International Press-in Association
www.press-in.org

News Letter

Volume 7, Issue 4 December 2022

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Message
From the New Director

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I am honored to join the international Press-in Association (IPA) as a new director and the first one from the steel industry. I am working for Nippon Steel Corporation, which is one of the large steel makers to supply steel tubular piles, sheet piles and so on. This article introduces a few distinctive steel products in Japan.

Hat-Type sheet piles[1] are a unique type of steel sheet pile, supplied since 2005. Before that, U-shaped sheet piles with an effective width of less than 600 mm were mainly used. In sheet pile wall built up of U-shapes, slipping of the interlocks at the central bending axis of the pile wall can lead to the reduction of the wall stiffness and strength. To overcome the inherent weakness of U-shape, Hat-Type sheet piles have been developed. This hat-shaped cross-section has interlocks at the edge of the wall where an individual pile can make up the wall height, resulting in full cross-section performance (i.e., noreduction). The effective width of 900 mm in Hat-Type makes it more rigid than U-shape, leading to easy installation with less deformation. Nowadays, Hat-Type has been more standard in Japan and started to be used in Asian countries such as Singapore.

Another unique steel product is a steel tubular pile with protrusions (ribs) on the outer or inner surface[2]. This pile is made by pipe forming using the special steel plate on which the high pressure of the hot-roll process embosses equidistant, parallel shear keys ridges. Utilizing this steel pile with outside ribs, the steel pipe soil cement pile method (i.e., composite pile) has been developed so far in which cement milk is injected into the original ground and mixed and stirred while the steel pile is installed at the same time. The pile has a large friction capacity due to adhesion between the surrounding soils, the soil-cement and the steel tubular pile with ribs.

In the future, technical fields of Press-in Technology are widely expanding beyond not only geotechnical engineering but also mechanical engineering, material engineering as above and other fields. As for the steel industry, we hope to contribute to the development of Press-in Technology, by providing high-quality steel products as well as the development of new products and advanced applications.

◆ A brief CV of Dr. Shinji Taenaka

Dr. Shinji Taenaka is head of Infrastructure & Construction Engineering Dept. of Nippon Steel Corporation and has more than 20 year-experience with a wide range of research on steel pipe piles and steel sheet piles from both geotechnical and structural engineering. He has contributed to several successful developments of piling methods, foundation systems and disaster countermeasures using steel pipe piles & sheet piles as well as novel steel products such as Hat-Type sheet piles.

[1] See Photo 3 on IPA News Letter Vol. 7, Issue 3
[2] See Fig. 5 on IPA News Letter Vol. 7, Issue 3

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Special Contribution

Steel Pipe Piles, Tubular Sheet Piles, Steel Sheet Piles Confronting Natural Disasters

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Manager
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The Japanese archipelago is an arcuate archipelago located off the eastern coast of the Eurasian Continent and in the northwestern coast of the Pacific Ocean, where the oceanic plates of the Pacific and the Philippine Sea plates subduct beneath the continental plates of the Eurasian and the North American plates. For this reason, trench-shaped submarine depressions called ocean trenches and ocean basins (troughs) exist off the south and east coasts of the Japanese archipelago, which frequently generates plate boundary earthquakes in these areas. In addition, cracks (faults) are formed in the land area of the surface of the plate as the continental plate is pushed by the oceanic plate, where intra-continental plate earthquakes, also called fault earthquakes or active fault earthquakes, often occur.

Surrounded by the Sea of Japan, the Sea of Okhotsk, the Pacific Ocean, and the East China Sea, the Japanese archipelago has a mild climate with four distinct seasons. On the other hand, it suffers wind and flood damage quite frequently, as steep mountainous areas account for 70% of the country, and besides, it often has heavy rain caused by mobile low-pressure systems and typhoons. Furthermore, climate change due to global warming in recent years, so-called guerrilla rainfalls (localized heavy rain), and localized heavy rain caused by the occurrence of linear rainfall belts have caused large-scale landslides and floods many times.

1. Steel pipe piles, tubular sheet piles and steel sheet piles in earthquake disasters

(1) 1964 Niigata Earthquake (M7.5): Major damage to a modern city due to liquefaction

At 13:01 on June 16th, 1964, this earthquake occurred with the epicenter about 40km south of Awashima Island in Niigata Prefecture. A large-scale liquefaction phenomenon occurred throughout Niigata City, which caused extensive damage to social infrastructure facilities such as rivers, ports, airports, railways, and general buildings. This earthquake captured worldwide attention as it was the first case where a modern city experienced large-scale liquefaction.

In Niigata City, reinforced concrete buildings suffered the most damage. More than 300 out of 1,500 buildings in the city were damaged, but 189 buildings sank or slanted without any damage to their superstructures. At the "Prefectural Kawagishi-cho Apartments" located on the left bank of the Shinano River, 3 out of 8 buildings were greatly tilted due to the liquefaction phenomenon, and one of them was almost overturned. It was also the time when color television began to spread, and the shocking images made the liquefaction damage known to the general public.

After the earthquake, a large number of investigators were dispatched from related organizations in order to investigate the damage situation to the buildings and in order to consider restoration methods as well. Since there was no fatal damage to the superstructures of the damaged buildings, there were few cases of demolishing and rebuilding even heavily sloping buildings. Most of the buildings were restored by raising the foundations in some way.

The Niigata Telecommunications Department Office Building (Photo 1.1) suffered damage with a maximum subsidence of 530 mm and a maximum tilt of 1/40 to 1/50, but no harmful cracks were found in the structure.

In this case of building restoration, in addition to the following reasons: (1) there was no damage that might hinder its continued use, (2) it was not desired to spend the cost of newly rebuilding it, (3) similar re-damage should be avoided, considering the construction cost and construction period, a method was adopted in which “as a structure to support the building, steel pipe piles were to be pressed into the foundations of the columns to raise the building horizontally”. For the restoration, while using the second floor and above of the building, steel pipe piles with a length of 1.0m were added, and the number of steel pipe piles corresponding to the column load were pressed in with a jack. Concrete was placed on the top of the pile, which was used as a jack fulcrum when raising the building (Fig. 1.1).

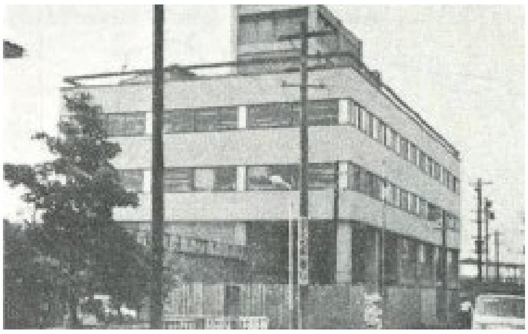

Photo1.1 Niigata Telecommunications Dept. Office Building[1)]

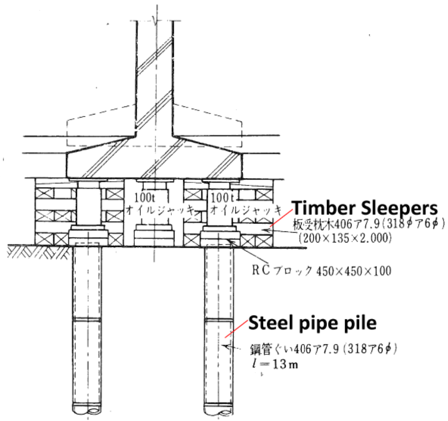

Fig.1.1 Detailed Drawing of Leveling[1)]

(2) 1968 Tokachi-oki Earthquake (M7.9): Standards were revised due to the damage to RC (Reinforced concrete) buildings

At 9:48 on May 16, 1968, the earthquake occurred with the epicenter off the east coast of Aomori Prefecture (far off Sanriku). The damage occurred from Tohoku Region to Hokkaido centering on Aomori Prefecture, with a 3m high tsunami hitting Erimo Cape in Hokkaido and a 3 to 5m high tsunami hitting Sanriku. There were geo-disasters that caused 52 casualties. 673 buildings were completely destroyed, 3,004 were partially destroyed, and 15,697 were partially damaged. Especially in Aomori Prefecture, reinforced concrete public buildings which had been built after 1960, such as Misawa Commercial High School (Photo 1.2), Hachinohe Higashi High School, Hachinohe Technical College, and Mutsu City Hall, were severely damaged. This led to the revision of the "Building Standard Law Enforcement Order", and also the "Standard for Structural Calculation of Reinforced Concrete Structures (Architectural Institute of Japan)" in 1971.

(3)1978 Miyagiken-Oki Earthquake (M7.4): The first earthquake to hit a large city with a population of over 500,000.

At 5:14 p.m. on June 12, 1978, this earthquake occurred with the epicenter (seismic intensity 5) approximately 100 km off the east coast of Sendai City, Miyagi Prefecture. Liquefaction caused damage to the lifelines such as gas and water supply on flat land along the coast, and conspicuous damage was caused to the first floors of buildings in industrial complexes located on reclaimed land. Landslides and collapses occurred at the boundary between the natural ground and embankments in new residential areas built on hilly areas. This turned out to be a heavy damage where 4,385 houses were completely or partially destroyed, and 86,010 houses were partially damaged. It was regarded as a typical urban earthquake that a large city with a population of more than 500,000 people encountered for the first time.

In this earthquake, excavation surveys were actively carried out on the foundation piles of building structures, and it was clarified that (1) PC piles (prestressed concrete piles), especially AC piles (high-strength concrete piles), were significantly damaged, (2) in the case of the buildings which had damaged piles, the ground was not extremely soft, but slightly soft. On the other hand, in the hilly residential area near the center of Sendai city built after 1960, many landslides occurred on the embankment. It was reported, however, that there happened no damage from the Tohoku-Pacific Ocean Earthquake that occurred later in March 2011, in the area where the collapsed land had been turned into a green space and a concrete leaning retaining wall had been constructed with a steel pipe pile foundation that also had served as an earth retaining wall, as a restoration method. (Photo 1.3).

