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

News Letter

Volume 8, Issue 3 September 2023

Inside This Issue

1. **Messages (P1)**
   New Directors
2. **Special Contribution (P3)**
3. **Director's Research & Activities (P9)**
4. **Reports (P15)**
   - Case History in USA
   - IPA board meeting
   - IPA seminar in Taiwan
5. **Young Members (P24)**
6. **Announcements (P28)**
7. **Event Diary (P29)**
8. **Corporate Members (P30)**
9. **Editorial Remarks (P32)**

Editorial Board

Messages
From the New Director

Jianfeng Xue
Senior Lecturer, School of Engineering and Technology
The University of New South Wales, Australia

Press-in technology is becoming more and more versatile with the development of driving machinery. It can be operated in various environment and ground conditions that are normally not accessible for hammer-in techniques or not safe for bored piles.

Since the press-in technology uses static loading to push piles or sheet panels into the ground, it follows the same press-in mechanisms of Cone Penetration Test (CPT). Being the most commonly used in-situ site investigation technique, CPT results provide the variation of the ground conditions, soil properties and water pressure profile. The tip resistance of the cones has been used widely to derive the bearing capacity of driven and bored piles. Due to the similar driven mechanisms used in CPT and press-in piles, it is more sensible and reliable to use CPT profiles to derive the bearing capacity of press-in piles and to use the press-in record to calibrate the variation of CPT readings, especially the variation of tip resistance in thinly layered soils.

With the development of machine learning and big data analysis algorithm, it is promising to establish are more reliable correlation between CPT profiles and the bearing capacity of press-in structures. Using advanced numerical modeling and data processing techniques can enhance the reliability of predicting the behaviors of press-in piles/sheet piles. In addition, the database developed from the CPT and press-in record of piles can enhance the reliability of probabilistic based design method for such structures.

Therefore, it is critical for the industry and academic community to work together to establish a database of press-in records and CPT profiles so that it can be used by more users to enhance the development of the technology. I look forward to collaborating with the member organizations within IPA to advance the technology.

◆ A brief CV of Dr. Jianfeng Xue

Jianfeng Xue is a Senior Lecturer at the University of New South Wales, Canberra. He is a Chartered Professional Engineer and a Fellow of the Institution of Engineers Australia. His research interests are in the areas of reinforced pavement engineering and probabilistic-based analysis of geotechnical structure.

Messages

From the New Director

Hidetoshi Nishioka

Professor, Dept. of Civil and Environmental Engineering
Chuo University

I am the newest Director of the IPA. I am honored to address our members in this newsletter. My specialty field is foundation structures and underground structures in geotechnical engineering. In particular, I focus on seismic design problems, which are particularly important in Japan, and scouring problems of river bridge foundations during heavy rainfall. I am also interested in reliability design methods.

My research approach is mainly based on model experiments in a gravity field. In the past, I have conducted many experiments using dry sand. However, in recent years, I have conducted many experiments using aluminum rod laminates to model the sand in two dimensions. This method is a very simple experimental method. It has the advantage that the behavior of sand as a discrete granular material can be expressed easily and clearly, and even inexperienced young students can easily conduct highly reproducible experiments, which is excellent from an educational point of view. Another advantage is that image analysis technology, which has developed rapidly and become less expensive in recent years, can be easily applied to evaluate the interaction between the ground and structural members.

In addition, we are trying to clarify phenomena from model experiments and establish design and construction methods that can be applied to actual projects. For example, I am researching a method for seismic reinforcement of foundations using sheet piles for foundation structures. For more details, please refer to "Pile Foundation" in the "IPA Booklet Series" available to members on the IPA website. Recently, we are also conducting experiments on the seismic behavior of box culverts and bearing capacity problems of scoured foundations.

I would like to contribute to making IPA more attractive to its members.

◆ A brief CV of Prof. Hidetoshi Nishioka

Hidetoshi Nishioka is a professor at the Foundation and Underground Structure Laboratory, Department of Civil and Environmental Engineering, the Faculty of Science and Engineering, Chuo University. He graduated from Tohoku University, Japan, in 1999 and received his Master of Engineering degree in 2001. Since 2001, he worked as a researcher at the Railway Technical Research Institute, and in 2018 he became the head of the Foundation & Geotechnical Engineering Laboratory. Then, in 2019, he moved to Chuo University as a professor. He received the degree of Doctor of Engineering from the Tokyo Institute of Technology in 2009. He has received both the Best Research Paper Award and the Innovative Technique Award from the Japanese Geotechnical Society and the Japan Society of Civil Engineers, respectively.

His hobby is skiing, and he passed the Crown Prize, the highest technical test of the SAJ (Ski Association of Japan), when he was a student at Tohoku University. Lately, however, he seems to be overspeeding due to his weight gain.

Special Contribution

Numerical Simulation of Penetration into Ground

Yosuke Higo

Professor, Graduate School of Management (double appointment)
Graduate School of Engineering, Dept. Urban Management
Kyoto University

1. Introduction

When structures such as sheet piles and piles are driven into the ground, the ground around the structures is significantly disturbed by large shear forces due to friction between the ground and the structures. In the case of pile driving, large deformation also occurs at the pile tip. It is very important to accurately analyze such large deformation of the ground and to evaluate the impact of structure penetration on the surrounding ground. This article reviews the Material Point Method (MPM), which is one of the mesh-free deformation simulation methods for soils. MPM has been rapidly developed as a method for simulating large deformation of solids and is spreading internationally. Applicability of MPM to numerical simulation of penetration into ground is shown through numerical examples of sheet pile penetration and footing penetration simulations.

2. Material Point Method

Numerical simulation techniques within a continuum mechanics framework are classified into three primary groups based on their definition of the element control domain. The initial category is the mesh-based approach, represented by the Finite Element Method (FEM). In FEM, the element domain is determined by nodes and their connectivity, distinctly outlining the control domain through node coordinates. Though adept for boundary value problems, FEM can face mesh-tangling during severe deformation due to the connectivity of elements. The second category involves particle-based method, where material properties gather around representative points. Interpolation functions define the circular (2D) or spherical (3D) control domain shape. Well-known within particle-based methods are the Moving Particle Semi-implicit (MPS) method (e.g., Koshizuka and Oka, 1996) and Smooth Particle Hydro-dynamics (SPH) method (e.g., Monaghan and Lattanzio, 1985), which describe the material domain through particle assemblies. Unlike FEM, particle-based methods lack clear material boundaries, necessitating special treatment of boundaries. Conversely, particle-based methods can avoid mesh-tangling since individual particle domains, formed by interpolation, remain disconnected. The third type is the grid-particle hybrid method, typified by the Particle-in-Cell (PIC) method (Harlow, 1956), Fluid-Implicit-Particle (FLIP) method (Brackbill and Ruppel, 1986) for fluid mechanics, and Material Point Method (MPM) (Sulsky et al., 1994) for solid mechanics. These methods also depict the material domain through particle assemblies. While similar to other particle-based methods in simulating objects through arranged particles, grid-particle hybrids offer clear boundary condition definition by applying conditions to grids. The boundary setup in hybrid methods resembles FEM, facilitating easier configuration compared to particle-based approaches. In these methods, material properties center on material points, while governing equations are solved at grid nodes. Interpolation functions aid in exchanging physical quantities between material and grid nodes.

Sulsky et al. (1994) initially introduced MPM as a derivative of the PIC method for solid mechanics, termed the "original MPM" in this context to differentiate from other MPM derivatives. Ongoing MPM evolution mainly centers on integrating control domain deformation. A novel method applied to geomaterial deformation, termed Arbitrary Particle Domain Interpolation (APDI) permits flexible material point control domain definitions (Kiriyama and Higo 2020). Fig. 1 illustrates the relationships among various 2D and 3D MPM implementations, defining their control domains. The original MPM represents a material point as a simple point (Fig. 1(a)), but this leads to numerical oscillations when material points cross grid boundaries. To mitigate this, Bardenhagen and Kober (2004) proposed the Generalized Interpolation Material Point (GIMP) method. GIMP manifests in uniform/unchanged (uGIMP) and contiguous particle (cpGIMP) forms. In cpGIMP (Fig. 1(c)), the control domain updates with deformation, while Sadeghirad et al. (2011, 2013) further advanced GIMP into the Convected Particle Domain Interpolation (CPDI) method, accommodating shear and rotational control domain deformations. CPDI divides into CPDI1 (Fig. 1(d)), with parallelogram deformations, and CPDI2 (Fig. 1(e)), with quadrilateral deformations. Extending to three dimensions involves expanding from two dimensions for the original MPM, GIMP, and CPD1 methods. CPDI2's three-dimensional formulation necessitates a distinct approach, using direct integration for volume integration. The APDI method circumvents this complexity through numerical integration, offering a comprehensive formulation for both 2D and 3D, along with adaptable control domain deformations. CPDI2 uses quadrilateral control domain deformation, whereas APDI accommodates diverse control domain deformations.

The governing equations of MPM are fundamental laws of mechanics: the conservation of mass and the linear momentum. The mass conservation always holds because the material point possesses mass throughout the calculations. Hence the conservation of the linear momentum, i.e., the equation of motion, is only one equation to be solved. Note that governing equations for liquid phases and interaction with the solid phase, e.g., Darcy's law, are needed when simulating hydro-mechanical coupled behavior of soils as porous media. The algorithm of MPM is schematically shown in Fig. 2. The continuum body is divided into multiple subdomains and represented by material points with mass of the subdomain. The history-dependent variables such as stress and strain are stored and delivered by material points. Hence, history-dependent constitutive equations can be introduced. The governing equations are solved on the background Eulerian computational grid and thus MPM does not face to mesh tangling problem even when the severely large deformation. Similar to FEM, the boundary conditions are imposed on the computational grids. Although the grids containing the particles can roughly define the boundaries of a continuum body, exact representation of the boundaries need coupling with element-based method.

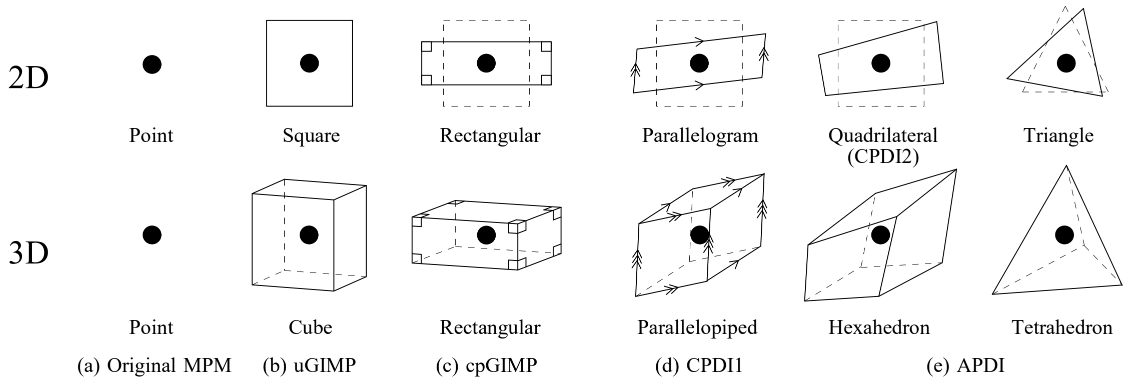


Fig. 1. Variations of particle domain for Material Point Method

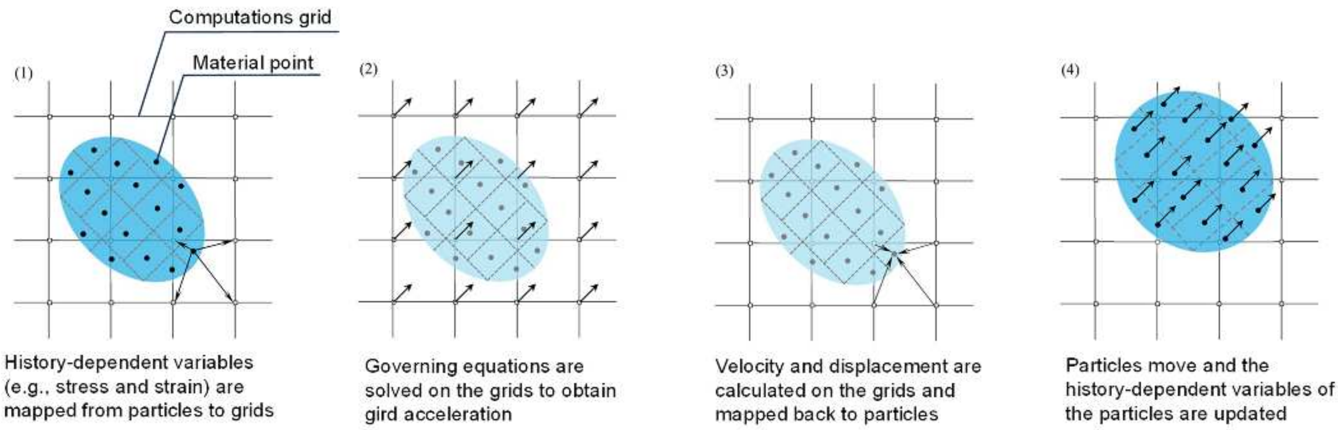


Fig. 2. Numerical algorithm of Material Point Method

3. Steel Sheet Pile Penetration

Numerical simulation of steel sheet pile penetration was conducted using a displacement-control method for simulating quasi-static press-in penetration and a stress control method for simulating dynamic hammer-blow penetration. The particle configuration and the boundary conditions are shown in Fig. 3. The thickness of the steel sheet pile is described by four particles allocated in two grids, which is much thicker than the real sheet piles, to avoid numerical instability when using smaller number of particles. The larger number of particles in one computational grid generally makes the accuracy of MPM simulation higher. The steel sheet pile is assumed to be a linear elastic body whose Lame constants λ and μ are 4.2×10^7 kN/m^2 are 2.80×10^7 kN/m^2, respectively. Although the second moment of area is larger than that of the real sheet pile, the set of elastic constants is determined to satisfy the bending stiffness of a real steel sheet pile. Consequently, the axial stiffness is underestimated. The model ground is an elasto-plastic body described by Mohr-Coulomb type yield function and Drucker-Pager type potential function. The internal friction angle and the cohesion are 30 degree and 8.5 kN/m^2, respectively. Particles of the ground in the vicinity of the sheet pile are modeled as interface particles whose internal friction angle and cohesion are assumed to be 20 degree and zero, respectively.

