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Study on the Principle of Cost Calculation and Economy of Steel Screw Anchors

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Abstract. With the popularization of mechanized construction of transmission line engineering and the improvement of environmental water protection requirements, some new foundations have been popularized, and have great advantages. The steel spiral anchor foundation has the advantages of short construction period, quick mechanization construction speed, and zero concrete and zero earthwork construction. According to the construction process and test requirements of steel screw anchor, the principle of calculating the construction and test cost of steel screw anchor is put forward, the economic critical point of steel screw anchor is obtained.

Keywords: Steel Screw Anchor; Cost Accounting Principle; Cost Analysis.

1. Introduction

The first use of spiral anchors can be traced back to the 1833, around the English Tidal Cove, where they were used as lighthouse foundations. In 1950, people began the systematic study of screw anchors. The vertical bearing capacity, horizontal bearing capacity and combined bearing capacity of screw anchor foundation have been studied by domestic and foreign scholars. In order to study the pullout resistance of screw anchors, the assumption of cylindrical failure surface is adopted, and the influence of anchor disc spacing is considered, four models with different number of anchors and spacing ratio were tested in soft marine clay [1]. Yenumula [2] has carried out the field horizontal loading test of the spiral pile with different anchor plate number in clay, and got the following conclusions: the horizontal bearing capacity of the spiral pile increases with the increase of the buried depth and the shear strength of the soil; The bearing capacity of screw pile is larger than that of single pile, and increases with the number of anchor plates. Shi Qian et al[3] carried out the model test of double-slice spiral anchor in sandy soil, and found that the uplift capacity would increase with the increase of the distance between the anchors and the depth of the anchors. By means of empirical formula method, static load test method and cone penetration test method, the influence of different variables on the reliability index of ultimate bearing capacity of single spiral pile under inclined load is studied, the calculation model of ultimate bearing capacity of spiral pile is analyzed, and the ultimate state equation is derived[4].

Although the screw anchor has accumulated a lot of experience in the technical research, especially in the mechanical research, the application of the screw anchor in the transmission line engineering is still in its early stage, and there is still no uniform standard for the calculation of the cost, therefore, it is urgent to explore a set of cost accounting principles for steel screw anchors to guide engineering practice. Based on the brief introduction of steel screw anchors, this paper puts forward the principle of screw anchors body installation quota and true test cost, and compares the cost with the traditional design basis under the same external conditions, the economic critical point of using steel screw anchor is obtained, which provides a cost basis for further popularizing and using steel screw anchor foundation.

2. Introduction of Steel Screw Anchor

Spiral Anchor Foundation is a kind of anchor structure which is composed of spiral anchor and upper cap, and mainly uses deep soil to resist the action of upper structure. According to the number of bolts, the screw anchor foundation can be divided into single-type screw anchor foundation and Group-type Screw Anchor Foundation. According to the angle between the bolt and the vertical direction, the single anchor type screw anchor foundation can be divided into single oblique anchor screw anchor foundation and Single Straight Anchor Screw Anchor Foundation According to the angle between the bolt and the vertical direction, the foundation of the group Bolt type screw anchor is divided into the group oblique anchor screw anchor foundation and the Group Direct Anchor Screw Anchor Foundation, group oblique anchor screw anchor foundation can be divided into different angle group oblique anchor screw anchor foundation and equal angle group oblique anchor screw anchor foundation, as shown in Figure 1.

