Event Report

IPA Press-in Engineering Seminar in Tokyo 2019

Yuki Hirose

IPA Secretariat

Traditionally, IPA Press-in Engineering Seminar has been held in Kochi, birth place of Silent Piler, over last ten years. This time, the 11th IPA Press-in Engineering Seminar was held outside Kochi, at a conference room of the Japanese Geotechnical Society (JGS) in Tokyo on 18th September 2019. The theme of the seminar was selected as the State-of-the-Art technology for estimation of subsurface information by utilizing data obtained during press-in piling called the “Press-in Data Monitoring System”. Over 70 participants attended this Seminar (Photo 1).

Photo 1. Overview of Seminar

After the opening address by Prof. Yoshiaki Kikuchi of Tokyo University of Science (Chair of Research Committee, IPA Director), four lectures were presented as follows:

Lecture 1 Title: Recommendations by JGS against the problems on foundation Pile by Dr. Hiroshi Furuya (Former Vice President of JGS, Senior Chief Engineer, Obayashi Corporation)

Lecture 2 Title: Estimation of subsurface information from data obtained during press-in piling by Mr. Hiroyuki Ishihara (Manager, GIKEN LTD.)

Lecture 3 Title: Improvements of Practical application of estimation method of ground information using Press-in data by Mr. Koichi Okada (Chief, GIKEN LTD.) and Ms. Nanase Ogawa (Assistant Manager, GIKEN LTD.)

Lecture 4 Title: Application of Press-in Data Monitoring System by Mr. Tomohisa Ozawa (President, Ozawa Civil Engineering and Construction Co. Ltd.)

Photo 2. Q&A Session

Many questions were raised by the audience in each Q&A session (Photo 2)

Prof. Osamu Kusakabe, President of IPA, gave the closing address, stating that the “Press-in Data Monitoring System” has a potential to enable designers and contractors to communicate and understand each other, and change the conventional processes of constructing structures better by sharing their feedback.

Prof. Kikuchi commented after the seminar that he was pleased to have more than 70 audiences in this seminar. Seminar topics were mostly focused on collecting subsurface Information during construction. These topics will be interested in not only practical engineers but also research engineers. Such a piece of Subsurface Information is important for practical engineers. He pointed out that the relation between the measured construction data during piling and soil properties are interesting to research engineers as well. The research committee of IPA plans to hold coming seminars in other places than Tokyo or Kochi, by which IPA hopes to improve the awareness of geotechnical engineers on the recent Press-in Technology.

Reports

11th IPA Press-in Engineering Seminar in Tokyo 2019 (Continued)

(1) Recommendations by JGS against the problems on foundation Pile

Naoki Suzuki
IPA Secretariat

Dr. Hiroshi Furuya gave a lecture on the JGS activity related to "Tilting Yokohama condo case" and introduced some recommendations on foundation pile made by a JGS special committee. "Tilting Yokohama condo case" was a controversial case of piling foundation, where several residents found a tilt between the two buildings, and they pointed out that "A handrail part of the corridor connecting the West Building and the Central Building was out of alignment by 20 mm". Subsequent investigations revealed that 8 piles did not reach the bearing layer, 2 piles did not have enough pile length, and data of other 45 piles were falsified. as is schematically illustrated in Fig.1. This scandal was taken up extensively by mass media such as newspapers and television, and widely spread to the public.

Dr. Furuya pointed out the following four issues from the investigative activity;

1) Chronic problems in the contract work: Construction sequence of pile foundations typically follows as geotechnical investigation, design, building confirmation, and selection of contractors. Generally, engineers in charge do not want to alter the initial design to meet the deadline of the pre-determined schedule, which might cause some delay. This problem often results that enough soil investigation is not carried out.
2) Lack of sharing topographical and geological information: Presently a data base of geological information covering most urban region in Japan is readily available to engineers for free. The ground under the tilting Yokohama building has a complex topography with uneven baring layer. If the existing data available were properly referred to, the initial design of pile foundations could have been made with higher accuracy.
3) Lack of knowledge on guideline concept: Guidelines or/and manuals for piling design and construction are aimed, in principle, to be written in such a way that everyone could reach the same results. However, for simplicity, these guidelines and manual sometimes omit the details such as preconditions and leave a room for engineers to interpret. Some practical engineers are lack of proper knowledge on soil investigation methods and interpretation of the results.
4) Lack of geotechnical engineers: A site supervisor familiar with the geotechnical engineering does not always manage constructions.

