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Consolidation and deformation characteristics of soft rock foundation in a hydrological wetland environment

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ABSTRACT

The widespread distribution of soft rock and soft soil in a hydrological wetland environment is a common geotechnical engineering problem encountered in coastal engineering construction. A study method for consolidation and deformation characteristics of soft rock and soft soil foundation in a hydrological wetland environment is proposed to solve this problem. The study area was limited to the K9+280-K11+120 section along the Fu-Nehe section of National Highway 111. The consolidation and deformation characteristics and loading conditions of soft soil foundation under embankment filling load, treatment methods of the soft rock foundation, stratum conditions, temperature changes, and time effects are analyzed. The results show that although the wetland soft rock and soil layer is not thick, the settlement of soft rock and soil accounts for more than 80% of the total settlement. The negative temperature has a certain influence on the consolidation settlement of soft rock foundation, which is mainly manifested in the difference between the settlement process of the central separation zone and the roadbed soft soil foundation. The pore water pressure of soft rock foundation dissipates to varying degrees. According to the monitoring results of settlement and pore water pressure, bagged sand wells are more suitable for soft rock foundation engineering treatment in a hydrological wetland. The research results can provide a reference for the study, calculation, and design of the consolidation and deformation of soft rock foundation in a hydrological wetland.

Características de consolidación y deformación de una fundación de roca blanda en el entorno de humedales hidrológicos

RESUMEN

La distribución generalizada de roca blanda y suelo blando en el entorno de humedales hidrológicos es un problema común de ingeniería geotécnica en las zonas costeras de construcción. Para resolver este problema se propone un método de estudio para las características de consolidación y deformación de rocas blandas y cimientos de suelos blandos en ambientes de humedales hidrológicos. Como área de estudio se definió la sección K9+280-K11+120 a lo largo de la sección Fu-Nehe de la Carretera Nacional 111. Se analizaron las características de consolidación y deformación y las condiciones de carga de los cimientos del suelo blando bajo la carga de relleno del terraplén, los métodos de tratamiento de los cimientos de rocas blandas, las condiciones del estrato, los cambios de temperatura y los efectos del tiempo. Los resultados muestran que aunque la capa de suelo y roca blanda del humedal no es gruesa, el asentamiento de roca blanda y suelo representa más del 80 % del asentamiento total. La temperatura negativa tiene cierta influencia en el asentamiento de consolidación de los cimientos de rocas blandas, que se manifiesta principalmente en la diferencia entre el proceso de asentamiento de la zona de separación central y los cimientos de suelos blandos de la calzada; la presión de poro del agua de la base de roca blanda se disipa en diversos grados. De acuerdo con los resultados de monitoreo del asentamiento y la presión del agua de los poros, los sacos de arena son más adecuados para el tratamiento de ingeniería de cimientos de rocas blandas en humedales hidrológicos. Los resultados de la investigación pueden proporcionar una referencia para el estudio, el cálculo y el diseño de la consolidación y la deformación de los cimientos de rocas blandas en humedales hidrológicos.

Introduction

The shrinkage of soil under pressure is called the compressibility of soil (Baral et al., 2018). The process of soil compression increasing with time and dissipation of excess pore water pressure is called consolidation of soil, which is generally divided into primary consolidation and secondary consolidation (Huang et al., 2017). Main consolidation refers to the compression process caused by the gradual dissipation of excess pore water pressure and the increasing effective force in soil (Zhang, 2017), while secondary consolidation refers to the slow deformation caused mainly by creep of soil skeleton (Tao et al., 2018) after the basic dissipation of excess pore water pressure. The characteristics of soft rock and soil deformation with time under load easily lead to uneven settlement and excessive post-construction settlement of roadbed built on soft rock foundation (Zhang et al., 2019; Zhang & Wang, 2018). Due to the different origins of soft rock and soil, their respective engineering properties also show some differences.

Hydrological wetland ecosystem is located in the transitional area between water ecosystem and terrestrial ecosystem (Yang et al., 2017). Specific hydrological conditions are the driving force of wetland formation and maintenance. Small changes in hydrological characteristics will lead to changes in wetland ecosystem. Therefore, hydrological wetland ecosystems are vulnerable to climate change and other human activities. The response and feedback mechanism of hydrological wetland ecosystem under the influence of global change and human activities is the focus and frontier issue of common concern in the international community (Guo, 2018). Consolidation and deformation characteristics of soft rock foundation in hydrological wetland environment are affected by many factors, such as physical and mechanical properties of soft rock and soil, sludge thickness of hydrological wetland, loading capacity, loading mode and field environment (Xu et al., 2017; Kotani et al., 2017). In the hydrological wetland area, in order to carry out the construction of soft rock foundation smoothly, cofferdams are built on both sides of most sections before foundation treatment, and counter-pressure barriers are built between cofferdams and roads. Due to the influence of hydrological tide, cofferdam and back pressure guard, the consolidation degree of silt foundation in hydrological wetland area is difficult to meet the design requirements during the design preloading period. In order to study the consolidation and deformation of silt in this kind of area, a lot of field tests have been carried out. However, the parameters of soil layer, initial conditions and boundary conditions of field prototype tests are difficult to adjust, and the influence of each factor on the deformation characteristics cannot be accurately analyzed.

