Study on the bearing capacity of micropiles in plateau mountainous area: A case study of a power supply project in a traction station in Sichuan

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Abstract. As a new type of environmental protection foundation, micropile has the advantages of convenient construction, small floor area, and has a broad application prospect. This paper takes a power supply project of a traction station in Sichuan as an example, and uses ABAQUS numerical analysis software to simulate the micro-pile foundation of the project site, then the influence of pile length and pile diameter on the bearing capacity of micro piles is analyzed. Combined with the load-bearing requirements of the transmission line for the foundation, it is believed that the micro-pile foundation in the plateau mountain area is prone to damage due to failure to meet the pull-out requirements. The research results provide a reference for the design and application of the micro-pile project in the plateau mountain area in the future.

1. Introduction
The micropile is a new type of small-diameter bored pile developed on the basis of tree root piles, the diameter is usually less than 0.40m, and the slenderness is relatively large (generally greater than 30), it has the advantages of flexibility and convenient construction[1]. At present, it has been initially applied in soft soil and loess foundations in some areas of China, and has achieved certain successful experience. Shin studied the influencing factors of micropile bearing capacity through experiments [2]; Patra found that as the axial pressure increases, the lateral friction resistance along the length of the pile will decrease [3]; Scott obtained through experiments that the ultimate pull-out bearing capacity is composed of lateral friction resistance and pile weight[4]; Liu Zilong studied the bearing capacity of the foundation through the pull-out test of micro piles[5].

So far, the research of micropile as a pile foundation has been relatively concentrated on the study of compressive bearing capacity of soft soil area. In this paper, combined with actual engineering, to study the bearing capacity of miniature piles in the mountainous area of Sichuan. It has important engineering significance for the popularization and application of micro-pile foundation in plateau mountain area.

2. Engineering situation
A micropile project is located in Songpan County, Aba Tibetan and Qiang Autonomous Prefecture, with an altitude of about 3000m. According to drilling, it is revealed that silt clay is 0-4m and crushed stone is below 4m. The stratum structure of the site is simple, the stratum changes are small, and no groundwater is seen. Figure 1 is the landform features of the project area, and Figure 2 is the Micropile...
3. Building a calculation model

According to the project profile, the use of symmetry to establish an axisymmetric model is shown in Figure 3. Sampling the test site and performing indoor geotechnical tests on the obtained borehole samples. The parameters calculated are shown in Table 1. In actual engineering, for harder soil, the elastic modulus\(E_0\) of the soil is often 2-8 times the compression modulus\(E_s\), the friction angle \(\delta\) between the pile wall and the soil can be taken from 0.75 to 1 times the effective internal friction angle of the soil. Since the micro-pile often uses secondary grouting and other construction techniques, the surface of the pile body is rougher than the general concrete pile, so the friction coefficient in the simulation takes a larger value.

![Figure 3. Numerical calculation model.](image)

| Material            | \(\gamma\) (KN/m³) | \(C\) (KPa) | \(\varphi\) (°) | \(E\) (Mpa) | \(\mu\) |
|---------------------|---------------------|-------------|------------------|-------------|---------|
| Silty clay          | 19.5                | 25          | 25               | 16          | 0.34    |
| gravelly soil pile  | 20.5                | 5           | 30               | 50          | 0.3     |
| pile                | 25                  | \(\backslash\) | \(\backslash\) | 300 00      | 0.2     |

According to the design data of the transmission line in the study area, the downward pressure load on the transmission tower is 600KN~1500KN, and the uplift load is generally 550KN~1200KN. Generally 100KN ~ 300KN. Thus, the loading method in the numerical simulation is as follows: The design value of the compressive bearing capacity of the designed single pile is 250KN, the estimated value is 375KN, and it is loaded step by step. The first level is loaded with 80KN, and then each level
is loaded with 40KN; The design value of the pile's anti-pulling bearing capacity is 195KN. In this section, it is loaded step by step. The first level is loaded with 40KN, and then each level is loaded with 20KN.

