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**| RESEARCH ARTICLE**

# Destruction and Protection Based on ANSYS Pile Foundations

**Xingsheng Jin[1a], Xuanpeng Cao[1a], Xingtao Jin[1b] and Dong Zhang[1a]**✉

[a]*School of Technology, Xinjiang Institute of Technology, Xinjiang, China*
[b]*School of Educational, Dingxi Teachers College, Gansu, China*
**Corresponding Author:** Dong Zhang, **E-mail**: 1808260857@qq.com

**| ABSTRACT**

In the process of pile foundation design and construction, pile foundation will produce different degrees of damage in order to protect the pile foundation from damage during the construction process. In this paper, three failure methods of pile foundation are analyzed by static simulation, namely the total deformation of the pile foundation, the maximum principal stress and the bending deformation of the pile body caused by excessive equivalent force. For the pile foundation, when the pressure value is between 2Mpa-3Mpa, the main stress, total deformation, and equivalent force of the pile foundation grow slowly, but when the pressure value exceeds 3Mpa, the deformation effect of the pile foundation increases significantly, and the distribution of the pile foundation is reasonably arranged in the later construction process to ensure that the pressure value of the upper part of the pile foundation is maintained at 2Mpa-3Mpa, so as to greatly reduce the damage of the pile foundation, of course, you can also use concrete materials with higher strength grades to reduce the deformation effect of the pile foundation and protect the pile foundation from being damaged.

**| KEYWORDS**

Pile foundation; numerical simulation; Destruction; protection

**| ARTICLE INFORMATION**

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## 1. Introduction

As a commonly used form of infrastructure in housing construction, a pile foundation is often used in some buildings involving large loads and requiring strong bearing capacity; a pile foundation is a foundation that connects a group of piles by a bearing platform (Qu, 2007) so that the single pile in the group and the surrounding soil together bear the load of the building. By arranging and arranging the individual piles reasonably, the pile foundation can provide force support in different directions, ensuring that the bearing capacity of the building is more stable and safe.

The pile foundation is usually composed of two parts, the foundation pile and the pile, according to the force of the pile foundation in the soil, can be classified according to the force performance: the pile foundation is divided into friction pile, end pile and uplift pile (Ren, 2018). Friction pile refers to the friction of sinking into the soft soil layer at a certain depth through the friction of the pile side soil, and the upper load is transmitted and diffused in the soil around the pile. In the numerical simulation of the pile foundation, the effect of the soil layer on the pile foundation is not considered, so the force of the pile column exists at the pile end, which simplifies the determination of the boundary conditions of the model in the later stage.

As a rigid material, when determining the boundary conditions of the pile foundation, the lower end of the pile foundation is completely consolidated by the method commonly used in engineering, and the upper end is assumed to be a spring constraint, and the complexity of the model constraint is simplified when the numerical simulation of finite element simulation is carried out to analyze the pile foundation model as a spring (Xing et al., 2010).

**2. Group Pile Foundation Model Parameters**

Select a load-bearing platform with a size of 10000mm*10000mm, the thickness of the pile is 200mm, the diameter of the pile foundation is 2500mm, and the length of the pile foundation is 8000mm, as shown in Figure 1 below.

The pile bottom is set as a fixed end constraint, and the end bearing pile is used for calculation and analysis; the pile foundation and load-bearing platform are made of C30, C40 and C50 concrete materials in turn, and the upper part of the pile is applied 1.25Mpa, 2Mpa, 2.25Mpa, 3Mpa, 3.75Mpa.

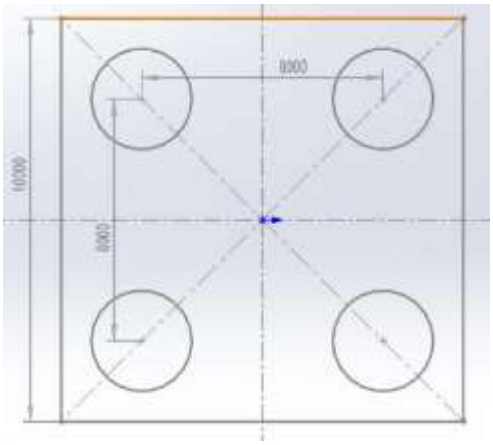

**Figure 1:** Diagram of the foundation parameters of the pile group

**3. Model Solving**

***3.1 Finite Element Calculation Model***

The pile model and pile model are shown in Figure 2 and Figure 3. In this paper, the four-bearing pile model is studied, and in terms of material properties, different strength grades of concrete are used to study the failure effect of the model.

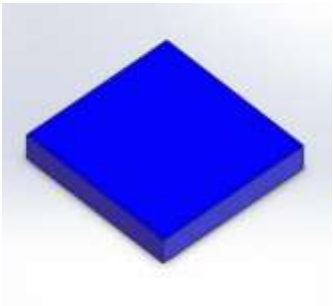

**Figure 2:** Bearing finite element model

**Figure 3:** Group pile finite element model

***3.2 Boundary Conditions Determination***

In the finite element analysis of the pile model, we apply a uniform load on the surface of the upper pile, add boundary conditions in the lower part of the pile according to the pile model, and add fixed support to the bottom surface of the pile foundation. When solving the total deformation, maximum principal stress and bending deformation of the model, the failure effect of pile group foundation under different loads is simulated through the analysis of the static module of ANASYS simulation software.

