Introduction of educational training and qualification systems for fostering press-in piling technicians in Japan

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ABSTRACT

Press-in piling works require a piling crew consisting of various technicians, such as a press-in piling machine operator, crane operator, piling hands, welders, etc. The workmanship of the press-in piling work depends greatly on the skills of these technicians. Therefore, the educational training of these technicians and a qualification system to confirm their skills are extremely important factors. In recent years, with the scientific elucidation of the press-in principle, the innovation and advancement of the press-in piling technology, and the expansion of the application range of the press-in method, the role required of these press-in piling technicians has changed. They are required to have the ability to observe the entire press-in piling works from a more comprehensive perspective, to have management skills to organize the site efficiently, and to be management engineers who contribute to the workmanship, cost, and safety of the construction. In addition, with the advancement of ICT and AI technologies, the skills and know-how of press-in piling itself are subject to mechanization and automation, and the role of technicians is facing the time to be reconsidered. What are the required roles of press-in piling technicians, and what should be the necessary training and qualification system? This paper introduces the educational training and qualification system for press-in piling technicians in Japan, where the press-in method was born and has been widely used and developed, and its operational examples and challenges, as well as the latest efforts toward digital transformation of press-in piling machines and future prospects.

Key words: *Press-in, technicians, digital transformation*

1. Introduction

Press-in methods, in which a static load is applied to a pile to penetrate into the ground, are classified into three types according to the method of obtaining the reaction force. The three types of press-in piling are: 1) walk-on-pile type press-in piling, 2) panel type press-in piling, and 3) deadweight type press-in piling, depending on the method of obtaining the reaction force. Among them, this paper focuses on the walk-on-pile type press-in method, which is widely used in the global construction industry.

The paper first introduces the current status of the educational training and qualification system for professional technicians engaged in press-in piling works in Japan, where press-in piling technology is widely used.

Then, the latest efforts for the digital transformation of the press-in method using ICT technology are introduced, and finally, the future skills required for press-in piling technicians and the educational training and qualification system in the future are discussed.

2. Legislated educational training and qualification system for the press-in piling work in Japan

2.1. Birth and development of the press-in method

The walk-on-pile type press-in method was implemented in 1975 when GIKEN LTD. (established in Japan in 1967 as a civil engineering company devoted to controlling construction pollution) developed the world's first walk-on-pile type press-in piling machine, the SILENT PILER™ as an environmentally friendly piling machine. Conventional pile driving machines often create nuisances such as noise and vibrations during pile installation works due to their design principles, which involve applying dynamic energy such as percussion and vibrations to drive piles (steel sheet piles, steel pipe piles, concrete sheet piles, and other construction materials) into the ground. In contrast, the SILENT PILER obtains its reaction force by clamping onto several piles already embedded in the ground, allowing it to install piles with static load employing hydraulic pressure resulting in minimal noise, vibration, and ground disturbance. Alongside its rational pile installation principle, the compact equipment size and applicability to high-quality prefabricated piles enable efficient piling works even in challenging working conditions.

Since its introduction, the SILENT PILER has evolved into a series of advanced press-in piling machines that enhance the capabilities of the press-in method across various soil conditions, construction environments and pile materials. These include (1) "CLEAR PILER™": Enables pile installation within restricted headroom, a consideration not addressed by conventional piling methods. (2) "ZERO PILER™": Allows for pile installation in close proximity to boundary lines and adjacent structures. (3) "CRUSH PILER™": Facilitates pile installation in hard ground such as sandy gravel and bedrock. (4) "GYRO PILER™"(rotary cutting press-in method): Capable of installing steel tubular piles through existing structures and underground obstacles (maximum applicable pile diameter: 2500mm). (5) "GRB System™": Enables piling works on previously installed piles completing all steps, including transporting, pitching and installing piles with minimum temporary works such as temporary platforms or berms, even if the piling works need to be carried out over water or on a slope, (6) Press-in piling machine for "combined walls": Installs multiple pile materials with a single press-in piling machine, providing a rational and economical wall structure as a combined wall. In addition, the scope of application for press-in piling machines is not limited to temporary piling in urban construction works with restricted working conditions, but has expanded to permanent structures. In Japan, the Great East Japan Earthquake of 2011 demonstrated the resilience of the embedded structures against external loads, leading to an increased application of piled structures for permanent use. The press-in method is now considered a preferable, faster and more efficient solution in disaster prevention, disaster mitigation and urban renewal projects.

