Case-History

Steel Sheet Pile Cofferdam in China (Hubei Province)

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In China, since they had to rely on expensive imported steel sheet piles before, the scope of application of steel sheet piles was limited to emergency projects such as disaster recoveries. In recent years, however, Chinese domestic production and mass production of steel sheet piles have progressed, and the price of steel sheet piles has become significantly lower than that of imported products, so the scope of application of constructions using steel sheet piles has been expanding. Recently, with the increase in infrastructure development such as high-speed railways and expressways, the number of steel sheet pile cofferdam has rapidly been increasing. Under such circumstances, cases of adopting the press-in piling method are increasing, especially for projects overcoming high construction difficulties. In this article, a case of cofferdam for construction of expressway bridge piers over a river is introduced.

1. Construction Outline

1.1 Construction Location

The construction site is the highway bridge (official name: Hegu Han River Highway Bridge) over the Han River in Xiangyang City, Hubei Province, China (Fig. 1). Xiangyang is a prefecture-level city located in the northwestern part of Hubei Province, China, and is the second largest city in Hubei Province. As shown in Fig. 2, the cofferdam by the press-in piling method was installed to construct the 23rd and 24th piers of this highway bridge.

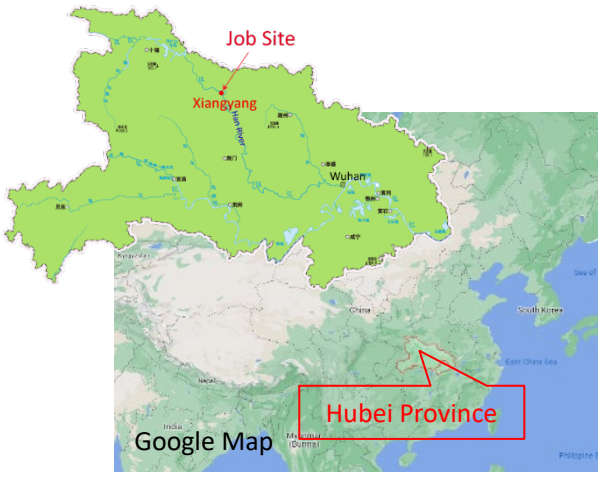


Fig. 1. Project location

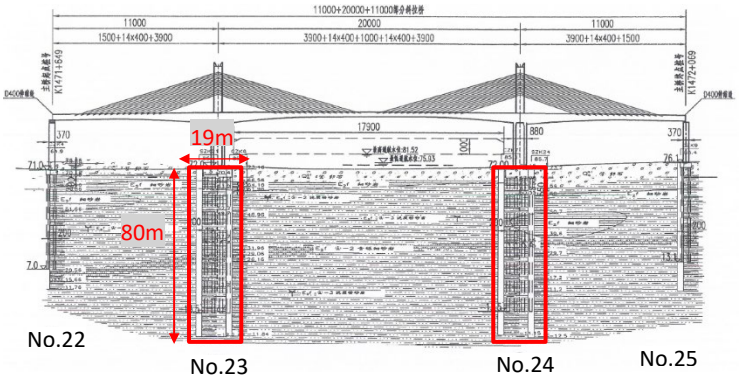


Fig. 2. Longitudinal section of the highway bridge

1.2 Background and objectives of the project

The name of this project is "G316 Hegu Han River Highway Bridge and Connection Project". G316 is an important highway in Hubei Province, which runs through Xiangyang from east to west and plays an important role in the economic development of the region. However, some sections of the G316 Highway are winding narrow routes with limited traffic capacity. To optimize the local road transportation network, Xiangyang City authorities have decided to implement this project.

Since the 23rd and 24th piers of this highway bridge were to be constructed in the river, construction of a cofferdam was a premise. Initially, in consideration of hard ground conditions, pre-drilling with an earth drill plus steel sheet pile driving by the vibratory hammer method was adopted. However, due to the fact that the ground was mixed with boulders and the ground loosened by predrilling was reconsolidated when the steel sheet pile was driven by a vibratory hammer, the construction became difficult. As a result, the design was changed to the press-in piling method with an auger that enables more reliable construction. The press-in work on the 23rd pier was carried out from December 2019 to April 2020, and the 24th pier from April to May 2020, and 182 cofferdam steel sheet piles were pressed in respectively.