Various topics were presented through this lecture. The author has a comment on the use of construction data which will make it easier to check uncertainties during and after construction due to complex terrain. , and also the author feels that engineers will have to keep in mind that new technologies are likely to be a black box, thus causing data falsification more easily. It will become more necessary for us to keep up with new technologies and understand their ideas than ever before.

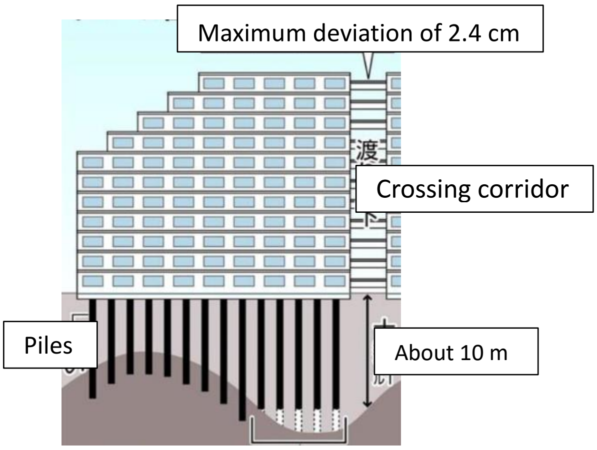

Fig.1. Illustration of "Tilting Yokohama condo case" (https://www.sankei.com/)

Photo 1. Dr. Furuya was giving a lecture

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Reports

11th IPA Press-in Engineering Seminar in Tokyo 2019 (Continued)

(2) Use of press-in piling data for estimating subsurface information: IPA-TC2 technical material

Yukihiro Ishihara

Manager, Scientific Research Section, GIKEN LTD. / Director, IPA

IPA-TC2 (Chaired by Dr. Osamu Kusakabe, President of IPA) finalized a Japanese technical material on the use of press-in piling data for estimating subsurface information in 2017, titled as 'Technical Material on the Use of Piling Data in the Press-in Method, I. Estimation of Subsurface Information'. This technical material was published by IPA and is accessible on IPA Website. This report overviews the research activities on the use of press-in piling data, which were presented in IPA Press-in Engineering Seminar in Tokyo.

1. Background

The design and construction of structures with piles are usually based on the subsurface information that are obtained by interpolating the results of the site investigation results carried out separately from each other with the distance of several dozens of meters or about one hundred meters. On the other hand, local variations are often found in the actual ground conditions, such as the inhomogeneity of the soil layers and the existence of weak soils or hard cobbles in the ground. The difference between the prior information and the actual conditions arising from the inhomogeneity of the ground is one of the major factors that deteriorate the rationality of design and construction of structures with piles. Besides the well-known features of the Press-in Method (low noise, low vibration, spatial efficiency etc.), a feature of an automatic acquisition of piling data for each single pile has been focused on by Giken research team, in the expectation of rationalizing the design and construction of piles.

2. Estimation methods

So far, methods of estimating subsurface information from piling data have been developed for three different installation techniques in the Press-in Method: Standard Press-in (without any installation assistance), Press-in with Augering (Crushpiling) and Rotary Cutting Press-in (Gyropiling). These estimation methods do not require any instrumentation with piles, but assume several conditions as listed in Table 1.

Table 1 Assumed conditions in the estimation methods

Installation techniques	Assumed conditions
Standard Press-in	1) Without interlock connection 2) With repeated penetration and extraction 3) Relatively small penetration rate
Press-in with Augering (Crushpiling)	1) Piling data during pre-augering process 2) Requirement in size and shape of auger head
Rotary Cutting Press-in (Gyropiling)	1) Measurement of the length of soil inside the pile

In Standard Press-in, the penetration of a pile is similar to that of a cone in CPT. This similarity is taken into account in the estimation method. The estimation process can be divided into four, as shown in Fig. 1 (Ishihara *et al*., 2015a). Firstly, the vertical jacking force applied to a pile by a press-in machine is decomposed into a base resistance (Q_b) and a shaft resistance (Q_s). Q_b is obtained as the difference between the jacking forces measured when the pile base passes a certain depth for the first time and for the second time in each cycle of the repeated penetration and extraction (Ogawa *et al*., 2012). Secondly, a unit base resistance (q_b) and a unit shaft resistance (q_s) are obtained from Q_b and Q_s, by considering the area on which Q_b and Q_s are acting. The plugging conditions are taken into account to define the effective base area by introducing *IFR* (Incremental Filling Ratio) for tubular piles (Lehane & Gavin, 2001; Ishihara *et al*., 2018), and this is extended to sheet piles considering the shape effect (Taenaka, 2013). Thirdly, the obtained q_b and q_s are converted into CPT q_c and f_s, by considering the scale effect on the plunging values of q_b (White & Bolton, 2005) and the rate effect based on the Finnie factor (Finnie *et al*., 1994; White *et al*., 2010; Bolton *et al*., 2013). Finally, the soil type and SPT *N* are estimated from q_c and f_s, based on the methods developed by Robertson (1990) and Jefferies & Davies (1993) respectively.

