# Foundation Pit Support Structure under Special Geotechnical Structure

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***Abstract:*** *Due to The Vast Territory of China, The Topography, Geological Conditions and Surrounding Environment of the Construction Project are Very Different. The Design and Construction of the Foundation Pit Support Project is One of the Most Closely Integrated Engineering Measures Combined with the Above Conditions. The Design and Construction of Deep Foundation Pit Support Engineering in Special Geotechnical Areas Has Become One of the Most Complicated Technical Problems in the Field of Civil Engineering Construction. Based on the Above Background, The Purpose of this Paper is to Study the Foundation Pit Support Structure Under Special Geotechnical Structure. This Paper Compares and Analyzes the Materials and Structure Types that Can be Used for Foundation Pit Support, And Concludes that Bamboo is an Economical and Environmentally Friendly New Material, Its Output Large, Good Mechanical Properties, Can Be Used For Temporary Support of Shallow Foundation Pits. It is Proposed to Use the Bamboo Tube as the Foundation Pit Support Material, And it is Applied in the Soft Soil Layer Foundation Pit Support Project in the form of Row Pile Support Structure. In this Paper, the Top Displacement of the Bamboo Pipe Pile is Larger than that of the Steel Pipe Pile, But the Maximum Pile Top Displacement of the Bamboo Pipe Pile is 1.8mm. The Maximum Displacement of the Pile Top is 18mm, The Displacement is Small, Within the Allowable Range, and in the Actual Project, the Pile Top is Generally Constrained to Further Control the Displacement of the Pile Top to Ensure the Safety and Stability of the Foundation Pit.*

***Keywords*****:** *Foundation Pit Support, Special Geotechnical, Row Pile, Bamboo Pipe Pile*

## 1. Introduction

In recent decades, along with the continuous development of China's railway construction, especially the continuous advancement of urbanization, the construction of underground railways and intercity railways has ushered in a new climax. The deep foundation pit has been developed rapidly in the past 30 years. In the past, due to the low height of the building, the depth of the foundation was very shallow, and the basement was rarely used. The excavation of the foundation pit was generally only used as a construction measure for the construction unit. There was no special design nor had it attracted too much attention of the engineering community. Now, due to the rapid development of high-rise buildings and underground space, deep foundation pit engineering has become the most prone to rock king engineering accidents [1]. Because deep foundation pits generally have large scale and deep depth, many engineering technical problems are easy to occur; at home and abroad, deep foundation pit engineering has become a more active field in geotechnical engineering. In the construction of railways, it is often encountered that deep and deep foundation pits with deep burial depth and temporary reinforcement are not only greatly increased investment, but also put a more severe test on construction safety [2]. In the development of subway and railway construction, a large number of deep foundation pit projects will be produced, and more and more special geotechnical conditions will be faced. The comprehensive consideration of safety and economy of the project is becoming more and more strict. We need to ensure the structural safety and the temporary nature of the support project to reduce the cost waste in the construction process. Therefore, it is necessary to deepen the research and summary of the scientific and rationality of the deep-base excavation engineering, especially the design and mechanism of deep and deep foundation pit engineering under special geotechnical conditions [3].

A good support scheme not only guarantees the quality of the project, meets the construction schedule, but also reduces the project cost. In the design of the foundation pit support structure, due to the requirements of the developer, the cost must be reduced, so the foundation pit of the soft soil layer is ensured. Under the premise of safe and reliable support, the support structure with convenient materials, economical cost, environmental protection and energy conservation urgently needs scholars to continuously discover and innovate. Aiming at the two problems of high-energy and high-contamination of soft soil layer foundation pits, especially the easily overlooked shallow foundation pit type engineering accidents and traditional support structure schemes, it is proposed to use China's abundant bamboo material as the new material for foundation pit support. According to its characteristics, the support structure of the bamboo pipe row piles is applied to the foundation pit support project to meet the requirements of ensuring the safety and reliability of the support, convenient material collection, economical and environmental protection support requirements, due to the reproducibility of the bamboo. Meet the requirements of sustainable development [4]. The application of the bamboo tube row pile support structure can effectively alleviate the environmental pollution and waste disposal caused by the foundation pit project, and is also a good way to utilize bamboo in the bamboo area. If the bamboo is used as a support pile, it belongs to the micro-pile according to its characteristics. The traditional micro-pile is generally a micro-pile or a pile. The micro-pile is still a new concept. There is no standard design specification for reference [5]. In recent years, the use of micro-pile structures in foundation pit support projects is still a new technology. The bamboo micro-piles are still rarely used in the current project. There is no reference to the literature. It is of great value to study the micro-pile structure of the bamboo tube. At present, most of the research on bamboo is limited to its physical properties. Based on this, most of the bamboo is used to make bamboo composite materials or used in non-structures. There are few studies on bamboo materials as supporting structural materials. A complete theoretical system has not yet been formed, especially with regard to the micropiles of bamboo tubes. According to the analysis of bamboo material, the bamboo has the performance as the supporting material of the foundation pit. Therefore, it is innovative to study the supporting structure of the bamboo pipe pile. The research results support the shallow foundation pit of the soft soil layer in the bamboo area of China. Engineering design has important reference significance and can produce significant economic and environmental benefits [6].

