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ICPE 2024, Singapore: Call for Abstract

Chun Fai Leung

Press-in technology is now commonly adopted for the installation of sheet pile walls and other types of foundations and structures in many countries worldwide. The method is proven to be safe, efficient with substantial time saving. In the near future, it is forseeable that press-in technology will be widely used for construction works related to the sustainability of mankind and migitation measures against climate change and disasters. These include the installation of seawalls using the technique against rising sea level, coastal protection, flooding, tsunami attacks, and providing stronger resistance to earthquake. Other works include environmental friendly construction, retaining structures reducing the impacts of landslides and muflows as well as volcanic eruptions.

In view of the above, the **3rd Intenational Conference on Press-In Engineering (ICPE-2024)** will be held in Singapore from 3 to 5 July 2024 with the theme 'The Superority of Press-In Piling towards Sustainable Construction in Tackling Climate Change for Infrastructure Development'. Researchers and practioners will gather in Singapore to present studies related to various press-in piling issues. Keynote speakers will be invited to deliver case studies related to the conference theme.

Authors are cordially invited to submit their abstracts to follwing URL or scan the QR code.

URL: https://2024.icpe-ipa.org/abstracts

Special Contribution

Potential role of Press-in Piling to increase the resilience of critical infrastructure in Europe

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Introduction

Extreme weather events can have catastrophic consequences on critical infrastructure such as flood defences (dykes) and transport networks. The decade from 2011 to 2020 was the warmest on record. A significant impact of rising temperature is frequent and intense precipitation events. Governments and infrastructure owners need to make informed decisions on investments that evaluate the risk of climate change and the benefits that accrue from making investments in mitigation and adaptation measures. However, these decisions are inherently uncertain and solutions should be implemented that minimize the whole life-cycle costs considering financial and environmental costs. To limit their exposure, infrastructure owners have been trying to move towards more proactive asset maintenance approaches. These allow them to invest money in a prudent, sensible fashion, which maximizes utility and subsequently gives the best return on their investment. European industry and academia have successfully used the European Framework research programs such as FP7, Horizon Europe, etc. to foster collaboration at a European level and deliver research excellence. The programs value impact in societal problems. A number of individual projects, e.g. SMART RAIL - Smart Maintenance and Analysis of Transport Infrastructure (https://cordis.europa.eu/project/id/285683) developed of state of the art methods to analyze and monitor existing transport infrastructure (such as bridges, tunnels and earthworks) and make realistic scientific assessments of safety. These engineering assessments of the current state were used to design remediation strategies to prolong the life of existing infrastructure in a cost-effective manner with minimal environmental impact. Later projects including Destination Rail -Decision Support Tool for Rail Infrastructure Managers (https://cordis.europa.eu/project/id/636285) developed decision support tools to allow infrastructure managers to increase network safety and reduce the cost of investment by using the information management systems, IMS to manage the network. These IMS used data from monitoring and real-time analyses to prevent unnecessary line restrictions and closures, achieved lower maintenance costs by optimizing interventions in the life cycle of the asset and optimized traffic flow in the network. The potential of artificial intelligence algorithms to assist in real-time object detection and predict asset degradation was developed in GoSAFE RAIL - Global Safety Management Framework for RAIL Operations (https://cordis.europa.eu/project/id/730817). Many of the early projects focused on Rail Networks. This was because a large proportion of the European rail infrastructure, bridges, tunnels and earthworks was developed from the 1850s. Given their age and form of construction, many of these assets are particularly vulnerable to climate impacts. The techniques developed were applied to critical infrastructure across the road, rail and inland waterway modes in the SAFE-10 - Safety of Transport Infrastructure on the TEN-T Network (https://cordis.europa.eu/project/id/723254).

As geotechnical engineers, we know that quantifying the interaction of soil and water is crucial for understanding the response of the ground. Geotechnical engineers can be at the forefront of tackling the challenge of changing climate primarily through mitigation (increasing the resilience of existing infrastructure) and through adaptation, (developing ways to harness low emission technologies to reduce Co2 emissions). The Press-in method of installation significantly reduces environmental impacts by minimizing noise and vibrations. The very advanced, largely automated systems increase worker safety. From an engineering perspective, the piles are installed in such a way that they maximize the available soil resistance and thus are immediately available to resist external loads resulting in a foundation system that is proven reliability against external loads and natural disasters. In this article, we consider a few critical applications where Press-in piles can provide excellent solutions to problems faced by infrastructure owners.

Transport Infrastructure

Europe needs a safe and cost-effective transport network to encourage movement of goods and people within the EU and towards major markets in the East. This is central to European transport, economic and environmental policy. Historic levels of low investment, poor maintenance strategies and the deleterious effects of climate change (for example scour of bridge foundations due to flooding and rainfall induced landslides) has resulted in critical elements of the rail network such as bridges, tunnels and earthworks being at significant risk of failure. The consequence of failures of major infrastructure elements is severe and can include loss of life, significant replacement costs (typically measured in millions of Euro's) and line closures which can often last for months.

Bridge Scour

Scour refers to the erosion of foundations soils during flood events is a leading cause of bridge collapse worldwide, Forde et al. (1999). A study by Wardhana & Hadipriono (2003). found that over 50% of the 500 bridge failures that occurred in the United States in an 11-year period were the result of flooding and scour problems. This issue presents a significant cost burden on bridge owners and managers worldwide between inspections, scour protection installation and repairing damage caused by the occurrence of scour. Scour failures typically occur quite suddenly and generally, without warning, potentially leading to loss of life. An example is the failure of Malahide Viaduct Rail Bridge on the TEN-T network between Dublin and Belfast in Ireland, See Fig. 1(a).

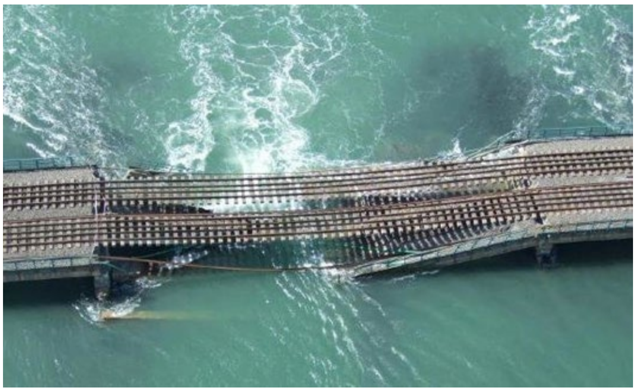

Fig. 1. (a) Bridge failure due to scour

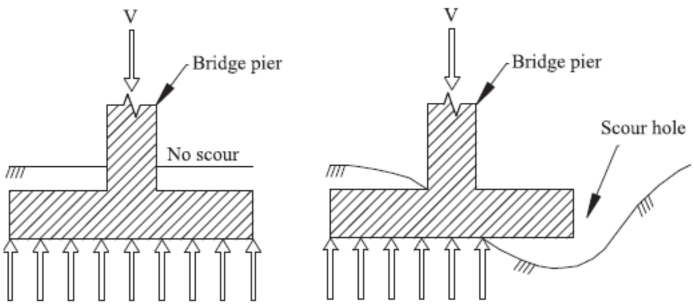

Fig. 1. (b) Mechanism of scour beneath a shallow foundation

The mechanism causing scour failure of a shallow foundation occurs as soil is removed from beneath a part of a shallow foundation, the soil beneath the part of the foundation still in contact becomes over-stressed and rotation will occur. Engineering solutions include; (i) allowing scour to occur and providing discrete structural piles that through the existing foundation (e.g. using the Gyropress system) in order to transfer the structural loads to deeper, more competent soils unaffected by scour or (ii) providing an enclosing structure that prevents scour under the structure, See Fig. 2. The unique clamping mechanism of the Giken piling system allows for remedial works to be undertaken even where scour is already in progress as described by Takuma et al. (2019)

Fig. 2. (a) Press-in piling solution for scour

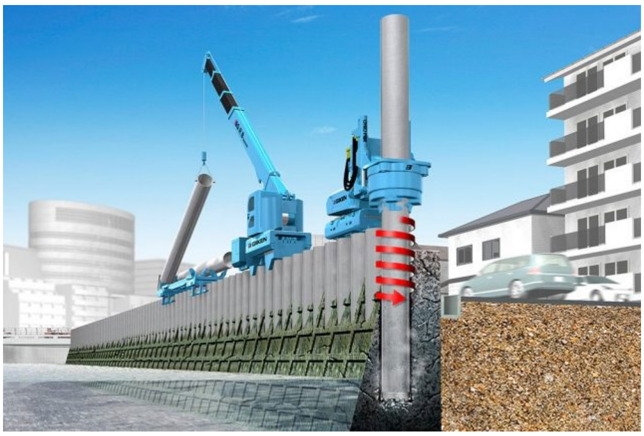

Fig. 2. (b) Gyropress system

Slope Stability

Whilst modern transport infrastructure benefits from engineered slopes, many slopes along railway networks were built more than 100 years ago, before modern design standards existed. As a result, the average angle of these slopes is usually much higher than would typically be permitted for modern transport infrastructure. Common problems affecting slopes are shallow (typically less than 2m deep) translational landslides caused by high rainfall; See Fig. 3a and deep-seated rotational failures caused by weak subsoils which are triggered by increased loading and/or changes in location of the water table level.

Fig. 3. (a) Example of shallow translational slip causing train derailment

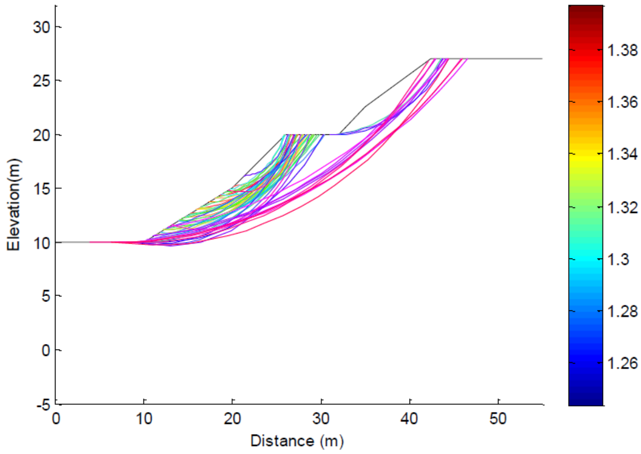

Fig. 3. (b) Analyses showing a range of shallow and deep failure mechanisms with similar Factors of Safety, ranging from 1.26 to 1.38.

Engineering solutions can be determined for the most likely failure mechanism, see Stipanovic et al. (2021). Reale et al. (2015) show that for a given slope, the two potential failure mechanisms might exist with very similar probabilities of failure, See Fig. 3b. Press-in piling methods The solution shown in Fig. 4 provides a solution for both failure mechanisms and can be implemented without interference to the rail traffic.

Fig. 4. (a) Implementation of an embedded retaining wall

Fig. 4. (b) Maintenance of traffic flow during construction works

Port Infrastructure

European Ports play a key role in vital supply-chains. They also act as hubs for interconnecting different transport modes. Challenges facing challenges including (i) increasing vessel size requiring deeper ports, (ii) coping with rising sea-levels and riverine flooding and (iii) providing adequate facilities to support the energy transition. The Port of Rotterdam situated close to Delft is one of the largest ports in the world. The Port of Rotterdam Authority invests in sustainable and future proof design solutions with the aim to reduce the port's CO_2 emissions by 50% in 2030 and achieve a zero-carbon footprint by 2050. One of the key steps in this process is optimizing the design of all the components of port infrastructure such as quay walls. The Port is currently constructing deep-sea quays in an area of land reclaimed from the North Sea known as Massvlakte II. A typical cross-section is shown in Fig. 5a. The primary soil retaining combi-wall is comprised of closely spaced open-ended tubular piles. The concrete relieving platform is supported by axially loaded piles, whilst additional horizontal resistance is provided by tension anchors. For the very deep seawall anchor capacities > 10 MN are provided by Muller Verpress (MV) tension piles. These consist of a steel I-beam impact driven into the soil whilst injecting grout under pressure through two grout pipes mounted at the pile toe. The Port Authority has invested significant resources in proof-load testing of the axial load piles in recent years through a research project, Improved Axial Capacity of Piles in Sand project, funded through Het Topconsortium voor Kennis en Innovatie (TKI) Deltatechnologie and seven industry partners: Delft University of Technology, Deltares, Dutch Association of Piling Contractors (NVAF), Dutch Ministry of Infrastructure and Water Management, Fugro, Port of Rotterdam Authority and the Municipality of Rotterdam. As part of this project axial load tests were performed on the most commonly adopted pile types in the Port of Rotterdam, See Fig. 5. Namely, precast concrete driven piles, driven cast-in place piles and screw-injection piles. Loads of to 25 MN were applied to cause geotechnical failure of the fully instrumented piles.

