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Application of Raft Foundation in Transmission Line Engineering

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ABSTRACT. *According to the idea that the larger the area occupied by the tower base, the greater the load bearing capacity or the lower foundation bearing capacity required, the main design idea is to take the continuous slab or beam slab reinforced concrete foundation on the soil as the supporting point, and form a platform by setting the plate surface and pier to provide the support point for the tower foot, forming a new type of new type suitable for the high water level area with poor bearing capacity The foundation type is especially suitable for the tower location with limited tower location and insufficient bearing capacity, foundation excavation is very difficult, cast-in-place pile construction is difficult to solve or the economic performance index is not good. This paper studies the technical characteristics of raft foundation and the possibility of its application in this paper. Through the calculation and analysis of typical tower type, the economic and technical comparison with plate foundation is made. Finally, the application suggestions of raft foundation in this paper are put forward.*

KEYWORDS: *Raft foundation, Transmission line, Suggestions*

1. Introduction

Foundation design plays an important role in transmission line design. The construction period of foundation accounts for about half of the whole project, the transportation volume accounts for about 60% of the whole project, and the cost accounts for about 20% of the whole project [1-3]. Balleshwar Singh studied the load settlement characteristics of raft foundation under the interaction of foundation and pile foundation. The influence of pile number, soil modulus and raft thickness on the axial force distribution is analyzed[4].Soubhagya karmakar carried out a series of comparative parameter evaluations of load sharing and settlement characteristics[5].J. S.rajeswari studied the effects of different seismic parameters on the response and bending moment of raft structures[6].The mechanical behavior of raft supported oil tank on non liquefiable and liquefiable sand was studied[7].Therefore, the design and research of the foundation is of great significance to the whole transmission line.

For the proposed 220kV line project, the section along the route can be roughly divided into three types of landforms: low mountains and hills, river alluvial plain,

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micro geomorphic units such as hillock and floodplain, with slightly undulating terrain.

Among the above landforms, the geomorphic unit is located in low mountains and hills (hillock), with large topographic relief, flat terrain of mountain gullies, and ground elevation of 30-50m.The geomorphic unit is river alluvial plain; the terrain is flat and low, the ground elevation is generally between 15 and 25 meters, and the river network is relatively developed. The geomorphic unit is the floodplain and riverbed of the tributary of Dasha River;the terrain is relatively flat and low, generally between 20 and 30 meters,which is a river network system.The geotechnical engineering conditions of the line along the low mountains and hills section are good, and the geotechnical engineering conditions along the alluvial plain section are general, which are suitable for engineering construction, and can generally adopt natural foundation; the engineering characteristics of foundation soil in flood plain section are relatively poor, and its bearing capacity is relatively low.

According to the geological survey along the line, most of the rock mass in the low mountain and hilly area of the line is stable.When the mountain overburden is thick and loose gravel soil,the mountain is steep (or large free surface is formed by manual slope cutting),during the foundation construction or project operation, especially under the effect of rainwater, there may be a small amount of small area of landslide and other adverse geological processes, so slope protection, retaining wall, flood drainage ditch and Restoration of vegetation and other remediation measures to ensure the safety and stability of tower foundation.

In this paper, a new type of tower foundation is proposed. It is planned to make full use of the characteristics of low bearing capacity and abundant construction area in high water level area to form a tower foundation type suitable for special high water level, seriously restricted tower position, very difficult foundation excavation, difficult to solve the problem of cast-in-place pile foundation or poor economic performance index.

2. Research Contents

2.1 Conventional Tower Erecting Method in Special High Water Level Area

Due to the high water level, the bearing capacity of soil is weak. In order to reduce the excavation depth and the available land area is large, the stepped or slab foundation is generally adopted to adapt to the terrain change; when the bearing capacity is small and the foundation size exceeds the foundation section range, the cast-in-place pile foundation is generally adopted.

2.2 New Type of Raft Foundation with Special High Water Level

When it is located in the alluvial plain and floodplain section, the terrain is flat, the terrain is low, the river network and water system are relatively developed, and

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the buried depth of underground water level is generally between 1.00 m and 2.00 m, it is difficult to solve the problem of economy and convenience by considering the type of slab foundation or cast-in-place pile foundation. In this case, in addition to the connection type of cast-in-place pile, combined with the characteristics of the project, the following new types are recommended Type of foundation.The slab continuous raft foundation and beam slab raft foundation are shown in Fig. 2-1 and Fig. 2-2.