***4. Analysis of ANSYS Simulation Results (Du et al., 2010)***

***4.1 Simulation of Deformation Effect of Pile Foundation—Based on Different Strength Grades of Concrete***

***4.1.1 Calculation Parameter Settings***

In the study of a pile foundation group of concrete with different strengths, the deformation value of the pile group foundation made of concrete of different strength grades is obtained sequentially by applying pressure values in the size range of (1.25Mpa-3.75Mpa) to the surface of the cushion cap.

The deformation of the pile foundation made of C30, C40 and C50 concrete under the condition of pressure strength of 3Mpa is given.

### *4.1.2 Model Result Output*

Figure 4 is a cloud of deformation of a pile foundation made of C30 concrete with a pressure value of 3Mpa.

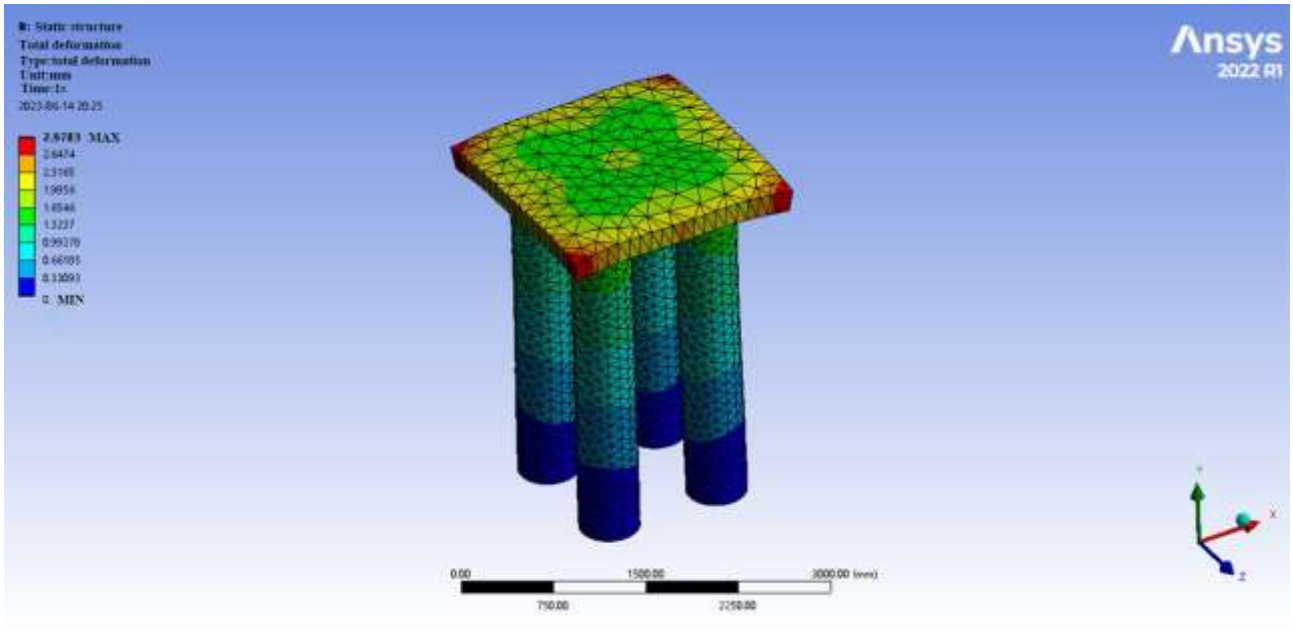


**Figure 4:** Cloud of deformation based on C30 concrete material-pile foundation

The maximum value of the overall deformation of the C30 concrete pile foundation is 2.9783mm, and the deformation is significantly reduced compared with the rest of the pile in the contact between the pile and the pile foundation.

Figure 5 is a cloud of deformation of pile foundation made of C40 concrete with a pressure value of 3Mpa.

