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The Support Effect and Numerical Simulation Research on Mangment for Retaining Wall in Port's Slope

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Abstract—Retaining wall is an important retaining structure，which is widely used in pit support and slope support. With the analysis of geological condition of typical port in Three Gorges Reservoir , numerical simulation was made by $FLAC^{3D}$ and the displacement rules of slope and inner force rules of retaining wall was analyzed in this thsis. Furthermore, slope's stability and variation of inner force through changing wall's size was analyzed. Then we can draw a constructive conclusion that changing wall 2's size constitue is the rational retaining structure constitue.

Keywords-retaining wall; retaining structure; Three Gorges Reservoir;numerical simulation ;mangment; $Flac^{3D}$

1. Introduction

The region which is located on the north bank of Changjiang River is low mountain erosion landform. The middle and low part of slope is mainly eroded by Changjiang River. The relative height rises to 108.8m and the elevation is 100~208.8m because of the large topographic relief. The ground slope angle ranges from 15 to 40 and total angle is 27. There is an elliptic floodplain which its' elevation ranges from 99.52~108.30m at the bottom of slope. According to survey datas, the soil is new series of artifical Quaternary fill (Q4ml), residual hillside waste (Q4el+dl), alluvium (Q4al), landslide pile (Q4del). The rock is sandstone and silty mudstone in Jurassic middle Shangshaximiao (J2S).

The site which is divided into several parts is beneficial to the draining surface water. According to survery, there is plentiful ground water in the slope. Changjiang's flucation is influenced on the unified surface which is supplied by raining and ground water. However, building region is lack of groundwater. Groundwater has no errosion for concrete because of its quality is well[1,2,3].

Rolling shipment berth is filling region. Several platforms which are supported by rag masonry weight retaining wall are set in this region. The platform has 145m, 150m, 155m, 160m, 165m, 170m and 175m. The retaining wall which located in front of 145m's platform is under the moderate wearthering bedrock. The filling height is about 5~18.5m. The height of filling is 10~18.94m in the region of 175m's platform which are supported by rag masonry weight retaining wall. The base is under the moderate wearthering bedrock, too[4].

2. Computation model and simulation analysis

2.1. Building computation model

Theplan and section plan of Qingcaobei port model as figure1 and figure 2.

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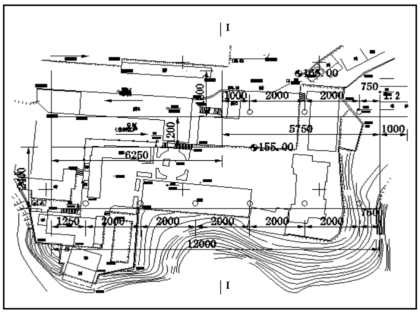

Figure 1 The plane of Qingcaobei port model

We should set model of Qingcaobei port which select section plan of I-I as the model of analysis and divide it into many grids. During the course of setting model, each region and layer should be defined its properties, such as retaining wall, rock bed, filling sand pebble bed, plain fill, silty clay, silt, silty lutite and sandstone. According to the features of port's distribution, we can apply 50m along y axial (along river wide) , 220m along x axial and 120m along z axial. The mode shape l is hexahedron except wedge separately. The specific is shown as figure 3.

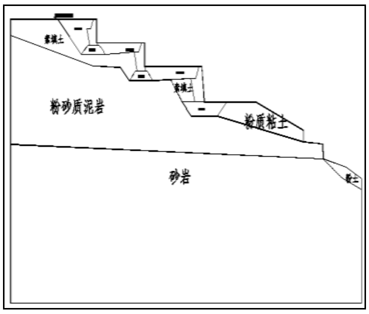

Figure 2 The section plane of Qingcaobei port model

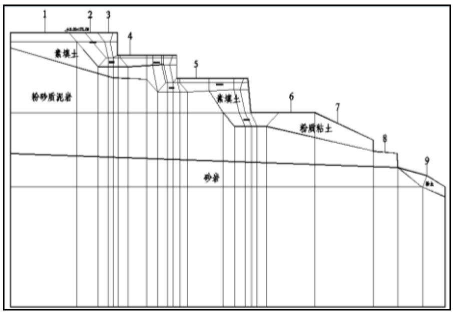

Figure3 The construction of Qingcaobei port's model

The choice of Qingcaobei port's slope parameters are shown as table 1.

