Research Journal of Applied Sciences, Engineering and Technology 6(8): 1483-1485, 2013
ISSN: 2040-7459; e-ISSN: 2040-7467

Submitted: October 31, 2012 Accepted: January 03, 2013 Published: July 10, 2013

Experimental Research on Double-Pipe Pile-Shoe of Steel Pipe Piles

[1]Hua Wei, [2]Dawei Zhu and [1]Haijun Wang
[1]College of Architectural Engineering, Shenyang University of Technology, Shenyang, Liaoning, 110870, China
[2]Shenyang Fire Brigade Detachment, Chinese People's Armed Police Force, Shenyang, Liaoning, 110026, China

Abstract: In order to clarify mechanical performance of a new kind of steel piles with double pipe pile-shoe, bored steel tubular pile specimens and doubled steel tubular pile specimens were made and compression experiments were carried out. Experiments show that single pipe pile has no high performances and cannot get entire plug effect; Reinforced single pipe pile with ribs has higher performances and can get entire plug effect as the same as close-end piles; Double steel pipe piles have higher bearing capacity, entire plug effect and good ductility. A wedge shape of pile-shoe is helpful to form wedge effect and get higher plug effect and a flat shape end of inner steel tube can get higher plug effect.

Keywords: Bearing capacity, double-pipe pile-shoe, plugging effect, steel pipe pile

INTRODUCTION

More and more large-diameter long steel pile piles have been used in ocean structures in harbor engineering and offshore engineering. Inner excavation method is a low-noise and low-vibration method, inserting the drills in the open-end steel pipe pile, drilling segments side by side press steel pipe with jack and then cast a concrete bulb to get a larger carrying capacity. But plug effect is not good enough for large diameter open-end piles. As an improvement measurement reinforcing ribs are designed inside steel tube, but it is not easy to be constructed. Based on the situation above, it is demanded to develop a new type of pile for inner excavation method in order to obtain excellent bearing capacity, plugging effect, workability and so on Kosaka *et al*. (1998), Li (1980), Lu and Yang (2012), Miura *et al*. (1986) and Wang *et al*. (2000). Therefore, taking account of the bearing capacity, ductility, workability and environmental protection, doubled steel tubular piles were developed, in order to clarify the influence of parameters on the bearing capacity, plugging effects and deformation ability of doubled steel tubular piles, compression experiments were carried out by 7 samples.

EXPERIMENT

Figure 1 is the design of seven test specimens. SYN-28 was only concrete filled pipe specimen; SYR-28 was on the based of SYN-28 and two rings were welded inside of steel pipe, the tube thickness is 8.2 mm. Another 3 pieces of specimens was with doubled steel pipe pile shoe. The tips of inner and outer pipes were cut either at an acute 45° angle (cut) or flat. The steel tubes were made of mild steel (SKK400, JIS) and its yield strength and maximum strength were 293 N/mm^2 and 456 N/mm^2, respectively. The thickness of steel tube is 10.8 mm (inner tube) and 8.2mm (outer tube). 28 days compressive strength of concrete was 20 N/mm^2 for SYN-28 and SYR-28 and 26.6 N/mm^2 for doubled steel tubular specimens.

The experiment was loaded through a 3000 kN capacity-testing machine. Load increment is 50~200 kN/min. Measurement items include axial compressive load, strains of steel tubes, displacement of bulbs and relative displacement between steel tubes and filled concrete. All of data were recorded automatically by THS-1100 high-speed data logger system.

RESULTS AND DISCUSSION

Failure modes: Figure 2 show the failure mode of bored steel tubular specimens and doubled steel tubular specimens at two stages.

Specimens of single pipe: Failure of specimen SYN-28 was due to relative bond-slippage between steel pipe and filled concrete. The longitudinal stress of steel pipe was only 6 N/mm^2 at its limit load. For specimen SYR-28, steel pipe had no obvious deformation; concrete fractured at the upper rib and formed an inverted cone, there was almost no relative slippage between steel tube and filled concrete.