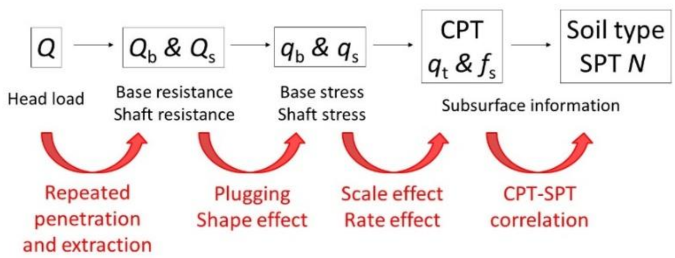


Fig. 1. Estimation process in Standard Press-in

In Press-in with Augering, two estimation methods were proposed (Ishihara *et al.*, 2015a), based on the knowledge acquired in the field of rock drilling. The first one is to estimate SPT N from a torque on the auger head (T_b), a penetration rate (v_d) and a rotation number (n) as shown in Eq. (1), with A and γ being constants. This is based on the knowledge that the parameter $T_b/(d_c)^{\gamma}$, where d_c is the depth of cut (= v_d/n), is proportional to the unconfined compressive strength of a rock (Nishimatsu, 1972; Fukui, 1996; Fujimoto, 2005) and the assumption that the unconfined compressive strength and SPT N are in proportional relationship. The second one is the method known as MWD (Measurement While Drilling) (JGS, 2004), in which SPT N is estimated from T_b, v_d, n and a base resistance on the auger head (Q_b) as shown in Eq. (2), with C_n the constant.

$$N = A\frac{T_\mathrm{b}}{(v_\mathrm{d}/n)^{\gamma}} \tag{1}$$

$$N = C_\mathrm{n}\left(Q_\mathrm{b} + 2\pi\frac{T_\mathrm{b}}{v_\mathrm{d}/n}\right) \tag{2}$$

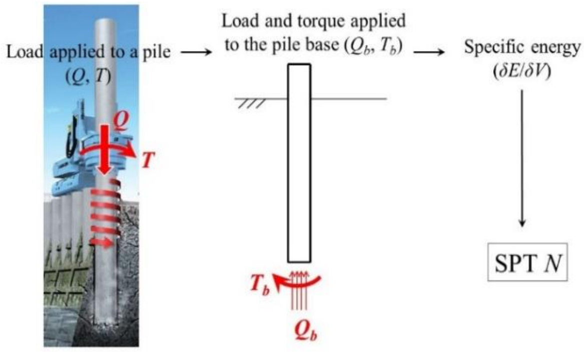


Fig. 2. Estimation process in Rotary Cutting Press-in

The estimation process in Rotary Cutting Press-in is divided into three, as shown in Fig. 2. Firstly, a vertical and a rotational jacking forces applied to a pile by a press-in machine (Q, T) are decomposed into base and shaft components (Q_b, Q_s, T_b and T_s), by introducing Eqs. (3) - (6) where δ_{sp}, D_o and v_r are the frictional angle at the soil-pile interface, the outside diameter of the pile and the rotational rate of the pile shaft, respectively (Ishihara *et al.*, 2015b).

$$Q = Q_\mathrm{b} + Q_\mathrm{s} \tag{3}$$

$$T = T_\mathrm{b} + T_\mathrm{s} \tag{4}$$

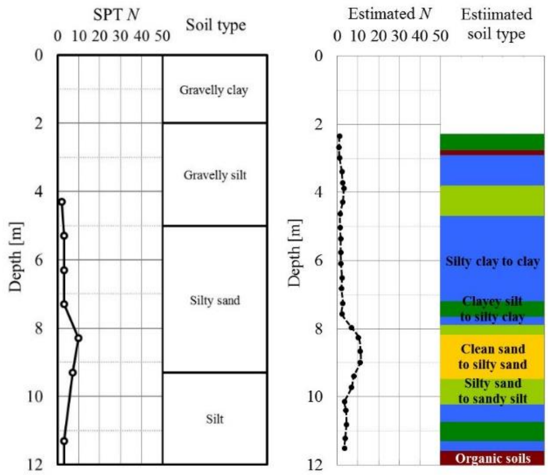
$$\frac{T_\mathrm{b}}{Q_\mathrm{b}} = \frac{\tan\delta_\mathrm{sp}}{3}D_\mathrm{o} \tag{5}$$

$$\frac{T_\mathrm{s}}{Q_\mathrm{s}} = \frac{v_\mathrm{r}/v_\mathrm{d}}{2}D_\mathrm{o} \tag{6}$$

