

PRELOADING AND HEAD CONNECTION METHOD FOR MICROPILE

Je-Yong Park¹, Changho Choi², Hyun-Sik Yu³, Hee-Jeong Yang⁴, Ki-Hwan Lee⁵

ABSTRACT

Micropiles are used extensively for underpinning or retrofit of existing foundations. In some cases, micropiles must be preloaded to reduce excessive settlements and to prevent overloading of the existing foundations when the new or additional load is applied. In this aspect, the preload must be properly and permanently locked in the head of micropiles. This paper describes a newly developed preloading and head connection method for micropile, provides a means of more efficiently enhancing the micropile-to-footing connection capacity and increasing the load carried by micropiles. An experimental study was conducted to investigate the total capacity of the micropile-to-footing connection. The results of tests showed that the developed micropile preloading systems (*i.e.*, steel cone and split-threaded wedges) could provide cost-effective engineering solution for strengthening existing foundations and increase the structural capacity of the micropile-to-footing connection.

1. INTRODUCTION

Micropiles were originally developed for underpinning existing structures. The underpinning of existing structures may be performed for preventing structural movement and upgrading load-bearing capacity of existing structures (Sabatini et al., 2005). In many cases, micropiles are installed through the existing footing such as spread footing or pile cap to resist additional loads caused by the vertical expansion of structures. With this application, the additional loads from the superstructure will be shared between the micropiles and the existing foundations, and soil-structure interaction analyses need to be performed to estimate the amount of load that will be shared by each individual foundation element.

Load transfer from the existing foundation to the micropiles is an important mechanism to consider when designing an existing foundation underpinned by micropiles. This mechanism has not been well investigated or understood (El Kamash et al., 2016). Although the complicated load-transfer mechanism of composite foundation systems makes an accurate prediction of individual loads difficult, it is important to estimate the load-sharing ratios between the foundation's components for the optimized design of micropile, depending upon the design concept employed.

¹ Executive Director, Golden Engineering Co.,Ltd., 11, Beobwon-ro 11-gil, Songpa-gu, Seoul, 05836, Korea. +82-70-4449-8326, +82-2-456-1614, pjycon@empas.com

² Research Fellow, Korea Institute of Construction Technology, Geotechnical Engineering Research Division, 283, Goyang-daero, Ilsanseo-gu, Goyang-si, Gyeonggi-do, 10223, Korea. +82-31-910-0785, +82-31-910-0221, chchoi@kict.re.kr

³ Manager, R&D Institute, Lotte E&C, 3, Naruteo-ro 10-gil, Seocho-gu, Seoul, 06527, Korea. +82-2-3483-7844, +82-2-3483-7899, yux2hnsk@lottenc.com

⁴ Senior Manager, R&D Institute, Lotte E&C, 3, Naruteo-ro 10-gil, Seocho-gu, Seoul, 06527, Korea. +82-2-3483-7843, +82-2-3483-7899, hjyang@lottenc.com

⁵ President, Golden Engineering Co.,Ltd., 11, Beobwon-ro 11-gil, Songpa-gu, Seoul, 05836, Korea. +82-70-4449-8323, +82-2-456-1614, lkhjin@hanmail.net

In some cases, preloading the micropiles prior to the connection to the existing foundations is necessary to transfer the part of the load from the existing foundations to the new micropiles. The purpose of preloading is to generate the displacement of micropile by jacking against the existing foundations during the installation phase, thereby preventing overloading of the existing foundations when additional load is applied.

This paper describes the developed micropile preloading systems and presents an experimental study on micropile-to-footing connection capacity. The results of tests showed that the developed method could provide cost-effective engineering solution for strengthening existing foundations and increase the structural capacity of the micropile-to-footing connection.