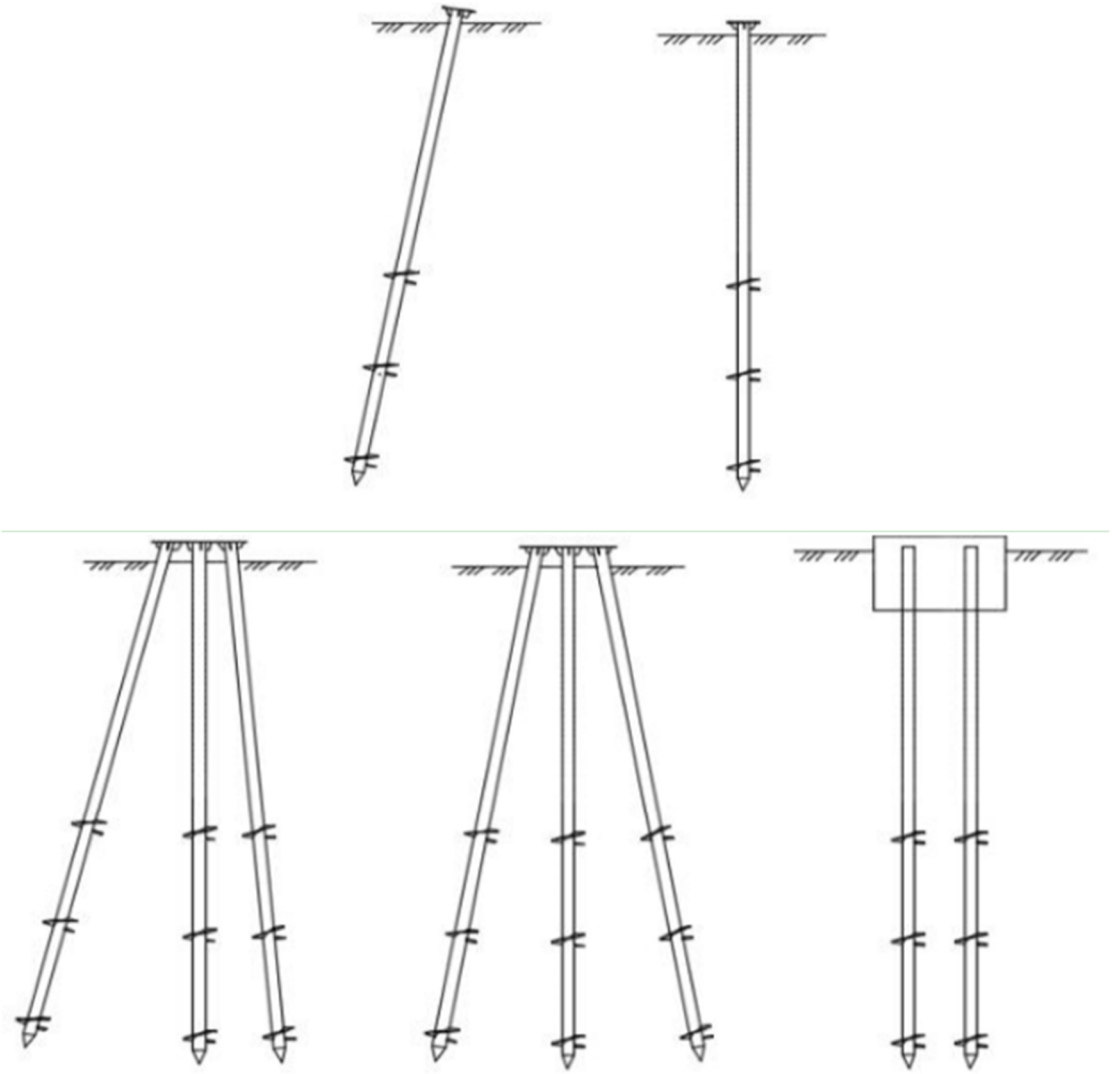

Figure 1. Screw Anchor Foundation

The single screw anchor is composed of an anchor head, an anchor plate, an anchor rod and a connecting piece, As shown in Figure 2

Figure 2. The composition of a single screw anchor

The construction procedure of steel spiral anchor foundation includes sub-pit measurement, drilling machine in position, spiral anchor drilling, top cutting of spiral anchor (group anchor) ,Angle Steel positioning of steel cap, steel cap welding(group anchor welding, single anchor factory welding), ultrasonic testing(group anchor),coating anticorrosive paint and basic acceptance of nine steps[5],and according to the requirements of the code, the steel screw anchor needs to do the true-type test before the construction, need to list the test cost.

3. Steel Screw Anchors, The Principle of Cost Accounting

According to the content of the supplementary quota(trial implementation) of the spiral anchor foundation engineering (national power grid electric rating [2020] No. 28) ,the steel spiral anchor foundation body construction needs to list the installation of the steel spiral anchor and the installation of the steel cap, the installation of screw anchors is divided into single anchors and group anchors, and the calculation is based on the number of designed anchors, taking “Root” as the unit of measurement, calculated in units of measurement. The installation work includes construction preparation, measurement, pile laying line, field transportation, steering pile and extension pile rotation, pile-to-pile connection, pile end cutting and grinding, site cleaning, tools transportation, etc. The installation work includes construction preparation, excavation and backfilling of welding working surface, lifting and positioning of steel bearing platform, welding of steel bearing platform, welding of reinforcing bar and plate, flaw detection, painting of anti-corrosion, cleaning of site, transportation of tools and instruments, etc. If steel spiral anchor foundation is used in transmission line engineering, the true test is usually used to verify the bearing capacity of foundation before construction.

