Underground Structure Foundation Pit Precipitation in the Diving Area on the Surrounding Deformation

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Abstract: This paper mainly studies the simulation of underground structure foundation pit precipitation on the surrounding building settlement and its influence on the surrounding deformation. Based on the actual precipitation case of the foundation pit in the permeable layer of the diving area, this paper uses the Midas GTS finite element analysis software to establish a three-dimensional stress-seepage coupling model. The impact of foundation pit precipitation on the surrounding deformation, and the hazards of groundwater seepage to the foundation pit project are analyzed, the types and applicable conditions of foundation pit precipitation are summarized, the mechanism of the effect of foundation pit precipitation on the surrounding environment is theoretically analyzed, and the application is given. The calculation method of the ground precipitation caused by the precipitation, and for the problem that the formation parameters are too complicated, the mathematical model is used to predict the settlement of the surrounding buildings during the precipitation process. The research and analysis in this paper show that the settlement value of the soil outside the pit caused by precipitation accounts for about 35% of the total settlement value, the settlement value caused by excavation accounts for about 65%, and the error range between the simulated value and the monitoring value is -5.56% -11.12%.

1. Introduction

In order to ensure that the construction of the foundation pit project can be carried out safely and steadily, the groundwater around the foundation pit needs to be An artificial drop below the design elevation. However, during the precipitation of the foundation pit in the diving area, the design of the precipitation is not appropriate, which has caused many engineering accidents and seriously threatened the safety of the existing buildings and personnel near the foundation pit project. These problems have aroused widespread concern in the community.

Although experts and scholars at home and abroad have made detailed studies on the precipitation process of foundation pits in diving areas, in actual projects, engineering accidents

caused by improper groundwater extraction are everywhere. These accidents not only bring irreparable damage to citizens 'lives and property. The loss is more serious because the occurrence of the accident will have a very bad impact on the domestic and international community. In order to avoid accidents, the relationship between the seepage of groundwater and the stress of the soil needs to be paid attention to in the choice of precipitation schemes, the establishment of water-stop curtains, and the selection of soil layers in the design of foundation pit precipitation in diving areas. For the above reasons, in the dive area foundation pit precipitation process, the technical means are used to accurately predict the displacement of the existing buildings around the foundation pit to ensure that the surrounding environment safety during the foundation pit precipitation process in the diving area is worth continuing.

Wu Y established the consolidation analysis method of earth-rock dam based on the coupling of physical state, stress deformation and seepage. This method introduces a permeability coefficient model that considers the physical state and shear stress level, and combines it with Biot's consolidation theory to simulate the coupling relationship. Taking the Nuozhadu high earth-rock dam as an example, based on the pore water pressure observation data in the neural network, the parameters of the permeability coefficient model of the core material are back analyzed using the parameter back analysis method of neural network and evolutionary algorithm[1]. Based on the M language provided by the Comsol Multiphysics analysis platform, Liu Z H established a three-dimensional finite element model of the high arch dam. Taking actual engineering as an example, he compared the coupled seepage-stress field at normal storage levels with uncoupled conditions. The seepage, stress and displacement fields of the dam were analyzed to discuss the coupling problem. However, the comparative experiments are not diversified enough, so that the coupling problem has not reached the final conclusion [2]. Fareed H proposed an incremental algorithm to calculate the correct orthogonal decomposition (POD) of the PDE simulation data. Specifically, he modified Brand's incremental matrix SVD algorithm to adapt to the data generated by the time-dependent PDE's Galerkin-type simulation method. The algorithm is suitable for data generated by various PDE numerical methods, including the finite element method and the discontinuous Galerkin method. The algorithm initializes and effectively updates the main POD eigenvalues and modes within the time step in the PDE solver without storing simulation data. He proved that the algorithm without truncation can accurately update the POD. He used finite element calculation to demonstrate the one-dimensional Burgers equation and two-dimensional Navier-Stokes problem, and proved the effectiveness of the algorithm. However, too many approximations in partial differential equations make the answer obtained by orthogonal decomposition not so accurate [3].