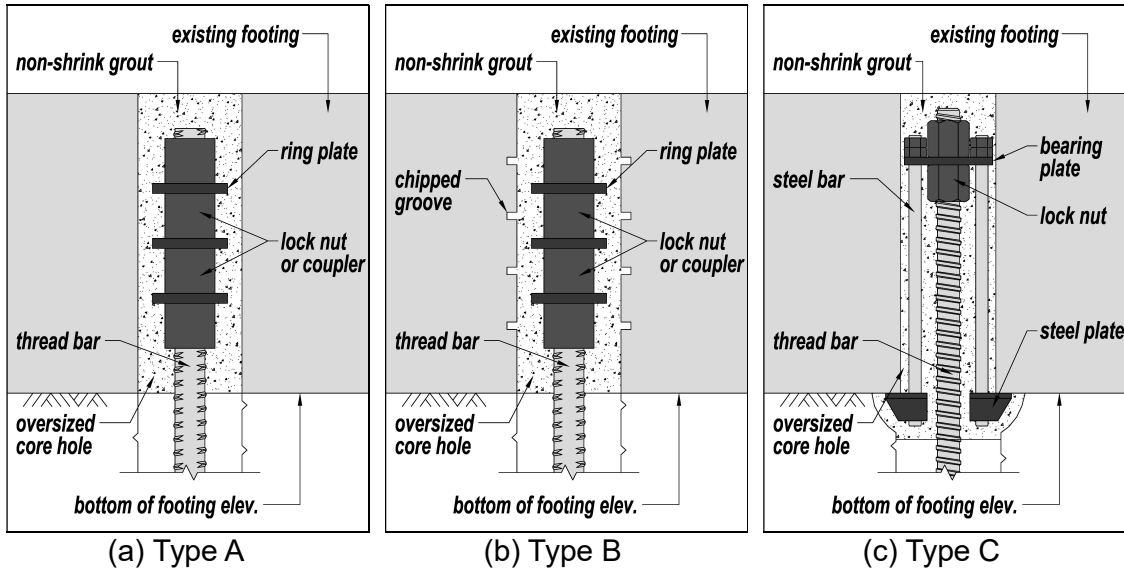
2. PRELOADING AND CONNECTION METHOD

The preloading and connection method, which may be used for applications where micropiles are installed through the existing foundations, was developed to increase the load-sharing ratio of micropile and enhance the micropile-to-footing connection capacity. The conventional connection method, typically used in South Korea, is shown in Figure 1 (Type A is normally used). Steel ring plates are attached to the top section of thread bar prior to pile installation. After the pile is installed, the annulus between the core hole and the micropile is cleaned and filled with non-shrink cement grout. Figure 2 shows the developed preloading and connection method. The construction sequence of the developed method are as follows (see Figure 3):

- Step 1: After the pile is installed, thread four reaction rods into the steel cone, and locate this steel cone above the centralizer through the core hole (typically 200mm diameter).
- Step 2: Place four split-threaded wedges around the cone.
- Step 3: Place bearing plate over four reaction rods. Thus, the bearing plate with five holes is seated on the thread bar (typically 65mm diameter).
- Step 4: Install four hex nuts and four temporary reaction rods. Set the hydraulic jack assembly on the existing footing. Gradually increase the pump pressure to the desired set point for interlocking between the wedges and the existing concrete (the cylinder moves upward). After that, remove the hydraulic jack assembly.
- Step 5: Place expandable steel bar (seated on the thread bar) and four nut holders. The compression preload is transferred to the thread bar via this expandable steel bar.
- Step 6: Set the hydraulic jack assembly on the existing footing, and gradually increase the pump pressure to the desired set point for preloading the micropile (the cylinder moves downward). Tighten the four hex nuts to fasten the bearing plate firmly using the nut holders. Therefore, the preload is locked in the micropile. The preload value determined by the design engineer is based on project-specific requirements.
- Step 7: Remove the hydraulic jack assembly, four nut holders and four

temporary reaction rods.

•Step 8: Fill the core hole completely with non-shrink cement grout.



(a) Type A (b) Type B (c) Type C
Figure 1. Micropile to footing connection detail (Conventional method)

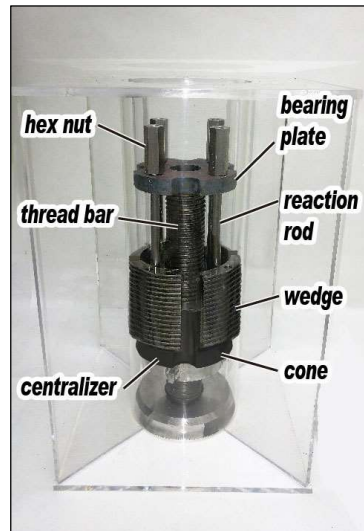
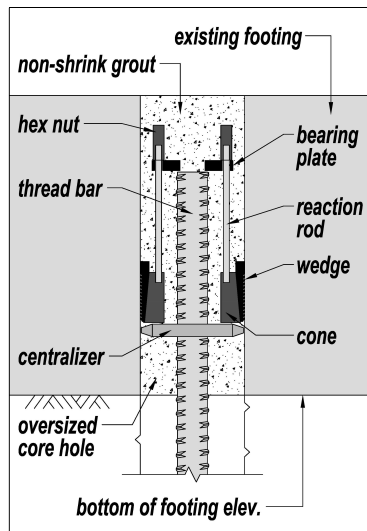