We have selected 9 points which can supervise it from the silty clay layer and back of each retaining wall in order to study displacement and stress. That is, without consideration of hydrodynamic press on slope, the 9 points' changing law of displacement will be studied further when load is added the first class retaining wall of the accumulation plan area. In addition, we should class three retaining walls from top to bottom. The first class retaining wall is noted wall 1, The second class retaining wall is noted wall 2 and The third class retaining wall is noted wall 3. Five supervise points are selected on each waterside of retaining wall. (It shows as fig.4). We will study the changing stress under the load of 30Kpa in the accumulation plan area of first class retaining wall in order to discover the interaction law of slope stability and retaining structure under loads. The numerical simulation of model will be analyzed by Flac3D [5].

2.2. Outcome.

The curve which is shown as figure 5 and 6 is horizontal displacement and vertical displacement under three kinds of load without considerate the hydrodynamic press. We can find that horizontal displacement at the second class retaining wall rise to peak and decrease rapidly. It has been stable when it comes to bottom of the third class retaining wall and silty clay layer. The load has seldom effect on the third class retaining wall during the course of variation from the back to downward. However, at the back of retaining wall, displacement of z direction has been changed rapidly from maximun to minimum within the 5 points. In general trend, displacement of z direction—settlement—decreased rapidly at the back of the third class retaining wall.

Settlement in the silty clay layer is relative stable. From above analysis, without consideration of hydrodynamic press, we can find that slope's settlement has been changed from maximun to minimum gradually at the scope of retaining wall's top. The slope's settlement is consistent from third class retaining wall to bottom. Load has effect on slope's stability and has great influence on z direction and x direction of each retaining wall backage. Yet, silty clay layer is hardly influenced on the load.

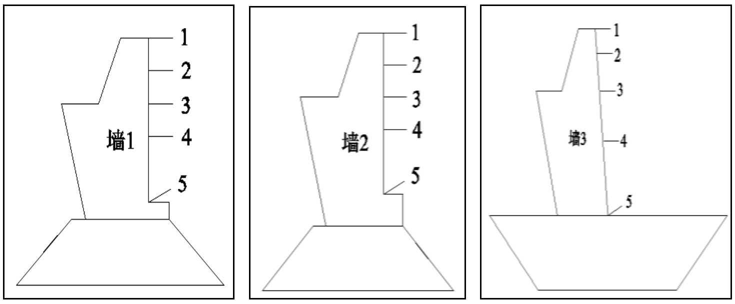

Figure 4 The point's setting of wall

TABLE I. PARAMETER OF QING CAO-BEI SLOPE'S SIMULATION

Construction and Soil layer	ρ (kg/m^3)	E (MPa)	v	K (MPa)	G (MPa)	c (MPa)	φ	σ t (MPa)
Retaining wall	2400	10000	0.20	5555.6	4166.7	1.0	30	1.0
Rock bed	2560	11000	0.20	6000	5000	1.0	30	1.01
①	2000	80	0.30	66.67	30.77	0	36	0.001
②	2080	6.44	0.33	2.10	2.42	0.014	6.2	0.001
③	1970	5.71	0.33	1.866	2.147	0.0265	11.8	0.001
④	2040	5.73	0.33	1.873	2.154	0.0241	12.3	0.001
⑤	2430	800	0.27	579.7	315	0.0284	29.3	0.10
⑥	2500	1500	0.25	1000	600	0.77	36.35	0.30

The shearing force and moment of retaining wall are shown as figure 7 to 12.