According to the requirements of JGJ106-2014, the vertical compression and static load test, vertical uplift and horizontal static load test of single pile are required after construction of steel spiral anchor foundation. According to the test load grade F(unit: KN) and the diameter d(unit: mm) of the screw-anchored single pile, the corresponding prices are given respectively in the guidance on the calculation of the test fee for the foundation of power transmission and transformation projects and the Deep Foundation test fee (GDFY-2023-04) .Therefore, the total cost of the steel screw anchor includes not only the cost of the project itself, but also the material and installation cost of the single anchor and the steel accessories of the test equipment, and the material and installation cost of the foundation of the reaction pile, and the cost of vertical and horizontal static load test of pile.

4. Compared to the Cost of a Traditional Base

Because the steel spiral anchor foundation is suitable for the soft soil areas such as common soil and sand, and the mechanization degree is high, the factors such as the entrance of planting anchor machine and loading body device should be considered, it is generally required that the spiral anchor foundation should be popularized when the terrain is flat, so the traditional foundation chosen in the comparative analysis includes cast-in-situ slab foundation and cast-in-place Pile Foundation. Based on a 750 kV line project in Ruoqiang, Xinjiang, comparing the advantages of steel screw anchor with

cast-in-situ slab foundation and cast-in-situ pile foundation by concrete, steel, earthwork, construction time and foundation cost, the data are shown in Table 1.

Table 1. Three types of basic single-base technical and economic comparison table

The underlying type	Steel Spiral Anchor Foundation	Straight Column Slab Foundation	Cast-in-place pile foundation
Concrete(m^3)	**0**	**10.08**	**12.15**
Steel(kg)	**4800**	**4421**	**836.93**
Earth(m^3)	**0**	**132**	**0**
Construction time(days)	**6**	**28**	**15**
Base cost (10,000 yuan)	**7.42**	**19.31**	**21.57**

Notes: 1. The cost of steel spiral anchor foundation does not include the test cost, 2. Steel without anchor bolts.

The test fee for steel screw anchors is shown in Table 2.

Table 2. Steel screw anchor test fee

Name	Cost (10,000 yuan)
Test single anchor	22.46
Reaction Pile	42.81
Static load test	32
5/2000 Total	97.27

As can be seen from Table 1 and Table 2, if only considering the project body, the steel spiral anchor foundation is compared with the traditional cast-in-situ slab foundation and cast-in-situ pile foundation, it has some advantages in construction period, cost, safety, environmental protection, material saving and so on, but the steel screw anchor needs to count the test cost, so from the angle of full cost, only when the scale reaches a certain amount, the steel screw anchor has economic advantage over the traditional foundation. The economic critical point of steel screw anchor is 97.27/(19.31-7.42) = 8.18 basis as compared with cast-in-situ slab foundation The economic critical point of steel screw anchor is 97.27/(21.57-7.42) =6.87 basis compared with cast-in-situ slab foundation.

5. Conclusion

This paper analyzes the composition of the cost of the screw anchor, puts forward the principle of calculating the cost of the steel screw anchor, and through comparing with the traditional foundation, the conclusions are as follows:

1) compared with the traditional foundation, the steel spiral anchor has the advantages of short construction period, saving earthwork excavation, saving materials, convenient and fast construction, high mechanization degree and low cost;

2) through the research on the construction process of the steel spiral anchor and the inquiry of the relevant specifications, it is found that the cost of the steel spiral anchor, in addition to the installation of the spiral anchor and the steel bearing platform, also includes the cost of vertical and horizontal static load test;

3) the steel spiral anchor is relative to the traditional foundation, there is an economic critical point under the consideration of the full cost, and different projects have different critical values due to different external conditions, which need to be measured after the Geological Survey and before the foundation design;

4) the steel spiral anchor has a comparative advantage over the traditional foundation in terms of time, cost, material saving and environmental protection when the number of steel spiral anchor is used in a project exceeding the economic critical value.

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