Figure 2. Micropile to footing connection detail (Developed method)

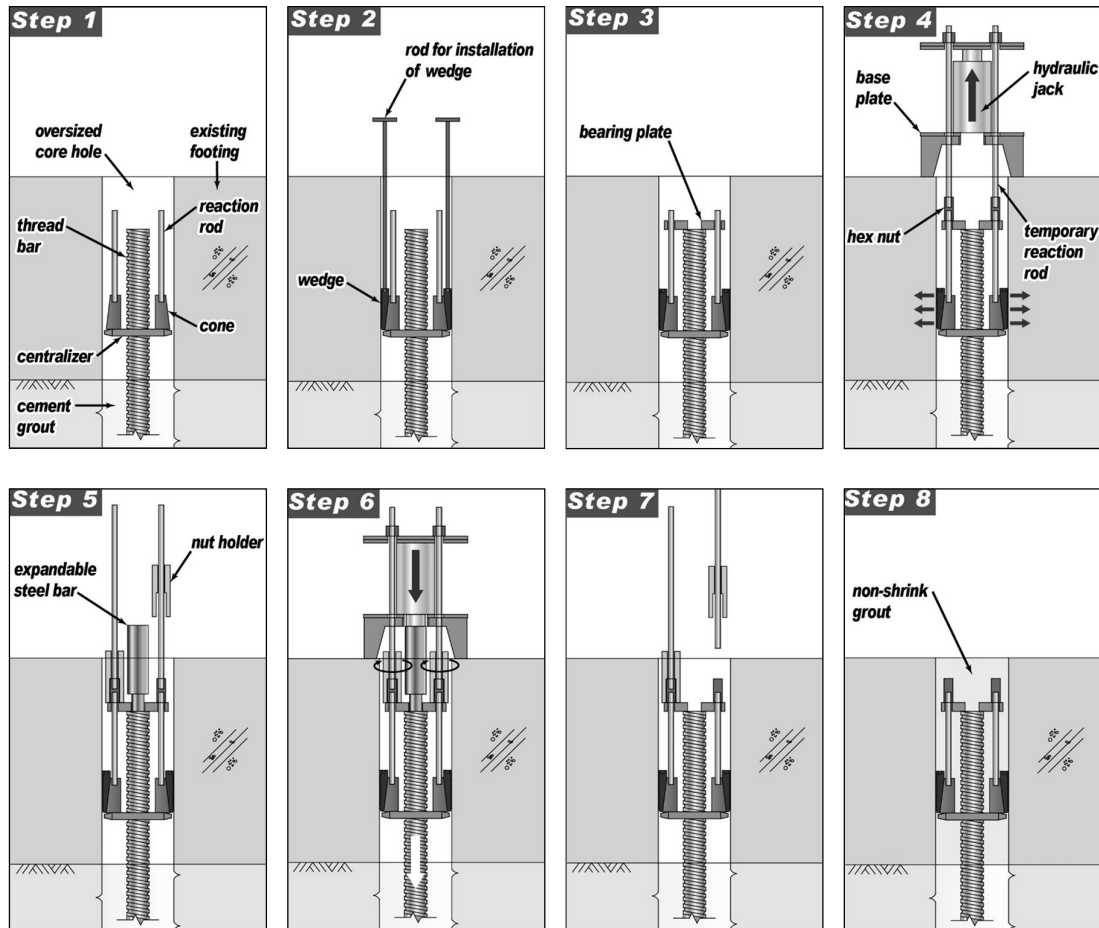


Figure 3. Construction sequence of the developed preloading and connection method

The advantages of the developed method are ease of installation, reduced construction time and cost reduction due to eliminating the need for typical preloading equipment which includes the reaction beam, tie-down anchors, etc.