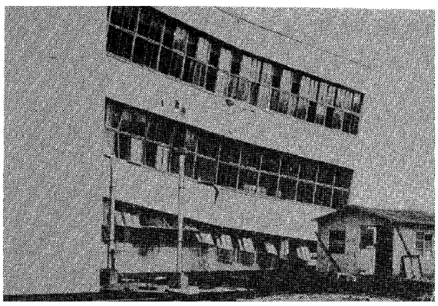

Photo 1.2 Damaged building of Misawa Commercial High School[2)]

Photo 1.3 Affected area in Sendai City[3)]

(4)1995 Hyogo-ken Nanbu Earthquake (M7.3): Steel pipe pile foundation demonstrated excellent seismic performance

At 5:46 on January 17, 1995, the earthquake occurred at the bottom of the Akashi Strait, with the epicenter at a depth of 16 km. It was the first large-scale earthquake with a seismic intensity of 7 recorded in Japan, which caused a major disaster that killed more than 6,000 people, mainly in the city of Kobe. It caused extensive damage to the infrastructure facilities such as roads, railways and ports, buildings such as ordinary houses, offices and condominiums, and the lifelines such as electricity, water and gas. Turning out to be an unprecedented earthquake disaster, it was later called the Great Hanshin-Awaji Earthquake.

Steel foundations and steel structures such as steel pipe piles, tubular sheet piles, and steel sheet piles had been used in many coastal facilities and structures including landfills. These damage conditions had something in common, and most of them were judged to be the effects of lateral displacement due to liquefaction of the surface ground and the backfill soil, sliding failure of the ground due to reduction in effective stress, etc. In addition, there were cases in which steel pipe piles used for piers were damaged because of the deterioration of the bearing strength of the pile material caused by the progress of corrosion due to insufficient anti-corrosion treatment. However, it was confirmed that many steel foundations and steel structures were generally sound, which turned out to show the characteristics of "steel" such as high strength and excellent deformation performance.

1) Damage to steel pipe piles, tubular sheet piles, and steel sheet piles in revetments, quay wall structures, etc.
A visual inspection was carried out by ship from the sea side for the seawalls, quay walls, piers, pier foundations, etc. which had used steel pipe piles, tubular sheet piles, and steel sheet piles in the coastal reclaimed land of Maya Wharf, eastern construction area, Ashiyahama, Nishinomiyahama, and Kobe Port Island, and Rokko Island as the target areas. Tables 1.1 and 1.2 show the damage status of structures and the damage rank of structures. About 70% of the 23 surveyed structures had no damage to the steel pipe piles (damage rank: A, B).

Table 1.1 Damage to structures [4)]

Structures \ Damge situation	A	B	C	D	Total
Seawall	2				2
Quay	1			1	2
Jetty quay	6	1	4		11
Pier Foundation	3	1			4
Locks/water gates	2				2
Facility foundation, etc.				2	2
Total	14	2	4	3	23

Table1.2 Damage ranks of structures

Damage rank	Damage situation
A	The superstructure, facilities, and foundation piles are all sound and functionally unaffected.
B	There is damage to the superstructure and facilities (functional impediment), but the foundation piles are sound.
C	There is damage to the superstructure and facilities (functional impediment), and some of the foundation piles need to be repaired and reinforced.
D	Damage to the superstructure, facilities, and foundation piles (functional impediment)

Note: Produced based on the information given in Table 1.1

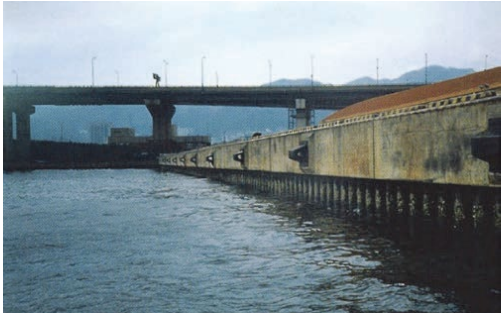

Photo 1.4 West side of Maya Wharf[6)]

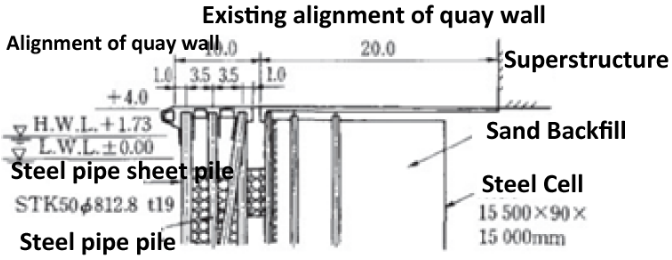

Fig. 1.2 Foundation of the west side of Maya Wharf[7)]

a) Damage to revetments and quay walls

At Port Island and Rokko Island, gravity caisson quays suffered severe damage, while pier structures suffered minor damage. “The Maya Wharf No. 1 Jetty West Quay (Photo 1.4)” was a seismic revetment with a horizontal design seismic intensity of 0.25. In the vicinity of the base of this jetty, a counterweight fill was placed on the sea side of the existing steel plate cell foundation, and further, a double-layer structure was adopted with a new quay-wall of steel pipe sheet piles with battered piles installed (Fig. 1.2). In addition, the tip of the pier had a very solid double-foundation quay with a steel plate cell on the land side and a caisson on the sea side, and although there were some cracks in the concrete due to uneven subsidence at the connection part between the horizontal pier and the caisson, there was no functional problem after the disaster.

On the other hand, the quay on the east side of Maya Wharf was a steel plate cell type quay that partially used OD400 (400mm in outer diameter) and OD500 steel pipe piles in the apron part, but the steel plate cells tilted toward the sea and buckling occurred in the steel pipe pile heads, and the function of the quay was hindered. The cause was attributed to the fact that the excessive horizontal force acted on the piles in the apron as the steel plate cells tilted forward due to the excessive flow pressure and the vertical and horizontal seismic motion because of the liquefaction.

b) Damage to the pier type wharf

Of the 11 surveys of pier type quay walls, 4 were functionally impaired. The characteristics of the damage common to these were as follows.

1, The caisson-type revetment on the land side was displaced toward the sea from the existing revetment line, and the revetment was inclined toward the sea.
2, Pier structures have two types; A structure type composed of vertical piles, and a type of vertical and better piles, and buckling was observed in steel pipe piles.
3, The top of the pier was slanted toward the land (in some quays, toward the sea).

At a certain quay, damage (one case) was observed in which one of the piles was broken in the direction perpendicular to the pile axis. The main cause was attributed to the fact that the thickness of the steel pipe plate was reduced due to corrosion because of insufficient anti-corrosion protection on the aging pier. Whereas no damage was observed in the structures for which new anti-corrosion methods had been adopted such as heavy anti-corrosion coating and FRP cover, and sufficient anti-corrosion measures.

c) Facility foundations (walkway behind the quay, foundations of ancillary facilities such as land-side cranes, etc.) and other damage situations.

At the Higashi-Kobe ferry wharf, the caisson quay was displaced approximately 1-2m toward the sea from the existing line, and the ground between the caisson quay and the footpath foundation collapsed about 2-3m. Steel pipe piles of OD400 were used for the footpath foundation, but the steel pipe piles and the footing were completely separated, leaving the steel pipe piles exposed. The main cause was attributed to the fact that the pile head was only embedded about 100 mm into the footing (no pile head rebar).

d) Actual cases of recovery

Shinko Pier No. 4 (-12m quay) (Photo 1.5), located at the base of the Shin-Kobe Ohashi Bridge leading to Port Island, had been used as an international passenger berth. Regarding the restoration method, as there were constraints because it was in the water area in front of the slip (between jetties), and the shed was close behind, a method was adopted in which steel pipe sheet piles were to be placed in front of the existing caissons, and underwater concrete was to be filled between them.

Photo 1.5 Shinko No.4 Pier (-12m quay) [8)]

2) Damage to steel pipe piles in building structures

A visual inspection was conducted on 45 building structures using steel pipe piles in Kobe Port Island, Rokko Island, Fukaehama-cho, and Naruohama-cho. Table 1.3 shows the damage to the foundations of building structures.

Table 1.3 Damage to the foundation of building structures [5)]

	Location conditions	Foundation damage		Sub-total	Total
		No	Yes		
Port Island	Inland	16	0	16	24
	Coastal area	0	8	8	
Rokko Island	Inland	16	40	16	18
	Coastal area	2	0	2	
Fukaehama-cho Naruohama-cho	Inland	2	1	3	3
Total		36	9	45	45

Classification of damage degree
Foundations were damaged: For those with exposed pile heads, the pile heads were damaged such as buckling or deformation, or the footings were damaged or displaced. If the pile heads were not exposed, the footings were obviously damaged or displaced.
No foundation damage: No damage or displacement on piles or footings.

a) Cause of foundation damage

There was no damage to the foundation in 36 out of 45 investigations (80%). Of the 9 cases where damage was confirmed, 8 cases were warehouses adjacent to the container berth in Port Island, and it was presumed that the foundation frame had been displaced due to the lateral displacement of the ground accompanying the berth damage. The other was a building located inland, where the top of the pile was exposed and a slight tilt was observed, but no damage to the superstructure was confirmed. Of the 36 foundations without damage, 4 had exposed steel pipe piles, but no damage such as buckling or deformation was observed. It was concluded that the reason why the two structures (both warehouses) in the Rokko Island coastal area had no damage to the foundations was that they were located relatively inland and had little impact from the damage to the berth.

b) Damage to the superstructure

Of the 45 cases surveyed, 13 cases had damage to the main body (beams, columns, walls), and there were 11 cases where the main body was sound but incidental facilities (stairs, connecting corridors, elevators, etc.) were damaged. There were 21 cases where both the main body and incidental facilities were sound and the damage was limited to subsidence of the surrounding ground (damage to underground pipes, damage to parking lots and sidewalks).

Of the 13 cases where the main body was damaged, 5 were condominiums and housing complexes, and the other 8 were warehouses adjacent to the container berth. The damage to the condominiums and housing complexes located in the inland area was mainly X-shaped cracks generated on the walls. The damage to the warehouse adjacent to the berth was caused by the movement of the foundation frame due to lateral displacement of the ground, and tilting and deformation of the entire building.

3) Survey results of the damage to steel pipe piles, tubular sheet piles, and steel sheet piles (summary)

A visual inspection after the Hyogo-ken Nanbu Earthquake (Great Hanshin-Awaji Earthquake) revealed that, except for some cases, most of the independent steel pipe pile foundations such as pier type quays and building foundations were found to be sound, regardless of subsidence of the surrounding ground or damage to the superstructure.