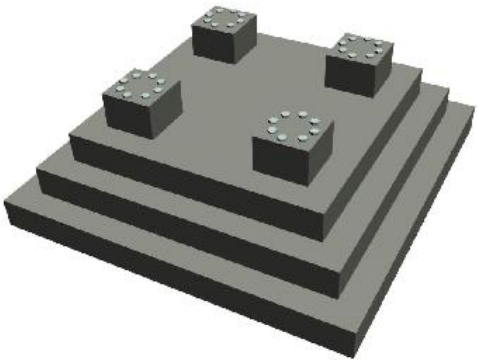

Fig.2 -1 Continuous Slab Raft Foundation

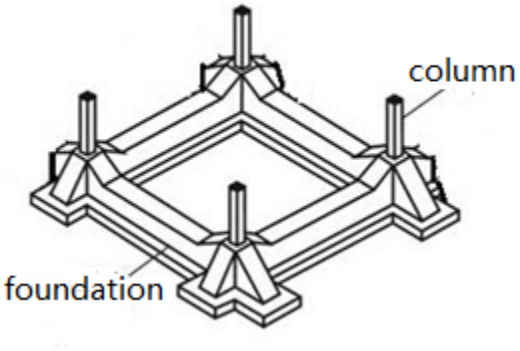

Fig.2 -2 Beam Slab Raft Foundation

2.3 Comparative Analysis of New Foundation and Conventional Cast-in-Place Pile Foundation

Compared with the connection type of cast-in-place pile, the design of tower leg of raft foundation at high water level is consistent, and earthwork excavation, foundation construction and later maintenance are carried out. If the groundwater

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level is shallow, the foundation construction of the tower will also face problems.

The raft foundation breaks through the conventional thinking, and the four leg foundation of the tower is designed as a whole. The load of the upper structure is transferred to the foundation through the main column. The stress is clear. Compared with the above conventional foundation types, the new raft foundation has the following advantages:

1)It mainly solves the problem of tower erection in high and high water level areas with poor geological bearing capacity and high groundwater level, and solves the problem of insufficient bearing capacity of tower plate foundation or cast-in-place pile foundation;

2)It is suitable for the geology where there are a lot of rocks in the underground layer, so it is not necessary to excavate and drill in large depth;

3)The construction is convenient, low risk, less damage to the environment, less waste rock and soil generated during construction, which is conducive to soil and water conservation and environmental protection;

4)Due to the large excavation area, multi-point construction can be carried out at the same time, and the air contact area is large, which is conducive to the maintenance of concrete, and can accelerate the formation of concrete strength, which can shorten the construction period;

5)The raft foundation has good integrity, high strength and strong ability to adjust the uneven settlement of the foundation, which is suitable for areas with soft geology and poor bearing capacity;

6)The drainage measures around the tower foundation are easy to construct and control, which is conducive to soil and water conservation;

2.4 Research Contents and Problems to Be Solved

The purpose of this paper is to study the tower location which is limited seriously, the foundation excavation is very difficult, the cast-in-place pile is difficult to solve or the economic performance index is not good. It is proposed to provide a new type of environmental protection foundation suitable for the above terrain, and establish the design calculation method of the new foundation.

3. Computational Analysis

3.1 Design Input

In this paper, JNRLH55/G3A-630/55type conductor is recommended, and OPGW-120optical cable is used for ground wire. Taking SZG2-33 tower type of double circuit tangent tower as an example, the foundation force table is shown in Table 3.1.

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Table 3 1 Force Table of Angle Steel Tower Foundation

Tower type	arm above ground (m)	Uplift foundation force (kN)				Foundation force under pressure (kN)				Foundation root (mm)
		Tmax	Nt	HX	HY	Nmax	Tn	HX	HY	
SZC2	33	432		53	44	-574		68	55	8239

3.2 Example Analysis

3.2.1 Analysis Method

The finite element analysis software is used to simulate the structure.

3.2.2 Material Selection

HRB335 and hpb300 steel are used as steel, the main beam is made of Φ 25 steel, the main board is made of Φ 16 steel, and the main column is made of Φ 20 steel.

The concrete strength grade of foundation is C25. The concrete strength grade of anchor bolt protection cap and foundation cushion is C15.

The base plate is 10mx10x0.5m, the beam is 1.5mx0.7m * 10m, and the column section is 0.6mx0.6m.

3.2.3 Combination of Working Conditions

The analysis results are as follows: the most unfavorable pull-up control and the most unfavorable down pressure control are selected

(1)A. D pull up, B and C press down

According to the above analysis, the maximum axial force of main beam is 336kN; the maximum axial force of diagonal brace is 322.68kN and-470.05kN. The maximum bending moment of 2-2 axis is - 35.06kN· m, that of 3-3 axis is - 366.26kN· m, that of 2-2 axis is - 352.37kN, and that of 3-3 axis is - 48.11kN.

It can be seen from the above analysis results that the maximum stress ratio of the structure is 0.85, and the structure is safe and reliable under the selected member section.

(2) C.D pull up, A and B press down

According to the above analysis, the maximum axial force of main beam is - 266.99kN; the maximum axial force of diagonal brace is 349.32kN; the maximum bending moment of 2-2 axis is - 35.42kN·m; the maximum bending moment of 3-3 axis is - 289.79kN·m; the maximum shear force of 2-2 axis is - 315.47kN; and the maximum shear force of 3-3 axis is - 48.01kN·m.