This article takes the settlement of the foundation pit adjacent to the foundation pit in adiving area as the research object, and uses finite element calculation to focus on the main influencing factors in the precipitation process, namely the depth of the water stop curtain insertion, the precipitation speed, The effect of precipitation on the buildings around the foundation pit, and the building settlement observations are predicted using the MAPSO-LSSVM mathematical model [4]. The main work of the paper is as follows:

(1)Discuss the similarities and differences of various calculation methods in calculating settlement, combined with effective stress theory to analyze the settlement trend of buildings around the foundation pit during precipitation, and clarify the main factors affecting the settlement of buildings during precipitation [5].

(2)Relying on the actual precipitation project of the foundation pit in the diving area, using the Midas GTS software, using a reasonable constitutive model to simulate the actual precipitation process of the project example, and comparing the simulation results with the actual monitoring results. Similar numerical simulation modeling and parameter selection provide reference. Based on

the analysis of the settlement monitoring data of the buildings around the foundation pit during the precipitation process, combined with the results obtained by the Midas GTS software, the settlement rules of the surrounding buildings and the groundwater seepage rules during the precipitation process were analyzed [6].

(3)On the basis of modeling and analysis of engineering examples, assuming other working conditions, discuss the insertion depth of the water-stop curtain, the method of precipitation, the rate of precipitation, the choice of soil parameters and the depth of the well in the case of precipitation. The degree of settlement influence of the buildings around the foundation pit [7]. It will provide reference for the design and construction of foundation pit precipitation engineering in similar diving areas in the future[8].

2. Realization of Foundation Pit Precipitation Method

2.1. Effective Stress in Soil during Precipitation of Foundation Pit in Diving Area

For saturated soil, the main components are the soil skeleton composed of solid particles and the water filled in the gap between the soil skeleton. When an external force acts, part of the external force is borne by the soil skeleton. This part of the force is called effective Stress, effective stress is transmitted through the contact between particles [9]. The other part of the external force is borne by the pore water. The water in the pore bears the normal stress. This part of the force is called the pore water pressure. The transmission of the pore water pressure is transmitted through the water in the connected pores of the soil skeleton. The principle of effective stress was summarized by Taishaji through massive experiments, and this principle was first published in 1936. The assumption of this principle is that the pores of the calculated soil are all filled with groundwater, that is, the calculated soil is idealized saturated soil. The calculated soil body is completely composed of solid particles and water, and the total stress acting on the soil body is equal to the algebraic sum of effective stress and pore water pressure, as shown in equation (1)

$$\rho = \rho' + u_w \quad (1)$$

Where: ρ represents the total stress (Pa) acting on the soil, ρ' provides the effective stress (Pa)for the soil skeleton,

u_w represents the pressure (Pa) provided by pore water.

From the above formula, it can be concluded that due to precipitation-induced settlement, the total stress acting on the soil around the foundation pit during precipitation remains unchanged, but the pore water pressure in the soil decreases as the groundwater level decreases . This also causes the effective stress in the soil to increase as the groundwater level decreases. The change of pore water pressure in the soil does not affect the deformation of the soil skeleton, because under the re-equilibrium state, the water pressure will act uniformly between the soil particles without causing displacement of the soil particles and affecting the shape of the soil skeleton Changes [10]. Groundwater is a free-body state and cannot bear shear stress, so changes in pore water pressure cannot affect changes in soil shear strength. Therefore, the main reason for the settlement during precipitation is that the effective stress of the soil has changed.

2.2. Foundation Pit Precipitation on Ground Settlement in Diving Area

The seepage consolidation caused by precipitation of foundation pits in the diving area is different from the overload consolidation. It can be classified and compared in terms of load area and stress, loading conditions, deformation mechanism, settlement results, etc. The analysis is as

follows:

(1)From the perspective of the load area and stress changes, the influence range of precipitation consolidation caused by precipitation is large, and its area can reach up to thousands of kilometers. The area where the stress changes generally has settlement; the consolidation load area caused by overload is small The influence range is relatively small, and the stress decreases with increasing depth [11].

(2)From the perspective of loading, the former force gradually increases over a period of time, and the change range is large; the latter load comes from the building, and basically does not change after the construction is completed.

