The current status and future development of Press-in method in China

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ABSTRACT

Originating from Japan, the eco-friendly Press-in method for sheet pile wall installation was firstly introduced in Shanghai's Ruijin Hospital project in 2003. Since then it has undergone more than a decade of development in China. Despite that the technology has gained certain popularity in the domestic market, it has not yet been widely adopted in large-scale infrastructure projects in China. This study focuses on the demand analysis of this engineering method in Chinese market, and evaluation of its technical advantages, before assessing its potential market opportunities. The main challenges faced in promoting this technology in China is also examined, to provide strategic recommendations for its wider application.

Key words: *Press-in method, Sheet piles, Earth retaining structures, Cut-off wall, Chinese market*

1. Introduction

In recent years, statistics from the China Iron and Steel Industry Association indicated a significant increase in the demand for steel sheet piles in China. The consumption grew from over 400,000 tons in 2014 to nearly 1.2 million tons in 2020, with an annual average growth rate of 17%. Concurrently, the production of steel sheet piles in China also saw a substantial increase. As a green and environmentally friendly product, the status of steel sheet piles has gradually risen against the backdrop of increasing global environmental protection requirements. However, the construction technology for steel sheet piles has not kept pace with this trend, in some cases even leading to social issues due to inappropriate choices of construction methods, for instance noise disturbances. The Press-in method, as a noise-free construction technique, has not yet been widely utilized in Chinese market. Bearing the situation in mind, this study aims to investigate the acceptance level of this construction method, analyze the barriers to its application in the current market, and explore potential strategies to promote its widespread use.

2. Objectives and Methodology of the Study

Specifically, the level of acceptance of this method among project owners, design institutes or consulting companies, general contractors, and specialist construction units, and its potential application in the Chinese market will be explored. The research will revolve around the following key objectives:

1. To assess the demand level and technological maturity of the Press-in method in the Chinese market.
2. To elaborate the application scenarios of the Press-in method.

3. To discuss the main challenges and potential solutions for promoting the Press-in method in China.

Methodology:

1. To collect primary data and opinions from all parties involved in construction.
2. To use online surveys to conduct extensive information collection and analysis targeting the user community of "GONGFAWANG"(Construction Method Webs http://www.gongfawang.com/).

3. The History and Development of Sheet Piles in China

Since the first use of Soviet-made U-shaped steel sheet piles in the construction of the Wuhan Yangtze River Bridge in 1955, steel sheet pile technology in China has gone through several important development stages. In the 1960s and 1970s, some domestic steel companies successfully replicated and produced their own models of steel sheet piles. In the early 2000s, China began to develop U-shaped steel sheet piles in line with German standards. In 2007, the relevant departments formulated the standard, "GB/T 20933-2007 Hot rolled U-sheet pile " (the current standard is " GB/T 20933-2021 Hot rolled sheet pile"). It provides important technical specification for steel sheet pile production. After 2011, several private steel mills began producing hot-rolled U-shaped steel sheet piles in succession. Today, many large domestic steel mills are capable of producing and researching various types of steel sheet piles and have begun exporting them in bulk to overseas markets.

The application scenarios of steel sheet piles in China are roughly similar to those in other regions of the world, mainly used in infrastructure projects. In recent years, due to the country's substantial investment in infrastructure, the demand for hot-rolled U-shaped steel sheet piles surged from 400,000 tons in 2014 to over 1 million tons in 2019 (**Fig. 1**), indicating strong market demand.

The main uses of steel sheet piles include both permanent and temporary structures. (1) Permanent structures: roads, railways, docks, embankments, retaining walls, breakwaters, docks, shipyards, sluice gates, drop pipes, foundation reinforcement, erosion prevention, and water-stop walls; (2) Temporary structures: temporary embankments,temporary island building, cofferdams for bridge construction, and retaining walls for temporary trench excavation for underground main pipeline; and structures for emergency rescue in construction for flood control, landslides, subsidence, and quicksand, and cut-off walls.

