Proceedings of the Twenty-fifth (2015) International Ocean and Polar Engineering Conference
Kona, Big Island, Hawaii, USA, June 21-26, 2015

ISBN 978-1-880653-89-0; ISSN 1098-6189

www.isope.org

Mechanical Properties of the Clamping Pressure Type Joint for Steel Pipe Pile

Chol-Ho Kim
General Manager of Engineering, Hokoku Engineering Co., Ltd
Edogawa, Tokyo, Japan

Masato Majima
Ceo, Soil-Design Inc.,
Chuo, Tokyo, Japan

Masahiro Ogawa
Assistant Manager of Engineering, Hokoku Engineering Co., Ltd
Edogawa, Tokyo, Japan

INTRODUCTION

Joint quality of steel pipe piles welded on site is generally influenced by welding work environment, such as technical skill of workers and weather conditions, especially rain and wind. With the clamping pressure type joint, steel pipe piles can be joined easily without welding, and quality of the joint becomes more stable and high quality.
In this paper, in order to achieve the practical use, load transmission mechanism and mechanical properties of the clamping pressure type joint for steel pipe pile are described.

KEY WORDS: Detached houses, Small diameter steel pipe piles, Non-welding joint, Ground reinforcement.

LOAD TRANSMISSION MECHANISM OF THE CLAMPING PRESSURE TYPE JOINT

The clamping pressure type joint resists the compressive force by inserting the upper and lower piles through the small void between inner and outer joints, and also resists the torsional force by connecting the upper and lower piles to the concaves of the inside ring of the steel pipe piles. The upper and lower pipes are inserted into the ring until they are touching the partition within the ring. 2 pins are then clamped through the aforementioned holes in the ring in four equidistant places, totaling 8 clamping pressure pins, 4 pins in one clamping action on opposite sides. Resistance for torsional force is ensured by the bending and deformation of the pipes within the ring caused by the clamped and crimped pins.
Fig.1-3 show detail of the clamping pressure type joint. 8 clamping pressure pins are then pressure clamped through the holes in the joint (Fig.7) using the hydraulic clamping pressure machine (Fig.4and Fig.5), constricting the steel pipe into the concaves of the inner ring surface of the joint. Fig.6 illustrates the compressive and torsional load transmission mechanism of the clamping pressure type joint.
Transmission of compressive force is attained through the upper pipe pile – joint – lower pipe pile by frictional resistance Ra1 and bearing resistance Ra2. Similarly, transmission of torsional force is attained by frictional resistance Rs1 and engagement resistance Rs2.

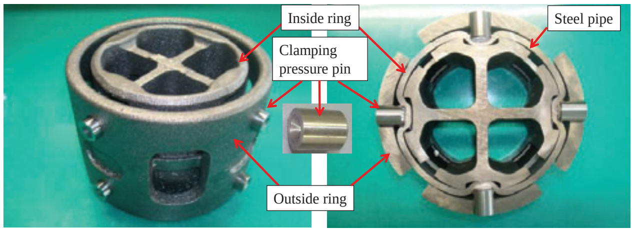

Fig.1 Overview of the technique (clamping pressure type joint)

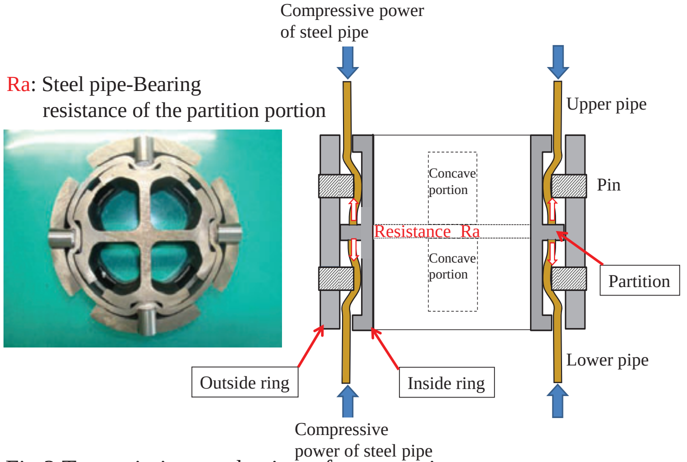

Fig.2 Transmission mechanism of compressive power

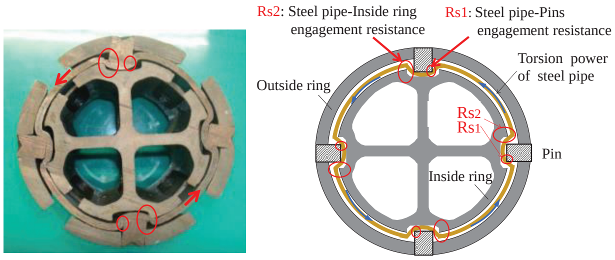

Fig.3 Overview of the technique (rotation & press fit method)