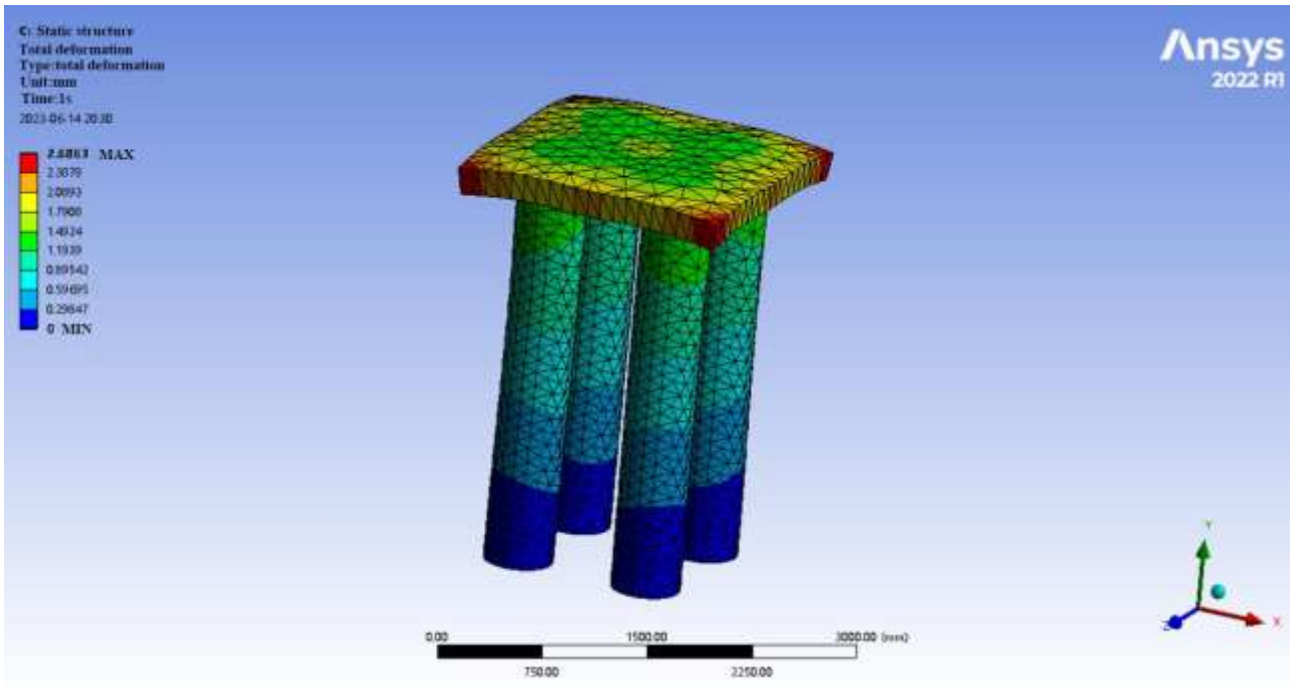


**Figure 5:** Cloud of deformation of C40 concrete material-pile foundation

The pressure applied on the bearing surface is 3Mpa, and the maximum value of the overall deformation of the C40 concrete pile foundation is 2.6863mm.

Figure 6 is a cloud of deformation of pile foundation made of C50 concrete with a pressure value of 3Mpa.

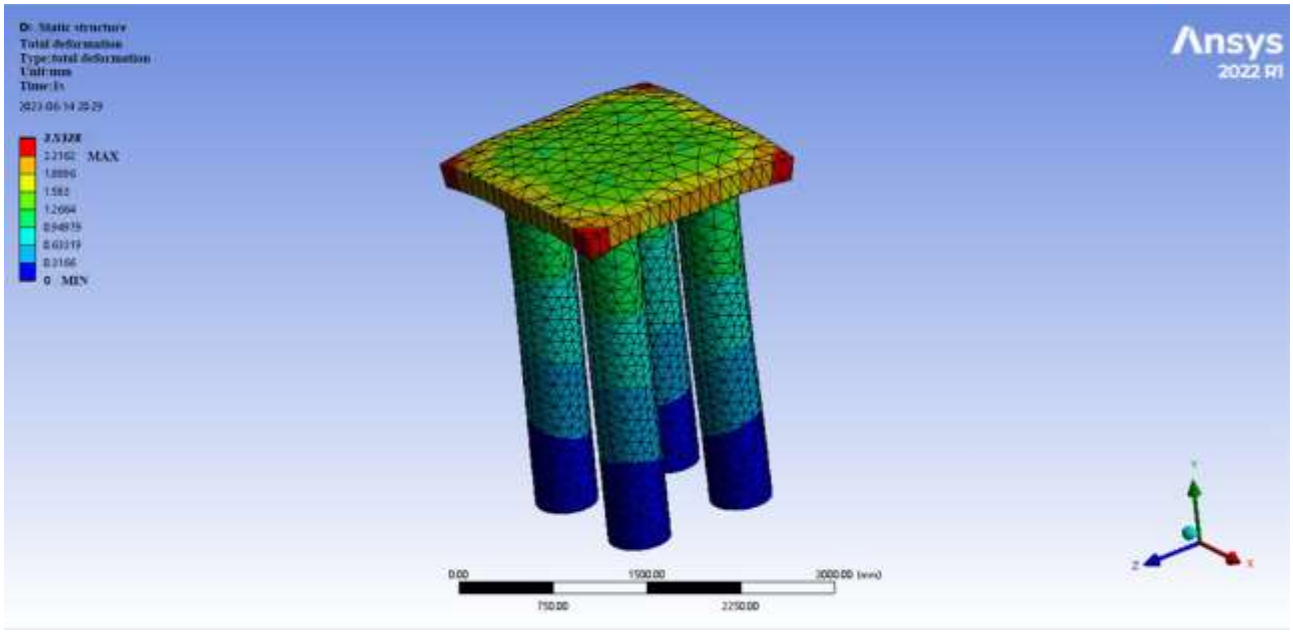


**Figure 6:** Cloud of deformation based on C50 concrete material-pile foundation

The pressure applied on the bearing surface is 3Mpa, and the maximum overall deformation of the C50 concrete pile foundation is 2. 5328mm, according to the cloud map of the deformation of pile foundation of three different concrete materials, in the part where the pile is in contact with the pile foundation, the deformation amount is reduced compared with the obvious changes in other parts of the pile, and the deformation of the four corners of the pile is large, and how to better reduce the deformation of the edge of the pile should be considered in the process of engineering construction, so as to better protect the pile foundation.