In line with this trend, the development direction of press-in piling machines has been shifting from a quantitative approach focusing on piling efficiency under various installation conditions to a qualitative approach that prioritize the performance and accuracy of substructures installed through the press-in method. Specifically, in Japan, there is a concerted effort to advance an approach that combines the real-time data logging capabilities of the press-in method with Information and Communication Technology (ICT). This aims to estimate ground conditions during pile installation and apply this information to optimize the operation of press-in piling machines. This approach is expected to achieve automated optimization of the press-in parameters, including the speed, force and stroke of the push and pull actions. This optimization aligns with subsurface information estimated from the press-in piling data obtained during the pile installation process. This integrated system resulting from this approach is currently in practical use, and is gaining traction in Japan as a technology that contributes to labor and manpower savings, along with improved productivity at construction sites.

The scientific evaluation of the press-in mechanism and the development of innovative, advanced piling equipment have significantly contributed to the implementation and expansion of the press-in method. However, in order to effectively realize these technologies and their impact on real projects, it is equally essential to cultivate skilled technicians with advanced knowledge and expertise in planning and implementing press-in piling works.

2.2. Education for press-in piling machine operation under Japanese laws and regulations

The Japanese legal framework concerning the operation of press-in piling machines encompasses the Industrial Safety and Health Act (law), the Ordinance on Industrial Safety and Health (Cabinet Order) and the Order for Enforcement of Industrial Safety and Health Act (Order of the Ministry of Health, Labour and Welfare). According to Article 59 of the Industrial Safety and Health Act, employers are mandated to furnish workers assigned to dangerous or hazardous operations with special education on safety and health pertinent to the work (hereinafter referred to as "special education"). Walk-on-pile type press-in piling machines, including the SILENT PILER, fall into the categories of "pile driver" and "pile drawer" as outlined in Article 10 of the Order of Enforcement of Industrial Safety and Health Act. The operation of such machines for foundation work is explicitly designated as a dangerous or hazardous operation under Article 36 of the Ordinance on Industrial Safety and Health. Consequently, special education is required for individuals involved in operating these machines. In compliance with regulations, the Minister of Health, Labour and Welfare defines the subjects and hours of special education in the Rules on Special Education for Safety and Health. For the operation of machines especially designed for foundation work, these rules specify a total of 7 hours for academic education and an additional 5 hours for practical education. Special education may be conducted in-house or by an external agency, but regardless of the approach, it is imperative that the employer assumes responsibility for its implementation. As one such external institution for special education, the Japan Press-in Association, established in 1979 as a voluntary organization with the aim of enhancing press-in piling skills and advocating for the widespread of adoption of the press-in method, has been playing a significant role. In 2016, it was incorporated as a general incorporated association. The association conducts academic education covering the subjects outlined in **Table 1**. The education provided encompasses more than just a comprehension of the mechanism and operational procedures of the press-in piling machine. It also entails an understanding of the distinctive working principles and theories of press-in method. This method involves the static installation of a new pile into the ground by leveraging the reaction force generated through clamping onto the piles already embedded in the ground. Practical education and skills training, including the operation of the press-in piling machine and signaling for operation, are delivered through in-house training by the employer and technical training by the press-in piling machine manufacturer. Notably, the special education conducted by the Japan Press-in Association draws a broad attendance from individuals involved in the press-in method and has become firmly established in the press-in piling industry as a foundational platform for enhancing technological proficiency and skills. This special education by the Japan Press-in Association commenced in 1982, and as of December 2023, it has awarded 7,220 certificates of completion.

Table 1. Subjects of special education (academic education) by the Japan Press-in Association

Subjects
Classification of construction equipment and foundations, types and uses of steel sheet piles
Knowledge of mechanics, hydraulics and engine/motor
Press-in piling machine (configuration, specifications, machine operation, safety devices, maintenance and inspection)
Knowledge of geotechnical engineering
Press-in method (features and advantages of the method, press-in principle, press-in construction theory and practice)
Press-in operation, driving assistance method, extraction operation
General knowledge of construction planning and site work
Health and safety, related laws and regulations

A total of 14 hours of academic training required for both the press-in piling machine and press-in piling machine assisted with augering is provided as a single course.