(3) From the perspective of the deformation mechanism, the total stress of the former soil layer is generally unchanged, and the change of the osmotic pressure caused by precipitation makes the soil stress change, the pore water pressure in the water barrier decreases, the effective stress increases, and the soil body is more dense, causing the surface Settlement [12]; at the moment of the latter loading, the load is borne by the pore water pressure, which is converted into the effective stress of the soil, resulting in settlement.

(4)Judging from the settlement results, due to the strong and weak permeability of different strata, the weak permeable layer changes more slowly than the confined head when the surface subsidence occurs due to precipitation, and the area where the settlement occurs is smaller than the area where the groundwater head drops; Generally, the effective stress and the degree of consolidation of the overload consolidation can reach the final value, and the super static water pressure dissipates to the equilibrium state.

2.3. Seepage Force on Effective Stress during Precipitation of Foundation Pit in Diving Area

As shown in Figure 1, groundwater is located on the surface of a saturated clay layer with a thickness of H. Below the saturated clay layer is a sand layer, which has the function of confined water. A pressure measuring tube is placed at the interface between the clay layer and the sand layer, and a stable constant water level surface below the water level surface Δh is artificially set next to the pressure measuring tube. The phenomenon.

The pore water pressure at point A shown in the figure is as shown in formula (2).

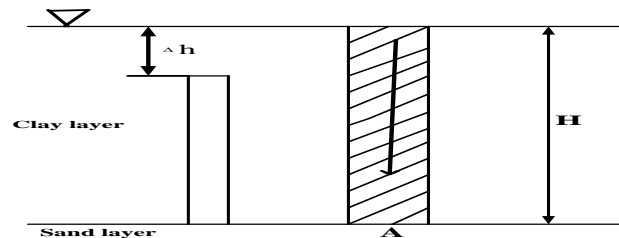$$u_w = \chi_w(H - \Delta h) = \chi_w H - \chi_w \Delta h \quad (2)$$

Figure 1. Schematic diagram of seepage

Then the effective stress at point A can be expressed by formula (3).

$$\rho' = \chi' H + J_A \quad (3)$$

In the formula, J A represents the total seepage stress of the soil layer above point A, and the seepage stress direction is downward, which is expressed by formula (4).

$$J_A = j \times H = \chi_w \Delta h \div H \times H = \chi_{w\Delta h} \quad (4)$$

Therefore, the effective stress at point A is expressed as formula (5).

$$\rho' = \chi' H + \chi_w \Delta h \quad (5)$$

The total stress at point A is expressed by formulas(5)and (3) and formula(6) can be obtained

$$\rho = \rho' + u_w = \chi' H + \chi_w \Delta h + \chi_w (H - \Delta h) = \chi_{sat} H \quad (6)$$

It can be seen from the above formula that when there is a water head difference in the soil layer, downward seepage will occur, and the downward seepage force will increase the effective stress in the soil layer [13]. In summary, the change of seepage force during the precipitation of the foundation pit in the diving area will indirectly affect the change of the displacement field of the soil layer around the foundation pit, which is also a cause of precipitation caused by precipitation.

After analyzing the above principles, it can be seen that the settlement of the surrounding environment caused by the precipitation of the foundation pit in the diving area is mainly due to the artificial lowering of the groundwater level, which reduces the pore water pressure in the soil layer and increases the permeability, thereby making it effective The stress increases. The increase of the effective stress in the soil layer will cause the deformation of the soil skeleton, which is the main reason for the settlement of the surrounding environment of the foundation pit during the precipitation process [14].

2.4. Continuous Equation of Seepage in the Process of Foundation Pit Precipitation

As shown in Figure 2, according to the principle of conservation of mass, the unit body is extracted from the seepage field in the soil, and each side length of the unit body is defined as Δx, Δy, Δz, and each side length in the unit body is parallel to the coordinate axis; The velocity of water flowing through the unit body is respectively,then the mass of water passing through the unit perpendicular to the coordinate axis in unit time is v_x, v_y, v_z. Through calculation, the mass of water flowing into the abcd surface of the unit body in unit time is pv_x, pv_y, pv_z,then the mass of water flowing out of the efgh surface of the unit body in unit time is as shown in formula(7) [15] .