2. Site condition and piling method

2.1 Site condition

At this site, there were two challenges that had to be overcome. The first was the construction period. In this project, all work was required to be completed within the dry season (December-February). The Han River, which flows through the construction site of Xiangyang City, is the largest tributary of the Yangtze River in China, and there is a danger of flooding in summer. As mentioned in 1.2, the predrilling plus vibrohammer method was initially adopted. This method required two steps, predrilling and steel sheet pile driving, which might slow down the progress of the work. On the other hand, in the press-in piling method with an auger, augering and pile installation could be performed in one process, therefore, more reliable and rapid construction was possible. The project was able to be successfully completed within the planned construction period. The second was the hard ground condition. The ground condition at the site, as shown in the borehole log in Fig. 3, was hard ground formed of cobbles and weathered siltstones. At the actual site, boulders (200 mm to 300 mm) were found as shown in Fig. 4.

Bore hole log

Project	G316 Hegu Han River Highway Bridge and Connection Project									
Job No.	2019-8-16					Hole No.	K1			
B.H.Elev (m)	72.41	坐标	X=3574077.50			Start Date	2019.8.10			
B.H. Diameter			Y=539407.62			End Date	2019.8.1			
地层编号	地层名称	时代成因	层底高程 (m)	层底深度 (m)	分层厚度 (m)	柱状图 1:80	地层描述	岩芯采取率 %	标贯击数 (击)	附注
①	卵石	Q_4^{al+pl}	68.31	4.10	4.10	Boulders	卵石:灰色,稍密,饱和;主要成份为石英岩、硅质岩。卵石粒径一般2.00~6.00cm,最大达12.00cm,含量约68%,磨圆度较好,主要呈次圆状,颗粒级配较好,充填细砂。			
②	细砂岩	E_2F	65.31	7.10	3.00	Fine Sand	强风化细砂岩:灰白色,细粒砂状结构,层状构造,主要成份石英、长石和少量泥质,风化裂隙发育,岩石胶结差,岩芯极破碎,主要呈砂状或砂柱状,局部含砾。岩石质量指标差,岩体完整程度为极破碎。			
③	泥质粉砂岩		60.41	12.00	4.90	Mudstone	中风化泥质粉砂岩:棕红色,粉砂状结构,层状构造,主要成份石英、长石和少量泥质。风化裂隙发育,岩芯较破碎,主要呈10.00~42.00cm柱状,少部分呈5.00~9.00cm块状,饼状,属极软岩。岩石RQD值61%,岩石质量指标较差,岩体完整程度为较破碎。			

Fig. 3. Bore hole log

By using the press-in piling method with an auger, steel sheet piles were able to be installed without problems in spite of such hard ground conditions. Unfortunately, due to the spread of the new coronavirus infection in January 2020, we were compelled to close the site for two months, but in order to catch up on the construction period, we introduced two press-in piling machines, and we were able to make it (Fig. 5). Since the press-in piling machines were small and it was easy to construct with multiple units, the construction was able to be completed within the planned period, and this effect of shortening the construction period was highly evaluated by the principal contractor.

Fig. 4. Boulders found at the site

Fig. 5. Shortening of the construction period by using two press-in piling machines.

2.2 Piling method

Fig. 6 shows the view of during the construction. At this site, the press-in piling method with an auger was adopted, in which the press-in resistance was reduced and the steel sheet piles were pressed in by excavating the ground using an auger as an auxiliary construction method. As illustrated in the process of Fig. 7, the ground at the tip of steel sheet pile being pressed in was excavated by the auger to create a state where the core was hollowed out in the ground, and the steel sheet pile was pressed in while pulling out the auger. In this construction, used steel sheet piles were pressed in with the press-in piling machine F201-C600. At construction sites in China, temporary steel sheet piles are often reused, so damage or deformation of steel sheet piles due to improper construction can be a problem. The press-in piling method with an auger not only made it possible to press-in the steel sheet piles with the minimum required press-in pressure, but also it was possible to install steel sheet piles with high accuracy, thus, we were able to minimize the wear of the steel sheet piles.