2.3. Types of technicians for press-in piling work and education and qualification based on the legal system

On the other hand, in addition to the press-in piling machine operator, it is essential to work together as a piling squad consisting of various technicians as shown in **Table 2**, depending on the nature of piling works. In Japan, the Ministry of Land, Infrastructure, Transport and Tourism (hereinafter referred to as "MLIT") and other authorities have developed various estimating standards based on the survey results of actual construction projects, ensuring that the construction budget for public works can be calculated appropriately. According to these standards, a standard piling squad of the press-in method consists of one piling foreman, one press-in piling machine operator, two piling hands, and one crane operator (two welders are added if pile splicing is required). On the actual construction site, as the complexity and difficulty of the construction work increase, and as the level of requirements and technology for quality control of the construction work becomes more sophisticated, it is becoming increasingly important to enhance the skills of each technician at the team level. This includes proficiency not only in the operation of the press-in piling machine but also in pile handling and pitching, welding, and the delivery and removal of materials and equipment. It is crucial to optimize overall management ensuring proper assignment of technicians and systematic execution of piling works in accordance with the site conditions.

Table 2. Professions and roles in press-in piling work

Job title	Role
Site supervisor (Foreperson)	Supervising other piling crews, monitoring progress of piling works and ensuring compliance with construction safety regulations
Press-in piling machine operator	Operating press-in piling machine
Piling hand	Performing work other than press-in piling machine operation, such as loading/unloading and sling work for piles and piling equipment
Crane operator	Operating cranes
Welder	Welding piles and other construction materials on site
Operator of other auxiliary equipment	Operating auxiliary equipment such as backhoes and water jet pumps, etc., as required by the type of work and site environment

In terms of workmanship, cost, and safety aspects, the importance of improving construction works has been discussed in the past in Japan. As a solution to this issue, the "Key Skilled Woker Scheme" was launched in 1996 as a private qualification program by a specialist contractor organization. This program certifies technicians with proficient work skills, extensive knowledge, and management skills to efficiently organize a construction site. It is based on the view that the role of skilled workers directly engaged in production activities at construction sites, especially foremen who play a core role in such activities, is crucial. With the revision of the Enforcement Regulations of the Construction Industry Law in 2008, the "Key Skilled Worker Scheme" was replaced with the "Registration Key Skilled Worker Scheme", established by the MLIT. This program is administered by certified organization approved by MLIT, and individuals who complete the training course are registered as key skilled workers. In April 2022, the MLIT accredited the training course for registration key press-in piling technicians conducted by the Japan Press-in Association, shown in **Table 3**, as one of the training courses for registration core skilled workers based on the Enforcement Regulations of Construction Business Act. As of December 2023, 296 individuals have been issued certificates.

Table 3. Contents of the educational training course for registration key press-in piling technicians

Subjects	Content (600-minute lecture, 60-minute examination)
General knowledge of key skilled worker	How to be a key skilled worker (key roles and skills at construction sites)
	On the job training
Laws and regulations	Related laws and regulations
Construction management, progress control, material management, and other technical management	Construction management and paperwork (construction planning procedures)
	Progress control
	Materials management
	Cost, Quality, Safety control
	Knowledge of construction materials and geotechnical engineering
	Basic knowledge of press-in methods

Table 4 below summarizes the educational training and qualifications for press-in piling technicians in Japan. In Japan, not only in the construction industry, but also in

various other industries, Articles 59 and 61 of the Industrial Safety and Health Law obligate individuals engaged in dangerous and hazardous work to undergo special education and skills training courses and obtain a license as necessary. Besides the safety and health license, there are other certifications intended to validate the knowledge and skills of technicians and enhance their professional status.

