

## Upgrading and Application of Small-sized Drilling Rig in the Protection of Transmission Tower near Deep Foundation Pit

SHAO Guang Biao<sup>1, a\*</sup>, WANG Hua Juan<sup>2, b</sup>

<sup>1</sup>Shandong JianZhu University, Jinan 250100, China

<sup>2</sup>Shandong Electric Power Engineering Consulting Institute corp., Ltd., Jinan 250013, China

<sup>a</sup>sgbou@126.com, <sup>b</sup>wanghuajuan@sdepci.com

**Keywords:** transmission tower; foundation pit; foundation underpinning; micro-pile; drilling rig.

**Abstract.** The small-sized drilling rig such as XY-100 is widely used in survey engineering. With the development of underpinning technique, more and more micro-pile should be drill near buildings and structures. The higher rig shelf should be upgraded for suit with limited space. The excavation of deep foundation pit lead to security risks when high voltage transmission tower near the pit. Based on the foundation underpinning technology and the deep foundation pit supporting method, a reinforcement design method is proposed for transmission tower foundation near deep excavation. In the method, the shallow foundation of tower is transformed into pile foundation firstly using micro-pile which transfer the loads to the deep soil layer. Then using micro pile composite soil nailing wall supporting technology to support for the vertical excavation of deep foundation pit. The micro-piles are drilled using the upgrading drill rig and the protection engineering achieved success.

### Introduction

With the speeding up of urbanization in our country, all kinds of civil construction and public transportation infrastructure increases rapidly, the development and utilization of underground space is increasing in the city, and some of the engineering construction approaches for high voltage transmission tower, foundation pit excavation in underground engineering construction is easy to cause deformation of soil, leading to differential settlement of the transmission tower, to the overall stability of the transmission tower and large transmission security hidden danger, even catastrophic consequences.

Transmission tower of 110kv line is located in Jinan, near the new municipal engineering excavation line parallel to the basic line horizontal distance is about 1.5 m, excavation depth is about 8.0m under natural ground and no slope space. Due to urgency and narrowly limited time schedule, the corner transmission tower should be protected when foundation pit excavation.

Transmission tower foundation generally designed with four independent shallow foundation, two basic tensile, compression of two base. Poles foundation uneven settlement or deformation caused large tower tilted will be induced near the excavation of foundation pit, which will threaten the normal use of transmission lines. In some practical projects for transmission lines to move and that required a longer period and a higher project cost. This paper take advantage of micro pile (also called the root pile, mini-pile) technology of underpinning reinforcement [1], guarantee the stability of transmission tower foundation and take its load transfer to the lower soil layer. According to the characteristics of transmission tower, the large construction equipment are limited in this protection engineering, the small-type drill rig is upgraded and flexibly worked for micro-pile near the power tower. With the help of upgraded drill rig, the joint use of root pile for foundation underpinning technology, and composite soil nailing support for foundation pit excavation in the protection of the transmission tower provides a reliable design method.

### Transmission tower foundation underpinning technique

Foundation underpinning is the foundation of original structure reinforcement and change, to improve the basic work state, such as uneven settlement, the structure of the building when the load

increases, etc. Transmission tower generally adopts the cast-in-place reinforced concrete shallow foundation. Top form additional load are appeared near the excavation and bad for foundation pit slope stability. A certain corner tower foundation arrangement as shown in figure 1. with the help of foundation underpinning technology, the additional loads can transfer to deeper soil layer and at the same time is conducive to the settlement and deformation control of the transmission tower foundation.

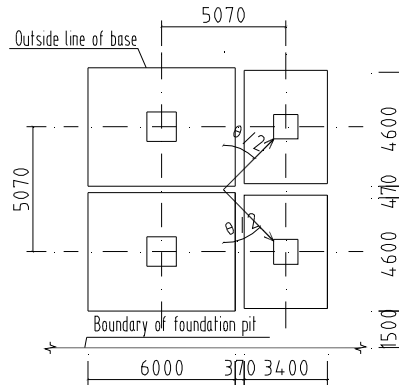


Fig. 1 The plan of corner tower foundation

Certain particularity and difficulty had existed in transmission tower foundation underpinning: (1) under the operation of the transmission tower operation and high safety requirements, large-scale construction equipment operation is highly restricted; (2) reducing as far as possible on the original foundation and the vibration of the foundation, to avoid affect the running of the transmission tower. Therefore foundation underpinning of tower should be given sufficient consideration of construction technology and machine of pile type selected to meet the above conditions.