Wang studied the construction scheme of the non-excavation micro-cluster steel pipe pile supported by the deep foundation pit of the landslide body engineering and verified its feasibility in the construction. In order to make the foundation pit support of a high-rise building in the excavation project located in the landslide control area pass the original anti-slide pile under the original anti-slide pile, the micro pile group + anchor beam + suspended spray anchoring is adopted. The structure, three of which are designed with vertical and four horizontal array arrangements. Wang can calculate the anti-sliding internal force by transforming the anti-slide pile force model into a uniform load model of a single pile and an elastic foundation beam “m” method of the concentrated load model of the top rigid frame. The shear and bending forces and the maximum displacement of the microcluster steel tube can be obtained [7]. The secant pile wall is a new type of foundation pit support structure. Stress distribution and feature analysis are of great significance for studying the deformation of foundation pit retaining walls. Through theoretical derivation and field experiments, Zhang analyzed and discussed the forces and bending moments of the secant pile wall. Based on the analysis of the influencing factors of the secant pile wall and the theoretical formula of the reinforced stress, the bending moment of the secant pile wall under different conditions is derived to ensure that the theoretical value is close to the measured value. Consider the comprehensive influence coefficient i between piles and soils, and modify the derived stress and bending moment formula. Finally, combined with the field test analysis, the reasonable value range of the comprehensive effect coefficient i is obtained, which can ensure the safety of the foundation pit support. Zhang's researched results can provide theoretical guidance for the deformation mechanism of the secant pile wall, simplify the calculation procedure of the secant pile wall, and provide a reliable basis for the design and construction of the foundation pit support structure [8]. At present, due to the shortage of urban land, more and more high-rise buildings and underground works, it is necessary to build a large number of deep foundation pits to study the impact of the city on the surrounding environment, foundation pit excavation process. Han proposed a finite element method to simulate foundation pit excavation of a large diameter annular beam support system. The step-by-step excavation and step-by-step support procedures in the construction steps were reproduced by simulating the example project. The calculation results show that the ring beam support system avoids large stress concentration and has little impact on the surrounding environment. The successful simulation of this example provides an effective reference for finite element analysis of similar projects

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and provides an effective tool for engineering analysis [9]. The finite element calculation of the plane rod support system is an indispensable part of the foundation pit support design, and the choice of boundary conditions is particularly important. In order to solve the problem of unreasonable boundary setting in the finite element calculation of the foundation plane bar support system. X proposed a combined elastic boundary containing only normal springs containing compression and tangential springs to study the effect of spring stiffness on the internal support force and deformation of the foundation pit in finite element analysis. Influenced by the traditional constraints on the internal support force and deformation, the combined elastic boundary can make the horizontal equivalent stiffness of the inner support more accurate and the internal force more accurate. The inner support force is independent of the stiffness coefficient of the ordinary spring and is only pressed and tangent. Furthermore, the displacement of the internal support is controlled by a tangential spring rather than just a compressed normal spring. The proposed combined elastic boundary has a clear physical meaning and is easy to obtain the value of the spring stiffness coefficient, so it can be applied to the design of foundation pit support [10].

By comparing and analyzing the materials and structure types that can be used for foundation pit support, it is concluded that bamboo is a kind of economical and environmentally friendly new material. Its output is large and its mechanical properties are good. It can be used for temporary support of shallow foundation pits. As the foundation pit support material, it is applied in the soft soil layer foundation pit support project in the form of row pile support structure. In this paper, the top displacement of the bamboo pipe pile is larger than that of the steel pipe pile, but the maximum pile top displacement of the bamboo pipe pile is 1.8mm. The maximum displacement of the pile top is 18mm, the displacement is small, within the allowable range, and in the actual project, the pile top is generally constrained to further control the displacement of the pile top to ensure the safety and stability of the foundation pit.

