

# Analysis on pile testing results of post-grouting bored pile

**A R Zheng**

CCCC Tianjin Port Engineering Institute Ltd. ,Key Laboratory of Geotechnical Engineering, Ministry of Communications, PRC, Key Laboratory of Geotechnical Engineering, Tianjin , Tianjin 300222, China  
airong717@163.com

**Abstract.** Based on static load test results, the bearing capacity of bored piles with pile-toe and pile-shaft post-grouting has been analyzed. The analysis reveals that: with post-grouting, the interface between pile and surrounding soil are strengthened and the relative sliding displacement in between is reduced; end resistance of pile is enhanced and can be mobilized at earlier stage with smaller sliding displacement. As a result, the performance of bored pile is improved with increased bearing capacity and reduced settlement.

## 1. Introduction

Pile-bottom sediment and pile-surrounding slurry cake are two inherent defects which can affect the pile-end resistance and pile-surrounding frictional force of grouting piles with shaft wall protection by drilling mud <sup>[1]</sup>. The post-grouting technology is widely used because it has good prevention effects on pile-bottom sediment and pile-surrounding slurry cake. Therefore, more specific researches on bearing capacity and reinforcement mechanism of post-grouting grouting piles are conducted <sup>[2~5]</sup>. This paper will analyze the vertical bearing capacity of post-grouting piles after the pile-end and pile-surrounding association according to the on-site pile testing.

## 2. Pile testing

More than 18000 piles are arranged for the foundation of grouting pile with shaft wall protection by drilling mud. In order to improve the bearing capacity of pile foundation, the quality of piles will be improved by the way of pile-end and pile-surrounding joint grouting. The pile-end grouting quantity is 1000kg. Different grouting ways will be applied to sites around the pile according to different pile length. A pile-surrounding grouting with the grouting quantity of 600kg is set within the pile length of 30m. If the pile length exceeds 30m, two lines of pile-surrounding grouting will be set and the grouting quantity of each line is 400kg.

The destructive static load tests are done to 66 post-grouting piles and 6 non-grouting piles. The average characteristic value of bearing capacity of some pile types is shown in Table 1. After the grouting process, their vertical bearing capacity shall be respectively improved for 144%, 120% and 97%.



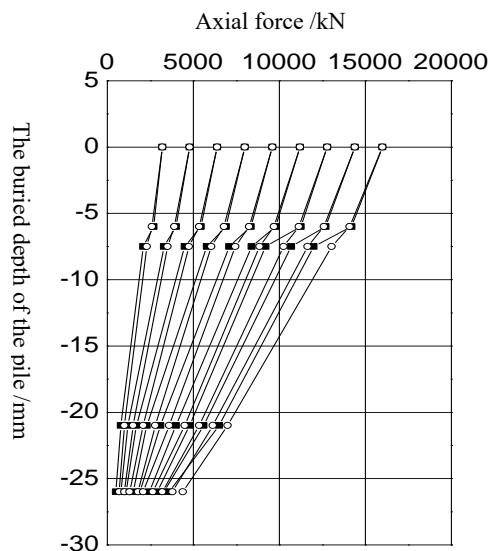
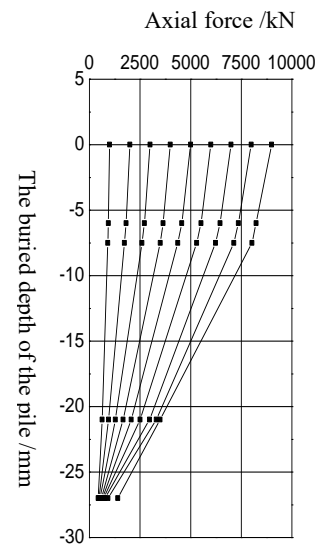
**Table 1.** Eigenvalue of bearing capacity of piles

Pile type	Stress Type	Bearing stratum	Pile diameter /mm	Valid pile length /m	Characteristic value of bearing capacity of non-grouting pile /kN	Characteristic value of bearing capacity of grouting pile /kN
1	Compression resistance	⑨ Fine sand	800	25	2050	5000
2	Compression resistance	⑨ Fine sand	1000	25	2750	6050
3	Compression resistance	⑩ Medium fine sand	1000	27.5	3500	6900

### 3. Calculation results and analysis

#### 3.1. Axial force transfer characteristics

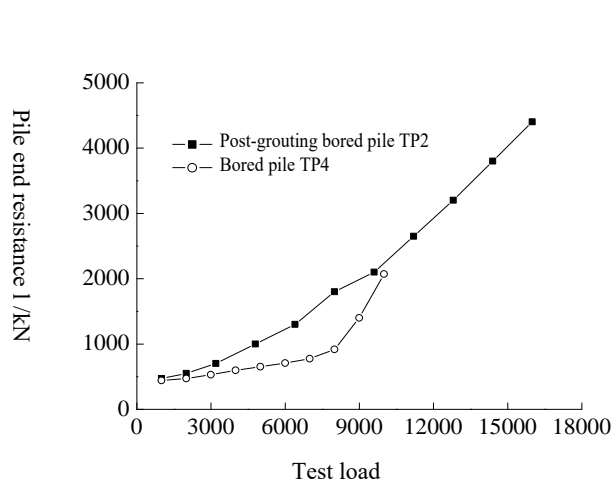
The length of non-grouting pile TP4 and post-grouting pile TP2 is 27.5m, both the diameter of the piles is 1.0m. During different loading stages, the buried depth of axial forces of cross sections of a pile along the pile is distributed as Figure 1 and Figure 2. The axial force of cross section of a pile will increase when the loads increase and will decrease with the increasing of depth under the load effect of the same level. In addition, the decreasing rate is different on different soil layers and during different loading stages. It represents that the slope of the axial force curve has differences. The slope of the axial force curve reflects the size of the pile-surrounding resistance. The smaller the slope is, the axial force difference between levels will be larger, and in other words, the pile-surrounding frictional resistance will be larger. Comparison of the axial force figure of the piles before and after the grouting shows that when the pile-top loads of the two testing piles are close to the maximum load value, the axial force curve slope of post-grouting piles is smaller than that of the non-grouting pile. This means that the frictional resistance of the pile-surrounding soil after the grouting is higher than that of non-grouted.

