Analysis of factors affecting the stability of high-fill embankments on slope foundation

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Abstract. In order to clarify the influence characteristics of various factors in the stability of high-fill embankments with slope foundation, the stability of high-fill embankments with slope foundation was systematically analyzed from the aspects of embankment height, pavement width, embankment gradient, slope foundation gradient, slope foundation-embankment relative stiffness, and slope foundation-embankment contact form by using numerical analyses. The results show that: the horizontal displacement and settlement of embankment, foot of embankment uplift increase with the increase of embankment height, pavement width, embankment gradient and slope foundation gradient; And the possibility of lateral extrusion of the embankment also increases. The safety coefficient of the embankment decreases, which is not conducive to the stabilization of embankment slope. Horizontal displacement and settlement of embankment, foot of embankment uplift decrease with the increase of embankment slope platform width, slope foundation stiffness and embankment slope step width. The safety coefficient of embankment is improved in these ways, which contributes to the stability of embankment. When the pavement width exceeds 20m, increasing the pavement width has less effect on the stability of the embankment; and increasing the width of the embankment slope platform has limited effect on improving the safety coefficient of the embankment. The safety coefficient of embankment increases with the gradient of slope foundation decreases; But when gradient is slower than 1:3.5, the improvement effect of embankment stability decreases. It can effectively reduce embankment settlement and uplift of embankment foot by setting the contact surface between slope foundation and embankment into a step. The horizontal displacement of the embankment decreases with the increase of the step width, but the horizontal displacement reduction gradually decreases. And it can effectively reduce the settlement of the embankment and the uplift of embankment foot . But when the step width is more than 1.5m, it will have less influence on the settlement and foot uplift of embankment; And the safety of the embankment is also improved.

Keywords: slope foundation; high-fill; embankment; stability; factor.

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1 Introduction

Highway construction from the plain to the mountain area with the development and construction of highway engineering. The construction of highway in mountainous areas is commonly associated with the problem of damage to high-fill embankments on slope foundation. High-fill embankments on the slope foundation are difficult to design and analyze due to factors such as embankment height, gradients of embankment and slope foundation, differences in engineering properties between the embankment and slope foundation, contact form between the embankment and the slope foundation, and vibration loads from traffic. There are more and more challenge of safety and stability of the embankment on slope foundation. Embankment on slope foundation is prone to large horizontal displacement and settlement at the top of the embankment in the later operation process. It may even cause serious diseases such as shoulder crowding, sliding, landslide, etc. These seriously threaten the safe operation of the highway and personal safety.

There are four main damage modes for embankment on slope foundation as follows[1]. ① The embankment as a whole slides along the contact surface between the embankment and the slope foundation. ② The embankment slides with the hillside overburden along the sloping bedrock face. ③ The embankment slides along a certain sliding surface which is the lying weak soil layer at the bottom of the lower embankment. ④ The embankment slides along with the rock at the base of the embankment along a weak rock formation. The stability of embankment on slope foundation is affected by various factors such as embankment gradient, fill height, pavement width, slope foundation gradient, and ultimate bearing capacity, etc[2-4]. When the embankment is built on a weak slope foundation, the stability is affected by the slop foundation gradient, the thickness of the weak soil layer, the embankment height, and the strength of the foundation etc[5-6]. For soil slope, the common analysis methods include Bishop[7-8], Janbu[9-10], Spencer[11], Morgenstern-Price[12], Sarma[13], etc. However, these methods have some limitations in the analysis of non-homogeneous slopes. For example, stability analysis requires a certain number of soil bars to ensure the reliability of the results of analysis, and most of these analysis methods are based on specific sliding surfaces and homogeneous foundation[14]. For these reasons, it is difficult to analyze the stability of embankment on slope foundation; Especially, the damage mode and sliding surface of embankment are often uncertain.However, the influence factors of embankment stability on slope foundation are different from those on flat foundation, and there are few the research results for embankment stability on slope foundation. So it is necessary to study the influence factors of high fill embankment stability on slope foundation.

This paper utilizes numerical analysis to systematically analyze the influence of the stability of high-fill embankments on earthy slope foundation from the aspects of embankment height, pavement width, gradients of embankment and slope foundation, slope foundation-embankment relative stiffness, and slope foundation-embankment contact form etc. The study can conduct with a view to providing technical references for the design, monitoring and maintenance of high-fill embankment projects on earthy slope foundation.

