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Finite Element Analysis of Treatment of Soft Subgrade Disease in Highway

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Abstract: For the treatment of highway subgrade disease under special circulation, the three-dimensional finite element model is established in order to study on the law of subgrade deformation under the action. The disease treatment effect of subgrade is analyzed by the result. The reason for the failure of the treatment is obtained.
Keywords: Subgrade disease, Numerical simulation, Deformation

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1. INTRODUCTION

The expressway in the western part of Guangdong Province is located in the coastal beach area, especially K73 + 200 ~ K74 + 665. It is near the deep pond-dense area, and the silt layer is 15 ~ 20m deep. There are more fish ponds around the road. The regular pumping of the fish ponds makes the roadbed long-term in the groundwater level changes in the role of the environment.The results show that [1] - [5], Under the action of the change of groundwater level, the strength of roadbed soil will be reduced to a certain extent, and its resistance to deformation will decrease, and all kinds of diseases will be easily generated. How to treat the roadbed disease effectively become the key to the smooth operation of the highway.

During the construction period, the soft foundation treatment was carried out by vacuum preloading combined with preloading method. After the treatment, the settlement of the soil was about 2m, and the mechanical properties of the soil were improved. Two years after the opening, the section of the road there is a long longitudinal cracks. As shown in Figure 1. After several repairs, road cracks still continue to develop the trend. Therefore, after eight years of traffic, the roadbed was reinforced.

2. TREATMENT PLAN AND DISEASE

Mainly from the following aspects of treatment:

1) Install the prestressed pipe pile on the foot. Two rows of prestressed pipe piles are arranged near the foot of the slope to resist the lateral slip of the subgrade. Pipe pile diameter of 400mm, the first row of piles from the foot of 1.2m, pipe pile spacing of 1.6m, column spacing

of 1.2m. According to the geological situation into the holding layer is not less than 3m. The pile top is reinforced concrete crown beam to enhance the integrity of the prestressed pipe pile.

2) Slope foot set cement mixing pile. In the longitudinal section of the slope of the foot of the appropriate placement of two rows of cement mixing pile, column spacing 1m, line spacing 0.5m, plum blossom layout, mixing pile diameter 0.5m, pile length 10m.

3) Slope set upwards inclined drain pipe. In the slope slope on the provision of a row of oblique drain pipe, the discharge pipe from the road surface height of 2m, spacing 5m, length 18m, elevation 5 °.

After this reinforcement, the road surface cracking disease to a certain degree of delay, but failed to fundamentally solve the problem. During the subsequent operation, the section of the cracks and re-cracking. Among them, k74 +378 ~ K74 + 540 the main lane in the middle of serious cracking, the maximum crack width of 12cm.

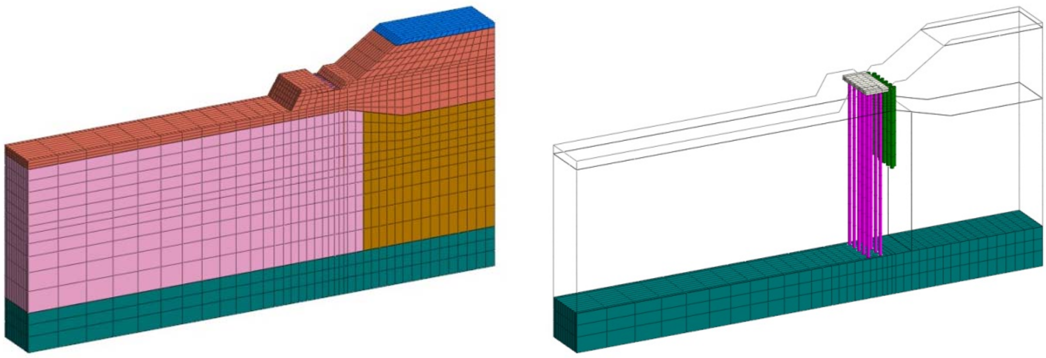
Fig.1 Paving cracking

3. NUMERICAL SIMULATION

In order to further analyze the causes of the damage of the roadbed, the finite element model is established. Considering the change of groundwater level, the deformation of the roadbed is studied. So as to obtain the reasons for the effect of treatment is not ideal, and make recommendations.