Fig.4 Hydraulic type clamping pressure machine

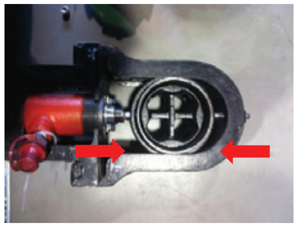

Fig.5 Clamping with uniform force

Fig.6 Clamping machine bit

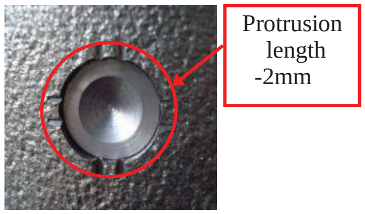

Fig.7 Straight view of the clamped pin in place

SPECIFICATION OF THE JOINT AND STEEL PIPE PILE

Quality of material of the clamping pressure type joint and steel pipe pile is described as Table 1 and Table 2.
Quality of material of the joint: FCD500-7 JIS G 5502 (Spherical as graphite cast iron)

Table 1. Ingredient and mechanical properties of the joint material

Item	Mechanical property		Remark		
	Tensile strength (N/mm^2)	Ultimate strength of=0.2%in compression set (N/mm^2)	Tensile strain (%)	Hardness (HB)	Major minerals
Spec	≧500	≧320	≧7	150~230	Ferrite+Pearlite

Table 2. Dimension and section of the steel pipe pile used in site

Diameter (mm)	Thickness (mm)	Unit mass (kg/m)	Cross-sectional area (cm^2)	Moment of inertia (cm^2)	Section modulus (cm^3)	Radius of gyration of area (cm)
ϕ 76.3	4.2	7.47	9.51	62	16.3	2.55
ϕ 89.1	4.2	8.79	11.20	101	22.7	3.01
ϕ 101.6	4.2	10.1	12.85	153	30.1	3.45
ϕ 114.3	4.5	12.2	15.52	234	41.0	3.89
ϕ 139.8	4.5	15.0	19.13	438	62.7	4.79
ϕ 165.2	4.5	17.8	22.72	734	88.9	5.68

MECHANICAL PROPERTIES OF STEEL PIPE PILE WITH THE JOINT

Strength of the clamping pressure type joint depends on the tightening force of 8 clamping pressure pins acting to the steel pipe pile. From the preliminary test result, the maximum tightening force which can be applied to the steel pipe pile was observed more than 100kN, and then loading tests were continuously carried out in order to confirm the compressive and torsional properties of the clamping pressure type joint in detail. In the loading tests, steel pipe piles of diameter ϕ76.3mm, ϕ 89.1mm, ϕ 101.6mm, ϕ 114.3mm, ϕ 139.3mm and ϕ 165.8mm were used and during the test, the tightening force to the steel pipe pile was sustained constant of 100kN. Overviews of the compressive and torsional loading tests are illustrated in Fig.8-10 and Fig.17-19, respectively.

(1) Mechanical properties of the steel pipe pile receiving compressive force

Evaluation and measurement of the joint compressive loading tests were conducted using 2 displacement gauges and 8 strain gauges, 4 on each steel pipe, placed 170mm from the center of the joints, as shown in Fig.10. On the other hand, the compressive loading tests of the jointless pipe was conducted with 4 evenly placed strain gauges.
Fig.11-16 show result of the compressive loading tests, and it was found that the allowable compressive yield strength of the steel pipe pile with the joint is the same or exceeds the strength of the base material (jointless steel pipe). Although maximum shrinkage of 1 mm in allowable yield strength was observed in the test, the shrinkage can be almost negligible for small buildings because the length of steel pipe pile is usually more than 5m, and the axial compressive displacement equivalent to the allowable bearing capacity Ra of ground is more than 4mm, which is considerably larger than the shrinkage of 1 mm.