### *4.1.3 Analysis of Model Results*

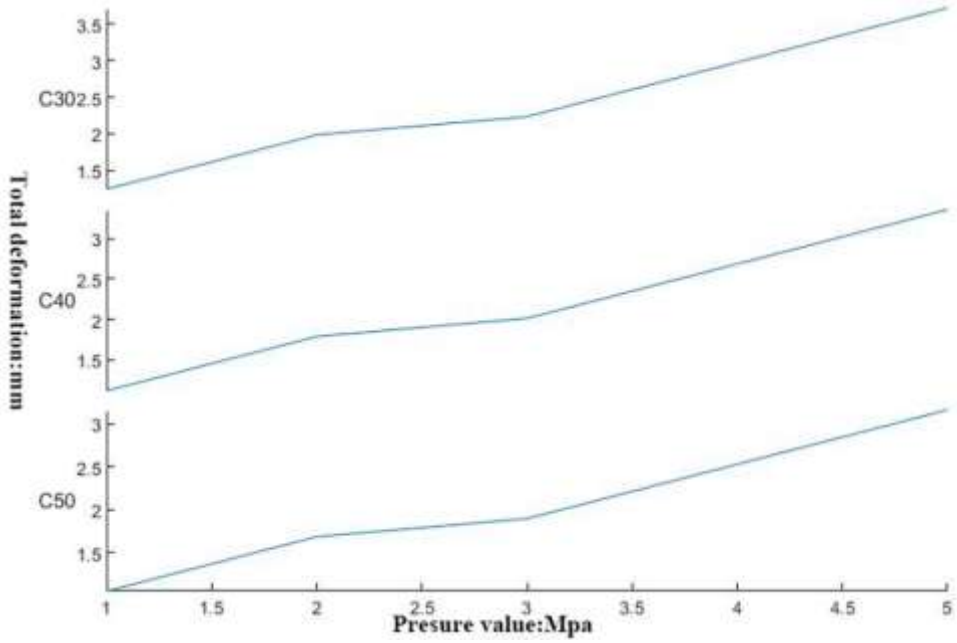


**Figure 7:** Total deformation of pile foundation under different pressures

In the range of pressure value of 2Mpa-3Mpa, the increase trend of deformation of pile foundation has slowed down; when the pressure value exceeds 3Mpa, the increase trend of deformation of pile foundation increases significantly and continues according to a certain growth ratio. Under the same pressure action, the deformation of pile foundation made of concrete of different strength grades is different, and the higher the strength grade of the concrete material, the smaller the deformation of the concrete

material; in the actual project, the material of the pile foundation is determined by analyzing the load value transmitted by the foundation building.

### *4.2 Maximum Principal Stress Analysis of Pile Foundation Under Different Pressure Strengths*

The maximum principal stress is the maximum principal stress in the soil mass generated by the external load acting on the pile foundation. The maximum principal stress is an important parameter to evaluate the bearing capacity and deformation characteristics of pile foundations, which has a significant impact on the nature and behavior of pile foundations.

#### *4.2.1 Model Parameter Setting*

The strength grade of C30 concrete material was selected, and the pressure of 1.25Mpa, 2Mpa, 2.25Mpa, 3Mpa, and 3.75Mpa was applied to the pile in turn, and the main stress change of the pile foundation made of C30 concrete was analyzed.