3.1 Build model

Take the section of K74 + 448 ~ K74 + 498 as an example. As shown in picture 2. Embankment filling height 9m, slope ratio 1: 1.5, foundation soil depth to take 31m, length 62m, width 6m.



(a) Subgrade model (b) Reinforcement scheme

Fig.2 Finite element model

3.2 Constitutive model and calculation parameters

The constitutive model of soil is Mohr-Coulomb model.

The name of the formation	Thickness of soil layer (m)	Mechanics		Severe γ(kN/m^3)	Elastic Modulus(MPa)	Constitutive relationship
		Φ (°)	C (kPa)			
Water stabilization	0.6m	20	80	18.5	45	Mohr-Coulomb
Filling	1~9m	12	14	18.4	10	Mohr-Coulomb
Silt 1	16~18m	8	10	16.3	6	Mohr-Coulomb
Silt 2	5m	6	7	15.6	3	Mohr-Coulomb
Gravel sand	0.6m	33	2	15.6	30	Mohr-Coulomb

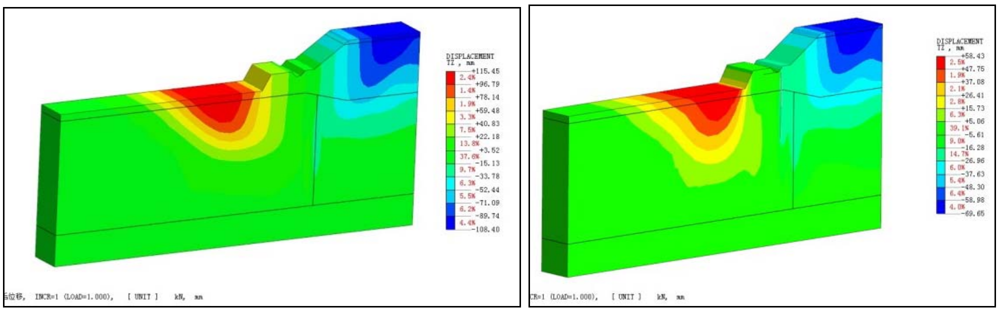
3.3 Analysis of working conditions

Disease treatment section is located in the fish pond area. Water pumping and storage of fish ponds can cause changes in groundwater level, fish pond pumping, groundwater level decline, water level changes in the soil moisture content decreased, whereas water content increased. In order to simulate this condition, the fish pond water level, the fish and pond water level down to the bottom of the pond (2.5m under the embankment); fish pond water, the fish pond water level rose to normal levels (0.8m under the embankment). Four times in the calculation of pumping water.

As the main discussion of the groundwater level changes when the roadbed deformation, so the numerical simulation of road surface load using static load.

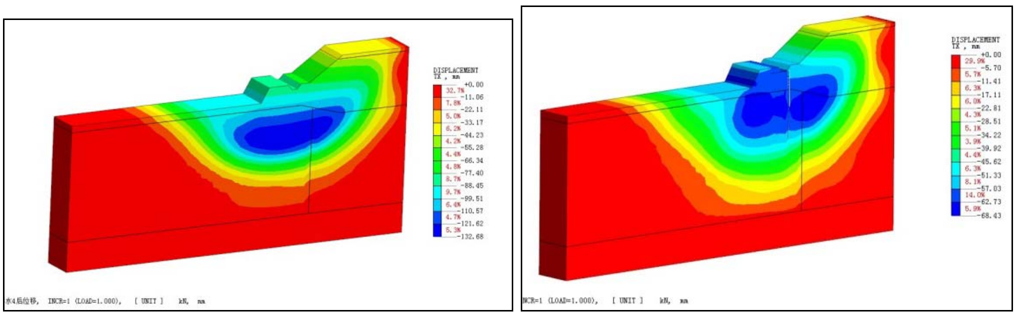
3.4 Result analysis

It can be seen from Figure 3, the reinforcement before and after the settlement of the basic range of the same, mainly concentrated in the roadbed. The maximum settlement before reinforcement is 108.40mm, and the maximum settlement after reinforcement is 69.65mm, which is 36% lower. It can be seen from Fig. 4 that the range of the horizontal displacement before and after reinforcement is basically the same. The maximum horizontal displacement before reinforcement was 132.68mm, 68.43mm after reinforcement, which is 48% lower. This shows that the pipe pile is a good way to limit the horizontal displacement of the roadbed. However, it should be noted that although the deformation of the roadbed has a certain degree of reduction, the absolute value is still large.