## 2. Proposed Method

### *2.1 Support Structure Selection Principle*

The selection of the type of deep foundation pit support structure as a key link in the technical and economic aspects of foundation pit engineering will directly affect the safety and stability of the foundation pit and economic costs, and whether it meets the requirements of environmentally sustainable development. In principle, the following are the main points for the selection of supporting structure schemes:

(1) Safety and reliability requirements

Foundation pit engineering involves many disciplines such as engineering, structure and geology, as well as many professional knowledge such as cost, management and construction technology. It is a comprehensive project and should pay attention to the guiding role of basic theory. The foundation pit engineering has strong regional characteristics. Often the foundation pit engineering project in the same area is different in the type selection and arrangement of the supporting structure. At the same time, there are many uncertainties in the foundation pit engineering. Therefore, in the selection of foundation pit support structure, we should combine and learn from local design and construction experience, choose mature and reliable plan, try to control or reduce the risk of foundation pit engineering, and strictly control the deformation requirements of foundation pit and surrounding environment.

(2) Economic rationality requirements

The foundation pit support structure is often used as a temporary support structure. After the foundation pit is excavated and the underground part is completed, its function or role has been basically completed. Under the premise of ensuring the safety and reliability of the foundation pit support structure, it should meet the purpose of convenient construction and cost saving. For deep large-scale foundation pit engineering projects, it is necessary to carry out the demonstration and comparison of the schemes in the case of meeting safety and technical requirements, and demonstrate the optimization from the aspects of project cost, construction period, construction convenience and environmental impact, determine the optimization plan.

(3) Environmental protection sustainable development requirements

In recent years, the state has promoted and created a resource-saving and environment-friendly society. During the construction, the foundation pit engineering project also put forward corresponding

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requirements. In the scheme and selection arrangement of the supporting structure, the pollution caused by the foundation pit construction should be reduced, and the construction waste after the removal of the supporting structure should be reduced. The support structure is combined with the main structure as conditions permit.

### *2.2 Support Structure Type*

The deep foundation pit support system consists of two parts, one part is the supporting retaining structure, including the pouring pile, the underground continuous wall, the precast pile and the cement soil mixing pile, etc., and the other part is to stabilize and assist the force transmission. The system includes a bolt and an internal support structure.

(1) Support structure type

1) Soil nailing wall and composite soil nailing wall

The soil nail wall structure is an in situ retaining structure with its own stability. It is mainly composed of soil nails, a surface layer for fixing, a soil body for reinforcement area, and a slope waterproof system. The composite soil nailing wall structure is composed of a soil nailing wall and other surrounding structures, such as a water curtain, a micro pile and a prestressed anchor (cable).

The soil nailing wall has the following advantages: the construction process is simple, and the site conditions have strong adaptability; the cost is low, and the engineering cost is saved; there is no support system in the foundation pit, and the area for construction work can be large. However, at the same time, the following problems exist: the ability to control deformation is general, the support system is deformed greatly; the soil nail is easy to affect the surrounding underground environment; it is not suitable for soft soil and loose sandstone layer with rich water content, and the excavation depth does not exceed 12.0 m.

2) SMW construction wall

The SMW construction method wall is also called the steel-type cement-soil mixing wall. The composite steel is inserted into the continuous-sleeve triaxial cement-soil mixing pile to form a composite retaining water-proof structure.

It has the following advantages: wide application range, can be used in soft soil, cohesive soil, sandy soil and sand pebble layer. The excavation depth in soft soil area should not exceed 13.0m; the maintenance body takes up little space; construction pollution and environmental impact are small , can be recycled. However, the following problems exist: the structural rigidity is small and the deformation is large; the backfill quality after the steel strip is removed is high.

3) Sheet pile retaining wall

The sheet pile retaining wall is used to drive the sheet pile member into the soil layer by the piling machine to form a continuous foundation pit retaining structure. The sheet pile retaining wall includes a reinforced concrete sheet pile retaining wall and a steel sheet pile retaining wall. The reinforced concrete sheet pile retaining wall is suitable for foundation pits with excavation depth not exceeding 10.0m. It has large structural rigidity and good economy and can be used as part of the underground structure. However, the reinforced concrete sheet pile retaining wall has the vibration of piling operation. With the noise problem, it has a greater impact on the surrounding environment. The steel sheet pile retaining wall is suitable for foundation pits with excavation depth not exceeding 7.0m, which can be reused and reduced the construction cost. However, the construction work of the steel sheet pile has great influence on the surrounding environment and the ability to control the surrounding environment is general.