With the development of computer technology, numerical calculation greatly strengthens the ability to solve complex geotechnical engineering problems. The numerical method is more and more used in soft foundation treatment projects, but the numerical analysis of consolidation and deformation characteristics of silt roadbed in hydrological wetland area is rare. The overload preloading of bagged sand well is a common method in soft foundation treatment (Zhu & Wen, 2017). For the consolidation analysis of sand well foundation, it is a three-dimensional problem with too much calculation. Generally, it is simplified to the plane strain problem of sand wall foundation (Yan et al., 2017). In order to better reflect the actual situation of the project, in recent years, in the construction of high-grade highway, on-site monitoring has been carried out in many soft rock base sections. Although the cost of on-site monitoring is high, which brings some inconvenience to the construction of the project, the monitoring results can be used to improve the calculation results and predict the post-construction settlement and final settlement of soft rock foundation. Based on this, the research method for consolidation and deformation characteristics of soft rock foundation under hydrological wetland environment is put forward, which provides the main analysis basis for judging whether the safety and preloading of embankment construction progress in soft rock foundation of hydrological wetland have reached stability.

Materials and Methods

Project Survey

The geological conditions along the Fuyu-Nehe section of National Highway 111 are relatively complex. The test section is K9+280-K11+120, which is about 20 km away from the hometown of Red-crowned Crane-Zhalong Nature Reserve. The two layers of soft soil encountered are deposited by hydrological wetlands (Ma et al., 2018). The first layer of soft rock is with the thickness of 0.3-0.5 m and is silty clay (Guang-Ze et al., 2018); the second layer of soft rock is with the thickness of 2-6 m and is silty clay, which has poor engineering properties. Two layers of undisturbed soil samples of soft rock are tested in laboratory. The main physical and mechanical indexes are listed in Table 1.

Table 1. Basic Physical Properties of Soft Rock and Soil

Determination index	Silty clay	Silty clay
Sampling depth/m	1.9—2.5	4.6—5.2
Moisture content/%	60.01	53.03
Density/g·cm-3	1.57	1.7
Relative density	2.16	2.37
Void ratio	1.21	1.13
Saturation/%	100	100
Liquid limit/%	58	50.27
Plastic limit/%	30.57	26.78
Liquid index	1.11	1.12
Plastic index	27.43	23.49

In the test section, 8 sections are selected for field study, and the monitoring results of one of the typical sections are analyzed (K9 + 280 and the treatment method is to lay geogrids on bagged sand wells) (Zhou et al., 2017). The geological conditions of the engineering in monitoring section and the buried position of the instruments and equipment are detailed as shown in Figure 1.

Determination of Permeability Coefficient

Sand wells have changed the drainage boundary conditions of the original hydrological wetland foundation (Hao et al., 2017), shortened the drainage distance, and the drainage conditions have been greatly improved compared with the natural foundation. Radial drainage consolidation is the main factor in sand well foundation, and the vertical permeability coefficient can be obtained from the geotechnical test value. Because of the heterogeneity of the sludge in the hydrological wetland area, the permeability coefficient obtained from indoor and outdoor tests is discrete, and the measured settlement curve can reflect the consolidation condition of the foundation comprehensively. The horizontal permeability coefficient (Sun et al., 2017) can be calculated by using settlement data. The theoretical solution of average consolidation degree of soil under various drainage conditions can be summed up as a general expression:

$$\bar{U} = 1 - \alpha e^{-\beta t} \tag{1}$$

Where, t is time, α and β are parameters to be determined.

According to the measured settlement-time curve, any three time t_1, t_2 and t_3 after the load stops are selected and $t_3 - t_2 = t_2 - t_1$. It can be obtained that:

$$\beta = \frac{1}{t_2 - t_1} \ln \frac{S_2 - S_1}{S_3 - S_2} \tag{2}$$

In the formula, the settlement values at time t_1, t_2 and t_3 are S_1, S_2 and S_3 respectively.

For the consolidation of shaft foundation (ideal shaft), there are:

$$C_h = \frac{\beta d_e^2}{\dfrac{8}{F(n)} + \dfrac{\pi^2}{4} \dfrac{C_v}{C_h} \dfrac{d_e^2}{H^2}} \tag{3}$$
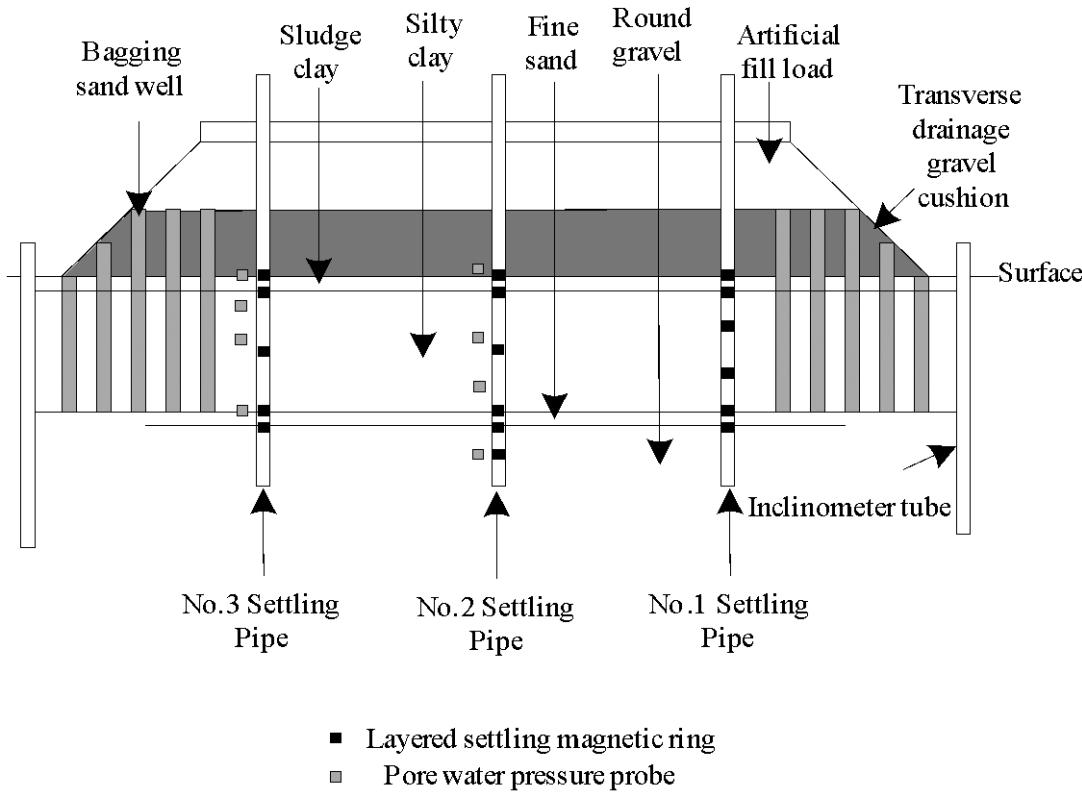
Figure 1. Geological bubble surface of test section, i.e. instrument burial map

Where, d_e is the diameter of equivalent circle, $d_e = \sqrt{\dfrac{2\sqrt{3}}{\pi}}L = 1.05L$, L is the distance between sand wells, H is the thickness of unilateral drainage soil layer, $F(n) = \dfrac{n^2}{n^2-1}\ln(n) - \dfrac{3n^2-1}{4n^2}$, n is the diameter ratio, C_v and C_h are the vertical and horizontal consolidation coefficients, respectively.

Transforming the Permeability Coefficient of Sand Well Foundation into That of Sand Wall Foundation

Starting from Baron's theory (Wei et al., 2018), and considering the effects of smear, lateral deformation and vertical seepage, the equivalent method between plane and axisymmetric problems of sand well foundation can be obtained. This method can only adjust the permeability coefficient (Zhang et al., 2017), and the spacing of sand wall can still be determined according to the need of meshing (Yang et al., 2018). The transformation formula is as follows:

$$k_{hp} = D_h k_h; k_{vp} = D_v k_v \qquad (4)$$

Where, k_h and k_v are horizontal and vertical permeability coefficients of sand well foundation, k_{hp} and k_{vp} are equivalent horizontal and vertical permeability coefficients of sand wall foundation, and D_h and D_v are adjustment coefficients.

The vertical permeability coefficient k_v of silt roadbed is 2.82×10^{-7} cm/s in laboratory test, and the horizontal permeability coefficient k_h=2.60×10^{-7} cm/s is calculated according to settlement data (Wang et al., 2018). The horizontal permeability coefficient and vertical permeability coefficient are k_{hp}=8.92×10^{-7} cm/s and k_{vp}=2.54×10^{-7} cm/s respectively when the sand well treatment area is converted into sand wall foundation.

Results

Analysis of Layered Settlement Monitoring Results

Figure 2 shows the change process of embankment filling height of test section. The starting time of abscissa is November 5. Before the installation of the observation equipment, the test section has been filled with gravel drainage cushion and part of embankment fill, and geogrid has been laid. Because of the influence of climate, the embankment has not been filled and the soft rock foundation has not been loaded during the whole winter (Liu, 2018). The main loading time is concentrated in the following five, six and seven months, which lasts more than 90 days. The thickness of the embankment is 1.8 m and the height of the embankment is 4.0 m.
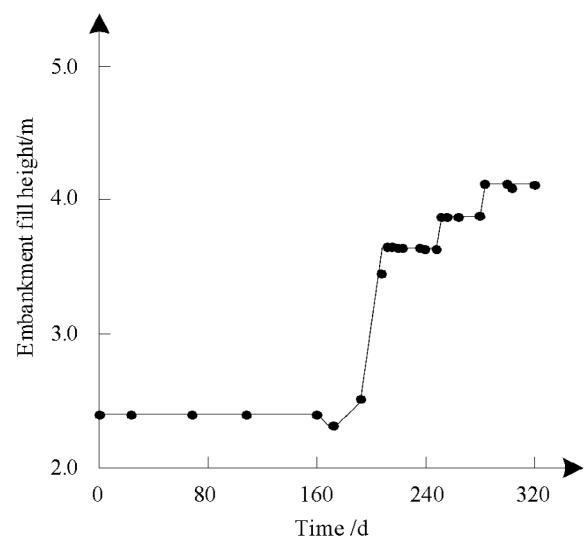