The loading conditions are shown in Fig. 3. In the displacement-controlled method, a constant displacement of 0.02 m/s was applied to the steel particles above the ground surface to penetrate the sheet pile. In the stress-control method, the top four steel particles were subjected to linearly varying surface forces in the form of triangular waves at intervals of 0.04 s to a maximum of 100 kN per unit depth, for a total of 400 kN, and the same surface forces were applied again after 0.56 s, repeated 19 times. The results of the analysis for a single blow were conducted beforehand, and the blow interval was determined as the time required for the ground vibration caused by the blows to settle down. The number of blows was set to be sufficient for the steel head to penetrate below the ground surface.

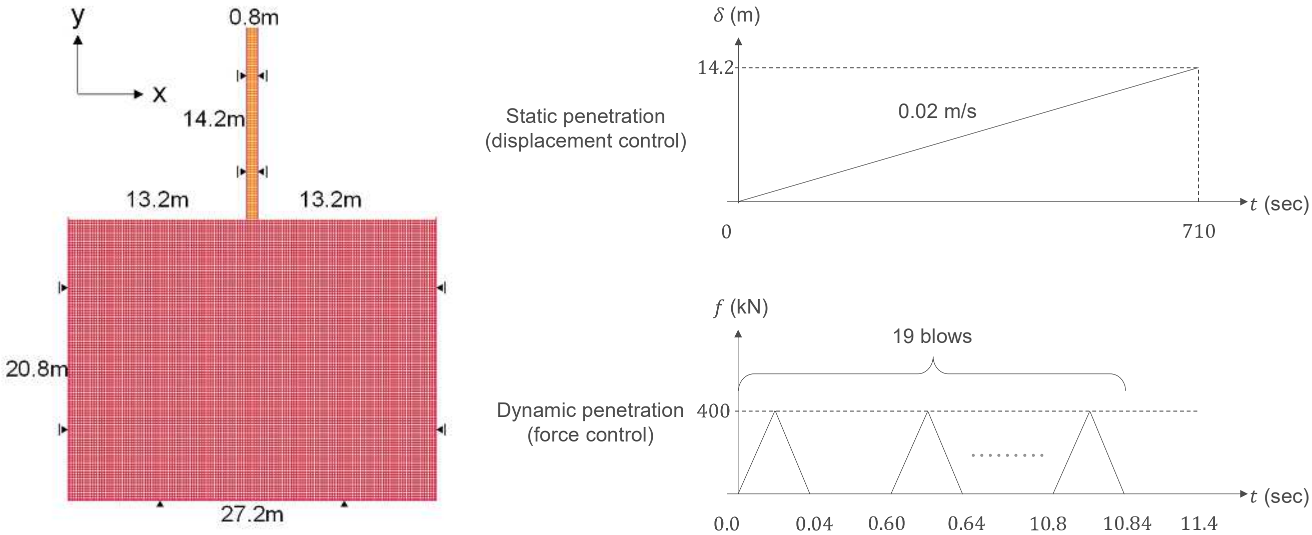
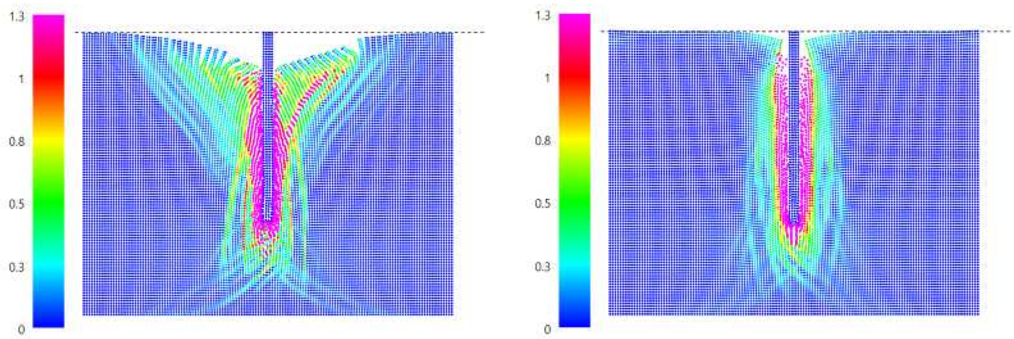
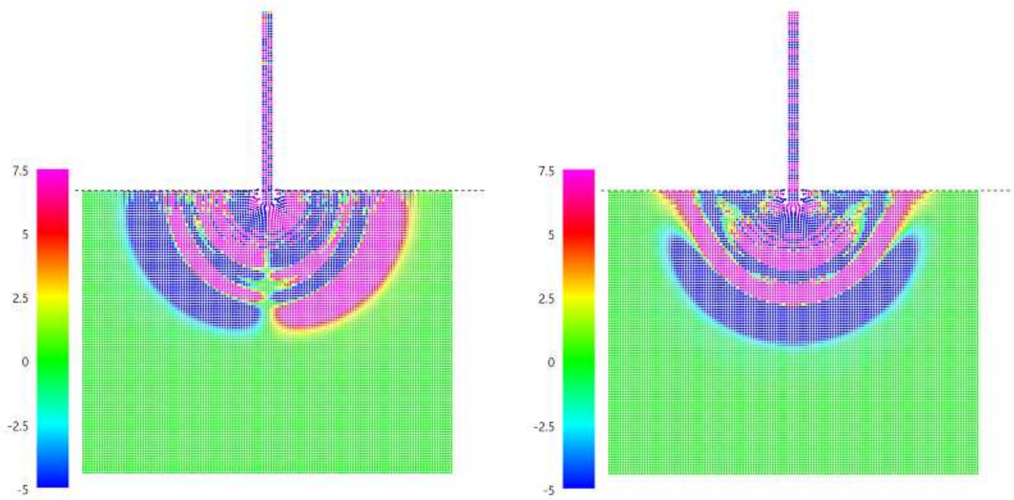


Fig. 3. 2D sheet pile penetration model (unit: m) and the loading conditions.



(a) Static press-in penetration (b) Dynamic hammer-blow penetration

Fig. 4. Numerical simulation of sheet pile penetration into ground. Maximum shear strain distribution for the static and dynamic penetration cases.



(a) x-direction (b) y-direction

Fig.5. Distribution of acceleration for the dynamic penetration case just after the first blow (0.12 second).

Fig. 4 show the maximum shear strain distribution at the end of penetration for the static and dynamic penetration. The results show that both the displacement-controlled and stress-controlled methods can simulate the behavior of steel penetration into the ground with large shear strain around the sheet pile. In the case of static penetration, the sheet pile drags the surrounding soil into the ground as the sheet pile penetrates, resulting in a large settlement. On the other hand, in the case of dynamic penetration, the steel penetration is observed without significant drag of the ground as observed in the case of the static press-in penetration.

The acceleration distributions in the x and y directions for the first blow in the dynamic penetration analysis are shown in Fig. 5. In dynamic penetration, the acceleration is distributed alternately positive and negative, and the acceleration propagates in the direction away from the sheet pile. In other words, the impact by the blow generates sparse and dense waves in the ground. While the ground is sparse near the steel, the confining pressure on the steel is reduced, which also reduces the frictional resistance between the ground and the sheet pile, which suppresses the dragging of the surrounding ground. On the other hand, in static penetration, the steel is constantly confined by the surrounding ground during penetration. Thus the frictional resistance is not reduced and the shear surface due to the frictional force reaches the ground surface as shown in Fig. 5. This causes significant drag of the surrounding ground over a wide area.

To evaluate even the stress level of sheet pile, much more particles must be placed in the thickness direction of the sheet pile, which is computationally too expensive. Although such an analysis is possible with a large-scale analysis using parallel computation, it will be difficult to implement in practice in the near future. However, it is possible to evaluate the behavior of the surrounding ground at least in practice by correctly evaluating the interaction between the ground and the structure.

4. Footing Penetration

Computational cost of three-dimensional numerical simulation by an explicit numerical integration scheme is too expensive to be done. A practical implementation scheme, the particle-element coupled method has been proposed. In this scheme, with the GIMP interpolation function, highly deformable regions are represented by material points. With the APDI interpolation function, material points are used, as if they were FEM elements, in the rest of the highly deformable regions. This combination of the GIMP and APDI methods makes it possible to divide the material domain into spatial discretization with different sizes. The particle-element is able to simulate extreme deformation by GIMP particles as well as to evaluate boundary values by APDI elements for the area of focus, which is sometimes difficult in purely particle-based methods due to the lack of an element boundary. The boundary between the particle and the element domains does not require any special treatments, but simply use interpolation function which satisfies partition of unity for each domain.

The three-dimensional model of the shallow foundation bearing capacity problem is shown in Fig. 6. The space around the footing and down to the bottom of the base ground is modeled with GIMP particles in a cubic manner. Each computational grid is a cube, 0.2 m on each side, and 8 particles are allocated per cell for the GIMP particles. Considering the symmetry of the scenario, a quarter of the domain is modeled. The normal direction of the lateral boundary is fixed (vertical roller condition), and the bottom surface is fixed. The other conditions for the three-dimensional analysis are listed in Table 1. Vertical load is incrementally applied to the base ground from 100 kPa to 600 kPa.

The snapshots of maximum shear strain distribution are shown in Fig. 7. At 100 kPa, the maximum shear strain is distributed like a stress bulb in the Boussinesq solution based on the elastic theory. At 200 kPa, the maximum shear strain is concentrated at the outer edge of the footing, forming a punching wedge beneath the footing. This strain concentration at the outer edge of the footing is identical to the theoretical solution for cohesive material. In the regime beyond 300 kPa, the base ground reaches the slip failure mode and the resisting slip line spreads in space. Settlement then increases continually to 400 kPa and surface deformation becomes visible in Fig. 7(d). However, there is no visual discontinuity in the base ground at this stage. The loading block continues to penetrate into the base ground up to 500 kPa and 600 kPa, where discontinuity between the loading block and the base ground becomes visible (Fig. 7(e) and (f)).

These results demonstrate that the particle-element coupled method is applicable to three-dimensional problems, reducing the implemental complexity and computational cost by dividing the domain into two parts (a large deformation domain and a small deformation domain). The computational cost is reduced by implementing the GIMP particles in the large deformed domain and the APDI particles in the small deformation domain. Use of a full particle model for the three-dimensional problem would result in an extremely high computational cost as compared with the two-dimensional model, but the particle-element coupled method makes it possible to perform the three-dimensional simulation at a reasonable computational cost.