before reinforcement after reinforcement

Fig.3 Settlements before and after treatment



before reinforcement after reinforcement

Fig.4 Horizontal displacement before and after treatment

It can be seen from Fig. 5 and Fig. 6 that the settlement and horizontal displacement of the subgrade surface are obviously reduced. The maximum surface subsidence of the subgrade is about 5 m at the centerline of the subgrade and the maximum settlement is reduced by 35%. The settlement difference of the subgrade is 52.7mm before reinforcement, and 27.1mm after reinforcement, and the settlement difference is reduced by 48%. The maximum horizontal displacement of the subgrade surface appears at the shoulder, and the horizontal displacement at the shoulder after reinforcement is reduced from 36.5 mm to 21.5 mm. This shows that the roadbed reinforcement is a certain effect, the roadbed uneven settlement and horizontal displacement has obvious relief, but the absolute value of roadbed deformation is still relatively large.

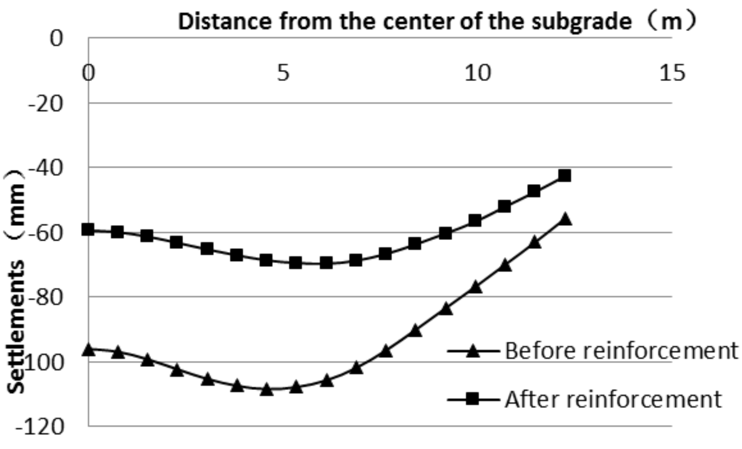


Fig.5 Settlements of different position

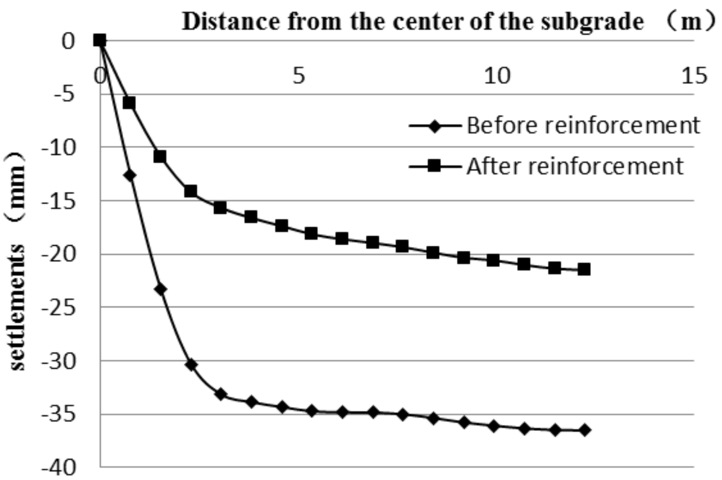


Fig.6 Horizontal displacements of different position

Figure 7 is a variation of the surface subsidence of the subgrade center line with the calculated conditions. Before the reinforcement, the surface settlement stability value is 47.10mm at the center of the road when considering the road overloading, and the value is 95.96mm when taking into account the impact of changes in groundwater level. Surface settlement increased by 103%. After the reinforcement, the surface settlement stability value is 36.22mm at the center of the road when considering the road overloading, and the value is 50.39mm when taking into account the impact of changes in groundwater level. Surface settlement increased by 39%.