Fig.8 Compression test apparatus

Fig.9 (a) Test without the joint

Fig.9 (b) Test with the joint

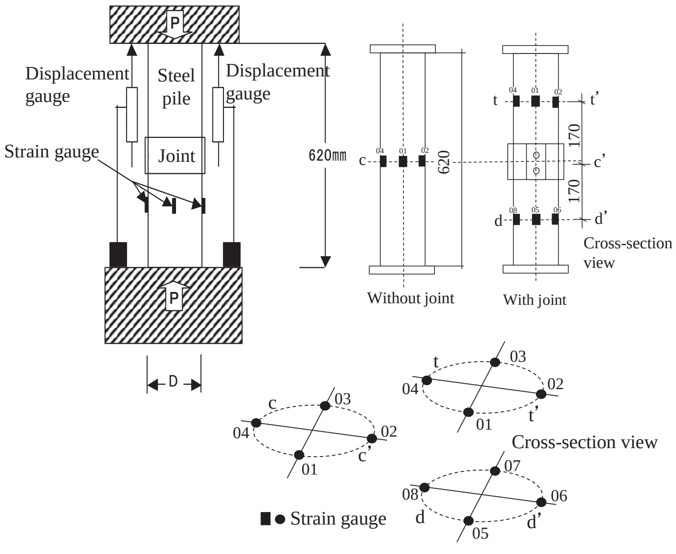

Fig.10 Outline of the compression testing device

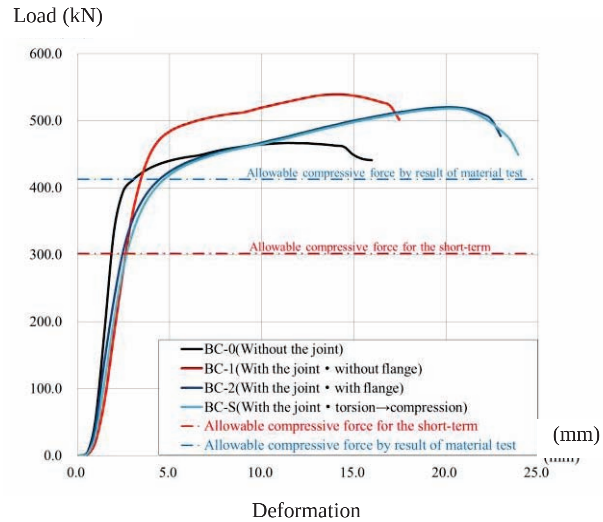

Fig.13 Results of the compression test (ϕ101.6mm)

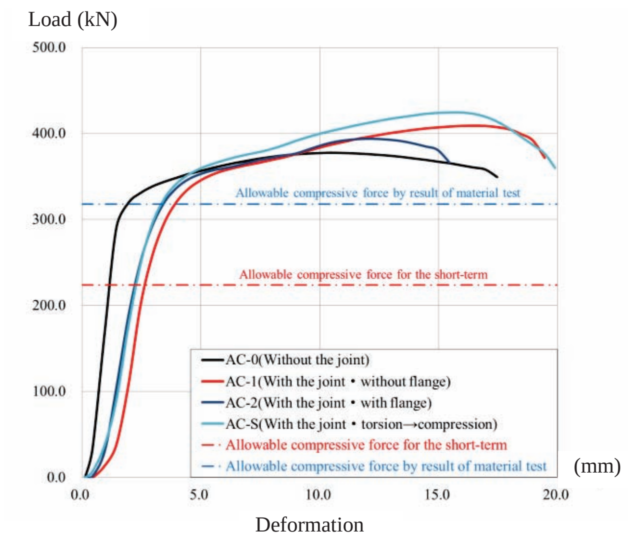

Fig.11 Results of the compression test (ϕ76.3mm)