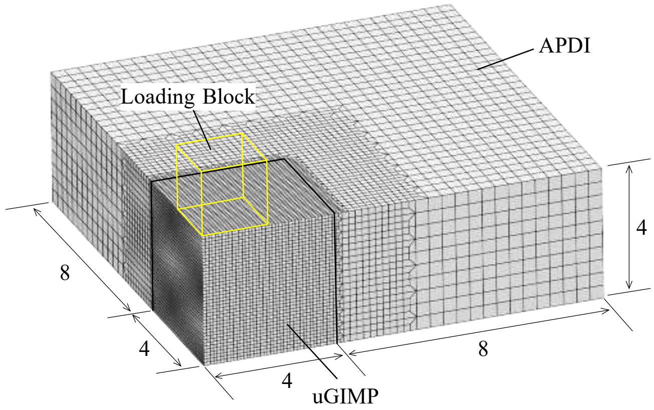
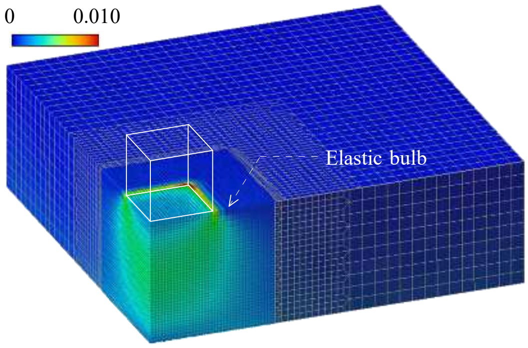


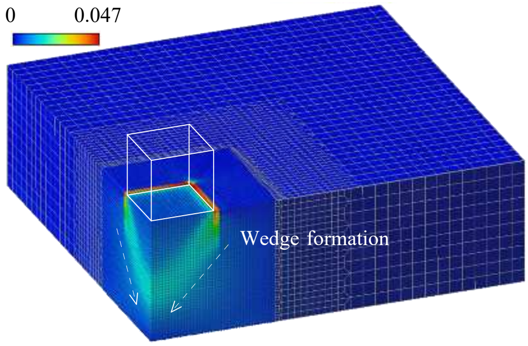
Fig. 6. 3D element-particle coupled footing penetration model (unit: m)

Items	Values
Particles per cell	8
Dimensions(H x W x D)	6 m x 12 m x 12 m
Width of cell	0.2 m
Time increment	0.00025
Damping factor	0.8
Convergence criteria	0.0001
Number of uGIMP interpolation Material Points	
Nearby Ground	64,000
Number of APDI interpolation Material Points	
Loading Block	8,000
Surrounding Ground	24,580

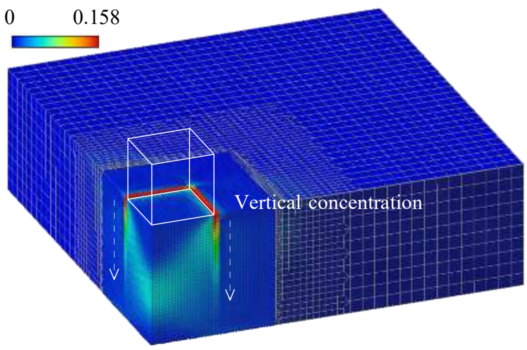
Table 1. Simulation conditions



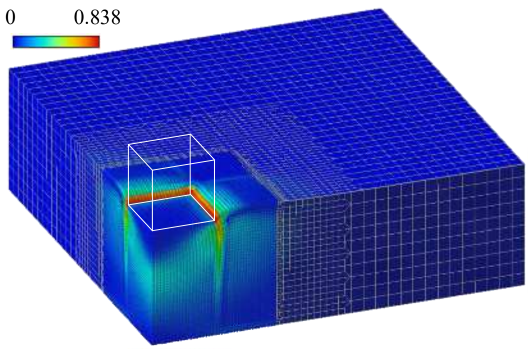
(a) 100 (kN/m^2)



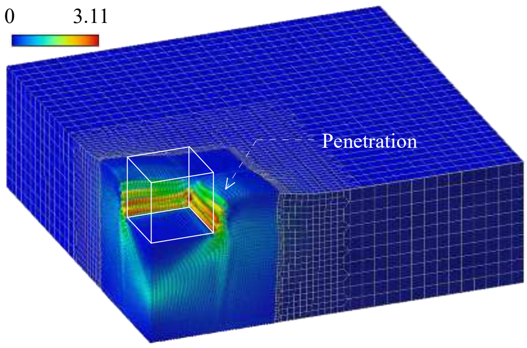
(b) Pressure=200 (kN/m^2)



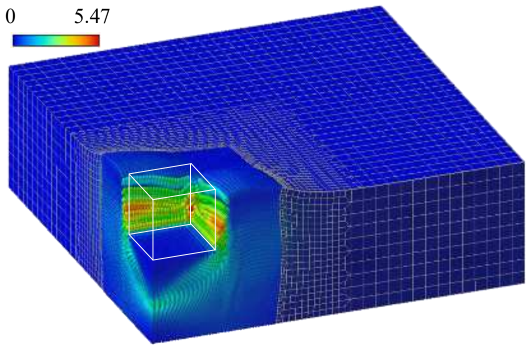
(c) Pressure=300 (kN/m^2)



(d) Pressure=400 (kN/m^2)



(e) Pressure=500 (kN/m^2)



(f) Pressure=600 (kN/m^2)

Fig. 7. 3D numerical simulation of footing penetration into ground. Maximum shear strain distribution at increasing

loading pressures.

5. Summary and Future Perspectives

The numerical simulations of penetration into ground successfully performed by MPM are demonstrated. To evaluate even the stress level of steel, multiple particles must be placed in the thickness direction of the steel, which requires a very large number of particles and is computationally too expensive. Although such an analysis is possible with a large-scale analysis using parallel computation, it will be difficult to implement in practice in the near future. However, it is possible to evaluate the behavior of the surrounding ground at least in practice by correctly evaluating the interaction between the ground and the structure.

In general, design and analysis are performed assuming ideal conditions after sheet pile and pile driving. In addition to MPM, several other methods have been developed that can be applied to large deformation simulations. Among them, MPM is similar to FEM in that the governing equations are solved on a background grid, and users of FEM, which is currently the most popular numerical analysis method, can use MPM relatively easily.

Acknowledgements

The author expresses sincere gratitude to the following three colleagues who performed the numerical simulations shown in this article: Dr. Takatoshi Kiriyama (Institute of Technology, Shimizu Corporation), Mr. Yudai Takegawa (Railway Technical Research Institute), and Gengo Kamamori (mater course student, Kyoto University).

References

Bardenhagen, S.G., Kober, E.M., The generalized interpolation material point method. Comput. Model. Eng. Sci. 5 (6), 447–495, 2004.

Brackbill, J.U. and Ruppel, H.M., FLIP: A method for adaptively zoned, particle-in-cell calculations in two dimensions, Journal of Computational Physics, 65, 2, 314-343, 1986.

Harlow, F.H., A machine calculation method for hydro-dynamic problems, Los Alamos Scientific Laboratory report LAMS, 1956.

Kamamori, G., Higo, Y., Takegawa, Y., Miyoshi, T., Analysis of subsoil behavior during static and dynamic steel penetration by Material Point Method, Proc. The 57th JGS annual conference, 21-6-1-05, 2022. (in Japanese)

Kiriyama, T. and Higo, Y., Arbitrary particle domain interpolation method and application to problems of geomaterial deformation, Soils and Foundations, 60 (6), 1422-1439, 2020.

Koshizuka, S. and Oka, Y., Moving particle semi-implicit method for fragmentation of incompressible fluid, Nuclear Science and Engineering, 123, 421–434, 1996.

Monaghan, J.J. and Lattanzio, J.C., A refined particle method for astrophysical problems, Astronomy and Astrophysics, 149, 1, 135-143, 1985.

Sadeghirad, A., Brannon, R.M., Burghardt, J., A convected particle domain interpolation technique to extend applicability of the material point method for problems involving massive deformations, Int. J. Numer. Meth. Eng. 86 (12), 1435–1456, 2011.

Sadeghirad, A., Brannon, R.M., Guilkey, J.E., Second-order convected particle domain interpolation (CPDI2) with enrichment for weak discontinuities at material interfaces, Int. J. Numer. Meth. Eng. 95 (12), 928–952, 2013.

Sulsky, D., Chen, Z., Schreyer, H.L., A particle method for history-dependent materials, Comput. Methods Appl. Mech. Eng., 118, 179–196, 1994.

Directors' research and development activities

R & D activities on the structures constructed by the press-in method

Yukihiro Ishihara, Nanase Ogawa, Masashi Eguchi, Kazunori Toda

Scientific Research Section, GIKEN LTD.

Some of the IPA events in Kochi this July were held in the newly opened facility of GIKEN "RED HILL 1967" (GIKEN, 2023). This facility is mainly composed of an exhibition area showing the real-scale "Implant™" structures constructed by the press-in method and two innovative buildings of steel sheet piles, and provides a variety of information on a "seeing is believing" basis. This article will briefly introduce some examples of the researches on these structures, conducted by the research team in GIKEN or by other researchers. Please note that it does not provide a comprehensive review of related research on each structure.

1. Implant Bell Cap Bridge – a bridge on a hatted tubular pile constructed with special press-in piling system

The "Implant Bell Cap Bridge" is a bridge utilizing the "hatted tubular pile" (Fig. 1) as its pier pile and securing the bridge function by settling the deck panels on the hatted tubular piles via the T-shaped beams, constructed by a special press-in construction system (Fig. 2). The hatted tubular pile consists of an open-ended tubular pile (a "pile part") and a bell-shaped cap (a "hat part"), with the hat part being connected to the pile part near the ground surface. This bridge can be constructed in a small space within a short period, since (1) the construction system can be positioned and move on the bridge and (2) the embedment depth of the pier pile can be smaller than the conventional tubular pile due to the effect of the hat part. The construction procedure of the bridge is to (1) install the hatted tubular pile, (2) settle the T-shaped beam on the pier pile, (3) settle the deck panels on the T-shaped bars and (4) move the construction machine forward on the deck panels. The removal of the bridge can be conducted by following the reverse procedure.

The vertical and horizontal resistance of the hatted tubular pile were investigated by the 1-g model tests and full-scale field tests (Ishihara et al., 2016).

In the full-scale field tests, the static vertical and horizontal load tests were conducted on the tubular pile (with the outer diameter D_o being 0.8 m) and the hatted tubular pile (with D_o being 0.8 m and the outer diameter of the hat part being 2.2 m). The hat part was rigidly connected to the pile part. The embedment depths of the tubular pile and the hatted tubular pile were 4.4 m and 4.7 m respectively.

The vertical load displacement curves obtained in the field tests are shown in Fig. 3. The vertical capacity of the hatted tubular pile was around 1.7 times greater than that of the tubular pile, if the capacity was defined as the resistance at the base displacement of 1/10 of D_o. One of the mechanisms to increase the vertical capacity of the hatted tubular pile was expected to be the increase in the soil stress beneath the hatted part and the subsequent increase in the shaft resistance of the pile part. This mechanism was investigated in the field test by comparing the axial stresses of the pile part or the tubular pile at several levels, but was not clearly observed. The initial vertical stiffness (when the base displacement was smaller than 1/100 of D_o) was comparable in the hatted tubular pile and the tubular pile. This was thought to be because a certain displacement was necessary to achieve the fully plugged condition of the hat part and the full mobilization of the strength of the

Fig. 1. Hatted tubular pile

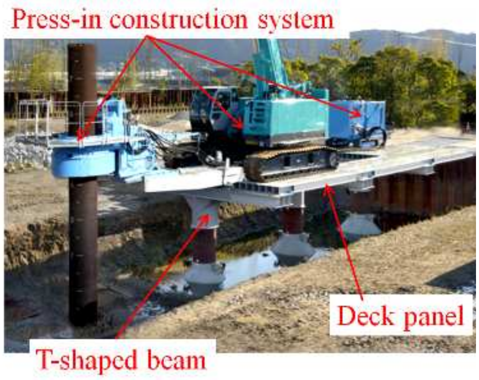


Fig. 2. Press-in construction system for the Implant Bell Cap Bridge

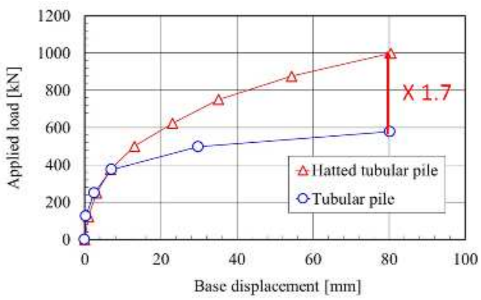


Fig. 3. Results of full-scale vertical load tests (after Ishihara et al. (2016))

soil beneath the hat part.