#### *4.2.2 Model Result Output*

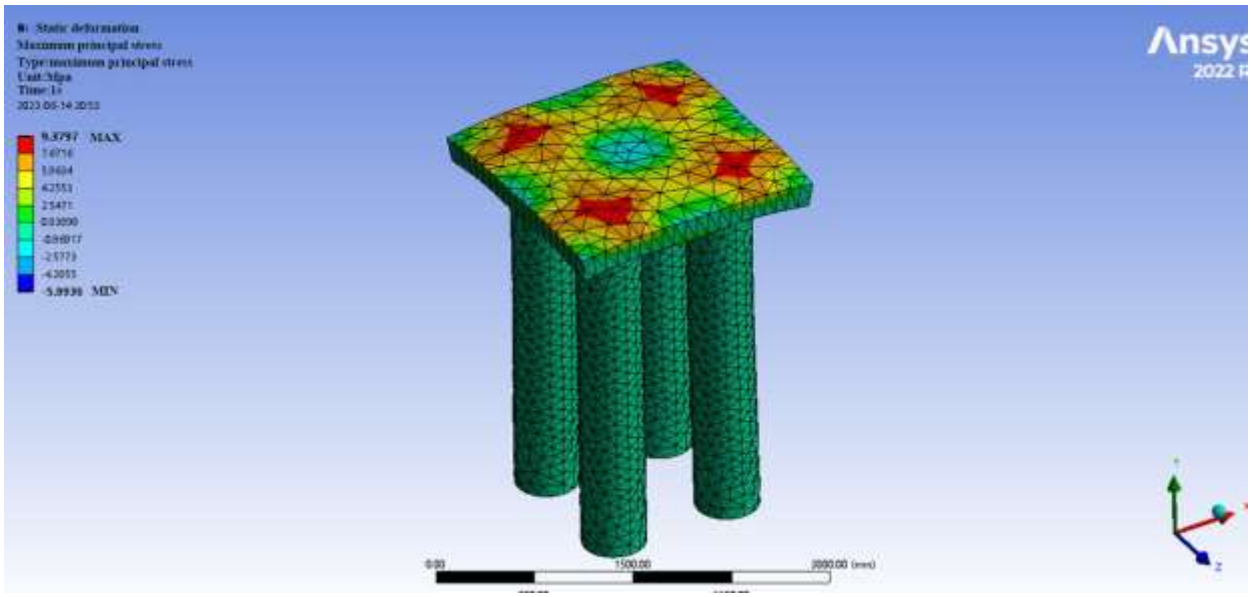


**Figure 8:** Maximum principal stress cloud of pile foundation at 1.25Mpa strength

The maximum principal stress cloud is obtained, as shown in Figure 8, and the maximum principal stress is 9.3797Mpa.

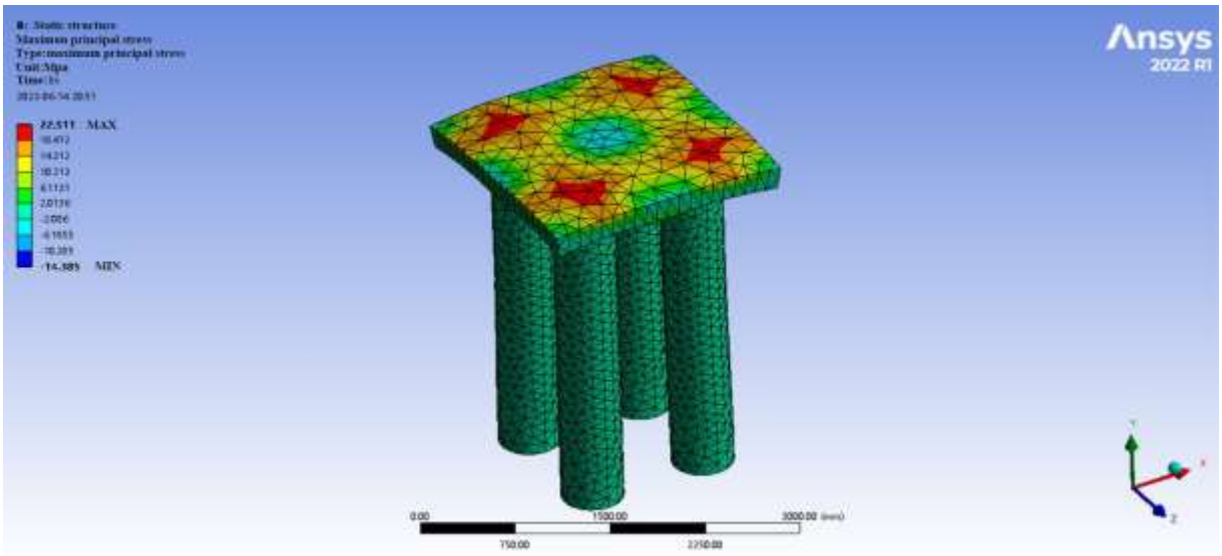


**Figure 9:** Maximum principal stress cloud of pile group foundation at 3Mpa strength

The maximum principal stress cloud is obtained in Figure 9: the maximum principal stress is 22.511Mpa. In the maximum principal stress cloud, the stress is borne by the part where the pile and pile foundation are in contact.