2 Numerical Analysis Modeling and Calculation Parameters

The geometric parameters of numerical analysis model such as embankment height, gradients of embankment and slope foundation, and slope foundation-embankment contact form, are established with reference to the provisions of the highway subgrade design specifications. It considered the stability influencing factors of the embankment filled on slope foundation. And the calculation parameters were selected according to the analysis purpose.

2.1 Numerical analysis model

It is assumed that the embankment is filled at once. And the embankment on slope foundation is analyzed as a plane strain problem. The geometric model is simplified as the Figure 1. The influence of different factors such as pavement width, embankment height, gradient of embankment, platform width, and slope foundation gradient, slope foundation-embankment relative stiffness and slope foundation-embankment contact form on embankment stability is considered.

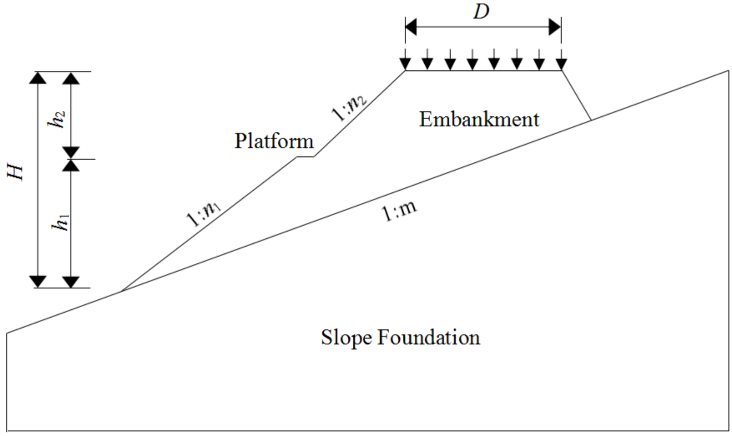


Fig. 1. Schematic diagram of geometric model of high fill embankment on soil slope foundation

2.2 Model parameters

The Mohr-Coulomb model was adopted for the numerical analysis. Specimens were made in accordance with the filling requirements of the highway subgrade design specifications and the general characteristics of the soil. And indoor tests were carried out to determine the calculation parameters in the Mohr-Coulomb model. The material parameters of soil are shown in Table 1.

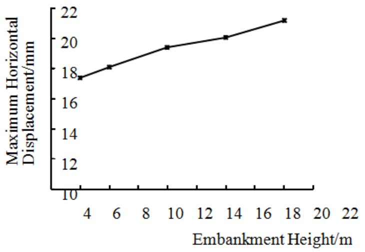
Table 1. Calculation model parameters of geotechnical materials for embankment and slope foundation

Types of soil	Poisson's ratio μ	Soil weight γ/kN*m^{-3}	Elasticity modulus E/MPa	Cohesion c/kN	Internal friction angle φ/°
Embankment	0.35	20	30	23	29
Slope foundation	0.30	22	40	32	16

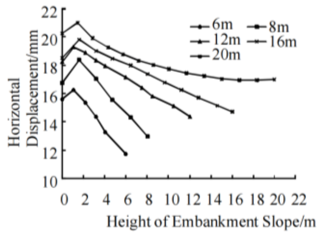
3 Analysis Results of Calculations

3.1 Influence of height on stability of embankment

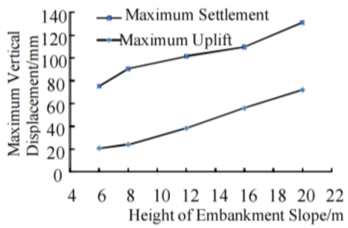
According to the regulations of highway subgrade design for the gradient and platform of embankment, the geometric model of subgrade was as follows: the pavement width was 26 m; the gradient of the upper embankment was 1:1.5; the gradient of the lower embankment was 1:1.75 (when the embankment height was more than 8m); and the platform of embankment was 1.5 m; and the gradient of the sloped foundation was 1:7.5. The calculated analyzed heights of the embankment slopes were as follows: 6.0 m, 8.0 m, 12.0 m, 16.0 m and 20.0 m.