The horizontal load displacement curves obtained in the field tests are shown in Fig. 4. The horizontal capacity, defined as the resistance when the horizontal displacement of the pile at the ground surface level reached 15 mm, of the hatted tubular pile was around 1.5 times greater than that of the tubular pile. The initial horizontal stiffness of the hatted tubular pile was also greater than that of the tubular pile.

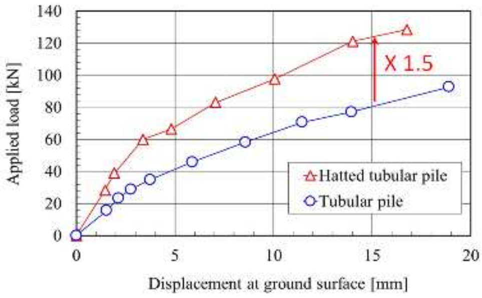
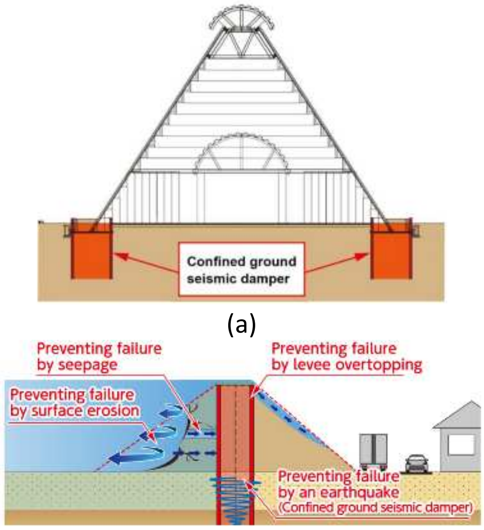


Fig. 4. Results of full-scale horizontal load tests (after Ishihara et al. (2016))

2. Confined Ground Seismic Damper – aseismic technology using a pressed-in sheet pile wall with a closed shape

The “Confined Ground Seismic Damper” consists of a pressed-in sheet pile wall with a closed shape and the ground confined by the wall. As exemplified in Fig. 5, it can be used beneath the structure (Fig. 5a) or as a structural component of the whole structure (Fig. 5b). It is expected to reduce the displacement of the structure due to the liquefaction of the ground, by preventing or mitigating (1) the sliding failure of the soil, (2) the deformation of the soil inside the wall, (3) the lateral movement of the liquefied soil, (4) the transmission of the excess pore water pressure and (5) the uneven settlement of the structure. It is also expected to provide a seismic damping function, by taking advantage of its structural flexibility in the liquefied ground.

As for the effectiveness for reducing the settlement and the inclination of the structure due to liquefaction, Kato et al. (2014) carried out 1-g model tests, centrifuge model tests and numerical analyses. The house models having the uneven load (Fig. 6) were used, with the sheet pile wall being connected to the spread foundation of the house. The ratio of the embedment length of the sheet pile wall to the thickness of the liquefiable layer (embedment ratio, z_{emb} / H_{liq}) was varied. The results are summarized in Fig. 7. When the embedment ratio was 1, the settlement and the inclination of the house were reduced by 90 % and 80 % respectively, as compared with the house having no sheet pile wall. In addition, the settlement and the inclination were confirmed to be reduced even when the embedment ratio was smaller than 1.



(a)

(b)

Fig. 5. Application examples of Confined Ground Seismic Damper (GIKEN (2023))

Toda et al. (2022, 2023) and Haigh (2022) conducted a series of 1-g large-scale model tests to investigate the vertical and horizontal resistance of the slab with a square sheet pile wall in a liquefiable ground. The tests were conducted using a soil tank shown in Fig. 8, where the liquefaction of the ground (the reduction of the effective stress) is simulated by using the seepage force generated by the water injection at the bottom of the soil tank (Ogawa et al., 2018). The extent of liquefaction was judged by the excess pore water ratio (r_u). The static vertical and horizontal load tests were conducted, with r_u being controlled constant during the tests either at 0, 0.3 or 0.6. Both the vertical and horizontal resistance were found to be smaller in the tests with larger r_u values. If plotted against r_u as shown in Fig. 9, both the vertical and the horizontal capacity were found to vary roughly linearly with r_u. These trends were consistent with those found for the single closed-ended tubular pile (Willcocks, 2021). These findings would be suggesting that the resistance of these structures in a liquefied ground could be estimated from their resistance in a non-liquefied ground.

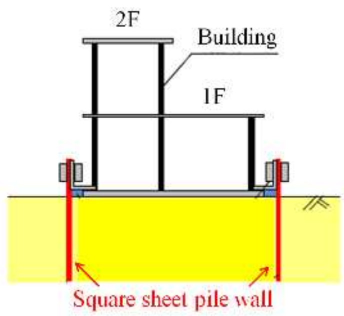


Fig. 6. House model used in the model test (after Kato et al. (2014))

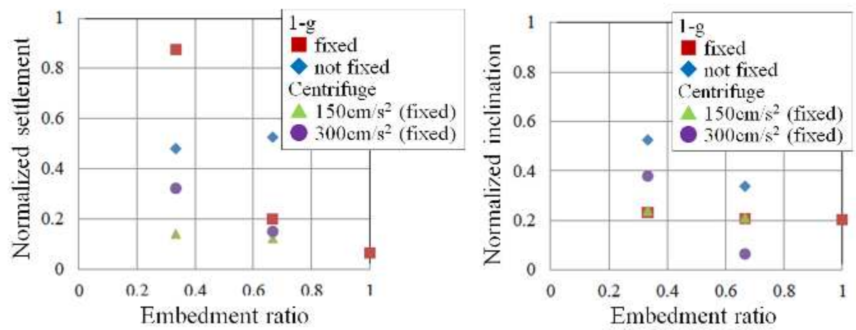
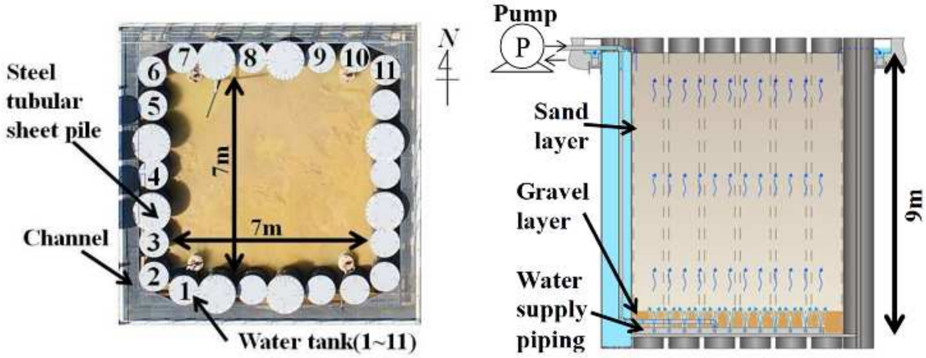


Fig. 7. Experimental results on the effect of square sheet pile wall on reducing settlement and inclination of house due to liquefaction (Kato et al. (2014))

Haigh (2022) conducted centrifuge tests and numerical analyses to



(a) Plan view (b) Side view

Fig. 8. Large-scale test apparatus for liquefaction (Ogawa et al. (2018))

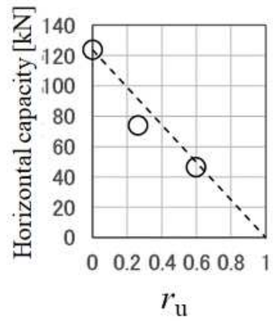
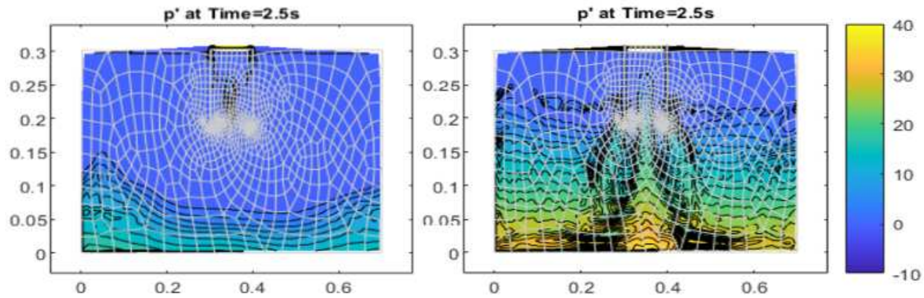


Fig. 9. Horizontal capacity vs. r_u (after Toda et al. (2023))

investigate the vertical and horizontal resistance of the same structure as was treated in the above-mentioned large-scale model tests, by applying a 0.36 g seismic loading to the model. She showed that a column of non-liquefied soil is created in and beneath the sheet pile wall a s shown in Fig. 10, and suggested that this will be one of the mechanisms for the structure to exhibit some resistance in a liquefied ground.



(a) Slab only (b) Slab with sheet pile wall

Fig. 10. Results of numerical analysis (in kPa) (after Haigh (2023))

3. Preload Retaining Wall – a preloaded retaining wall consisting of steel sheet piles

The "Preload Retaining Wall" is a retaining steel sheet pile wall having an inclination angle and a bow shape. As shown in Fig. 11, the construction procedure of this wall is to (1) install the sheet piles by the press-in method at a certain inclination angle, (2) excavate one side of the wall, (3) apply a horizontal load (Preload) to the wall in its head, (4) fill the gap behind the wall with a backfill material and (5) remove the Preload.

Gao (2014) and Ishihara et al. (2015) conducted 1-g model tests and field tests to compare the deformation of a normal wall (a retaining sheet pile wall having no inclination), a slanting wall (a retaining sheet pile wall having an inclination angle of 5 degrees) and the Preload Retaining Wall having the same inclination angle with the slanting wall, when a

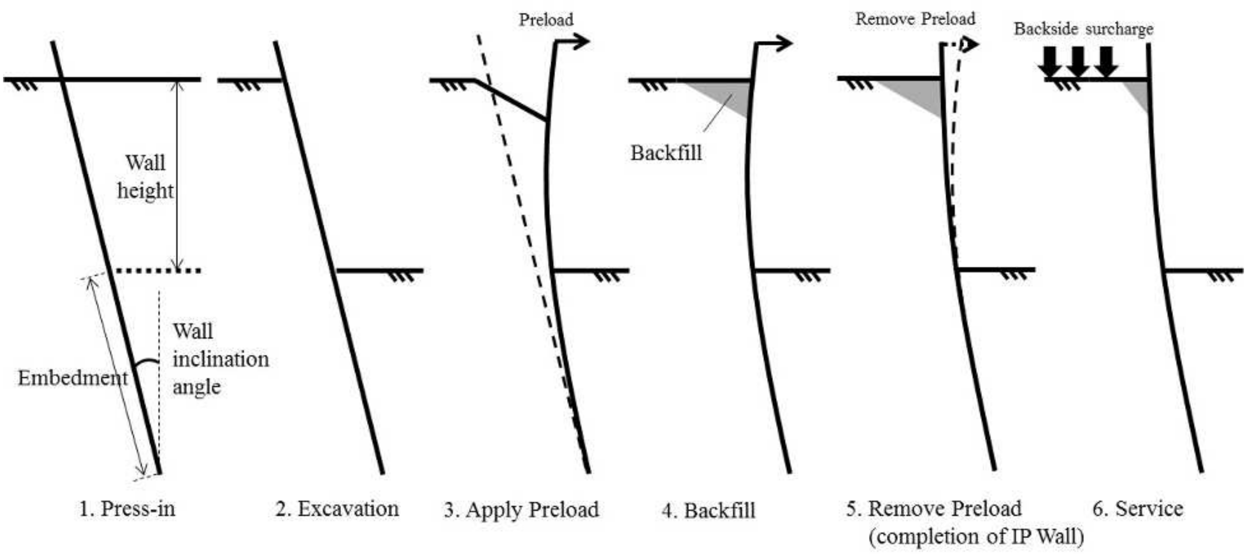
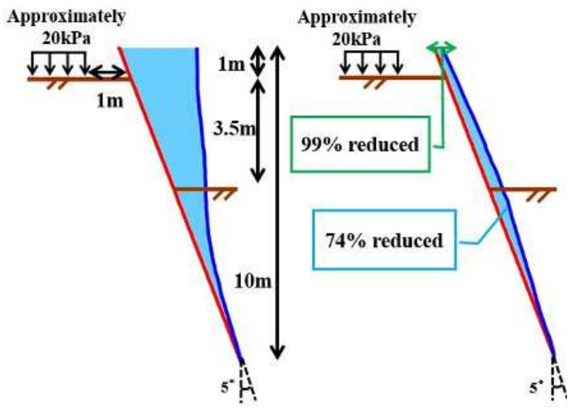


Fig. 11. Construction procedure of Preload Retaining Wall (Ishihara et al. (2015))

backside surcharge was applied behind each wall. The results are illustratively summarized in Fig. 12. The horizontal displacement caused by the surcharge of 20 kPa was smaller in the Preload Retaining Wall than in the slanting wall, by 99 % at the wall head and 74 % for the entire wall. The deformation pattern of the Preload Retaining Wall was different from that of the slanting wall. The maximum horizontal displacement was found near the excavation bottom in the Preload Retaining Wall, while it was found in the wall head in the slanting wall.

