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The Seismic Reaction Analysis and Research Status of the Curtain-covered Pile Pier

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Abstract

Curtain-covered pile dock structure is a new type of dock structure, which is easy to destroy when earthquake occurs. This paper summarizes the engineering value and theoretical significance of seismic reaction in the curtain-covered board pile terminal, expounds the current seismic response analysis method, the soil structure model and the treatment of the dynamic boundary conditions, summarizes the research results of the seismic response of the dock structure in recent years, and puts forward some insights on the seismic reaction analysis of the subsequent curtained board pile terminal.

Keywords

Curtain-mounted Pile Pier; Earthquake Response; Analysis Methods; The Model of Soil Structure; Boundary Conditions.

1. Introduction

As one of the main structural forms of the pier, the board pile pier, with its simple structure, less material consumption, cheap cost, the main components can be prefabricated in the prefabricated plant, construction convenience, construction speed, the complex foundation adaptability and other advantages, favored by the Hong Kong industry, its design methods and construction technology is improving day by day, is a very promising dock form.

In 2002, under the auspices of Liu Yong embroidery, the China First Aviation Engineering Survey and Design Institute developed a new form of board pile terminal on the basis of the underground wall-mounted pile terminal- curtain-mounted board pile terminal structure[1]. Curtain-type board pile pier structure includes front wall, curtain pile, anchor wall, lever, dock facilities, etc., the structure is shown in Figure 1. The curtain-type pile structure relies on the cover effect of the pile, which can effectively reduce the soil pressure of the front wall, and the constraints provided by the steel lever at the front wall end, greatly improve its lateral force condition, can be applied to the construction of deep-water pier berths, and make the board pile pier among the large-scale deep-water terminal structure. Although China has made great progress in the construction of the board pile pier, it is still faced with various objective problems. Our country is located between the Eurasian seismic belt and the Pacific Rim seismic belt, which makes our country a country with frequent earthquakes under the clampdown of these two large seismic zones[2]. Seismic load has a great impact on the internal strength and stability of the structure of the pile terminal, and under the influence of strong earthquake, it can also liquefy the backfilling soil behind the pile wall, which can bring serious damage to the dock facilities. At present, under the effect of earthquake curtain-mounted pile terminal structural mechanics is still constantly improving, is now its research status quo is reviewed.

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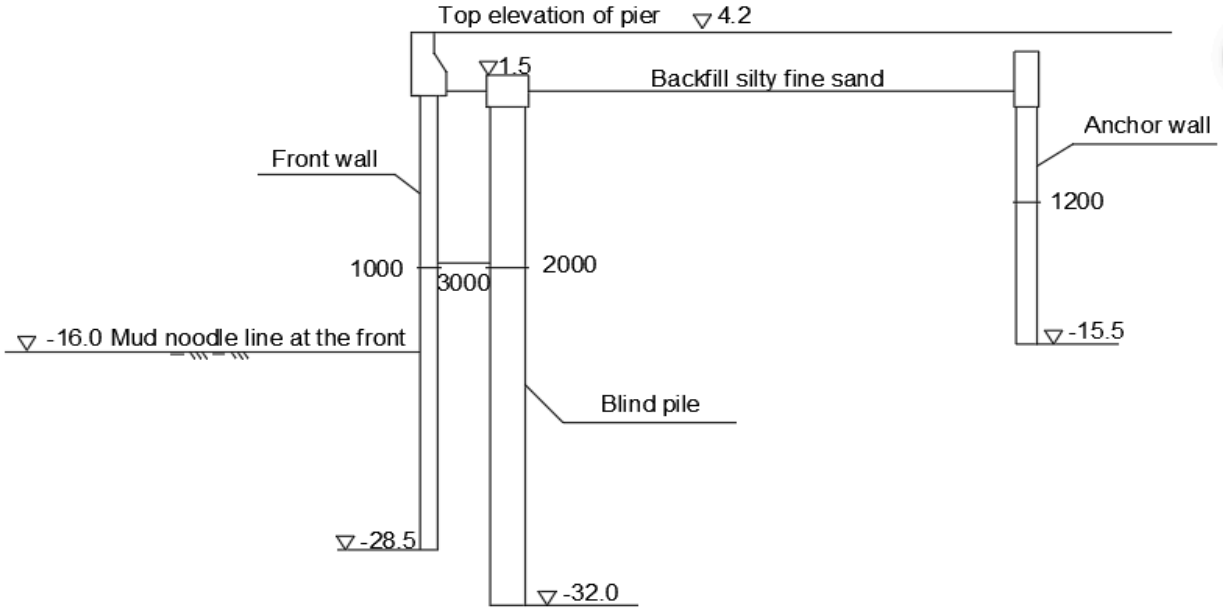