Micro pile technology on the basis of the transmission tower in the research focus and get more engineering application in recent years [2, 3]. Micro pile is a kind of small diameter pile, using pressure grouting process machinery into a hole, the diameter is less than 350mm, generally pile length not exceed 30m. The pile can be used in a variety of arrangement of the straight pile and inclined pile, construction fast, operation space is small compared with the ordinary pile etc. And mainly used in ancient buildings protection, foundation underpinning and bracing engineering of deep foundation pit. So when transmission tower foundation underpinning by micro-pile program can better solve the above problems: (1) micro pile construction machinery is simple, can use small drill to pore-creating within the plane size 1.5 m \* 2.5 m and 2.5 m headroom. The small rig should drill a hole through the concrete foundation and other soil layer, and strong adaptability to the surrounding environment; (2) the pile hole diameter is small, pore forming process on the original foundation and foundation soil almost do not produce additional stress, noise and vibration caused by the construction is very small, and does not affect the normal use of transmission tower; (3) Upper load force can be downward clearly. Meanwhile the soil mechanical characteristics can be improved through the secondary high pressure grouting, which can effectively improve the bearing capacity of single pile and the ability to resist overturning. Fig. 2 is schematic diagram of transmission tower foundation underpinning by micro pile, micro pile can be used directly or inclined piles, pile top and planting bar foundation through the new cap and achieve effective connection.

When underpinning using root pile, pile can be thought of not effect during construction. But after the underpinning construction, base even produce minimal subsidence, micro pile will force quickly and take part of the structure load, at the same time reduce basal force on soil layer. If structure continues to sink, micro pile of load will increase gradually, until all the load borne by the micro pile.

Because of the tiny pile diameter is small, bearing capacity of friction pile can be calculated only when all pile in the soil. The compressive bearing capacity of single pile can be calculated by Eq.1.

$$P_{up} = U \sum_{i=1}^n L_i q_{sik} \quad (1)$$

In the formula:  $U$  is the circumference of pile body;  $L_i$  is the depth of the  $i$ th layer of soil;  $q_{sik}$  is the limit of soil lateral resistance standard, when the second high pressure grouting, the value of  $q_{sik}$  increased reference to JGJ94-2008 tables 5.3.10.

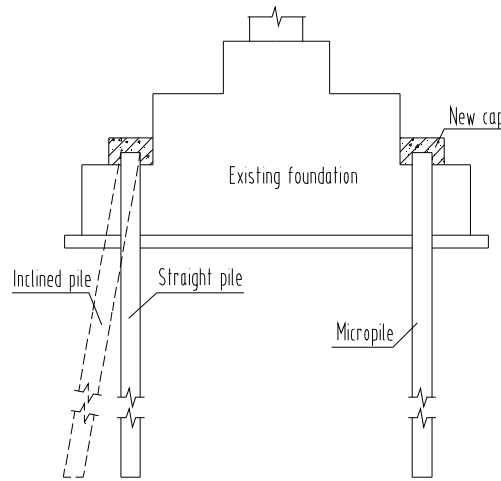


Fig. 2 Foundation underpinning with micro-pile

### Miniature pile composite soil nailing wall supporting technology

Foundation pit supporting type is more, such as pile-anchor bracing structure, inner supporting structure and soil nailing wall structure. The soil nail wall supporting are consisted by the in situ soil, soil nailing and concrete surface. Through soil nail, the surface layer and the common role of undisturbed soil, formed on the basis of the active restriction mechanism of complex, has greatly improved the structure of the slope soil strength and resistance to deformation ability, decrease the lateral deformation of soil, enhance the stability of the overall characteristics. When no slope space or limited to constructed the scheme of composite soil nailing wall is used. The composite soil nailing wall is a kind of composite supporting system in which the soil nailing wall united and one or more of the following individual supporting technology, such as pre-stressed anchor, waterproof curtain, micro pile, etc. Typical miniature pile composite soil nailing support section as shown in fig. 3.

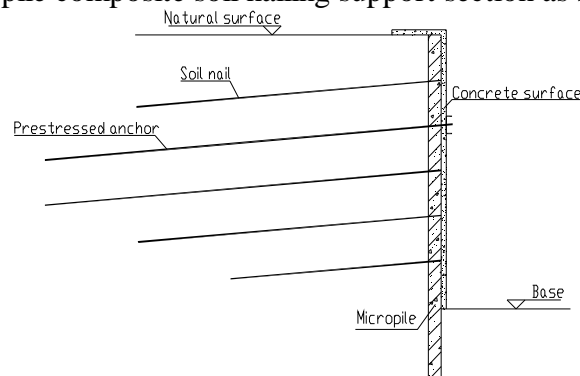


Fig. 3 Micro pile composite soil nailing profile sketch

Miniature pile composite soil nailing wall has flexible, wide applicable range, low cost, short construction period and the characteristics of safe and reliable. In practical engineering, the composite soil nailing wall in all kinds of technology according to the organic combination of engineering need to be flexible, so that the construction is simple, economic and reasonable, comprehensive performance is outstanding, and deformation and the overall stability of the slope can meet the requirements.

### Design example

**Engineering geological profile.** According to the survey report, the proposed site belongs to the alluvial plain of sand silted geomorphic unit, the root cause of the formation is mainly for quaternary alluvial loam. The soil layer affected foundation pit engineering mainly include: (1) layer of grain filling,

yellow-brown, main composition of ash, gravel and clay, the average thickness of 2.13 m; (2) layers of clay, yellow-brown, plastic, toughness and dry strength of medium, accidentally see sand and shells, the average thickness of 4.19 m; (3) layer and the clay, taupe, plastic ~ hard plastic, toughness and dry strength of medium, the iron manganese impregnation, occasional loess-doll and shell, the average thickness of 3.38 m; (4) layer and the clay, brown yellow, plasticity, toughness and dry strength of medium, the iron manganese impregnation and tuberculosis, about 5~25% loess-doll, particle size of 2 ~ 5 cm, the average thickness of 5.24 m. Site groundwater type quaternary pore water, the water level during the exploration depth of 10.50 ~ 13.81 m.