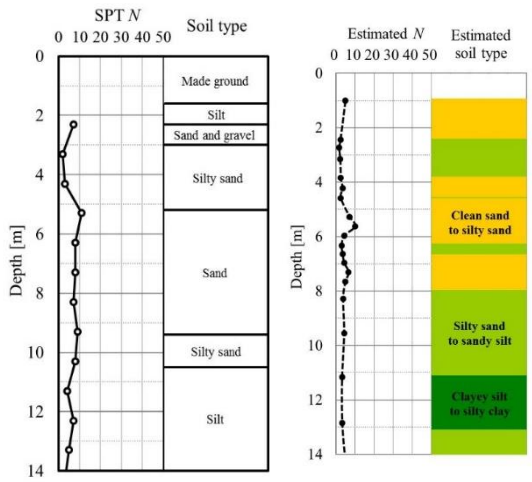
Of these, Eq. (5) is based on the assumption that both Q_b and T_b are expressed by a unit base resistance (q_b), while Eq (6) is obtained by assuming that a frictional stress on the pile is shared by Q_s and T_s according to the ratio of v_d to v_r. The validity of the latter assumption is discussed by Bond (2011). Secondly, the incremental energy (δE) required for deforming a soil below the pile base by a volume of δV is calculated from Q_b and T_b. $\delta E/\delta V$ is an index called Specific Energy, which is widely used to represent the performance of machines for rock drilling (Teale, 1965; Hughes, 1972). According to Hughes (1972), Li & Itakura (2012) and others, there is a linear correlation between the Specific Energy in rock drilling and the unconfined compressive strength of the rock. By extending it, the Specific Energy required for penetrating something into a ground may be assumed as being in proportion to the unconfined compressive strength of the ground. By considering the proportional relationship between the Specific Energy required for Rotary Cutting Press-in and that for the penetration of an SPT sampler, SPT N value is obtained.

3. Case studies

Fig. 3 is the comparison between the subsurface information obtained by SPT and that estimated from the piling data in Standard Press-in, where a closed-ended tubular pile with D_o = 318.5mm and a sheet pile with the width of 600mm were pressed-in at v_d = 20mm/s and 30mm/s respectively. The peak values of N



(a) Closed-ended, D_o = 318.5mm, v_d = 20mm/s (C11-05)



(b) Sheet pile, 600mm wide, v_d = 30mm/s (J0617-05)
Fig. 3. Comparison of SPT & boring (left) and estimation (right) (Standard Press-in)

and the soil type are well estimated, while the values of *N* (other than the peak values) are underestimated. The previous case studies including these two have revealed that the effect of plugging condition on the estimated results is significant while the effect of penetration rate is not. Fig. 4 is the comparison between the subsurface information obtained by SPT and that estimated from the piling data in the pre-augering process in Press-in with Augering, using an auger head with the number of wings of three and the outside diameter of 450mm. The trend of the variation of *N* with depth is well estimated, while big differences are found at some depths. Through the case studies including this, these differences are believed to be associated with the existence of large gravels or stones, judging from the records in SPT. Fig. 5 is the comparison between the subsurface information obtained by SPT and that estimated from the piling data in Rotary Cutting Press-in. The trend of the variation of *N* with depth is well estimated in this case, where the plugging condition were confirmed as almost constant with depth. Another other case study, on the other hand, has clarified that the effect of the plugging condition on the estimated results is significant. If the plugging condition varies with depth, it is recommended to measure the length of the soil column inside the pile with a sufficient frequency of data sampling so that *IFR* can be estimated continuously with depth.

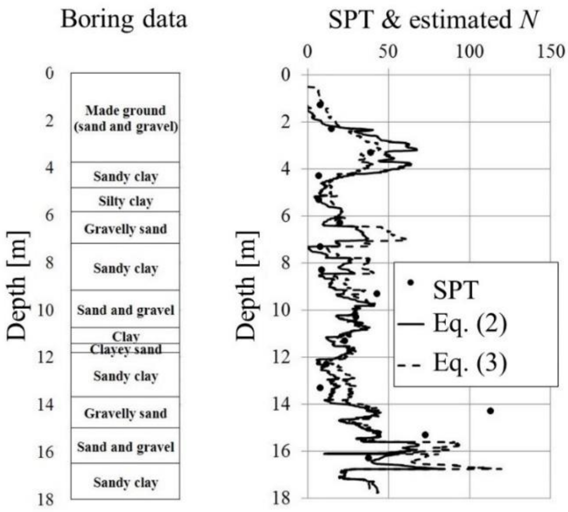


Fig. 4. Comparison of boring (left), SPT and estimation (right) (Press-in with Augering)