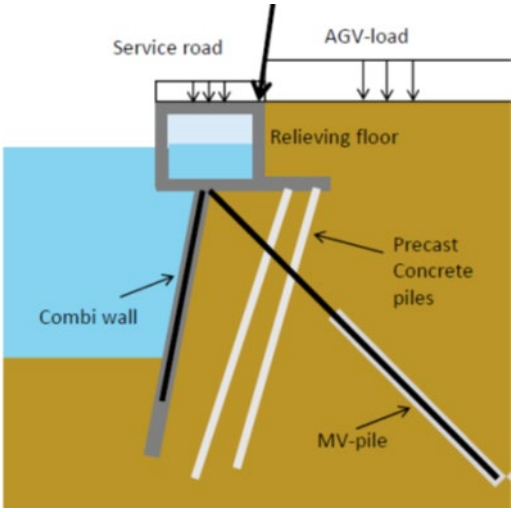

Fig. 5. (a) A typical deep sea quay wall

Fig. 5. (b) Axial load test set-up

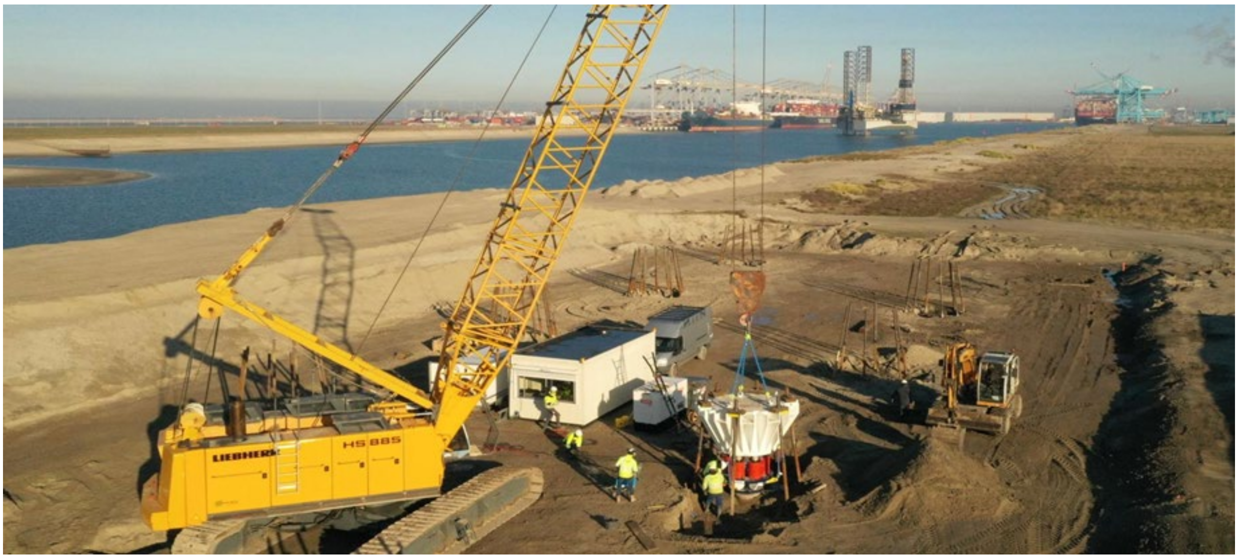

Fig. 5. (c) Overview of test site

One of the primary objectives of this field test program was to investigate whether limiting values of pile shaft and base resistance, prescribed in design codes were too conservative in the dense sand deposits encountered in port. Whilst CPT values are typically higher than 30 MPa in the sand later where piles are founded, a limit of 15 MPa is set for the base resistance and in the case of the shaft resistance, the q_c profile is limited to 12 MPa for layers less than one meter in thickness, and 15 MPa for layers greater than one meter in thickness. The load test results indicated that limiting resistance was not required. The impact of removing the limiting values is shown in Fig. 6a with respect to pile volume and 6b regarding the financial and environmental costs (considering only material volume).

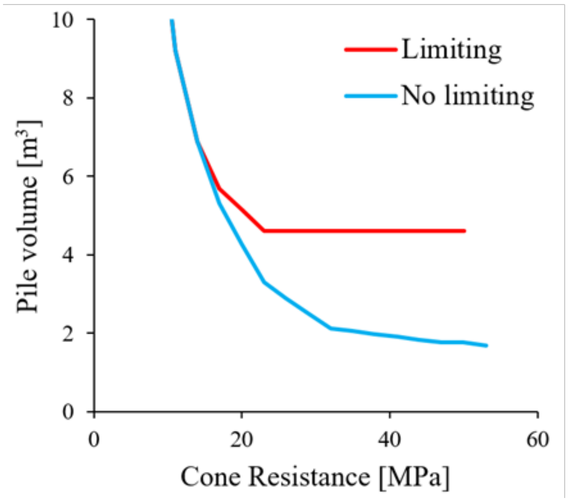

Fig. 6. (a) Impact of cones resistance on pile volume obtained for each realization using the NEN 9997-1 design method with and without limiting resistances

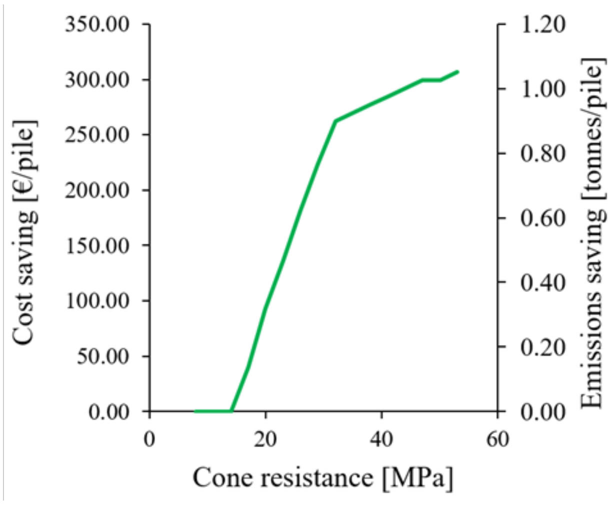

Fig. 6. (b) Resulting savings from utilizing the design method without limiting resistances compared to the design method with limiting resistances

The load tests also revealed that installation method, quality control of pile construction and time were significant factors for the Port authority in choosing a pile system. The research program encourages other pile types to be tested in the geotechnical conditions prevalent at the Port and a Push-in systems could have many benefits that could prove to be commercially attractive over the life cycles considered in Port infrastructure projects.

Urban Quay Walls

Historic quay walls provide the unique character of many Dutch cities. However, their age and various deterioration mechanisms have led to huge challenges in preserving these cultural heritage items. Many local authorities in the Netherlands are engaged in research and market consultation on how to prolong the life of these structures. Given the constraints of space, the need to minimize noise and vibration in the historic city center locations, where heritage buildings are founded on deep, soft clay deposits, Press-in piling has many advantages over conventional construction systems. From their European headquarters in the Netherlands, Giken piling work closely with local partner organizations to provide solutions. A recent project, Lijnbaan in the Hague involved reconstruction of 44m of quay wall using an F301-G1000 machine, See Fig. 7a. A key constraint at the site was that existing trees were to be preserved and construction works were very tightly scheduled as the canal has very high traffic volumes and work had to be completed before the tourist season. G-Kracht B.V., a joint venture company established predominantly by GIKEN Europe B.V. recently completed the pilot phase of a quay wall renovation project in Amsterdam, See Fig. 7b.

Fig. 7. (a) Reconstruction of a section of quay wall at Lijnbaan, Den Haag

Fig. 7. (b) The renovation project in Amsterdam

The municipality of Amsterdam is particularly concerned about quay wall stability in the city following a recent quay wall collapse. As a result, it is investing heavily in a research program, led by the Dutch research agency, NWO to investigate about 200 kilometers of quay walls, and where necessary, to restore these. societal partners to search for solutions within this challenging area. TU Delft are heavily involved in the entire program, including the UrbiQuay project led by the University of Twente which will develop an integrated life-cycle assessment tool to allow owners to decide on lifetime extension measures for their quay walls. Building on their work at the Port of Rotterdam, the geotechnical engineering group at TU Delft will develop an assessment method to quantify the actual safety level of the existing quay walls and thus quantify any structural upgrade solutions.

Summary

There are a wide range of markets for which Press-in piling systems can provide solutions for both private and public sector clients in the EU. At the moment one of the most exciting markets for both companies and researchers is the offshore renewables market. Many EU governments have proposed ambitious targets for the development of offshore wind in particular in the coming years. The supply charge is still being constructed for most of these projects. Offshore floating wind is one of these new markets. Foundation systems will have to provide long-term resistance to cyclic loading. Research on traditional piling systems has shown that installation actually significantly damages the soil resistance required to withstand the loading experienced. Press-in piling could significantly mitigate this damage whilst providing an environmentally friendly solution for many developments. The method also addressed many of the objectives expressed the European Commission in policy documents on the future of Europe. The automation processes were developed to provide benefits in worker safety and quality of life. The systems provide data during installation that is vital for the new wave of digital twins that are being created. Giken Ltd. is already engaged in collaborative projects through the International Press-In Association, IPA and directly through collaboration in EU Horizons research projects e.g BEEYONDERS' – Breakthrough European technologies Yielding construction sovereignty, Diversity & Efficiency of Resources (https://beeyonders.eu/project/). This project led by Acciona Construction aims to make extensive use of AI, automation, and digitization and demonstrate these techniques in real-world applications, including quay wall constructions.

References

Forde, M. C., McCann, D. M., Clark, M. R., Broughton, K. J., Fenning, P. J., & Brown, A. (1999). Radar measurement of bridge scour. Ndt & E International, 32(8), 481-492. https://doi.org/10.1016/S0963-8695(99)00026-2

Reale, C. Xue. J, Pan, Z and Gavin, K. (2015) Deterministic and probabilistic multi-modal analysis of slope stability, Computers and Geotechnics, Volume 66, May, Pages 172–17.

Stipanovic, I. Allah-Buksh,Z. Reale, C. and Gavin, K. (2021) A multi-objective decision making model for risk-based maintenance scheduling of railway earthworks, Applied Sciences Special Issue, Vol. 11, No.9, pp 965.

Takefumi, T, Nishimura, H. and Nagano, M (2019) Emergency bridge abutment repair with pressed-in pipe piles, Proc. 8th International Conference on Case Histories in Geotechnical Engineering.

Wardhana, K., & Hadipriono, F. C. (2003). Analysis of recent bridge failures in the United States. Journal of performance of constructed facilities, 17(3), 144-150. https://doi.org/10.1061/(ASCE)0887-3828(2003)17:3(144)

Directors' research and development activities

Analysis of load-settlement behavior in bi-directional static load tests of bored piles

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Abstract

The presence of soft-toe conditions is a common problem of cast-in-place bored piles. This paper describes a modified method for obtaining the equivalent pile head load-settlement curve from the results of bi-directional pile load tests. The modified method considers soft-toe conditions in which the load-displacement along the side and toe of the pile are estimated using cubic-spline interpolation in place of the traditional hyperbolic approximation. The proposed method is applied to test data obtained from BDT data to illustrate the method and compare the resulting equivalent pile-head load-settlement obtained from the conventional method of analysis.

I. Introduction

Cast-in-place bored pile foundations are a commonly used foundation scheme in the Philippines. Bored pile foundations offer several advantages over pre-cast reinforced concrete pile foundations: less vibration and potential for damage to adjacent structures, less wastage because piles are cast to the required length, and greater capacity to resist large lateral loads and bending moments. Bored piles tend to be larger in diameter, carry larger loads, and are often more expensive when compared to driven piles with similar axial capacity. Bored piles generally range in diameter from 0.8m to 3.6m, although the majority of bored piles constructed in the Philippines are between 1.0m to 1.2m in diameter.

Because bored piles are larger than driven piles, they generally carry larger loads. This allows a single bored pile to replace a group of driven piles and avoids pile-group interaction effects. However, the reduced redundancy has serious consequences since the failure of a single bored pile may be catastrophic. This emphasizes the need for proper pile testing to ensure that the pile has sufficient capacity to carry the design load within set displacement tolerances. In the Philippines, piles are tested using both the static load and the high-strain dynamic tests. In the conventional static pile load test, a load frame is supported on four reaction piles constructed so that the test pile is placed in the middle of the load frame. A hydraulically driven load cell is placed on the top of the test pile, which pushes down on the test pile. The test pile is instrumented with displacement transducers at the top of the pile to measure settlement at the top of the pile. From the results of the test, a load settlement plot is obtained from which the ultimate load can be estimated.