**Tower foundation reinforcement design.** According to Eq.1 and soil parameters according to the survey report, pile diameter is designed for 220 mm, built-in 140 mm diameter, wall thickness 5 mm steel tube, when the effective pile length is 15 m, the bearing capacity characteristic value of up to 264kN, design value of single pile bearing capacity characteristic is 250kN and satisfy the pile body material compressive strength of normal section. And basis weight of the upper structure load calculation, each independent foundation base load about 1400kN, so 6 steel pipe piles should be arranged. Pile arrangement and local section as shown in Fig. 4, due to a quarter of the independent foundation is located inside the tower frame, for the construction inconvenience and considering asymmetric effect, set up five straight pile, two inclined pile, total of 7 piles, tower based load effectively to ensure that the lower soil.

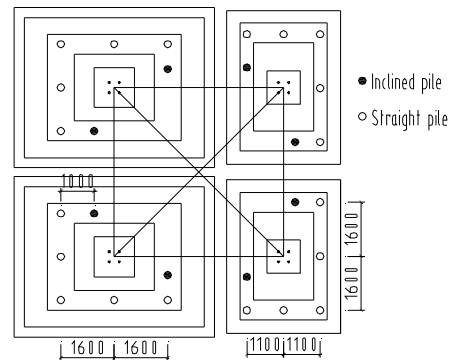


Fig. 4 Transmission tower foundation underpinning arrangement

**Miniature pile composite soil nailing design.** After determining the Angle tower foundation reinforcement scheme, soil lateral deformation due to foundation pit excavation and support design of the foundation pit should be considered. In view of the construction site restrictions, vertical slope excavation of foundation pit be adopted, using micro pile composite soil nailing wall supporting scheme, micro pile diameter 180mm, same as the underpinning pile body material, but no need for secondary grouting. Miniature pile built-in depth of 2.0 m, 0.75m horizontal spacing; Supporting profile setting anchor 2 rows and 2 rows soil nailing, their horizontal spacing of 1.5m, and the horizontal angle of 15°. Anchor need to set up the waist beam tension to control the deformation of the foundation pit wall. Supporting design section as shown in Fig. 5.

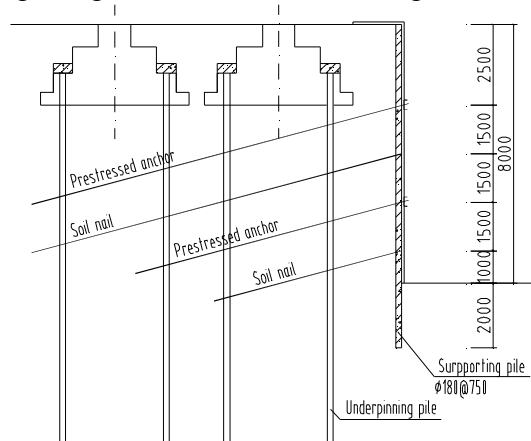


Fig. 5 underpinning technology combined composite soil nailing support section

The stability of composite soil nailing wall integral calculation is not consider tower loads and its overall stability coefficient are more than 1.3, satisfied with the relevant specification requirements. In the subsequent engineering construction, the upgraded drill rigs are used for boring for underpinning pile and supporting pile, which provides guarantee to finish on time for the municipal engineering.

### **Summary**

Based on miniature pile foundation underpinning and composite soil nailing wall supporting technology, the transmission tower foundation near deep foundation pit protected successfully using upgrading small-sized drilling rig. In design scheme: (1) the foundation underpinning design make full use of characteristics of micro pile, such as construction space requirements is low, the impact on both the structure characteristics of bearing capacity and clear, ensure the smooth implementation of the foundation underpinning, have created favorable conditions for the foundation pit excavation; (2) the foundation pit supporting design, fully consider miniature pile supporting role in advance, the use of composite soil nailing wall technology, guarantee the stability of the foundation pit slope.

Use of upgrading small-sized drilling rig to create micro piles for deep foundation pit of transmission tower foundation underpinning and the reinforcement design scheme of compound soil nailing, verified by practical engineering, to provide similar to the protection of the transmission tower design effective technical reference.

### **Acknowledgements**

This work was financially supported by National Natural Science Foundation of China (51008183).

### **References**

- [1] Y.G. Huang, F. Zhou, The application of the micro steel pipe piles in foundation reinforcement engineering, *Sichuan Architecture*, 26(2006) 76-77.
- [2] R.Z. Su, W. F. Zheng, X.L. Lu, Y.F. Cheng, Experimental on uplifting characters of micropiles of tower foundations in soft soils, *Electric power construction*, 12(2008)23-25.
- [3] D.P. Liu, Transmission line analysis of the application of micro-pile foundation, *Anhui electric power*, 2(2009) 35-38.