The common point of the revetments, quay structures, and building structures with foundation deformation was that they were all located near the reclaimed revetments. Although there was no direct pile body damage due to the seismic motion, it was speculated that, in the coastal area, the caisson quay walls and revetments moved significantly due to the fluid pressure accompanying the lateral displacement of the ground, which caused deformation and tilting of the steel pipe piles of the pier and the foundations of the factory warehouses located nearby.

(5) 2004 Niigata Prefecture Chuetsu Earthquake (M6.8): Recorded seismic intensity 7 for the second time in recorded history

At 17:56 on October 23, 2004, it occurred with the epicenter 13 km deep in Kawaguchi-cho, Kitauonuma-gun, Niigata Prefecture (currently Nagaoka City). It was an inland earthquake with a maximum seismic intensity of 7, which was the second time in recorded history after the Hyogo-ken Nanbu Earthquake. There were 19 aftershocks with a seismic intensity of 5 lower or more by the end of December of this year.

Photo 1.6 Landslide at Former Yamakoshi Village[9)]

Due to the rainfall caused by the typhoon that had passed three days before the earthquake, landslides occurred one after another on the slopes of the hills. In the former Yamakoshi Village, houses collapsed with earth and sand (Photo 1.6), and there was damage caused by the outflow of irrigation water from Nishikigoi farming ponds making use of terraced rice fields. In mountainous tributaries, collapsed sediment clogged river channels, forming natural dams that cut off traffic routes, leaving many communities isolated.

There is a case of restoration of a railroad bridge damaged by this earthquake by pressing-in a steel sheet pile continuous wall around the damaged pier and thereby carrying out the repair and the seismic reinforcement at the same time. By filling the interior of the steel sheet pile continuous wall with concrete and integrating it with the existing pier, the shear strength and deformation performance of the piers were improved. By installing steel sheet piles (also used as a temporary cofferdam) with a compact press-in machine, the need for large-scale temporary construction work was eliminated and thus the construction period was shortened.

(6) 2011 off the Pacific Coast of Tohoku Earthquake (M9.0): An unprecedented catastrophe caused by a giant tsunami

At 14:46 on March 11, 2011, it occurred with the epicenter off Sanriku, about 70 km east of Sendai City. The huge earthquake that occurred at the boundary between the North American plate and the Pacific plate recorded a magnitude of 9, the largest in Japan's history, and a violent shaking with a maximum seismic intensity of 7 lasted for more than 2 minutes. About 30 minutes after the earthquake, a gigantic tsunami with a wave height of 10 m or more and a maximum run-up height of 40 m swept the Pacific coast of the Tohoku region, causing devastating damage to the coastal areas of Hokkaido, Tohoku and Kanto (Photo 1.7, Photo 1.8). As of March 2021, 15,899 people died and 2,526 people were missing due to this earthquake, 90% of whom were victims of the huge tsunami. It was called the Great East Japan Earthquake because it was an unprecedented earthquake disaster that spread from Hokkaido to Kanto.

Photo 1.7 A huge tsunami that hit Miyako city, Iwate Pref [10)]

Photo 1.8 Seawall damage at Sanriku Town, Ofunato city [10)]

Liquefaction damage was also serious in landfills in the coastal areas and on the soft ground along the rivers. In Urayasu City, Chiba Prefecture, for instance, a large amount of groundwater containing sand erupted, causing manholes to rise and buildings to tilt. The lifelines were also severely damaged. Furthermore, at the Tokyo Electric Power Company's Fukushima Daiichi Nuclear Power Plant, the electrical system of the reactor was damaged by flooding caused by the huge tsunami, and the core cooling system stopped. As a result, the cooling water inside the reactor pressure vessel evaporated, and as the water level dropped, the hydrogen generated by the chemical reaction between the exposed fuel rods and the steam leaked into the reactor building and exploded, causing the ceiling and walls to be destroyed. After all, evacuation of residents still continues in some areas because of the scattering of highly concentrated radioactive materials caused by the venting that was carried out to lower the pressure inside the reactor containment vessel. It was an accident that raised a big problem to society regarding the safety of nuclear power plants.

After the earthquake, our association conducted surveys on steel foundations and steel structures such as steel pipe piles, tubular sheet piles, and steel sheet piles in various fields such as roads, railways, ports, and construction. The result was published as a report (October 2011)[11] and a second report (December 2012)[12].

Photo 1.9 Bearing deformation[11]

Photo 1.10 Damage to Kamaishi Bay mouth breakwater[10]

1) Damage to structures using steel pipe piles, tubular sheet piles, and steel sheet piles

The damage to structures using steel pipe piles, tubular sheet piles, and steel sheet piles in the Great East Japan Earthquake was as follows.

a) Road and railway field

No major deformation was found in the main bodies of the bridge foundations, except for the bridges whose superstructure and substructure were washed away by the tsunami. As for the bridges that were washed away, it was assumed that the damage to the foundations themselves due to the seismic motion was minor. As damage to the foundation bodies due to the earthquake motion, although some deformation of the bearings and cracks on the embankment slopes at the abutments were confirmed, no major deformation was confirmed in the foundation bodies, and they were found almost sound (Photo 1.9).

b) Construction field

In many areas, the tsunami caused enormous damage such as the outflow, overturning, collapse, and inclination of buildings. In Onagawa Town, the tsunami also caused pile foundation structures to fall over (Table 1.4). On the other hand, no damage was confirmed in the structural frame of the building using the steel pipe pile foundation.

c) Port field

The post-earthquake tsunami caused major damage to breakwaters and seawalls in many areas of the Tohoku region, including collapse, etc. (Photo 1.10), but damage to quay walls and seawalls was limited.

Table 1.4 Damage to overturned buildings(pile foundation structures) in Onagawa Town[12)]

Damaged buildings	Onagawa Police Box	Ejima Kyosai Hall	Hotel building	Seafood processing warehouse
Structure scale	2 story RC building Long side x short side x height = 10m x 4.8m x 10m Tower ratio: short side = 2.08 long side = 1.00	3 story steel building (partially 4F) Long side x short side x height = 16m x 8.4m x 12m Tower ratio: short side = 1.43 long side = 0.75	RC 4F Long side x short side x height = 5.6m x 5.6m x 14.5m Tower ratio: short side = 2.59 long side = 2.59	RC 2F Long side x short side x height = 20m x 8.8m x 10m Tower ratio: short side = 1.14 long side = 0.50
Damage situation	・Tumble north on the spot ・It seems that PHC piles of OD300 were used for the foundation piles. ・All piles broke near the pile head ・The extracted part is exposed while being connected to the footing ・There are collision marks on the roof and walls	・It seems that the tsunami was received from the short side of the building. ・From the tsunami footage taken in the vicinity, it seems that the building did not topple over until the first wave (pushing wave) of the large tsunami reached the third floor of the building. ・It seems that PHC piles of OD250 were used for the foundation piles. ・At the bottom of the exposed footing, the pile head joint rebar filling concrete, and one pile that was pulled out remain. ・The length of the pulled pile was 6.0m (broken at the originally welded spot?) ・Except for this one stake, the stakes appear to have been left at their original positions on the building.	・It seems that it was swept west (uprush direction) more than 70m from its original position. ・It seems that PHC piles of OD300 were used for the foundation piles. ・Most of the piles broke at the original position of the building. ・Only one pile was dragged as far as the position where the building was washed away and broke. ・At the original position, four piles remained about 2m pulled out.	・It looks like it fell over after being hit by a tsunami (push wave) in the direction of the short side. ・Although there were some traces of having been connected with stakes on the bottom of the footing, (1) No traces of rebar cages, etc., can be confirmed at the joints of the foundation piles. (2) There are no traces of foundation piles embedded in footings. (3) Footing thickness is very small. Therefore, it seems that the footing and the pile were not connected.
Damage photos		 Reprinted from Note 1*	 Reprinted from Note 1*	 Reprinted from Note 2**

Note 1* Yahoo! JAPAN: Great East Japan Earthquake Photo Preservation Project
Note 2** TETSU (Satoshi Nakayama): Tama Watch, May 6, 2011, Tsunami Damage, Onagawa Town, Miyagi Prefecture

2) Steel foundations and steel structures that contributed to restoration and reconstruction

For the recovery and reconstruction of the Tohoku Region Pacific Ocean Earthquake (Great East Japan Earthquake), steel pipe piles, tubular sheet piles, and steel sheet piles were used in a lot of cases because they had excellent strength, deformation performance, quality, and workability for disaster-resistant city development and infrastructure reconstruction. Here introduced are some application cases of steel pipe piles, tubular sheet piles, and steel sheet piles which made a particularly large contribution.

a) Application case of steel pipe piles and steel sheet piles [Ishinomaki disaster recovery work: construction period from October 2011 to March 2014]

[Damage situation]
Due to crustal movement and liquefaction caused by the earthquake, the entire fishing port area settled by approximately 1.3m (average value), and various facilities such as piers and wharves were destroyed or damaged by flooding. The designed water deep -7m quay (extension 270m) and -6m quay (extension 700m) settled about 1.15m in the entire area, and the head of the steel sheet pile in front of the revetment was pushed out to the sea side with a maximum of 46 cm in and out of the sheet pile normal line. Also, the apron collapsed and was constantly submerged.

[Recovery method]
While restoring the original shape, a design was made for the purpose of raising the height of the subsidence, and regarding the steel sheet piles that caused the normal deviation, new sheet piles were installed slightly forward the existing sheet piles (Photo 1.11). A new steel pipe pile was also installed for the H-shaped steel that had collapsed in the existing apron. A steel sheet pile was driven at 1.7m forward the normal line to the old revetment, Steel piles with 600 mm in diameter and 12 to 17 m in length were driven into the apron area, and the front steel sheet piles were tied with about 13m long tie rods to serve as an anchor (Fig. 1.3).

