Research on Control Measures for Sedimentation of Substation Site and Deformation of Retaining Walls

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Abstract: With the gradual acceleration of economic construction in China, the demand for electric power is increasing, and the state's investment in the construction of transformer station is increasing. However, after years of operation and use of transformer station, there will cause engineering problems in the substation result from the sedimentation of substation and the deformation of retaining walls, which affects the normal application. This paper researches the sedimentation of substation and the deformation of retaining walls, analyzes the factors and performance of the deformation of retaining walls, and puts forward the corresponding engineering treatment measures according to characteristics of the sedimentation of substation to effectively reduce the factors endangering the substation. In addition, this paper analyzes the main causes of the engineering problems such as the sedimentation of substation and the deformation of retaining walls.

Substation is the place to receive and distribute electric energy in the power system, which plays the role of voltage transformation and shunt. Each substation has its own role. When a certain transformer fails, it will cause power failure to the power supply object, and it will also have a negative impact on the whole power network. Therefore, it must be required that the quality of substation construction is high. With the gradual development of power system in China, many substations need to be built on the complex geological terrain [1]. The complex terrain causes many serious problems in the substation, such as the sedimentation of substation and the deformation of retaining walls. These problems affect the daily operation of the substation and the construction of Chinese power network. Therefore, it is necessary to research the sedimentation of substation and the deformation of retaining wall, and take effective measures to solve these problems.

1. Topography and Engineering Geological Conditions

The topography of substation site is a hill with a gentle top, which extends into the southwest as a whole with a slope of approximately 4 to 9 degrees. The terrain of substation site is wide and gentle hillside, the surface height is 490-500 m, and the relative height is 1-7 m. Due to the topographic characteristics of the site, the groundwater is mainly the flowing water between the rocks. The topography of the site is relatively independent [2] and there is a height difference of about 20m from the surrounding bottom surface. The main strata of the site are impervious clay and mudstone. Precipitation is the main source of bedrock fissure water and drains from top to bottom. The upper layer of the site is quaternary ice-water accumulation clay, the middle layer is residual clay, and the lower layer is cretaceous jiaguan formation purplish red mudstone and siltstone. Plain fill, clay 1, clay 2, and mudstone are the main strata of the site, of which clay 1 is usually yellowish brown with a certain humidity and hardness in a hard state. The upper part of its composition contains such minerals as iron, zinc and calcium in a yellow color, and the lower part is yellowish

brown mixed with a small amount of pebbles. There are obvious friction marks in the clay 1 stratum, the thickness is generally 1.8-6.3 m, and the stratum exists in the substation site. Clay 2 is purplish red in color with certain humidity and hardness, and contains silt rock. The state of the stratum has a certain correlation with the state of the bedrock, the thickness is 0.9-2.9 m, and its distribution is consistent with clay 1. Plain fill is mainly gray and brownish yellow in color with a certain humidity, but its structure is relatively soft. It is composed of rubble, bricks and clay, and the layer thickness is 2-5 m. Its main purpose is to fill the field, and the distribution area is the low part of the deformation area. The mudstone is purple in color with a thin layer of muddy siltstone, and the cracks in it are not expansive. The mudstone is soft and has obvious signs of weathering and is thicker. The total thickness of mudstone and strongly weathered layer is generally less than 2.5 m, and the distribution state is close to the horizon.

2. Characteristics of the Sedimentation of Substation and the Deformation of Retaining Walls

It can be observed that the road of the substation cracks and some depressions appeare, in which the maximum depth of the depression is 45 cm, the difference in depression is about 25 cm, and the backfill soil close to the retaining wall is subsidenced about twenty centimeters.

In this station, the distance between the surrounding wall and the outer retaining wall is about 3-7 m, and the deformation of the retaining wall appears and the cracks are large on the east and north sides. The main types of cracks are inclined, micro, slip, and through cracks. The width of the crack is 1.9-3.1 cm, among which the largest crack is 4.9 cm. The drainage at the retaining wall in the substation site is abnormal, and the drainage hole does not work.

Through cracks mostly appear at the corners of the wall, and the retaining wall slips in the direction of the right-angle side. The other right-angle side causes the cracking of the concrete material due to the excessively high tensile force, which causes the base to the top of the wall. The performance of a through crack is the appearance of a through crack from the base to the top of the wall. The crack patterns through the cracks are all the same [3], which is characterized by many micro cracks around the cracks.

Slip cracks are cracks caused by lateral sliding of the retaining wall in the direction of the free wall. Most of the crack patterns are cracks with the same width from the bottom to the top of the wall, and will not change with the height of the wall.

Inclined cracks are cracks caused by the inclination of the retaining wall in the direction of the free wall. Most of the crack patterns are from the bottom to the top of the wall, and the width of cracks increases as the height of the wall increases.

Micro-cracks are the corner of the wall, and the cracking of the concrete material results in a small crack from the corner to the deformation joint [4]. The crack pattern is an inclined small crack from the corner to the deformation joint. The crack pattern is about 2 mm, which can be identified.