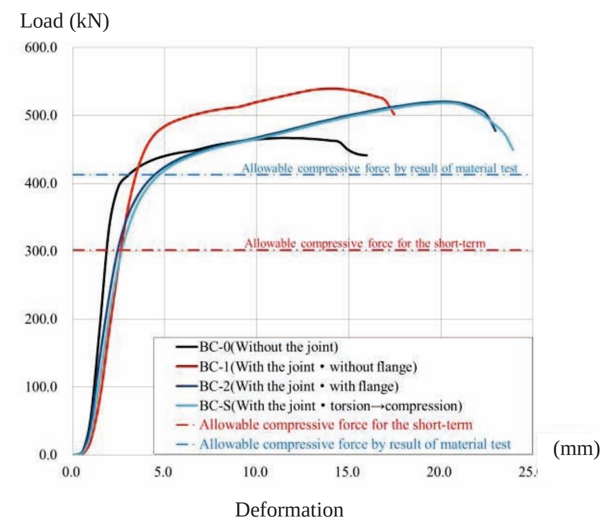

Fig.14 Results of the compression test (ϕ114.3mm)

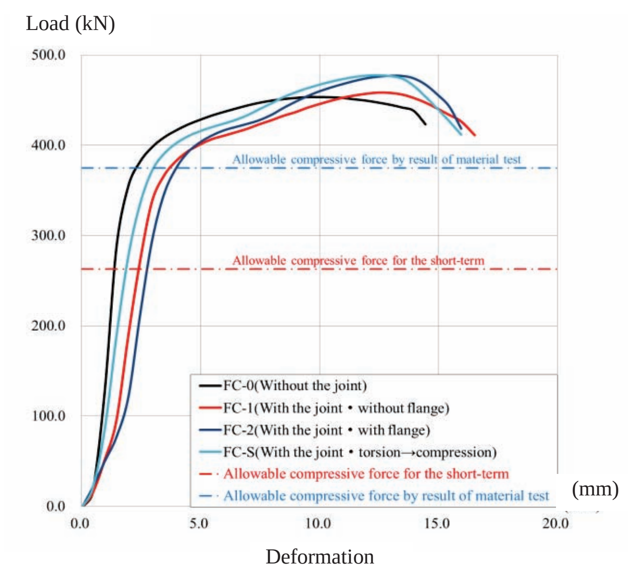

Fig.12 Results of the compression test (ϕ89.1mm)

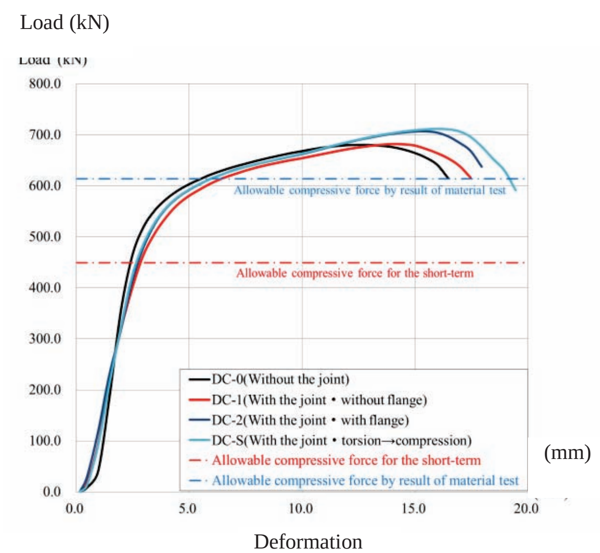

Fig.15 Results of the compression test (ϕ139.8mm)

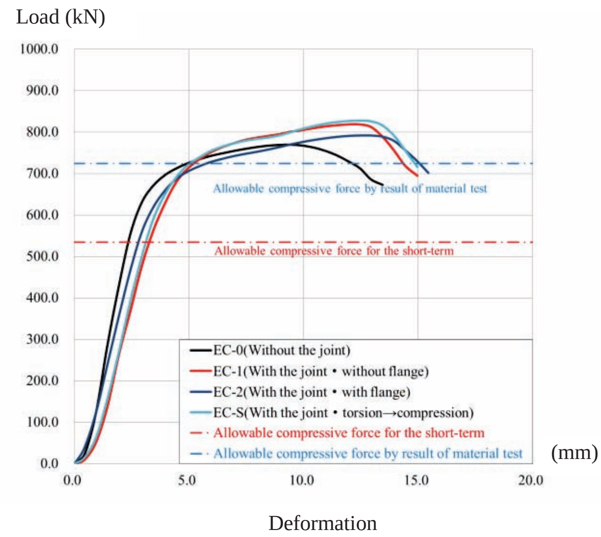

Fig.16 Results of the compression test (ϕ165.2mm)

(2) Mechanical properties of the steel pipe pile receiving torsional force

As with the compressive loading tests, evaluation and measurement of the torsion tests with the joint were carried out using 8 strain gauges, 4 on each steel pipe, placed 170mm from the center of the joints, as shown in Fig.19. On the other hand, the torsion test without the joint was also conducted with 4 evenly placed strain gauges.