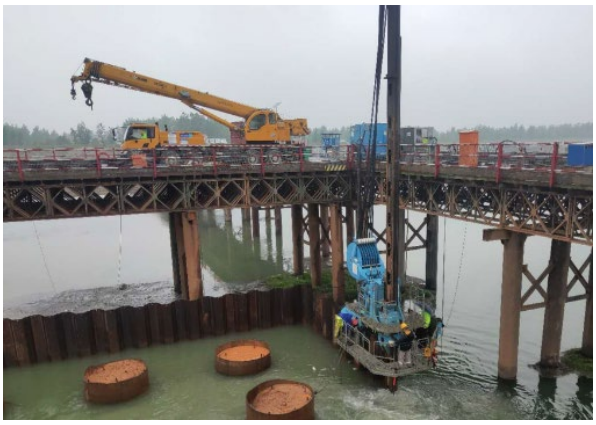
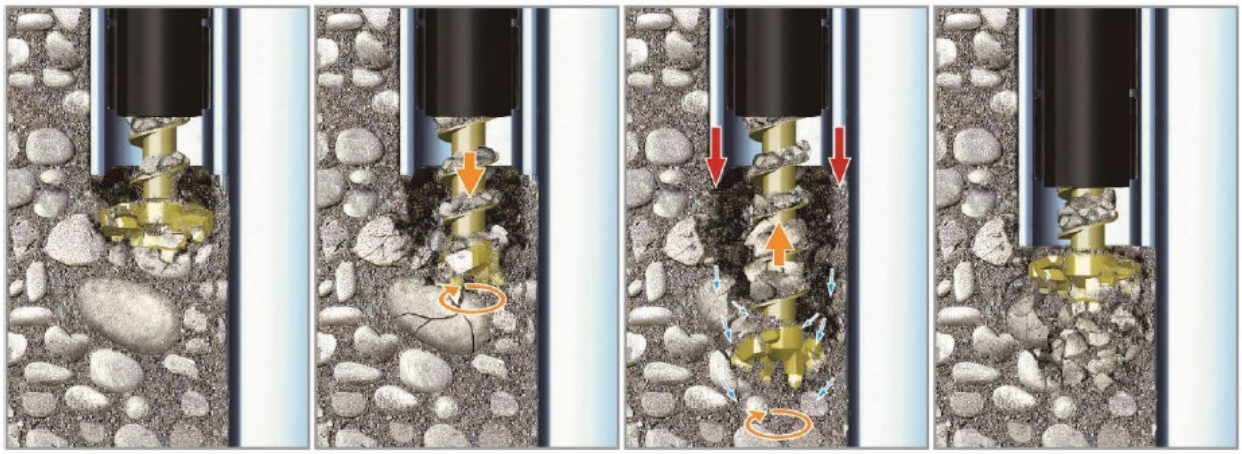


Fig. 6. A view of during construction



1. Start the operation 2. Augering at the pile toe 3. Press-in the pile while extracting the auger. 4. Repeat 1 to 3.

Fig. 7. Press-in process (extracted from the Press-in Retaining Structures: A Handbook Second Edition, 2021)

3. Concluding Remarks

In this work, we faced various problems such as the unpredictable impact of the new coronavirus and harder ground conditions than expected. But we were able to complete the construction as planned. In the future, we will continue to promote the press-in piling method so that it may be adopted not only for temporary constructions but also for permanent constructions of bridge piers. This case study was published as one of the activities of TC6 (Technical Committee on Investigation and analysis of the development status of Press-in technology in China), which is a technical committee newly established by the International Press-in Association. From now on we will continue to introduce you construction cases in China.

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