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Technical Advantage and economic analysis of spiral anchor foundation in desert area

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Abstract. State grid corporation “Infrastructure Technology [2022] No.14”document spiral anchor application as a recommended application of technology, requirements for the application of engineering as far as possible, since then, spiral Anchor Foundation is widely used in tower foundation of transmission line engineering. Using desert, Gobi, desert and abandoned mines to build photovoltaic power plants has become the“14th five-year plan” new energy development priority, supporting the rapid development of power grid transmission projects, there are more and more overhead power lines across the desert. Compared with other types of foundation, spiral anchor foundation in desert area not only has higher feasibility in technology, but also has more obvious advantages in material consumption and environmental protection, in particular, it can realize the advantages of zero-concrete and zero-earthwork construction, greatly saving the project cost.

keywords: Desert area; spiral anchor foundation; Economy.

1. Introduction

The total area of desert in our country is about 700,000 square kilometers, and that of Gobi is more than 500,000 square kilometers.It is mainly distributed in the northwest,the north of North China and the northwest of Northeast China,and the northwest arid area is the most concentrated desert area in China, accounting for 80% of the total desert area.Xinjiang is the most widely distributed desert area,accounting for about 60% of the national desert,Gobi area.

According to the 14th five-year plan,China will build a large-scale clean energy base integrating wind, light,water, fire and storage during the 14th five-year plan period,as the top priority of China's new energy development during the 14th five-year plan period,the construction of large-scale wind and solar power bases, focusing on the desert, Gobi and desert regions,is accelerating,for example,provincial 750 kV transmission line projects and inter-provincial UHV transmission line projects are also closely distributed.Because of the particularity of the terrain,material supply and construction environment in desert area,the foundation selection has become an important factor affecting the construction schedule,difficulty and cost.

In 2022,the state grid corporation issued the“Infrastructure Technology[2022]No.14 document,which listed the spiral anchor foundation application as the recommended application technology,and required the application of engineering as far as possible.Compared with other foundation types in desert area,spiral anchor foundation has the advantages of convenient construction,high mechanization,material saving and quality assurance,and has the advantages of quick construction period and low cost,it is worth popularizing in the desert and Gobi regions.

2. Desert constraints on transmission line foundations

In the past, the tower foundation of power transmission line engineering in desert area was mainly the gravity foundation structure of cast-in-place reinforced concrete with large size.In the current“Technical specification for design of overhead transmission line foundation”,the Earth weight method is generally used in the design and calculation of uplift stability.However,due to the

lack of relevant research and field true test data,as well as the differences in the basic properties of eolian sand,the selection of uplift angle is difficult to grasp, especially,there is no clear regulation about tower foundation under heavy load in desert area.This leads to designers in the foundation design is inevitably too conservative and increase the size of the foundation,resulting in high material consumption and cost of the foundation.For the section with mobile dune,the design usually increases the depth of the foundation to ensure the safety of the foundation,which further pushes up the cost of the foundation.

The natural environment in the desert region is bad,the sand is dry and loose,and the self-independence is poor. When the foundation pit is excavated,it is often necessary to break in the retaining structure at the edge of the foundation range and reach the determined depth of the foundation before the excavation can be carried out,this undoubtedly increases the difficulty and cost of foundation construction.The harsh natural environment in the desert also brings great difficulties to the maintenance of cast-in-place concrete.The construction quality of the foundation has become one of the key factors for the safety of transmission lines in the desert area, it will not only affect the service life of the foundation,but also adopt the repairing measures such as bonding steel,enclosing steel or enlarging the foundation column.

Another problem of using cast-in-place reinforced concrete foundation for power transmission line in desert area is material source and transportation. The desert area is deserted,the traffic conditions are poor, and there is no water source.These objective conditions lead to the problems of long transportation distance of materials,tight water source,difficult construction,etc.,thus lead to high cost of cast-in-place foundation,poor applicability.

The main factors that restrict the foundation of transmission line in desert area are as follows:

(1) The desert area is sparsely populated and the transportation is inconvenient,which is not conducive to the large-scale application of commercial concrete.The cast-in-place concrete foundation is usually prepared on site, and raw materials such as sand, stone, cement and water need to be transported to the site, transportation workload,high cost；

(2) It is difficult to ensure the quality of the project because of the drought and water shortage in desert area and the difficulty of concrete field mixing and maintenance；

(3) In desert area,most of sand dunes are fixed and semi-fixed, and the geological conditions are mainly loose sand, the volume of Earth and rock increased more than the general geological conditions,increasing construction costs;

(4) After construction,wind-proof and sand-fixing measures should be taken to prevent the foundation from being buried or eroded by wind；

(5) The temperature difference in desert area is big,the construction in winter needs to take protective measures,and the working environment is bad,so the construction time should be shortened as far as possible.