Corresponding Author: Hua Wei, College of Architectural Engineering, Shenyang University of Technology, Shenyang, Liaoning, 110870, China

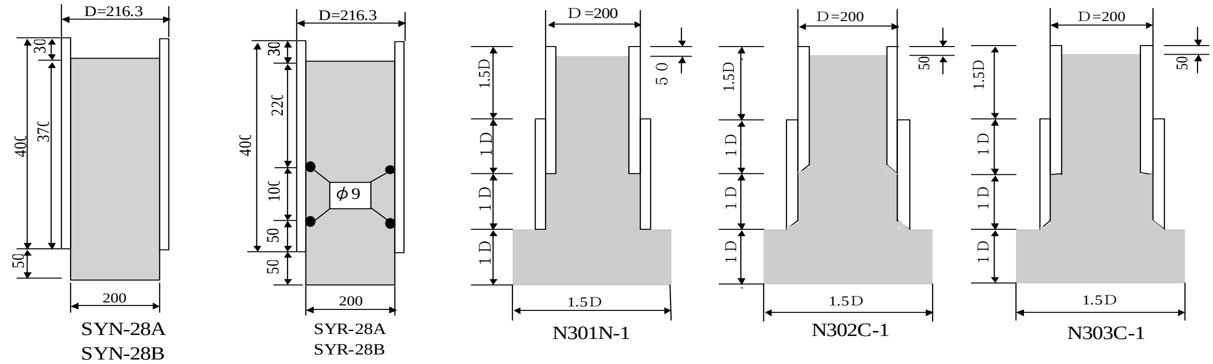

Fig. 1: Test specimens

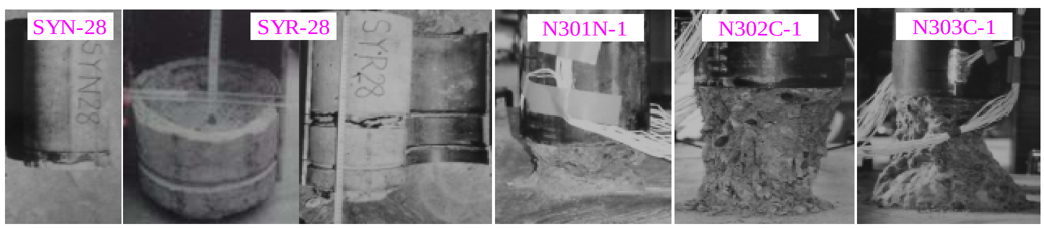

Fig. 2: Destroy of specimens

Table 1: Bearing capacity and plugging effect factor

	Detailed size				Stage 1			
Specimens	Inside pipe (mm)	Outside (mm)	Extension of outside tube (mm)	Cross section (m^2)	Maximum load (kN)	Maximum stress (N/mm^2)	Relative displacement (mm)	Plugging effect factor α
SYN-28	φ 200.0	φ 216.3		0.0314	159.7	5.1	1.21	0.51
SYN-28	Ring Φ 9	φ 216.3		0.0314	1316.1 (312.9)	41.9 (10.0)	7.27 (1.20)	4.19 (1.0)
N301N			200	0.0314	786.9	52.1	0.17	2.51
N302C	φ 200.0	φ 216.3	200	0.0314	940.8	30.0	0.31	3.00
N303C	t = 10.8	t = 8.2	200	0.0314	1411.2	44.9	0.36	4.49

Specimens with double-pipe pile shoe: For specimens with base, there are two stages for the failure course. Firstly, the concrete bulb was split from the outer edge of steel pile shoe to the bottom edge of the bulb. With increasing of axial compressive load, the concrete base failed to form a concrete cone and there was almost no relative slippage between steel tube and filled concrete. It is considered that failure mode is the same as closed-ended pile and entire plugging effect were produced. The tip's shape of outer tubes almost has no influence on the failure mode.

Bearing capacity and plugging effect: Table 1 shows the bearing capacity. It can be seen that the bearing capacity and cohesive strength of specimen SYR-28 (with ribs) are 8.2 times higher than that of specimen SYN-28. It is considered that ribs can promote the bearing capacity and the unification between concrete and steel. For doubled steel tubular specimens, bearing capacity of N303C-1 shows 79.3% higher than that of N301N-1, 50.0% higher than that of N302C-1. It is understood that the bearing capacity and cohesive strength of doubled steel tubular specimens are better than that of bored steel pipe specimens. In the case of doubled steel tubular specimens, specimen with outer steel tube of wedge shaped end shows more excellent bearing capacity than that of specimen with ordinary steel tube. As for inner steel tube with wedge shaped end, it has no obvious effect on the cohesive strength.