4) Row pile pouring pile retaining wall

The pile-retaining pile retaining wall is a combination of bored piles arranged in a continuous column-column manner to form a retaining wall structure. Commonly used forms are: split type, bite type, double row type, tangent type, staggered type and grid type. This type of retaining wall has the advantages of high structural rigidity, strong resistance to deformation, and no soil squeezing. However, attention should be paid to the quality of the hole in the drilling construction, to prevent the collapse of the wall and the diameter of the pile, and to pay attention to the dredging operation at the bottom of the hole.

5) Underground continuous wall

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The underground continuous wall is divided into two types: cast-in-place type and pre-made type according to the production method. Currently, the forms of underground continuous wall slot commonly used in engineering are: one-line type, L-type, T-type and ∏ type. Various combinations of groove segments can be made to form cylindrical, lattice and other irregular structures to meet engineering requirements. It is suitable for foundation pit engineering with large depth of foundation pit, high waterproof requirement, limited construction space and strict control of surrounding deformation.

It has the following advantages: noise and vibration during construction are small; the rigidity of the wall is large, the impermeability is good, and the effect of blocking water and soil pressure is taken into consideration; it can be used as a subterranean outdoor wall and can be used for reverse construction. There are the following problems: the construction has spoil and waste mud treatment problems; the quality of the groove is high, and the problem of collapse of the wall should be paid attention to; the underwater casting process of the underground continuous wall; the waterproof design of the indirect seam of the wall and groove of the underground continuous wall is high.

(2) Internal support system

The inner support system is a structural form that is arranged in the foundation pit and supports the retaining structure. It has the advantages of strong control of deformation, no influence or invasion of the surrounding underground space, but there are problems such as high cost and work space in the pit. Due to the difference in the main structure, the shape and size of the foundation pit, the environmental conditions around the site, and the design and construction methods, it is difficult to determine the uniform standard for the selection of the inner support structure. For the selection principle of the inner support structure design, it should adopt the characteristics of symmetrical balance and strong integrity to ensure the structural force of the structural members is clear and the connection nodes are safe and reliable. At the same time, it should also facilitate the construction of the support structure and facilitate the excavation and transportation of earthwork economically and reasonable. For the inner support structure design, the statically indeterminate structure should be adopted. For the part where the internal support structure is damaged due to the failure of individual rods, redundant restraint rods should be set to ensure safety and stability.

The inner support can be divided into steel support, reinforced concrete support and steel and reinforced concrete combined support according to the choice of support system materials.

1) Steel support

The steel support is a form of a support structure formed by combining steel members by bolting or welding. Usually, the node is simple and the direct arrangement of the force is directly arranged. It has the following advantages: construction erection and dismantling are convenient, construction is simple, and the construction period is accelerated; it can be reused to save cost. However, the following problems exist: it is not suitable for foundation pits with complicated shapes and irregularities; when the length of the steel support is too long, the joints are too much to form a splicing construction deviation; the rigidity of the steel support rods is small, and the control ability for deformation is general.

2) Reinforced concrete support

The reinforced concrete support has the characteristics of large overall rigidity and integrity of the structure, and various arrangements can be flexibly adopted according to the requirements of the foundation pit engineering. Commonly used arrangements are: orthogonal support, support and gusset combined side truss support and circular support.

The orthogonal support form has the characteristics of clear force between the members, large rigidity and small deformation of the support structure, and is the most structural form of controlling the deformation ability among the planar arrangement modes of all the inner supports. However, there are dense support members, and the space available for construction work in the foundation pit is small. The support form of the combination of the support, the gusset and the side truss has less influence between the support members, the force is relatively independent, and the unsupported area in the foundation pit is large.

For the annular support form, the lateral pressure of the soil is transmitted to the cofferdam and the side truss through the envelope structure, and then transmitted to the ring through the tie beam, and the ring is mainly subjected to pressure. The circular ring support has the following advantages: the force performance is reasonable; the area of the foundation pit can be used for construction work, and the

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earthwork excavation is accelerated; the material consumption is saved, the economic benefit is obvious; and the utility model can be used for the construction of a narrow site. However, the following problems exist: the circular support construction is difficult to lay out, the construction process is high and the difficulty is high; the earth excavation should be as uniform as possible to ensure that the circular support is evenly stressed.

