil arch is roughly the same , so the x direction does not produce due to pile back due to lack of friction caused by the failure modes , assuming uniform distribution, is also on the thickness of the micro- segment static equilibrium conditions consider the y direction by the force , namely :

$$2(F_x \cdot \tan\varphi + c \cdot t \cdot dz) \geq ql \cdot dz \tag{5}$$

Computing to facilitate the desirable equal sign (4) Substituting into (5) have:

$$\frac{ql^2}{8f}\tan\varphi + ct = \frac{ql}{2} \tag{6}$$

Reasonable arch axis is assumed that the soil arch , the arch by the direction of the axial force along the axis of the tangent of the arch , and arch foot suffered tangential direction of the axial force :

$N = \sqrt{F_x^{\,2} + F_y^{\,2}} = \frac{ql}{8f}\sqrt{l^2 + 16f^2}\,dz$, At the same time there normal direction force is zero , in addition, the soil arch arch of the foot position by gravity stress . Analysis: the normal stress along the arch of the foot tangent direction of major principal stress , weight stress is the intermediate principal stress , the minor principal stress is the normal direction of the force and size zero.

$$\sigma_1 = \frac{N}{t \cdot dz} = \frac{ql}{8ft}\sqrt{l^2 + 16f^2}\,,\ \sigma_2 = \gamma z\,,\ \sigma_3 = 0 \tag{7}$$

(7) into (2) can be obtained:

$$\left.\begin{aligned} &\frac{ql}{8ft}\sqrt{l^2 + 16f^2} - \frac{b(1-\sin\varphi)\gamma z}{(1+b)(1+\sin\varphi)} = \frac{2c\cos\varphi}{1+\sin\varphi} \\ &\gamma z \geq \frac{(1-\sin\varphi)}{2} \cdot \frac{ql\sqrt{l^2 + 16f^2}}{8ft} \end{aligned}\right\} \tag{8a}$$

$$\left.\begin{aligned} &\frac{1}{1+b}\left(\frac{ql}{8ft}\sqrt{l^2 + 16f^2} + b\gamma z\right) = \frac{2c\cos\varphi}{1+\sin\varphi} \\ &\gamma z \leq \frac{(1-\sin\varphi)}{2} \cdot \frac{ql\sqrt{l^2 + 16f^2}}{8ft} \end{aligned}\right\} \tag{8b}$$

(6) and (8) :

$$\left.\begin{aligned} &\frac{ql}{8ft}\sqrt{l^2 + 16f^2} - \frac{b(1-\sin\varphi)\gamma z}{(1+b)(1+\sin\varphi)} = \frac{2c\cos\varphi}{1+\sin\varphi} \\ &\frac{ql^2}{8f}\tan\varphi + c \cdot t = \frac{ql}{2} \\ &\gamma z \geq \frac{(1-\sin\varphi)}{2} \cdot \frac{ql\sqrt{l^2 + 16f^2}}{8ft} \end{aligned}\right\} \tag{9a}$$

$$\left.\begin{aligned} &\frac{1}{1+b}\left(\frac{ql}{8ft}\sqrt{l^2 + 16f^2} + b\gamma z\right) = \frac{2c\cos\varphi}{1+\sin\varphi} \\ &\frac{ql^2}{8f}\tan\varphi + c \cdot t = \frac{ql}{2} \\ &\gamma z \leq \frac{(1-\sin\varphi)}{2} \cdot \frac{ql\sqrt{l^2 + 16f^2}}{8ft} \end{aligned}\right\} \tag{9b}$$

Calculation of the soil arch suffered load , the pressure part of the pile soil mass is calculated according to the Rankine earth pressure formula . When the soil , as well as the role of soil arching uniformly distributed known by (9) can be obtained soil arch span and the arch vector . In practical applications , you can pile spacing divided by the appropriate factor of safety as the actual pile spacing , the safety factor References[3] , the overall stability of the slope coefficient of the request of the appropriate value , it is recommended take 1.3 1.5, ultimately support the pile center distance is

$L = l/k + 2\Delta l$.

II. Conclusion

(1) retaining reasonable pile spacing is a key issue in the foundation pit supporting structure design . The pile spacing is too large may cause the supporting effect of failure is too small and easy to unnecessary waste . Generally from the technical and economic point of view , it should guarantee the condition of the pit walls safe as far as possible choose a large pile spacing to reduce the number of supporting piles , which will bring considerable economic benefits .

(2) pit pile - anchor structure , supporting piles to determine pile spacing should be considered the beneficial effects of soil arching effect between piles , the balance of soil arching between static pile conditions and soil arch arch foot strength conditions joint control , in order to make the results more in line with the actual characters of the supporting structure .

(3) Mohr -Coulomb strength criterion is a special case of the unified strength theory when the intermediate principal stress coefficient . Borrow the unified strength theory arch arch foot on the soil strength analysis can consider the contribution to the strength of the intermediate principal stress on soil arching . However, the unified strength theory to determine the spacing of the supporting piles is still in the initial research stage , therefore , how to actual working conditions the choice of appropriate values to be more thorough and meticulous research .

References

[1]. Jia Haili, Wang Chenghua and Li Jianghong.: Analysis of soil arching effect of the anti-slide pile retaining piles of pile spacing [J]. Journal of Engineering Geology Vol. 12(1), (2004), 98-103.

[2]. Yu Maohong: The geomaterials unified strength theory and its application [J]. Journal of Geotechnical Engineering ,16(2),(1994):1-10

[3]. Guo Yuancheng, Guo Chengxiang and Ye Yongfeng.: Based on rational spacing between the level of soil arching effect row pile retaining structure [J]. Sichuan Building Science. 34(4):136-139Vol. 12(1), (2004), 98-103.