Table 4. Educational training and qualifications for press-in piling technicians

Profession	Education/Training and Qualification	Implementing organization
All	Training for registration key press-in piling technicians	Japan Press-in Association
Site supervisor (Foreman)	Education for foremen and safety and health supervisor	Employer or external safety and health advisor
Press-in piling machine operator	First- and second-class press-in piling technicians	Japan Press-in Association
	Special education for the operation of press-in piling machine	Employer or external agency (Japan Press-in Association)
Piling hand	Slinging operation skill training course (lifting load of 1 ton or more)	Training institute registered with the Director of the Prefectural Labor Bureau
	Special education for lifting sling (lifting load less than 1 ton)	Employer or external organization
Crane operator	Crane operator's license (lifting capacity of 5 tons or more)	The Institute for Safety and Health Qualifying Examination
	Mobile crane operator's license	The Institute for Safety and Health Qualifying Examination
	Skill training course for light capacity mobile crane operation	Registered training institute with Director General of the Prefectural Labor Bureau
Welder	Gas welding operator's license	The Institute for Safety and Health Qualifying Examination
	Gas welding skill training	Training institute registered with the Director of the Prefectural Labor Bureau
	Arc welding special education	Employer or external organization
Operator of other auxiliary equipment	Technical training for the operation of vehicle-type construction machine (for foundation work, machine weight of 3 tons or more)	Training institute registered with the Director of the Prefectural Labor Bureau
	Special education for the operation of vehicle-type construction machine (for foundation work, machine weight less than 3 tons)	Employer or external organization
	Technical training for the operation of vehicle-type construction machine (for leveling ground, transport, loading, and excavating, machine weights of 3 tons or more)	Training institute registered with the Director of the Prefectural Labor Bureau
	Special education for the operation of vehicle-type construction machine (for leveling ground, transport, loading, and excavating, machine weight under 3 tons)	Employer or external organization

3. Practical training and certification by private companies

3.1. Technical training by private companies

In addition to the legal training and qualification programs described in Chapter 1, private companies also offer a wide range of technical training programs. These technical training courses, mainly provided by press-in piling machine manufacturers, were originally designed to enhance the skills of press-in piling technicians and boost their productivity. Consequently, they tend to be more practical in nature compared to training and qualification programs based on the legal system. For reference, the following **Table 5** is a summary of curricula covered in the manufacturer-led technical training courses.

Table 5. Example of technical training by a private company (GIKEN LTD., a press-in piling machine manufacturer)

Classification	Curriculum
Classroom lecture (approx. 2 days)	Press-in principle and its theory (The Press-in Essentials)
	The Five Construction Principles
	Penetration techniques according to site conditions (mainly ground conditions)
	Types of press-in methods according to

	site conditions (working conditions and construction purpose)
	Auxiliary equipment used in the press-in method
	Basic flow of press-in and extraction operations
	Machine inspection and maintenance
	Health and safety
	Press-in piling skills training courses - Structure of press-in piling machine - Assembly and disassembly of machine - Operation of the press-in machine
Practical training (approx. 5 days)	Skills training using actual equipment will be provided through operations including unloading, assembling and operating of the press-in piling machine, installation and extraction of piles, dismantling and loading of the machine.
Teaching materials to be used	- The Press-in Essentials - Textbook on the press-in method assisted with augering - Press-in piling machine instruction manual

The technical training outlined above comprises classroom lectures on press-in theory (**Fig. 1**) and practical field training (**Fig. 2**). It caters not only to the press-in piling machine operator but also extends to the site supervisor, crane operator, and piling hands who constitute the press-in piling squad. In addition, a simulator, mimicking the operation of a press-in piling machine on a PC is incorporated into the training for press-in piling machine operators.

Apart from the basic training, both the classroom and practical training courses encompass a dedicated curriculum for each press-in mode including standard press-in, press-in assisted with water jetting, press-in assisted with augering, and rotary press-in piling. This specificity is crucial due to variations in pile materials, equipment used, press-in techniques, and construction management considerations depending on the chosen press-in mode. Furthermore, a separate curriculum is offered for the non-staging method, specifically designed to facilitate press-in piling work in challenging working conditions where working space is restricted.

The training materials are also available in English, enabling the possibility of conducting training sessions overseas.

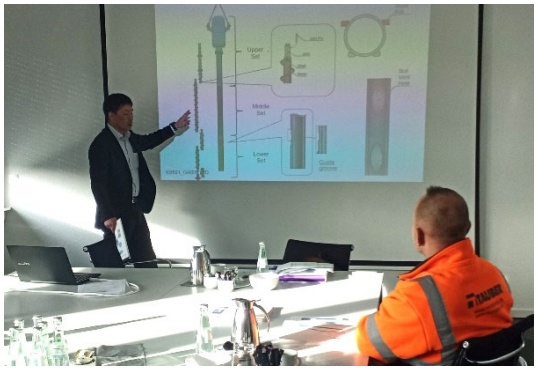


Fig. 1 Classroom lecture

Fig. 2 Practical training

3.2. Qualification system by private companies

Qualification certificates (**Fig. 3** and **4**) will be issued to trainees upon completion of the prescribed training courses. These certificates are differentiated based on the curriculum classified by press-in mode, as described in 2.1. In Japan, because of the existence of a legal qualification system, certificates issued by private companies and organizations are not mandatory for presentation during site induction or project orientation. Nevertheless, this system proves effective in enhancing the practical skills of press-in piling technicians and elevating their awareness and improving their social status as qualified professionals within the industry.