3) Steel and concrete combined support

The combined form of steel and concrete support is mainly divided into two types: steel and concrete combined support in the same support plane; and different support plane combinations of steel support and concrete support. It can be combined according to the force of the structure and the construction requirements.

In the selection of the type of deep foundation pit support structure, the principles of safety, reliability, economic rationality and environmentally sustainable development should be followed. The main retaining structures in deep foundation pit engineering include: soil nailing wall and composite soil nailing wall, row pile pouring pile, steel cement soil mixing pile and underground continuous wall. The soil nails in the soil nailing wall and the composite soil nailing wall are easy to affect the surrounding underground structures, and the excavation depth should not exceed 12.0m; the steel-reinforced soil-soil mixing piles have small structural rigidity and are not conducive to controlling deformation; the construction of sheet pile retaining wall has great influence on the surrounding environment; while the piled pile or underground continuous wall is often used as the retaining structure of the deep foundation pit due to its high rigidity and strong control deformation ability. In addition, a single or multiple layers of anchors or supports can be added depending on the depth of the foundation pit. The anchor rod stabilizes the retaining structure from the outside of the foundation pit, and transmits the force to the pressure-producing soil layer by means of axial tension. There is no correlation between the anchor rods, and the working area in the pit is large, and the cost is relatively high. The low-end features; while the inner support structure keeps the support pile stable from the inside of the foundation pit, and the support rod members interact with each other. In view of the current development of urban construction and the shortage of land resources, most of the foundation pit engineering projects are located in densely populated areas of surrounding buildings. The distribution of above-ground and underground structures is complex. Due to its mechanism of action, the bolt system often exceeds the red line of the land or the underground pipeline. The effect is not used, and the inner support structure becomes a common support system. Among them, the annular inner support is used as a common internal support form due to the advantages of reasonable force performance, large working area in the pit, and material saving.

## 3. Experiments

### *3.1 Experimental Principle*

In view of the narrow construction site, the construction method of large sloping and grooving cannot be adopted. The building foundation is a large-area 4-6m shallow foundation pit project. The test simulation prototype is a shallow foundation pit with an excavation depth of 4m, which is supported by micro pipe piles. Under ideal conditions, the influence of groundwater level is not considered and only one soil type is considered. Insufficient depth of the supporting structure will affect the stability of the supporting structure. The depth of the embedded structure should be checked. The depth of the supporting pile should be no less than 0.4 times the depth of the excavation. It is assumed that the depth of the pile is $1_d$ 2m, take the ground additional load as q is 20kPa, according to the requirements of "Technical Regulations for Building Foundation Pit Support", verify whether the falsely set $1_d$ meets the formula. The earth pressure is calculated according to the following formula.

Active earth pressure intensity:

$$\sigma_a = (\gamma z + q)K_a - 2C\sqrt{K_a} \tag{1}$$

$$K_a = \tan^2(45° - \varphi/2) \tag{2}$$

Passive earth pressure strength:

$$\sigma_p = \gamma z K_p + 2C\sqrt{K_p} \tag{3}$$

$$K_p = \tan^2(45° + \varphi / 2) \tag{4}$$

Stability check:

$$\frac{E_a h_p}{E_a h_a} = \frac{181.10 \times 0.85}{82.13 \times 1.48} = 1.27 \geq K_e \tag{5}$$

When the safety level is one level, $K_e$ should not be less than 1.25. If the stability check is satisfactory, the pipe pile can be inserted to a depth of 2m.

### *3.2 Experimental Equipment*

The test was carried out in a large model box. The bending strain of the two micro-piles of the bamboo tube and the steel tube was mainly observed. The following equipment was used to monitor and measure the displacement of the pile top and the strain of the pile.

(1) Model box: The box body is made of tempered glass, and the outer frame is welded with angle steel of ×100×100×8mm. The net size of the box body is 1.8m×1.2m×1.6m.

(2) DH3816 static resistance strain gauge test system: Fully intelligent tour data acquisition system, which can measure 60 measuring points with resolution up to 1μV.

(3) Displacement measuring instrument: strain gauge displacement meter with accuracy of 0.01 mm dial gauge, measuring range of ±25 mm and resolution ≤ 0.05% F·S.

(4) BX120-1AA type resistive strain gauge: the substrate size is 3 mm × 2.5 mm, the wire grid size is 1 mm × 1 mm, the sensitivity is 2.0 ± 1%, and the resistance value is 120.