Three retaining wall which are under shearing force are shown as figure 7 to 9. As we can see from figures, the forth point's shearing force of wall 1 is maximum, others is hardly zero. The second point's shearing force of wall 2 is maximum which reached -850KN. The total even shearing force is greater than wall 1. The forth point's shearing force of wall 3 is maximum which reached -100KN, others is hardly zero. In a word, shearing force is minus and shearing force of wall 2 is maximum.

The moment of retaining wall is shown as figure 10 to 12. The max moment that reaches -144KN m is forth point of wall 1. Other moment is zero. The max moment of wall 2 is -1600 KN m and other moment is greater than wall 1. The moment of forth point of wall 3 is maximum which reaches -400 KN m. The changing trend of wall 3 is same as wall 1 but moment is smaller. On the contrary, moment of wall 2 is greater than other walls.

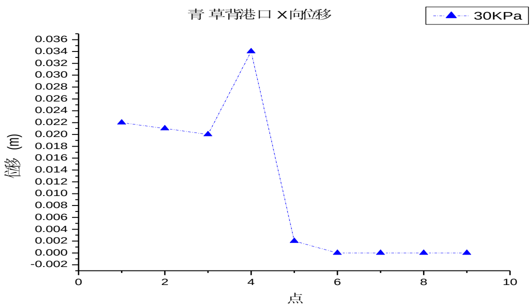

Figure5 The horizontal displacement under different loads

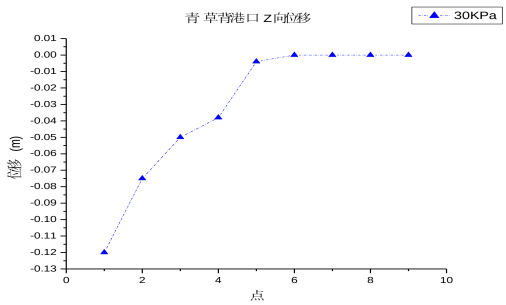

Figure6 The vertical displacement under different loads

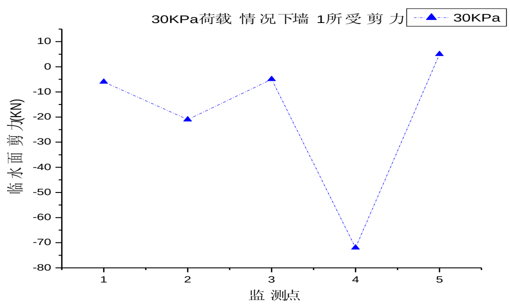

Figure7 Shearing force of wall 1

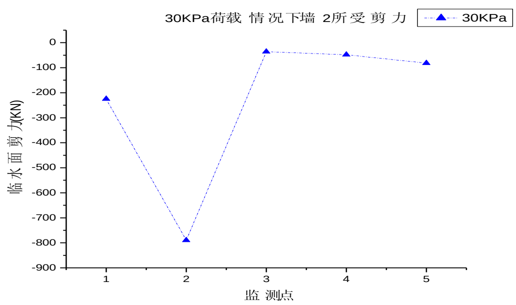

Figure 8 Shearing force of wall 2

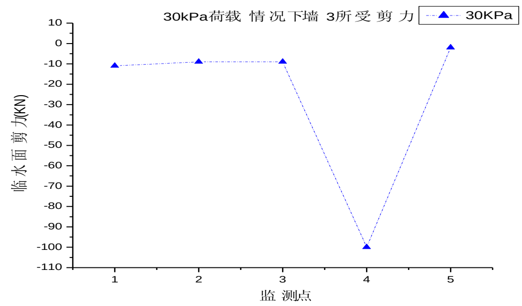

Figure 9 Shearing force of wall 3

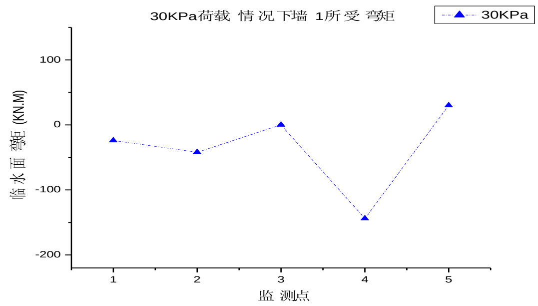

Figure 10 Moment of wall 1

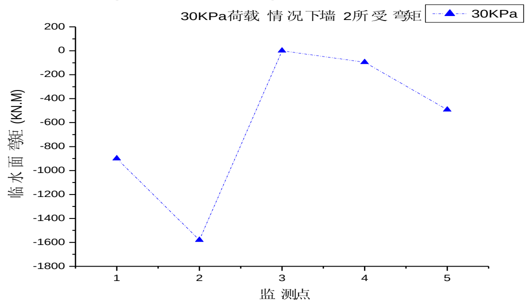

Figure 11 Moment of wall 2

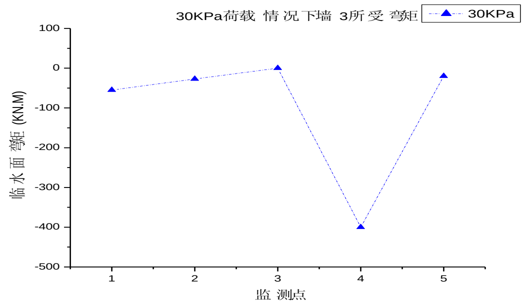

Figure 12 Moment of wall 3

3. Evaluation of stability