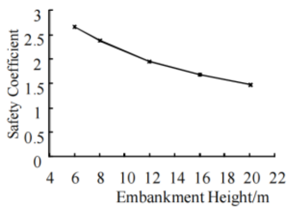
(a) Maximum Horizontal Displacement of Embankment



(b) Horizontal Displacement along Embankment Slope



(c) Maximum Vertical Displacement of Embankment



(d) Safety Coefficient

Fig. 2. Deformation of Embankment at Different Filling Heights on Slope Foundation

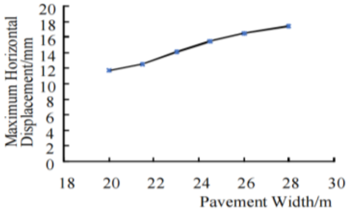
Figure 2(a) and Figure 2(b) show that the horizontal displacement of embankment generally increases with the increase of embankment height; and the possibility of lateral extrusion of the embankment increases too. The maximum horizontal displacement is located between 1.0 m - 2.1 m from the toe of the embankment. There are differences in the distribution of horizontal displacements of embankments with different heights along the embankment slope. When the embankment height is within 8.0 m, the horizontal displacement along the embankment slope decreases linearly after reaching the maximum; The decrease values of both 6.0m and 8.0m embankment are similar. When the embankment height is 12.0m-16.0m, the horizontal displacement along the embankment slope also decreases linearly after it reaches the maximum, but the reduction values are smaller than that of the 8.0m embankment. When the embankment height is 20.0m, the horizontal displacement along the embankment slope decreases nonlinearly, and it tends to stabilize.

On the one hand, the stress in the foundation will be weakened by spreading along the depth direction of the soil layer. When the embankment height is low, the pavement load is transferred to the embankment slope at a limited distance; and only a part of the pavement load can affect the embankment slope. The load far from the top of the embankment slope has a limited effect on horizontal displacement of embankment. When the embankment height is low, the horizontal displacement of the embankment is small. While the embankment height increases, the pavement load far from the top of the embankment slope also affects horizontal displacement of embankment. Therefore, the horizontal displacement of the embankment increases as the embankment height increases. On the other hand, the platform of the embankment is equivalent to applying counter pressure loading near the foot of the embankment, which affects the distribution of horizontal displacement along the embankment slope. The platform can reduce the horizontal displacement of the embankment; but the effect of controlling the lateral extrusion of the embankment is limited

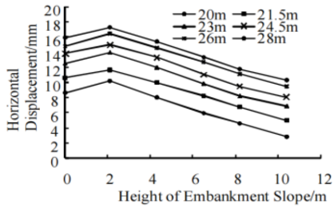
Embankment settlement generally consists of two components: compressive deformation of the embankment and settlement of the subgrade due to lateral extrusion of the embankment. The compression deformation of soil layer increases with the increase of embankment height. And the lateral displacement of embankment increases with the increase of embankment height too. The maximum settlement of the embankment also increases with the increase of the embankment height under the combined action of the two factors (Figure 2(c)). The stress diffusion of pavement load in the subgrade affects the deformation characteristics of embankment. When embankment height is low, the embankment deformation is mainly influenced by the loads near the top of the embankment slope. The load away from the top of the embankment slope also influenced the embankment deformation as the embankment height increased, which resulted in the maximum embankment bulge increasing with the embankment height. And when the embankment height increases, the safety coefficient of the embankment decreases (Figure 2(d)). When the embankment height is 20.0m, the safety coefficient of the embankment is 1.475, which is still compliance with the stability safety coefficient recommended by the code, and the embankment is safe and reliable.

3.2 Influence of pavement width on embankment stability

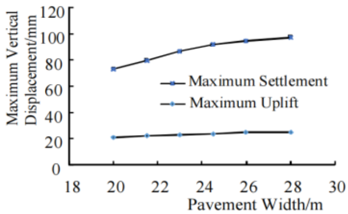
According to the regulations of highway subgrade design, the geometric model of subgrade was follows: the embankment height was 8.0m; and the gradient of embankment was 1:1.5; and the gradient of slope foundation was 1:7.5; and the pavement widths were as follows: 20.0 m, 21.5 m, 23.0 m, 24.5 m, 26.0 m and 28.0m.