$$(pv_x + \frac{\Delta}{\Delta x} pv_{x\Delta x})\Delta y \Delta z$$

$$(7)$$

It can be obtained by calculation that the mass difference of the water flowing in the x direction of the unit body during the seepage process is shown in formula (8).

$$(pv_x + \frac{\Delta}{\Delta x} pv_x \Delta x)\Delta y \Delta z \Delta u = \frac{\Delta pv_x}{\Delta} \Delta x \Delta y \Delta u \quad (8)$$
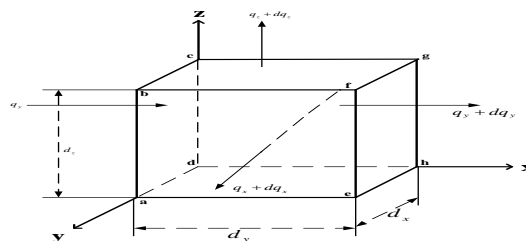

Figure 2. Schematic diagram of the unit in the seepage zone

Through calculation, the mass difference of the water flow passing through the unit body in the y-axis and z-axis directions at the same time are respectively

$$\frac{\Delta(pv_y)}{\Delta}\Delta x\Delta y\Delta z\Delta u \quad (9)$$

$$\frac{\Delta(pv_z)}{\Delta z}\Delta x\Delta y\Delta z\Delta u \quad (10)$$

The sum of the masses of water flowing through the unit at the same time can be calculated according to formula (9).

According to formula (10), it can be deduced that the flow rate per unit surface area of the unit body q values v in unit time. On this basis, it is stipulated that the density of water is p, and the volume strain of soil element is, the left end of equation (10) can be written as equation (11).

$$[\frac{\Delta v_x}{\Delta x}+\frac{\Delta v_y}{\Delta y}+\frac{\Delta v_z}{\Delta z}]p\Delta x\Delta y\Delta z=[\frac{\Delta q_x}{\Delta x}+\frac{\Delta q_y}{\Delta y}+\frac{\Delta q_z}{\Delta z}]pdxdydz \text{)(11)}$$

Simplification is available(12).

$$[\frac{\Delta q_x}{\Delta}+\frac{\Delta q_y}{\Delta}+\frac{\Delta q_z}{\Delta}]dxdydz=\frac{\Delta\varepsilon_v}{\Delta u}dxdydz \quad (12)$$

It can be seen from formula (12) that the amount of soil compression in a unit time is numerically equal to the total amount of water flowing through the unit soil in a unit time [17].

3. Simulation Experiment of Foundation Pit Precipitation Data

3.1. Foundation Pit Precipitation Model

The excavation area of the foundation pit model is about 1545.6, the total length of the foundation pit is 73.6, the standard section width is 21, and the excavation depth is about 17.3. Combined with the relevant technical specifications for the monitoring of urban rail transit engineering, the stipulations for the division of the impact area of the foundation pit project: the main impact area is within 0.7H or Htan (45/2) H, and the secondary impact area is 0.7H around the foundation pit Within the range of (2.0 ~ 3.0) H or Htan (45-p/2) ~ (2.0 ~ 3.0) H, the possible affected area is outside the range of the foundation pit (2.0 ~ 3.0) H, where H is the design depth of the foundation pit , p is the friction angle in the rock and soil body, as shown in Figure 3 [18].
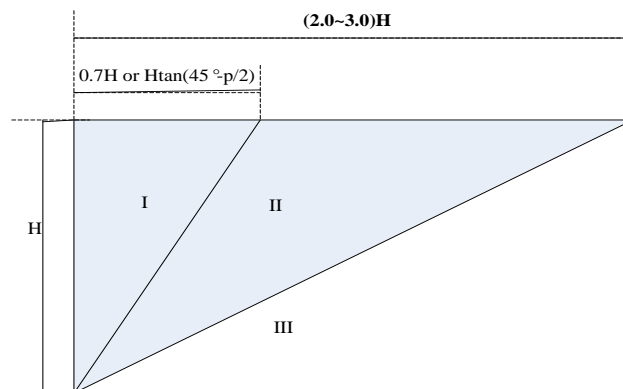