Figure 2. Change process of embankment fill height in test section

Figure 3 and Figure 4 show the settlement curves of the magnetic rings on the subsidence tube of the test section. The buried position of each subsidence pipe and each magnetic ring on each subsidence pipe is shown in Figure 1.
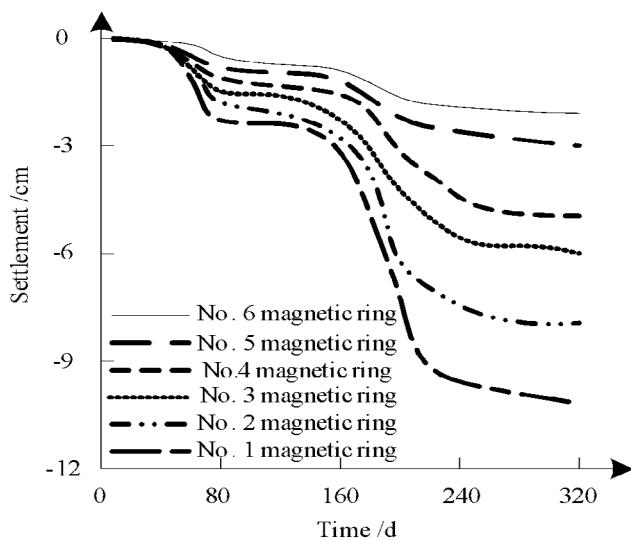
Figure 3. Settlement curves of magnetic rings in No. 1 settling pipe of test section
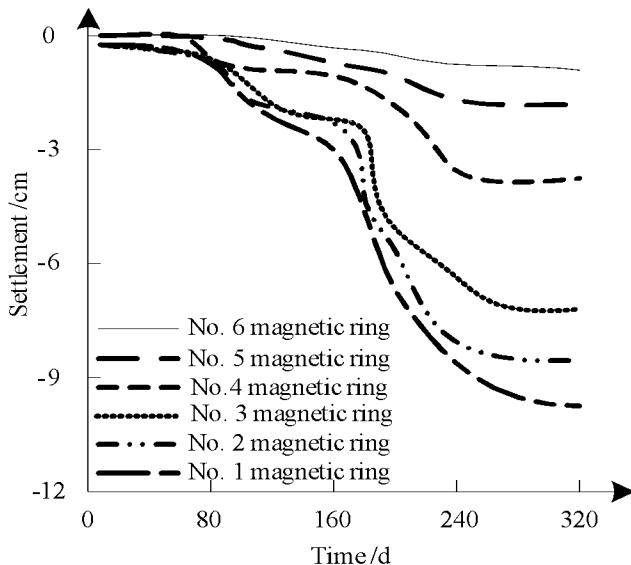
Figure 4. Settlement curves of magnetic rings in No. 2 settling pipe of test section

Figure 3 shows the settling process curves of the magnetic rings of No. 1 settlement pipe in the test section. The layered settlement pipe is buried on both sides of the embankment fill in the test section, i.e. at the shoulders of both sides of the embankment. The characteristics of the settlement of the magnetic rings are as follows: from November 19 to January 9, there is no obvious settlement process; from January 9 to February 17, the settlement of the magnetic rings has increased, and then until May 1, that is, before the embankment filling load, the settlement of the magnetic rings of the settlement pipe at the shoulder has not increased significantly. After May 1, the embankment filling began to load, and the settlement of the magnetic rings of the settlement pipe at the shoulder increased obviously. The main reason for this settlement process is that the temperature decreases from November 19 to January 9, and the embankment fill gradually freezes in depth. From January 9 to February 17, it is

the coldest season in the region (Issaka & Ashraf, 2017; Liu & Baghban, 2017). The freezing depth reaches the maximum. The embankment fill forms a shell-like freezing layer with the thickness of 2.5 m, which has good integrity and high strength. It can transfer the load from the middle to the edge of the embankment, resulting in the edge soil. The pressure increases, which is consistent with the observation results of the increase of the earth pressure in the process of embankment freezing.

Figure 4 shows the settling process curves of the magnetic rings of the No. 2 settlement pipe in the test section. The layered settlement pipe is located in the central partition zone of the embankment fill. From November 19 to February 17, the following year, during the freezing process of embankment fill in winter, there is no obvious settlement of soft soil foundation at the central separation zone of the two test sections. From February 17 to May 1, it is the season when the temperature of embankment filling gradually rises. The shell-like freezing layer of embankment filling gradually melts. The pressure on the soft soil foundation at the central separation zone increases gradually. The settlement of the magnetic rings of the subsidence tube increases, especially the settlement of the magnetic rings near the surface of the soft rock foundation.

Every year from May to September is the construction season of highway construction in the northern region. The embankment filling speed is faster, especially concentrated in May, June and July. The settlement of soft rock foundation has an obvious acceleration process. The more the closer to the surface settlement of soft rock foundation is, the greater the settlement of soft soil is, and the settlement of soft soil accounts for more than 80% of the total settlement. In addition, the treatment method of soft soil foundation for bagged sand well is adopted in the test section. From the settlement data of the test section, it can be seen that the slope foundation of the settlement curve of the soft soil foundation treated by the bag sand well is small at the later stage, which indicates that the treatment of the shallow soft rock foundation of hydrological wetland is more conducive to drainage consolidation of the soft rock foundation and reduce the post-construction settlement.

Analysis of Pore Water Pressure Monitoring Results

Tables 2 and 3 describe the variation curve of pore water pressure in the test section.