Photo 1.11 New Installation of steel sheet piles of designed water depth - 7m quay[13)]

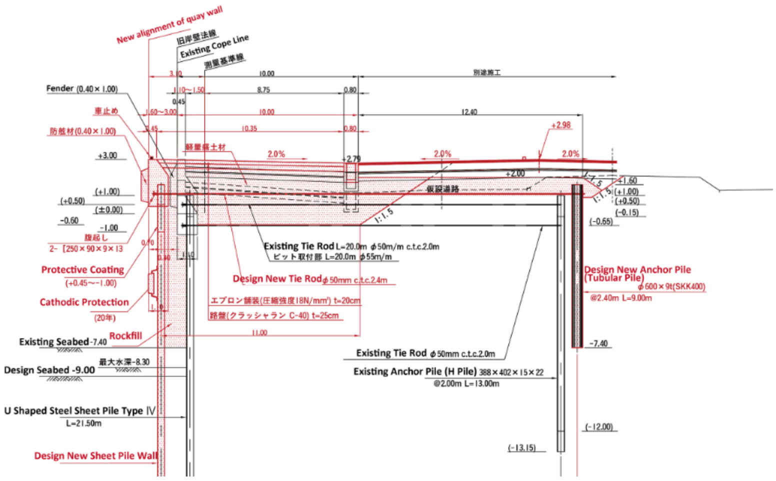

Fig. 1.3 Designed water depth - 7m quay wall restoration standard cross section[13)]

b) Application case of tubular sheet piles [Ishinomaki Port Higashihama Coast Seawall Restoration Work]

[Damage situation]
An upright concrete embankment with TP (Tokyo peil) + 3.3 to 3.5m, which was built in the 1960s and 1970s, settled by approximately 1m due to the earthquake, and besides, the front of the seawall was scoured by the tsunami surge and collapsed during the undertow, resulting in two levee breaches.

[Recovery method]
A new seawall was decided to be constructed as a disaster recovery project, and a plan of an upright embankment with an embankment structure of continuous self-supporting tubular sheet piles with a height of TP + 7.2m was adopted (Fig. 1.4). A normal coastal embankment required a slope on the sea side in order to ensure the specified strength without affecting the harbor road behind it, so a relatively expensive construction cost and a long construction period were issues. For this reason, a continuous wall made of self-supporting tubular sheet piles was adopted as an upright embankment on the sea side which also would be able to suppress lateral flow during liquefaction (Photo 1.12).

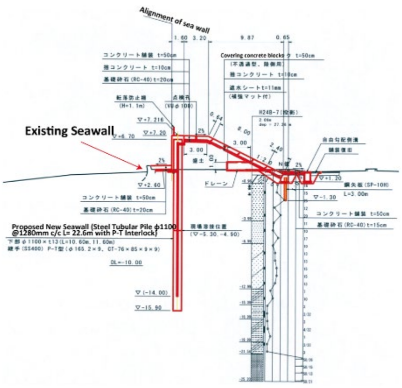

Fig. 1.4 Ishinomaki Port Higashihama coastal seawall standard cross section[14)]

Photo 1.12 Installation of tubular sheet piles on the Higashihama coastal embankment of Ishinomaki Port[14)]

2. Steel pipe piles, tubular sheet piles, and steel sheet piles in the case of typhoon and heavy rain disasters

(1) September 2015 heavy rains in the Kanto and Tohoku regions: Steel sheet piles contributed to the restoration of levee breaches in the first-class rivers

Typhoon No. 18, which occurred on September 7, 2015, went north over the southern Sea of Japan. After making landfall on the Chita Peninsula of Aichi Prefecture at around 10:00 on September 9, it advanced to the Sea of Japan and became an extratropical cyclone at 21:00 on the same day. After that, due to the influence of the moist air of Typhoon No. 17 flowing from the south into the low pressure that had changed from the typhoon, heavy rains spread over a wide area from western Japan to northern Japan, and the Kanto and Tohoku regions experienced record rainfall. In particular, from September 9th to 10th, Nikko City, Tochigi Prefecture, recorded 551 mm of rainfall in 24 hours, which was the highest since observation began in 1975, and other observation points (16 points) also broke observation records for the 24-hour precipitation. Under these circumstances, heavy rain special warnings were issued by the morning of the 10th in Tochigi and Ibaraki prefectures. The Kinugawa River overtopped and overflowed in Ibaraki Prefecture, which is located in the midstream region. In the early afternoon, the embankment on the left bank of the Kinugawa River in Misaka-cho, Joso City, collapsed for approximately 200m. Eventually, a wide area in Joso City sandwiched between the Kinugawa River and the Kokaigawa River was submerged, the city hall main building, which had been completed the previous year, was flooded, and more than 5,000 houses were completely or partially destroyed, causing extensive damage due to long-term flooding (Photo 2.1). The levee breach of the Kinugawa River was the first case since it had occurred in Tochigi Prefecture in August 1949, and the levee breach of a state-managed river in the Kanto region was the first since it had occurred in the Kokaigawa River in August 1986.

The restoration work for the collapsed levee was carried out for two weeks as an emergency restoration by means of a rough cofferdam and steel sheet pile double cofferdam (Fig. 2.1). After that, in January 2016, during the non-flood season, the main restoration work was started. After removing the rough cofferdam and the steel sheet pile double cofferdam that had been constructed during the emergency restoration work, the embankment foundation was replaced, impermeable steel sheet piles were installed to prevent water leakage thorough embankment, and the embankment and bank protection work was carried out and completed at the end of May.

Photo 2.1 Flooding situation in Joso City, Ibaraki Prefecture (9/10)[15)] (Provided by Kanto Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism)

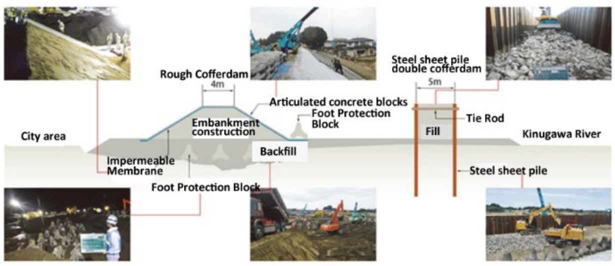

Fig. 2.1 Rough cofferdam, steel sheet pile double cofferdam/standard sectional view [16)] (Provided by Kanto Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism)

(2) Heavy rain in July 2018 (Western Japan Heavy Rain): The backwater phenomenon caused severe damage, the worst flood in the Heisei period (1984-2019).

The seasonal rain front, which had been stationary in northern Japan since June 28, moved north toward Hokkaido on July 4, then moved south to western Japan on July 5, and remained stationary near western Japan until July 8. Typhoon No. 7, which had occurred in the south of Japan on June 29th, moved north over the East China Sea, passed out into the Sea of Japan, and turned into an extratropical cyclone at 3:00 pm on July 4th. After that, the warm and extremely humid air continued to be supplied to the vicinity of Japan, and the record heavy rain fell over a wide area from western Japan to the Tokai region.

In Ehime, Okayama, Hiroshima and other prefectures, river floods and geo-disasters occurred one after another, leaving 245 people dead or missing in 14 prefectures. The number of victims of floods and geo-disasters surpassed the cases of heavy rain and typhoon No. 10 in July 1982, turning out to be the worst disaster in the Heisei period. 6,767 houses were completely destroyed and 7,173 houses were flooded above the floor level. There were breaches of the river embankments at 2 spots of the nationally managed rivers and 25 spots of the municipally managed rivers, and 2,581 geo-disasters occurred in 32 prefectures[16].

In Mabi-cho, Kurashiki City, Okayama Prefecture, low-lying land spreads at the confluence of the Oda River and the Takahashi River, and there often occurs flood damage due to the backwater phenomenon. Although it was an area with high flood risk, urbanization was progressing rapidly with the development of railways and roads. In the Oda River, which was affected by the Takahashi River whose water level rose because of the heavy rain, the backwater phenomenon caused the embankment to burst for about 100m at the confluence region with the Takama River. In addition, there occurred embankment collapses at 8 spots, and the water overflowed at 4 spots, flooding an area of 1,200 ha and flooding 4,600 houses (Photo 2.2). The turbid current that flowed into the floodplain surrounded by the embankments of the Takahashi River and the Oda River had no place to escape in the closed area, and the maximum inundation depth reached 5m. Many residents were unable to escape, and 51 people died.

The Oda River's emergency countermeasure work consisted of rough coffering of the embankment where it had collapsed using sandbags and sheets. After that, a steel sheet pile double cofferdam was constructed behind the rough cofferdam in order to construct a temporary embankment for temporary use. The construction of the steel sheet piles was carried out around the clock (Photo 2.3), and the emergency work was completed in a total of 14 days (Photo 2.4).

Photo 2.2 Collapsed Odagawa embankment[18]

Photo 2.3 Double cofferdam of steel sheet piles driven 24 hours a day[18]

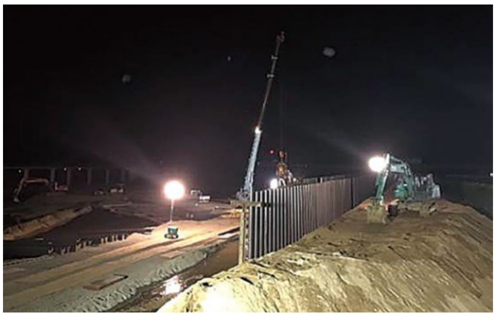

Photo 2.4 Completion status of steel sheet pile double cofferdam[18]

3. For future disaster prevention and mitigation (the roles required of steel pipe piles, tubular sheet piles, and steel sheet piles)

(1) Social contribution to the realization of national resilience
Based on the lessons learned from the Great East Japan Earthquake, as a basic law to promote nation-building that shall protect the lives and properties of the people from large-scale disasters and accidents, the "Basic Law for National Resilience (2013 Law No. 95)" was enacted and enforced by lawmakers in 2013, and based on it, the Cabinet approved the Basic Plan for National Resilience in June 2014. In this plan, as a basic concept, we will go beyond the scope of "disaster prevention" in the conventional narrow sense, and no matter what kind of disaster occurs,

1, The protection of human life shall be maximized.
2, Important functions of the state and society shall be maintained without being fatally damaged.
3, Damage to public property and public facilities shall be minimized.
4, Rapid recovery and reconstruction

with the above four items as the basic goals, it is proclaimed to promote "national resilience" to build a safe and secure national land, region, and economic society with "strength" and "resilience." In addition, it states that the public and private sectors will vigorously pursue initiatives and comprehensively promote them across ministries and agencies in cooperation with local governments.