**Figure 1.** Axial force distribution of post-grouted bored pile**Figure 2.** Axial force distribution of non-grouting bored pile

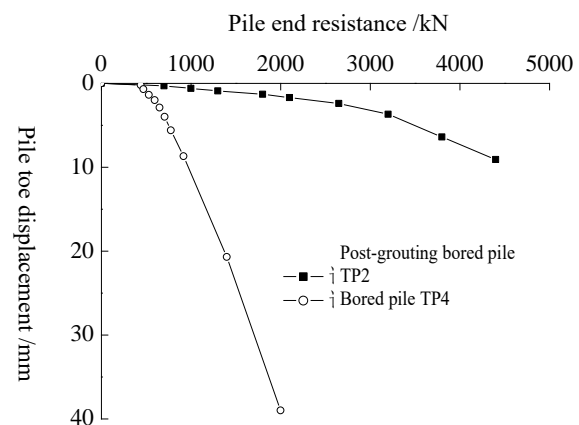
#### 3.2. Performance features of pile-end resistance

The relationship among the pile-surrounding frictional resistance, the load and the displacement of pile tip is shown as Figure 5 and Figure 6. Under small loading effect, the difference of pile-surrounding frictional resistance before and after the grouting becomes small, which presents a linear relation with

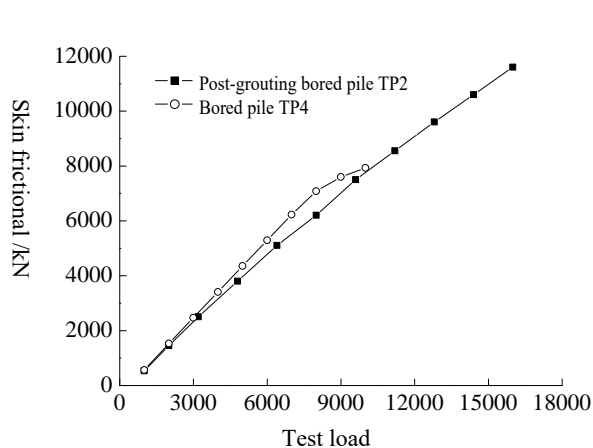
the load. When it is loaded to 8000kN, the pile-surrounding frictional resistance of non-grouting pile TP4 will decrease along with the increase of test load; the settlement amount will increase suddenly and finally reach the limited lateral frictional resistance. During the loading process of post-grouting pile TP2, the pile-surrounding frictional resistance basically has the linear relation with the pile-top load and the changes of pile-tip displacement relation curves are also mild, failing to reach the peak. This is because the post-grouting greatly improves the pile-surrounding interface conditions and the limited frictional resistance of the pile-surrounding soil, which can finally improve the pile-surrounding frictional resistance.



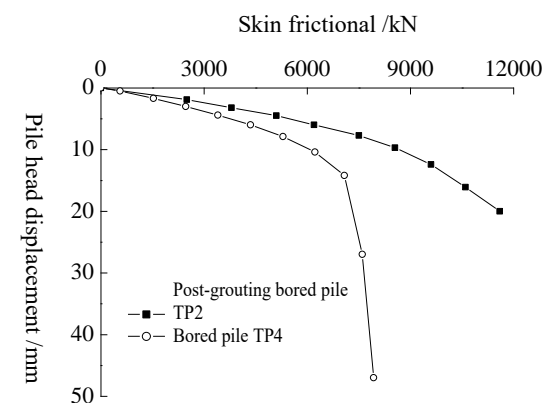
**Figure 3.** Relationship between pile end resistance and test load



**Figure 4.** Relationship between pile end resistance and pile toe displacement



**Figure 5.** Relationship between skin friction and test load



**Figure 6.** Relationship between skin friction and pile head displacement

#### 4. Conclusion

(1) Pile testing results show that compared with the grouting pile under the vertical loading effect, the settlement amount of the pile-end and pile-surrounding association grouting pile is significantly reduced while the bearing capacity is greatly improved.

(2) After the grouting process, because of the enhancement of the strength of soil around the pile and the improvement of conditions of the interface between pile and soil, the pile-surrounding frictional resistance increases obviously. It still maintains the linear relationship with load under large pile-top loads. In addition, the pile-soil relative displacement is also reduced.

(3) The reinforcement of sediment and the improvement of strength of the pile-end bearing stratum greatly reduce the pile-end displacement. With only a small pile-end displacement, great tip resistance can be played. It is played in advance, which reduces the difference between that of the pile-surrounding frictional resistance. They can bear the pile-top load better, which will improve the vertical bearing capacity of piles.

## References

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