Figure 3. Impact zoning of foundation pit precipitation project

In summary, the boundary values in the model are 243.6, 161, and 60, and a reasonable model boundary size can be selected according to the appropriate magnification of the excavation size of the foundation pit, which is helpful to reduce the impact of the size effect. In order to simplify the model, the subterranean continuous wall is used to replace the bored piles [19]. There are no civil buildings within the actual impact of the project. In order to study the impact of foundation pit precipitation on the surrounding environment, it is assumed that there is a multi-layer frame structure at a distance of 20 from the surrounding surface of the foundation pit. 24, 12 wide, 6 floors above ground, 2.75 high, 1 underground, 4.3 high, with pile foundation and pile length 22 [20].

3.2. Model Material Parameter Selection

In order to make the numerical analysis process closer to the example, the modified Mohr-Coulomb model was adopted for the soil. In the actual project, the soil layers are not evenly distributed, and some soil layers contain inter layers. In the model, the soil layers are evenly distributed and are approximately replaced. The thickness of each soil layer and the main physical and mechanical indexes of the soil are shown in Table 1:

Table 1. Soil thickness and basic parameters of soil

Layer number	Name of soil	Thickness	Test weight	Poisson's ratio	Cohesion	Internal friction angle	Elastic Modulus	Lateral pressure coefficient
1	Miscellaneous soil	2.6	14	0.37	10	11	7.1	0.46
2	Silt	3.1	25.3	0.31	28	29	11.8	0.38
3	Silty clay	7.7	19.3	0.53	12	24	14.2	0.47
4	Silt	5.6	20.7	0.37	0	30	18.5	0.32
5	Silty clay	7.4	30.3	0.38	34	13	19.6	0.47
6	Coarse sand	32	23.3	0.43	0	39	38	0.33

The structural materials mainly involved in the model include ground connection walls, steel supports, buildings and water cut curtains. In the model, the water cut curtains are obtained by the extraction function of the software. The permeability coefficient is 0. The basic parameters of other structural materials are shown in Table 2.

Table 2. Basic parameters of structural materials

Structure name	Severe	Poisson's ratio	Modulus of elasticity
Ground to wall	27	0.3	32400
Steel support	79.5	0.1	235000
Building	29	0.3	32700

3.3. Numerical Simulation Analysis Steps

The model simulates the processes of foundation pit precipitation, excavation and support. In the actual project, the foundation pit precipitation should start before the foundation pit is excavated, and the precipitation should always keep the groundwater head height below 1m of the layered excavation surface of the foundation pit. The actual multi-layered and complex groundwater is simplified as a submerged layer and confined water, and the precipitation process is set up through the head nodes in the model. The excavation sequence of the earthwork of the foundation pit

complies with the design conditions and the principle of space-time effect, that is, the principle of "layered section excavation, first support and then excavation, and no over-excavation is strictly prohibited". Excavate the foundation pit to 0.5 below the first layer of steel support, construct the first layer of steel support, and apply prestressing. After the steel support construction is completed, the excavation can be continued; the next step of the steel support and the excavation of soil are carried out in the same way Elevation from body to base. The model simplifies the precipitation and excavation process, which is divided into four precipitations and four excavations. Midas GTS software realizes the simulation of different construction phases on site by defining construction phase groups [21]. The analysis steps are as follows:

(1)Initial seepage field analysis, the stage type is selected as steady state, all soil and ground connection walls are rigidly connected to the grid, and the boundary conditions activate the initial water level and the total water level in the pit;

(2) Initial stress field analysis, activation of self-weight load and displacement constraint boundary conditions;

(3) Building construction, passivating the soil grid of the basement of the building, activating all building structural grids, activating the torsional boundary conditions of the pile foundation, the superstructure load is equivalent to static load and activated here;

(4) The displacement is cleared, and the conditions of activation data and passivation data are not changed;

(5) Ground connection wall construction, activate the foundation pit ground connection wall and water cut curtain grid group, and passivate the rigid connection grid;

(6) The first precipitation to -3.5, activate the water head 1;

(7) The first excavation to -2.5, construction of the first support at -2, passivation excavation 1, activation of steel support 1;

(8) The second precipitation to -9.5, activate water head 2, passivate water head 1;

(9) The second excavation to -8.5, construction of the second support at -8, passivation excavation 2, activation of steel support 2;

(10) The third precipitation to -14.5, activate the water head 3, passivate the water head 2;

(11) The third excavation to -13.5, construction of the third support at 13 meters, passivation excavation 3, activation of steel support 3;

(12) The fourth precipitation to -18.3, activate water head 4, passivate water head 3;

(13) The fourth excavation to 17.3, passivation excavation 4.

