Theoretical study on the upper plate of assembled prestressed slab cable Foundation

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Abstract: According to the characteristics of mountain terrain, in response to the national grid proposed two new requirements, and actively carry out the bearing performance of the new foundation type in suitable conditions, research design method. In this paper, the theory of slab on the base of assembled prestressed plate is studied. The calculation of lower pressure stability, uplift overturning and horizontal anti sliding are analyzed

Keywords: load-carrying properties; Prefabricated prestressed cable Foundation; Down pressure stability; Uplift overturning; horizontal sliding

1. INTRODUCTION

As a new type of foundation in transmission line, prefabricated prestressed slab foundation has its own force characteristics. The stress process can be divided into: the upper plate mainly bears the pressure under the tower, prevents the lower pressure damage; the lower plate is connected by the anchor cable and the upper plate; the lower plate mainly bears the uplift force transmitted by the transmission tower under the action of the unbalanced tension of the conductor, so as to prevent the uplift damage. Assembly prestressed slab cable foundation is shown in figure 1. The width of the plate is B and the thickness is h. Because the foundation plate is mainly used to bear the under compression load, the influence of the lower plate and anchor cable can be ignored under the condition of the lower compression load, and the form of the upper plate is similar to a shallow foundation. Therefore, the design of prestressed anchor cable foundation can refer to the shallow foundation design. Axial load foundations indicate the cases where lateral load acting on a tower would be transferred as uplift and compressive loads on the individual foundations at each corner[1].

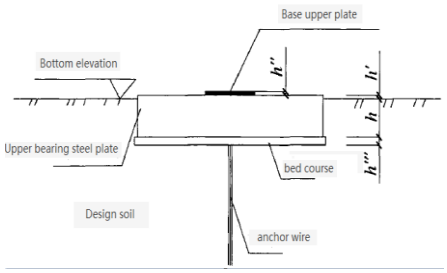

Fig.1 cable foundation of assembled prestressed plate

2. STABILITY CALCULATION OF THE UPPER PLATE UNDER COMPRESSION

When the prestressed anchor cable foundation is under the action of the lower compressive load, the foundation the upper plate is mainly used to bear the pressure, so that the earth pressure caused by the upper load is not too large, and the stability of the soil is required. The pressure of the upper plate should be checked according to the lower form:

(1) When axial load is applied:

$$p \le f_a \le \gamma_{if} \qquad (2\text{-}1)$$

Where:P---- Average design value of the upper plate foundation under axial load(kPa);

f_a —Eigenvalue of subgrade bearing capacity after modification(kPa);

γ_{if} — The adjustment coefficient of foundation bearing capacity should be 0.75.

(2) When the foundation the upper plate is subjected to eccentric load, it must comply with the requirements of the formula (2-1), but also comply with the provisions of the following:

$$p \le 1.2 f_a / \gamma_{if} \qquad (2\text{-}2)$$

Where: P_{max}—Maximum design value of the upper plate foundation under axial load(kPa);

f_a —Eigenvalue of subgrade bearing capacity after modification(kPa);

γ_{if} —The adjustment coefficient of foundation bearing capacity should be 0.75.

3.CALCULATION OF OVERTURNING STABILITY OF FOUNDATION THE UPPER PLATE

Due to the influence of wind load and earthquake

load, the upper structure of transmission tower will transmit a large horizontal force to the lower foundation, so the foundation should be checked against overturning. The action of soil above foundation should be simplified as the pressure equivalent to the soil weight. [2].

The embedment depth of the upper plate is relatively shallow, and the effect of the lateral soil pressure on the foundation is very small, Therefore, the lateral soil pressure is not taken into account when checking the overturning resistance of the slab, Under the action of the lower pressure, generally the moment on the edge of the slab is balanced by the upper plate gravity and the upper vertical force of the upper plate.

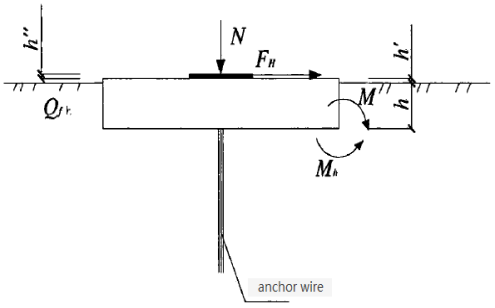

Fig. 2 Calculation sketch of overturning of foundation upper plate under compression

Fig. 2 is the calculation sketch of the overturning of the upper plate under compression, Referring to the relevant provisions, the overturning stability checking method of the combined foundation of the iron tower shows that the overturning moment and the horizontal force provided by the upper plate of the foundation are calculated with the edge of the soleplate as the turning fulcrum, Thus, the calculation formula of overturning stability of the foundation plate is obtained.

When the depth of the upper plate foundation and the size of the floor are determined, the ultimate overturning moment Ma can be calculated according to the formula, and can be calculated respectively under the action of the two-way overturning moment:

$$M_h = \frac{(Q_{fa} + N)l}{2} \geq KF_H(h + h' + h'') \qquad (2\text{-}3)$$

Where: l — The length of the upper plate parallel to the overturning direction,m;

K — The safety factor of overturning stability can be determined according to table 1;

h — Embedded depth on the foundation,m;

h' — The upper panel of the foundation is exposed to height,m;

h'' — Height of steel plate, m。

Table 1 safety factor of overturning stability design

Tower type	Overturning stability K
Intermediate Tower	1.5
Tensile type	1.8
Corner type, terminal type and large span type	2.2

Whether it is long or short, the ultimate overturning moment of the foundation should be greater than the calculated overturning moment, otherwise the foundation will be in danger of overturning. When the foundation is subjected to the uplift force derived from the tower leg, the calculation diagram is shown in figure 3.