Tables 2 and 3 show that pore water pressure dissipates in varying degrees during the freezing process of embankment fill. During the whole winter, from Feb. 17 to pre-loading, the observed pore water pressure increases gradually, but the rising amplitude and rate are not obvious. The main reasons are: (1) the temperature gradually rises, snow melts and rainfall influences, and the groundwater level gradually rises. (2) Due to the melting of embankment fill, the frozen crust layer begins to melt. Except near the slope angle, the soft rock foundation is subjected to the increase of the base pressure caused by embankment fill.

Since the beginning of May, embankment filling begoind to be constructed. The additional stress of soft rock foundation increased under the action of filling loading, resulting in a significant increase in excess pore water pressure in the foundation soil. The change process of excess pore water pressure is very synchronous with the loading process of filling. That is, the excess pore water pressure increases obviously during loading. The faster the loading rate is, the larger the loading is, the faster the excess pore water pressure increases. The excess pore water pressure dissipates obviously after stopping loading.

From the curve of pore water pressure change of two test sections, it can be concluded that the drainage consolidation process of soft rock foundation is greatly influenced by geological conditions. Normally, the shallower the pore water pressure probe is buried, the larger the excess pore water pressure is generated in the initial stage of loading, because the excess pore water pressure is caused by additional stress. The more the nearer to the surface of soft rock foundation is, the greater the additional stress caused by embankment filling load is. From Tables 2 and 3, it is easy to find that the excess pore water pressure dissipation of the deep buried probes No. 5 and No. 1 is very fast, basically after loading, the excess pore water pressure dissipation has been completed, because the two probes are buried in the well permeable gravel layer.

Through the curve of pore water pressure change in the test section, it can be concluded that the excess pore water pressure dissipates quickly in

Table 2. Pore Water Pressure Variation Curve of No. 2 Hole in Test Section

Time	No. 8 Void Hydraulic Probe (Initial Buried Depth - 3.6 m)/kPa	7 Void Hydraulic Probe (Initial Buried Depth - 4.7 m)/kPa	No. 2 Void Hydraulic Probe (Initial Buried Depth - 5.6 m)/kPa	No. 5 Void Hydraulic Probe (Initial Buried Depth - 7.4 m)/kPa
November 5th	5.89	17.43	31.78	36.54
December 15th	2.76	15.04	30.65	33.99
January 25th	-2.31	13.03	28.89	30.94
February 27th	-2.24	12.4	30.23	30.23
April 7th	1.95	13.86	32.06	33.15
May 17th	3.6	17.66	33.74	35.42
June 26th	11.22	23.79	42.73	46.91
August 5th	7.05	17.68	33.15	35.06
September 15th	6.97	19.07	29.66	35

Table 3. Pore Water Pressure Change Curve of Test Section 3

Time	No. 6 Void Hydraulic Probe (Initial Buried Depth - 3.6 m)/kPa	No. 3 Void Hydraulic Probe (Initial Buried Depth - 4.3 m)/kPa	No. 9 Void Hydraulic Probe (Initial Buried Depth - 4.9 m)/kPa	No. 1 Void Hydraulic Probe (Initial Buried Depth - 6.0 m)/kPa
November 5th	3.98	11.03	21.18	32
December 15th	3.99	8.57	18.26	30.1
January 25th	4.02	6.02	10.05	27.95
February 27th	4.1	5.11	7.6	16.24
April 7th	5.17	7.58	7.93	29.17
May 17th	6.46	9.74	12.15	31.03
June 26th	15.03	15.37	19.34	38.86
August 5th	11.2	14.19	16.82	28.62
September 15th	9.85	14.3	16.91	27.44

soft soil foundation treated by bagged sand wells. This shows once again that the use of bagged sand wells to treat the soft rock foundation of hydrological wetland is more conducive to the drainage consolidation of soft rock and soil, and increases the stability of soft rock foundation.

Effect of Water Level Variation on Consolidation and Deformation Characteristics of Soft Rock and Soil

Consolidation and Deformation Characteristics of Water Level with the Same Change Range

Figure 5 is the settlement time history curve, and Figure 5 (a) is the whole settlement time curve of surcharge preloading.

Figure 5 shows that settlement deformation mainly occurs during loading and decreases with the increase of depth. Sediment curve on top of silt takes eight data points per day, while other curves only take one data point per day. Settlement value changes periodically every day, and the change range is basically unchanged. From Figure 5 (b), it can be clearly seen that the periodic variation of settlement caused by hydrological tides is the same as that caused by tidal frequencies, and its influence decreases rapidly with the increase of depth. The amplitudes of settlement cycle change are 35 mm and 5 mm at the top and 16 m below the silt surface, respectively.

Figure 6 is a pore pressure-time history curve, from which the effect of tide on pore pressure is found.

Figure 6 (a) is the pore pressure-time history curve in whole process. At the initial stage of loading, because of the small load, the hydrological tide

has a great influence on pore pressure. The pore pressure increases with the depth. However, with the development of loading process, the pore pressure decreases with the depth increasing, indicating that the pore pressure caused by loading is greater in the shallow part than in the deep part, but when the drainage consolidation process is almost finished, pore pressure increases again with the increase of depth. It can be seen from Figure 6 (b) that hydrological tide causes periodic variation of pore pressure. The frequency of variation is the same as that of hydrological tide, and the law of variation of pore pressure is opposite to that of hydrological tide. This is because pore pressure is influenced by both hydrological tides and the upper load caused by hydrological tides, and the variation of pore pressure with depth is small.