Steel pipe piles, tubular sheet piles, and steel sheet piles, which have contributed to the construction of various new infrastructures, are expected to contribute greatly to the realization of national resilience, taking advantage of their excellent properties (strength, deformation performance, quality, workability, workability, etc.) to protect the country from natural disasters as a clue to reduce disaster.

(2) International contributions to the realization of a better and more sustainable world
As in Japan, natural disasters occur frequently in all regions of the world, such as sea level rise due to global warming, torrential rains and storms caused by growing tropical cyclones, accompanying wind and flood damage and geo-disasters, as well as earthquake damage, geo-disasters , tsunamis caused by earthquakes and volcanic eruptions, etc. In order to realize a "sustainable and better world" in the future, it is essential to develop and rebuild infrastructure in every country in the world. Confronting many natural disasters, while being overwhelmed countless times, Japan has advanced and developed its goods and technologies. Japan should make use of its strengths and keep striving to contribute to the resolution of international issues in cooperation with other countries and international organizations.

Fortunately, steel pipe piles, tubular sheet piles, and steel sheet piles are ready-made products, and in extreme terms, they can be transported anywhere in the world. In particular, since the press-in method makes it possible to construct tubular sheet piles and steel sheet piles with relatively small construction machines, it is an ideal method for emergency measures and restoration work in the event of a natural disaster. While combining the convenience and performance of steel materials with the excellent workability of the press-in method, we would be more than happy if we could make an international contribution by aiming to spread this method all over the world

4. Conclusion

In this article, due to space limitations, we selected and introduced domestic disasters that have become important occasions which turned out to demonstrate the significance of steel pipe piles, tubular sheet piles, and steel sheet piles. It was discussed how steel pipe piles, tubular sheet piles, and steel sheet piles have contributed to disaster prevention, mitigation, and disaster recovery. In addition, in the cases where unfortunately damage occurred but they failed to contribute to disaster prevention or mitigation, the causes were explained.

In Japan, where natural disasters occur frequently, steel pipe piles, tubular sheet piles, and steel sheet piles have been playing an important role for infrastructure development and urban formation. With the exception of some cases, no fatal damage has been confirmed even in the massive earthquakes and giant tsunamis rarely seen in human history, such as the Hyogo-ken Nanbu Earthquake (Great Hanshin-Awaji Earthquake) and the Tohoku-Pacific Ocean Earthquake (Great East Japan Earthquake). In addition, it has been recognized again that it is a useful material that can greatly contribute to early recovery after a disaster. This is synonymous with the fact that the characteristics of the material were fully demonstrated because the construction had been appropriately conducted, which means that the importance of construction was reacknowledged at the same time.

In the future, whereas there is an urgent need to respond to new issues such as the promotion of aging and earthquake resistance measures as well as the development of disaster prevention bases, we are determined to continue to work with steel pipe piles, tubular sheet piles, and steel sheet piles that would contribute to society while coordinating with the construction, aiming for a safe and secure society.

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◆ A brief CV of Mr. Toshiharu Hirose

After graduating from Shibaura Institute of Technology in 1987, Hirose joined Kubota Corporation where he was involved in developing demand for steel pipe piles in the construction market, technical studies on design and construction, and development of construction methods, etc. In June 1989, he joined the activities of the JASPP. He has served as the chairman of the Technical Committee from 2004 to 2021. Currently, He is involved in the management of the JASPP as the Technical Director of the JASPP.

Interview Report

A novel pile extraction method: The best practical use of the GEOTETS Method (Simultaneous backfilling during pile extraction)

Tsunenobu Nozaki

General Manager, GIKEN LTD.

Fig. 1 Overview of GEOTETS Method

Foreword

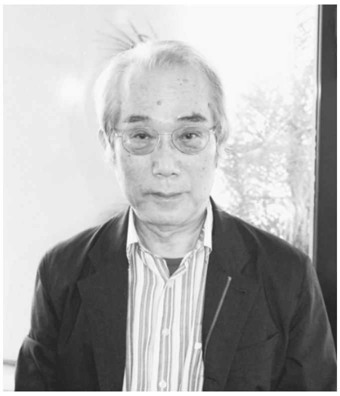
When temporary retaining walls are required, prefabricated piles such as steel sheet piles are often utilized since they can be extracted and reused optimizing economy. However, the process of pile extraction may cause ground displacement due to voids which occur during pile extraction. The extent of the problem of ground displacement is not normally easy to predict, and robust solutions to this had not been in place until recently.

The GEOTETS Method (simultaneous backfilling during pile extraction), which can analyze and minimize the ground displacement risks, has been attracting attention in recent years. In this report, the IPA interviewed the GEOTETS Method Research Society to get to the core of the method and its future potentiality.

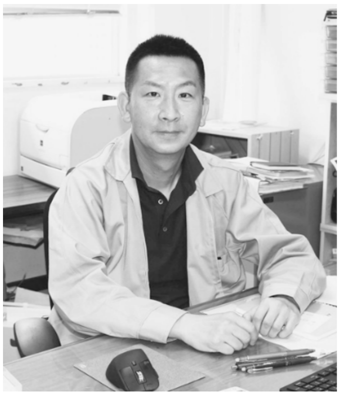
Name of the method: GEOTETS Method (simultaneous backfilling during pile extraction)
Interviewee: Mr. Hiroaki WATANABE, chairman of GEOTETS Method Research Society (Hyogo, Japan)
URL: https://www.hikinuki.jp/

Mr. Hiroaki WATANABE
Chairman of the GEOTETS Method Research Society

Mr. Yasuhiko NISHI
CEO of Civil Assist Co., Ltd., Kyoto, Kyoto, Japan



Hiroshi YOKOTA, Professor Emeritus
at University of Miyazaki
(Co-researcher)



Yoshinori FUKUBAYASHI, Associate Professor
at University of Miyazaki
(Co-researcher)

Q1: What is the GEOTETS Method (simultaneous backfilling during pile extraction)

Steel sheet piles are currently the most popular retaining wall pile materials to be extracted and reused in the construction of temporary retaining walls. With the GEOTETS Method, injection pipes (small diameter steel pipes) used for backfilling are installed adjacent to the sheet pile retaining walls before sheet pile extraction. Spacing between adjacent injection pipes differs, depending on site conditions. The typical spacing is every 6 sheet piles. The dual component reactive backfilling materials are mixed on-site and discharged from the tip of the injection pipe, simultaneously with pile extraction. Generally, the backfilling material is around 4 times the volume of the sheet pile (minimum two times). However, this may need to be adjusted in accordance with the actual void volume and other site conditions.

The backfilling material does not harden while fluid, but only when standing. Thus, voids can be fully backfilled with the materials. Moreover, only absolute minimal alkali contents of the material seep into surrounding water, therefore, the method is also environmentally friendly. The sequence of the GEOTETS Method is described in Fig. 2, Fig. 3 and Fig. 4 below.

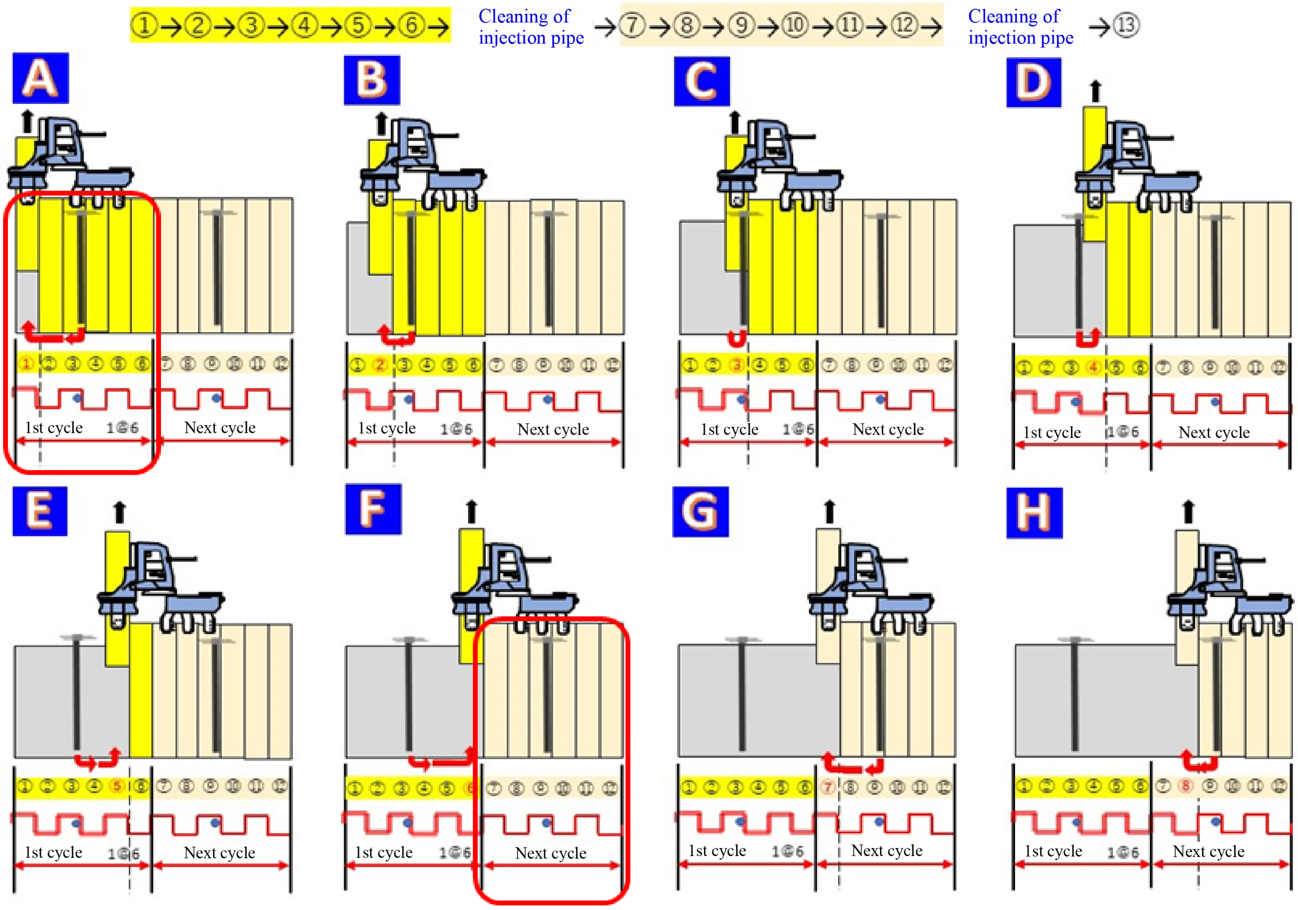


Fig. 2. Sequence of GEOTETS Method

Fig. 3. Insertion of injection pipe

Fig. 4. Backfilling (above water)

View the webpage of GEOTETS Method Research Society for more details.