### *3.3 Experimental Plan*

The test was completed in a large-scale model box, simulating the shallow foundation pit support project with the excavation depth of 4m in the actual working condition. In the same model box, the steel pipe micro-pile and the bamboo-tube micro-pile were symmetrically arranged, according to the analysis of the pile body during the loading process. Strain and pile top displacement are used to evaluate the effect of foundation pit support. The strain of the pile body is measured by attaching a micro strain gauge to the surface of the pile body, and the displacement of the pile top is measured by the square meter of the pile end.

The size of the model foundation pit is 100cm×80cm×40cm, and the single-row pile of steel pipe and the single-row pile of bamboo tube are respectively arranged in the two short-side directions of the foundation pit. The pile spacing is 10cm, the pile body is embedded in the bottom of the pit 20cm, and the long side of the foundation pit is equal in length. Fine bamboo tube dense row support. The strain of the pile body is measured by attaching strain gauges, and each strain pile is pasted with a strain gauge at 10 cm, 30 cm, and 50 cm in the axial direction. The bamboo pipe piles are numbered 1#-9# from the left and 10#-18# from the right side of the steel pipe piles. Since the material specifications of the steel pipe piles are the same, only the data of the five side piles on the symmetrical side is measured.

In the deformation measurement, the bonding quality of the strain gauge will directly affect the measurement result. Before the paste, the surface of the test piece is processed, and the cross mark is placed at the pasting position, and the upper and lower strain gauges are kept on the same vertical line, and the surface is coated with fine sandpaper. After cross-polishing, the polished surface is cleaned with anhydrous ethanol; after the strain gauge is pasted with 502 glue, a plastic film is placed on it and the excess glue is squeezed out along the axial direction of the strain gauge with a finger and discharged. The liquid bubble in the adhesive layer is to be completely dried and solidified before being wire-welded; after the strain gauge is connected to the wire, the epoxy resin moisture-proof layer is immediately applied, and after being dried, it is wrapped with PVC tape.

In the displacement measurement, the reference point of the dial gauge measurement should be the fixed point. Therefore, the bracket parallel to the pit wall is placed on the model box, and the dial gauge support is fixed on the bracket to reduce the measurement error.

## 4. Discussion

In the model experiment, the bamboo piles were selected to have smooth surface and no mildew and thin bamboo tubes. The basic parameters are shown in Table 1.

*Table 1. Basic parameters of bamboo micropiles*

| Test piece label | Outer diameter | Wall thickness | length | Section moment of inertia |
|---|---|---|---|---|
| 1# | 17.4 | 4.2 | 600 | 4234.4 |
| 2# | 14.9 | 3.5 | 600 | 2639.9 |
| 3# | 16.2 | 3.2 | 600 | 2991.0 |
| 4# | 15.8 | 2.9 | 600 | 2733.4 |
| 5# | 16.4 | 3.0 | 600 | 2945.1 |
| 6# | 16.7 | 3.3 | 600 | 3378.5 |
| 7# | 18.3 | 3.6 | 600 | 5069.8 |
| 8# | 16.0 | 2.9 | 600 | 2702.2 |
| 9# | 15.9 | 3.1 | 600 | 2664.3 |

### *4.1 Experimental Analysis of Bamboo Piles*

The test was carried out three times to study the deformation characteristics of the micro-pile top displacement and the pile body during the loading process. After 12 hours of static load observation, there is no obvious deformation and crack in the foundation pit. The measured data of the steel pipe pile and the bamboo pile are smaller than the previous engineering data. It is preliminarily determined that the support of the two supporting row piles is good. The supporting edge of the bamboo pile continued to use the three-stage static pressure. After static pressure for one month, there was no obvious change in the foundation pit. After the bamboo tube pile was taken out, the bamboo pile was not broken and the surface was free of cracks. Through the data results and long-term observation, the bamboo pile support effect is good. The time strain curve of the bamboo column is shown in Figure 1 and Figure 2.

The bamboo tube piles are selected for representative 5# and 9# analysis, showing the deformation and loading relationship of the support piles. The strain is faster in the first half hour of each stage of loading, and then slowly increases; the deformation is basically stable in the first three hours of each loading stage. The deformation trend indicates that the bamboo piles are stable in the short term and there is no obvious mutation. The maximum strain of the support pile is near the middle part, and the strain of the bamboo pipe pile is about 500με.