4. Simulation Results and Analysis of Foundation Pit Precipitation Data

4.1. Not Considering the Impact of Foundation Pit Precipitation, only Considering the Impact

When the influence of groundwater seepage factors is not considered and only the influence of excavation factors is considered, the soil around the foundation pit is significantly subsidenced. The areas with different colors represent different settlements. As the excavation depth increases, the areas with larger soil settlements also become larger. The depth of soil is different, and the degree of impact on excavation is different. There is a clear boundary between the settlement of different depths of soil [22]. In the horizontal direction, with the envelope structures on both sides of the foundation pit as the starting point, as the distance increases, the displacement settlement generally exhibits a parabolic change trend. Extract the calculation results in the cloud image, draw the curve of the settlement after each excavation with the distance from the edge of the foundation pit as the horizontal axis and the settlement of the foundation pit as the vertical axis, and compare it with the actual monitoring value.
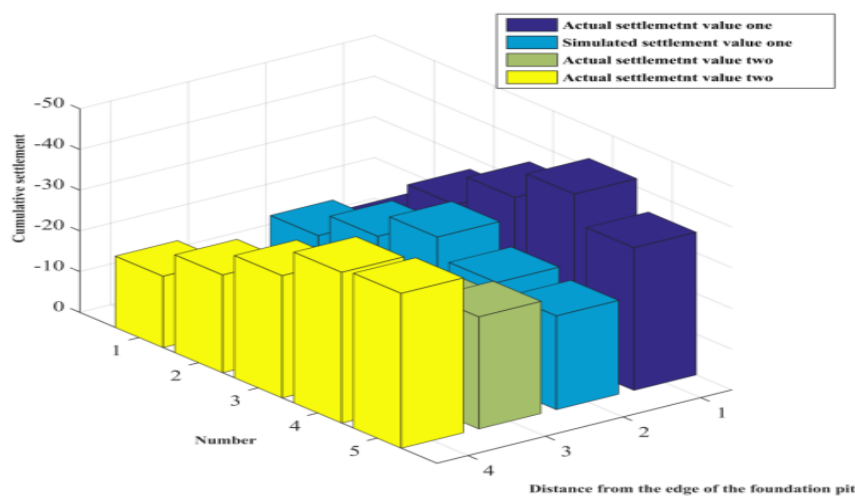
Figure 4. The actual value of precipitation excavation settlement and working conditions-a three-dimensional diagram of simulated values

Figure 4 Comparison of measured and simulated values for each excavation settlement shows that simple excavation will cause significant ground settlement, and its maximum settlement occurs at a horizontal distance of 15-20 from the envelope. The change trend of the overall settlement is generally consistent with the actual monitoring settlement. Within 20m from the envelope structure, as the distance increases, the amount of settlement also increases. After exceeding this distance, the degree of surface settlement of the soil outside the pit is gradually reduced by the excavation of the foundation pit, and the settlement value becomes smaller until it exceeds the area affected by the excavation of the foundation pit. Although the change trend is generally close, there is a certain difference from the true value. As the excavation depth increases, the area affected by the excavation increases. The overall settlement also increased significantly with increasing excavation depth. The maximum settlement of the first excavation is -9.4, and the horizontal distance from the edge of the foundation pit enclosure is 15m; the actual maximum settlement is -7.1mm, and the horizontal distance from the edge of the foundation pit enclosure is 10. At this time, due to the shallow excavation depth, the small surface settlement is not obvious. When excavating to the bottom of the pit, the simulated maximum settlement is -29.4, and the horizontal distance from the edge of the foundation pit envelope is 20; the actual maximum settlement is -32.6, and the horizontal distance from the edge of the foundation pit envelope is 20 [23]. In the four excavation simulations, although the surface settlement calculation is partially greater than the actual value, the average value is less than the actual value. This shows that for the foundation pit engineering simulation with groundwater seepage, if the influence of precipitation is not considered, the reliability of the simulated value will low.