Q2: What inspired you to develop the method? Please tell us about the background of the development.

Removal of retaining walls may cause ground displacement due to voids which occur during pile extraction. However, the risk of ground displacement is sometimes disregarded or ignored despite its importance. Even if it had been considered, there had not been a robust solution to ground displacement, and the problem has remained in the construction industry for a long time.

In the past, cement & bentonite grout injection was generally utilized to fill voids caused by pile extraction. However, it was not practical to carry out injection works concurrently with pile extraction. As a result, the surrounding ground was left unstable for a certain period of time after pile extraction, which sometimes caused ground displacement. This fundamental problem has been known for more than 20 years in the industry and the GEOTETS Method inventor was often asked if this problem could be overcome. In order to meet industry expectations and satisfy his desire to develop an original method, he decided to put his idea to practical use. He implemented his concept of “simultaneous backfilling” to minimize risks of ground displacement. Furthermore, he deemed that his technology would be backed by academic theories, therefore, he cooperated with the University of Miyazaki at the early stage of his development.

Q3: Currently, how is the risk of ground displacement assessed, in the case of pile extraction?

We still see projects in which ground displacement risk is disregarded or ignored. According to *“Specification for Temporary Structures of Road Earth Works (1999 Edition, Japan Road Association)”*, the theoretical extent of ground displacement typically reaches 45°+ϕ/2 as shown in Fig. 5. Where the extent of ground displacement is concerned, the magnitude of the displacement is normally estimated taking the pile installation method, excavation sequence, lateral deformation of retaining walls and pile extraction method into consideration. However, depending on ground conditions, it is known that the actual extent of ground displacement sometimes reaches further than the formula (45°+ϕ/2) suggests. It may be up to 2-3 times the pile length. Thus, we think that the risks of ground displacement are greater than the theoretical formula stated in the specification.

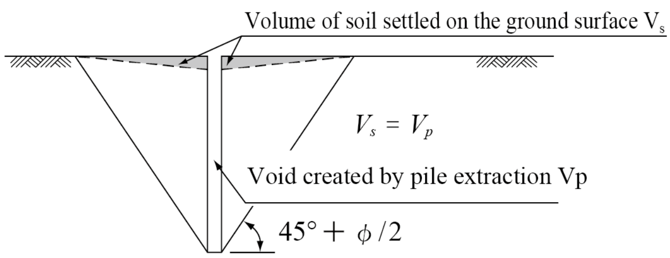


Fig. 5. Theoretical extent of ground displacement due to pile extraction

Q4: Please tell us about process of bringing the method to the market?

We first brought the method to the market in 2007. After that, at the introduction stage of marketing, our brand recognition was not widespread and the majority of inquiries we received were kind of SOS inquiries, which required urgent remedial works after ground displacement had occurred. It took us quite a long time to disseminate information to people about the risk of ground displacement. However, after the method gained recognition to a certain degree with the increase in method usage, the majority of inquiries we receive nowadays are ground displacement prevention rather than SOS inquiries. Regarding the GEOTETS project achievements, there were 130 project applications in 2021 and 530 in total as of June 2022.

Q5: How does the GEOTETS Method Research Society assess incoming inquiries?

It is not easy to measure the magnitude of the ground displacement in advance. However, the GEOTETS Method Research Society is able to estimate both the extent of ground displacement and settlement to a certain degree by utilizing the Peck’s formula, based on the given geotechnical investigation report and examining previous project data. We compile an estimation and similar project data as a report and submit it to the project owner.
Nevertheless, how much risk they take is eventually up to the discretion of the project owner, taking into account the cost benefit performance on each project in determining the volume of the backfilling.

Q6: It is sometimes the case that sheet piles are left in place even if they are for temporary use, due to uncertainties of the potential risk of ground displacement. If this is excessive risk aversion, is it avoidable by utilizing the GEOTETS Method?

Certainly, the GEOTETS Method enables project representatives to minimize the risk since that was the reason for its development. In fact, project representatives who do not want to leave temporary sheet piles in place because they may become obstacles in future development if they are left in place, often rely on the method. Specifically, it is against the law to leave temporary material in public land in Japan so the GEOTETS Method is quite often specified on projects. “Extractability” and “Reusability” are the biggest advantages of steel sheet piles. These advantages are not a factor with regard to cast in-situ bored pile walls, or slurry walls. Therefore, we would appreciate it if people could maximize the effectiveness of steel sheet pile solution by utilizing the GEOTETS Method.

Q7: What project information is required when inquiring about the GEOTETS Method for a particular project?

The GEOTETS Method Research Society requires information about ground conditions, type of pile installation and extraction method, excavation sequence, type of temporary frameworks or anchors, lateral deflection of the retaining wall related to excavation, allowable ground displacement (lateral movement and settlement) to assess actual extent and amount of ground displacement.

Q8: Does the GEOTETS Method have other advantages rather than minimizing ground displacement?

Although it is not the objective of the method, the backfill material lubricates sheet pile surfaces, which reduces pile extraction resistance force, resulting in shorter construction time and a reduction in were and tear on the piling machine. In general, sheet pile cut-off walls are left in place when being used in contaminated soil to prevent contamination seepage. However, they can be extracted if the GEOTETS Method is utilized since the gelatinized backfill material is considered impermeable. Thus, the cost of sheet pile material can be minimized. The typical coefficient of permeability k of the gelatinized backfill material is around 1.0×10^{-6}cm/s.

Q9: What is the applicable depth for the GEOTETS Method?

Although the deepest application up to now is 40m, our goal is to reach 50m in the near future.

Q10: Can the GEOTETS Method be carried out in a cold weather environment?

As with cold weather concreting, it can be carried out if the backfilling material is cured for the cold weather environment.

Q11: Can the GEOTETS Method be carried out in restricted headroom, such as under overhead obstructions?

Restricted headroom does not cause any concern, as injection pipes (minimum 1.5m) can be spliced and lowered to the required depth.

Q12: Are there any unfavorable working conditions for the GEOTETS Method?

Attention must be paid if the groundwater flow velocity is 1.0×10^{-2}cm/s or greater. If so, the solidification of the backfilling material might be corrupted.

Q13: Up to now, all applications of the GEOTETS Method were carried out in Japan. Are there any plans to implement the method outside of Japan?

We acquired a patent for the method at the initial stage of the development, eyeing the global market. As the first step of expanding overseas, we have established an office in Vietnam and employed Vietnamese engineers there. We also plan to penetrate into Thai and Singapore markets sometime in the future. From these bases, we will expand our business further into the South East Asian market.

In order to disseminate information about the GEOTETS Method to the global market, we also plan to establish an English webpage describing the method.

Q14: We have heard that one of the issues with the GEOTETS Method is that it is not fully documented. Do you have a plan to fully document the underground backfilling sequences of the method?

530 projects utilizing the GEOTETS Method have already been completed, and we can supply sample case histories to assess similar upcoming projects. Although we need to do this on a case-by-case basis at the moment, we could compile the know-how into a technical document or specification and open it to the public.

Another challenge is to improve the accuracy of predicting the volume of the backfilling material, depending on working conditions. As we accumulate case histories and analysis results of the method and put these into a database, we would eventually be able to picture the situation below ground.

Q15: Please tell us about your predictions for the future. Do you have a target number of actual applications and/or corporate members?

Basically, it is ideal if both pile extraction and backfilling are carried out in one operation, by the same company. Therefore, we would like IPA corporate members to be members of the GEOTETS Method. As a short-term goal, we are targeting 200 applications in the year 2022.

Q16: Please proffer your message to people in the industry.

It will be more and more emphasized to reuse temporary retaining wall materials, in terms of reducing the risks of obstacles in future developments, SDGs and decarbonization. However, currently in the construction industry the potential risk of ground displacement due to the extraction of retaining walls, tends to be underestimated. Therefore, if proper countermeasures are not in place during extraction works, it may result in undermining the advantages of reusing temporary retaining wall materials. As we stated previously, we would dissuade people from relying completely on or underestimating the risk with the theoretical formula of the extent of ground displacement ($45°+\phi/2$). To reiterate, the actual extent of ground displacement sometimes reaches further than the formula ($45°+\phi/2$) suggests.

In the future, with further dissemination of the GEOTETS Method, we want to develop a better formula than the current one, which can be adopted in standard construction guidelines or specifications.

Report

11th IPA Board Meeting in Singapore

IPA Secretary

The 11th Board of Directors Meeting was held on Thursday, 17 November 2022, in Singapore with an attendance of 17 directors onsite and 3 directors online. Due to the Covid-19 pandemic, it was the first time to hold a meeting physically since Prof. Leung was elected as IPA's president.

Before the Board meeting, the meetings of the Standing Committee including the Administration Committee, Research Committee, Development Committee, Publicity Committee, and Award Committee were held separately. Every committee reported their activities of FY2022 and shared their opinions and advice.

The following agenda was discussed in the Board meeting.

- Activity report by President
- Progress reports of Standing Committees
- Establishment of Nomination Committee
- Progress reports of ICPE2024
- Next Board meeting in Japan

The Secretary General, Mr. Yaegashi, was retiring from IPA and Prof. Leung stated that he would let the Directors know by email when he would appoint the new Secretary General according to the Constitution.