Effect of Water Level Variation on Drainage Consolidation

The actual situation of consolidation of silt roadbed in hydrological wetland area is very complicated. Even if the external hydrological tide changes the same, because of the difference of the elevation of the silt top surface itself, the change of water level in the roadbed will be different, and most sections are filled with cofferdams, whose permeability varies greatly. Therefore, the influence of hydrological tide on pore pressure and settlement in the measured values of each section is also quite different. The actual effect of hydrological tide in engineering is to change the range of water level change at the top of silt, and the range of influence is different at different sections. From figure 7, it can be seen that the larger the variation range of water level on the top of silt is, the larger the variation range of settlement is. This effect is a linear relationship. From Figure 7, it can also be found that when the hydrological tide falls below
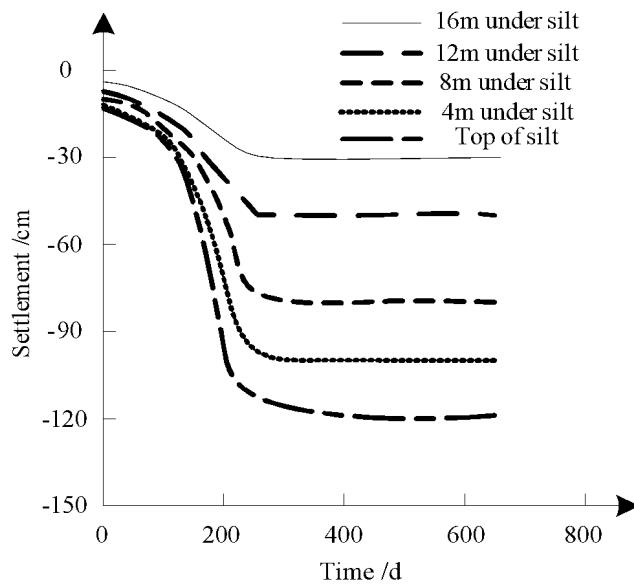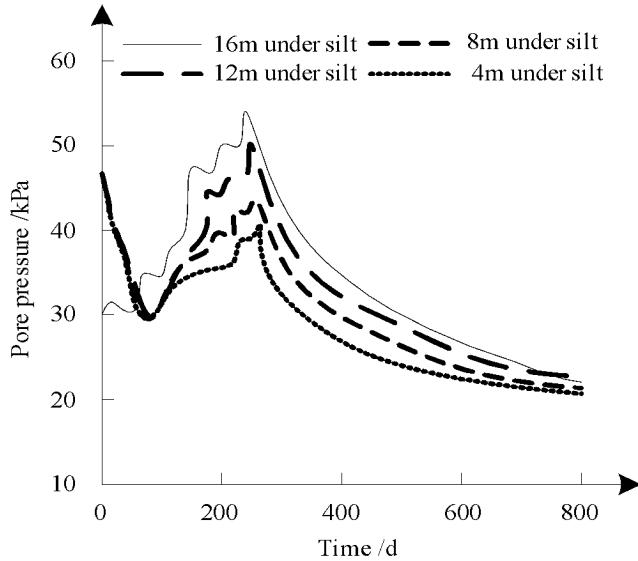
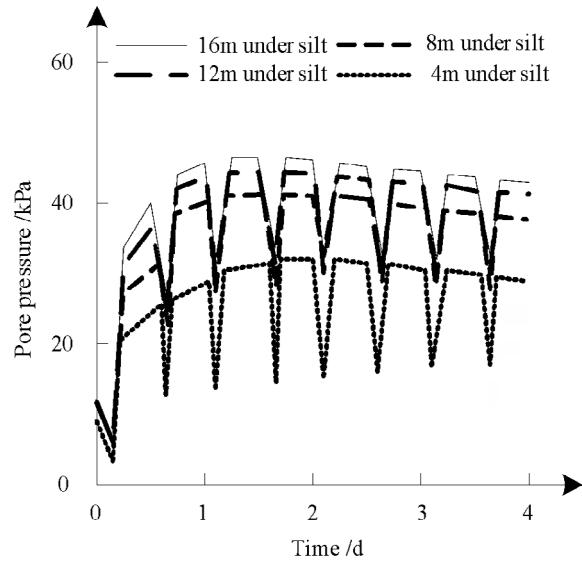(a) Settlement-time curve of preloading with surcharge
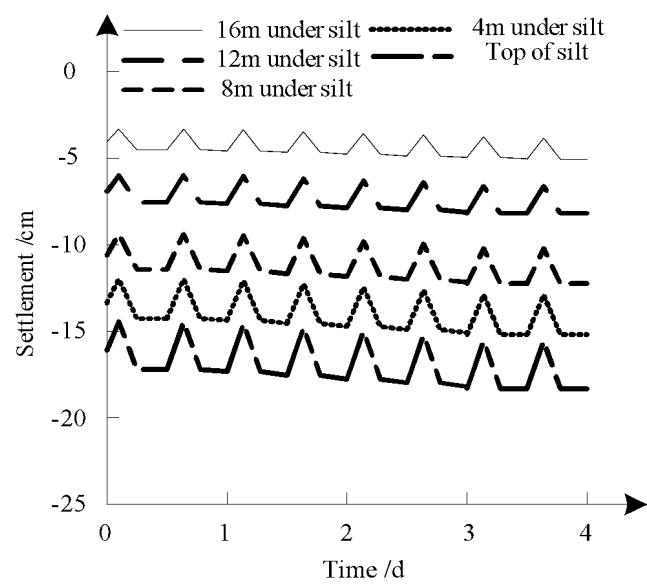
(b) Settlement-time curve 4 days before construction commencement

Figure 5. Settlement-time curve

(a) The whole process (one calculation per day)

(b) Former 4D

Figure 6. Pore pressure-time curve

the top of the silt, the settlement varies with the variation of water level. The larger the variation of water level is, the smaller the settlement is. This indicates that the hydrological tide will reduce the consolidation settlement.