Ishihara et al. (2015) conducted numerical analyses to investigate the mechanisms for the smaller deformation of the Preload Retaining Wall confirmed in the field tests. They suggested based on the analysis results that the possible mechanisms were (1) the enhanced stiffness of the soil in the excavation bottom as a result of the loading history due to the Preload and (2) the improved shear strength of the backside soil as a result of the increased horizontal stress due to the elastic reaction of the steel sheet pile wall to the Preload, as summarized in Fig. 13.

A simple method to determine the amount of Preload was proposed by focusing on the first of the above-mentioned two mechanisms (Ishihara et al., 2015). The appropriate amount of Preload was assumed to correspond to the amount of the surcharge to be experienced in service, in terms of the effect on the soil in the excavation side. A conceptual two-dimensional diagram was introduced as shown in Fig. 14, where the effect of the Preload or the surcharge is expressed by the combination of the horizontal load and the moment at and around the cross point of the wall and the excavation bottom (in the vertical axis), while the deformation of the soil in the excavation side is represented by the summation of the horizontal displacement of the wall below the excavation bottom (in the horizontal axis).



(a) Slanting wall (b) Preload Retaining Wall
Fig. 12. Field test results (Ishihara et al. (2015))

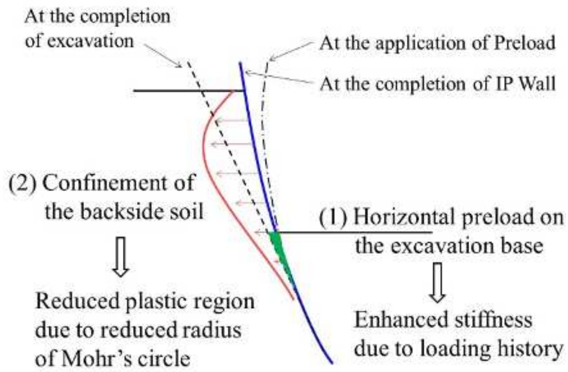


Fig. 13. Mechanisms of smaller deformation of Preload Retaining Wall (Ishihara et al. (2015))

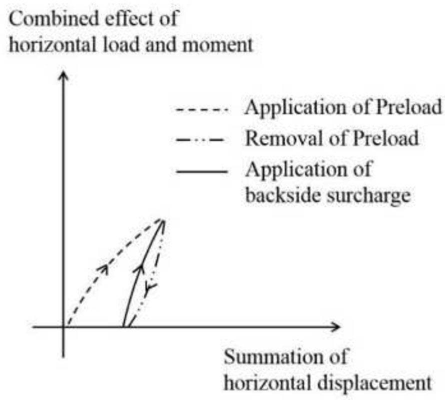


Fig. 14. Conceptual diagram for design of Implant Preload Wall (Ishihara et al. (2015))

4. Implant Barrier – a protective wall consisting of strut members (steel tubular piles) and wall members (concrete, metal, fiber etc.)

The "Implant Barrier" is a protective wall to be used for the disaster prevention and mitigation, by reducing the hydrodynamic load of tsunamis, wave surges and so on. As shown in Fig. 15, it mainly consists of the strut members (steel tubular piles) and wall members (made of concrete, metal or fiber). The strut members are aligned with a certain distance with each other, by being installed into the ground by the press-in method. The wall members are made either of concrete, metal or fiber, and are fixed to the strut members. The structural stability of the Implant Barrier is supposed to be assured by the strut members and optionally by the sheet piles.

The wall members of the Implant Barrier (hereinafter called "Barrier") can be porous sheets made of fiber. In this case, the reduction of the hydrodynamic load will be achieved by the energy loss of the flow when it passes through the Barrier. Suzuki et al. (2016) proposed a theoretical approach shown in Fig. 16 to consider the energy loss of the flow by introducing the "loss factor" (η), defined by $\eta = f / \lambda^2$ where f is the friction factor and λ is the aperture ratio of the Barrier. They confirmed its validity by conducting a series of two-dimensional hydraulic model tests in the apparatus shown in Fig. 17, using a surge-type tsunami. As shown in Fig. 18, the estimated and the measured tsunami load on the Barrier (F_B) and the flowrate of the tsunami after passing

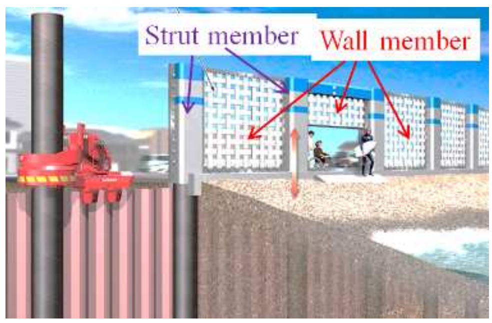


Fig. 15. Basic structure of Implant Barrier (after GIKEN (2023))

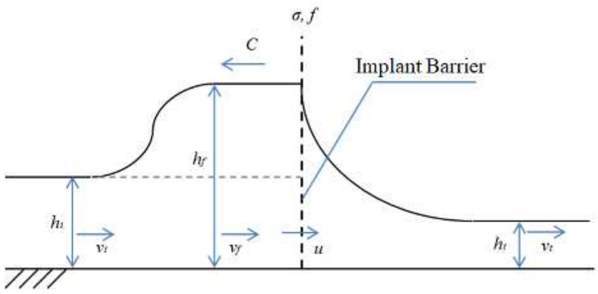


Fig. 16. Theoretical approach for Implant Barrier (after Suzuki et al. (2016))

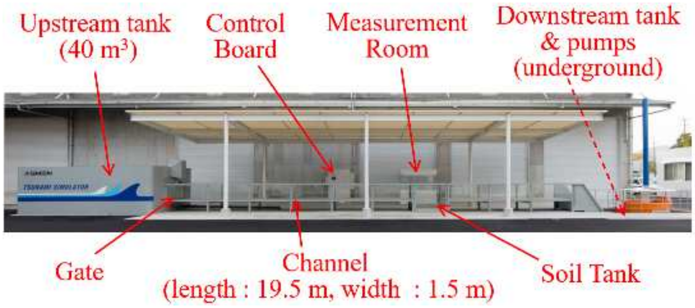


Fig. 17. Experimental apparatus to simulate tsunami (after Ishihara et al. (2018))

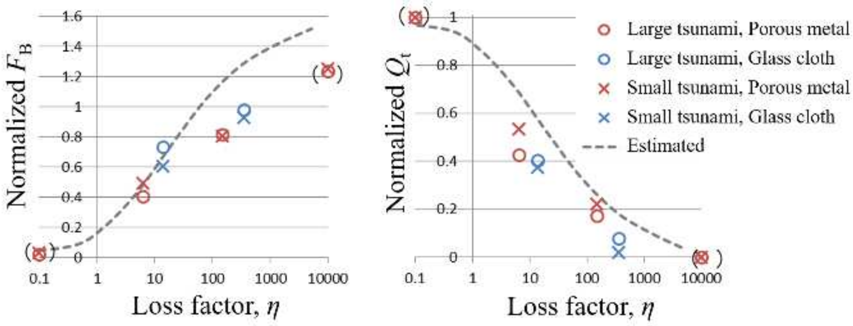


Fig. 18. Experimental results in comparison with estimated results (after Suzuki et al. (2016))

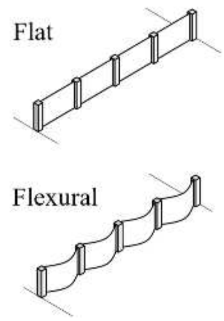


Fig. 19. Shapes of wall members (after Toda et al. (2021))

the Barrier (Q_t) were confirmed to agree with each other to some extent, if tsunami did not overflow the Barrier. A trade-off relationship was confirmed between F_B and Q_t with regard to the loss factor η, where increasing the η value (i.e. reducing the aperture ratio λ) led to greater F_B and smaller Q_t values. In addition, an experimental method to obtain η was also introduced to cope with the difficulty in defining the λ value of the porous sheet made of fiber.

Toda et al. (2021) proposed a method to apply the theoretical approach of Suzuki et al. (2016) to the tsunami overflowing the Barrier, by introducing the "equivalent aperture ratio" and the "equivalent loss factor". Its validity was assessed by comparing with the results of the hydraulic model tests conducted in the same apparatus. As a result, the water depth behind the Barrier was well estimated, while the water depth in front of the Barrier and the tsunami load on the Barrier were underestimated.

Toda et al. (2021) also investigated the effect of the shape of the wall members of the Barrier (flat or flexural, as shown in Fig. 19) on reducing the tsunami load behind the Barrier (F_D), by using the porous sheet made of fiber for the wall members. They confirmed that the flexural shape was slightly more effective. For example, the Barrier with λ = 24 % was confirmed to reduce F_D by 75 % if the wall members were flat and by 80% if they were flexural.

References

Gao, G. 2014. Comparing performance of different sheet pile walls. M.Eng. Thesis, University of Cambridge, 50p.

GIKEN. 2023. GIKEN RED HILL 1967, Akaoka Kochi, Japan. https://redhill1967.giken.com/en/

Haigh, A. 2022. Performance of Implant structures. M.Eng. Thesis, University of Cambridge, 52p.

Ishihara, Y., Ogawa, N., Okada, K. and Kitamura, A. 2015. Implant Preload Wall: a novel self-retaining wall with high performance against backside surcharge. Press-in Engineering 2015, pp. 68-82.

Ishihara, Y., Ogawa, N., Okada, K., Inomata, K., Yamane, T. and Kitamura, A. 2016. Model test and full-scale field test on vertical and horizontal resistance of hatted tubular pile. Proceedings of the Third International Conference Geotec Hanoi 2016 - Geotechnics for Sustainable Infrastructure development, pp. 131-139.

Kato, I., Hamada, M., Higuchi, S., Kimura, H. and Kimura, Y. 2014. Effectiveness of the sheet pile wall against house subsidence and tilting induced by liquefaction. Journal of Japan Association for Earthquake Engineering, Vol. 14, No. 4, pp. 35-49. (in Japanese)

Ogawa, N., Ishihara, Y., Ono, K. and Hamada, M. 2018. A large-scale model experiment on the effect of sheet pile wall on reducing the damage of oil tank due to liquefaction. Proceedings of the First ICPE 2018, Kochi, pp. 193-202.

Suzuki, N., Ishihara, Y. and Isobe, M. 2016. Experimental study on influence of porosity and material of pile-type porous tide barrier on its tsunami mitigation effect. Journal of Japan Society of Civil Engineers, Ser. B3 (Ocean Engineering), Vol. 72, No. 2, pp. I-491-I-496. (in Japanese)

Toda, K., Mori, A., Ishihara, Y. and Suzuki, N. 2021. Experimental study on tsunami mitigation effect of pile-type porous tide barrier. Proceedings of the Second International Conference on Press-in Engineering 2021, Kochi, pp. 444-453.

Toda, K., Ishihara, Y., Eguchi, M. and Mori, A. 2022. Experimental study on a foundation reinforced by square sheet pile wall. Japan Society of Civil Engineers 2021 Annual Meeting, 2p. (in Japanese)

Toda, K., Ishihara, Y., Eguchi, M. and Mori, A. 2023. Horizontal resistance of a slab reinforced by square sheet pile wall in a liquefied ground. Japan Society of Civil Engineers 2023 Annual Meeting, 2p. (in Japanese)

Willcocks, F. 2021. The vertical and horizontal performance of pressed-in tubular piles in liquefied ground. M.Eng. Thesis, University of Cambridge, 52p.

IPA News Letter Volume 8, Issue 3 September 2023

Case History

Permanent Basement Walls with Pressed-in Sheet Piles in Portland, Oregon, U.S.A.

Takefumi Takuma

Senior Advisor
Giken America Corp.

Steel sheet piles are utilized as temporary as well as permanent earth retaining elements. As a matter of fact, a sheet pile wall can be designed and built to function in both ways to achieve faster construction with lower project cost. Some of the new multi-unit residential and office buildings in the U.S. are built with sheet pile basement walls instead of more-typical concrete-based walls, such as diaphragm and secant pile walls. Sheet pile basement walls come with the following advantages in many cases.