Figure 8 shows the variation of the horizontal displacement of the shoulder with the calculated conditions. Before the reinforcement, the horizontal displacement stability of the shoulder is 3.57mm when considering the road overloading, and the value is 36.53mm when taking into account the impact of changes in groundwater level. The horizontal displacement increased by 924%. After the reinforcement, he horizontal displacement stability of the shoulder is 3.99mm when considering the road overloading, and the value is 21.50mm when taking into account the impact of changes in groundwater level. Surface settlement increased by 439%.\

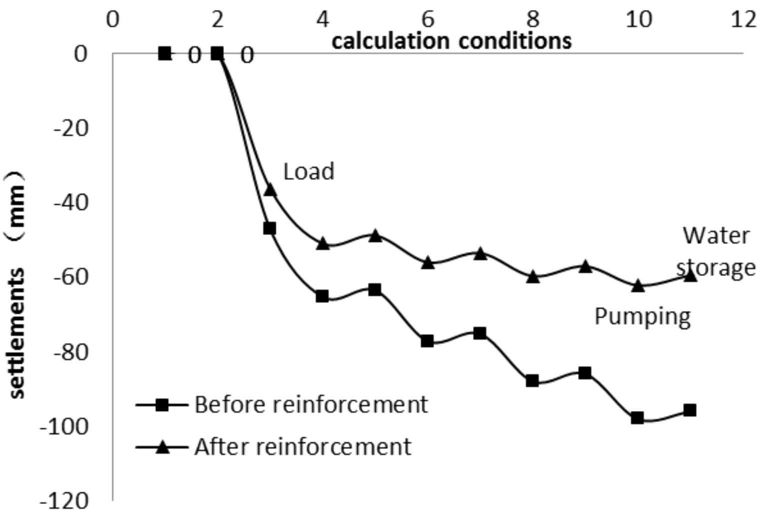


Fig.7 Relations with settlements and calculation conditions

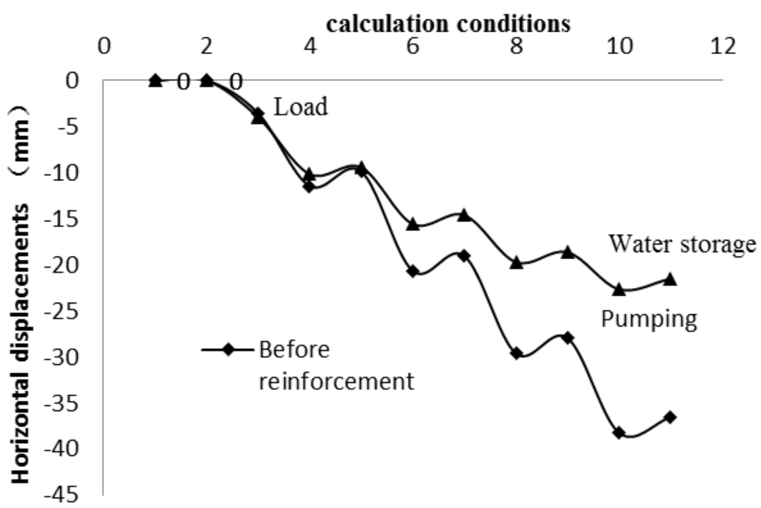


Fig.8 Relations with Horizontal displacements and calculation conditions

From the above we can see that the groundwater on the roadbed deformation has a greater impact. Groundwater level decline, roadbed deformation accelerated; groundwater level rise, roadbed deformation rebounded. At the same time, roadbed reinforcement produced a certain effect. Before the reinforcement, the deformation of the subgrade is increasing.After the reinforcement, the deformation of the subgrade will continue to increase, but the increase rate will slow down. Finally, after reinforcement, the absolute value of roadbed deformation is still relatively large, the surface subsidence at the center of the roadbed is 50.99mm, the horizontal displacement of the shoulder at the shoulder is 21.50mm, and continues to increase. Therefore, the roadbed disease still appears.

4. CONCLUSION

In this paper, the finite element simulation analysis of a highway subgrade disease treatment effect, analysis shows that the groundwater level changes on the roadbed deformation has a greater impact. It is necessary to consider the change of groundwater level for the treatment of this type of road disease.

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