II. Bi-directional Static Load Test

An alternative to the conventional static load test is the bi-directional (BDT) test (ASTM D8169-18), in which a load cell is installed within the pile. The BDT test was first proposed and developed by Osterberg [1]. Since its inception, the Osterberg Load Cell test has undergone numerous modifications and improvements [2]. Fig. 1 shows a typical setup for a bi-directional static load test. The test involves the use of a load cell embedded into the pile. The load cell is ideally installed at the equilibrium point within the pile, which corresponds to the estimated point at which the ultimate side and end-bearing resistance are simultaneously reached during the loading of the cell. The equilibrium point is estimated based on the preliminary computations needed to estimate the pile capacity. Installation of the load involves first fabricating the rebar cage of the upper and lower segments of the pile separately and then welding the two segments together with the cell sandwiched between the two segments. Strain gauges can be attached to the rebar cage at selected locations in the upper segment of the pile allowing the variation in axial load to be estimated and these selected points to be estimated. In general, strain gauges at not installed below the Osterberg cell due to difficulties in passing wires from strain gauges to the data acquisition system at the ground surface through the load cell. The completed load cell is then placed in the pre-drilled shaft prior to concreting of the pile.

When compared to conventional top-loaded static pile load tests, BDT tests are safer, require less space to perform, and do not require reaction piles. Provided that the load cell is installed close to the equilibrium point, bi-directional loading enables the pile to be tested to double the load cell capacity. The most notable advantage of BDT is its ability to simultaneously monitor the load settlement behavior of the upper and lower segments of the pile separately.

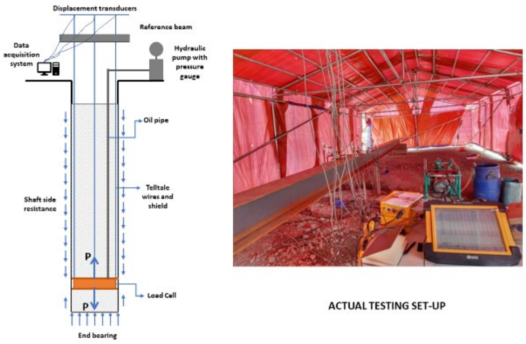


Fig. 1. Bidirectional test setup (from Gong et al. 1984 [4])

During testing, pressure in the load cell is measured by a manometer, and the displacement is measured by means of tell-tale rods and displacement transducers. Pressure to the load cell is applied by a high-pressure oil pump on the ground surface. During loading, the load cell expands, pushing the upper shaft upward and the lower shaft downward. The displacement resulting from resistance in the upper segment and the combined side and base resistance for the lower segment of the pile shaft are measured separately and result in two load-settlement curves for the upper segment and lower pile segment.

One of the challenges in interpreting results from the bi-directional pile load test is obtaining the equivalent load-settlement curve corresponding to a conventional top-loaded static pile load test. The pile head settlement in bi-directional static loading tests is calculated based on: (1) the side shear load-displacement curve, obtained from the upward movement of the top of the load cell, and (2) the end bearing load-displacement curve, obtained from the downward movement of the bottom of the load cell. The original method assumes that: the pile is a rigid body, the movements of the pile head and bottom are the same, and the upward skin friction is equal to the downward skin friction. The equivalent pile head settlement is obtained by adding the side friction to the end-bearing load at the same deflection. However, neglecting the portion of the elastic shortening of the pile results in an underestimation of the pile-head settlement when the load-displacement curve is computed using the original method. The magnitude of the underestimation increases with increasing pile length. In order to address this limitation in the original method, Fellenius et al. [3] used the finite element method to obtain the equivalent top-loaded load-settlement curve from BDT results.

It can be shown that bearing capacities and the factors of safety decrease when elastic compressions of the piles are considered. Gong et al. [4] proposed precise and approximate conversion methods based on the theory of elasticity. Lee and Park [5] proposed a simplified elastic method for constructing a realistic pile load-settlement curve. In the simplified elastic method, a shape factor dependent on skin friction distribution is assumed for calculating the elastic shortening of the piles. The proponents of this method present empirical evidence based on pile load tests to show that the equivalent load-settlement curve obtained from BDT results using the simplified elastic method is similar to those obtained from conventional top-loaded static pile tests. The following section describes the simplified elastic method.

III. Construction of the equivalent load settlement curve

This section describes the modified procedure involved in constructing the equivalent load settlement curve for the BDT assuming a deformable linear elastic pile as described in [5]. Derivation of the closed-form expressions for computing the elastic shortening of the pile, which are not included in [5], is first discussed, after which their use in constructing the equivalent load settlement curve is explained.

3.1 Bottom loaded pile

The elastic shortening of δ_0 of a pile with constant stiffness AE and length L subjected to an upward force Q_{net} applied to the bottom of the pile, and downward side resistance is given by the equation:

$$\delta_0 = (1 - c_1)\frac{Q_{net}L}{AE} \tag{1}$$

where the parameter c_1 depends on the distribution $f(z)$ of the side resistance along the length of the pile according to the equation:

$$Q_{net} = \int_0^L f(z)dz \quad c_1 = \int_0^L z\,f(z)dz / Q_{net} \tag{2}$$

The value of c_1 for each load step in the BDT is calculated from the elastic shortening δ_0 of the upper segment of the pile. In this case, the load Q_{net} represents the difference between the load Q applied by the load cell, and the buoyant weight W_b of the upper segment of the pile. It should be noted that the load cell must overcome W_b before the pile segment can displace upward. The elastic shortening at each load step of the test is determined from the displacement of the top of the load cell, corresponding to the bottom of the upper pile segment, and displacement at the top of the upper segment of the pile, which are routinely measured at each load. Consequently, the value of c_1 for each load $Q_{net} = Q - W_b$ can be computed only for values Q is greater than W_b.

3.2 Top loaded pile

The elastic shortening δ_L of a pile with constant stiffness AE and length L subjected to a downward force Q_T applied to the top of the pile at the ground surface, an upward force Q_b applied to the bottom of the pile, and an upward side resistance varying along the of the pile according to the function $f(z)$

$$\delta_T = c_1 \frac{Q_T L}{AE} + (1 - c_1)\frac{Q_b L}{AE} \quad (3)$$

The expression for δ_L as given in equation (3), is used to estimate the elastic shortening for both the lower pile segment of a BDTs and conventional top-loaded pile test, in which Q_T is the load applied at the top of the pile, $Q_b = Q_T - F$, and F is total side resistance.

3.3 Approximation load-settlement curves from bi-directional pile tests

In the original procedure developed by Osterberg [1], the load-settlement curves obtained from the bi-directional load test are separately approximated using the hyperbolic relationship proposed by Konder [5]:

$$P = \frac{u}{a + b\,u} \quad (4)$$

in which P is the load corresponding to a settlement u. The parameters a and b are parameters obtained by fitting the results of the Bi-directional pile load test into equation (4). Separate values of a and b are obtained for the upward and downward load-settlement curves, such that the end-bearing load Q_B and side resistance Q_s are approximated according to the following hyperbolic relationships:

$$Q_B(u) = \frac{u}{a_B + b_B u} \quad (5)$$

$$Q_s(u) = \frac{u}{a_s + b_s u} \quad (6)$$

Gross test loads are used in the regression analyses to determine the parameters a_B, b_B, a_s and b_s. Value of Q_S and Q_B are valid only for values of u within the range of the test data.

The first approximation to the load-settlement curve is obtained by solving for the top load corresponding to a given displacement u using equation (5) for the lower pile segment and equation (6) for the upper pile segment is given b:

$$Q_T(u) = Q_s(u) + Q_B(u) - W_b \quad (7)$$

Although equation (7) assumes that the pile behaves as a rigid body, some elastic compression due to Q_s is included in u. To correct this, the elastic compression δ_0 in a pile due to Q_s is computed using equation (7). Using $Q_T^*(u_1)$ and equation (3), the elastic compression δ_T in a top-loaded pile is computed and added to u_1 to give the settlement u_1^* corresponding to Q_T^*. The values of u_1^* and Q_T^* are plotted to give the load-settlement curve for the equivalent top-loaded pile. Although the specific distribution of skin friction $f(z)$ along the pile is not known. The coefficient c_1 can be computed from equation (1) using the BDT load-displacement data from the upper pile segment.

For cases involving bored piles with soft-toe conditions, the load-displacement curve may deviate significantly from a hyperbolic relationship depending on the extent of the soft-toe conditions. For such cases, the author suggests using cubic spline interpolation, which has the ability to represent more complex relationships. Cubic spline interpolation is a numerical method for fitting a curve through a given finite set of data points in a piecewise manner using third-order polynomials. The results curve is smooth and continuous until the second-order derivatives. For purposes of this study, cubic spline interpolation was performed using a subroutine function based on Press et al. [7]. The proposed method involves replacing Equations (5) and (6) with:

$$Q_B(u) = \Phi(u, \hat{u}_B, \hat{Q}_B) \quad (8)$$

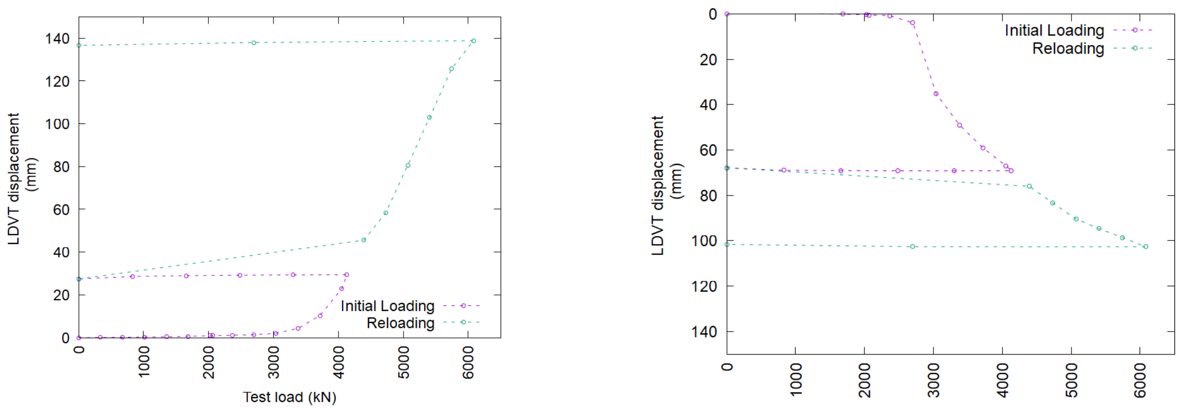
$$Q_s(u) = \Phi(u, \hat{u}_S, \hat{Q}_S) \quad (9)$$

where Φ is the cubic interpolation function $(\hat{u}_B, \hat{Q}_B)$ are the load-displacement data from the lower segment of the BDT, and $(\hat{u}_S, \hat{Q}_S)$ are the load-displacement data from the upper segment of the BDT. The remaining steps of the procedure remain the same.

IV. NSCR Project Test pile TP-3

The North-South Commuter Railway (NSCR) Project involves the construction of a 146-kilometer railway system in the Philippines connecting the National Capital Region with the provinces of Laguna in the south and Pampanga in the North. Since many parts of the railway system lie on sites underlain with soft clays and liquefiable sand, pile foundations are widely used in many structures in the system. This section describes the analysis of the BDT performed on a bored part within the NSCR System.

The test involved a 1.5 m diameter cast-in-place bored pile 36 m in length cast with concrete having a 21-day unconfined compression strength of 28 MPa. The maximum equivalent top-down test load was 13,516 kN. The load cell was placed 6.4 m above the pile toe. The load-settlement curve is shown in Fig. 2. The initial load cycle wherein the pile was loaded to twice the working load (8,264 kN), with measured maximum upwards and downwards load cell displacement of 29.4 mm and 69.15 mm, respectively. Unloading then followed, during which residual settlements of 27.45 mm and 67.9 mm were recorded after the complete removal of the test load. Then the pile was loaded to 8,786 kN (next higher load stage from 2 x Working Load) and then loaded in increments of 676 kN (5% of Target Max Test Load of 13,516 kN). Loading prematurely ended at the maximum test load of 12,614 kN with measured maximum upwards and downwards load cell displacement of 138.8 mm and 102.68 mm, respectively, as the upward load cell displacement was close to the maximum allowable stroke of 150.0 mm.