Fig.20-25 show result of the torsional loading tests, and it was found that " boundary of strain hardening" for the steel pipe pile with the joint are clearly larger than that of the base material (jointless steel pipe). Here, the "boundary of strain hardening" means the difference of angles of rotation between the beginning of strain hardening and the maximum torque value. In addition, decrease of the torque was not observed even exceeding the rotation angle of 30° for the steel pipe pile with the joint.

Fig.20-25 also indicate that the torsion strength exceeds the calculated allowable load for the short term, and the allowable torsion yield strength of the joint installed steel pipe is the same or exceeds the strength of the jointless steel pipes. High torsion strength is especially crucial during press and rotation fit construction.

Fig.17 Torsion test apparatus

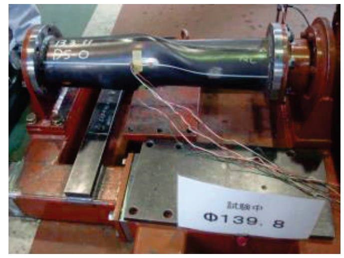

Fig.18 (a) Test without the joint

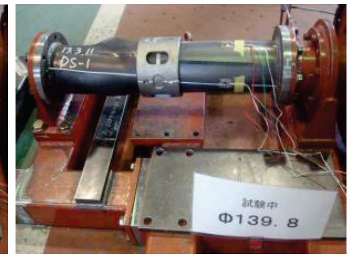

Fig.18 (b) Test with the joint

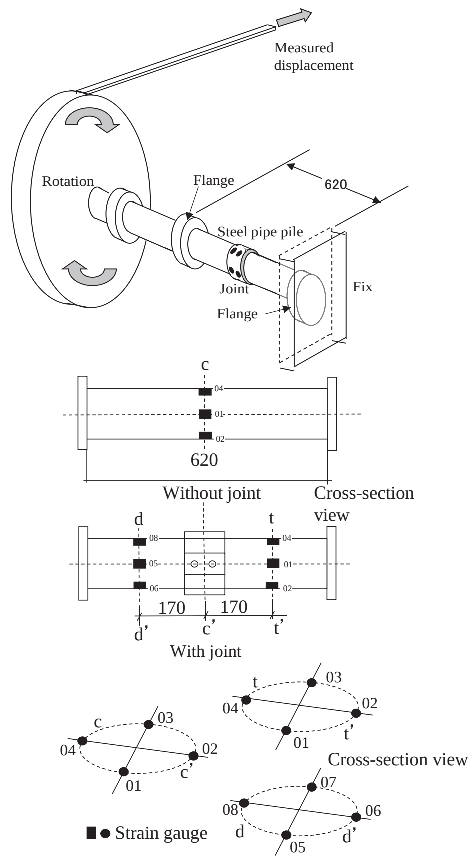

Fig.19 Overview of the torsion testing device

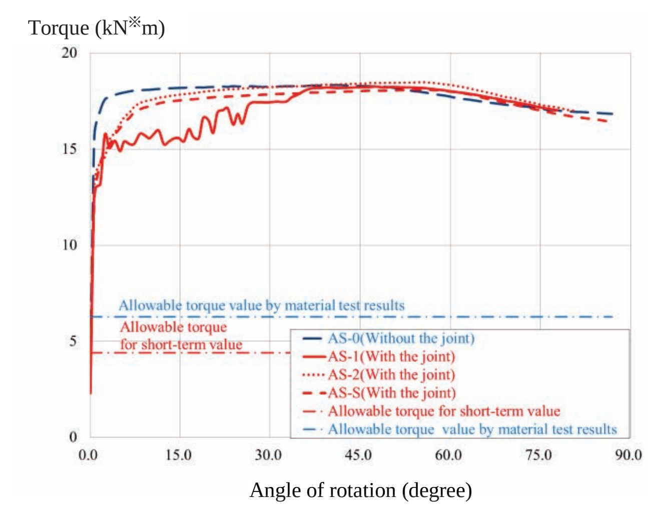

Fig.20 Results of the torsion test results (ϕ76.3mm)