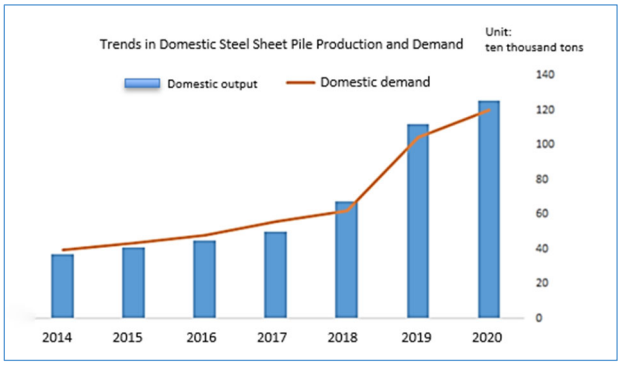

Fig. 1 Trends in Domestic Steel Sheet Pile Production and Demand

Data Source: China Iron and Steel Industry Association

The Chinese market mainly uses U-shaped steel sheet piles. Unlike the Japanese market, where 600mm wide hot-rolled U-shaped steel sheet piles are mainly used for permanent projects, in China, steel sheet piles of this specification are more commonly used in temporary deep foundation pits and earth retaining structures. On the other hand, in recent years, Japan has extensively adopted more efficient 900mm wide hat-shaped steel sheet piles for permanent projects. However, due to patent restrictions and import costs, the application of these extra-wide steel sheet piles is relatively limited in China. The main reason for this limitation is that the domestic market demand for such steel sheet piles is constrained by cost-effectiveness considerations, which restrict their widespread use.

Furthermore, China has now developed into the world's largest steel sheet pile rental market. In this market, the rental products of steel sheet piles are mainly classified by length. 400mm wide SP-III type steel sheet piles typically come in lengths of 6m and 9m, while 400mm wide SP-IV type are mainly 12m and 15m. For demands exceeding 18m, 600mm wide SP-IVw type U-shaped steel sheet piles are commonly used. Nonetheless, the application proportion of steel sheet piles in permanent projects is relatively low, accounting for only about 5% of the total market size.

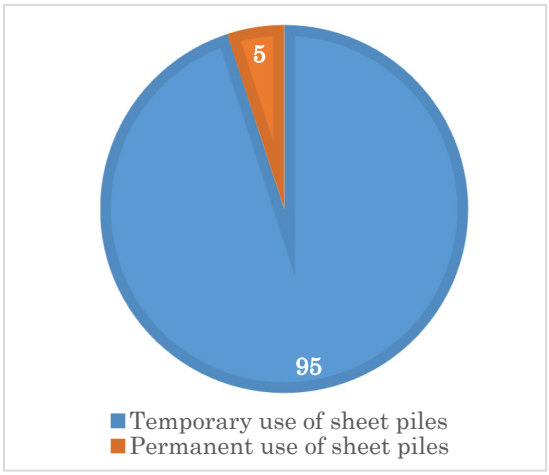

Fig. 2 Distribution of Steel Sheet Pile Usage Structure in China
Data Source: China Iron and Steel Industry Association

4. Construction Technology of Steel Sheet Piles

In China, the usage of steel sheet piles is substantial, yet the selection of construction techniques suitable for different regions and environments has not been standardized. Currently, the construction of steel sheet piles primarily utilizes the vibration method, with the press-in method as a supplementary approach. The vibration method encompasses both electric and hydraulic driving mechanisms, with the hydraulic method further divided into excavator-modified, standard hydraulic, and high-frequency types. The choice of vibration method must take into account the construction site, environment, and the length of the steel sheet piles. The press-in method, on the other hand, is mainly employed in special projects with limited construction environments, particularly in situations where working space is constrained, and noise and vibration restrictions are stringent.

5. Application Projects of Press-in method

The application of the Press-in method in China is becoming increasingly widespread. Since its first implementation in Shanghai Ruijin Hospital in 2003, this technology has been particularly suited for locations with strict environmental impact requirements due to its no-vibration, low-noise characteristics. With societal progress, in recent years, the the press-in method has gradually gained recognition from more project owners, design institutes, and general contractors, with its application areas continuously expanding. This includes flood prevention and disaster mitigation emergency projects (**Fig. 3**), water supply pipeline installation and reconstruction projects (**Fig. 4**), historical building renovations (**Fig. 5**), cofferdam for bridge piers (**Fig. 6**), and permanent reinforcement projects for river embankments (**Fig. 7**). Considering the frequent occurrence of extreme natural disasters in recent years, enhancing disaster prevention and mitigation capabilities has become particularly important. Therefore, the Chinese government issued additional national bonds in the fourth quarter of 2023 to support post-disaster recovery and enhancement of disaster prevention and mitigation capabilities, where the application of environmentally friendly Press-in method will be further promoted.