(a) Upper pile segment

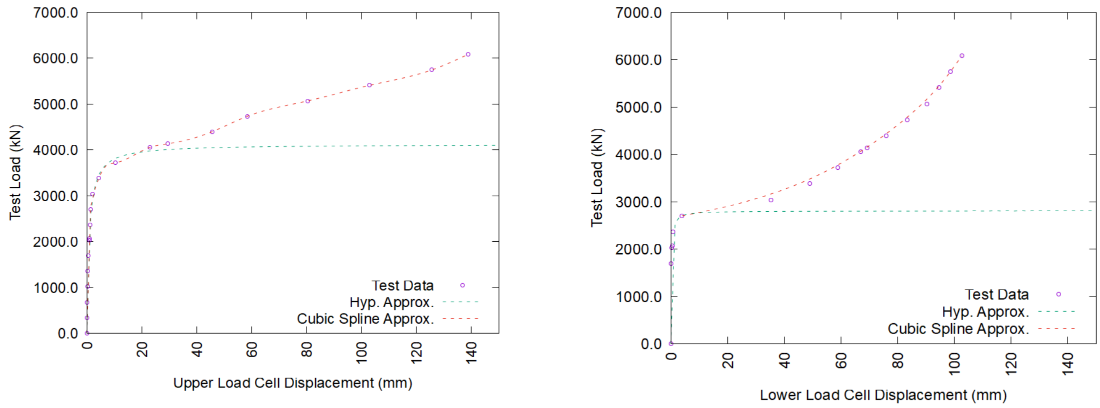
(b)Lower pile segment

Fig. 2. BDT results

Fig. 2b shows a change in curvature from concave downward to concave upward, starting at a gross load of 2703 kN during the initial loading stage. This is surmised to be due to the presence of soft toe conditions at the base of the test pile. During the initial stages of the initial loading, the soft toe condition resulted in significantly larger displacements in the lower segment of the pile compared to the upward segment. However, at higher loads during the reloading stage, the soft toe appears to attenuate, resulting in an increase in stiffness with increasing test load.

During the process of obtaining the equivalent top-loaded load-settlement plot, the upward and downward load-displacement plots were each initially fitted into a hyperbolic function using Equations (5) and (6) to obtain the equations that would relate the pile load and displacement. However, it was noted that for a given displacement, the hyperbolic approximation significantly underpredicted the equivalent load for both the upper and lower pile segments. To better model both the upward and downward load-displacement behavior based on the load test data, the load settlement curve was modeled using a cubic spline, and Equations (8) and (9) were used in the calculations for obtaining the equivalent top-loaded displacement-load curve.

The resulting hyperbolic and cubic spline curves are plotted versus the test data for the upper and lower pile segments in Fig. 3. It can be seen that the cubic spline curves, while not as smooth as the hyperbolic functions, result in a load-displacement curve that is much more faithful to the BDT load-displacement data.



(a) Upper pile segment (b) Lower pile segment

Fig. 3. Interpolated load-settlement for upper and lower pile segments

The calculated equivalent top-down load-settlement plot, both for the uncorrected and corrected pile's elastic shortening, is shown in Fig. 4 based on the procedure described in previous sections. Based on the analysis, it may be concluded that in the equivalent top-down load set plot, the pile set at twice the working load (2xWL = 8,264 kN) is estimated to be about 85.4 mm and only about 3.6 mm under working load (4,132 kN). The predicted pile set at the working load of 3.6 mm satisfies the design criterion of 12 mm at the working load. However, the predicted pile settlement of 85.4 mm does not meet the maximum allowable settlement of 38mm at twice the working load. It is also apparent that the predicted residual settlement at twice the working load will be greater than the maximum allowable value of 6.5 mm.

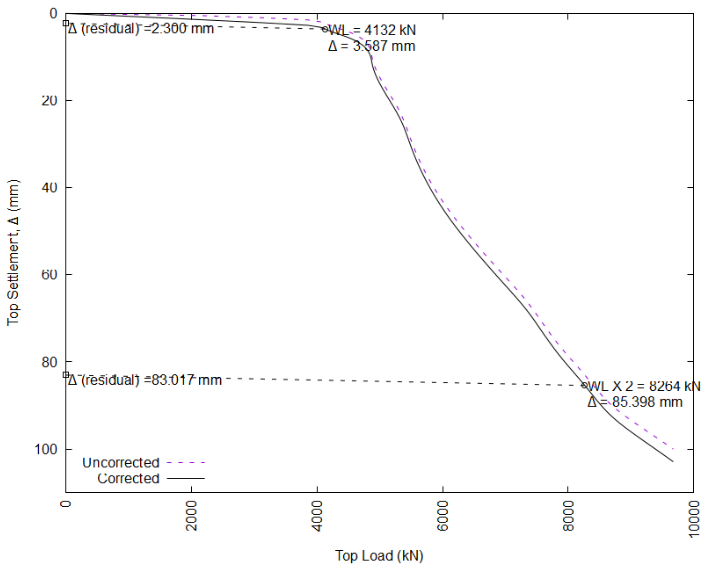


Fig. 4. Equivalent top-loaded load displacement curve

V. Conclusion

In the Philippines, the occurrence of soft toe conditions in bored piles is commonplace. For bi-directional pile load tests, the presence of soft toe conditions is manifested by large settlements for the lower segment of the pile. Experience indicates when a soft toe is present, the load-settlement behavior cannot be accurately modeled using the conventional hyperbolic function. The use of a hyperbolic function to estimate the load-settlement behavior often leads to an underprediction of the allowable pile capacity.

In such cases, it is proposed that the load-settlement curve be approximated from test results using cubic spline interpolation. It can be shown that despite the presence of soft toe conditions, side resistance due to skin friction provides generally provides sufficient pile capacity in almost all but the most unfavorable subsurface conditions. Given the prevalence of soft toe conditions, it is recommended that more research be undertaken to identify the underlying lapses in the construction methodology leading to these types of construction defects, as well as appropriate quality control measures aimed the minimizing their occurrence, as well as quality assurance measures aimed at identifying such constructions defects when they do occur.

REFERENCES

[1]. Osterberg, J. O. “A new simplified method for load testing drilled piles” Foundation Drilling, 1984, 23 (6): 911.
[2]. Osterberg, J. O. “The Osterberg load test method for bored and driven pile: The first ten years” Proc. 7th Inst Conf. and Exhibition on Piling and Deep Foundations. Vienna, Austria. June 15-17, Deep Foundation Institute, Englewood Cliffs, N.J., 1.28.1-1.28.11. 1998.
[3]. Fellenius, B., Altaee, A., Kulesza, R. and Hayes, J.: O-cell testing and FE analysis of a 28-m-deep barrette pile Manila, Philippines, ASCE Journal of Geotechnical and Geoenvironmental Engineering, Vol. 125 No. 7 (July 1999), 566-575.Osterberg, J. O. “A new simplified method for load testing drilled piles” Foundation Drilling, 1984, 23 (6): 911.
[4]. Gong Weiming, Dai Guoliang, Jiang Yongsheng, Xue Guoya. Theory and practice of self-balanced loading test for pile bearing capacity Journal of Building Structures, 2002, 23 (1): 8288.Osterberg, J. O. “A new simplified method for load testing drilled piles” Foundation Drilling, 1984, 23 (6): 911.
[5]. Konder, R. L., Zelasko, J. S. “A hyperbolic stress-strain relationship for sands,” Proceedings of the 2nd Pan-American Conference on Soil Mechanics and Foundation Engineering, Vol. 1, Brazil (1963) p. 289.
[6]. Lee J S, Park Y H. Equivalent pile load-head settlement curve using a bi-directional pile load test. Computers and Geotechnics, 2008, 35 (2):124133.
[7]. Press, W. H., Vetterling, W. T., Teukolsky, S. A., & Flannery, B. P. (1988). Numerical recipes. Cambridge University Press, London, England.

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Case History

Recent Applications of The Press-in Methods in Africa: The Cases of Senegal & Egypt

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Abstract. This paper gives insight into the first two applications of the Press-in methods in Africa, recently experienced in Senegal and Egypt. The Senegal Project is the Dakar port, the second largest port in western Africa behind Abidjan's port. The first objective is to describe the adopted construction method called Gyropress^{TM} Method, and then to compare it with conventional piling work proposed during the preliminary design. This method can accomplish the regeneration and reinforcement work without removing the existing underground structures and installing piles in very stiff ground conditions. A pile wall of length 350 m is built by installed alternated piles of diameters 1000 mm and 318.5 mm. Such an interlock installation method allows for preventing soil particle protrusion. The Gyro Piler™ facilitates the berthing and vessel unloading at the wharf during the construction, with limited vibration and noise, minimum impact on existing infrastructures, and, cost-effectiveness. The second project is the pediatric hospital in Cairo. From among the Press-In alternatives, GIKEN's "Zero Clearance Method" was adopted to ensure both the minimization of dead space between the adjacent structures and the alleviation of construction noise and vibration. In this project, utilized Zero Sheet Piles are 46 no. 7.5 meters and 100 no. 10.5-meter in an area of approximately 30 x 19 square meters. The Zero Piler^{TM} Giken Seko works permitted safe and efficient sheet pile driving. The first two projects have proven the superiority and efficiency of environmentally friendly Press-in Methods in the Middle East and North Africa region.

1. Introduction

Press-in technologies, while being practiced worldwide for two decades due to their effectiveness compared to current foundations and retaining techniques, have not yet attracted the project owners and entrepreneurs in Africa up to 2018. The only way to make possible the execution of Press-in technologies in Africa was to link the JICA funds to help many African countries when coming to the execution of infrastructure projects. In this framework, the first two applications of the Press-in technologies were decided in Africa. The aim of this paper is to report on the first two case histories during which the implementation of IPA technologies took place.

The first project is the renovation of the free platform of the quay wall of Dakar Port (Senegal). The main objective of this project is the renovation of the free platform quay wall of Dakar Port. The second project is the construction of a retaining wall on hard ground condition for the Cairo pediatric hospital. This project will provide helpful support in combatting shortages including specialist doctors, medical equipment, and medical facilities.

2. Free Platform Quay Wall Renovation, Dakar Port (Senegal)

2.1 Overview of Dakar Port

Dakar port, constructed in 1936, is located at the most Western point toward the Atlantic Ocean. This port annually handles around 15,180,000 tons of goods and serves as a transit to inland countries for 14% of its total capacity. The third wharf constructed in 1939 is destined for landlocked countries, 95% is reserved for the Republic of Mali under a bilateral agreement. The transit of goods has increased by 2.5 times from 2010 to 2015 and, then, continued gradually up to 2022. The increase in goods has caused considerable deterioration over the total length of the wharf, which threatened to collapse. Moreover, large vessels are constrained by draught, and puddles of water form on the quay during the rainy season. Thus, the government of Japan, through JICA, provided grant aid of 3.971 billion yen under the ODA program for the rehabilitation of the wharf after a request from the Senegalese authorities in October 2013.

2.2 Third Wharf Description: operations and quay structure

The operated cargo volume in 2010 was 850,000 tons; in 2018, it was expected to attain 1.2 million tons. The planned ship type is Handymax (Bulk Carrier) sized at 35,000 DWT. The existing structure of the wharf consists of a gravity quay type of length equal 350m. This quay is one of three sides of a bay of length 360 m and width of 200 m where the current depth of the seabed is 12.0 m.

2.3 Geotechnical Survey

The geotechnical survey conducted onshore and offshore allowed identifying three layers from the seabed. The first layer is a plastic and hard marl clay of 1 to 3 m thickness. The second layer is a fractured grayish limestone-marl having a moderately low compressive strength from 3 to 12 meters. The third layer is a fractured grayish limestone moderately with low compressive strength up to 17 meters. The unconfined compressive strength of the marl and limestone-marl layers varied from very low to high strength (from 2.6 MPa to 68.8 MPa).

2.4. Design of the platform quay renovation

The existing quay, seriously deteriorated, comprises five gravity blocks resting on the seabed and overlaid by concrete blocks (Fig. 1). The simplest way to renovate the quay consisted to add gravity cellular blocks, filled with added material, and to fill out the space between the existing quay and the new one by backfill material. Such a plan of construction necessitates an enlargement equal to 22m inside the bay from the existing quay. The main concern was that the distance to the opposite quay pier would be narrowed during the operation, reducing maritime safety and convenience. To overcome this inconvenience, the change of quay structure type from gravity to the quay on piles sounded suitable.

Fig. 2 shows the layout of the quay on piles solution. The planned piles, embedded 2 m in the seabed, are distanced 5-6 m from the existing gravity quay wall. For constructing the quay on piles, the Gyropress method was selected. This method of installation is described, in brief, hereafter.