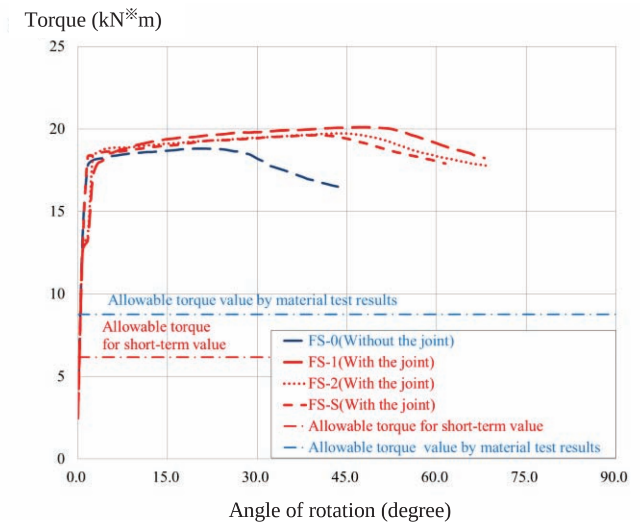

Fig.21 Results of the torsion test results (ϕ89.1mm)

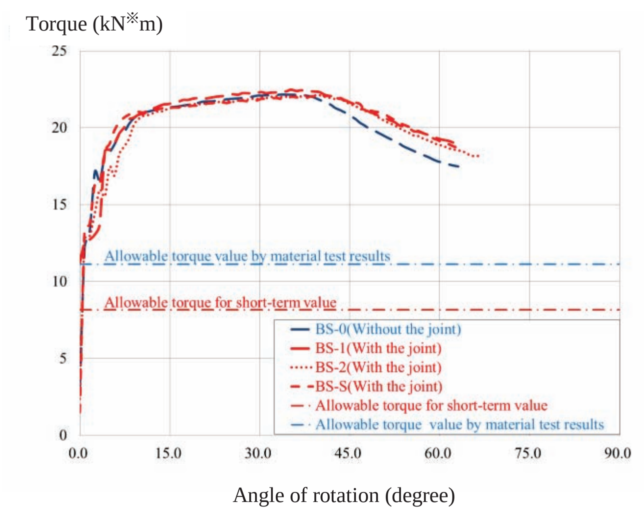

Fig.22 Results of the torsion test results (ϕ101.6mm)

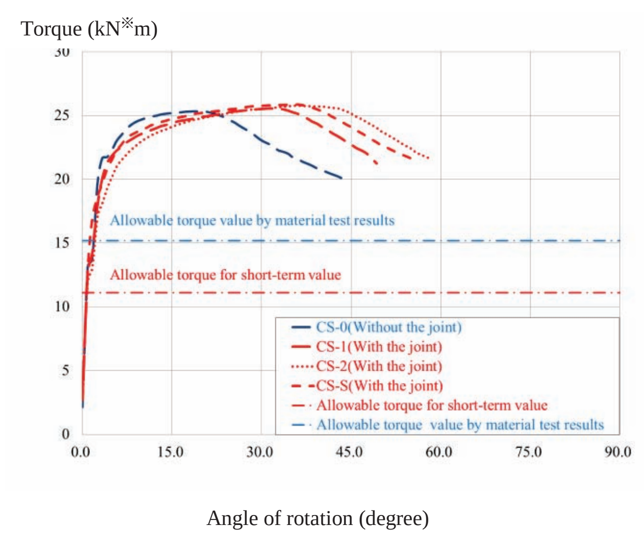

Fig.23 Results of the torsion test results (ϕ114.3mm)

