Experimental study of assembled foundation of partially prestressed RPC pole

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Abstract. This project relies on the science and technology project of Fujian electric power co., LTD., to develop a new type of high-strength concrete pole and design a supporting assembly-type foundation. The true type test is carried out in the pilot project to verify the stability of the assembled pole foundation and analyze its mechanical performance. The experimental analysis proves that the assembled foundation of this project has good mechanical performance and can be widely used in the construction of distribution network.

1. Anti-overturning checking method of pole foundation
According to DLT 5219-2015, the anti-overturning calculation of pole foundation was carried out.

1.1. Pole base without chuck
For pole foundation without chuck, the ultimate overturning force or ultimate overturning moment should meet the requirements of the following formula after the foundation burial depth is determined[1].

\[ S_i \geq \gamma_i S_e \]  
\[ M_i \geq \gamma_i H_s S_e \]  
\[ S_i = \frac{mb_h^2}{\eta \mu} \]  
\[ M_i = \frac{mb_0 h'}{\mu} \]  
\[ \eta = \frac{H_0}{h} \]  
\[ \mu = \frac{3}{1 - 2\theta^3} \]  
\[ \theta = \frac{r}{h} \]

1.2. Pole foundation with chuck
When the upper chuck is installed at 1/3 of the buried depth of the foundation, the calculation diagram is shown in Figure 1[2].
Figure 1 Basic calculation diagram with chuck

Calculate the transverse pressure of the chuck and determine the chuck length:

\[
P_t = \gamma S_0 - mh_t \left( \theta^2 - \frac{1}{2} \right)
\]

\[
L_u = \frac{P_t}{y_1(m\phi + 2\phi_i \tan \beta)}
\]

\[
L_u = L_u + b
\]

1.3. Assembled basic design

The size and reinforcement of the new assembled foundation are shown in Figure 2.

2. Experimental study on the anti-overturning performance of the new prefabricated foundation

2.1. Specimen preparation

The concrete adopts C60 concrete, the steel bar adopts 8mm and 6mm steel bar, the diameter of connecting bolt is 24mm, the length is 240mm. The specimen mould is made of steel.
2.2. Test purpose
The mechanism of overturning and instability of a new prefabricated chuck pole was studied by prototype test\[^{3}\].

The anti-overturning performance of new prefabricated chucks with different loading directions was studied by prototype test\[^{4-5}\].

The influence of chucks at different positions on the anti-overturning performance of foundation was studied by prototype test.

2.3. Test contents
The chuck is located at 1/3 of the buried depth of the foundation and the overturning test is conducted with the loading direction of 0 °.

The chuck is located at 1/3 of the buried depth of the foundation and the overturning test is conducted with the loading direction of 45 degrees.

The chuck is located at the bottom of the foundation and the loading direction is 0 degree.

2.4. Test plan
A 6m pole with a tip diameter of 150 and a 4.5m pole with a tip diameter of 230 were used in the prototype test.

(1) loading device: the reaction device adopts a loader with four wheels stuck, and USES inverted chain hoist to load step by step.

(2) Measuring equipment: 2 displacement meters, 2 static resistance strain meters, 12 earth pressure boxes, wires, force sensors, load meters, tape measures, tape measures.

(3) Loading procedure: the method of loading is adopted step by step. The load of the upper stage is applied, and the load of the lower stage is applied after the foundation is stabilized. The load of each stage is 1/10 of the estimated load. Load termination condition: the applied load cannot continue to increase, or the foundation displacement increases rapidly (the foundation displacement is more than 5 times of the previous foundation displacement). Ultimate load value: the load of the previous stage at the end of loading. The layout of the loading test site is shown in Figure 6.

2.5. Test process and phenomenon
As the load is applied, the pole is slightly inclined, the soil in the front of the pole is cracked first, the soil in the front is arched, the rear of the pole is gradually detached from the soil, and the detachment depth gradually increases. When the new type chuck is located at 1/3 of the electric pole, its anti-overturning ability is similar to that of the traditional chuck. However, the new type chuck has the anti-overturning capability that meets the requirements in all load directions. The Angle of the chuck can be adjusted according to the actual situation during installation. When the new chuck is located at the bottom of the pole, the bearing capacity is greatly improved.