### *4.2.3 Analysis of Model Results*

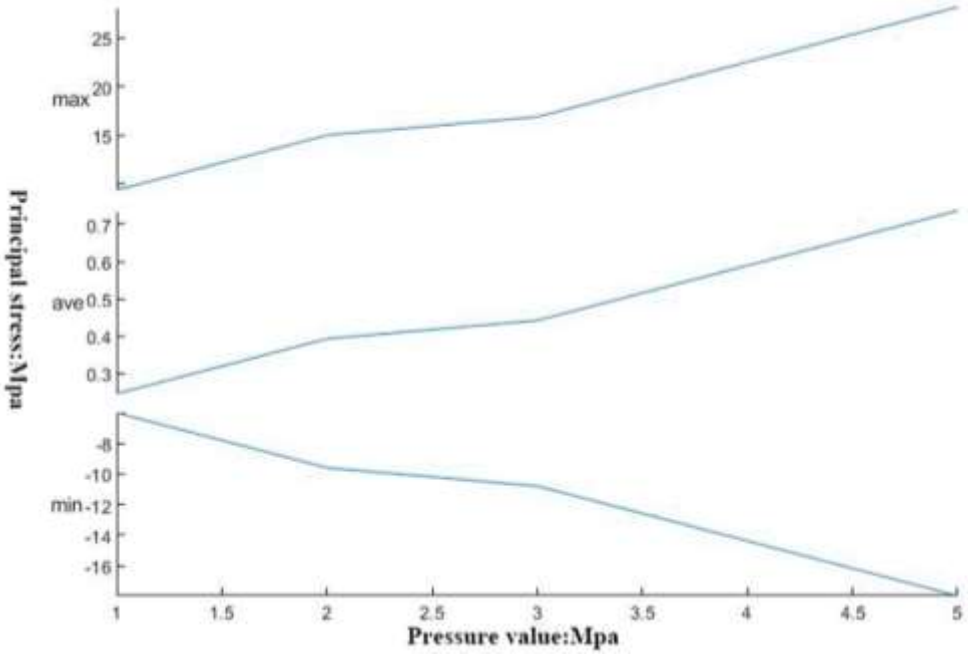


**Figure10:** Stress values of pile foundation under different pressures

The maximum strength grade of C30 concrete is 30Mpa; when the maximum principal stress value exceeds 30Mpa, that is, when the upper load finds 4Mpa, the contact part between the pile foundation of C30 concrete material and the pile foundation is damaged, so if the upper load of the pile exceeds 4Mpa during the design, it is necessary to select concrete with higher strength grade as the material of the pile foundation.

### *4.3 Equivalence Force Analysis of Pile Foundation Under Different Pressure Strengths*

Equivalent forces are one of the factors that need to be considered in the design and construction of pile foundations. Equivalent forces have a direct impact on the performance and lifetime of the pile foundation. Equivalent forces directly affect the load-bearing capacity of the pile foundation. When the equivalent force exceeds the bearing capacity of the soil, soil deformation and failure occur. This will lead to a decrease in the bearing capacity of the pile foundation, which may lead to settlement or deformation. Therefore, it is necessary to accurately calculate the equivalent force according to the nature and load characteristics of the soil to ensure that the bearing capacity of the pile foundation meets the design requirements.

### *4.3.1 Model Result Output*

C30 concrete was selected as the material for pile foundation for finite element analysis:

Figure 11 shows the equivalent force cloud of the pile foundation under the condition of a pressure value of 2.25Mpa, and the maximum equivalent force value of the pile foundation is 24.282Mpa.

Figure 12 shows the equivalent force cloud of the pile foundation under the condition of a pressure value of 3.75Mpa, and the maximum equivalent force value of the pile foundation is 40.469Mpa.