Fig. 3 Flood Prevention and Disaster Mitigation Emergency Projects - Standard Press-in

Fig. 4 Water Supply Pipeline Reconstruction Projects - Press-in with Water Jetting

Fig. 5 Historical Building Renovation Projects - Standard Press-in

Fig. 6 Bridge Cofferdam Projects – Press-in with Integral Augering

Fig. 7 Permanent Reinforcement Projects for River Embankments - Press-in with Water Jetting

6. Press-in method Survey

To better understand the prevalence of the Press-in Method in the Chinese market, a survey was conducted through "GONGFAWANG". The main purpose of this survey was to gather information on the application of Press-in method and opinions from industry professionals. The survey was designed to gain detailed insights into the awareness, frequency of application, and the advantages and challenges of the Press-in method in actual construction sites. The results of the survey will help us more accurately assess the acceptance level and potential for development of this technology in the Chinese market, providing empirical evidence and strategic recommendations.

6.1. Survey Questionnaire Design:

a. Respondent background information:
i Gender
ii Age
iii Education level
iv Work experience (years)
v Field of expertise
vi Type of work unit
b. Construction process related survey:
i Experience in steel sheet pile construction
ii Equipment used
iii Reasons for work stoppage during construction
iv Awareness of Press-in method
v Impression of Press-in method
vi Experience in using Press-in method
vii Types of Press-in method used
viii Participation in preliminary consultations for Press-in method
ix Reasons for not using Press-in method
x Proportion of Press-in method in steel sheet pile projects

6.2. Survey Questionnaire Design:

Respondent statistics (total of 115 responses):