- Simpler design and construction with a choice of a cantilevered, braced, or anchored wall.
- More flexible choice for a basement construction sequence among top-down, bottom-up, or hybrid of both.
- Narrower wall footprint, i.e., larger inner space of a basement. See Fig. 1.
- Can be designed to bear vertical loads, which likely reduce the size or the number of vertical load-carrying columns.
- Can achieve watertightness with sealing or welding of interlocks.

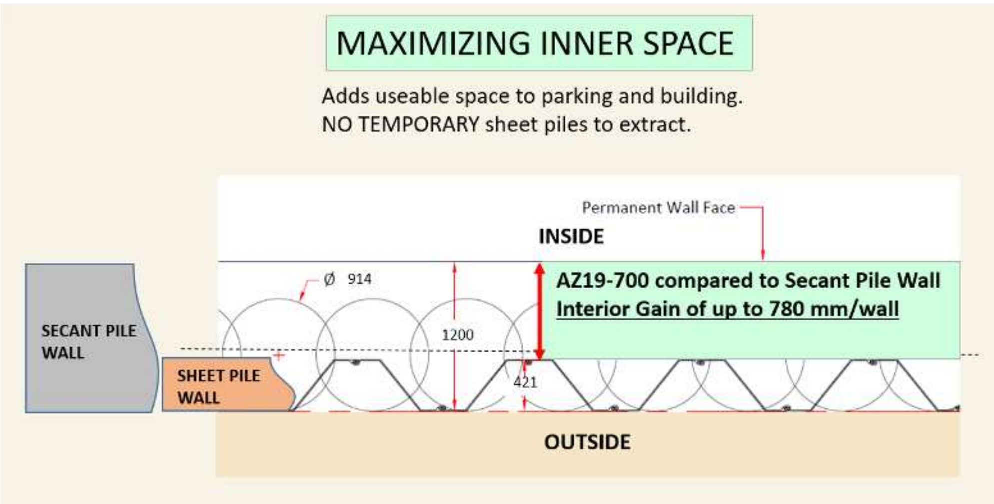


Fig. 1. Larger inner apace with sheet pile wall than with secant pile wall
(Base drawing: Nucor Skyline)

Fire resistance should be attained with intumescent paint coating or placement of insulating panels, curtain walls, or concrete. Some sheet piles have been tested to meet applicable codes and standards.

A large-scale urban redevelopment project in Portland, Oregon in the U.S.A. took advantage of the sheet pile wall basement structure with the footprint of 140m x 61m. The 2018 project built 380 apartment units, 1,900m^2 of ground level retail space, and two levels of underground parking structures for 602 parking spaces on two city blocks. See Fig. 2 for an architect’s rendering of one of the buildings. Due to its proximity to nearby buildings, a tight installation tolerance, and hard soil conditions with gravel and cobbles below a certain depth, press-in piling with an auger attachment was adopted as shown in Fig. 3. Excavation followed press-in piling as shown in Fig. 4 and tie-backs were installed for further excavation. Fig. 5 shows a basement garage with sheet pile walls of a different project as an example.

ArcelorMittal provides reference materials on this type of underground structure at the following link.
https://sheetpiling.arcelormittal.com/applications/underground-car-parks/

Acknowledgement

The author appreciates assistance provided by Dennis Guimond, a retired employee of Nucor Skyline, Blake Patsy of KPFF Consulting Engineers, Chris DellAringa and Taylor Stevenson of Blue Iron Foundations and Shoring LLC, and Ian Vaz of Giken America Corp.

Fig. 2. Architect's rendering of Conway Block 294E Building in Portland, Oregon
(https://cairnpacific.com/block-2945-e)

Fig. 3. Press-in piling with auger attachment
(Photo: Blue Iron Foundations and Shoring LLC)

Fig. 4. Press-in piling (far right) followed by excavation
(Photo: Blue Iron Foundations and Shoring LLC)

Fig. 5. Example of completed basement with sheet piles (different project)

Reports

IPA Board Meeting 2023 and related events

IPA Secretariat

On July 3rd, 2023, the 13th IPA Board Meeting was held at the GIKEN's newly established facility "RED HILL 1967" in Akaoka, Konan City, Kochi Prefecture, which was opened in April this year. Last year in July, Chairman Leung visited the same facility and was deeply impressed by its development as a new base for press-in technology dissemination. With the intention of having other board members experience the facility as well, this gathering was realized. A total of 23 directors and auditors, consisting of 13 members from overseas and 10 members from Japan, gathered in Kochi.

On July 3rd, before the Board Meeting, there was a facility tour of "RED HILL 1967" and after the meeting, there was another facility tour of the GIKEN LTD.'s Kochi Head Office, followed by a social gathering with the company's executives and their employees. On the following day, July 4th, the participating directors and auditors split into four groups and engaged in various activities aimed at contributing to the local community from an academic perspective, increasing the recognition of IPA, and advancing press-in engineering.

Board of Directors Meeting 2023

The IPA Board Meeting on July 3rd was held in a hybrid format, with a total of 25 directors participating, exceeding the quorum (Photo 1). Out of the 25, 21 directors and 2 auditors attended the meeting in person, 1 director joined online, and 3 directors submitted proxies. The meeting began with a greeting from Chairman Leung, who introduced the successful IPA Seminar on Press-in Technology held in Taipei in June of this year, which attracted nearly 100 participants and local sponsors. It was also mentioned that there are plans to hold similar seminars in the future in Europe, including the Netherlands, as well as in Asia, including Thailand, the Philippines, and Hong Kong.

Photo 1 Board meeting

At the Board Meeting, important matters related to the operation of the IPA were proposed, confirmed and approved, such as the appointment of Vice Presidents for FY2023-2024, the appointment of Chairperson and Vice Chairperson of each Standing Committee, the confirmation of members, and the establishment of the Steering Committee and the Nomination Committee. In addition, as a report item, Chairperson of each standing committee explained the activity plan for this year, and the information on the preparation status of ICPE2024 was shared with the members by President Leung. Finally, there was a discussion regarding the revision of the articles to add some provisions in order to translate the original text of the Constitution, By-Laws, and Regulations into English. This proposal received unanimous approval from all attending directors. The revision proposal is scheduled to be presented at the general meeting next year.

Following the Board Meeting, each Standing Committee Meeting was held to discuss this year's activity plan and specific measures. At the joint committee meeting of the Administration Committee, Development Committee, and Awards Committee, there was a lively discussion on measures to promote the active participation of young researchers and engineers, including students.

Tour of "RED HILL 1967"

Prior to the Board Meeting, a tour of GIKEN LTD.'s new facility "RED HILL 1967" was held (Photo 2). At the beginning of the tour, Mr. Kitamura, Honorary President of IPA and Executive Chairman of GIKEN LTD., explained the history and background of the development of this facility in Akaoka, his birthplace, and the concept of the facility development, "seeing is believing". During his speech, Mr. Kitamura referred to the challenges faced by the outdated construction industry and the mission of press-in technology. He highlighted the need for the construction industry to embrace the latest technologies in order to realize something unprecedented, and emphasized that press-in incorporates many of these cutting-edge technologies. He encouraged the experts and professionals present to investigate how press-in differs from conventional methods based not on precedents but on fundamental principles. Mr. Kitamura expressed his desire to receive various opinions to further refine and enhance press-in technology.

During the facility tour, Honorary Chairman Kitamura took the lead in giving an explanation, and the directors and auditors asked many technical questions about GIKEN's unique facility structure and construction principles of the machines on display.

"RED HILL 1967" will be introduced in detail in another issue, but it is a facility named after the place name "Akaoka", and 1967, the year when GIKEN LTD. was founded. The facility has a total area of 36,000 square meters and consists of the following four main parts:

The first is the Museum of Piling Machines, which includes the first Silent Piler and piling machines for other methods. The second is a demonstration area showing the press-in system and the pile structures built with the system, the third is a research building built with a structure in which the pressed-in steel sheet piles serve as both foundation and frame of the building, and the last one is GIKEN’s largest plant Kochi No. 3 plant.

Photo 2 Group photo at “RED HILL 1967”

Tour of Facility of GIKEN

After the IPA Board Meeting at RED HILL 1967, we moved to the Kochi Head Office of GIKEN LTD., where we had a facility tour (Photo 3). During the facility tour, GIKEN presented some examples of the use of structures using pile materials constructed with press-in machines promoted by GIKEN and the test equipment that demonstrates their superiority as structures, such as a mechanical underground parking lot built by pressing piles into the ground in a cylindrical shape, a tsunami simulator using a pile-type breakwater model that is firmly supported by being pushed into the ground, and a caisson-type breakwater model that can withstand the external force by its own weight. The IPA directors and auditors, although some of them were visiting the company’s facilities for the first time, were very interested in the GIKEN Group's technology, which promotes practical solutions to various social problems and issues related to construction through research and development.

Photo 3 Facility tour in GIKEN office

Afterwards, 15 executives and employees from GIKEN participated in the social gathering sponsored by GIKEN, where local cuisine and local sake from Kochi were served. We were able to feel that the interaction and exchange of opinions with IPA Honorary Chairman Kitamura and other GIKEN Group officers and employees has become a very valuable and important opportunity for the IPA directors and auditors as well.

Lecture Tour in Kochi

Acquisition of young members including students and promotion of their activities is one of the important issues for the development of the society and the progress of press-in engineering. Taking advantage of this opportunity where prominent directors in the field of geotechnical engineering were gathering from all over the world, IPA held some lectures by IPA directors on July 4th, for students majoring in geotechnical engineering at local academic institutions, Kochi University of Technology, and National Institute of Technology, Kochi College. Nearly 80 students attended each session, and the students listened intently to the insightful lectures given by each director.

Academic Lecture at Kochi University of Technology

Lecture 1	Learning Soil Mechanics in 45 Minutes	
	Dr. Osamu Kusakabe	Executive Director, IPA Professor Emeritus, Tokyo Institute of Technology
Lecture 2	Relationship between "Soil Mechanics" and "Social Infrastructure Facilities"	
	Dr. Kenichi Horikoshi	Director, IPA President & Representative Director, Seiwa Consultants Co., Ltd.

Academic Lecture at National Institute of Technology, Kochi College

Lecture 1	Singapore - Garden City and Sustainability	
	Prof. Chun Fai Leung	President, IPA Emeritus Professor, National University of Singapore
Lecture 2	HIPER™ Piles for Sustainability	
	Dr. Andrew McNamara	Vice President, IPA City, University of London and Chief Engineer, Skanska UK Building
Lecture 3	The Role of the Geotechnical Engineers in Solving Global Challenges	
	Prof. Kenneth Gavin	Vice President, IPA Professor, Delft University of Technology

Photo 4 Group photo at Kochi University of Technology

Photo 5 Group photo at National Institute of Technology, Kochi College

Research Interaction with GIKEN Science Department

Following the previous day, we held an opinion exchange meeting among IPA directors and auditors and the members of the Scientific Research Section of GIKEN LTD. on July 4th at RED HILL 1967, for the purpose of connecting researchers and practical engineers and promoting the progress of press-in engineering in theory and practice

Some presentations were made for the 12 directors and auditors regarding the joint research with the University of Cambridge, utilization of press-in construction data, some research outcomes regarding the performance of river embankments with double sheet pile wall structures, and some others. There was a lively question and answer session on the content of the presentations, and it was a meaningful time for both parties.

Seminar for the public on geotechnical engineering

On July 4th, 2023, the ``Seminar on Geotechnical Engineering - From the Laboratory to the Field -'' was held in Kochi City. Approximately 60 people participated, including policy makers, researchers, engineers, contractors, and students. It was held locally, and five IPA directors, and each director introduced the contents of research in their specialized fields and the latest topics. The program was as follows.

Presentation 1	Development of Rapid Loading Test of Piles	
	Prof. Tatsunori Matsumoto	Vice President, IPA Emeritus Professor, Kanazawa University
Presentation 2	Pixel-free image analysis technology and model experiments	
	Dr. Katsutoshi Ueno	Director, IPA Associate Professor, Tokushima University
Presentation 3	Scouring damage of river bridge foundations and its restoration technology	
	Prof. Hidetoshi Nishioka	Director, IPA Professor, Chuo University
Presentation 4	Topics related to piles used in harbors and oceans	
	Prof. Yoshiaki Kikuchi	Director, IPA Professor, Tokyo University of Science
Presentation 5	Deformation and failure behavior simulation of foundations and retaining wall structures using centrifugal models	
	Dr. Jiro Takemura	Director, IPA Associate Professor, Tokyo Institute of Technology

After each lecture, questions were accepted, and there were scenes where researchers asked questions to each other. Furthermore, several directors commented that new challenges from both research and practical perspectives could lead to societal innovation and change. During the break time, lively discussions were also observed, and the event ended successfully.