After the Board meeting, all directors were invited to visit the National Singapore University (NUS) which will be the venue of ICPE2024. The next Board meeting will be held on June 2023 in Kochi, Japan.

Photo 1 Board meeting in Singapore

Report
From Europe Regional Office (Netherlands)

Yuta Kitano

Technical Assistant Manager
Giken Europe B.V.

Introduction

The Europe IPA regional office is Giken Europe B.V. which is a subsidiary of GIKEN LTD. The office was moved from the UK to the Netherlands in 2020. It mainly oversees the European market. Giken Europe is providing services consisting of construction method proposal, rental/sales services of our machines, technical instruction for a piling operator and team, construction planning and design support, and machine maintenance.

The Press-in Method in Europe

We have received a lot of inquiries about our method or machines from a lot of countries. If I say something about the Netherlands where I am living, they are attempting to renovate the huge number of aging quay walls, including those in urban areas such as the city of Amsterdam, Den Haag, and the others located in very narrow spaces that are adjacent to a road, train rail, water traffic and so on. The quay wall itself is also a historical structure. Therefore, caring out renovation within a compact space and minimum nuisance is required. Therefore, we can see the Press-in Method a lot in the urban area. I feel that the Press-in Method with a sheet pile is getting normal here, while it is also getting to be interested in Gyropress Method™, which is a method to install a steel tubular pile with rotation by utilizing the press-in principle. It is a more efficient way to the renovation of a quay wall because it does not require any temporary works, such as temporary sheet pile, to remove existing quay wall. (More details are available on the website: https://www.giken.com/en/wp-content/uploads/press-in_gyropress.pdf).

The first project using Gyropress Method was completed this summer with very good feedback from people involved in this work. So, I believe that Gyropress Method is suitable for the Dutch and European markets. And next project using Gyropress Method started this November. We are planning to show this incredible solution to the European market through this project.

Recent Case Study in Den Haag, the Netherlands

You can see a video here https://www.youtube.com/watch?v=ZnVy9whGUGg

If you used a traditional way in is project, it would be necessary to install sheet piles in front of an existing quay wall as a cut-off wall, pump-up water inside the wall, remove the existing quay wall then make a new concrete wall there. It needs space for the works and needs to remove trees in the area, and stop all the traffic. While Gyropress Method can install a tubular pile into an existing quay wall by using cutting teeth attached to a pile toe and rotation torque, which means it does not need to secure a space, remove trees, and stop traffic. Also, less work is demanded, so it leads to a shorter period of construction.

The project information is as below.

<u>Background</u>

The city of Den Haag has jurisdiction over approx. 62 km of quay walls in total. Of these, approx. 23 km of wooden foundations need to renovate for the following reasons.

- Most of the quay walls are 100 years old construction.
- Many of the wooden foundations have suffered from bacterial damage.
- Increased loads on the quay walls due to increased traffic such as cars and trams.
- Project Owner: Municipality of Den Haag
- Main contractor: collaboration (combination) of Van Gelder and Gebr. De Koning

Piling Information

- Construction length: approx. 44.0 m
- Pile: steel pipe pile ϕ609.6
- Pile length L=9.5 m

Fig.1 Under construction & Cross section

Recent Case Study in Berlin, Germany

Giken Europe has completed works using the Implant™ Method and GRB™ System with the Press-In Piling technology reinforcing a railway embankment in Berlin, the capital of Germany. The project site was located in a confined space adjacent to a residential district and live railway which was an excellent opportunity to demonstrate the benefits of GRB System. GRB System contains SILENT PILER™ F401-1400 (double-U), POWER UNIT on UNIT RUNNER™ UR3, CLAMP CRANE™ CB3-6 and PILE RUNNER™ TB18. All piling works were completed on top of the installed piles and eliminated the need for temporary platforms and workspaces for cranes, materials and other construction equipment. Construction works were completed without affecting residents, existing infrastructure or train operations. Giken Europe B.V. provided technical consulting and installation work. The installation work utilizing GRB System attracted the attention of many construction parties who visited the site. Project owners, consultants and contractors are seeking to adopt

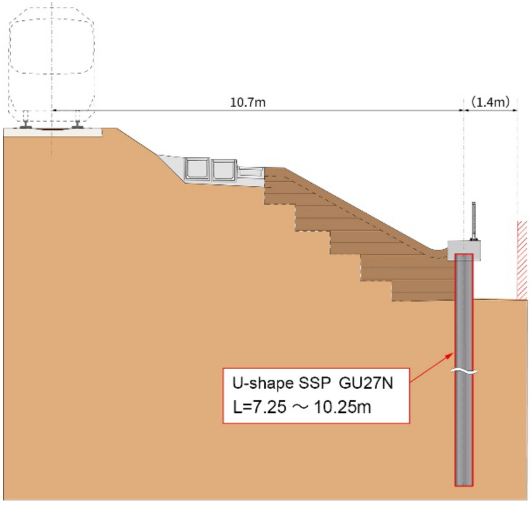


Fig.2 Cross section

GRB System in other projects. They have begun considering other railway embankment reinforcement projects. The GIKEN Group expects to expand the adoption of the Implant Method and GRB System across the German market.

Fig.3 Under construction

Information

- Project Owner: Deutsche Bahn (DB) AG Netz
- Main contractor: Company Echterhoff Bau GmbH, Berlin
- Number of piles: 187 pairs (374 sheets)
- Pile: U type sheet pile (GU27N)
- Pile length L=7.25 to 10.25 m

Future Prospects for the Press-in Method in Europe

As mentioned above, some projects using the Press-in Method, Gyropress Method and GRB System were implemented or will start. In the meantime, we are feeling that these methods are suitable for the European market. We are definitely certain that our methods will be able to make their life and construction better.

Moreover, a structure built by piles is very efficient for future renovation because only removing piles and re-install new piles are required.

Thus, we would like to show more and more advantages of our methods to the markets through the coming projects. If you are interested in our activities and solutions, please contact me!

Event Report

Global Best Practices of Press-in Piling Method - IPA 15th Anniversary Seminar in Singapore -

IPA Secretary

The Global Best Practices of Press-in Piling Method - IPA 15th Anniversary Seminar in Singapore - was held by International Press-in Association (IPA) on 18 November 2022 in Singapore and it has been the first time to hold the event in physically since the Covid-19 pandemic started. IPA was founded in February 2007 and this seminar was held to commemorate the 15th Anniversary of the Association. A total of 91 participants attended this seminar including IPA Directors from 11 countries, consultants, contractors, and geotechnical engineering practitioners.

To further commemorate this special occasion, the seminar commenced with experts presenting the most recent advances in the applications of Press-in Piling in Asia, Europe, North America, South America, and Africa. Many of these projects such as coastal protection are highly relevant to Singapore and Southeast Asia. The past, present, and future of IPA were also presented as follows:

◆ **Program:**

Presentation 1	Brief introduction of IPA and Press-in Technology	
	Mr. Hisanori Yaegashi (Japan)	Secretary General, IPA
Presentation 2	Remembering the early days of Press-in Piling research	
	Prof. David White (United Kingdom)	Professor, University of Southampton
Presentation 3	Recent applications to the Press-in Piling Method in Asia with emphasis on coastal protection	
	Mr. Hiroki Kitamura (Singapore)	Giken Seisakusho Asia Pte., Ltd.
Presentation 4	The application of Press-In Piling to increase the resilience of critical infrastructure in Europe	
	Prof. Kenneth Gavin (Netherland)	Professor, Delft University of Technology
Presentation 5	Recent Notable Press-in Piling Projects in North America	
	Mr. Takefumi Takuma (United States)	Giken America Corp.
Presentation 6	Recent application of Press-in Piling Method in Brazil: Downstream retaining structures for tailings dams	
	Dr. Marcos Massao Futai (Brazil)	Associate Professor, Geoinfra University of Sao Paulo
Presentation 7	Recent applications of the Press-in Piling Method in Africa: Senegal and Egypt case histories	
	Prof. Mounir Bouassida (Tunisia)	Professor, University of Tunis El Manar - National Engineering of School of Tunis -
Presentation 8	Recent research on the use of Press-in Piling data	
	Mr. Yukihiro Ishihara (Japan)	Manager, GIKEN LTD.
Presentation 9	Future of IPA	
	Prof. Chun Fai Leung (Singapore)	President, IPA Emeritus Professor, National University of Singapore

Prof. Leung, the President of IPA remarked that the Press-in methods have new applications in his presentation. These applications are multi-disciplinary in nature involving Civil engineers for construction, Mechanical engineers for machine and equipment innovation and development, Climate engineers for evaluation of water level rise, Coastal engineers for evaluation of impacts on seafront structures, Environmental engineers for evaluation of effects of new construction on the environment and Others. He also announced that the ICPE 2024 will be held from 3 to 5 July 2024 in Singapore and expressed his appreciation to all participants, and organizers at the final.

Photo 1 The venue of seminar

Photo 2 Prof. Leung is presenting

After the seminar, 46 people attended a live site press-in piling demonstration. The project is the construction of a private 2-storey house. On the project, the press-in piling method is being utilized to install Zero Sheet Piles (NS-SP-J Sheet Piles) which form an approximately 12m x 27m rectangular shape retaining wall, for the construction of a single-level underground parking lot Right on the boundary lines to maximize land use, 9m long sheet piles were being installed by the Zero Piler. Type of the Press-in Piling Method is known as the “Zero Clearance Method”. The sheet piles are to be left in place as permanent basement walls, in conjunction with cast in-situ concrete walls. The ground condition is soft-medium stiff clay (old alluvium) with the maximum SPT *N* value of 14. The Standard Press-in Mode (no driving assistance used) was utilized taking the ground conditions into account.

According to the contract managing director, Mr. David Liaw Wie Sein of Guan Chuan Engineering Pte., Ltd., the Zero Clearance Method is the most suitable for the construction of substructures in dense residential areas where construction nuisances are unacceptable. In addition to that, he stated “The method also enables project owners to maximize the dimension of the substructure, by constructing it right next to the boundary lines.”

Since it is crucial to maximize land use in urban areas, the IPA envisages that the Zero Clearance Method will also gain popularity in other countries.