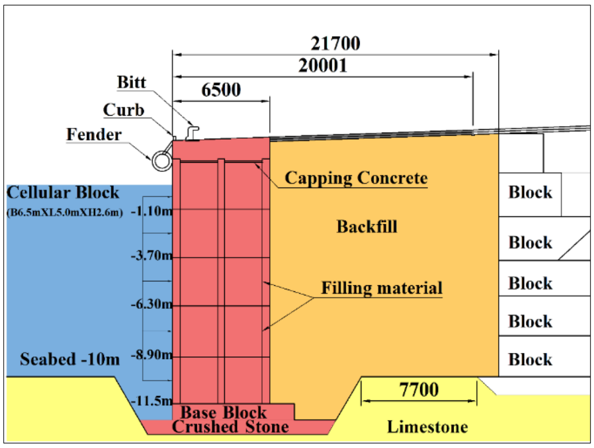

Fig. 1. Initial plan of construction of gravity cellular blocks

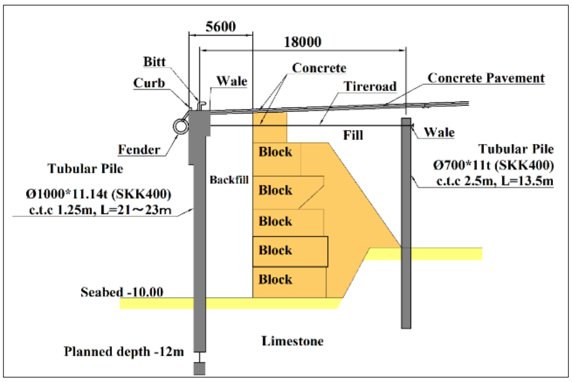

Fig. 2. Quay on piles solution

Table 1 summarizes the reasons for selecting the Gyropress Method for the installation of the quay on piles solution. This latter, confronted with the initially planned gravity wall solution based on four criteria, reveals much suitable. For those reasons, the owner of the project favored the quay on piles solution using the Gyropress method briefly described hereafter.

2.5. The Gyropress Method (rotary press-fitting method)

The Press-in Method, using Gyro Piler™ F401-G1200, installs piles by rotation with the assistance of cutting ring bits attached to the pile toe. This technique was successfully implemented to improve the berths at Nagasaki Port (Japan) from September 2017 to March 2018.

The initial piling represents the first operation to implement the Gyropress Method. This operation comprises three steps, [1]:
1) Insert the steel grid offshore;
2) Put the reaction on the steel grid, and
3) The setup of the Gyro-piler.

Photo 1 illustrates the Gyropress Method of piles installation using special bits to overcome the cutting of hard ground conditions as reinforced concrete.

Table 1. Comparison of the "All casing" and Gyropress methods of installation

	All casing method	Gyropress Method	All Casing Method
Overview	Using a workboat such as a guide barge or a pile driving ship, a casing is installed, at first. After placing the steel pipe pile inside, the casing grips it and rotates downward. An excavator removes the crushed stone. It is a current construction method for port piers. Since the work will be carried out offshore by a workboat, the adjacent berths cannot be used during the construction period; a minimum space is required in advance.	Due to the rotary cutting press-fitting, all processes can be performed on the steel tubular pile. For this reason, adjacent berths can be used even during the construction period, hence, there is little economic loss. In addition, it does not affect the water area facilities (berths, routes, etc.) in the port.	Using a work boat such as a guide barge or a pile driving ship, a casing is installed first. After placing the steel pipe pile inside, the casing grips it and rotates downward. An excavator is used to remove the crushed stone. This is a general construction method for port piers. Since the work will be carried out offshore by a work boat, the adjacent berths cannot be used during the construction period, so the minimum space is required in advance.
Machines	Seven (7) machines: Casing, guide barge, working barge, crawler crane, hoist ship, tugboat, anchorage ship.	Three (3) machines: Gyro Piler, Crawler Crane Power unit.	7 Machines: Casing, guide barge, working barge, crawler crane, hoist ship, tugboat, anchorage ship.
Workability	Workboats need to be circulated and towed. Since it is a workboat, the process and quality are easily affected by weather and sea conditions. It occupies a wide area by using workboats and mooring lines.	Since everything is done on land or on piles, the work process and quality are not easily affected by weather and sea conditions. No special skills are required because general construction machines are used.	Work boats need to be circulated and towed. Since it is a work boat, the process and quality are easily affected by weather and sea conditions. It occupies a wide area by using work boats and mooring lines.
Safety	Due to the large number of work vessels, it is necessary to ensure the safety of vessels moving over the sea.	It does not interfere with the traffic at sea because no work boat is used.	Due to the large number of work vessels, it is necessary to ensure the safety of vessels moving over the sea.
Environment	Due to workboats, represent a concern about the impact on the natural environment and people.	Because it is a vibration-free and noise-free press-fitting method, it has less impact on the surrounding environment.	Since many work boats are used, there is concern about the impact on the natural environment and people.

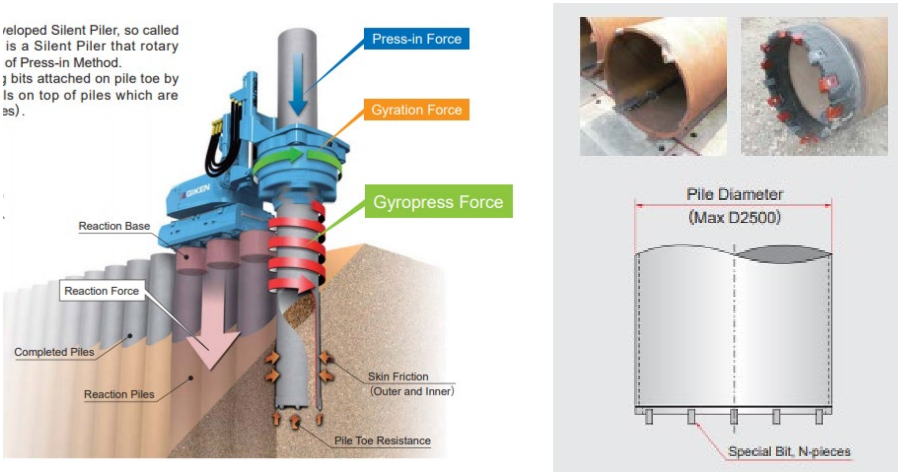

Photo 1. Cutting reinforced concrete overcoming various ground conditions by selected bit arrangements.

Beneficial effects of the Gyropress Method are:

- It was necessary to use a method that would have less impact on the weathered limestone layer.
- The operation at the third wharf should not be stopped as 95% of its capacity is destined for landlocked countries.
- The initial plan was changed from the gravity quay type to a quay on piles to avoid the reduction of the bay width.
- The "All Casing Method" is not recommended, as it requires many working vessels that would interfere with the berthing and vessel unloading at the wharf.
- The Gyropress enables to carry out safe, rapid and environmentally friendly construction method that minimizes the impact on the wharf, without stopping the operation at the port.

3. Construction of Retaining Wall on Hard Ground for the Hospital Facilities in Cairo (Egypt)

The Egypt Project in Cairo one of the largest cities in the Middle East and North Africa, deals with the construction works aiming at the expansion of the facilities at the Cairo University Pediatric Hospital. The hospital was established in 1982 with the support of Japan and is known locally as the “Japanese Hospital”. It has played a central role in providing pediatric healthcare at an affordable cost. However, with aging facilities and limited space; there is a need to enhance the hospital’s capacity by establishing a new infrastructure for which a retaining wall construction, incorporating below-ground excavation was originally planned with traditional construction and piling methods.

The project construction is to build a new pediatric ward in a narrow area surrounded on three sides by existing buildings. The original plan was to use other construction methods, but due to concerns about the impact on the adjacent wall structure, hence the Silent Piler method was adopted.

Potential negative impacts on existing adjacent structures as well as high groundwater levels led to a change in the design, utilizing Giken’s Press-In method of sheet pile installation.

Construction Method

For the Cairo’s Hospital project, the called “Zero Clearance Method” was adopted [2]. This method of installation performed well by using the Zero Piler Machine to construct a continuous steel structure wall at zero meter clearance from an existing structure. The normal Silent Piler requires at least 500 to 600 mm clearance from the existing structure, whereas the method allows zero mm clearance, therefore the maximum construction space can be used. It resulted in the use of the “Zero Clearance Method” of extensive practice, by GIKEN in Japan, operating by the machine called Zero Pile.
The Zero Piler with auguring system enabled piling, near Cairo’s hospital, in hard ground conditions at zero clearance without disturbing the neighborhoods.

4. Conclusions

This paper reported the first two experienced Press-In methods in Africa.

The first case history is the Free Platform Quay Wall Renovation of Dakar Port (Senegal). There were major challenges to overcome in this project. It was necessary to use technology with less impact on the weathered Limestone layer. The operation at the third wharf of Dakar port should not be stopped as 95% of its capacity is destined for landlocked countries. The initial Plan “gravity quay type” also called “The All Casing Method” requires many working vessels that would interfere with the berthing and vessel unloading at the wharf. This quay on piles option turned out unsuitable since it reduces the width of the bay. As a suitable option, the Press-In “Gyropress Method” enabled to carry out safe, rapid, and environmentally friendly construction that minimizes the impact on the wharf, the operation at the port unstopped, and the width of the bay only reduced to 5.6 m.

The second case history is the construction of a retaining wall on hard ground for the New Pediatric Hospital Facilities in Cairo, (Egypt). Piling at zero clearance distance from the existing buildings, the Zero Piler with the auguring system, without disturbing the neighborhoods, was another success of the Giken Press-In technology.

5. References

[1] International Press-In Association (2021). Manuel des structures de soutènement par vérinage. 2ème édition. French IPA Handbook.
[2] Giken Ltd (2014). Construction Revolution: Zero Clearance method.

IPA News Letter Volume 8, Issue 2 June 2023

Interview Report

Overview and Practical Applications of Retaining System by Double-layered Sheet Piles

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Foreword

Sheet piles have been used in many countries since their first production in Europe in the early 20th century. They are commonly employed for basic foundation structures, such as retaining walls and cofferdams for both temporary and permanent use in the construction of a wide variety of infrastructures. In the case of retaining walls, sheet pile walls are normally propped or anchored when the required retained height is generally greater than 3-4m, in order to restrict lateral deflection of the wall. Alternatively, piles with higher modulus than sheet piles are utilized to achieve a freestanding cantilever retaining wall.

In this report, the IPA introduces the "**Retaining System by Double-layered Sheet Piles**", which enables sheet piles to achieve high modulus walls with a reasonably thin wall thickness, and rationalize bulk excavation works and further construction works. The IPA interviewed the innovator of the method to understand the core idea of the method and its actual practical applications.

Name of the method: Retaining System by Double-layered Sheet Piles
Interviewee: Mr. Naoshi Inoue, KAJIMA CORPORATION

Q1: Could you please tell us about the advantages of the "Retaining System by Double-layered Sheet Piles"?

1) High rigidity: Greater retained height can be achieved compared with normal sheet pile walls.
2) Fewer temporary props required: Bulk excavation works and following construction works can be more easily facilitated.
3) No need for tieback or ground anchors: Less space is required behind the wall.
4) High availability: Sheet piles are widely available and accessible in most areas.
5) Uncomplicated constructability: By utilizing sheet piles, installation works can be carried out trouble-free in limited space.
6) Extractable: Risks of obstacles in future developments are reduced. SDG and decarbonization goals can be more easily met.

Due to the above advantages, the effectiveness of construction works related to retaining structures and substructures can be facilitated with reasonably low costs.