The video recordings of the lectures of this seminar (in Japanese) are now available on the IPA members' website. If you wish to watch them, please visit the following URL.
IPA members' site: https://member.press-in.org/en/login

To watch the videos, membership registration with the International Press-in Association is required. You can proceed with the registration process by visiting the following URL.
URL: https://www.press-in.org/en/page/join

Photo 6 Group photo at the seminar

Photo 7 Q&A Session at the seminar

Finally, we are firmly convinced that this series of events has marked a significant step forward for the International Press-in Association (IPA) in its pursuit of "integrating theory and practice" to visualize the invisible underground and create and provide the true value that society truly needs.

Event Report
IPA Seminar on Press-in Technology in Taiwan

IPA Secretariat

The IPA Seminar on Press-in Technology in Taiwan was held on June 14, 2023, at the Importers and Exporters Association of Taipei (IEAT) in the central Taipei, Taiwan. It was cosponsored by the Taiwan Geotechnical Society (TGS), the Taiwan Foundation Engineering Institute, the Taipei Foundation Engineering Institute and the Sino-Geotechnics Research and Development Foundation. The one-day seminar was attended by about 100 people, including engineers, contractors, academic researchers, machine manufacturers, pile suppliers and other interested industry colleagues. The seminar covered the full spectrum of the press-in piling method, which was requested by the press-in piling industry in Taiwan in order to expand their capability for future projects.

The seminar began with an opening address by Prof. Tai-Tien Wang, the president of the Taiwan Geotechnical Society (TGS), followed by nine presentations covering the following topics.

1. Prof. Chun Fai Leung, the president of the IPA, delivered a presentation titled “The prospect of International Press-in Association (IPA)”. He outlined the advantages of the press-in piing method and activities of the IPA, including its future prospects.

2. Mr. Tomotaka Hirose, assistant manager of GIKEN Seisakusho Asia Pte., Ltd., provided his presentation on “Press-in Retaining Structures: A Handbook (Construction)”, which was revised in 2021.

3. Mr. David, Kuo-Wei LIN, the president of Chuen Chang Enterprise Co., Ltd., introduced the current status of the press-in piling industry in Taiwan in his presentation, “To see the new possibilities for future application of steel sheet piles from the past summary of the silent piling work in Taiwan”.

4. Prof. Tatsunori Matsumoto, the vice president of the IPA, an emeritus professor at Kanazawa University, explained “Press-in Retaining Structures: A Handbook (Design)”, in line with the previous presentation which featured the “Construction” portion of the handbook.

5. Mr. Kai-Yu Wu, the assistant general manager of Tung Ho Steel Enterprise Corporation, described the challenge to develop steel sheet piles in Taiwan, with structural improvement over the current sheet pile models available in the Taiwan market.

6. IPA director and assoc. prof at the Tokyo Institute of Technology, Jiro Takemura, lectured on one of the IPA’s research activities “Application of cantilever type steel tubular pile wall embedded to stiff ground (TC1)”.

7. Mr. Chou, Yung-Chuan, the business manager of CECI Engineering Consultants, Inc., presented his experience with the press-in method on his previous project as “Case Study of Press-in Method for Archeology at Historic Site of Taipei MRT Station”.

8. Mr. Yasuhiko Nishi, the Senior Advisor of the GEOTETS Method Research Society, detailed their innovative ground displacement prevention method in his presentation “Simultaneous removal and filling method for earth retaining members contributing to SDGS”.

9. Mr. Tsunenobu Nozaki, the General Manager of the IPA, featured “Case Histories of the Press-in Piling Technologies and Applications for Permanent Structures”, which covered a wide variety of applications of the press-in piling method.

This was the first full in-person conference, with invited speakers, held by the IPA post Covid-19 pandemic. The main advantage of a full in-person conference over an online or hybrid conference is the person-to-person proximity to other attendees. The day before the conference day we had a welcome dinner at a local restaurant, to warm up the relationship between the co-organizers in Taiwan and the IPA (Photo 1). It was also a good opportunity to update guests on information, regarding both the Taiwan construction industry and the press-in piling industry.

Photo 1. The welcome dinner

On the day of the conference (Photo 2), there were enthusiastic questions after each session to obtain in-depth knowledge of the latest press-in piling method. Apart from the technical discussions, break times and lunch times were also used by the attendees as an in-person networking opportunity. Possible future plans in Taiwan, further activities of the IPA and mutual business developments were keenly discussed among the parties.

Photo 2. Conference day

The conference was sponsored by the 6 organizations, whose advertisements were inserted into the conference guidebook and circulated to all attendees.

Gold:	Chuen Chang Enterprise Co., Ltd.	GEOTETS Method Research Society	GIKEN LTD.
Silver:	Taiwan Foundation Engineering Institute and Taipei Foundation Engineering Institute		
Bronze:	Taiwan Professional Geotechnical Engineers Association	Tung Feng Construction Engineering Co., Ltd.	

Up to now, U-shaped steel sheet piles type 3 and type 4 have been predominantly used in Taiwan. Due to the limited availability of other pile types, the press-in piling method has been almost exclusively used for temporary earth retaining structures and cofferdams. In regards to the market area, the press-in piling method has been mostly utilized in the south of the country due to geographical reasons and ground conditions. Therefore, the IPA feels that there is substantial future potential for the expansion of the press-in piling method in Taiwan. The key factors of the expansion will be the introduction of a wider range of applicable pile types, applicable substructure types and methods for the construction of deeper foundations.

Young Members

Introduction of Recent Initiatives and Bidirectional Cyclic Simple Shear Apparatus on Research of Liquefaction

Atsushi Mohri

Researcher, Port and Airport Research Institute
National Institute of Maritime, Port and Aviation Technology

I completed my doctoral program at the Department of Civil Engineering, Graduate School of Tokyo University of Science in March 2022. My research theme from the master's course onwards is about piles, and I had an opportunity to make a presentation at ICPE2018, Kochi, and ICPE2021, Kochi, while I was in school. In particular, since ICPE2018 was the first international conference for me, it was a memorable experience for me to get a real sense of overseas research situations.

As the theme of my doctoral program, I conducted model experiments on the behavior of ground reaction forces acting on passive piles, targeting the piles used in the steel pipe pile-type breakwater reinforcement method. In this construction method, by installing steel pipe piles in a row on the inner port side of the breakwater, it could be expected that the passive resistance received from the ground on the port side when the piles are displaced should have a reinforcing effect. Since various pile deformation modes could be considered depending on the distribution of the external force acting on the pile, it was necessary to investigate the behavior of the ground reaction force under different deformation modes. Based on the experimental results, I attempted to show this behavior in terms of the magnitude and depth distribution of ground reaction coefficients. However, I thought that the analysis method that examines the differences in ground shear modes (simple shear, compression/extension, rotation) at the ground element level might be more appropriate for such phenomena, so I am currently preparing to implement this theme.

I joined the Port and Airport Research Institute last year. The research themes so far have focused on: (1) the effect of seismic reinforcement of existing coastal parapet levees using high-stiffness sheet pile walls by means of a three-dimensional underwater shaking table, and, (2) the liquefaction test focusing on the effects of shear direction and shear history by using a Bidirectional cyclic simple shear testing apparatus.

In the first research on the seismic reinforcement effect of seawalls, as shown in the Fig. 1, I focus on a structure where a high-stiffness sheet pile wall is to be newly installed on the front side of the parapet, which is a coastal protection facility, and the front side of the ground is to be improved. In this structure, the lower end of the newly installed sheet pile wall is located in the liquefaction layer. Therefore, I am conducting model experiments and a validity check of the analysis model to confirm its subsidence behavior.

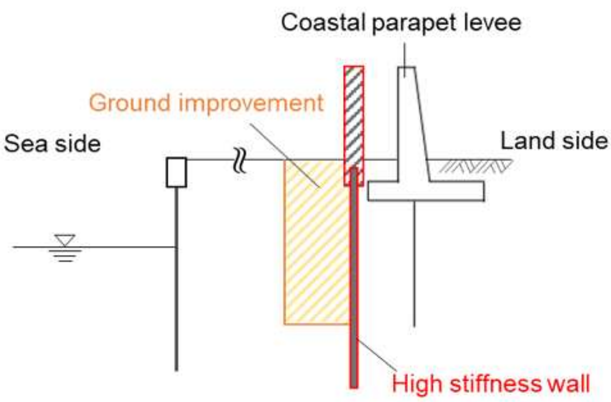


Fig. 1. Cross section of the seawall seismic reinforcement

In the second study on liquefaction, I am using a bidirectional cyclic simple shear apparatus, developed by Dr. Yudai Aoyagi (currently affiliated with the Public Works Research Institute) shown in Photo 1. This test equipment is designed so that the bottom cap under the specimen can move freely in the horizontal plane under back pressure and confining pressure. Moreover, instead of using conventional methods such as wire-reinforced membrane or stacked rigid rings for the K0 condition of the specimen, it adopts a cell pressure-controlled method, which enables detailed examination of the stress state of the specimen. By using the test equipment with these characteristics, I am investigating the effects of multi-directional and irregular seismic motions on liquefaction and re-liquefaction strength. In addition, by further improving this test equipment, I would like to utilize it for my research on the resistance behavior of the ground around piles subjected to horizontal forces at the ground element level.

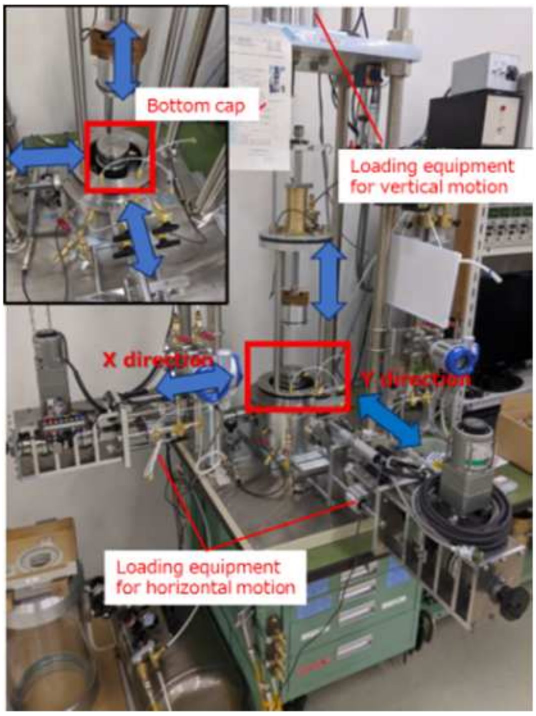


Photo 1. Bidirectional cyclic simple shear apparatus

Young Members

Revised Empirical Method for Predicting the Ultimate Bearing Capacity of Concrete Driven Piles Based on the PDA Results

Kong Sotheara

Instructor, Faculty of Georesources and Geotechnical Engineering
Institute of Technology of Cambodia (ITC)

Deep foundation systems consisting of precast concrete driven piles are commonly used in Cambodia due to the often-challenging geotechnical conditions underlying most project sites. Numerous searchers have proposed empirical methods to predict the ultimate bearing capacity of concrete driven piles based on correlations with in-situ tests such as the Standard Penetration Test (SPT), Cone Penetration Test (CPT), and Pressure Meter Test (PMT) and pile load test results. One of the most widely used empirical methods in Cambodia is that proposed by De Court (1982, 1995), which takes into account both the soil type and method of installation. In De Court's method, the shaft resistance for a pile with perimeter P_i in a soil layer with a SPT N-value of N_i and thickness of Δz_i is given by the relationship:

$$fs = (A_N + B_N \cdot N_i)\, P_i\, \Delta z_i$$

For displacement piles, $A_N = 10$ and $B_N = 2.8$, while for non-displacement piles, A_N ranges between 5 to 6 and B_N ranges between 1.4 to 1.7. The base resistance for a pile with a cross-sectional area of A_b in De Court's method is given by the relationship:

$$q_b = (C_N\, N_b)\, A_b$$

where N_b is the average SPT N-value within the effective depth of influence below the pile base which is often taken to be 3 pile diameters. Values of C_N for different soil types and methods of installation are summarized in the Table 1.