3. CONNECTION LOAD TEST

The displacement-controlled compression load tests were performed on the micropiles connected to Reinforced Concrete (RC) footings to compare the two connection methods. Table 1 shows the reinforcement, RC footing and grout properties assumed for the specimens. For installation of the micropiles, 200mm diameter core holes were drilled through the RC footings (see Figure 4(a)). The prefabricated micropiles were installed in the core holes, and the core holes were filled with grout. The full-scale prototype three wedges were installed for the developed connection. The test set-up is shown in Figure 4(c), and the tests were performed until yield.

As shown in Figure 5, the total structural capacity of the developed connection is enhanced due to interlocking between the split-threaded wedges and the existing concrete.

Table 1. Reinforcement, RC footing and grout properties

Connection method	Reinforcement	RC footing			Grout
		Dimensions B×L×H mm (in)	Compressive strength MPa (ksi)	Core hole diameter mm (in)	Compressive strength MPa (ksi)
Conventional Method (Type A)	<ul style="list-style-type: none"> • Thread bar - D=65mm • Ring plate (3 pcs) - OD=170mm - T=25mm 	1,000 (39.37) × 1,000 (39.37) × 600 (23.62)	27 (4.0)	200 (7.87)	30 (4.5)
Developed method	<ul style="list-style-type: none"> • Thread bar - D=65mm • Cone (1 pc) - Hc=100mm • Wedge (3 pcs) - Hw=100mm 	1,000 (39.37) × 1,000 (39.37) × 600 (23.62)	27 (4.0)	200 (7.87)	30 (4.5)

Note: D=thread bar diameter; OD=ring plate outside diameter; T= ring plate thickness; Hc=cone height; Hw=wedge height; B=RC footing width; L=RC footing length; H=RC footing height



(a) RC footing coring (b) Ring plates attached to thread bar (c) Test set-up
Figure 4. Preparation of specimens and test set-up

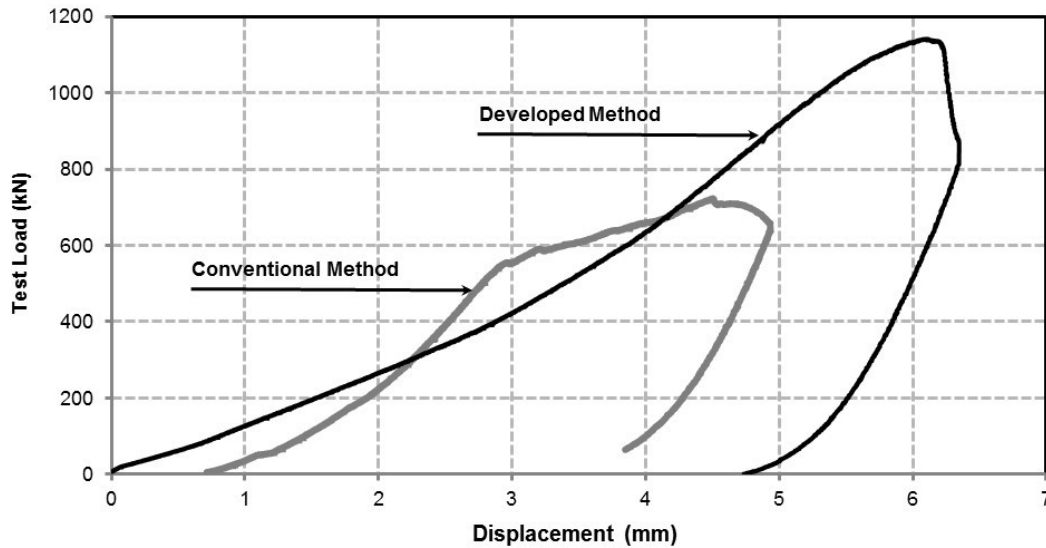


Figure 5. Results of connection load tests

4. CONCLUSIONS

Due to eliminating the need for typical preloading equipment which includes the reaction beam, tie-down anchors, etc., the developed micropile preloading and connection method is both efficient and economical. Thus, this method can provide competitive and useful engineering solution for strengthening existing foundations, depending on the specific application.

However, additional research on the structural behaviors, including time-dependent prestress loss and wedge-concrete interlocking under different preloading conditions, is certainly required for further development of this method.

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