The larger the variation range of silt top water level is, the greater the influence on pore pressure variation range is. The influence relationship is also a linear relationship, as shown in Figures 8, 9 and 10.

When the water level is the same as the top of the silt, the variation range of water level has little effect on pore pressure, but from the whole pore pressure-time history curve in front, it can be seen that the variation range of pore pressure curve caused by each variation range of water level increases with the development of consolidation and drainage process. Therefore, attention should be paid to the influence of hydrological tide on settlement and pore pressure in site measurement during construction of hydrological wetland areas.

Discussion

Considering the role of hydrological tide in the silt roadbed in hydrological wetland, the horizontal permeability coefficient of sand well silt roadbed is calculated based on the field measured data, and the three-dimensional sand well roadbed is converted into the plane strain sand wall roadbed, and the equivalent permeability coefficient is determined. The consolidation and deformation characteristics of soft rock foundation under hydrological wetland environment are calculated as follows:

(1) At the shoulder position on both sides, the settlement of embankment fills is not obvious at the initial stage of freezing. In the coldest season, the settlement increases. Then, until the embankment fills are loaded, the settlement near the slope does not increase significantly; at the central partition zone of
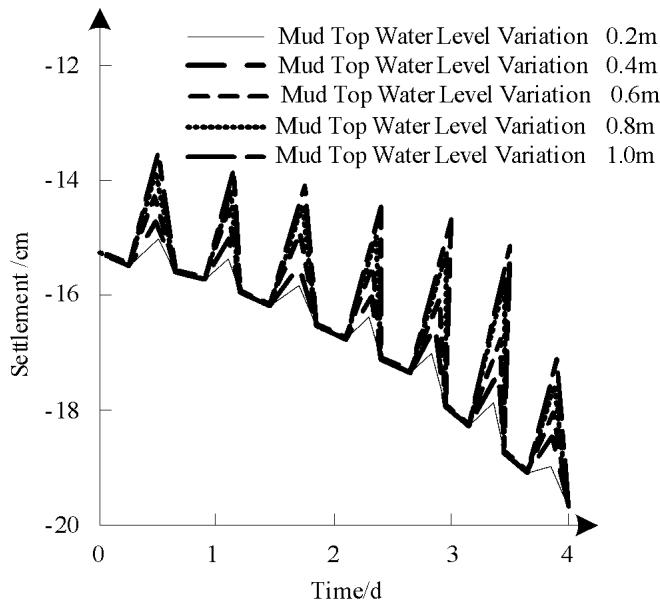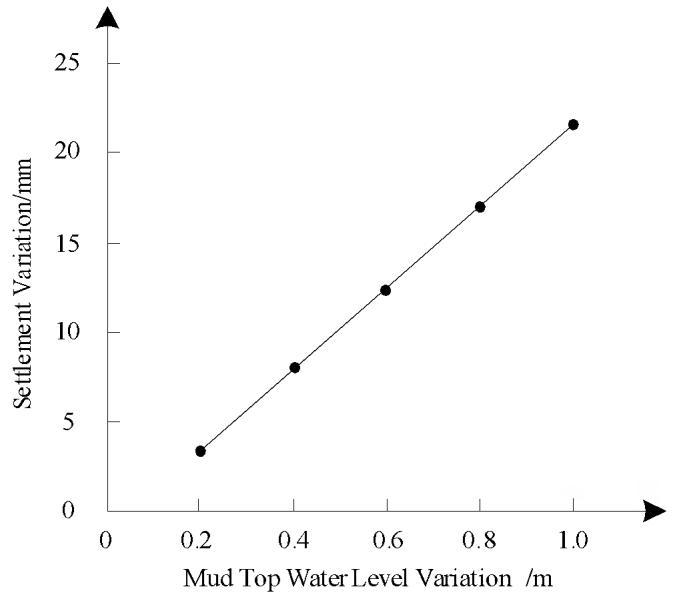
Figure 7. Settlement-time relationship curve under different water level variation ranges
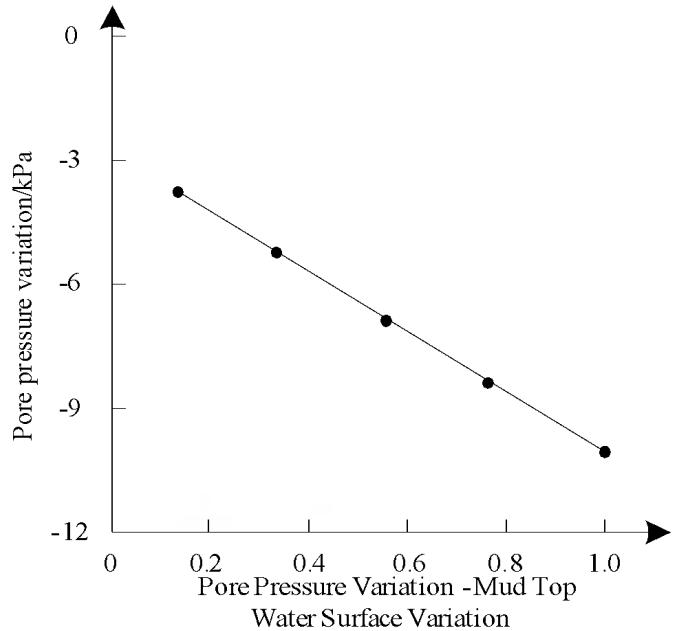

