Field Test on Sheet-Pile Wharf with Separated Relieving Platform

Hui-ming TAN[1], Zhi-bin JIAO[2], Jia CHEN[1]
1. College of Harbour, Coastal and Offshore Engineering, Hohai University, Nanjing, China
2. Geotechnical Engineering Department, Nanjing Hydraulic Research Institute, Nanjing, China

INTRODUCTION

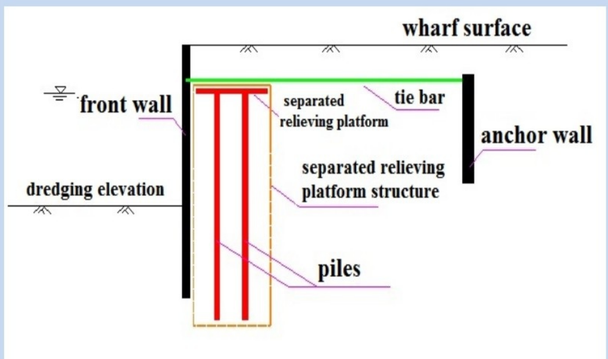

Figure 1 – Sketch of the New Sheet-pile Wharf

With the development of large scale wharf construction and more application in the deep water areas, A new type of wharf named sheet-pile wharf with separated relieving platform was developed in China, which has been applied more and more in new large wharf construction and reforming construction of existing small wharf in the deep water. Compared to the traditional sheet-pile wharf, the separated relieving platform structure, which is made of relieving platform and piles, is the special part for the new kind of wharf. Due to the existence of platform structure, the upper vertical loads can be partly carried by platform and transferred to the deeper foundation soil directly, and the horizontal soil pressure from landside can also be born by piles. Therefore, the loads carried by the front wall have been reduced markedly. In order to clarify the load transfer mechanism of the new structure, the field test has been conducted. The measuring instruments have been installed during wharf construction, and the main measurements were displacements and stresses of structures and pulling force of tie bar. With the instruments referred above, the behavior of the whole wharf has been in completion.

FIELD TEST

Subsoil investigation

The testing field locates in Tangshan port, China Bohai bay area. The test port is a 100,000 ton cargo berth, forward is a container berth. The mainly coastal distribution is powder sandy coastal, distribution thickness can be more than 80m, some regions are powder sand with sludge, the shore is gently, mud surface elevation is high, the port mainly constructed by digging, so sheet-pile wharf is the most suitable structure form. According to the field geotechnical investigation results, the ground soil layer from up to below is: ①silty-fine sand, ②2mucky clay, ③1fine to medium sand, ②3silty clay, ③1fine sand. Through the field drilling sampling and laboratory test , each soil layers' physic-mechanical index are obtained(can be seen in table 1). The field underground water level is mainly affected by ocean tide.

Table 1 the main physic-mechanical index of soil layers

Serial number	name	thickness	γ/(kN·m^{-3})	w/%	c_q/kPa	phi/(°)
①	Silty-fine sand	3.58	20.31	20.4	0.0	29.30
②$_2$	Mucky clay	7.10	17.56	42.4	14	16.63
③	Fine to medium sand	7.90	19.20	19.8	0.0	31.40
②$_3$	Silty sand	3.55	19.77	22.9	19	23.72
⑤	Fine to medium sand	15.6	19.20	19.8	0	31.40

Wharf construction

The main design scheme of testing wharf structure is: setting cast-in-place reinforced concrete behind the wall to undertake soil gravity above the bearing surface and even load on the surface of wharf. The base of bearing platform is made up of two cast-in-place concrete pile, distance of pile is 5.25m and perfusion distance is 4.4m, the sea side piles are 4.0m away from the wharf apron, and is constitute of 1200mm×1600mm(bending direction) perfusion square pile, pile bottom elevation is -36.0m; the land side piles are 1200mm×1200mm perfusion pile, whose bottom elevation is -36.0m; The thickness of concrete bearing platform is 1.0m, the top and bottom elevation of bearing platform are 0.3m and -0.7m. The tie rod-which connect breast wall and anchor wall-applied Q345ϕ95; The thickness of anchor wall is 1.1m, wall bottom elevation is -15.0m, and the top elevation of wall is -0.5m. On the anchor wall, nose girder are constructed, and the top elevation of it is 3.0m.