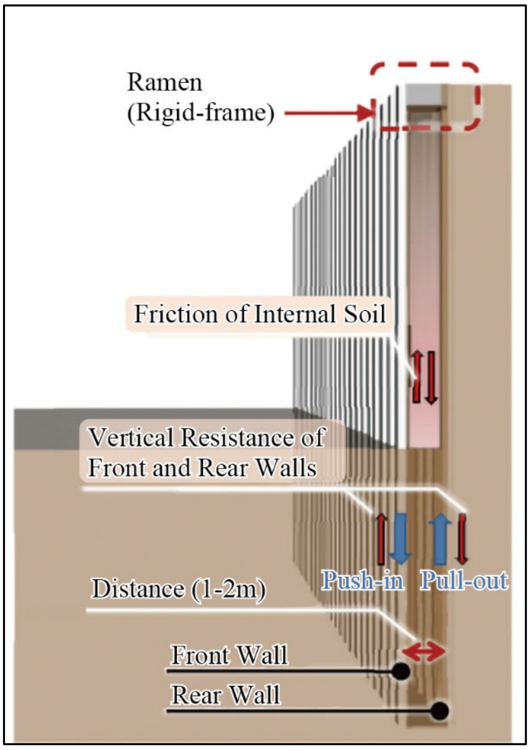


Fig. 1. Overview of Retaining System by Double-layered Sheet Piles

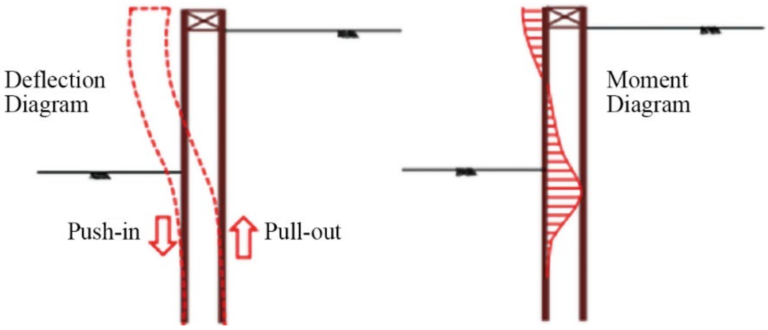


Fig. 2. Behavior of Retaining System by Double-layered Sheet Piles

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

In general, temporary support systems, such as props, ground anchors and tieback anchors, are employed when the retained height of a sheet pile wall is 3-4m or greater. Although the temporary support system is effective to maintain lateral deflection of the retaining wall within a certain limit, it may obstruct the following construction works of substructures or require a longer construction time or more construction space behind the wall. As an alternative, high modulus walls, represented by a soil mixing wall (SMW) or other cast in-situ walls are utilized to minimize or eliminate the necessity of temporary support systems. However, these high-modulus retaining walls require large piling equipment and a larger working space, which also accompanies a lot of enabling works. Even if the cast in-situ walls are only for temporary use, most of the time they are left in place, which might be obstacles in future developments.

In order to satisfy such working conditions, the "Retaining System by Double-layered Sheet Piles" was developed to provide economical high-modulus retaining structures with minimum temporary support systems and less working space at relatively low costs.

Q3: As of Feb. 2023, how many projects have the "Retaining System by Double-layered Sheet Piles" been utilized in?

There have been 5 actual projects since the first application in 2020.

Q4: How can we inquire about the method?

Inquiries about the method can be made at the URL below. Kajima Corporation assesses incoming inquiries on a case-by-case project basis.

INQUIRY (KAJIMA CORPORATION)：https://www.kajima.co.jp/english/contact/index.html

Q5: What kind of geotechnical analysis software is required for the utilization of the method?

General FEM software, which has an elasto-plastic analysis function for retaining wall design, can be used.

Q6: What determines the distance between the two walls?

When the double-layered sheet pile walls are designed, the distance between the walls is determined by taking into account 1) the land available behind the front surface of the retaining wall, 2) the required rigidity of the ramen and 3) the constructability of the walls. The greater the distance, both the rigidity of the ramen and its constructability tend to decline. Therefore, a maximum distance of 2m is recommended to satisfactorily meet the above criteria.

Q7: There are two types of rigid connections to fix two sheet pile walls i.e. Steel Frames and RC. How can we decide on the most suitable connection method in relation to the working conditions?

In terms of a structural point of view, both types can equally be utilized as long as the required rigidity of the ramen is achieved. In the past, the type of rigid connection was selected mainly considering working conditions and environmental aspects. For instance, if the hot work (cutting and welding operations) is restricted, steel connections are not normally used. On the other hand, an RC connection is normally avoided when stringent noise & vibration limits are in place.

Fig. 3. RC Connection

Fig. 4. Steel Connection

Q8: Are there any additional items related to project management when constructing the double-layered sheet pile walls compared with normal sheet pile wall?

In order to provide uniform space between the front and rear wall, installation tolerances need to be controlled more stringently compared with a normal sheet pile wall.

Q9: Can curved walls be installed?

Yes, curved walls can be constructed. The minimum radius of the wall is governed by the maximum angle of deviation in the interlocks of sheet piles.

Q10: If a circular double-layered sheet pile wall is constructed and the space between the two walls is filled with concrete, can we expect "arching effect"?

Arching effect can be expected, and as a result, lateral deflection of the wall can be minimized.

Q11: How much water tightness can we expect with the double-layered sheet pile wall?

It is thought that the water tightness is simply doubled in the case of the double-layered sheet pile wall.

Q12: If the retaining wall requires bearing capacity, can we also expect skin friction on the insides of the double-layered wall?

With the double-layered sheet pile wall, skin friction can be expected on entire surfaces of the embedded sheet piles.

Q13: What is the achievable bending stiffness of the wall compared with a normal sheet pile wall?

4-8 times greater bending stiffness can be expected compared with a normal sheet pile wall.

Q14: Could you please tell us about your promotional activities in bringing the method to the market?

We are currently promoting the method by inserting advertisements in construction journals and introducing the method at academic seminars.

Q15: Could you please tell us about your future promotional plan, including overseas markets?

We conduct our promotional activities in both the domestic market and overseas markets. At this time, we are prioritizing Southeast Asia and also countries such as India and Bangladesh in the Subcontinent.

Project Case History

1. Purpose of Project

   Construction of a water purification plant
2. Overview and Purpose of Retaining Wall

   "Retaining System by Double-layered Sheet Piles" by utilizing U sheet piles Type IV
   (Rectangular Cofferdam, Inner Dimension 19.2m x 14.4m, Retained Height 8.2m)
   Installation Method: Press-in Piling Method (assisted with Water Jetting)
   Extraction Method: Press-in Piling Method
   *See Figure 5.
3. Ground Conditions

   *See Figure 5.

In order to construct a water purification plant on the project, the "Retaining System by Double-layered Sheet Piles" was chosen to carry out bulk excavation works without a temporary support system. The site investigation record shows that there is a thick sandy layer underlying the top cohesive layer. With a high groundwater table and an adjacent new structure, the design of the retaining structure was complicated. Under such conditions, the bulk excavation of over 8m was carried out without a temporary support system.

As Figure 5 shows, the cofferdam was designed in a rectangular shape. As for the riged-frame (ramen), the RC connection was selected because of the additional beam effect at the top of the retaining wall. The bulk excavation was carefully carried out down to the formation level (8.2m below the ground level). At the same time, the lateral deflection of the wall was monitored using surveying equipment and inclinometers.

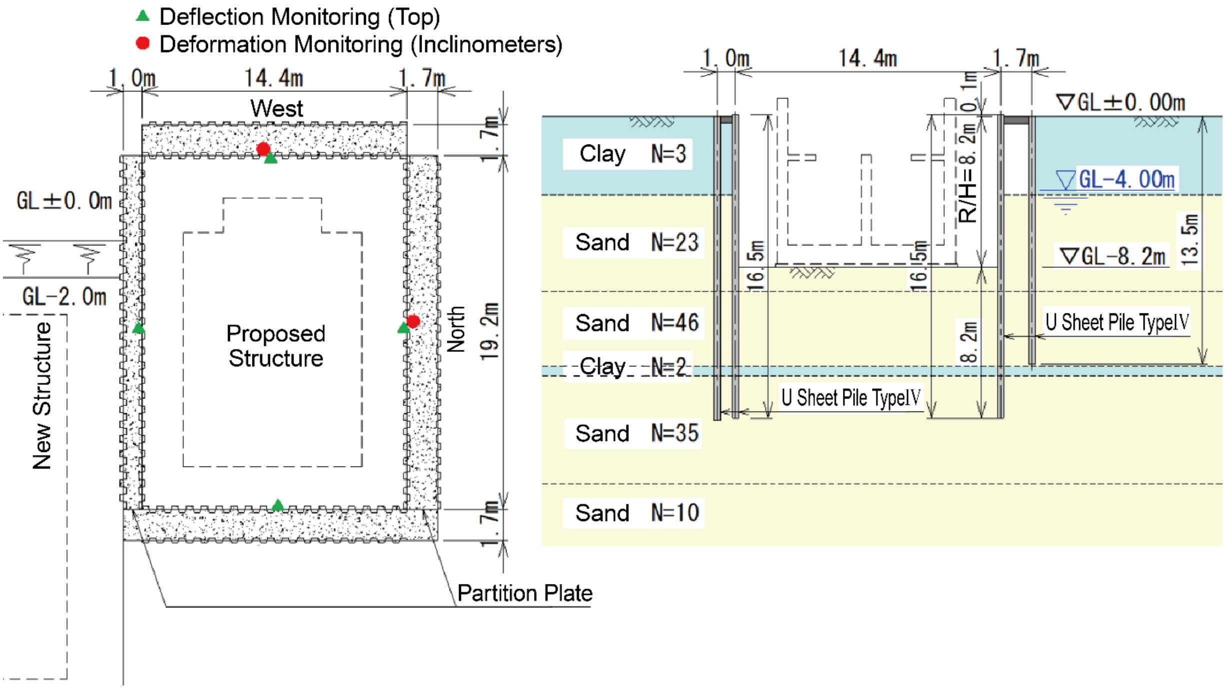
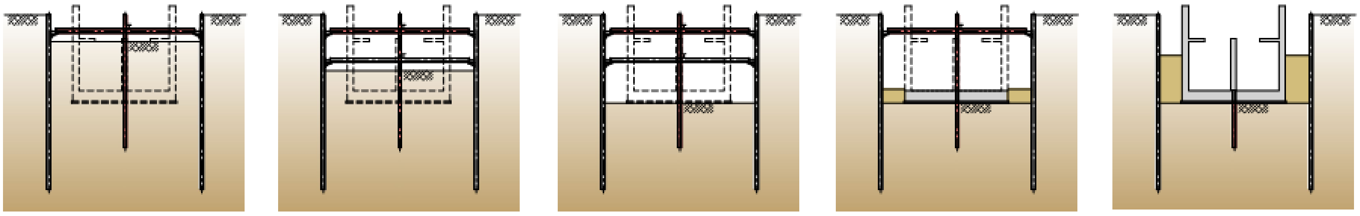


Fig. 5. Plan and Cross Section of the Double-layered Wall

Fig. 6. Excavation and Construction of Substructure

Original Design (Single Sheet Pile Wall with 2 Level Props)



Initial excavation. Install intermediate vertical support. Install 1st level props.

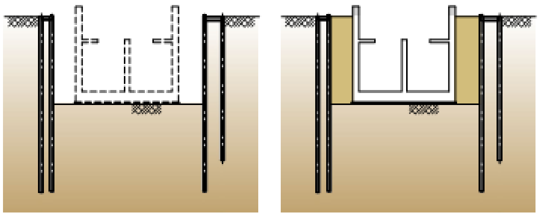
2nd excavation. Install 2nd level props.

Excavation down to formation level.

Base slab construction. Remove 2nd level props.

Side wall construction. Remove 1st level props. Remove intermediate vertical support. Backfilling.

Double-layered Wall



Excavation down to formation level.

Substructure construction. Backfilling.

Advantages of Double-layered Wall

- Reduction of construction sequences.
- Improvement of constructability of substructure.
- Increased construction safety due to a better range of vision and a larger work space.
- Better quality of substructure due to intermediate vertical support being obsolete.

Fig. 7. Comparison in Construction Sequences

As Figure 7 shows, the "Retaining System by Double-layered Sheet Piles" enabled the excavation and construction works for the substructure to be carried out in a spacious environment without obstructive temporary support systems. Thus, the constructability, safety of the substructure construction and the quality of substructure were enhanced.