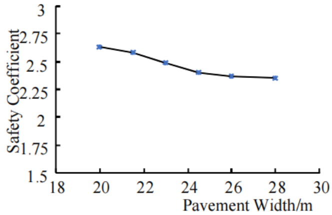
(a) Maximum Horizontal Displacement of Embankment



(b) Horizontal Displacement along Embankment Slope



(c) Maximum Vertical Displacement of Embankment



(d) Safety Coefficient

Fig. 3. Deformation of Embankment at Different pavement width on Slope Foundation

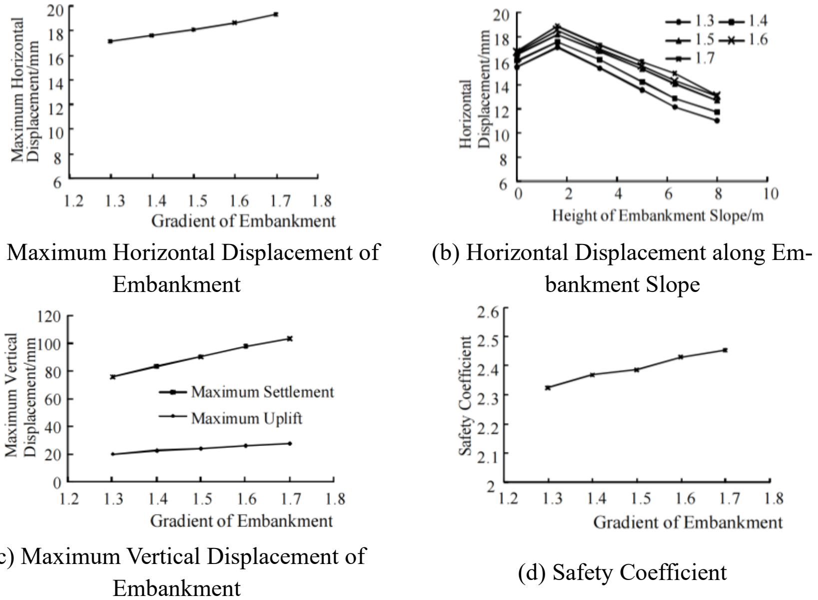
Figure 3(a) and Figure 3(b) show that the horizontal displacement of the embankment increases with the increase of the pavement width, and the maximum horizontal displacement is located at about 2.1 m from the foot of the embankment. The distribution of the horizontal displacements of the embankment with various pavement widths is consistent along the direction of the embankment height. The maximum horizontal displacement of the embankment increases nonlinearly with the increase of the pavement width, and it tends to slow down gradually. On the one hand, the width range of pavement load increases with the increase of pavement width, and the horizontal load on embankment slope increases too. On the other hand, the embankment height is only 8 m. When the load is far away from the embankment slope,the load spreading to the embankment slope is already small. So the influence on the deformation of the embankment slope is limited. It results in pavement load which is far away from the embankment slope transfer light load to the embankment slope after diffused in embankment. The increase of pavement width has limited influence on horizontal displacement of embankment. Although it causes the embankment slope horizontal displacement to increase, but the increase range is decreasing.

The variation trends of maximum settlement and maximum uplift of embankment in Figure 3(c) are obviously different from those in Figure 2(c). The maximum settlement and uplift of embankment are less affected by pavement load than that affected by embankment height. Both of them increase with the pavement width, but the trend slows down. The main reason is that the embankment height is unchanged, and the embankment soil compression depth is unchanged, and the upper load is certain; but it only increases the scope of load. According to the distribution law of additional stress on the foundation under vertical uniform strip load, the smaller the ratio of load width to calculated depth, the smaller the change of additional stress coefficient [15]. Therefore, the increasing trend of pavement settlement will slow down with the increase of pavement load width.

The safety coefficient of the embankment decreases with the increase of the pavement width(Figure 3(d)). When the pavement width is 20.0m, the safety coefficient of embankment is 2.63. When the pavement width is 28.0m, the safety coefficient of embankment is 2.35. So when the pavement width increases by 8m, the safety coefficient of embankment decreases only by 0.28. The safety coefficient of the embankment is higher than the standard value. It is shown that when the pavement width exceeds 20m, it has little influence on the stability of the embankment.

3.3 Influence of gradient of embankment on embankment stability

According to the regulations of highway subgrade design for the gradient of the embankment, the geometric model of subgrade was follows: the pavement width was 26.0 m; the embankment height was 8.0 m; the gradient of the slope foundation was 1:7.5; and the gradients of the embankment were as follows: 1:1.3, 1:1.4, 1:1.5, 1:1.6, and 1:1.7.