Wharf construction is divided into three periods: construction period of structure, apron scouring period, superstructure installing period (loading period). The dredging depth of wharf is 16.0m. Taking into account that time to be relatively stable is long as internal force variation is small in different period, the terminal time between each period should be enough to make sure stable construction condition, and test the change rule of structure internal force.

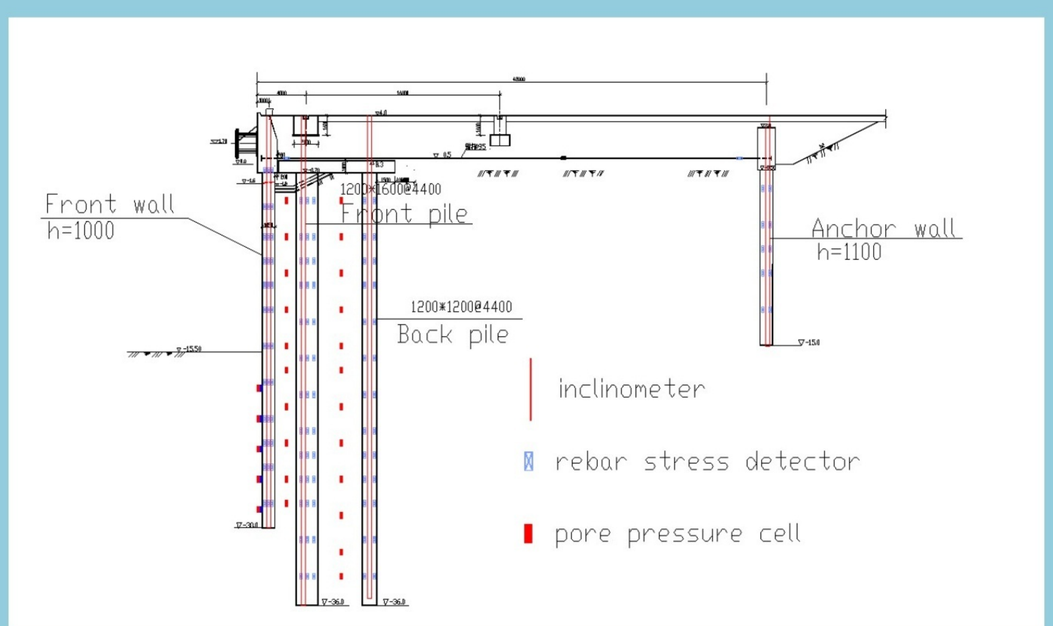

Figure 2 – Section view of wharf structure with instrumentation

Instrumentation program

In order to discuss the new kind of wharf's bearing mechanism, to analyze the function of relieving bearing platform, the key testing points are distribution rules of pile and wall, bridle rob's changing rule, the internal force (bending moment) of pile and wall, deformation and etc. During the construction of wharf structure and installing of relevant equipments to design location, the mainly used instruments include: soil pressure cell, reinforcement tensiometer, tensometer and etc. Instrumentation layout scheme can be seen in figure 2. To reduce the impact-which caused by structure construction-on testing data, stable data after the accomplishment of main part have been chosen to be the initial value of each measure point before dredging.

KEY RESULTS

I. Front wall

Front wall is one of the most important structure of wharf, its main function is to undertake soil pressure difference between seaside and landside soil body. The bending moment of front plays a very important role in wharf design. The measured value in field test has been showed in figure 2, the measured value in it is observed result on end of observation term. From the figure, the measured value showed an obvious inflection point of front wall bending moment, the seaside front wall above the inflection point undertakes tension, landside undertakes pressure (negative moment), landside front wall below the inflection point undertakes tension, seaside undertake pressure(positive moment), the inflection point elevation is about -15m, which is approximately to excavation depth. In field test, due to the influence of different conditions, and changes in water level and other conditions, the maximum bending moment value of front wall did not occur in observation term, but occurred in observation period, the maximum negative bending moment is -696.8 kN·m/m , and the maximum positive value is 754.8 kN·m/m . The maximum positive and negative values are similar, which means the design of front wall is acceptable. The specific maximum bending moment are shown in table 2.