It can be seen from the above analysis results that the maximum stress ratio of

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the structure is 0.61, and the structure is safe and reliable under the selected member section.

Ⅰ.Foundation force

Na = 574.00 kN Nx = 68.00 kN Ny = 55.00 kN

Te = 432.00 kN Tx = 53.00 kN Ty =44.00 kN

Ⅱ.Geological parameters

Soil category: 3

Bearing capacity correction factor: 7 (width correction:0.30,depth correction:1.50)

Basic bearing capacity of foundation: internal friction angle of 90 kPa soil:φ=15°

Soil cohesion: C = 40kPa, foundation coefficient: M = 4000kN/m^4

Actual saturation of foundation soil:SR = 0.8

Number of soil layers: 1 (soil thickness: 5.00 m, soil weight: 17.00 kN /m3)

ⅢⅠ.Groundwater and weak underlying layer

The groundwater level is 1m.

There is no soft substratum.

Ⅳ. Others

Calculation type: optimized calculation; concrete weight: 22.00kN /m3

Additional partial coefficient of foundation: 1 (γf = 1.1)

----------Foundation size----------

Foundation buried depth:2500mm, main column outcrop:200mm

Height of main column:1200mm diameter of main column:1000mm

Plate height:400mm

Bottom plate width:10000mm

Beam height:1500mm

Front root opening:6626mm, lateral root opening:6626mm

----------Stability calculation----------

Foundation bearing capacity calculation:

Pmin>0(47.28kPa>0)

P < fa/γrf (158.06 kPa < 166 kPa)

Pmax < 1.2•fa/γrf (238.84 kPa < 265.6 kPa)

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----------Strength calculation----------

Ⅰ. Calculation of bearing capacity of normal section of main column:

Type of main reinforcement: HRB335 diameter of main reinforcement: 14mm diameter of stirrup:8mm

Cover: 40mm number of main reinforcement: 24 main reinforcement spacing: 124mm

Reinforcement ratio:0.4704%>0.4647%

(As = 2574mm2< 3695mm2= 24)

Ⅱ. Calculation of bearing capacity of bottom plate:

(154.16kPa <180.00kPa)

Ⅲ. Calculation of uplift shear capacity of base plate:

(136.41kPa <180.00kPa)

----------Concrete and ground bolt----------

Ⅰ. Concrete grade: C25

Volume of foundation concrete: 4.624 x 4 = 18.498 M3

Ⅱ. Grade of anchor bolt: 35; diameter of anchor bolt: 36 mm

(input area of ground bolt = 745 mm2> area of calculated ground bolt = 568mm2)

Number of anchor bolts: 4 x 4 = 16.

4. Economic Comparison and Analysis of Conventional Slab Foundation

For the convenience of comparison, the foundation force of the same double circuit straight-line tower is calculated and analyzed in the same tower foundation section and geological conditions. The buried depth of groundwater level is generally between 1.00m and 2.00m. Select the slab foundation and the new raft foundation of this topic for technical index comparison.

According to the example analysis, under the same geological conditions, compared with the slab foundation, raft foundation can save 3.2% of concrete, 4.5% of reinforcement and 1.8% of construction cost compared with slab foundation; for double circuit tower, it can save 3.6%, 4.5% and 2.7% respectively.

5. Construction Inspection

Mass concrete should use the same kind of cement, admixture, admixture and the same proportion. To improve the workability of concrete, reduce the amount of

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cement and reduce the heat of hydration, the amount of which should be determined by test. The quality of admixtures and admixtures shall comply with the provisions of the current national standard “standard for quality control of concrete” (GB 50164). The heat storage curing method should be adopted, and the temperature difference between inside and outside should not be greater than 25℃. The inclined plane thin-layer pouring and tamping should be adopted for pouring, and the natural flow should be used.

6. Research Conclusion

The raft foundation breaks through the conventional thinking, and the four leg foundation of the tower is designed as a whole. The load of the upper structure is transferred to the foundation through the main column. The stress is clear. Compared with the above conventional foundation types, the new raft foundation has the following advantages:

(1)It mainly solves the problem of tower erection in high and high water level areas with poor geological bearing capacity and high groundwater level, and solves the problem of insufficient bearing capacity of tower plate foundation or cast-in-place pile foundation;

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(4) Due to the large excavation area, multi-point construction can be carried out at the same time, and the air contact area is large, which is conducive to the maintenance of concrete, and can accelerate the formation of concrete strength, which can shorten the construction period;

(5) The raft foundation has good integrity, high strength and strong ability to adjust the uneven settlement of the foundation, which is suitable for areas with soft geology and poor bearing capacity;

(6) The drainage measures around the tower foundation are easy to construct and control, which is conducive to soil and water conservation;

By comprehensive comparison, the new raft foundation is recommended for 11 foundations in the area with high water level and weak soil bearing capacity.

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