(a) Maximum Horizontal Displacement of Embankment

(b) Horizontal Displacement along Embankment Slope

(c) Maximum Vertical Displacement of Embankment

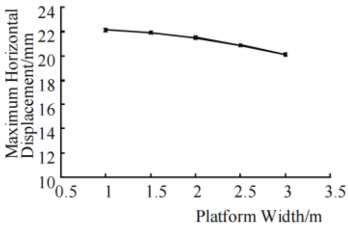
(d) Safety Coefficient

Fig. 4. Deformation of Embankment at Different Gradient of Embankment on Slope Foundation

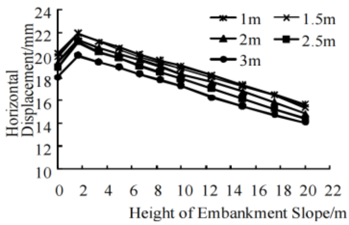
Figure 4(a) and Figure 4(b) show that the horizontal displacement of embankment decreases with the decrease of the gradient of the embankment. The maximum horizontal displacement is located at about 1.6 m away from the foot of the embankment. The horizontal displacement distribution of the embankment is basically the same in various gradients of the embankment. And the settlement of the embankment approximately linearly decreases with the decrease of the gradient of embankment (Figure 4(c)). On the one hand, the horizontal displacement of the embankment decreases with the gradient of the embankment, which affects the settlement of the embankment. On the other hand, the embankment height is 8m in this calculation. When the embankment is slow, the average height of the embankment decreases, which also affects the calculation of the embankment settlement. The uplift at the foot of embankment is similarly affected. It makes the uplift of the foot of embankment decrease linearly with the decrease of the gradient of the embankment. Reducing the gradient of the embankment, the safety coefficient is gradually increased, which is conducive to the safety and stability for the embankment (Figure 4(d)).

3.4 Influence of platform width on embankment stability

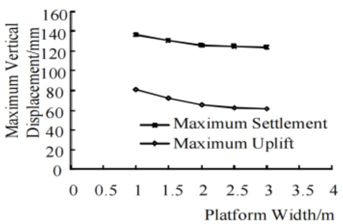
According to the regulations of highway subgrade design for the platform width of the embankment, the geometric model of subgrade was follows: the pavement width was 26.0m; the embankment height was 20.0m; the gradient of the upper embankment was 1:1.5, and the gradient of the lower embankment was 1:1.75; and the gradient of the slope foundation was 1:7.5. The widths of the platform were as follows: 1.0m, 1.5m, 2.0m, 2.5m, 3.0m.



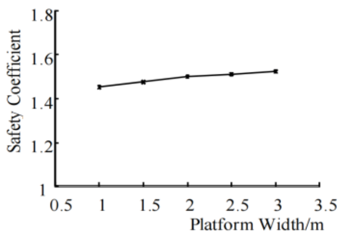
(a) Maximum Horizontal Displacement of Embankment



(b) Horizontal Displacement along Embankment Slope



(c) Maximum Vertical Displacement of Embankment



(d) Safety Coefficient

Fig. 5. Deformation of Embankment at Different Platform Width on Slope Foundation

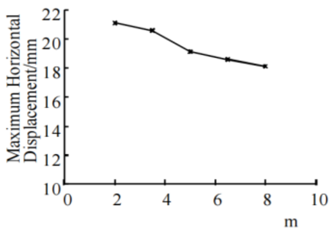
Figure 5(a) and Figure 5(b) show that the horizontal displacement of the embankment decreases with the increase of the platform width of the embankment. The maximum horizontal displacement is about 1.7m away from the foot of embankment. The horizontal displacement distribution characteristics of the embankment with various widths of the intermediate platform are basically the same along the height direction of the embankment slope. The maximum horizontal displacement of the embankment decreases approximately linearly with decreasing embankment gradient. Setting Platform is equivalent to load shedding on the upper part of the embankment or applying counter-pressure loads on the lower part of the embankment, which is conducive to the stabilization of embankment. In addition, the calculated heights of embankments were 20.0 m. Increasing the platform leads to a reduction in the average calculated height of the embankment, which also facilitated the control and stabilization of the horizontal displacement of the embankment, especially those in the middle and lower portions of the embankment.