From above curve, we can find that the moment which is beared by third class retaining wall is very large. It is proved that retaining wall has been good effect on retaining slope. Morever, we can also find that the displacement of first three points is large from slope's displacement curve. The forth point's displacement reaches peak and other point's displacement decreases gradually. The first forth point's settlement of slope is large, too. The trend is dowand and the last five point's settlement is stable. Then we can draw a conclusion from above analysis that the potential sliding surface maybe occurred between the first and forth supervise point. It is implied from inner force curve of Qingcaobei port slope that the second class retaining wall has the greatest inner forces. Whether shearing force or moment of wall 2's forth point are greater than wall 1 and wall 3. So the conclusion is that wall 2 is the main retaining structure against slide force. It has great effect on slope's stability.

4. Mangment and Study of Retaining wall's Size

With changing wall's size, new stability of slope will be studied in this stage. The main changing is wall 2's size which platform attains to 3 meters and the width of retaining plat attains to 4 meters. The further resrarch that including displacment and inner force will be studied as follows.

4.1. Study of Displacement

We decide to study horizontal displacement and vertical displacement of slope by changing wall 2's size. The study is shown as figure 13 and figure 14.

The figure 13's data is shown to us that displacement of first 3 points attain 1.75-2cm, the forth point attains to max displacement which is 3 cm. So we can fiand that the obvious horizontal displacement has been taken place at the first class retaining wall of slope. The second class retaining wall's horizontal displacement is the maximum and others is little.

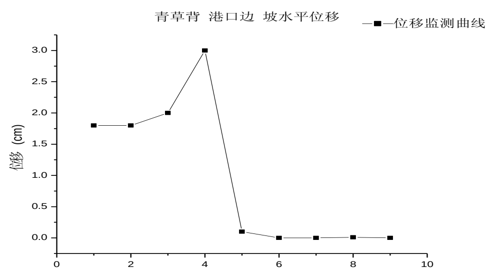

Figure 13The slope's horizontal displacement of Qingcaobei port's supervise points (changing wall's size)