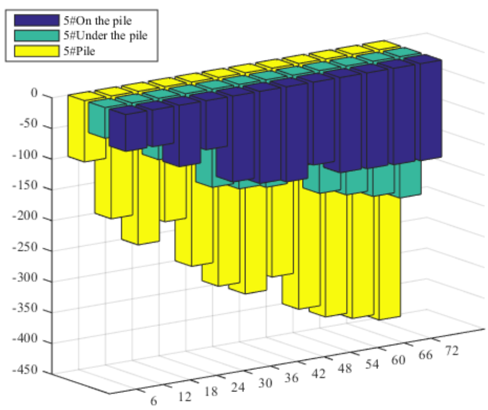


*Figure. 1 Time strain curve of No. 5 bamboo pipe pile*

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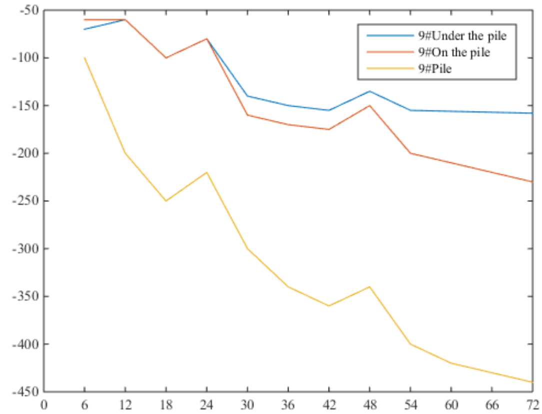


*Figure. 2 Time strain curve of No. 9 bamboo pipe pile*

### *4.2 Experimental Analysis of Steel Pipe Piles*

The strains of the steel pipe piles are selected to have representative 10# and 14# analyses, as shown in Figures 3 and 4. The deformation and loading relationship of the support piles are shown. The deformation trends of the two types of piles are similar. The strain is faster in the first half hour of each stage of loading, and then slowly increases. The deformation is basically stable in the first three hours of each stage of loading. The deformation trend indicates that the bamboo piles are stable in the short term and there is no obvious mutation. The maximum strain of the two kinds of support piles is near the middle part. The maximum strain of the steel pipe pile is about 300με. The deformation of the steel pipe pile is smaller than that of the bamboo pipe pile, but the difference is not very large, and the deformation is within a reasonable range.

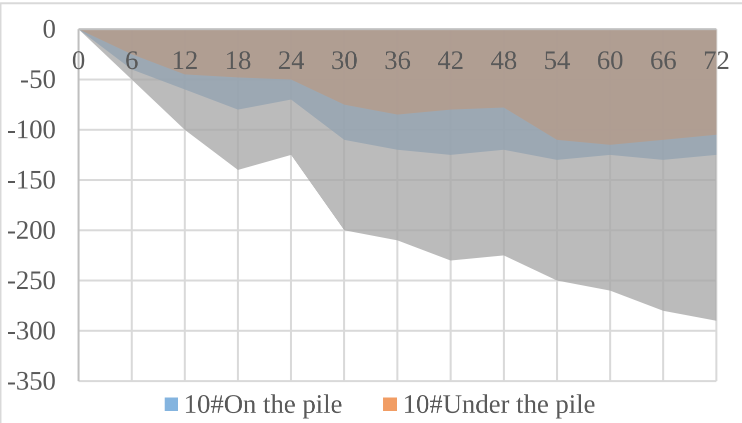


*Figure. 3 Time strain diagram of No. 10 steel pipe pile*

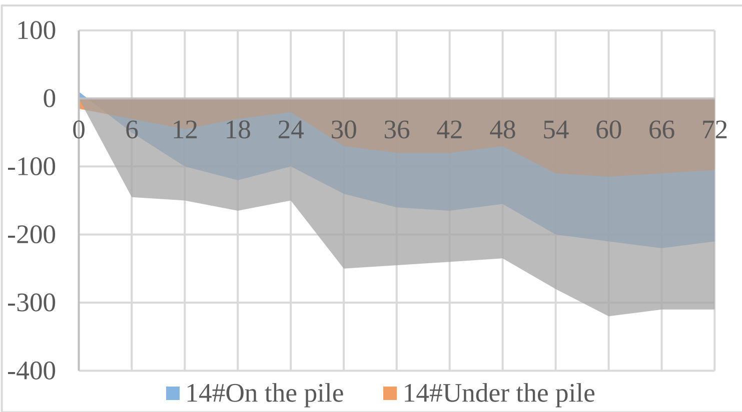


*Figure. 4 Time strain diagram of No. 14 steel pipe pile*

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Most of the two kinds of retaining piles have the largest strain in the pile, the strain under the pile is the smallest, the upper and middle strain gauges are all in the tension state, and the pile wall under the long time pile has a slight uplift. The reason may be that the soil arch occurs. In the test model, the soil is not completely compacted, and there are large pores. The soil is unevenly deformed under the action of static load, which leads to stress adjustment, and the soil arching effect is generated, which leads to the maximum stress in the middle of the pile body. In the application of the shallow bamboo foundation of the actual soft soil layer, the bamboo arch pile can reasonably consider the influence of the soil arching effect on the design pile spacing, and fully exert the soil arching effect and the bearing capacity of the retaining pile.