The settlement of the embankment decreases with the increase of the width of the platform in embankment, but the reduction amplitude decreases gradually (Figure 5(c)). Figure 5(c) shows that increasing the width of the platform can reduce the deformation of the embankment, but it does not decrease continuously with increasing the width of the platform. This is mainly because of that the embankment height in the calculation is 20.0 m. The platform in embankment makes the average height of the embankment decrease, which also affects the settlement value of the embankment. In addition, the filling soil below the platform also plays the role of a counter-pressure. The uplift at the foot of the embankment was similarly affected. In addition, the safety coefficient of the embankment increased with the increase of the width of the platform, but the improvement was less significant (Figure 5(d)). When the platform width is 1.0m, the safety coefficient is 1.47; and when the platform width is 3.0m, the safety coefficient is 1.52. Therefore, the effect of improving the safety coefficient of the embankment by increasing the platform width is limited.

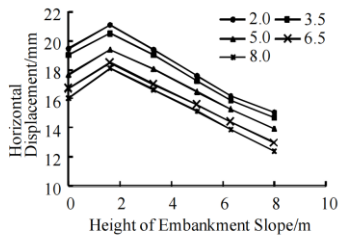
3.5 Influence of gradient of slope foundation on embankment stability

According to the regulations of highway subgrade design,the geometric model of subgrade was follows: pavement width was 26.0 m, and the embankment height was 8.0 m, and the embankment gradient was 1:1.5. In order to analyze the influence of the slope foundation gradient on the stability of the embankment, the slope foundation gradient gradients were as follows: 1:2.0, 1:3.5, 1:5.0, 1:6.5, and 1:8.0.

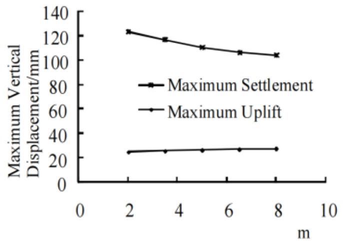
Figure 6 (a) and Figure 6 (b) show that the horizontal displacement of the embankment decreases with the decrease of the slope foundation gradient; and the maximum horizontal displacement is located at about 1.6 m from the foot of the embankment. The horizontal displacement distribution of the embankment in each gradient of slope foundation is basically the similar along the embankment height slope. The maximum horizontal displacement of the embankment decreases with the decrease of the gradient of slope foundation. The embankment height is constant in this calculation, so the load spreading from the road surface to the slope of the embankment is basically unchanged. And the slope foundation gradient is slowed down which is conducive to the anti-sliding between embankment and foundation. Thus, the maximum horizontal displacement of the embankment decreases with the gradient of slope foundation.



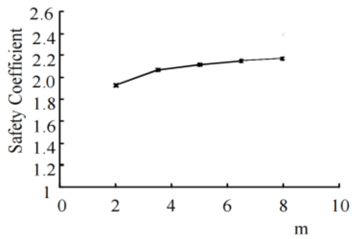
(a) Maximum Horizontal Displacement of Embankment



(b) Horizontal Displacement along Embankment Slope



(c) Maximum Vertical Displacement of Embankment



(d) Safety Coefficient

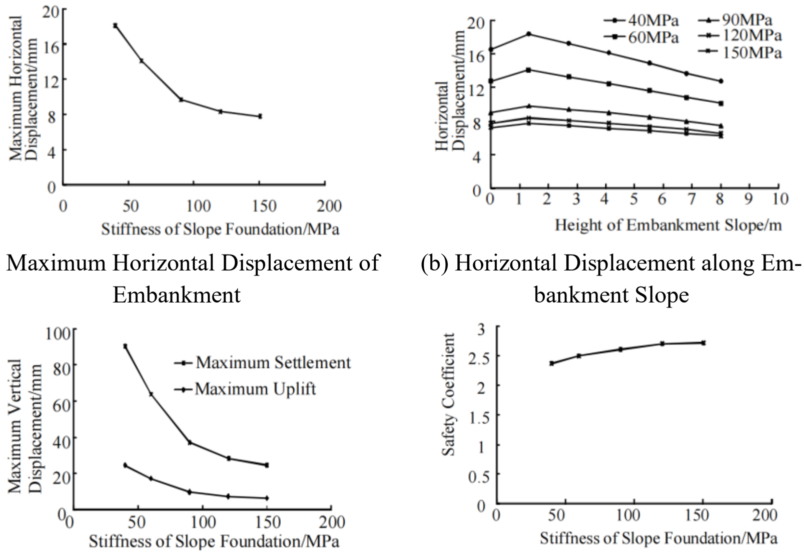
Fig. 6. Deformation of Embankment at Different Slope Foundation Gradient