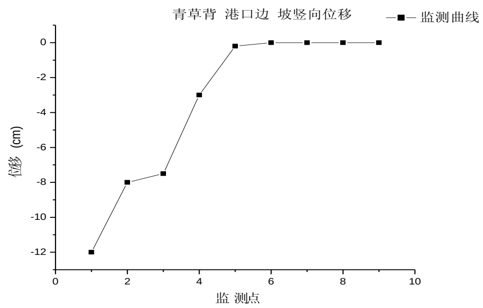

Figure 14 The slope's vertical displacement of Qingcaobei port's supervise points (changing wall's size)

We can find that the max vertical displacement is the first point which attains to 12cm. The second and third point's displacement are 8cm or so and other displacement decrease rapidly. It is obvious for us that the displacement is settle because of the negative displacement. The great settle has been taken place on the first class retaining wall. There is clear settle on the second class retaining wall.

So we can draw a conclusion that the place which is subjected to deformate is between the top of wall 1 and top of wall 2. That is to say, slip surface maybe take place on the scope of the first supervise point of wall 1 and the forth supervise point of wall 2. So wall 2 is the main retaining structure of slope.

4.2. Study of Shearing Force

The shearing force curve of three retaining wall is shown as figure 15 to figure 17.

The wall 1's shearing force distribution is shown as figure 15. The shearing force of fifth point attains to -225kN and other is close to zero on wall 1. So the max shearing force is located at the wall 1's bottom.

Figure 16 shows the wall 2's shearing force distribution. We can find that the fifth point's shearing force is the maximum and other is little. So the maximum is located at the bottom, too. The shearing force of wall 2 is larger than wall 1.

Figure 17 shows the wall 3's shearing force distribution. We can find the same situation that the maximum is located at the bottom. The shearing force of wall 3 is smaller than wall 2 and wall 1.

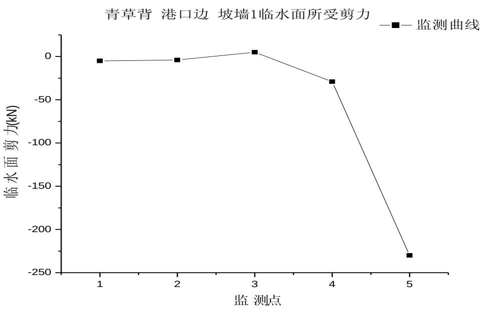

Figure 15 The diagram of shearing force in the front of wall (wall 1)

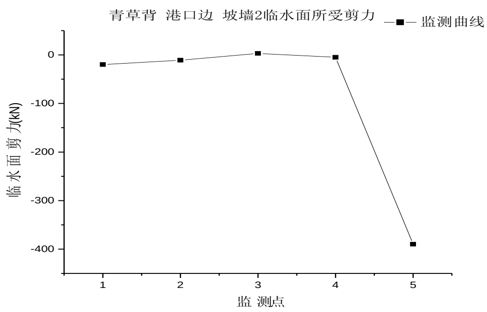

Figure 16 The diagram of shearing force in the front of wall (wall 2)

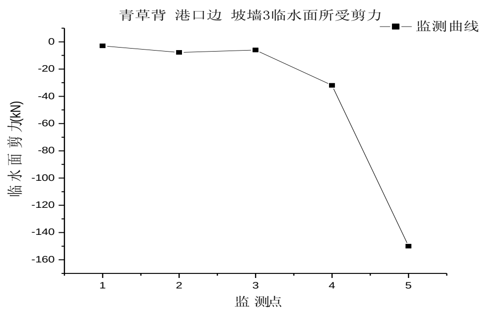

Figure 17 The diagram of shearing force in the front of wall (wall 3)

4.3. Study of Moment

The moment curve of three retaining wall is shown as figure 18 to figure 20

Figure 18 shows the wall 1's moment distribution. We can find that the fifth point's moment is maximum which attains to -1380 kN m and other point's moment is not more than -200 kN m.

Figure 19 shows the wall 2’s moment distribution. It also conveys to us that the fifth point’s moment is the maximum which attains to -2340 kN m and other point’s moment is not more than -50 kN m. The moment of wall 2 is more than wall 1.