Figure 1. A view of the structure of the curtain-covered pile pier

2. Engineering value and theoretical significance

Compared with gravity docks and high pile docks, the board pile pier has the advantage of adapting to complex foundations. China's water depth conditions and geological conditions of better port sites have been fewer and fewer, is gradually entering the shoals, beaches, powdery coast and silt coast to build the port era, the development and utilization of the natural environment and construction conditions relatively poor shore line become inevitable, which provides a broad space for the development and promotion of the board pile terminal. The development of the board pile pier in the past few years is limited because, first, the prominent contradiction between the board pile section and the bending moment, and second, the lack of a new dock structure form to solve this problem, curtain-mounted pile structure solves this problem very well. Curtain-mounted pile pier with its own advantages is undoubtedly more favored, is the reason why this kind of pier has been widely valued in recent years.

At home and abroad due to seismic action caused by the destruction of the board pile terminal disaster often occurs, under the strong earthquake action may also be able to make the backfilling soil behind the pile wall liquefy. However, there are fewer observation data and fewer experimental models on the dynamic reaction of the structure of the board pile terminal, so it is difficult to describe the response of the board pile terminal under the effect of earthquake accurately. Although some simple practical methods are given in the specification to study and analyze it, because of the different levels of economic, scientific and technological development and the experience gained in different countries, the seismic design methods of the pile terminal are not the same. It is of great significance and value to carry out seismic response analysis on the pile pier, both academically and in engineering.

3. Research status

Seismic analysis of the structure is an important part of the research structure, the foundation and upper structure of the curtain-covered pile pier is a common working system, the seismic movement of the foundation is transmitted to the upper structure by wave vibration form through the foundation, and the deformation intensity characteristics of the upper structure have changed significantly[3]. Curtain-covered pile pier is a new form of structure, which was rarely reported at home and abroad before the 20th century. So far, there is less research and analysis on seismic dynamics related to the structure of the curtain-covered board pile terminal, and it is necessary to continue to carry out the

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dynamic response analysis under the seismic load of the curtain-covered board pile terminal in order to ensure the safety of the national economy.

In the study of seismic response, the theory of seismic design has developed from linear to nonlinear, from static to dynamic, from one-dimensional to multidimensional, and the main seismic dynamic response analysis methods are: reaction spectrometry, random vibration and time-range analysis. Reaction spectrometry was first proposed by Housner and is one of the more widely used seismic analysis methods. Random vibration can reflect the change of seismic movement with space. The time-range analysis method can directly obtain the acceleration, velocity and displacement time of the structure during the seismic action, so as to obtain the internal force change of the whole structure and the whole process of gradually yielding, destroying and collapsing the structure, and the time-range analysis method uses real seismic waves, which can be used to test the rationality of other methods. In the numerical simulation of power finite element, the reasonableness of the input method of seismic wave directly affects the reliability of the calculation results, and in the analysis model of finite element-infinite element coupling, seismic load will be made by acceleration time frame as seismic wave input model The displacement time of the structure produces drift, and entering the seismic wave as an equivalent load weakens the effect of the seismic wave, while the displacement time range obtained after the acceleration time curve is re-integrated as the seismic wave input method will get better results[4].

Because the working principle and nature of soil are extremely complex and have a lot of uncertainty, there is not yet a realistic and effective model to fully explain the dynamic stress-strain relationship of soil. For a long time, many scholars at home and abroad have established dozens of dynamic models based on the dynamic stress-strain relationship unearthed by experiments, which are divided into two main types: viscous elastic model and elastic model, in addition to the internal time model[5]. At present, the Mohr-Coulomb model is used in the dynamic analysis of the structure of curtain-type piles.

Curtain-mounted pile dock structure static calculation analysis generally only need to intercept out the larger area analog infinite element foundation, set a fixed boundary on the boundary can meet the calculation accuracy requirements, but for the use of finite element analysis wave propagation scattering problem, requires the outer wave in the calculation area propagation did not reflect on the boundary, generally there are two treatment methods: the lost intercept boundary is large enough, the calculation period outside wave is not reflected back to the calculation area; The second is to intercept certain calculated areas and set artificial boundaries on the truncation boundary to eliminate the reflection of the wave. At present, the artificial boundary conditions are mainly boundary element boundary, infinite element boundary, transmission boundary, sticky elastic boundary and sticky boundary[6].