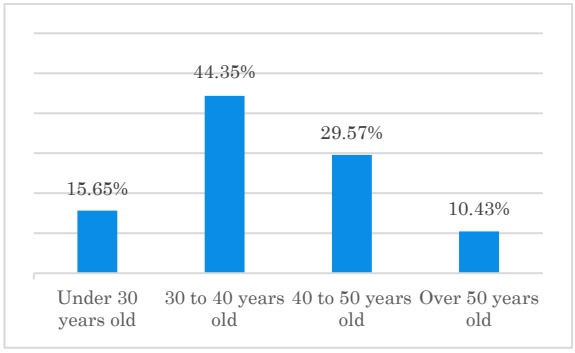

Fig. 8 Age Distribution

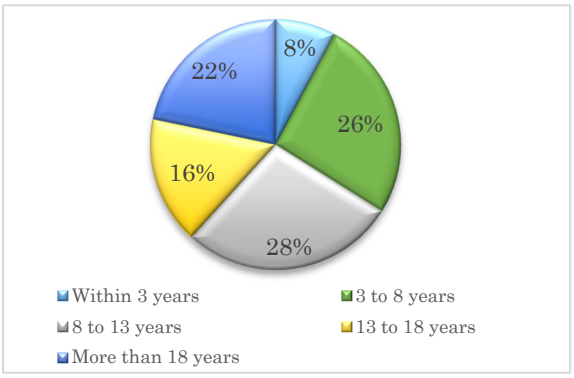

Fig. 9 Work Experience

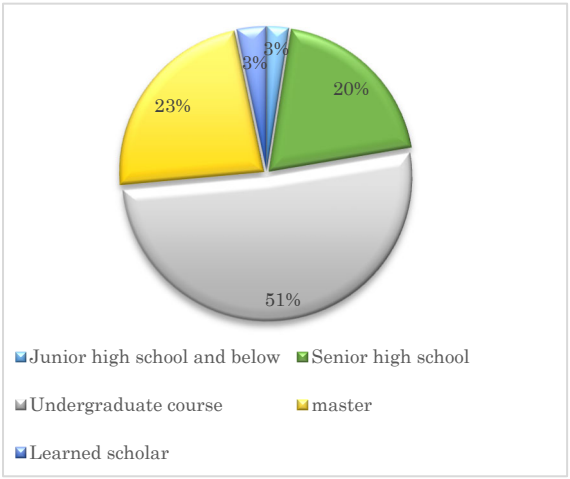

Fig. 10 Highest Educational Attainment

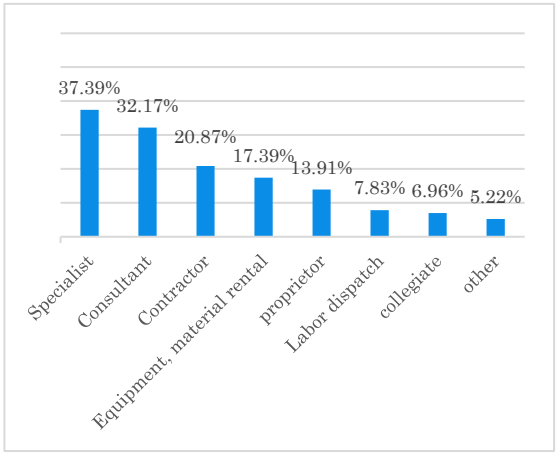

Fig. 11 Business Category

Fig. 8 shows age distribution: 45% are aged 30-40, and 30% are aged 40-50, with middle-aged professionals dominating.

Fig. 9,Fig. 10 shows work experience and education: Those with over 8 years of experience account for 66%, and those with a bachelor's degree or higher account for 80%, indicating that participants generally have a high educational background and extensive work experience.

Fig. 11 shows business category: Over 30% come from professional construction, consulting, survey, and design units, showing a diverse industry background.

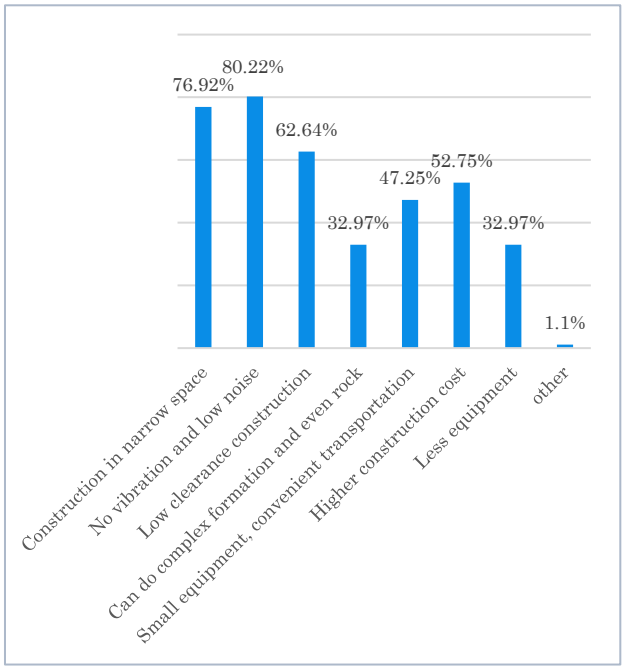

Fig. 12 Impression of Press-in Method

6.3. Awareness and Application of Press-in method:

According to Fig. 12, we can learn the following.

Understanding of the technology: About 80% of respondents are familiar with the Press-in method, indicating that the technology has a certain level of market recognition.

Application scenarios of the technology: The technology is mainly applied to special projects with environmental constraints, such as limited working space, low headroom, complex soil strata, and necessity of pile penetration into rock, where its advantages can be fully utilized.

Technical advantages and concerns of the technology: Respondents recognize the environmental friendliness, low noise, rock penetration, and compactness for easy transportation as advantages of the Press-in method.

However, there are concerns about the cost compared to traditional, less expensive methods, and the limited availability of equipment in the market.

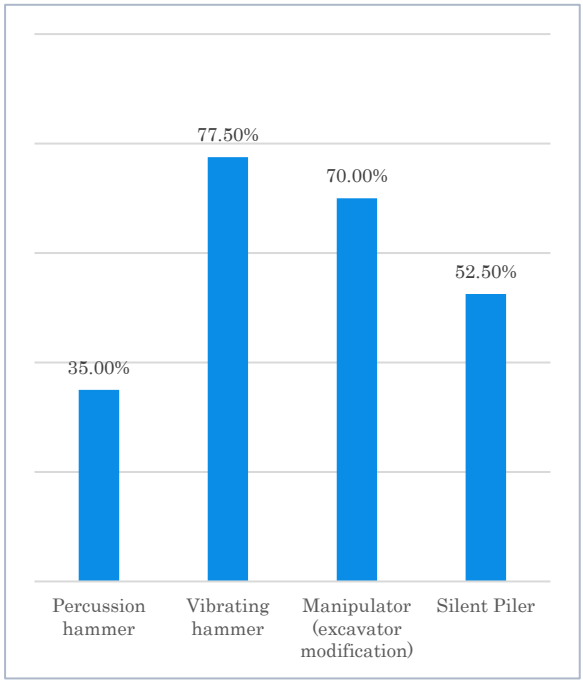

Fig. 13 Equipment Used

6.4. Press-in method Market Status

Through Fig. 13, we have learned that the current market situation of Press-in method is as follows.