The embankment settlement decreases and slows down with the slope foundation gradient(Figure 6(c)). The deformation of the embankment can be reduced by slowing down the slope foundation gradient, but it does not decrease continuously with the continuous slowing down of the slope foundation gradient. On the one hand, the gentle gradient slope foundation reduces the possibility of the embankment sliding along surface of the slope foundation[16]. On the other hand, the gentle slope foundation gradient increases the average calculated height of the embankment. The settlement of the embankment decreases and tends to slow down with the decrease of the slope foundation gradient under the joint influence of them, but the change of embankment uplift is not obvious. The slope foundation gradient decreases, and the safety coefficient of the embankment is improved (Figure 6(d)). When the slope foundation gradient decreases from 1:2.0 to 1:3.5, the safety coefficient increases by 0.14, and then the safety coefficient increases and slows down.

3.6 Influence of relative stiffness of slope foundation-embankment on stability of embankment

According to the regulations of highway subgrade design,the geometric model of subgrade was follows: pavement width was 26.0m, and embankment height was 8.0m, and embankment gradient was 1:1.5, slope foundation gradient was 1:7.5. In order to analyze the influence of the slope foundation-embankment relative stiffness on the stability of the embankment, the modulus of elasticity of the slope foundation were as follows:

40 MPa, 60 MPa, 90 MPa, 120 MPa, 150 MPa; the ratio of the slope foundation stiffness to embankment stiffness were as follows: 1.33:1, 2:1, 3:1, 4:1, 5:1.



(a) Maximum Horizontal Displacement of Embankment

(b) Horizontal Displacement along Embankment Slope

(c) Maximum Vertical Displacement of Embankment

(d) Safety Coefficient

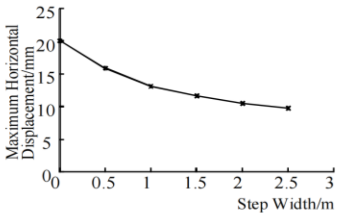
Fig. 7. Deformation of Embankment at Different Relative Stiffness of Slope Foundation-Embankment on Slope Foundation

The horizontal displacement of the embankment decreases with the increase of the slope foundation stiffness(Figure 7(a), Figure7(b)). The maximum horizontal displacement is located about 1.3m away from the foot of the embankment. The distribution of horizontal displacements of embankment slopes that were filled on the slope foundation with different stiffness varies greatly along the embankment height slope. When the slope foundation stiffness is low, the extreme value of the horizontal displacement of the embankment appears near the slope foot. With the increase of slope foundation stiffness, the extreme value of the horizontal displacement of the embankment is gradually insignificant. The horizontal displacement of the whole embankment slope is close. It shows that when the relative stiffness of slope foundation and embankment is small, the embankment will slip in circular arc. While the relative stiffness of slope foundation and embankment is large, the embankment will slip in a whole.

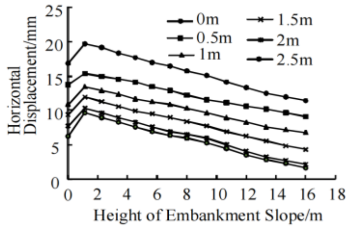
Figure 7(c) shows that the improvement of slope foundation stiffness can effectively reduce embankment settlement and uplift of embankment foot. With the increase of slope foundation stiffness, the vertical deformation of embankment is mainly caused by the compression of embankment soil layer. Increasing the stiffness of the slope foundation can also improve the overall safety of the embankment slope (Figure 7(d)). When the slope foundation stiffness increases from 40MPa to 150MPa, the safety slope factor of embankment increases from 2.37 to 2.71.

3.7 Influence of slope foundation - embankment contact form on embankment stability

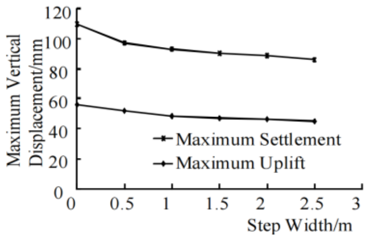
According to the regulations of highway subgrade design,the geometric model of subgrade was follows: pavement width was 26m, and embankment height was 16m, and upper embankment gradient was 1:1.5, and lower embankment gradient was 1:1.75, and the middle platform of embankment was 1.5m, the gradient of slope foundation was 1:4. In order to analyze the influence of the contact form between slope foundation and embankment on the stability of embankment, the step widths of the contact surface between slope foundation and embankment were set as follows: 0 m, 0.5 m, 1 m, 1.5 m, 2 m and 2.5 m.