Figure 9. Settlement Variation - Mud Top Water Level Variation
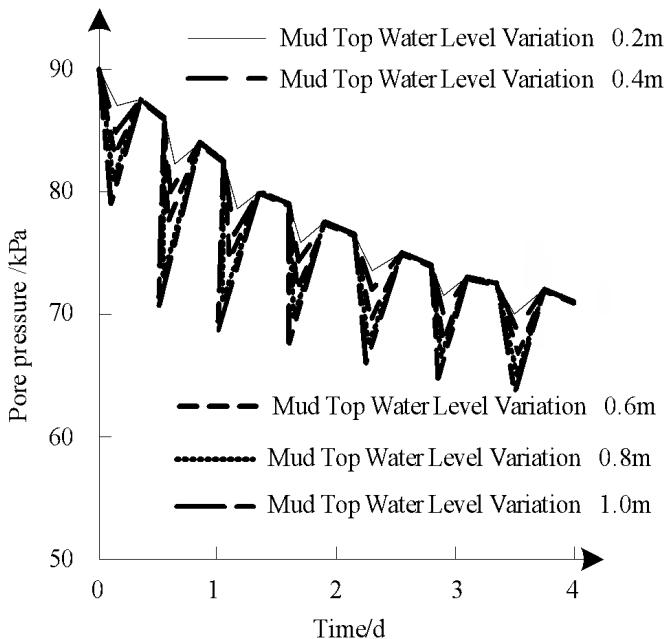
Figure 8. Pore pressure-time relationship curve under different water level variation ranges

Figure 10. Pore pressure variation range - mud top water level variation range

embankment fills, there is no obvious settlement in the whole winter. As the temperature rises gradually, the settlement increases, and the settlement near the surface of the soft rock foundation increases obviously. During the construction season, the settlement of the soft rock foundation increases obviously, and the closer to the surface the settlement is, the larger the settlement of the soft rock soil accounts for more than 80% of the total settlement. The slope of the settlement curve of soft rock foundation treated by bagged sand well is smaller in later stage, which indicates that bagged sand well treatment method is beneficial to drainage and consolidation of shallow soft rock foundation of wetland in cold region, and reduces post-construction settlement of soft rock foundation.

(2) During the whole winter, pore water pressure dissipates in varying degrees; the change of excess pore water pressure is very synchronous with the loading process of filling soil, and the excess pore water pressure increases obviously during loading. The faster the loading rate is, the larger the loading is, and the faster the excess pore water pressure increases. The excess pore water pressure dissipates obviously after stopping loading. The excess pore water pressure of soft rock foundation treated by bagged sand wells dissipates quickly, which is more conducive to drainage consolidation of soft rock and soil, and increases the stability of soft rock foundation.

(3) During the freezing process of embankment fill, the earth pressure near the central separation zone decreases gradually, while the earth pressure near the embankment slope increases gradually. During the melting process of embankment fill, the earth pressure near the central separation zone increases gradually, while the earth pressure near the embankment slope decreases gradually.

(4) Hydrological tides and back pressure guards play an important role in drainage and consolidation of silt roadbed. The regularity of settlement and

deformation caused by hydrological tide changes. The settlement-time history curve changes periodically with the increase of hydrological tide, and its influence decreases with the increase of silt depth. The pore pressure dissipation curve is also affected by hydrological tides. With its periodic variation, the frequency of variation is the same as that of hydrological tides. The law of variation of pore pressure is contrary to that of hydrological tides, and its influence decreases with the increase of depth.

(5) When the variation of silt top water level caused by tide is different, the periodic variation range of settlement and pore pressure is linearly related to the variation range of silt top water level. When the hydrological tide is lower than the silt top, the variation range of silt top water level has no effect on pore pressure, but it has obvious effect on settlement. The larger the variation range of water level is, the smaller the settlement is, indicating that the hydrological tide will decrease the settlement at consolidation stage.

Conclusions

The engineering geological problems faced by the construction of high-grade highway on soft rock foundation are mainly the settlement and stability of soft rock foundation. The engineering properties of soft rock and soil are different because of different causes. In this paper, the research method of consolidation and deformation characteristics of soft rock foundation in hydrological wetland environment is proposed. The correlation of Engineering properties, treatment methods and time effect of soft rock foundation in hydrological wetland is studied by combining on-site monitoring with numerical calculation. In the future study and work, we should carry out further work in this area, especially the experimental study on the structure of soft rock and soil and the compression and strength characteristics of soft rock and soil at different depths, as well as on-site monitoring of deformation of soft rock foundation in hydrological wetland during embankment filling. By evaluation of post-construction consolidation settlement and stability, construction loading rate is controlled by using monitoring data in further study, to ensure that the stability of soft soil foundation can guide construction more effectively.

Acknowledgements

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