On the other hand, in foreign countries, there is currently no qualification system for press-in piling technicians based on laws and regulations. Consequently, qualification certificates issued by press-in piling machine manufacturers often serve as a means to verify the skills of press-in piling technicians for specific projects, even in the absence of official certification. Notably, in areas where the press-in method has gained widespread adoption, project specifications may include a requirement for presenting a press-in piling technician's

certification. GIKEN LTD., the manufacture of the SILENT PILER, has been conducting skill training courses in many countries around the world since its first overseas sales in 1986. The number of participants who have completed these courses has reached 1,026 in 22 countries, excluding Japan.

Fig.3 Certificate of qualification

Fig.4 Certificate of completion

3.3. Future prospects

The manufacturer-led practical skills training and qualification system will persist as a global initiative, representing a fundamental effort to elevate the skill levels of the entire press-in piling industry and facilitate the widespread adoption of the method. Currently, the region demonstrating a mutually complementary relationship with the official educational training and qualification system based on legal framework is limited to Japan. The aspiration is for the educational training and qualification system for the press-in method to be officially embraced in regions where the method is disseminated and the number of press-in piling technicians surpasses a specific threshold. In such cases, it is anticipated that the press-in piling industry will play a proactive role in advocating for government support. The existing skill training and qualification systems established by private organizations, operating at the grass-roots level, can serve as valuable references. As the application of such an educational training and qualification system evolves globally, aspiring to become a universal framework, it is hoped that the International Engineering Alliance (IEA) will take the lead. The IEA, with its objective to ensure quality in engineering educational training and practice, international equivalence, and enhanced mobility of engineers, could be instrumental in developing and promoting such a system. International discussions within the IEA should be referenced and considered in the ongoing efforts to establish a globally recognized framework.

4. Technological innovation in the press-in method and prospects for educational training and qualification systems

As digital technology progressively replaces traditional analog processes across industries, the construction is no exception. The demand for information-based construction, utilizing ICT technology, has arisen to enhance productivity and safety, particularly in projects involving hazardous tasks. In the realm of the press-in method, ongoing efforts are being made to develop automated and remote operation systems. This involves harnessing the unique characteristics of the press-in method, wherein the press-in machine can dynamically control pile behavior during installation through hydraulic mechanisms, integrated with ICT. This chapter delves into technological innovations, such as automated and remote operation technology of the press-in piling machines and the digital transformation of the press-in piling process. Furthermore, it explores the potential impact of these innovations on the educational training and qualification system for press-in piling technicians.

4.1. Progress in automated operation technology

Automated operation technology for press-in piling machines has a long history, with conventional systems serving as supplementary operating assist techniques, where the machine operates automatically based on operator-set values for operation parameters. In contrast, the PPT System™ (Press-in Piling Total System) developed by GIKEN LTD. in 2017, represents a significant advancement. This automated system enables

the press-in piling machine to autonomously assess ground conditions and other working parameters using measured data such as press-in force, extraction force, pile penetration depth, and construction time. It then automatically selects and operates the optimal parameter values based on these conditions. Furthermore, GIKEN LTD. is currently in the process of conducting verification tests for a new automated installation technology named "iNAVILINK™". This technology goes beyond traditional automated system by introducing a feature that manages the accuracy of installation processes, encompassing tasks from pile setting out to pile top alignment of the press-in pile. This advancement aims to expedite progress toward achieving autonomous installation of press-in piling machines. The distinctions between the conventional manual operation by the operator and the operation using iNAVILINK are outlined below.

4.1.1 Conventional manual operation by the operator

(including the use of operating assist techniques, **Fig. 5**)

1) The operator visually checks the status of the pile and the press-in piling machine (e.g. inclination).
2) Drawing upon personal experience, the operator estimates the pile's condition in the ground, predicts whether there is any deviation from the specified pile position, and determines whether correction to the orientation of the pile and press-in piling machine is necessary.
3) The operator then operates the press-in piling machine and adjusts the orientation of the pile and press-in piling machine as needed.
4) The operator performs the press-in piling while making adjustments to the press-in force and speed as necessary.