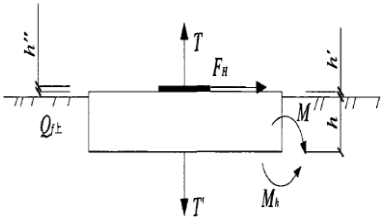

Fig. 3 calculation diagram of overturning when the upper plate is pulled out

When the lower plate can provide enough pullout force, the upper plate of the foundation will not topple under the uplift condition. The edge of the base plate at the bottom of the upper plate is the fulcrum of rotation, which can be obtained according to the moment equilibrium:

$$T' = T - Q_{fa} + 2F_H(h + h' + h'')/l \qquad (2\text{-}4)$$

When the upper plate of the foundation is subjected to biaxial eccentric loading, the following formula can be used to calculate the T':

$$T' = T - Q_{fa} + 2F_x(h + h' + h'')/l + 2F_y(h + h' + h'')/b \qquad (2\text{-}5)$$

4. HORIZONTAL ANTI SLIDING CALCULATION OF FOUNDATION PLATE

In general, the lateral resistance is rarely considered in the design of shallow foundation of buildings, and the lateral allowable force of the foundation is considered only when the pile foundation is deep buried. But the prefabricated prestressed anchor plate foundation belongs to shallow foundation, which is different from the ordinary shallow foundation. Therefore, the calculation of anti sliding is very necessary for the assembly of prestressed anchor cable Foundation.

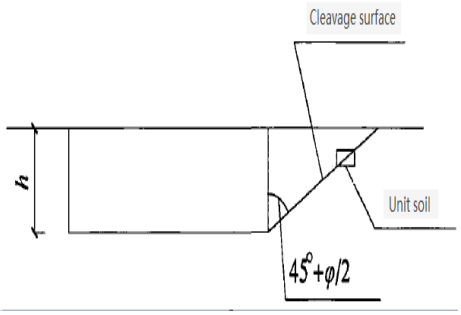

Fig. 4 passive earth pressure calculation diagram

At present, there is no specific regulation for the horizontal anti slide checking of the foundation similar to the foundation slab, so we should first analyze theoretically the ability of the lateral soil to resist the horizontal force of the upper plate.

The reference of passive earth pressure of retaining wall calculation principle, when the upper part of the

foundation plate under horizontal load, horizontal displacement occurs, the upper part of the foundation plate and the soil when reaching the limit displacement, appear as in Figure 4 a slip surface will be in the soil, according to the strength theory of soil, two principal stressσ1 andσ3 should meet the following formula:

$$\sigma_1 = \sigma_3 \tan^2(45^\circ + \phi/2) + 2c\tan(45^\circ + \phi/2) \quad (2\text{-}6)$$

$$\sigma_3 = \sigma_1 \tan^2(45^\circ - \phi/2) - 2c\tan(45^\circ - \phi/2) \quad (2\text{-}7)$$

When the upper plate of the foundation is subjected to uplift force and horizontal force, the upper plate edge and soil are squeezed to appear passive Lang Jin state. The vertical stress of Z at any depth of the soil around the upper plate member has been changed into small principal stressσ3, while the horizontal stress σx is the major principal stressσ1. In the same way by type (2-6) and type (2-7) based around the upper plate of passive earth pressure strength

$$\sigma_p = \gamma z K_p + 2c\sqrt{k_p} \quad (2\text{-}8)$$

Where:Kp — coefficient of passive earth pressure

$k_p = \tan^2(45^\circ + \phi/2)$

The total passive earth pressure of unit width is

$$E_p = -\gamma h^2 K_p + 2ch\sqrt{k_p} \quad (2\text{-}9)$$

Where:h — embedded depth of foundation,m;

γ — Soil gravity, kN/m^3;

c — Cohesive force of soil mass, kN/m^2.

When the upper plate of foundation is subjected to horizontal force, horizontal displacement occurs, and when a limit displacement is reached, a sliding surface, such as figure 2-4, appears in the soil. Referring to the calculation formula of anti sliding stability of retaining wall in the relevant design of transmission tower foundation and the formula of anchor wall in the design specification of retaining wall, the checking formula of anti sliding stability of the upper plate is as follows:

Long side length of base plate:

$$\frac{E_p b}{H_{x\max}} \geq 1.3 \quad (2\text{-}10)$$

Short side length of base plate：

$$\frac{E_p b}{H_{y\max}} \geq 1.3 \quad (2\text{-}11)$$

Where：

$H_{x\max}$, $H_{y\max}$ —Horizontal force design values in two directions when the upper part of the upper part is pulled up by the uplift force, kN;

b — Width of foundation upper plate, m;

l — Length of base plate, m.

5. CONCLUSIONS

(1) The overturning moment and horizontal force provided by the upper limit of the slab on the assembled prestressed slab foundation are calculated with the bottom edge of the slab as the rotating fulcrum;

(2) Calculation principle of passive earth pressure on retaining wall based on horizontal anti sliding calculation;

(3) The main stress and overturning force of the upper part of the assembled prestressed plate foundation are mainly subjected to the lower pressure and the overturning force.

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