Photo 3 Site Visit

Photo 4 Group photo

Event Report

Workshop: Earth-Fill Dam Anti-Seepage Solution by using Press-in Piling Method with Steel Sheet Pile applied to reservoirs

Vu Anh Tuan

Associate Professor, Le Quy Don Technical University, Vietnam

Director of IPA

On 14th October 2022, in Bac Kan province of Vietnam, Directorate of Water Resources (Ministry of Agriculture and Rural Development) in collaboration with the Department of Agriculture and Rural Development of Bac Kan province and the Japan International Cooperation Agency (JICA) held a workshop "Earth-fill Dam Anti-seepage Solution by Using Press-in Method with Steel Sheet Pile Applied to Reservoirs". Co-chairs of the workshop included Mr. Dong Van Tu - Deputy Director of Directorate of Water Resources, Mr. Ha Kim Oanh - Deputy Director of Department of Agriculture and Rural Development of Bac Kan province and Mr. Tomohisa Ozawa - Representative of JICA. About 150 delegates from several Directorates of the Ministry of Agriculture and Rural Development, some Research Institutes, Universities, Irrigation Construction Investment Management Boards and representatives of Departments of Agriculture and Rural Development of 16 provinces attended the workshop. As for the International Press-in Association (IPA), Prof. Matumoto Tatsunori (Vice President of IPA) and Assoc. Prof. Vu Anh Tuan (Director of IPA) attended the workshop.

Photo 1. Mr. Dong Van Tu - Deputy Director of Directorate of Water Resources presents the opening speech.

Press-in technology is a static pile pressing technology which is capable of reducing noise and vibration during construction instead of the traditional methods of pile construction by driving or vibrating hammer methods. Press-in technology can be used in places with extremely limited conditions such as difficult terrain, limited space, limited noise, on slopes, and on water... Press–in with augering and Gyro Piler have overcome the limitations of the traditional method of static pile jack-in which is not applicable where there is difficult geological ground such as hard ground, rock and gravel ground (Photo 2).

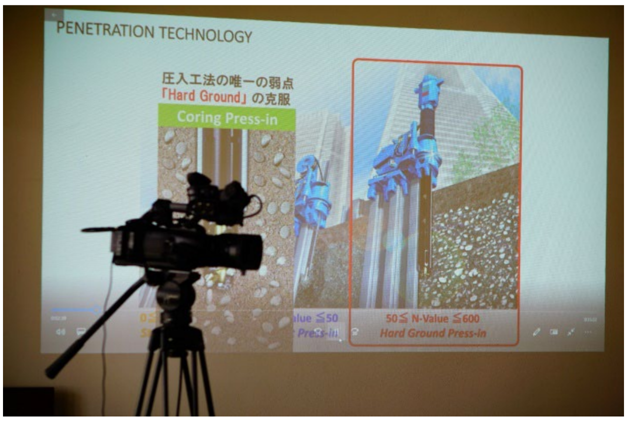


Photo 2. Press-in method to install sheet piles into hard ground

Five keynote lectures related to Press-in technology were presented at the workshop, as follows:

1. “Introduction on Press-in technology”, by Joint venture Ozawa Dobuku-Hashimotogumi;
2. “Introduction on Vietnamese standard for sheet pile, construction and supervision”, by Dr. Thai Quoc Hien (Institute of Hydraulics/Ministry of Agriculture and Rural Development of Vietnam);
3. “Survey report in Vietnam”, by Assoc.Prof. Le Thanh Hung (Thuy Loi University);
4. “Numerical analyses of an earth dam reinforced by steel sheet piles: Influence on water shielding and slope stability”, by Prof. Matsumoto Tatsunori (Kanazawa University and Vice President of IPA);
5. “Handbook of Press-in retaining structures”, by Assoc.Prof. Vu Anh Tuan (Le Quy Don Technical University and Director of IPA).

Apart from attending the workshop, the delegates and experts also conducted a site visit to the Keo Coi Irrigation Reservoir in Na Ri district, Bac Kan province (Photo 3). This project is expected to apply Press-in Technology to handle water leakage through the dam and increase the overall stability of the structure.

Press-in piling technology can bring optimum solutions in concern with engineering technique, economy, environmental friendship, and aesthetics, which traditional construction methods are impossible.

Photo 3. Site visit to Keo Coi reservoir, Na Ri district, Bac Kan province, Vietnam.

Photo 4. Organizing committee and keynote speakers.

Young Members Column

Ke Chen

Ph.D. student, Tongji University

I received my master's degree in Civil Engineering from Hunan University. Currently, I am a third-year Ph.D. student at Tongji University, Department of Geotechnical Engineering. Our research group is mainly oriented to solving problems encountered in civil engineering practice, such as the mechanical behavior of pile foundations for offshore wind turbines, rainfall-induced slope instability, and structure-interface stability under dry-wet cycles. I have gained much experience in the field over the past three years since I joined our group at Tongji University. I have also learned how to critically analyze experimental data and convert it into abstract physical laws that can be applied in engineering practice. I joined the International Press-in Association (IPA) on June 7, 2022, as a student member.

In the past two years, our research group studied the influence of adsorbed film on the hydraulic properties of unsaturated soil. We established a unified hydraulic constitutive model based on fractal theory for unsaturated porous media, and the title of the research work is "A fractal hydraulic model for water retention and hydraulic conductivity considering adsorption and capillarity". The model can describe the water retention characteristics and relative hydraulic conductivity of unsaturated soil in the entire suction range, as shown in Fig. 1. It is found that the pore size distribution of the soils mainly controlled the transport characteristics of capillary water, but had a slight influence on the hydraulic properties of adsorbed water, which was dominated by the type and content of minerals and specific surface area of the soil.

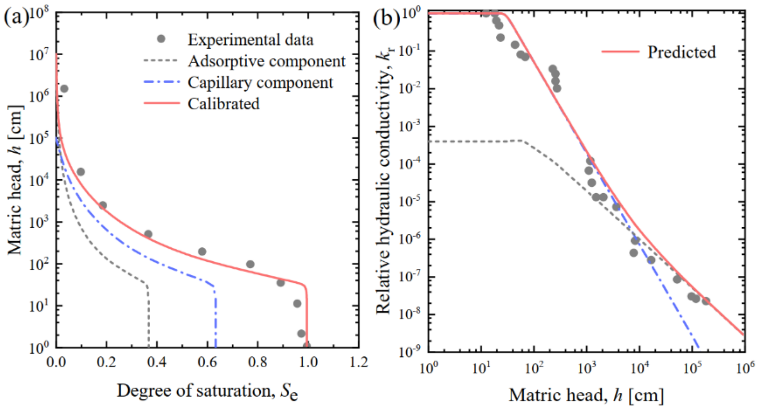


Fig.1 Measured and predicted hydraulic properties of clay loam:
(a) calibrated SWRC; (b) predicted kr-h curve
From: https://doi.org/10.1016/j.jhydrol.2021.126763

The earth's surface soils are unsaturated, however, most of the research in the literature is based on saturated soils, and their effective stress equation cannot be used to estimate the stress state of unsaturated soils. Therefore, developing a more generalized mechanical framework for unsaturated soils is necessary. My research currently focuses on the mechanical behavior of unsaturated soils, including the strength characteristics and stress-strain relationship. In addition, I am also interested in the mechanical response of the unsaturated soil-structure Interface. These studies are critical for evaluating the bearing capacity of pile foundations, earth pressure development of retaining walls, and slope stability issues under wet and dry cycles. I understand that the International Press-in Association provides a great platform for engineers and researchers from different organizations and institutions to share their experiences and findings, which help to develop innovative technology for the betterment of society.

Event Dairy

Title	Date	Venue
■ **IPA Events** https://www.press-in.org/en/event		
The Third International Conference on Press-in Engineering (ICPE 2024)	3-5 July 2024	Singapore
13rd IPA Press-in Seminar 2022 in Chiba	13 February 2023	Chiba, Japan
■ **International Society for Soil Mechanics and Geotechnical Engineering** http://www.issmge.org/events		
16th International Conference on Geotechnical Engineering	7-8 December 2022	Lahore, Pakistan
GEOSYNTHETICS 2023	5-8 February 2023	Kansas City, United States
International Conference on Advances in Structural and Geotechnical Engineering	6 March 2023	Hurghada, Egypt
8th International Conference on Unsaturated Soils	2 May 2023	Milos Island, Greece
■ **Deep Foundations Institute** https://www.dfi.org/events/		
6th International Conference on Grouting & Deep Mixing	15-18 January 2023	New Orleans, United States
Conference on Foundation Decarbonization and Re-use	21-23 March 2023	Amsterdam, Netherlands
SuperPile 2023	7-9 June 2023	Atlanta, Georgia
■ **Others**		
24th Annual International Conference & Expo	7-9 February 2023	San Diego, United States

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Editorial Remarks from persons in charge

Dr. Vu Anh Tuan
(Associate Professor, Le Quy Don Technical University, Vietnam)

Warmly welcome to the IPA Newsletter, Volume 7, issue 4. I strongly believe that you will find interesting and valuable information from reading this newsletter. On behalf of the persons in charge, I highly appreciate the authors and the secretariat for their great contributions to this issue. Last month, on the occasion of the IPA 15th Anniversary Seminar in Singapore, the director board of IPA had a meeting in person after a long time of meetings online only. Also, the publicity committee had discussions on the plan for publishing the newsletters. This is a real optimistic signal for the IPA movements after over two years of Covid 19 pandemic. I hope that you will receive more helpful information from reading the IPA newsletter due to the strong collaborations of members of the publicity committee and other IPA members

Dr. Chen Wang
(Assistant Professor, Tongji University, China)

We are so glad that this IPA Newsletter has been successfully issued. All the people who have dedicated themselves to preparing this issue are appreciated. Due to the efforts made by all the members, including researchers and technicians, in the association, significant achievements in both academic and commercial aspects have been made in the past years. Meanwhile, with the constantly organized or co-organized seminar, workshops, webinars, and conferences, the academic impact of IPA is continually increasing. We are also glad to see more and more talented young members from all around the world involved and assembled here because they are the future of the big family. In the next stage, we will focus on more valuable research topics during the design, construction, and maintenance of the press-in piling methods. On behalf of the editorial board, we wish you all the best for the coming new year!