3.1 The current situation of seismic effect of curtain-covering board pile pier

The first scholar in China to carry out the research on seismic response of curtain-mounted pile terminal is Jiang Jianping, who combined with the Beijing-Tanggang 32-covered board pile terminal project, with the help of ABAQUS finite element software, studied the interaction between the structure of the pile and the soil under the seismic load of different acceleration peaks, as well as the changes in the bending moment of the front wall, the bending moment of the curtain pile and the pull of the lever 0.1g, the maximum bending moment of the front wall increased by about 10%, the maximum bending moment of the curtain pile increased by about 21%, the pull force of the rear lever increased by about 25%, the seismic soil pressure on the front wall structure above the seafloor elevation is not obvious, the impact on the seabed elevation below the front wall part of the impact is significant, the pressure of moving soil along the pile distribution of the curtain pile is significant: under the seismic action of the curtain pile still plays the role of the front wall retaining soil[6]. Through the large nonlinear finite element ADINA program, Gao Peng studied the difference between the front wall and the curtain pile, the length of the curtain pile, the thickness of the curtain pile, the strength of the curtain pile, the seismic acceleration amplitude and a series of seismic design

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parameters on the residual displacement and force characteristics of the front wall, and drew some conclusions[7]. By establishing a numerical finite element model, Tang Yuyuan compared the power response calculation results under the seismic action of the curtain-type board pile structure with the single anchor pile structure, and the results showed that: compared with the single anchor board pile structure, due to the existence of the curtain pile, the sea-side bending moment of the front wall of the curtain-block structure was reduced by about 16.5%, the land-side bending moment was reduced by about 23%, and the curtain pile could effectively improve the force of the front wall. Under the influence of seismic load of different intensity, the maximum force of the front wall and the lever of the curtain-blocking pile structure are less than the single-anchor plate pile structure to varying degrees, and the curtain pile plays a great role in reducing the soil pressure of the front wall and enhances the seismic performance of the structure[8]. Based on the three-dimensional numerical model, Yusong studies the influence of different seismic waves on the dynamic response of the structure of the curtain-block pile, and concludes that the acceleration time curve of the front wall and the top point of the curtain pile is very similar to the incident wave, but the maximum moment of acceleration appears lags slightly relative to the phase of the incident wave, the second type of site has amplification effect on the input seismic wave, El-Centro wave is the most easily propagated to the upper structure in the field, and the Northridge wave is the most difficult to spread to the upper structure. Northridge wave amplification is the most obvious and El-Centro wave amplification is the worst[9].

3.2 The current situation of the study on the liquefaction of strong earthquake in the curtain-covered board pile terminal

From the collected data, at present, only Han Xiaokai has carried out a liquefaction study on the structure of the curtain-mounted pile terminal, and he introduced the circular bullet plasticization model on the platform of FEM-FDM soil coupling calculation, and formed saturated sand and soil power with the help of FORTRAN programming software The numerical method of liquefaction analysis shows that saturated sand and powder are prone to liquefaction under seismic action, but the water pressure ratio of the superpores of the liquefaction soil layer increases and a larger horizontal flow deformation occurs, and the horizontal damage to the front wall is greater than the vertical damage; After soil liquefaction, the self-shear stress of the pile is larger than before the soil liquefaction, the maximum stress of the front wall shear is located at the junction of the seabed and the front wall, and the maximum stress of the curtain pile is located in a position parallel to the bottom of the front wall; The rear lever pull gradually becomes larger, and the front lever pull gradually becomes smaller[10].

4. Conclusion

Although some progress has been made in the seismic dynamic response analysis of the structure of the curtained pile terminal, there are still many problems that need to be studied in depth.

(1) The Mohr-Coulomb model belongs to the geostatic structure model, and its application in the seismic dynamic reaction analysis of curtain-mounted pile structure is not clear.

(2) The analysis of finite element under seismic action needs to find that the outer wave is not reflected on the boundary when calculating the region propagation, han Xiaokai uses the finite element boundary in the strong seismic liquefaction analysis of the curtain-mounted pile terminal, which requires the boundary intercepted by the model to be large enough; You can also eliminate the reflection of waves by setting artificial boundaries at truncated boundaries. The selection of model boundary under strong earthquake liquefaction is still worth studying.

(3) There are many factors affecting the dynamic characteristics of the curtain-mounted pile terminal, and from the current general practice, each influencing factor is considered separately, and the theoretical analysis results are still very different from the actual characteristics.

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