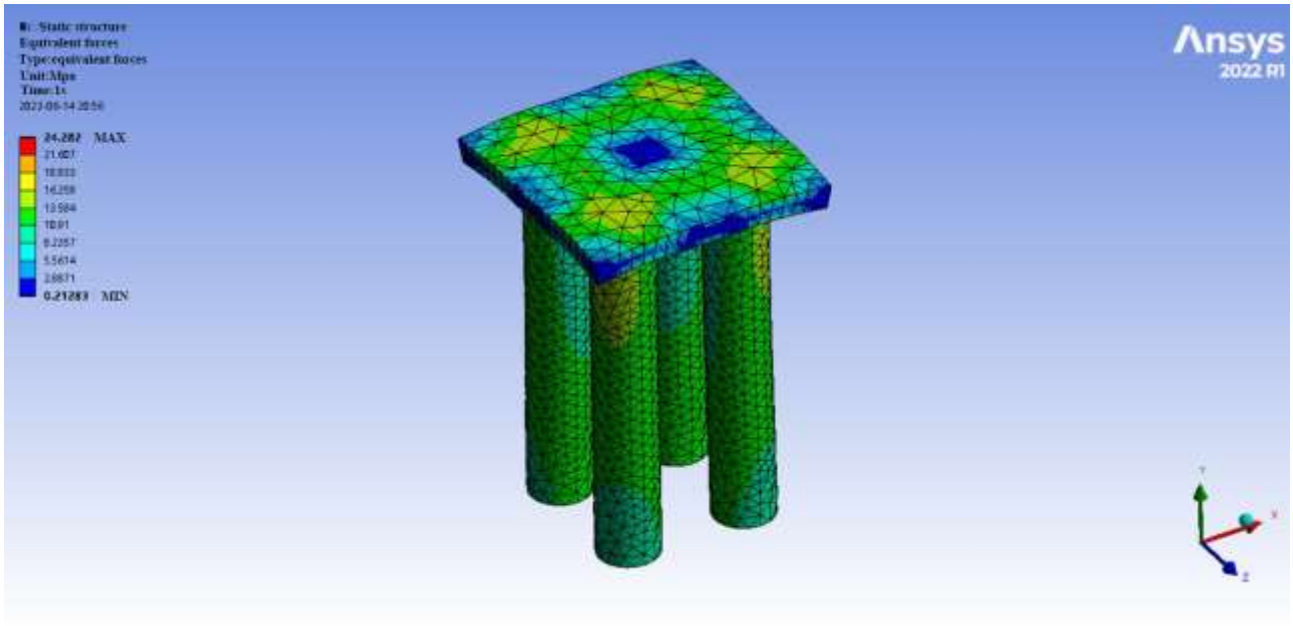


**Figure 11:** Isometric force cloud diagram of pile foundation at 2.25Mpa strength

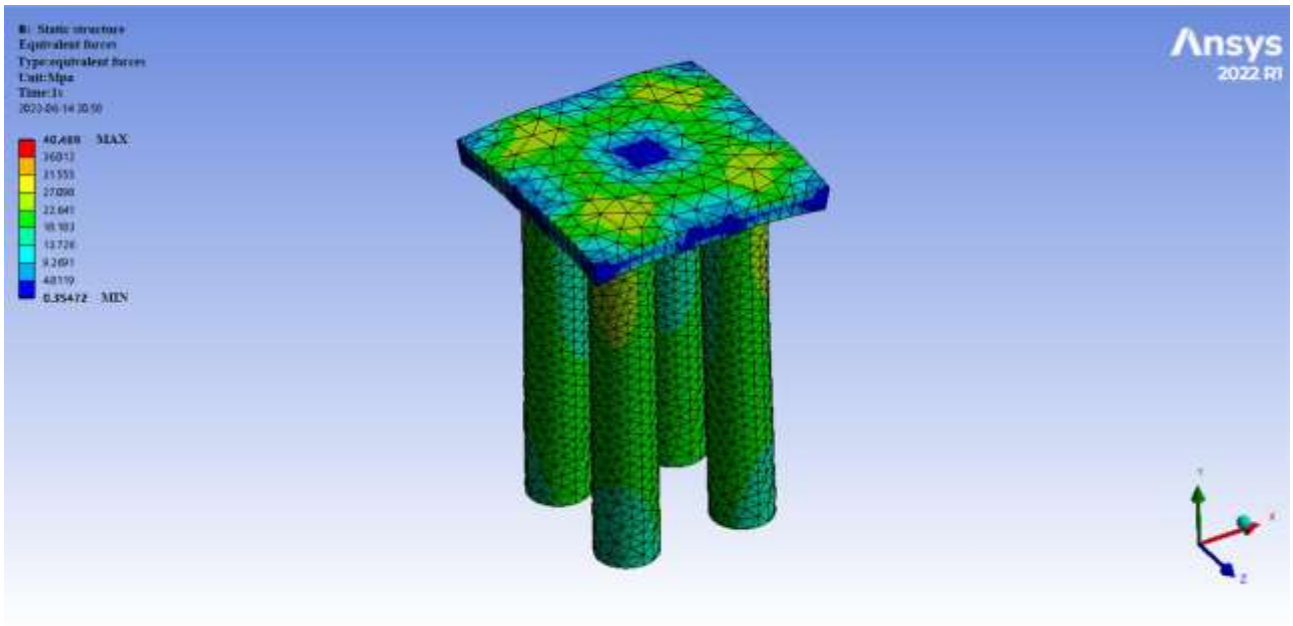


**Figure 12:** Isometric force cloud diagram of pile foundation at 3.75Mpa strength

### *4.3.2 Analysis of Model Results*

In the case of increasing upper load, the average, maximum and minimum values of the equivalent effect are also increasing, and the excessive equivalent force value of the pile foundation directly leads to the reduction of the bearing capacity of the pile foundation: when the equivalent force of the pile foundation exceeds the bearing capacity of the soil, the soil will deform, and plastic failure, resulting in a decrease in the bearing capacity of the pile foundation, and the settlement and deformation of the pile foundation will also increase: so that the pile foundation loses its original stiffness and the ability to withstand external loads. This leads to a shorter service life and even failure of the pile foundation.

The increase of the equivalent force will also lead to an increase in the relative horizontal displacement between the piles so that the horizontal displacement of the pile foundation will change, which will affect the stability of the pile foundation.