The plug effect has great influence on the drivability and bearing capacity of the pile. It is expressed as following equation:

$$\alpha = P_{max}/(A.\ q_u) \tag{1}$$

where,

P_{max} = The bearing capacity of pile
A = The cross section area
q_u = The limited stress of ground and it is 9800 kN/m^2 (AIJ, 2001)

The shape of pile-shoe affects bearing capacity and plug effect. The value of SYN-28 is 0.51 and SYR-28 is the same as close-end pile. The plug effect of double

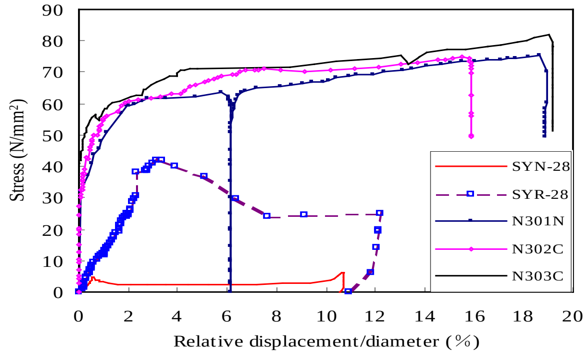

Fig. 3: The relationship of relative displacement and stress

steel tubular specimens is over 2 times higher than close-end pile. Furthermore, the wedge shape of pile-shoe is helpful to form wedge effect and get higher plug effect. But the cut shaped end of inner steel tube can get higher plug effect.

Relative displacement between filled concrete and steel pipe: Figure 3 shows relationships between stress and relative displacement. At the yield point, SYN-28 did not yield and SYR-28 had large relative displacement, but double steel pipe piles had very small relative displacement. At the failure point, doubled steel pipe piles have higher ductility than single pipe specimens.

CONCLUSION

Based on compression experiments, the bearing capacity, plug effects and deformation ability are discussed. The following conclusions were derived:

- Doubled steel pipe-shoe piles have perfect performances and entire plug effect. A wedge shape of pile-shoe is helpful to form wedge effect and get higher plug effect and a flat shape end of inner steel tube can get higher plug effect.
- Single pipe pile has no high performances and cannot get entire plug effect. Reinforced single pipe pile with ribs has higher performances and can get entire plug effect as the same as close-end piles. But the rib is an obstacle for excavation.

ACKNOWLEDGMENT

This study was financially supported by Liaoning Provincial Educational Department Fund (L2010412), Scientific Research Foundation for the Returned Overseas Chinese Scholars (20086211), Shenyang Science and Technology Plan Fund (F10-205-1-08) and “Liaoning BaiQianWan Talents Program” Fund (2010921077), (201121050). The supports are gratefully acknowledged.

REFERENCES

AIJ, 2001. Recommendation for Design of Building Foundation. Architectural Institute of Japan, Tokyo, Japan.

Kosaka, M., H.J. Wang, H. Matsuda, Y. Shioi and A. Hasegawa, 1998. Experimental study on plugging effect at tip bulb of bored steel tube piles. J. Struct. Eng., 44(1): 1685-1692.

Li, G.H., 1980. Dynamics of Anti-Seismic Engineering. Shanghai Science and Technology Press, Shanghai, China.

Lu, M.Q. and Q.S. Yang, 2012. Nonlinear finite element analysis on mechanical behavior of concrete filled rectangular steel tubular column. J. Shenyang Univ. Technol., 34(2): 224-230.

Miura, K., K. Kawakami, K. Tazaki and H. Yamasita, 1986. Development of bored steel pipe pile - TN piling method. Report Steel Eng. Japan, 321(1): 35-41, (In Japanese).

Wang, H.J., A. Hasegawa and Y. Shioi, 2000. Development of doubled steel tubular pile by an inner excavation method. J. Hachinohe Inst. Technol., 19(1): 91-103.