4. Calculation results and analysis

4.1 The influence of pile length on the bearing capacity of micro pile

(1) The effect of pile length on bearing capacity of compressive pile

Load-settlement curve at the top of compressive piles with different pile lengths are shown in Figure 4. As shown in the figure, under the same load, when the pile length is short, the settlement at the top of the pile is large. As the pile length increases, the settlement at the top of the pile decreases significantly, and the decrease tends to be slow. It can be seen that, within a certain load range, increasing the pile length can effectively reduce the single pile settlement, thereby improving the bearing capacity of the pile foundation, but after reaching a certain load, continuing to increase the pile length changes the single pile settlement little. In addition to the pile with a length of 6m, the remaining pile lengths can meet the maximum compression load-bearing requirements of the transmission and transformation tower.

(2) The effect of pile length on the bearing capacity of uplift pile

Figure 5 is a graph of Load-displacement curve of pile under different pile lengths. It can be seen from the figure that each pile length can meet the uplift force of 100KN. The load-displacement relationship curve can be divided into three stages: In the first stage, when the load is small, the uplift displacement will remain unchanged with the increase of the load. At this time, the uplift load is mainly borne by the weight of the pile body, the side friction resistance plays a small role, and the load-displacement relationship is in the elastic stage. In the second stage, as the load continues to increase, the slope of the load-displacement relationship curve increases at this time, that is, the increase speed of the displacement under the load becomes faster, and the load-displacement relationship is in the elastoplastic stage. In the third stage, the slope of the curve is greater, the displacement growth rate is faster, and a small increase in the pile top load may pull the pile body out.

4.2 The effect of pile diameter on the bearing capacity of micropile

(1) Influence of Pile Diameter on Bearing Capacity of compressive pile

Figure 6 is a graph of Load-settlement curve of pile under different pile diameters. As shown in the figure, as the pile diameter increases, the settlement of the pile top decreases significantly, and the decreasing trend of the pile top settlement gradually slows down, when the pile top load is 360KN, as the pile diameter increases, the pile top settlement decreases sequentially by 22.95%, 29.45%, and 18.53%.

(2) The effect of pile diameter on the bearing capacity of uplifted piles

Figure 7 is a graph of the Load-displacement curve of pile under different pile diameters. As shown
in the figure, under the same load, when the pile diameter is small, the displacement of the pile top is large. As the pile diameter increases, the pile top amount of displacement decreases significantly and the degree of reduction tends to be slow.

Figure 6. Load-settlement curve of pile under different pile diameters.

Figure 7. Load-displacement curve of pile under different pile diameters.

4.3 Comparison and selection of foundation piles

The engineering performance of the micro-pile foundation includes the stability and economy of the foundation, the stability is expressed by the bearing capacity of the foundation, and the economy is expressed by the bearing capacity compared to the volume of the upper pile body. Sort out the calculation results to obtain Figures 8-9.

Figure 8. Influence of pile diameter on engineering performance of miniature piles.

Figure 9. Influence of pile length on engineering performance of miniature piles.

It can be seen from the figure: as the pile diameter increases, the stability of the pile's bearing capacity increases and the economy decreases; as the length of the pile increases, the pile's bearing capacity increases and the stability increases, the economy increases but the range gradually decreases. Considering that the pile length is large and the construction is difficult, combined with the load-bearing requirements of the project, it is determined to select a miniature pile with a pile length of 8m and a pile diameter of 300mm to form a 2×2 group pile foundation as the test foundation.

5. Conclusion

(1) For the power transmission project in the plateau mountain area, the micro-pile foundation can meet the foundation bearing requirements. The increase of pile length and pile diameter can effectively improve the bearing capacity of the foundation, but the increase of pile diameter reduces the economy of the foundation.

(2) For the pile foundation of the test site, it is recommended to use a 2×2 group pile foundation
composed of micro piles with a length of 8m and a diameter of 3m as the test foundation.

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