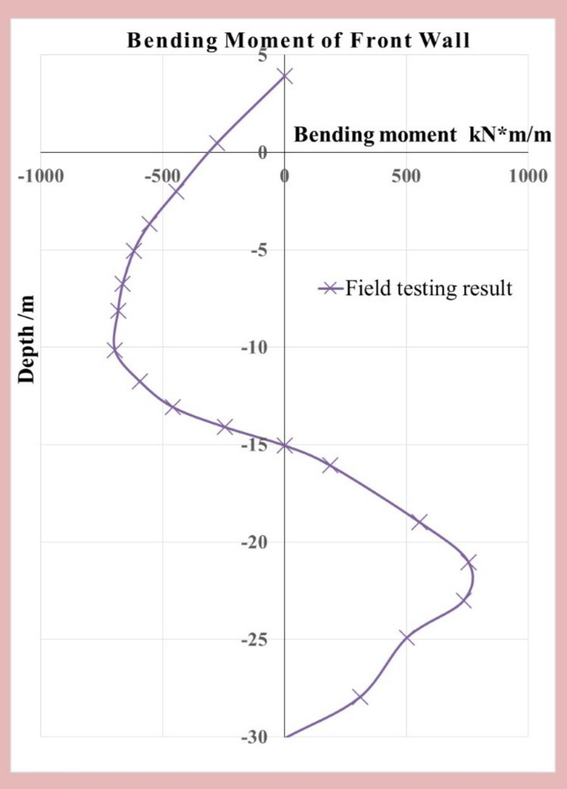

Figure 3 – Bending moment of front wall

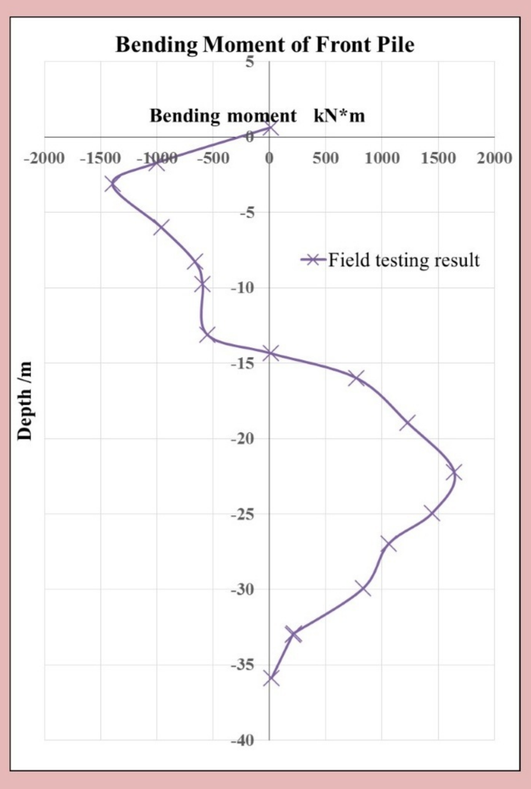

Figure 4 – Bending moment of front pile

II. Front pile (Seaside pile)

Figure 4 is bending moment distribution of front pile (seaside pile). From the figure, we can see that there is inflection point alone the bending moment depth distribution, seaside front wall above the inflection point undertakes tension, landside undertakes pressure (negative moment), landside below the inflection point undertakes tension, seaside undertakes pressure (positive moment), and the measured inflection point's elevation is about -15m. Likewise, the maximum value of front wall's bending moment in field test is constantly changing, but the maximum value occurs in the end of the observation term, the measured value is 1643.5 kN·m. That the maximum bending moment of pile is bigger than the maximum bending moment of front wall indicates that relieving platform works well in undertaking the back soil pressure and upper load, and that decrease load working on front wall. The specific maximum value are shown in table 2.

In the whole structure system of covered sheet-pile wharf, the tie rob has played a key role to connect the front wall and anchor wall. Once the tie rob is damaged, the whole system will be unavailable, resulting in severe destruction. Therefore, the safety factor will be enough big in designing. The maximum test tension of tie rob is 321 kN.

Table 2 Field testing results of wharf structure

Member	Front wall		Front pile（seaside）		Tie rob
Internal force	Maximum positive moment	Maximum negative moment	Maximum positive moment	Maximum negative moment	Maximum tension
Measured value	754.8	-696.8	1643.5	-1396.1	321

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