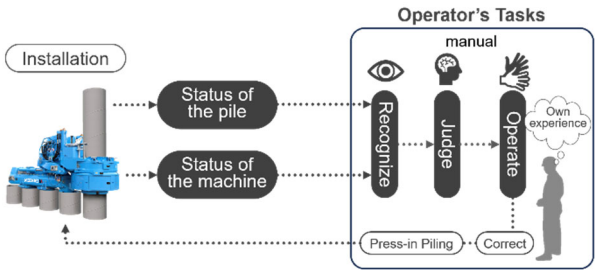


Fig. 5 Conventional installation process

4.1.2 Operation using iNAVILINK (Fig. 6)

1) The Implant NAVI™ (pile installation accuracy management system) quantifies the behavior of the pile during installation, such as penetration depth and inclination into the ground, based on the original information of the pile before the installation starts.
2) Various sensors built into the press-in piling machine quantify the status of the machine as digital data.
3) Digital data indicating the status of the pile and press-in piling machine are automatically input into iNAVILINK.
4) iNAVILINK calculates the deviation between the current pile position (estimated position for the underground part) and the specified position, and determines the necessary correction amount, and outputs signals to each actuator accordingly.
5) The PPT System's automated operation performs press-in piling with suitable press-in speeds and strokes based on ground conditions.

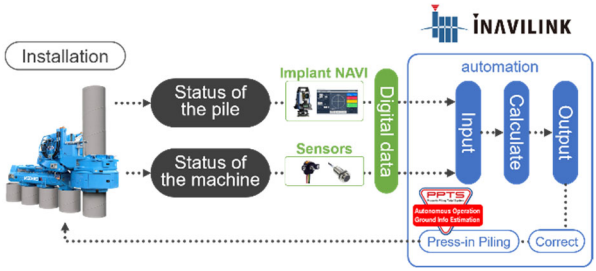


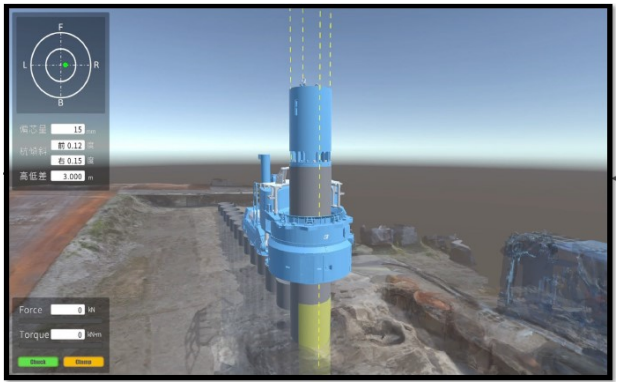
Fig. 6 Installation process using iNAVILINK

The conventional installation process requires operator involvement in all phases. iNAVILINK automates the operator's roles in situation recognition, judgment, and machine operation, and is expected to elevate the automation rate of press-in piling from 30% to 65% of the total process (In the case of Gyropress Method™). In addition, in the conventional press-in method, installation time and accuracy are contingent on the operator's skill. In contrast, iNAVILINK enables stable installation without relying on the operator's skill.

4.2. Development of remote operation and remote operation support systems

In addition to the automated operation technology, G-Lab Vision (remote operation support and simulation technology) is currently under development. It integrates a 3D model of the press-in piling machine, pile, and surrounding environment at the time of installation with real-time information from the Implant Navi and various

sensors inside the machine within a 3D virtual space. In order to conduct press-in piling works effectively, it is necessary to observe the status of the pile and press-in piling machine from multiple viewpoints. By creating a real-time digital twin, the construction status can be observed from various perspectives in the 3D virtual space, allowing for remote operation from outside the visual field. Additionally, it enables visualization of pile installation with the tips of piles underground, which is not possible in real space. While there are some issues to be addressed, in the future, particularly concerning the amount of pile deformation such as distortion and deflection in the ground caused by the installation, the current version of G-Lab Vision is expected to enhance progress and quality control of press-in piling works. This improvement is achieved by visualizing the installation status in the ground and comparing it to the specified pile location (**Fig. 7**).