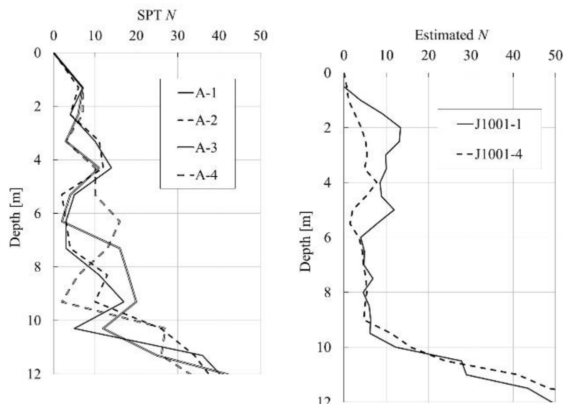


Fig. 5. Comparison of boring & SPT (left) and estimation (right)

4. Practical use of the estimated results

Based on the discussion through case studies, the technical material recommends that the estimated results should be limitedly used as reference information in termination control of piling work (e.g. confirmation of the bearing stratum), judgement of alteration of installation techniques, and so on, at the moment. Three examples are mentioned as follows. 1) Contractors grasp the trend of variation of the estimated *N* with depth and confirm the bearing stratum. They propose an alteration of the embedment depth, if significant variation in the depth of bearing stratum. 2) Contractors alter the press-in conditions (to operate press-in machines) based on the estimated information and improve the efficiency of piling work. 3) Contractors summarize the estimated information and propose an alteration in construction plan (e.g. re-selection of installation assistance) when unexpected ground conditions are encountered.

It is also recommended in the technical material that additional subsurface investigations should be conducted if the validity of the estimated results is dubious due to a significant difference from the existing subsurface information. In such a case, however, the limitation in the applicability of SPT to a hard ground (Mitsuhashi, 1995; Ogawa *et al.*, 2013) have to be considered. Other options could be a trial digging or a large-diameter core tube sampling (Watanabe *et al.*, 2006). A ground-penetrating radar (Kimura *et al.*, 2000) or a surface-wave method may also be the options if their present technical limitations (difficulty in classifying cobbles and cavities in the former and low dissolution in the latter) are overcome.

5. Future challenges

The author expects the estimation techniques to be practically used in actual construction projects. At the same time, continuous efforts are necessary on (1) updating the values of parameters by accumulating estimation results, (2) removing some of the restrictions in table 1 or developing new estimation methods, (3) direct estimation of pile performance, (4) developing better measurement techniques, and so on, to further sophisticate these techniques. Due to the uncertainties related with the ground, the concept of Observational Method addressed by Terzaghi (Peck, 1969) is still effective in the present construction projects; design calculations are still a sort of assumption that requires confirmation or modification during the construction phase (Kusakabe, 2017). The author expects that the estimation techniques assure a firm step forward for the press-in piling industry in this context. An English version of the IPA-TC2 technical material are to be prepared in the near future.

6. References

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Reports

11th IPA Press-in Engineering Seminar in Tokyo 2019 (Continued)

(3) Improvements of Practical application of estimation method of ground information using Press-in data

i) Expansion of the usage of estimation of ground information during press-in with augering

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"Silent Piler" pushes a pile into the ground by static loading, and the press-in force and penetration depth can be recorded during press-in. We call these measurement data "Press-in data". These data have been often used by piler operators for checking piling work and by Client for managing quality of piling. Moreover, "Press-in data" contains valuable information such as ground information.

Fig.1 illustrates the "Press-in Data Monitoring System" using Press-in data. This system features two new technologies: First is automatic piling to optimize piling work. This system can optimize the piling work automatically by using Press-in data for estimating ground conditions. Second is estimation of ground information such as N value or soil classification by using Press-in data. In the actual ground. If we use this system, it will become easier to confirm the bearing stratum or check the construction plan because we can obtain the data from all the piles.