Table 1. C_N Factor for Base Resistance

Soil Type	Displacement Pile	Non-Displacement Piles
Sand	325	165
Sandy Silt	205	115
Clayey Silt	165	100
Clay	100	80

In this study, the correlation between the shaft and base resistance estimated using De Court's Method with estimates obtained from CAPWAP Analysis of High-strain Dynamic Pile PDA Tests performed on driven concrete piles in Cambodia and the Philippines investigated. The number of sites, piles and boreholes used in this is summarized in Table 2.

Table 2. Summary of Data Set

Data Source	Pile Type	Number		
		Sites	Piles	Boreholes
Cambodia	Regular Concrete Driven Pile (Dia. 0.3 x 0.3 & 0.4 x 0.4)	6	23	15
	Spun pile (Outside Dia. 0.35)	1	13	4
Philippine	Regular Concrete Driven Pile (Dia. 0.4 x 0.4, 0.45 x 0.45 & 0.5 x 0.5)	3	15	9

For De Court's Method, SPT N-values were normalized to an overburden of 1 ton/ft^2 and an efficiency 60%. The resulting adjusted SPT value $N_{1,60}$ was used in subsequent calculations used to estimate the side and end resistance using De Court's Method. The analysis of correlation used a linear regression with an assumed zero intercept. Table 3 summarizes the ratio of the estimate based on the PDA test results versus the theoretical estimates based on SPT N-values using De Court's Method, and the corresponding Coefficient of Correlation R^2.

Table 3. Summary of Ratios and Coefficients of Correlations

Data Source	Pile Type	Ratio and Coefficient of Correlation		
		$\frac{f_s (PDA)}{f_s (SPT)}$ R^2	$\frac{q_b (PDA)}{q_b (SPT)}$ R^2	$\frac{Q_{ult} (PDA)}{Q_{ult} (SPT)}$ R^2
Cambodia	Regular Concrete Driven Pile (Dia. 0.3 x 0.3 & 0.4 x 0.4)	2.0847 0.705	0.9846 0.7975	1.7607 0.8400
	Spun pile (Outside Dia. 0.35)	1.5404 0.9781	0.3231 0.8764	1.038 0.9796
Philippines	Regular Concrete Driven Pile (Dia. 0.4 x 0.4, 0.45 x 0.45 & 0.5 x 0.5)	1.141 0.9773	1.0093 0.8960	1.137 0.9773

The ratios summarized in the preceding table can be used to estimate the equivalent PDA side resistance, end resistance, and total axial capacity of driven piles. In all cases, the correlation coefficient was greater than 0.7. The regression model generally tended to slightly underpredict the equivalent PDA resistance based on the theoretical resistance estimated from De Court's Method. Based on the results of this study, it can be concluded that De Court's Method can be used to estimate the equivalent side resistance, end resistance, and total axial capacity of regular concrete piles driven in the Philippines. For Regular concrete piles driven in Cambodia, De Court's Method tended to accurately estimate the equivalent PDA end resistance while underestimating the side resistance by a factor of 0.5. For Spun piles driven in Cambodia, De Court's Method tended to overpredict the PDA end resistance by a factor of 3.0 while overestimating the side resistance by 0.67. The overprediction of the end resistance of spun piles can be attributed to the assumption that the pile tip is closed and thus treated as a displacement pile despite it being open at the start of driving. One explanation for the difference between piles driven in the Philippines and Cambodia concerning the factor for side resistance is that in the Philippines, the practice is to proof-test the pile to double the design load. In contrast, in Cambodia, piles are generally tested to three times the design load.

◆ A brief CV of Mr. Kong Sotheara

Kong Sotheara is an Instructor at the Faculty of Georesources and Geotechnical Engineering, Institute of Technology of Cambodia (ITC). He is also a student in the MS Civil Engineering (Geotechnical Engineering) Program of the University of the Philippines Diliman. His areas of expertise are in the general area of pile foundations and stability of MSE Walls. He graduated with an Engineer's degree in Georesources and Geotechnical Engineering, Faculty of Georesources and Geotechnical Engineering (GGE) from Institute of Technology of Cambodia (ITC).

Announcement

Recent Highlights in the Press-in Piling Industry

IPA Secretariate

1. **"RED HILL 1967" A facility to witness and experience the superiority of the Press-in Technologies opens**

News Articles by GIKEN LTD.: https://www.giken.com/en/release/02_jun_2023/

GIKEN LTD. has opened the Information Transmission Base "RED HILL 1967", a facility for expanding the awareness of the superiority of press-in technologies located in Akaoka-Cho, Konan City, Kochi Prefecture. The facility was already shown to stakeholders, prior to the start of accepting tours for the public on 16 May.

2. **World Heritage-listed Canal Quay Wall Renovation Project in the Netherlands Receives Japan Construction International Award**

News Articles by GIKEN LTD.: https://www.giken.com/en/release/12_jun_2023/

GIKEN Group is participating in a project to renovate the quay walls of World Heritage-listed canals in the Netherlands. The project has received an award in the Pioneering Activity Category of the 6th Japan Construction International Award of the Ministry of Land, Infrastructure, Transport and Tourism of Japan (MLIT). This category recognizes activities that contribute to the realization of high-quality infrastructure overseas.

3. **Dakar Port No. 3 Terminal Renovation Project in Senegal Receives Outstanding Civil Engineering Achievement Award [Group-2] from Japan Society of Civil Engineers**

News Articles by GIKEN LTD.: https://www.giken.com/en/release/13_jul_2023/

GIKEN SEKO CO., LTD., a company of GIKEN Group is participating in a Japanese Official Development Assistance (ODA) project in Senegal. This project, the Dakar Port No. 3 Terminal Renovation Project, has received a 2022 Outstanding Civil Engineering Achievement Award from the Japan Society of Civil Engineers (JSCE). The award is given to groundbreaking projects that make important contributions to the development of civil engineering technology and to the development 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
■ **International Society for Soil Mechanics and Geotechnical Engineering** http://www.issmge.org/events		
11TH INTERNATIONAL CONFERENCE ON SCOUR AND EROSION (ICSE-11)	17-21 September 2023	Copenhagen, Denmark
INTERNATIONAL CONFERENCE ON "CASE HISTORIES IN GEOTECHNICAL ENGINEERING" & 4th AsRTC6 URBAN GEOENGINEERING SYMPOSIUM	25-28 September 2023	West Jakarta, Indonesia
THE SECOND MEDITERRANEAN SYMPOSIUM ON LANDSLIDES	5-7 October 2023	Hammamet, Tunisia
First International Conference on Geotechnics of Tailings and Mine Waste	24-26 October 2023	Ouro Preto, Brazil
21st Southeast Asian Geotechnical Conference and 4th AGSSEA Conference (SEAGC-AGSSEA 2023)	25-27 October 2023	Bangkok, Thailand
The 5th International Conference on Geotechnics for Sustainable Infrastructure Development	14-15 December 2023	Hanoi, Vietnam
■ **Deep Foundations Institute** https://www.dfi.org/events/		
DFI-India 2023: 12th Annual Conference on Deep Foundation Technologies for Infrastructure Development in India	5-7 October 2023	Vadodara, Gujarat, India
48th Annual Conference on Deep Foundations	31 Oct. -3 Sep. 2023	Seattle, United States
■ **Others**		
2nd International Conference on Construction Resources for Environmentally Sustainable Technologies	20-22 November 2023	Fukuoka, Japan

Corporate Members

Takeuchi Crane Industry
竹内クレーン工業
Japan

Mizuho Jyuki Co., Ltd.
有限会社 瑞穂重機
Japan

IZUMO GIKEN LTD.
株式会社 出雲技研
Japan

MIYAZAKI KISO CONSTRUCTION Co. Ltd
宮崎基礎建設 株式会社
Japan

DAIWA-KIKO CO., Ltd
大和機工 株式会社
Japan

NARASAKI SANGYO CO., LTD.
ナラサキ産業 株式会社
Japan

TUNGALOY CORPORATION
株式会社 タンガロイ
Japan

NIPPON STEEL CORPORATION
日本製鉄 株式会社
Japan

Sakiyamagumi, Ltd
株式会社 崎山組
Japan

JFE Steel Corporation
JFE スチール 株式会社
Japan

Endo Kogyo Co., LTD.
株式会社 遠藤工業
Japan

MC Chugoku Construction Machinery Co., Ltd.
エムシー中国建機 株式会社
Japan

Fuji Tokushu Co., Ltd.
株式会社 フジ特殊
Japan

SATO JUKI Corporation
株式会社 佐藤重機建設
Japan

Ishii Kiso-Contstruction Co., Ltd.
株式会社 石井基礎工事
Japan

SHANGHAI TRUST MACHINERY IMPORT & EXPORT Co., Ltd.
China

GIKEN LTD.
株式会社 技研製作所
Japan

SUGISAKI KISO CO., LTD.
杉崎基礎 株式会社
Japan

Guan Chuan Engineering Construction Pte Ltd
Singapore

Kuroda Tekkou Co., Ltd.
有限会社 黒田鉄工
Japan

Akatsuki Industrial Co., Ltd.
株式会社 暁産業
Japan

YOKOHAMA INDUSTRIAL PRODUCTS JAPAN CO., LTD KINKI COMPANY
横浜ゴムMBジャパン 株式会社 近畿カンパニー
Japan

株式会社 角藤
KAKUTO CORPORATION
Japan

Oobu Co., Ltd
Japan

Yagojidousha Seibi Koujyou Co., Ltd.
株式会社 矢後自動車整備工場
Japan

Yokoyama-Kiso Co., Ltd.
株式会社 横山基礎工事
Japan

ITOCHU TC CONSTRUCTION MACHINERY CO., LTD.
伊藤忠TC建機 株式会社
Japan

CKK GROUP
中部工業 株式会社
Japan

FUJIIGUMI Co., Ltd.
株式会社 藤井組
Japan

SHANGHAI TUNNEL ENGINEERING CO., LTD.
China

Corporate Members

KAKIUCHI Co., Ltd.
株式会社 垣内
Japan

CHIBAKOBEX Co., Ltd
株式会社 千葉コベックス
Japan

株式会社ヨネイ
YONEI & CO., LTD.
Japan

SANKOH MACHINERY CORPORATION
三興機械 株式会社
Japan

RINKO KORPORATION
株式会社
リンコーコーポレーション
Japan

Daishin Kikou Co., Ltd.
有限会社 大晋機工
Japan

CITEC INC.
シーアイテック 株式会社
Japan

DAIICHI KISO CO., LTD.
株式会社 第一基礎
Japan

Kajikawa Construction CO., LTD
株式会社 梶川建設
Japan

THE BANK OF KOCHI, LTD.
株式会社 高知銀行
Japan

Sakamoto Sangyo Co., Ltd.
サカモト 産業株式会社
Japan

THAI FULLMORE CO., LTD
Thailand

株式会社カナモト
Kanamoto Co., Ltd.
Japan

株式会社 小澤土木
Ozawa Civil Engineering and Construction Co. Ltd.
Japan

GIKEN SEKO CO., LTD.
株式会社 技研施工
Japan

Kyoeisangyo co., Ltd
共栄産業 株式会社
Japan

Maruka Corporation
株式会社 マルカ
Japan

CHOWA KOUGYOU KYUSYU CO., LTD.
調和工業九州 株式会社
Japan

株式会社エスイージー SEG
スペシャル・エンジニアリング・グループ
SEG Corporation
Japan

Editorial Remarks from persons in charge

We are pleased to publish the September issue. This issue emphasizes the idea of the 'seeing is believing' basis and introduces various research and development activities, including analytical ground visualization, and examples of applications in the USA. In addition, the IPA Board meeting and related events and a seminar in Taiwan will be reported.

Record-breaking heat continues in Japan, with temperatures approaching 40℃ above body temperature in many places, expected to continue into September. In July, the UN chief issued a warning that “the era of global boiling has arrived”, and extreme heat waves are occurring in several regions of the Northern Hemisphere, including southwestern USA, Mexico and southern Europe, as well as Japan and China. This has resulted in higher sea water temperatures, more frequent hurricanes and stronger typhoons, and in some areas large-scale fires. We must make sure that we tackle these climate change-induced disasters. The Press-in Method has achieved a great deal in disaster countermeasures and disaster recovery, and research and development is underway to make further contributions. The International Press-in Association would like to deepen the discussion with the directors and members on what we can do.

The 3rd International Press-in Conference will be held next year on 3-5 July 2024. The theme of this international conference is 'Superiority of press-in piling towards sustainable construction in tackling climate change for infrastructure development' The deadline for submission of abstracts has been extended to 31 October 2023 (https://2024.icpe-ipa.org/abstracts). We look forward to discussing with you at this international conference.

Shinji Taenaka

Tsunenobu Nozaki