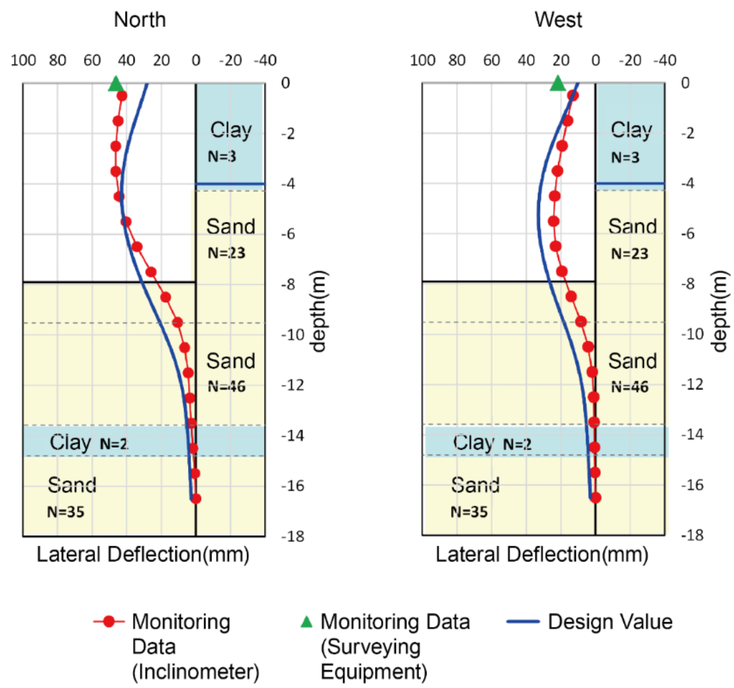
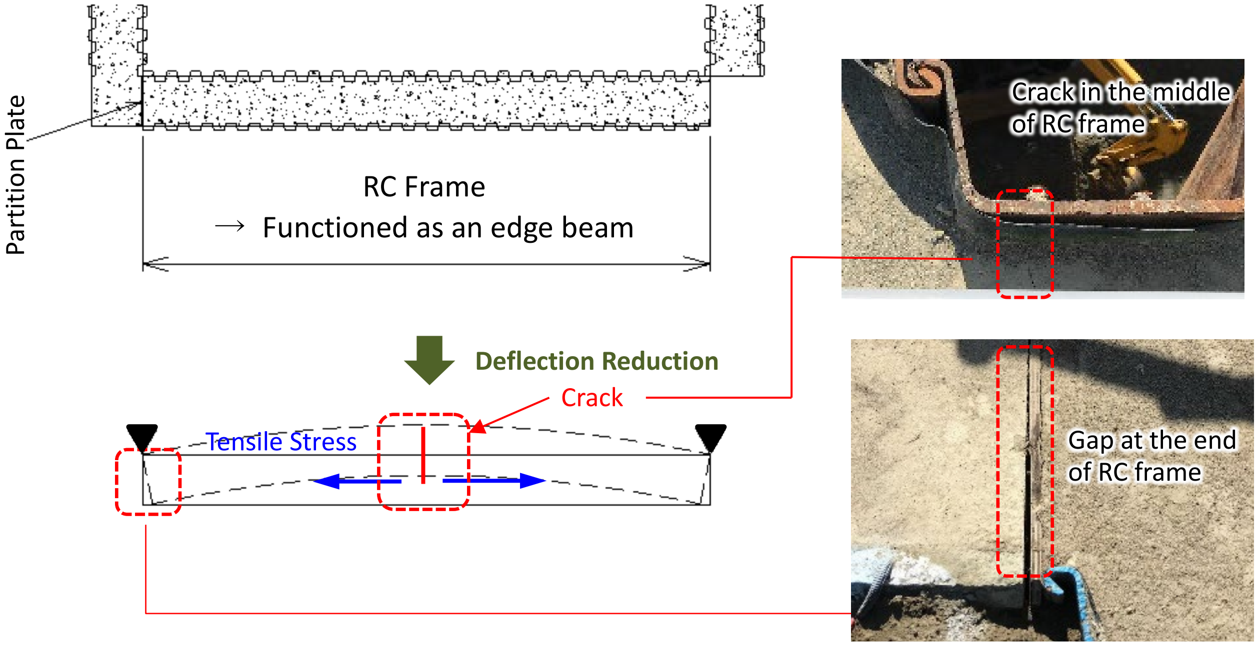


Fig. 8. Deflection Design Values and Monitoring Results

Figure 8 shows deflection monitoring results on monitoring points which are indicated in Figure 5. The wall deflection profiles show that the retaining wall bent in an S-shape profile, which shows that the ramen (riged-frame) at the top of the wall effectively met its functionality. The maximum deflections of the double-layered walls were found to be below the pile top level. In contrast, in the case of a cantilever retaining wall, lateral deflection is normally greater at the top of the wall.

The main purpose of the connection between the front wall and rear wall is basically to fix the walls rigidly to form a ramen (ridged-frame). In addition to this, it is assumed that the RC ridged-frame also acts as an edge beam at the top of the retaining wall. This additional benefit was observed, as shown in Figure 9. There are cracks in the middle of the RC frame and a gap at both ends of the RC frame, which shows that the RC frame was impacted by its bending during excavation. We expect this secondary effect (acting as an edge beam) increases the advantages of the double-layered wall.



The crack and gaps in the RC frame show that the RC frame also acted as an edge beam.

Fig. 9. Edge Beam Effect Observed on the Project

REFERENCE

Inoue, Naoshi., et al., 2022, Development and applications of “Retaining System by Double-layered Sheet Piles” for rationalization/streamlining bulk excavation, *The Construction Technology Research Meeting* (in Japanese).

Report

Ordinary General Assembly 2023

The IPA Ordinary General Assembly 2023 was held from 15 to 26 May 2023. The total votes have achieved the quorum, and all the presented Agendas were resolved in accordance with Article 22 of the Constitution.

- Period: 15 to 26 May 2023
- Meeting place: IPA Website (On-line voting through the Members Site)
- Agendas: https://www.press-in.org/en/page/general_assemblies
- Number of eligible members: 741 (Individual Members: 691, Corporate Members: 50)
- Quorum: 371 (a majority of members）
- Total votes： 389 ［achieved quorum］ (Turnout 52%）

Votes on each Agenda：

	Agendas	Affirmative votes	Dissenting votes	Results
Agenda 1	Activity Plan for FY 2023	389	0	Approved
Agenda 2	Budget for FY 2023	389	0	Approved
Agenda 3	Election of Directors and Auditors for the term 2023–2024	389	0	Approved

The list below shows the incoming and outgoing members of IPA Directors. Thanks to the outgoing directors for their great contributions during the terms, and very welcome the new directors.

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Japan

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Kiyoshi Minami
Managing Executive Officer
Muramoto Corporation
Japan

Report

Application of the GYRO PILER to replace damaged quay walls in Amsterdam

Andrew McNamara

Senior Lecturer
City, University of London

Jignasha Panchal

Technical Manager
Keltbray Holdings Limited

The city of Amsterdam was built around a dam on the Amstel River during the late 12th century. The city is well known for its historic canals and waterways which have been the predominant method for transporting goods, services and people across the country. The waterways are still very much in use and are a highly efficient means of working and moving around the city although the original construction dates back as much as 100 years.

The sides of the highly trafficked waterways are retained with brick walls that are supported on ancient timber piles. The walls require regular repair owing to erosion caused by the high velocity of water from the propellors of barges navigating very tight bends. This causes washout of the retained soil which results in sink holes, as shown in Fig. 1. There are many examples of stretches of canal where the local council has carried out remedial works and installed conventional sheet piled walls in front of the eroded canal walls, which were subsequently backfilled to provide lateral restraint to the walls (Fig. 2). This is not a particularly cost effective or aesthetic solution and results in narrower waterways; a schematic diagram of the remedial works is shown in Fig. 3.

Fig. 1. Photograph of sink hole appearing alongside the canal wall (Giken, 2023)

Fig. 2. Remedial works installed for temporary stabilization

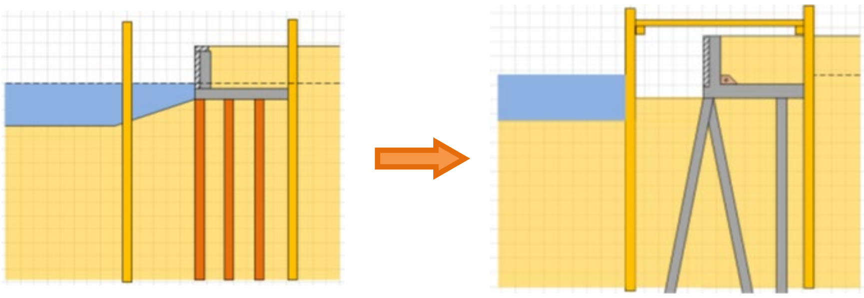

Fig. 3. Schematic diagram of the current remedial works undertaken using sheet piles (Giken, 2023)

Project details

A site was identified at Singel in the heart of Amsterdam which required an urgent and innovative long-term solution to improve the integrity of the retained canal walls, without disrupting the local walkways and roads. This site was identified as suitable for a pilot project that could be used to demonstrate the viability of new construction technologies with the aim of applying the generic solution to the repair and replacement of approximately 600km of historic canal walls across Amsterdam.

A collaborative project team, G-KRACHT, was formed of Giken Europe, De Koning and H G Van Gelder. The final proposal made use of the GIKEN GYRO PILER, which allowed construction to take place from a barge next to the canal, with access to the site and delivery of materials all taking place from the waterway. This construction technique reduced the overall construction program as the method of working eliminated the requirement for a temporary works access platform.

The scope of works began with the installation, preparation and mobilization of plant and equipment on the barge. 508mm diameter tubular piles of 9mm wall thickness, were designed as the primary means of retaining the canal walls and were installed along and through the existing brick wall line, see Fig. 4. The benefits of the GYRO PILER, to core through existing structures and obstructions, including timber, was demonstrated on this project as it avoided the need to carry out any extensive and disruptive enabling works. The tubular piles were installed to an average depth of approximately 23m and a lubricant was pumped along the length of the pile to ensure that the cutting head could push through the obstructions. For every 508mm diameter tubular pile, one 273mm diameter closure pile was installed to approximately 14m using a driving head mounted on an excavator which was working from the barge (Fig. 4). Tie rods were installed to each of the tubular piles as shown in Fig. 5.

Fig. 4. 23m deep x 508mm diameter piles with shorter small diameter closure piles between

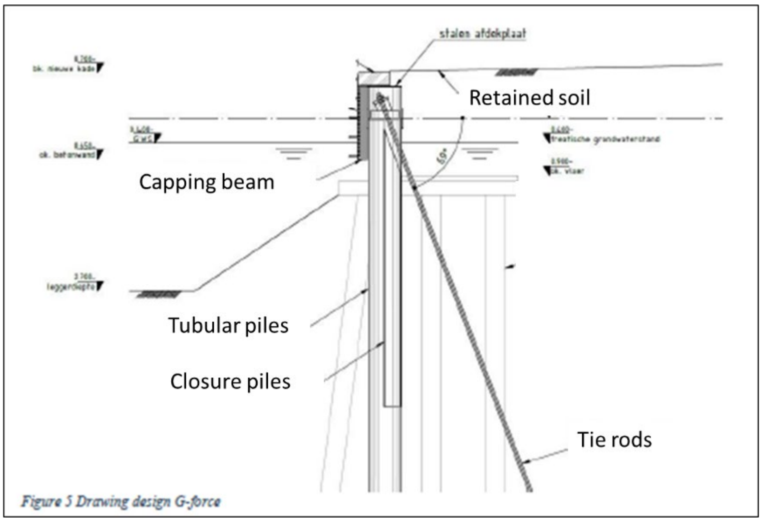

Fig. 5. Section of the remedial works proposed to the quay wall showing tubular piles and inclined tie rods and small diameter closure piles

Photographs taken during the site visit are presented in Fig. 6 showing the site set up that was used to carry out the works. The works were restrained to the quay wall and all service equipment was located on the barge thereby minimizing disruption to the general public and pedestrian walkways immediately adjacent to the site.