3. The technical advantages of screw anchors

Spiral Anchor Foundation is a new type of foundation developed in recent years,as shown in Figure 1,the foundation is similar to a magnified screw,by applying torque into the soil, and then obtain sufficient pull-out and compression resistance, the utility model is an anchor structure which is composed of an anchor rod,an anchor plate, an upper platform,etc..As a kind of precast foundation,the Spiral Anchor Foundation has the advantages of high construction efficiency,high mechanization, energy saving and environmental protection,and can greatly shorten the construction period and reduce the project cost,it has been increasingly studied and popularized by relevant units in China.

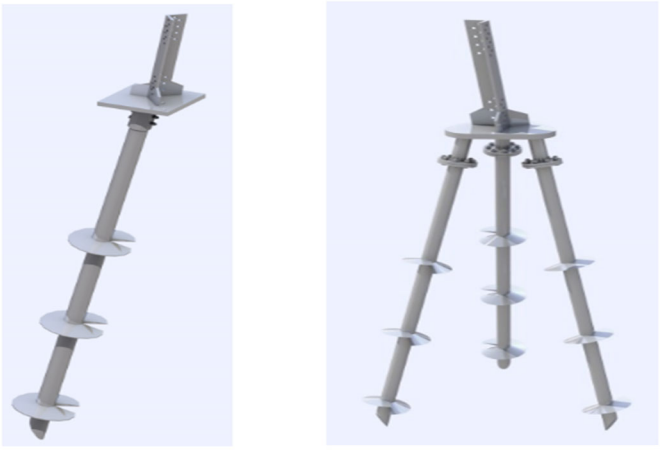

Figure 1. Inclined single screw anchor foundation and All-steel group screw anchor foundation with different inclined angles

Based on the analysis of transmission line construction demand and the characteristics of spiral anchor foundation in desert area,it can be concluded that spiral anchor foundation has a broad application prospect in desert area.The construction efficiency of spiral anchor foundation is high,the period is short,and no earthwork is produced.The bearing capacity of foundation is little affected by the erosion of the upper sand layer,and the structural components can be prefabricated in 100% factory,the quality of the foundation body is guaranteed,the joints are less connected,the construction and transportation are convenient,the field assembly is simple,the consumption of the foundation material is less, and the total steel structure can realize zero concrete consumption,it has remarkable social,economic and ecological benefits.It is feasible to adopt prefabricated foundation with spiral anchor in desert area,which can avoid the defects of common foundation and has unique congenital technical advantages.

4. Cost Calculation and economic analysis of screw anchors

4.1. The cost of the screw anchor foundation

The cost of the spiral anchor foundation includes the construction cost of the foundation and the test cost of the pile. The construction cost of the main body is divided into single anchor and group anchor, screw anchor installation and cap installation are listed, and the“Root”is calculated as the unit of measurement; The test fee for the pile shall be in accordance with the provisions of the standard for the power construction quota station of the State Grid Company Limited (GDFY-2023-04) , according to the different load grade F (unit: KN) and the different diameter d (unit: mm) of the single pile with screw anchor, the corresponding prices are given respectively.Therefore, the total cost of the screw anchor includes not only the cost of the project itself,but also the material and installation cost of the single anchor for the test 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.

4.2. Compared to the cost of a traditional base

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，

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.When the number of the designed spiral anchor foundation exceeds 9 bases in a project,it is more economical than the designed cast-in-situ slab foundation, it is more economical than the design of cast-in-place Pile Foundation.

5. Conclusion

Based on the analysis of the technical characteristics and economy of the spiral anchor foundation in desert area,the technical advantages and economic critical point of the spiral anchor foundation are put forward, the conclusions are as follows:

(1) Compared with the traditional foundation in desert area, the 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) Besides the installation of the spiral anchor and steel cap,the cost of the spiral anchor also includes the cost of vertical and horizontal static load test;

(3) Compared with the traditional foundation,the spiral anchor has an economic critical point under the consideration of the full cost. Different projects have different critical values due to different external conditions, which need to be calculated after Geological Survey and before foundation design;

(4) When the quantity of the spiral anchor used in a project exceeds the economic critical value,the steel spiral anchor has a comparative advantage over the traditional foundation in terms of time, cost,material saving, environmental protection, etc..

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