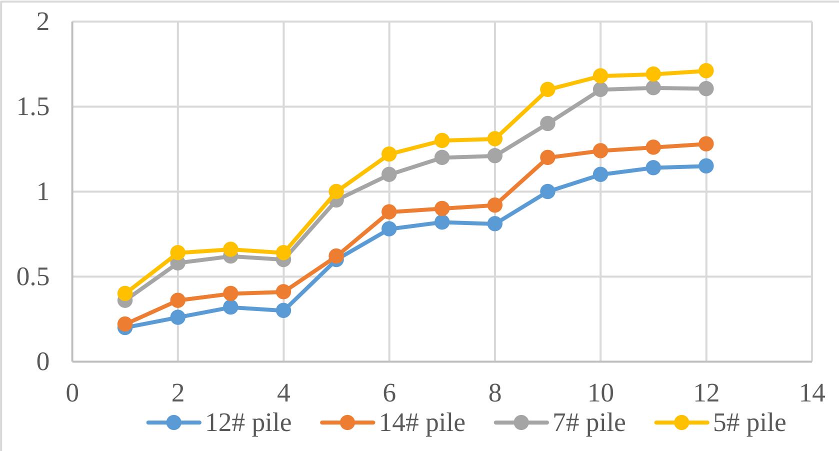


*Figure. 5 Pile top displacement time curve*

As shown in Figure. 5, the top displacement of the two types of pipe piles changes greatly one hour before each stage of loading, and the displacement is basically unchanged after three hours of loading, which is consistent with the strain variation law of the pile body. The top displacement of the bamboo pipe pile is larger than that of the steel pipe pile, but the maximum pile top displacement of the bamboo pipe pile is 1.8mm. The maximum displacement of the pile top is equivalent to 18mm, the displacement is small, within the allowable range, and in the actual engineering, the pile top is usually restrained to further control the displacement of the pile top to ensure the safety and stability of the foundation pit.

## 5. Conclusions

This paper briefly analyzes the common quality problems of deep foundation pit engineering; analyzes SMW construction wall, sheet pile retaining wall, soil nailing wall and composite nail wall, row piled pile retaining wall, underground continuous wall, steel support, reinforced concrete support, the advantages and disadvantages of the supporting structure, such as support, steel and concrete combined support, and the scope of application; the layout of the inner support structure of the ring, the vertical arrangement of the inner support, the influence of the insertion of the pile (wall) on the force and deformation of the structure .

With the development of new rural areas and the development of urbanization, a large number of foundation pits excavated in soft soil layers have been concerned, especially for shallow foundation pit types. This paper focuses on such foundation pits and proposes an environmentally friendly foundation pit. The retaining structure meets the requirements of safe and reasonable, economical and environmentally friendly construction and convenient construction of such foundation pit engineering. This paper analyzes the characteristics of such foundation pit engineering, analyzes the selection of foundation pit support materials and structure selection, selects the bamboo tube as the new structural material, and supports the structure of the piles. Through the indoor comparison model test, the preliminary verification of the bamboo, the feasibility of support for pipe row piles is selected. The support structure of bamboo pile single row pile and double row pile is selected to model and analyze the support effect of two support structures in actual engineering. This paper does not discuss the influence of the key parameters such as the buried depth, pile spacing and row spacing of the bamboo pipe pile on the deformation of the foundation pit. The influence of the crown beam and the coupling beam on the overall deformation of the double-row pile of the bamboo tube has not been studied. Further research on these aspects can be made in the future.

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Due to the limited time and ability, this paper has done some relatively shallow work on the mechanism and application of the foundation pit support structure in special geotechnical areas. It has only a preliminary understanding of this aspect, and many aspects have not been considered. It aims to provide reference and guidance for the construction of similar projects in the future through the practice and exploration of the deep foundation pit support structure in special rock areas. It is suggested that some work can be carried out in the future on the applicability of other reinforcement measures in special geotechnical areas, the value of geotechnical parameters under different working conditions and the effectiveness of other auxiliary measures.

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