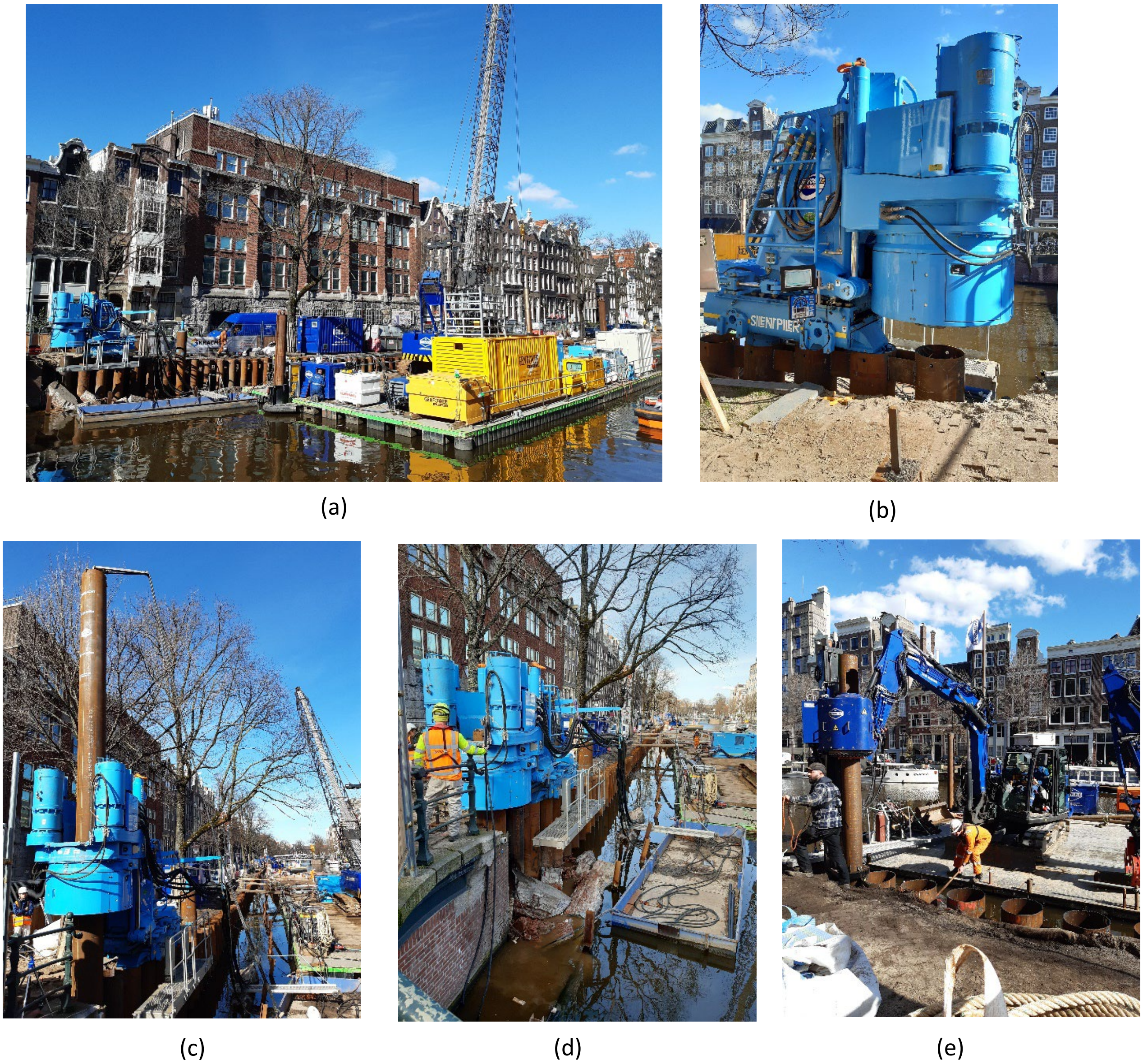

Fig. 6. Photographs of (a) the piling site and barge, (b) the GYRO PILER set out on the pile, (c) the tubular pile half installed in the pile position, (d) the brickwork obstruction that was driven through using the GYRO PILER, and (e) the short closure piles being installed using the attendant excavator from the barge.

The GYRO PILER GRV0611e was deployed for this project and has the capacity to install piles between 500-600mm in diameter and can apply up to 1.2MN force during the driving and extraction process. The operation of the equipment was controlled remotely, limiting the requirement for operatives to be at the face of the pile driving process. Tubular piles were stored on the barge and were supplied to the GYRO PILER using the service crane before being rotated and installed through the existing brickwork and underlying strata. The speed at which the pile was installed and the minimal noise, vibration and disruption to the local surroundings were evidently minimal during the works demonstrating that this technique is well suited to the inner city and developed areas.

Conclusion

The GYRO PILER has been used to successfully install a remedial piled wall along a canal in Amsterdam. Restrictions on site included extremely confined working conditions with site access for materials and equipment possible by canal only. Environmental constraints included the need to protect mature trees and minimize settlements and any nuisance to the general public. The technique adopted was able to overcome all of the constraints whilst installing tubular piles through difficult obstructions that included timber piles and was successful in minimizing disruption to the surrounding area.

IPA News Letter Volume 8, Issue 2 June 2023

Young Members

Load-Settlement Behavior of Precast Jacked Concrete Piles from Static Load Tests and High-Strain Dynamic Pile Load Tests in the Philippines

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MS Civil Engineering - Geotechnical Engineering specialization of the University of the Philippines Diliman

I graduated Cum Laude in BS Civil Engineering, also from the University of the Philippines Diliman. I am also currently Managing Director at BRB Solutions Inc. My areas of expertise and research include high-strain dynamic load testing and pile integrity testing.

Installing precast displacement piles by pile jacking is a relatively new technique but growing in popularity because of the reduced noise and vibration compared to traditionally driven piles. Estimating the ultimate capacity and settlement of jacked piles for specific subsurface conditions is of interest to piling stakeholders. The jacked pile installation method allows for the measurement of a static capacity during the installation, which in some cases can be a reliable estimate of the pile's ultimate capacity as measured by a compressive static load test (SLT) [1]. SLTs and high-strain dynamic compressive pile load tests (HSDPTs) can also be performed after a certain amount of time has elapsed since installation to estimate the increase in skin friction due to pile "set-up". While SLTs have been referred to as the most reliable predictor of long-term pile capacity and behavior [2], HSDPTs are more commonly used in the Philippines for evaluating the capacity of jacked piles and in some cases, have completely replaced SLTs. HSDPTs, while providing a good approximation of results from SLTs, are typically more affordable to conduct, less time-consuming, and can be done on a greater number of piles at a project than SLTs [3]. An estimated pile top load-settlement curve can also be generated from an HSDPT, similar to what is measured in a SLT. However, a common limitation encountered when conducting HSDPTs is the incomplete mobilization of ultimate capacity relative to what can be obtained in an SLT. Nevertheless, there remains uncertainty regarding which load test to use for certain projects, as well as the equipment and load required to fully mobilize ultimate capacities in test piles, particularly because of significant increases in pile capacity due to pile setup in certain types of soils.

Presented here are SLT and HSDPT results of tests conducted on ten (10) prestressed, jacked, square concrete piles with 45 cm width, 30 m length, and a specified allowable capacity of 750 kN installed with a hydraulic static pile driver in silty clay in the Luzon, Philippines region. Final jacking forces applied on the piles during installation ranged from 456 to 2018 kN. Four (4) piles were subjected to SLTs following the "Quick Test" procedure, while six (6) piles were subjected to HSDPTs. These tests were conducted as non-destructive proof tests to prove that the piles can support at least a certain multiple of a provided allowable capacity. SLTs were conducted up to 2.5 times the allowable capacity, while a target capacity of 2.0 times the allowable capacity was used for the HSDPT. Signal matching analysis was conducted on HSDPT data to generate ultimate capacity estimates and estimated load-settlement behavior.

Significant capacity increases, or pile setup, were found between the date of installation and the date of load tests for all 10 piles tested. All target capacities were attained during both SLTs and HSDPTs. Additionally, the measured capacities were 1.19 to 5.43 times the final jacking force measured during installation, indicating that capacities had increased. However, using the Davisson Offset Limit Method, a widely used method for static load capacity estimation [4], capacity estimates from HSDPTs were found to be closer to actual ultimate capacities compared to estimates from SLTs, despite smaller target capacities used during the HSDPT. Load settlement curves from the HSDPTs (also called PDA tests) and SLTs, as well as the Davisson-Offset Line, can be seen in Fig. 1. This is likely because of the relative ease in mobilizing additional capacities during a HSDPT, which typically requires increased hammer drop heights. Additional reaction piles or dead loads are typically needed to increase loads in a SLT. As such, HSDPTs may be a superior option for maximizing measured capacities when a significant and uncertain amount of capacity increase is expected in a project.

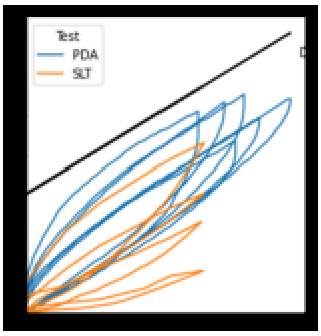


Fig. 1. Load-settlement curves of jacked piles from SLTs and estimated by HSDPTs

References

[1] Yetginer, A.G., White, D.J. and Bolton, M.D. (2006). Field measurements of stiffness of jacked piles and pile groups. Geotechnique, 56(4): 349-354.
[2] Likins, G. E., Rausche, F., Thendean, G. and Svinkin, M. (1996). CAPWAP Correlation Studies. Fifth International Conference on the Application of Stress-wave Theory to Piles (STRESSWAVE '96): Orlando, FL; 447–464.
[3] Komurka, V. E., & Theiss, A. G. (2018). Savings from Testing the Driven-Pile Foundation for a High-Rise Building. In IFCEE 2018 (pp. 87-101).
[4] Fellenius, B. H., & Tech, P. (2001). What capacity value to choose from the results a static loading test.

Announcement

Appointment of the new Secretary General of International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE), Dr. Andrew McNamara

IPA Secretariat

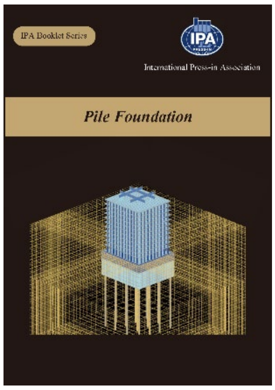
We are pleased to annouce that Dr. Andrew McNamara, Vice President of the IPA since 2022, will be appointed as the new Secretary General of International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE). He will take up the appointment after the next ISSMGE Council Meeting on 13 August 2023 held in conjunction with the 17th Asian Regional Conference on Soil Mechanics and Geotechnical Engineering, Astana, Kazakhstan.

Dr. Andrew McNamara has been Chief Engineer at Skanska Building and a Senior Lecturer in Civil Engineering at City, University of London. His dual position in academia and industry follows 18 years predominantly working for contractors prior to undertaking doctoral research in 1998. He is recognized by the community for both research and his professional contribution to civil engineering. His construction projects have included landmark developments Battersea Power Station, The Gherkin, Heron Tower and The Scalpel whilst research has focused on developments in deep foundations. He leads the Centre of Excellence in Temporary Works and Construction Method Engineering at City, University of London where he established a unique MSc degree program in this specialist area. He is a former chair of ISSMGE technical committee TC104 on Physical Modelling in Geotechnics.

On behalf of IPA members, we would like to offer our respectful congratulations and best wishes for his continued success.

"Pile Foundation" was published

Pile Foundation was published in March by International Press-in Association. This booklet is an edited version of a series of articles that appeared in the IPA Newsletter since 2017. It provides a review of some development history, innovation in foundation engineering concepts, the performance of several foundation setups and preparations of guidelines in certain countries. The combination of views from prominent geotechnical professionals in a perspective of the real practices and case studies, research and development at the university and implementations in different countries are highlighted for this edition. The PDF version is now available on the IPA members' website, please access the following URL to download.



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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		
9TH INTERNATIONAL CONGRESS ON ENVIRONMENTAL GEOTECHNICS	25-28 June 2023	Chania, Greece
17TH ASIAN REGIONAL GEOTECHNICAL ENGINEERING CONFERENCE	14-18 August 2023	Astana, Kazakhstan
8TH INTERNATIONAL SYMPOSIUM ON DEFORMATION CHARACTERISTICS OF GEOMATERIALS	3-6 September 2023	Porto, Portugal
11TH INTERNATIONAL CONFERENCE ON SCOUR AND EROSION (ICSE-11)	17-21 September 2023	Copenhagen, Denmark
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		
58th Japan National Conference on Geotechnical Engineering	11-14 July 2023	Fukuoka, Japan
Japan Society of Civil Engineers 2023 Annual Meeting	11-15 September 2023	Hiroshima, Japan

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Editorial Remarks from persons in charge

A warm welcome to the June 2023 IPA Newsletter (Vol. 8, Issue 2). The IPA has continued to encourage and facilitate fascinating research, coordinate activities and sustainability-led agendas, to collate a selection of an interesting and informative selection of novel and forward-thinking articles within this issue of the newsletter. We would also like to express a note of gratitude to all parties and authors who have been involved with preparing this edition.

This Newsletter issue has presented a number of interested articles exploring the potential for press-in engineering to provide a robust solution for repairing, protecting and replacing critical infrastructure, with recent applications in Europe and Africa presented as case studies. The unique solutions that can be achieved with press-in technology highlight the methods of increasing the bending capacity and watertightness of sheet piled walls by introducing a double-skinned retaining wall. Different types of load testing methods were also presented with applications presented from the Philippines. Some this summary alone it is clear that the work of the IPA extends across the globe, with its uses ranging from temporary to permanent words. Improving and extending on the IPA's activities to date will only serve to improve design, construction and sustainable practice in the coming years, and I am hopeful that more members join and become involved in this exciting movement.

And on a final note, to support the IPA's activities which aim to promote best practice and innovation in the industry, I hope that you will take note of the Call for Abstracts for the 3rd International Conference in Press-in Engineering. The conference will be held next year in Singapore and abstracts should be submitted before 31st July 2023. This conference is set to be an exciting opportunity to learn about the latest technological and sustainable advancements in Press-in Engineering with a focus on tackling climate change for infrastructure developments; this will be a must attend conference so please do submit an abstract at https://2024.icpe-ipa.org/abstracts.

Jignasha Panchal

Mark Albert H. Zarco

Daisuke Hirose