Figure 20 shows the wall 3’s moment distribution. We can find that the fifth point’s moment is maximum which

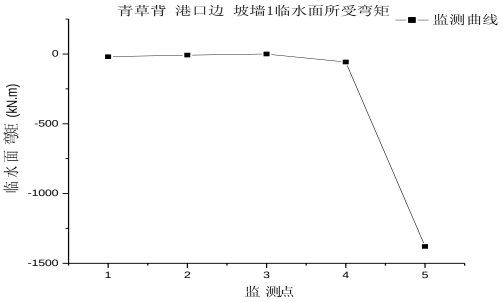

Figure 18 The diagram of moment in the front of wall (wall 1)

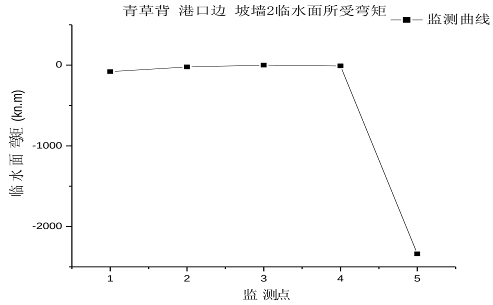

Figure 19 The diagram of moment in the front of wall (wall 2)

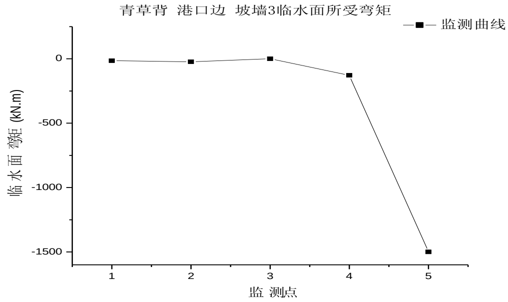

Figure 20 The diagram of moment in the front of wall (wall 3)

attains to -1500 kN m and other point’s moment is not more than -50 kN m. It is demonstrated that the moment of wall 3 bottom is very large and the moment of wall 3 top is minmum which attains to zero. The moment of wall 3 is close to wall 1.

5. The Comparison Between Old Size Retaining Wall And New Size Retaining Wall

The changed size retaining wall’s (model 2) changing rules of displacement is the same as old size retaining wall (model 1). The horizontal displacement of model 2 is less than model 1, but the vertical displacement of model 1 is equal to model 2. It is clear that the horizontal deformation has been under control and the settle has not changed.

The changing rules are different between model 1 and model 2. The maximum shearing force of model 2 is located at the bottom of wall. However, the wall 1 and wall 3’s maximum shearing force of model 1 is located at the middle of wall and wall 2’s maximum shearing force is located at the second supervise point. The wall 1’s shearing force of model 2 is more 150kN than model 1 because of changing size. At the same time, wall 2’s shearing force of model 2 is less 450kN than model 1. It tells us that great changes has been taken place in wall 2. Wall 3’s shearing force dosen’t change any more.

The moment changing rule of model 2 is the same as shearing force rule. The maximum moment of model 2 is located at the fifth point. In model 1, the maximum moment of wall 1 and wall 3 is located at the forth point and wall 2 is located at the second point. With the change of model’s size, the maximum moment of each wall is greater than old model.

6. Conclusion

In all, slope’s deformation and inner force of wall 1, wall 2 and wall 3 have been changed in various degrees with the changing size of wall 2. The horizontal deformation of slope has been under control and vertical displacement still has remains unchanged. The wall 1’s shearing force has been improved properly and the wall 1’s moment has increased, too. Wall 2’s shearing force reduces little and moment increases much. Wall 3’s moment increases much larger but shearing force increases little. We can find way form above conclusion that slope’s deformation becom smaller and three retaining wall’s inner force and distribution becom much even with the changing size of wall 2. So we can draw a conclusion that changing wall 2’s size constitue is the rational retaining structure constitue.

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