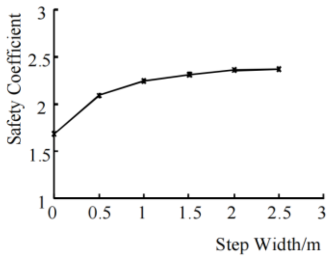
(a) Maximum Horizontal Displacement of Embankment



(b) Horizontal Displacement along Embankment Slope



(c) Maximum Vertical Displacement of Embankment



(d) Safety Coefficient

Fig. 8. Deformation of Embankment at Different Slope Foundation - Embankment Contact Form on Slope Foundation

Figure 8(a) and Figure 8(b) show that the horizontal displacement of embankment can be effectively reduced by setting a step at the slope foundation and embankment contact surface. The horizontal displacement of the embankment decreases with the increase of the step width, but the magnitude of the decrease is gradually decreasing. The relative slip deformation between embankment and slope foundation is reduced by setting steps at the contact surface between slope and embankment. However, when the width of the step is narrow, and especially when the foundation stiffness is low, the step is easy to break due to the relative slip of the embankment, which weakens the embankment and foundation occlusion effect. In addition, the narrow width of the step will also affect the strength of the soil at the contact between the embankment and the slope foundation, because the embankment soil at the step is difficult to be compacted. Therefore, the steps on the slope foundation are not too narrow. Regulations of highway subgrade design stipulates that, when the gradient of slope foundation is 1:5-1:2.5, the original ground should be dug up steps, and the width of the steps should not be less than 2m.

The contact surface between slope foundation and embankment can effectively reduce the settlement of embankment and uplift of embankment foot. However, when the width of the step exceeds 1.5m, it has little influence on controlling the settlement and uplift deformation of embankment(Figure 8(c)). The contact surface between the slope foundation and the embankment is set as a step, which changes the contact form of them; it can effectively controls the horizontal displacement of the embankment. This method only changes the form of the contact surface of slope foundation and embankment; and other external conditions do not change. So the horizontal displacement of the embankment can be controlled, but the settlement of the embankment will not be greatly improved.In addition, the contact surface of slope foundation and embankment is set into a step, which improves the overall safety of the slope (Fig. 8(d)).

4 Conclusion

1. Increasing embankment height, pavement width, embankment gradient and slope foundation gradient are not conducive to the stability of embankment.Horizontal displacements and settlements of embankment, uplift deformation of embankment foot increase with the increasing embankment height, pavement width, embankment gradient, and slope foundation gradient. The possibility of lateral extrusion of embankment increases, and the safety coefficient of embankment slope decreases.
2. The increases of embankment slope platform width, slope foundation stiffness and step width of the slope foundation and embankment contact surface are beneficial to the stability of embankment. Horizontal displacement and settlement of the embankment, the uplift deformation of embankment foot decreased with the increase of the platform width of embankment slope, slope foundation stiffness and the width of the step. And the safety coefficient of the embankment is improved.
3. When the pavement width exceeds 20m, increasing the pavement width has less effect on the stability of the embankment. Reducing the slope foundation gradient is beneficial to the stability of the embankment. However, when gradient is slower than 1:3.5, the improvement effect of embankment stability decreases. So, when the gradient of the slope foundation exceeds 1:3.5, its influence on the deformation and stability of the embankment should not be ignored.
4. The horizontal displacement of embankment can be effectively reduced by setting step at the contact surface between slope foundation and embankment. It decreases with the increase of step width; and the reduction amplitude decreases gradually. It can effectively reduce embankment settlement and uplift of embankment foot by setting the contact surface between slope foundation and embankment into a step. When the width of the step exceeds 1.5m, it has little influence on the settlement and uplift of the embankment. The overall safety of the embankment slope has also been improved.

5. It is suggested that steps should be set at the interface between the embankment and the slope foundation to reduce the possibility of sliding along the interface between the embankment and the slope foundation when the embankment is filled on the slope foundation with large stiffness (such as rock slope foundation). But the width of the steps should not be less than 2m.
6. The research results can provide theoretical basis and technical support for highway embankment construction on slope foundation, especially in mountain area. It can also provide guidance for the management and maintenance of embankment on slope foundation.

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