2.6. Test data and analysis
Will be fabricated base floor direction is defined as 0 degrees direction, for prefabricated foundation in foundation embedded depth of 1/3, respectively 0 degrees direction and the direction of the load, 45
degrees for the embedded depth of foundation at the bottom of the fabricated based on 0 degrees direction load, located at the base of the foundation buried depth is equivalent to the basis of independent foundation of assembly. The applied horizontal load, tilt rate, anti-overturning bending moment and other data are shown in Table 1, Table 2.

Table 1 Anti-overturning test data of assembled chuck when load direction is 0°/45°

| Ordinal number | Applying horizontal load (kN) | Tilting rate (%) | Anti-overturning bending moment (kN·m) | Ordinal number | Applying horizontal load (kN) | Tilting rate (%) | Anti-overturning bending moment (kN·m) |
|----------------|------------------------------|-----------------|----------------------------------------|----------------|------------------------------|-----------------|----------------------------------------|
| 1              | 0.87                         | 0.033           | 2.61                                   | 1              | 0.55                         | 0               | 1.65                                   |
| 2              | 1.81                         | 0.133           | 5.43                                   | 2              | 1.09                         | 0               | 3.27                                   |
| 3              | 2.81                         | 0.166           | 8.43                                   | 3              | 1.62                         | 0.033           | 4.86                                   |
| 4              | 3.64                         | 0.2             | 10.92                                  | 4              | 2.25                         | 0.033           | 6.75                                   |
| 5              | 4.37                         | 0.2             | 13.11                                  | 5              | 2.76                         | 0.1             | 8.28                                   |
| 6              | 5.15                         | 0.233           | 15.45                                  | 6              | 3.25                         | 0.2             | 9.75                                   |
| 7              | 5.99                         | 0.267           | 17.97                                  | 7              | 3.79                         | 0.233           | 11.37                                  |

Table 2 The anti-overturning test data of assembled foundation when the load direction is 0°

| Ordinal number | Applying horizontal load (kN) | Tilting rate (%) | Anti-overturning bending moment (kN·m) | Ordinal number | Applying horizontal load (kN) | Tilting rate (%) | Anti-overturning bending moment (kN·m) |
|----------------|------------------------------|-----------------|----------------------------------------|----------------|------------------------------|-----------------|----------------------------------------|
| 1              | 0.44                         | 0               | 1.32                                   | 8              | 4.15                         | 0.2             | 12.45                                  |
| 2              | 0.76                         | 0.033           | 2.28                                   | 9              | 4.98                         | 0.233           | 14.94                                  |
| 3              | 1.12                         | 0.033           | 3.36                                   | 10             | 5.7                          | 0.3             | 17.1                                   |
| 4              | 1.52                         | 0.067           | 4.56                                   | 11             | 6.29                         | 0.4             | 18.87                                  |
| 5              | 1.92                         | 0.067           | 5.76                                   | 12             | 6.74                         | 0.567           | 20.22                                  |
| 6              | 2.65                         | 0.1             | 7.95                                   | 13             | 7.88                         | 1.133           | 23.64                                  |
| 7              | 3.38                         | 0.133           | 10.14                                  | 14             | 8.31                         | 1.467           | 24.93                                  |

3. Conclusions and recommendations
By test data can be seen, the traditional chuck after installed on pole, against overthrow the increase of ability is limited, if you want to have a better ability to resist capsizing can be installed at the same time, chuck, prefabricated chuck on the ability to resist overturning limit 3-4.5 times that of traditional chuck, and cross sectional ability to resist overturning when chuck under loads in various directions, and traditional chuck only two directions can play a better ability to resist capsizing, visible cross sectional chuck in the construction of chuck installation direction when installation requirement is not high, can also be used for Angle pole, tension rod have special requirements such as pole. When the cruciform chuck is installed at the bottom of the foundation, the anti-overturning ability is similar to that of the independent foundation. The cruciform chuck is equivalent to the independent foundation that can be assembled, which saves the process of supporting molds in the construction site and provides convenience for the construction.

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