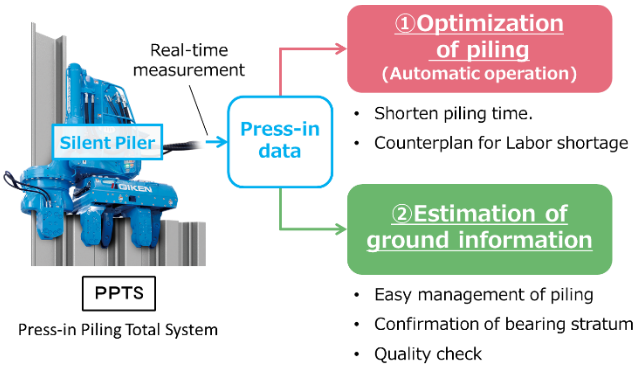

Fig.1. Press-in Data Monitoring System

	Standard Press-in	Press-in with augering	Press-in with rotary cutting
①Optimization of piling	–	✔	–
②Estimation of ground information	✔	✔	✔

Table.1. Scope of application of Press-in Data Monitoring System

We have been using Press-in Data Monitoring System since 2013. Although current Press-in Data Monitoring System has some limitations on scope of application (Table.1), it was confirmed that automatic operation by Press-in Data Monitoring System saved the piling time up to 30%. Laborsaving and productivity improvement were confirmed in some construction sites. Estimation of ground information by Press-in Data Monitoring System is gradually used for reference of changing construction method.

In Japan, Ministry of Land, Infrastructure and Transport promotes "i-Construction" for laborsaving and productivity improvement. Press-in Data Monitoring System can be selected to one of the possible solutions for these movements. For example, it is possible to achieve uniformity in operation speed in foreign countries where there are few experts who could operate the silent piler.

In the estimation method of ground information, N value can be estimated in press-in with augering (Fig.2) (IPA,2017). However, there is a limitation that this estimation method can only be used in a specific shape of auger. This is a problem because other shapes of auger are often used in construction sites. We devised the method that can estimate N value with any shapes of auger by using correction coefficients for each auger shape (Okada et al., 2018).

Fig.2. Press-in with augering

Auger shape is very complicated, so we simply modeled Auger shapes by diameter and number of wings (Fig.3). For the torque T generated on this modeled, the auger shape can be expressed eq.1,

$$T = N_w * q_b * tan\delta * \frac{1}{2}R^2 L \ \cdots (\mathrm{eq.1})$$

Here, N_w: number of wing, q_b: unit base resistance, δ: wall friction angle, R: diameter of auger, L:width of wing. According to this equation, it is possible to use same estimation method by correcting torque generated from other auger shapes into that is generated by a specific shape of auger.

In order to check the validity of this correction, a field test was conducted with many types of auger shape in the same site and N values were estimated from press-in data (Fig.4). These graphs show that estimated N values without correction vary greatly. On the contrary the estimated N values with correction do not vary largely and are similar to N values in this site. It means that the correction is considered to work as assumed. In the future, we will work for practical use of estimation method by conducting validation of this correction in different types of ground.

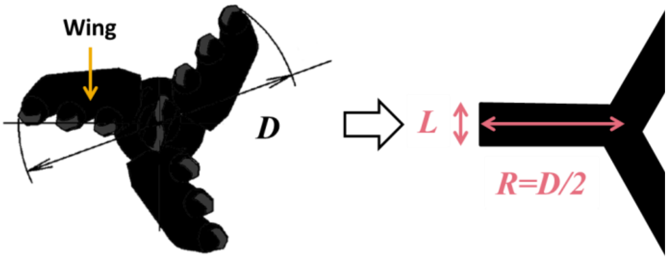

Fig.3. Model of Auger head shape

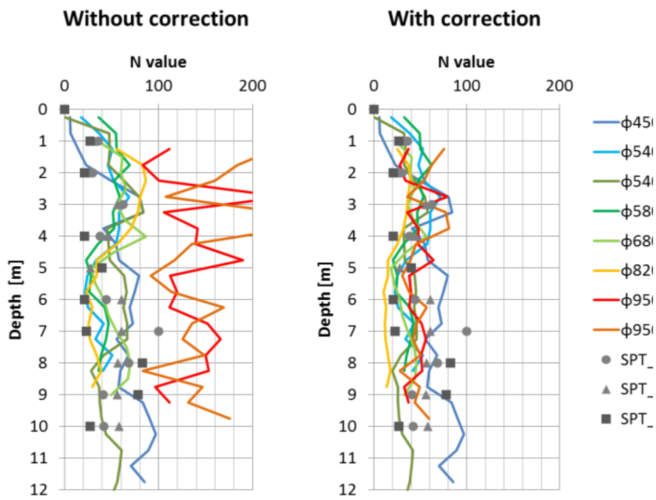

Fig.4. Comparison of Estimated N values

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ii) Expansion of the usage of estimation of ground information during press-in with Standard Press-in Method

Nanase Ogawa
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1. Estimation of subsurface information and issues in the standard press-in Method

In standard press-in, a pile is installed by a static jacking force in soft ground with *N*-value of 25 or less. This technique has used a series of down and up movement with hydraulic cylinders to install a pile/sheet pile. The mechanism to install a pile/sheet pile is similar to that of a Cone Penetration Test (CPT), so cone resistance (q_c) and shaft resistance are estimated from the press-in force, and the estimation method of N-value and soil classification has been established[1)].