Yellow colored area: Specified pile location
Gray colored area: Actual pile location

Fig. 7 G-Lab Vision display screen

The system is expected to expand the scope of construction support by enabling operators to remotely monitor site conditions. Additionally, it aims to enhance productivity per operator by enabling one operator to monitor and operate multiple sites. Furthermore, by ensuring compatibility with the VR environment, this system will facilitate simulations that closely resemble actual construction sites.

4.3. Impact on training of press-in piling technicians

The role and training of press-in piling technicians are poised for significant changes in the future, driven by the increasing automation and digital transformation of the press-in method. Automated operation technology will allow machines to assume the role of operators, traditionally requiring many years of experience. This advancement makes it possible to reduce the time needed for skill acquisition and facilitate the transfer of skills by accumulating construction know-how as a system rather than relying solely on individual experience. The progression of systemization is also expected to introduce new roles for setting up and managing the system, necessitating corresponding training. In addition, the development of remote operation and remote support technologies will empower operators to work from any location. Furthermore, as mentioned in 2.1, current skills training is confined to simulated experience of press-in piling machine operation on a PC. However, integrating VR-based simulations into skills training is anticipated to provide operators with more realistic experiences enhancing the effectiveness of learning. The digital transformation of the press-in piling machine, together with the development of public skills educational training and qualification systems mentioned above, is expected to establish an environment where press-in piling technicians from various countries can receive sufficient training in a short period of time and become globally available.

5. Conclusion

The digital transformation (DX) approach to construction work is expected to make further advancements in the future, offering solutions to various challenges faced by the construction industry and at construction sites. In the context of construction work, characterized by diverse environments across different sites and challenges in standardizing work and operations, DX is expected to improve the reproducibility of optimal work, and contribute to higher productivity and safety. Furthermore, in the Japanese construction industry, confronted with a shrinking and aging workforce, DX is seen as a crucial tool to address the issue of technical succession. By sharing knowledge, including the experiences and skills of technicians, often unique to individuals, DX can play a pivotal role in transferring this critical knowledge. The accumulated knowledge will be organized into a comprehensive database, not only benefiting the actual construction process but also influencing the design phase. This includes the creation of

3D construction plans, simulation of construction scenarios, and optimization of structural designs based on this wealth of knowledge. Additionally, it is expected that DX will pave the way for the development of fully unmanned autonomous construction systems utilizing AI.

On the other hand, the act of construction itself remains unchanged: handling real materials and equipment on construction sites, where the construction environment is not uniform in terms of topography, ground, weather conditions, etc., and is subject to constant change. The role of identifying potential problems, devising unbiased solutions, and providing feedback for the further application of DX technology will continue to be fulfilled by people in the future. In this context, the future training of press-in piling technicians will necessitate more than just expertise in press-in piling machine operation and other related techniques. It is important to cultivate the ability to become a comprehensive engineer/technologist who is well versed in the principles and theory of press-in piling construction, understands the purpose of construction itself, and is capable of establishing, managing, and implementing the optimal construction system and process based on the site conditions, considering both the design and construction perspectives.

Moreover, the applicability of the press-in method is expected to expand further with technological innovations. In Japan, the MLIT's "Promoting the Development of Innovative Technologies for Autonomous Construction, such as on the Moon" project has acknowledged the superiority of the press-in principle. The principle not only facilitates construction in low gravity environments but also contributes to downsizing mechanical systems. Ongoing efforts are aimed at developing and demonstrating specific technologies for construction on the moon and in other space environments. As science and technology are evolving day by day, we find ourselves entering a new era where both construction methods and social systems established by construction are undergoing transformations. This period of transition and the creation of new paradigms highlight the need to reconstruct knowledge based on universal principles. The digital transformation of the press-in method serves as an example, showcasing how press-in piling can scientifically and numerically advance, grounded in principles and aligned with construction theory.

From this perspective, the academic education on the principles and theory of the press-in method, conducted by the Japan Press-in Association and press-in piling machine manufacturers, is particularly timely. It will serve as the foundation for future educational training and qualification systems essential for the press-in piling industry as it progresses into a new stage of value creation.

In conclusion, we trust that this report will serve as a valuable reference for individuals interested in press-in piling technician training. Additionally, we hope it will serve as a case study for other countries where press-in piling technology is expected to proliferate. Above all, we aim for it to be a beneficial source of information for enhancing the status and treatment of technicians involved in the press-in method.

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