Earth Reinforcement, Ochiai, Yasufuku & Omine (eds) © 1996 Balkema, Rotterdam. ISBN 90 5410 833 9

The study of the technique against the sliding of reinforced soil walls on soft subgrade

Lin Xin
Chongqing Institute of Communication, People's Republic of China

ABSTRACT: On the base of the case of a reinforced embankment which was built on soft subgrade, we will discuss the external stability of the renforced soil embankment and its technique against sliding.

1. INTRODUCTION

On the highway around the city in Beibei district of Chongqing, a reinforced embankment was built at the bank of the Longfeng stream.At the begining of 1994, when the embankment were filled up to the designed elevation, the reinforced earth wall failed generally. A number of breaks was brought about on the road base. The maximum breadth of the breaks is 0.3 metres, and the maximun settlement is 1. 0 metres. Concrete panels fissured, and the top of the wall moved apparently. The movement curves is shown in Fig.1.

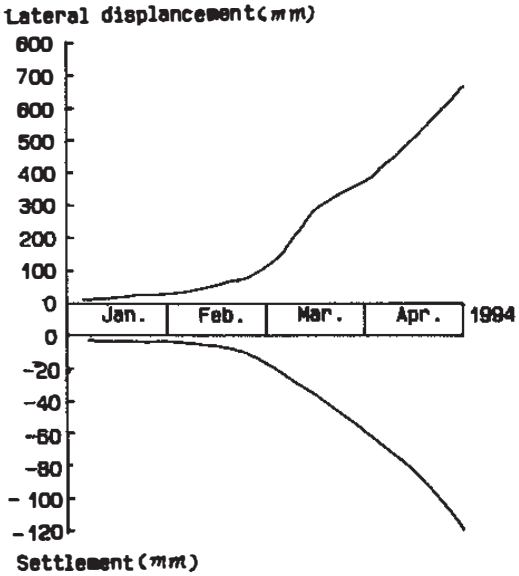


Fig.1 the displacement curves for the top of the wall

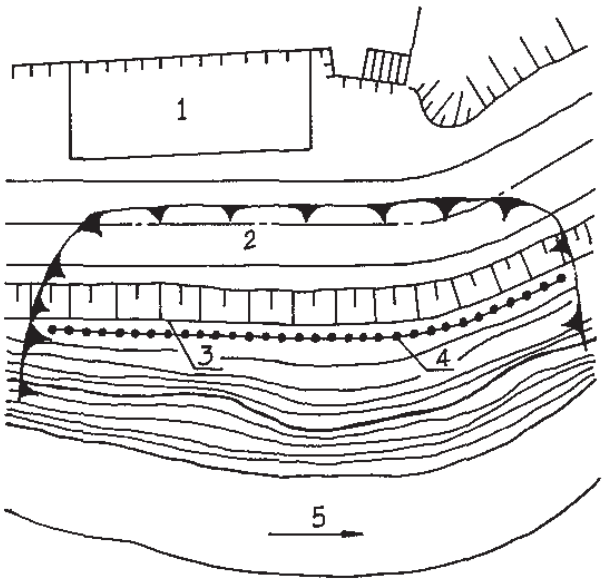
As shown in Fig. 1, The horizontal movement was up to 650 millimetres in four months, while the vertical settlement was 100 millimetres simultaneously, and the speed of the movement is 5.42mm/d and 0.83mm/d respectively. The land in front of the wall went up apparently.

2. THE OUTLINE OF THE CASE

The breadth of the roadbed was 25.0 metres. The length of the landslide was about 150.0 metres along the center line of the road [Fig.2], the body of the landslide was about 16.5 metres in thickness.

Within the range of the landslide, the height of the reinforced wall was from 3.0 metres to 8.0 metres. The ratio of the slope of the embankment behind the wall was 1:1.5, and the height of the slope was from 5.0 metres to 6.0 metres.

In front of the wall, there was the Longfeng stream. In the winter, the elevation of the water surface of the stream was lower, the subgrade soil of the wall was in natural condition, and its stability was better. The range of the height difference between the water surface of the stream and the surface of the land in front of the wall was 9.5 metres to 13.5 metres, and the range of the horizontal distance was 38.0 metres to 45.0 metres During the flood season, the river floods over the subgrade soil of the wall,and the subgrade will softem.



1-sport ground 2-highway 3-reinforced wall
4-piles against sliding 5-Longfeng stream
Fig.2 plane layout

3. GEOTECHNICAL CONDITOIN

By drilling and investigating, we can devide the strata into three layers [Fig. 3]

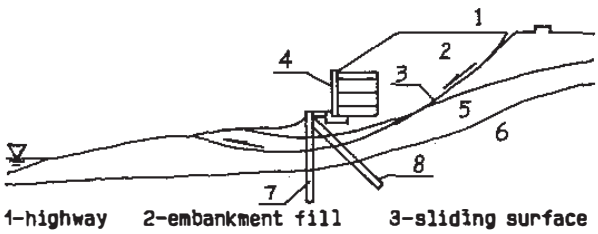
The first layer: fill of the roadbed. This stratum was consist of clay, stone pieces, concrete pieces, bricks etc., and is 2.40 metres to 7.80 metres in thickness.