In the case where the standard Press-in method is used to estimate subsurface information, the condition needs the Press-in data acquired in the state which the interlocks disconnected. Under this condition, after estimating data in without interlock, it is necessary to pull out the steel sheet pile, and reconstruction in with interlock, which will increase the time required compared to normal construction. It is an important issue to remove the condition without interlocks in order to reduce the time and to increase the number of working examples.

2. Verification for solving problems

In cases where the steel sheet pile constructed with interlock, the evaluation of the interlock resistance becomes a problem. The interlock resistance refers to the resistance generated along the interlocking part between a reaction pile and an installation pile. Fig. 1 illustrates an image of installation and extraction operations with interlock. Fig. 1-(1) shows the initial installation, the pile head load (Q_1) at the time consists of tip resistance (Q_b), shaft resistance (Q_s) and joint interlock resistance (Q_i). After installation in the predetermined length, it immediately turns into extraction operation, and extracted the predetermined length, and then it turns to installation motion again. Fig. 1-(4) presents the situation during reinstallation, where the pile head load (Q_2) consists of the shaft resistance (Q_s) and the joint interlock resistance (Q_i) at early depth. Therefore, the tip resistance (Q_b) during installation can be estimated from the difference between Q_1 and Q_2.

Fig. 2 presents the field date, showing that the pile head loads are plotted with depth for the cases with and without interlocks. Obviously, the head load with interlock is larger than without one. The difference is considered to be the value of resistance between interlock. Fig. 3 shows the results of CPT index which are the measured value, and estimated results from Press-in data. The estimation results are similar to the measured one that the change with depth can be estimated, like the value are larger in sandy layer at 4-6m depth than other depths. However, all the peak values are evaluated small. The estimated *N*-value shows the similar tendency as the estimated CPT index. Fig. 4 is the estimation results of subsurface soil profile information. In cases of without interlock, the soil classification of sandy and cohesive soil is generally consistent with the CPT results. On the other hand, in the case of with interlock, the whole layers have judged to be sandy soil.