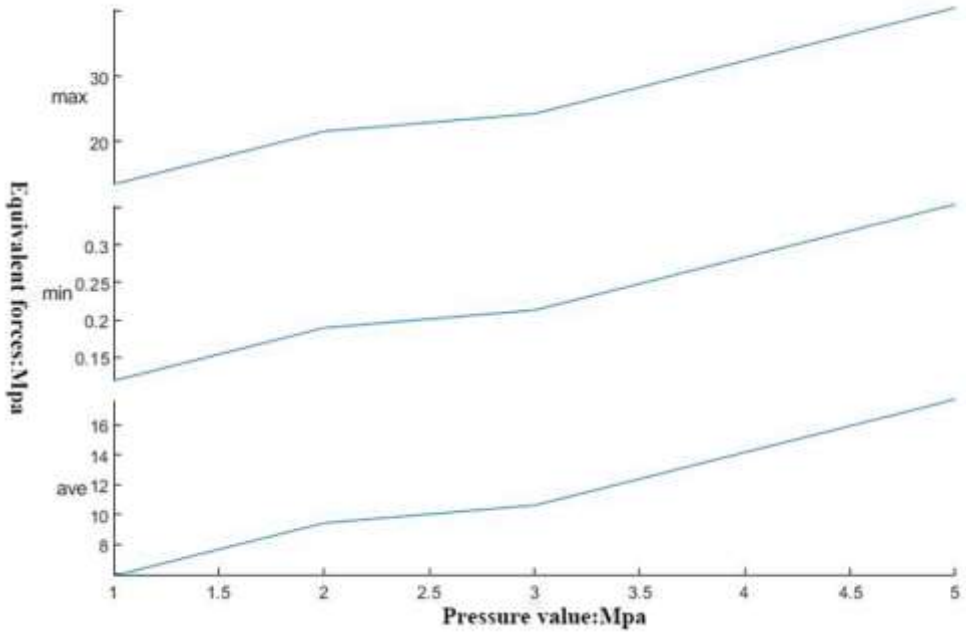


**Figure 13:** Equivalence forces of pile foundations under different pressures

**5. Design and protection of pile foundations**

***5.1 Design Code for Pile Group Foundations (Wang et al., 2017)***

The design of the pile body should be based on the topography and load situation according to the terrain and load situation, determine the pile length, pile diameter, pile distance and, steel reinforcement and other parameters; the pile head should adopt widening, thickening and stiffening and other measures, pile foundation design should comprehensively consider the strength of the pile body and load transfer force, so as to determine the size and arrangement of the pile foundation, according to the geological survey data, Load characteristics and design requirements, calculate and analyze the bearing capacity of pile foundations. According to the design specifications and construction specifications, adopt appropriate construction methods and processes. Ensure that the construction quality meets the acceptance requirements, and regularly monitor and maintain the pile foundation, timely discover and deal with deformation and damage problems, and ensure the safety and stability of the foundation.

***5.2 Deformation, Breakage and Protection of Pile Foundation***

The deformation of a pile foundation mainly includes settlement deformation, inclination deformation, horizontal displacement, pile body bending deformation; when the upper load of the pile is large, the pile foundation will occur pile body bending deformation and pile body in the working process of horizontal or vertical load, bending moment will occur so that the pile body bending deformation to a certain extent.

When designing the pile foundation, consider how to better reduce the hazards caused by the deformation of the pile foundation to ensure the stability and service life of the building.

***5.3 Maximum Principal Stress Damage and Protection of Pile Foundation***

The main stress failure of a pile foundation usually occurs in the pile body and foundation failure under uneven load when the pile foundation when load borne by the pile foundation reaches a certain value; under the strong load, the pile body and foundation will occur uneven stress distribution, eventually leading to local failure and overall instability.

The main stress failure mode of pile foundation is mainly pile bending failure, foundation slip failure, settlement failure; pile bending failure is in weak soil layer or soft rock layer if the stiffness of the pile body is too low, when the load exceeds its bearing capacity, the pile body will appear bending failure.

In view of the problem of main stress failure of pile foundation, it is necessary to comprehensively consider various factors in the design and construction and take appropriate technical measures, such as increasing the number of piles, improving the bearing capacity of piles, and adopting reinforcement measures to improve the safety and stability of pile foundations.

### *5.4 Damage and Protection of Group Pile Foundation with Equal Force*

Equidynamic force failure of a pile foundation refers to the failure that occurs when the total stress of the foundation exceeds its bearing capacity. According to the principle of mechanics, the stress distribution between the pile and the soil will be formed after the force of the pile foundation, and the stress of the soil around the pile gradually decreases with the increase of distance, while the stress of the soil under the pile is greater.

The equivalent force failure mode of pile foundation is mainly settlement failure, pile bending failure, foundation shear failure, pile compressive failure; through the above finite element analysis, the upper part of the pile bearing under the condition of bearing strong load, the pile body is subject to bending moment and caused by pile bending failure.

In order to avoid damage to the group pile foundation and other effects, it is necessary to fully consider various factors in the design and construction, including foundation conditions, building loads, load distribution of different pile bodies, etc., and adopt reasonable pile body length, pile spacing, steel reinforcement and other design measures; in the construction, it is necessary to strictly master the installation and effective detection and control of piles to ensure the safety and stability of the foundation.

## 6. Conclusion

This paper mainly simulates several common failure methods of pile foundation so as to provide relevant theoretical support for subsequent engineering construction and finds through numerical simulation that the principal stress of pile foundation, The equivalent force and the total deformation increase with the increase of the pressure value, but when the pressure value is maintained between 2Mpa-3Mpa, the damage of the pile foundation is significantly slowed down, and when the pressure value exceeds 3Mpa, the failure strength of the pile foundation increases significantly, and the deformation effect is significantly lower than that of the concrete material with lower strength grade for the concrete material with higher strength grade. In the actual engineering construction, if you need to choose the pile foundation as the building foundation, to protect the pile foundation from being damaged in the construction stage, you need to consider the distribution of the pile foundation to ensure that the pressure value of the pile foundation is maintained within 2Mpa-3Mpa if the construction area is limited, it is impossible to reduce the pressure of the upper part of the pile by adjusting the distribution of the pile foundation, you need to consider the concrete material with higher strength level to pour the pile foundation.

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