Equipment Selection: Vibratory hammers and excavator mounted vibratory hammer are the mainstream equipment, with 52.5% of respondents indicating they have encountered the press-in piling machine in various forms, demonstrating the gradual popularization of press-in piling technology.

Market Application Scale: Despite 80% of respondents being aware of the Press-in method, its application in steel sheet pile projects is low, with only 35% or fewer projects involving Press-in method.

Main Reasons for Not Adopting This Technology: Construction cost is very high compared to traditional piling methods.

Reasons for Work Suspension with Traditional Piling Methods: Resident complaints rank first, reflecting changes in the social environment and an increase in residents' awareness of their rights.

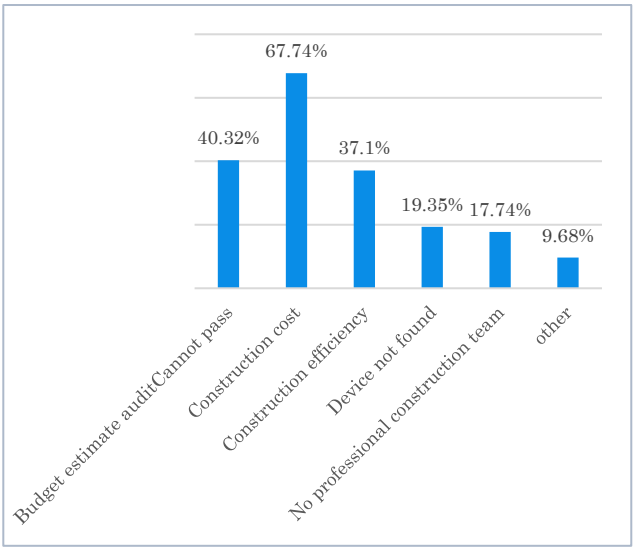

Fig. 14 Reasons for not using Press-in Method

6.5. Barriers to the Promotion of Press-in Method:

According to Fig. 14, we can learn the following.

Main Reasons for Not Using Static Processes: Difficulty in budget auditing (40%) and construction costs (68%).

Deficiency in Construction Budget: Since this technology is a new construction method, it has not yet been adopted as a standard construction method in standard budgeting system of the government department.

7. Concluding Remarks

This study explored the current application and potential of the Press-in method in the Chinese market. The results indicated that this technology had been widely recognized within the piling industry, particularly for projects sensitive to environmental disturbance. Its characteristics of reduced vibration and low noise, along with the capability to operate in constrained working space, make it an ideal choice for meeting stringent construction environment. However, wider adoption of the technology is hindered by factors for instance the construction period, quoting/budgeting systems, and construction costs. To promote the Press-in method more effectively, the following measures are proposed:

1. Strengthening policy support: Providing a stable external environment for the application of the Press-in method through establishment of guidelines and industrial standards in relation to the method selection for the press-in method.

2. Enhancing Awareness and Promotion: Deepening the understanding and awareness of the Press-in method both within and outside the industry through seminars and on-site technical demonstrations.

3. Optimizing Cost and Efficiency: Reducing construction costs and improving construction efficiency through technological innovation, while actively promoting the rational use of second-hand equipment, especially in cost-sensitive market.

4. Expanding the Cooperation Network: Deepening the understanding of market needs and leveraging resources from various parties to jointly promote the Press-in method through close cooperation with client, machine sales agents, and industry associations. This includes providing customized solutions to meet unique needs, expanding market influence through the sales network of agents, and improving industry recognition and application of the technology through collaboration with industry associations in standard drafting and technical exchanges.

8. Acknowledgements

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China Iron and Steel Association: https://www.chinaisa.org.cn/

GONGFAWANG: http://www.gongfawang.com