4.2. Only Consider the Impact of Groundwater Seepage without Considering the Excavation

The simulation results when considering only the influence of groundwater is show in Figure 4.
Line 5 is a histogram comparing the actual value of the four-time precipitation excavation of the foundation pit with the simulated value of the second working condition considering only the influence of precipitation factors. It can be seen from Figure 5 that the cumulative settling amount of the simulated value during the first precipitation in working condition 2 is relatively small, and the maximum value is only 1.3mm, which is related to the small precipitation amplitude, which is only 1m. The analysis simply considers the change trend of the simulated settlement value of

precipitation, and it can be concluded that the overall change trend of the surface settlement and the change trend of the water level drop are generally consistent. With the increase of the distance from the edge of the foundation pit, the funnel type first decreases and finally The trend tends to be stable. It can be clearly seen from the comparison between the change trend of the actual monitored value and the simulated value of the surface settlement of precipitation excavation. Although the change trend of the two is similar overall, there are differences [24]. With the distance from the foundation pit, the actual and simulated settlements tend to stabilize until they are close to zero, but the actual settlement monitoring value changes in a parabolic shape rather than the funnel shape in the simulated values. The difference between the two shows that during the construction period of foundation pit precipitation excavation, precipitation is a non-negligible factor that causes surface settlement, but it does not occupy a dominant position, and the approximate proportion can be obtained in the third analysis of working conditions.
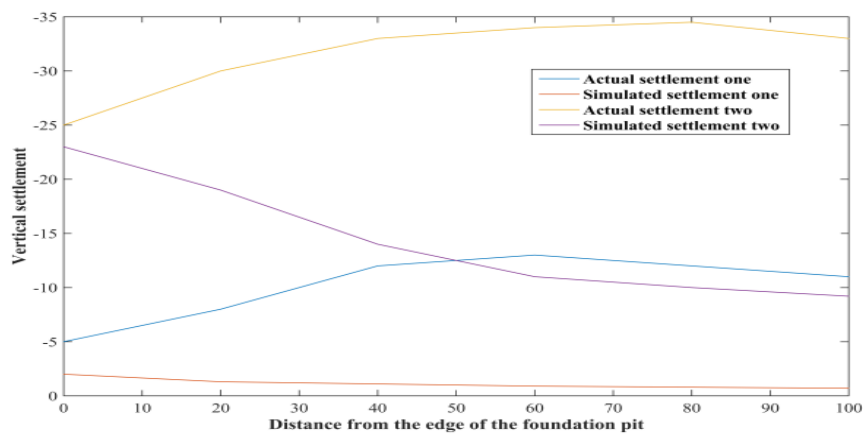

Figure 5. The actual value of precipitation excavation settlement and the second simulation line of working conditions

4.3. Also consider the impact of foundation pit precipitation and excavation

By extracting the results of the nodes within the range of 0.5m ~ 20.5m from the left side of the ground connection wall, a curve diagram of the amount of deformation and actual monitoring of the foundation pit after simulated four precipitation excavations is drawn, as shown in Figure 6.
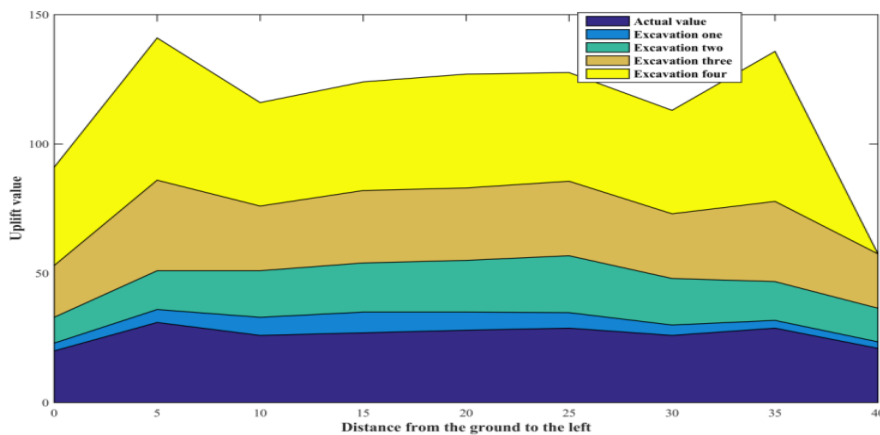