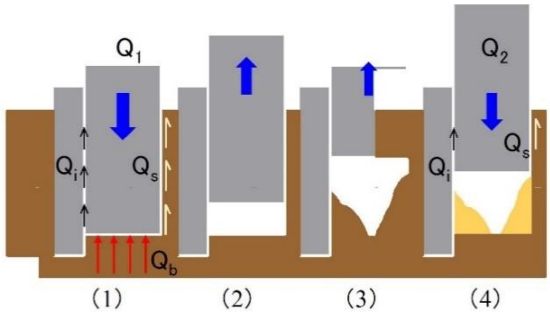

Fig. 1. Resistances and sheet pile base

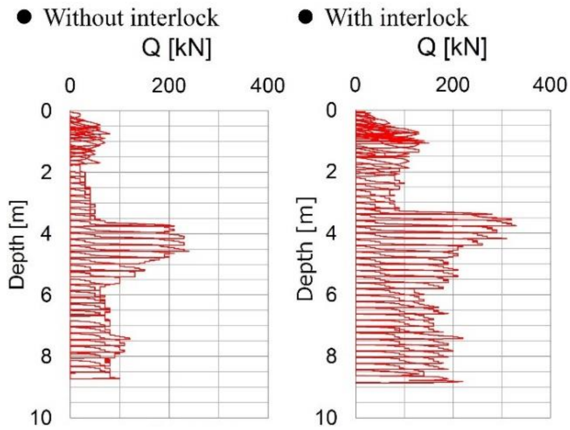

Fig. 2. Press-in force

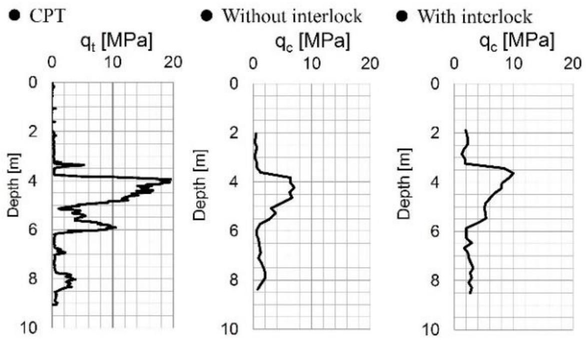

Fig. 3. Cone resistance

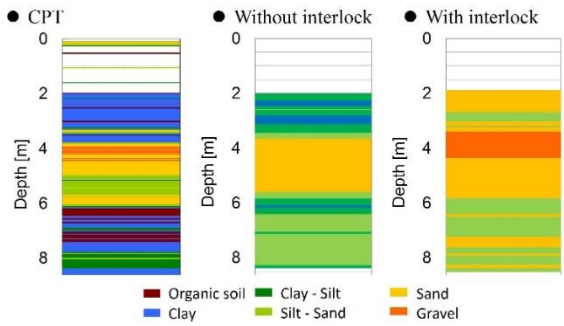

Fig. 4. Results of the estimation

3. Summary

The CPT index, *N*-value and the soil classification were estimated using the Press-in data with interlock. In all cases, the trend of change with depth could be grasped. In addition, the peak value of the cone index and *N*-value were underestimated, as for the soil classification, the particle size was evaluated to be larger. In the future, we will continue to accumulate the Press-in data in order to improve the practicability of estimation method.

4. Reference

1) International Press-in Association (IPA), 2017. Technical material on the use of piling data in the Press-in Method Ⅰ. Estimation of subsurface information, pp. 7-32. (in Japanese).

Reports

11th IPA Press-in Engineering Seminar in Tokyo 2019 (Continued)

(4) Application of the Press-in Data Monitoring system

Masafumi Yamaguchi
IPA Secretariat

The fourth lecturer was Mr Tomohisa Ozawa, President of Ozawa Civil Engineering and Construction Co. Ltd. which is one of the leading piling contractors in Japan. He presented an application example of the Press-in Data Monitoring system, where a piling method was changed from a vibrator hammer assisted by water jetting to press-in assisted by augering due to unexpected ground conditions. The purpose of the piling work in the project was to construct six temporary earth retaining walls of rectangular shape. Each earth retaining consisted of 14.0-15.5m steel sheet piles which had to be installed into hard shale whose SPT *N* value is over 50. At the stage of the tender, a vibratory hammer assisted by water jetting was specified by the client, which was unlikely to succeed due to the ground conditions.

Photo 1. Mr. Ozawa was giving a lecture

"We encountered some difficulties in changing the piling methodology" Mr Ozawa said. "First of all, the test piling had to be conducted by the vibratory hammer for all steel sheet piles, even though we expected it would not be a success. This was at the direction of the client. It was a waste of time and cost. Secondly, all bore hole logs had to be re-collected at each temporary retaining wall as proof of the methodology change, which also extended the construction duration and increased the cost. Thirdly, the client did not have the cost estimate standard[1)] of the pressing-in assisted by the augering". Solving the second issue, the Pile Penetration Total (Hereinafter referred to Press-in Data Monitoring) system was utilized by Ozawa Civil Engineering and Construction Co. Ltd. The Press-in Data Monitoring system is the latest technology to estimate and record ground condition during pre-boring. By utilizing this system, the client accepted that there was no need for any additional borehole logs. Furthermore, the client also approved one or two piling tests by vibratory hammer at each retaining wall instead of all the steel sheet piles after several meetings and a cost estimate standard[2)] issued by Japanese Press-in Association to estimate the piling cost.

In conclusion, Mr Ogawa said "Press-in Data Monitoring system was useful, of course. Additionally, the technical material[3)] based on the science was important to prove that the latest technology is valid. For the estimation, the cost estimate standard made by past applications was helpful. They enabled us to logically and smartly discuss with the client and the main contractor based on science, technology and applications." I think that every participant understood their opinion and saw massive potential in the system.

1)In Japan, public clients (i.e. Ministry of Land, Infrastructure, Transport and Tourism) use the cost estimate standard to estimate a piling cost published by themselves or some associations. This client was a private one.
2) Japanese Press-in Association (JPA), 2017. The cost estimation standard of the Hard Ground Press-in Method.
3) International Press-in Association (IPA), 2017, Technical material on the use of piling data in the Press-in Method Ⅰ. Estimation of subsurface information (in Japanese).

Photo 2. Press-in assisted by augering

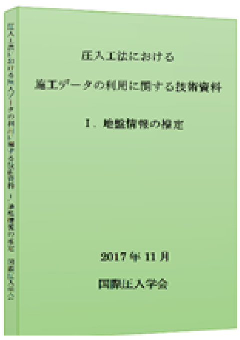

Photo 3. The technical book