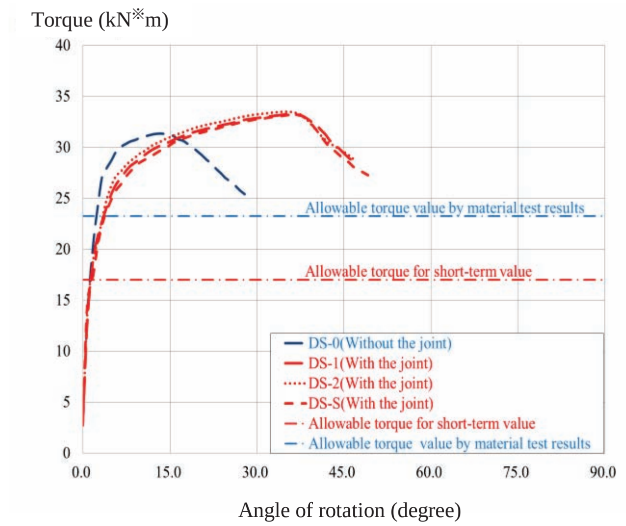

Fig.24 Results of the torsion test results (ϕ139.8mm)

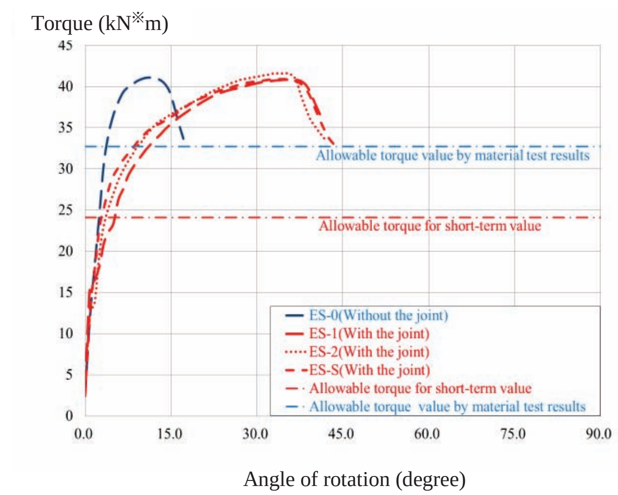

Fig.25 Results of the torsion test results (ϕ165.2mm)

JOINT AND PLACEMENT PROCEDURE

Fig.26 shows the joint and placement procedure of the clamping pressure type joint.

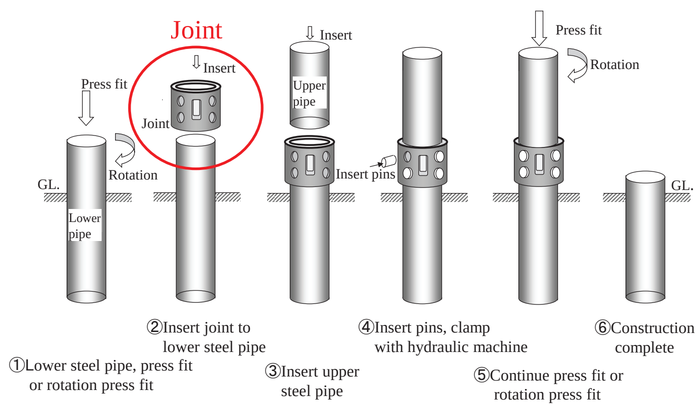

Fig.26 Installation process of the clamping pressure type joint

SUMMARY

From the compressive and torsional loading test results, the maximum loads of the clamping pressure type joint were observed larger than both the allowable stresses for temporary loading and long sustained loading of the base material (steel pipe pile). These test results indicate that the allowable stresses of steel pipe pile is well within the limits of the clamping pressure type joint, and also the high strength and good performance of the steel pipe pile is confirmed. In addition, it was found that the allowable torque value for temporary loading of the steel pipe pile can be used as the upper limit value of the torque where rotary-press fitting method is executed in construction site.
Lastly, although the joint is made of highly resistant spherical graphite, further research into the effects of salt water and potential corrosion of the pipe pile may be necessary, especially when being used near coastal areas.

REFERENCES

Architectural Institute of Japan (2008). “Recommendations for Design of Small Buildings Foundations”.

Wakame, Y, Maki, Y, and Nagasaka, M (2009). “Mechanical property of the bolt type joint for steel pipe pile,” *Summaries of technical papers of annual meeting Architectural Institute of Japan*, (Tohoku, Structure I).