Figure 6. The area of the actual foundation pit bottom uplift value compared with the simulation value of the four excavations

The actual value in this figure refers to the actual uplift value when precipitation is excavated to -17.3. According to the comparison curve between the actual value of the pit bottom uplift and the four-time simulated pit bottom uplift considering the impact of precipitation and excavation. Figure 6 shows that when the excavation depth is not large, the simulated values of the first and second pit bottom uplift are presented In the middle of the bottom of the pit, there is a high elastic bulge. The highest bulge appears at a distance of 10.5 from the left ground connection wall. The maximum bulge amounts are 10.2 and 19.9, respectively. The change trend of uplift value of the third and fourth pit bottoms is basically consistent with the change trend of the actual monitoring value, showing a plastic uplift in which the maximum amount of uplift appears on both sides and the middle uplift is smaller. Among them, the actual uplift value and the minimum value of excavation 3 and excavation 4 occurred at 0.5 from the left side of the foundation pit, and the uplift values were 19, 18.7 and 37.5, respectively. The maximum value of the actual uplift appears at a distance of 3m from the left side of the foundation pit, and the uplift value is 33.1. The maximum values of the third and fourth excavations appear at the positions 18 and 3 from the left side of the foundation pit, respectively. It is 35.9, 54.3. Part of the reason for the deformation of the pit bottom uplift of the foundation pit is the excavation of the soil body. The original weight of the soil body in the original pit is unloaded. At this time, the spring bulge may appear at the bottom of the pit, showing an elastic uplift form; another part is the enclosure structure The deformation of has a pushing effect on the soil in the pit. The two effects work together on the bottom of the pit, and a plastic uplift form appears. In addition, the effect of the additional foundation pit precipitation factors on the foundation pit soil and the surrounding structure should be monitored and prevented in the actual project [25].

5. Conclusion

This paper analyzes the mechanism of building settlement during the dewatering of the foundation pit in the diving area, and compares the calculation results of the finite element simulation and the mathematical model with the actual values to verify the reliability of the model and the proposed method used in this paper. The insertion depth, precipitation method and precipitation speed of the water stop curtain are calculated as the influencing factors, from which the influence of these influencing factors on the settlement around the foundation pit is obtained. , The change of soil conditions and the depth of precipitation wells. The research of this subject has certain practical significance.

In this paper, through the seepage-stress coupling analysis, the working condition 3 modeled according to the engineering example is simulated. By comparison, it is found that the maximum value of simulated cumulative settlement and the actual maximum value of cumulative settlement appear at the same position, which is about 1.16 times the excavation depth of the foundation pit 20m from the edge of the foundation pit. The comparative analysis of the three working conditions shows that the settlement value caused by precipitation accounts for about 35% of the total settlement value, and the settlement value caused by excavation accounts for about 65%. The simulation results of the cumulative settlement of the surface soil outside the three pits in the working conditions are best fitted with the actual monitoring values, indicating that the modeling method is effective and can provide a reference for similar engineering simulations. The analysis of foundation pit engineering with precipitation must consider the influence of precipitation.

This paper analyzes the deformation and internal force of the foundation pit of the underground structure. The data shows that the settlement of the pile foundation is related to the distance from the foundation pit to the excavation depth and the excavation depth. Small, where the difference in settlement is 11.9mm, and differential settlement is one of the reasons that causes the building to tilt.

With the increase of the buried depth of the pile foundation, the overall horizontal displacement shows a decreasing trend, which is almost zero after exceeding the depth of the foundation pit precipitation excavation. The closer it is to the foundation pit, the slower the tendency of the displacement decrease within the excavation depth range, and the farther the pile foundation is from the foundation pit, the faster the displacement decrease within the excavation depth range. The change trend of the internal force of the pile foundation is generally consistent with the change trend of the horizontal displacement.

Funding

Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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