The second layer: clay. This clay layer was above the rock stratum, and was underneath the fill of the embankment, and was in plasticity condition as well. The footing of the reinforced wall and the fill of the embankment were all located in the clay layer.

The third layer: mudstone. It is underneath the clay layer. The strongly weathered layer is 1.2 metres to 3. 9 metres in thickness.

4. STABILITY ANALYSIS OF THE REINFORCED WALL

Fig. 3 shows the cross section of the reinforced wall and the embankment. In order to make clear the causes of the downslide of the wall, we will calculate the following mechanisms: sliding along the base of the wall, overturning about the toe of the wall, and general slope stability failure.



1-highway 2-embankment fill 3-sliding surface
4-reinforced wall 5-clay 6-rock stratum
7-vertical pile 8-tilting pile 9-Longfeng stream
Fig.3 Section layout

4.1 Stability against sliding along the base of the wall

The reinforced soil mass can be regarded as gravity wall. Under the action of the external loads, including the horizontal earth pressure from the soil being retained behind the wall, surcharge loads applied to the top of the wall and the traffic loads, the factor of safety of the reinforced wall against sliding is 0. 74, less than the required value of 1. 3, which means that shear strength of the backfill material and foundation soil are not large enough to withstand the external loads.

4.2 Stability against overturning

Earth pressure due to the fill behind the reinforced wall causes the wall to overturn about the toe of the wall, while the self gravity of the reinforced soil and the fill on the top of the wall resist the wall overturning. The sum of the resisting moments divided by the sum of the driving moments is 2.05, greater than the required factor of safety. Therefore, the stability against overturning is sufficient.

4.3 General slope stability

Calculation parameters: the unit weight of the embankment soil is 19.0KN/m^3 in nature, and 20.4KN/m^3 in saturation. Because the fill of the embankment has fissured, the mechanical parameters on the sliding surface can be taken as c=0, φ =7° , the ground soil sustaining the reinforced wall is clay, with its unit weight being 20.0KN/m^3 in nature, and 20.5KN/m^3 in saturation. The clay has been

sheared and deformed, therefore surplus shear strength parameters can be taken in the calculation for stability analysis, i.e. c=13.67KPa, φ =13.7° .

The reinforced soil mass was treated as a gravity retaining structure. On the base of the bricks of the embankment, and the characteristics of the deformation for the ground surface in front of the wall, we could suppose a number of failure surfaces. Among the failure surfaces, the minimum overall factor of safety for general slope stability was about 0.84, therefore the reinforced embankment wall could not satisfy general slope stability. The results of theoretieal analsis were in accordance with in-situ situation.

5. REINFORCING MEASURES

5.1 Reinforcing design

As shown above, the factor of safety against sliding along the base of the wall was only 0.74, and the factor of safety for general slope stability waw about 0.84. Therefore, the main reason of movement for the wall was that the factor of safety against sliding was not great enough, we must take the reinforcing measures against the sliding of the reinforced wall.

At the wall, the value of the downsliding force caused by embankment soil was 320KN/m along the failure surface. In front of the wall, there has designed a row of piles tied back agaist sliding[Fig. 2, Fig. 3] . The vertical piles are 0. 8 metres in diameter, and the anchored piles are 0.3 metres in diameter. These piles prevent the ground soil from sliding down so as to stop the reinforced wall moving. The space between piles was 2.5 metres center to center. The length of the vertical piles was 12.0 metres to 13.0 metres, and the tilted ancher piles were 13.0 metres to 15.6 metres in length. The angle between the vertical piles and the tilted piles was 45°

5.2 Construction

In order to assure the safety of the reinforced wall and the embankment during construction, construction procedure must be carried out as the following.

1. Drilling holes

In order to prevent the soil around the borehole from falling so as to cause the wall unstabilizing, drilling must be performed jumping over two piles.

2. Cleaning holes

Holes must be cleaned in order to reduce the thickness of debris at the bottom of the holes.

3. Hanging steel bar gabions

After cleaning out the debris at the bottom of a hole, the steel bar gabions were hung into the hole immediately.

4. Filling in conerete for the pile

Concrete should be filled from the bottom to the top of the pile continunously.

5. Filling the linking beam and the retaining slab between piles.

After concrete being filled into the hole., the linking beams and the slabs retaining soil between the piles could be constructed.

6. CONCLUDING REMARKS

1. The structure against sliding offers restriction to the ground soil, confines its lateral displacement, improves then its stability and bearing capacity so as to ensure the safety of the reinforced wall.

2. The construction of the structure against sliding began in september of 1994, and came to an end in April of 1995. After reinforcement of the subgrade, there have been no signs the of deformation and fissures on the embankment as well as on the concrete face of the wall, As a result, the safety of traffic is ensured.

3. It is proved in practice that the technigue of the tived-back pile is a useful alternative to other conventional systems.

References

Lin Xin, 1989. Investigation of stability analysis on the composite soil slope, Highway Geotechnigue 1, 15-18.

James K. Mitchell. Reinforcement of earth slopes and embankments, National Cooperative Highway Research Program Report 290, National Research Council,

Washington D.C
Lin Xin & Zhongchun Oayang. The mechanical behaviour of the vertical rock slope foundation and its anchor -nailing reinforcement technique, Proceedings of the International Symposium on Earth Reinforcement Practice. FUKUOKA/KYUSHU/JAPAN/11- 13, November 1993.