3. Cause Analysis and Control Measures

3.1 Cause Analysis of Sedimentation of Backfill

According to the actual measurement and research analysis, most of the backfill of the substation site is excavated clay, and there is no fine stone on the upper part of the soil layer. Due to different soil properties, the compressibility of clayey soil is larger than that of sandy soil. Due to the weak compressibility of sandy soil, it has better water permeability. After compression deformation, a stable stratum can be formed in a short time. The compressibility of clayey soil is larger, the water permeability is weaker, and the process of water passing through its pores and pressing deformation is slower, which is usually required to be long time to be stable. The time of substation construction is long enough, but it is still not stable and prone to deformation. The clay in the collection site is analyzed for its expansibility through civil engineering test. During the test, it is found that the clay gap is gradually narrowing, and its development direction is horizontal expansion and vertical expansion. The expansion coefficient indexes measured by Clay 1 are: the expansion force is 40.5

Pe/kPa, the contraction coefficient is 0.47 CsL /%, the natural water content at 1 m under the ground is 24.15 w /%; the expansion force of Clay 2 is 40.5% Pe/kPa, the contraction coefficient is 0.32 CsL /%. There is a certain relationship between the groundwater level and the sedimentation of the site. With the decrease of the groundwater level, the sedimentation of the site is gradually accelerating. The main source of groundwater is rainfall. A large amount of rainfall will make the groundwater level rise, which indirectly leads to the sedimentation of the site. To sum up, there are many factors that affect the sedimentation of the substation site. The sedimentation takes place for a long time and its stability is low.

3.2 Cause Analysis of Deformation of Retaining Wall

The main problems of retaining wall are sliding, inclining and abnormal drainage hole. The soil quality and drainage of the site cause the retaining wall to slide and tilt. The occurrence of the site backfill is relatively soft, which is prone to uneven sedimentation. At the same time, the uneven site settlement changes the site slope, which makes the site drainage deviate from the planned position, so that the surface water can not be discharged according to the planned direction. As a result, the surface water on the site flows back into the backfill. The soil in the backfill of the site is mostly clay, which has good water absorption capacity. When the surface water of the site seeps into the backfill, the sedimentation occurs in the soft area of the backfill. When the rainwater seeps down, it appears behind the retaining wall, but it can't flow out along the drainage outlet. The rainwater seeps along the base of the wall, causing the base of the wall to be in the state of expansion all the time. The seeping water produces the buoyancy to the bottom of the retaining wall, reducing the stability of the base and the shear resistance of the base together with the friction of the base. Consequently, the deformation of retaining wall is occurred. In addition, when the infiltrated surface water appears behind the retaining wall, the underground water level behind the retaining wall is higher; forming a larger pressure, generating thrust on the retaining wall, and the underground water level will affect its stability, resulting in the deformation of the retaining wall. In the actual project, many factors will not be considered as in the study. When the backfill behind the retaining wall has high water content, the internal pressure will increase [5], and the cohesive force and internal friction force will decrease, which leads to the sliding of the retaining wall and increases the probability of inclination. To sum up, rainfall is the main reason for the deformation of retaining wall. On the one hand, rainwater infiltration causes the base of the retaining wall to be in an expansive state, resulting in a lower stability of the base of the retaining wall; on the other hand, the increase of the internal pressure of the backfill leads to a greater stress on the side of the retaining wall; finally, rainfall causes a higher expansion strength of the clay under the base of the retaining wall and results in buoyancy, reducing the friction of the base. The comprehensive effects of these aspects make the retaining wall deform too fast and reduce the stability of the retaining wall.

3.3 Control Measures

According to the above research, we can know the factors that affect the sedimentation of substation and the deformation of retaining wall. Although the clay in the backfill soil of the site has been consolidated for decades, it is still easy to cause penetration, tilting, and sliding cracks in the retaining wall of the substation. The sedimentation and road cracking of the backfill in the station can not cause harm to the safety and stability of the substation, but the potential risks must be paid attention to [6]. During the treatment, without affecting the daily application of the substation, the construction of gravel should be applied to the backfill soil sedimentation of the substation site for landfill treatment, and the landfill backfill soil should be further processed by road rollers and graders. For the abnormal drainage in the site, a ditch is established to guide. In view of the deformation of retaining wall, an effective drainage system is established to increase the stability of the retaining wall, and anti-slide piles are added to strengthen the retaining wall.

4. Conclusion

In summary, the substation plays a key role in the power system, and a stable site is the key point

to ensure the normal operation of the substation. Therefore, it is necessary to carry out reasonable control measures in accordance with the project, find the main factors of the problem, and take corresponding measures to govern it. The analysis of this project shows that the deformation of the site is caused by the expansion of the clay, the roads in the station crack and sags appear, causing rainwater to seep into the backfill of the site and causing the site to settle. It can be found that it is a vicious cycle process. The subsidence of the substation causes rain in addition, the poor drainage system results in excessive stress on the side of the wall, reducing the anti-slip ability and stability of the retaining wall and making the retaining wall slip and crack. The settlement of the backfill soil on the site is the main factor affecting the deformation in the substation, so the quality of the backfill soil must be guaranteed, and the quality of the backfill soil must be strictly monitored. In addition, it needs to weaken the impact of field topography changes on substations, carry out corresponding system repairs, increase the fixing and protective measures for retaining walls, and finally establish a corresponding management mechanism. Moreover, it is necessary to regulate the site settlement and deformation of retaining walls in substations to improve the standardization of its governance.

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