LOAD TESTING

SESSION LEAD : MAARTEN PROFITTLICH (FUGRO) / RODRIGO SALGADO

Presented papers:

In-situ vertical load test of piled raft foundation and corresponding simulation using 3D finite element analysis. Presented by : H. Numoto

ABSTRACT

Piled raft foundation is a common foundation structure that reduces settlement of structures by adding piles to raft foundation. It is well known that the bearing capacity and settlement behaviors of a piled raft foundation are complicated. Numerous experiments and analyses have been conducted to clarify the load sharing between piles and rafts and the settlement behavior of piled raft foundations. However, there are not so many cases in which the actual behaviors, such as the load sharing between piles and raft and the settlement, have been confirmed by in-situ loading experiments. In this study, an in-situ vertical load test on a piled raft foundation model was conducted on a test site. In the test site, volcanic cohesive soil was found below the top fill layer of 1 m thick. The volcanic soil layer was underlain by tuffaceous clay, sandy silt and sand layers. The piled raft foundation model was composed of a square concrete raft of 1.5m × 1.5 m × 0.5 m supported by four steel pipe piles with an outer diameter of 101.6 mm and a length of 3.5 m. 3-dimensional finite element simulation was conducted to get deeper insight into the bearing mechanism of the piled raft foundation model.

Evaluation of Vertical Bearing Capacity for H section Steel Pile with Soil cement Ground Improvement. Presented by : S. Koga

ABSTRACT

In recent years, works to improve existing structures and strengthen their seismic resistance have increased. Pile construction in narrow spaces is constrained by the site and process. Furthermore, noise and industrial waste need to be considered with regard to their effects on the surrounding environment. Therefore, a construction method of H section steel pile construction combined with soil cement ground improvement using a mechanical agitator was developed. This method is characterized by having no need to drill up to a fixed depth as in the pre boring pile construction method. Instead, soil is agitated along with the cement milk at the original position. In this study, static compression load tests on the soil-cement composite pile that were constructed with the mechanical agitator ground improvement method were carried out to evaluate the vertical bearing capacity. Furthermore, it was evaluated the performance of vertical bearing capacity on the H-section steel piles with soil-cement ground improvement to compare the evaluation method as shown in the design specifications in Japan.

The Increase in Pile Capacity with Time for Heavily Overconsolidated Clays. Presented by : B. Stevens

ABSTRACT

Results are presented for the restarting of 48-in. (1.22-m)-diameter open-ended pipe piles driven in heavily overconsolidated clays for the Ruby Platform off the coast of Trinidad and Tobago. The piles were restarted after delays of about 1, 5, 13 and 15 days at a penetration of about 78 ft (24 m). The soil resistance to driving was computed using the Case-Goble bearing capacity formulation. The total skin friction and total end bearing were determined versus pile penetration. The CAse Pile Wave Analysis Program (CAPWAP) was used to determine the distribution of the soil resistance along the length of the pile and at the pile toe.

Static Axial Reciprocal Load Test of Soil-Cement Mixing Pile Applying as Permanent Pile. Presented by : K. Watanabe

ABSTRACT

The soil-cement mixing wall has previously been used as an earth retaining wall during excavations, and was treated as a temporary structure. At present, a method has not been established for evaluating its assumed vertical bearing capacity and tensile resistance when bearing a building body load or something similar. In recent years, rationalization of the foundation structure, reduction of the environmental burden, and other needs have been rising, studies have been proceeding into the application of soil-cement mixing walls as permanent piles. In addition, with the previously temporary soil-cement mixing wall now being used as a permanent pile, it can be expected that eliminating the need for new work and reduce construction expenses. This study aimed for the application of the embedded portion of soil-cement mixing wall as a permanent pile, and evaluated the magnitude of the bearing capacity and the tensile resistance for assuming the failure between ground and pile in the static axial reciprocal load test for single soil-cement mixing pile.

Data processing of fibre-optic strain gauge data for axial pile load testing. Presented by : M. Dekker

ABSTRACT

Field testing is invaluable for optimising pile design, particularly with new pile types, or unfamiliar or layered ground conditions. For axial pile load testing, axial shaft strain gauges can provide crucial extra information to enable more detailed test interpretation and answer key questions regarding piles' dynamic, cyclic or monotonic loading responses. Fibre-optic strain gauges offer advantages over conventional electrical resistance or vibrating wire gauges, including better survival rates, closer spacings and secure installation without needing to alter pile geometry. However, fibreoptic strain gauge data require significant processing to ensure good quality, physically meaningful information. This paper outlines strain gauge system selection and automated data processing applied to optimise test interpretation for a recent axial pile test campaign. The processing corrects for temperature variations, addresses scatter in spatial variations and identifies erroneous outlying data points. Successful processing relied on working from sound physical principles, observing and recording site operations meticulously and employing engineering judgement to help resolve anomalies that arose in the recorded datasets.

Calibration Test Results of Rapid Load Test on Bored Piles Embedded in Sedimentary Rock Formation in Singapore. Presented by : Oh

ABSTRACT

In Singapore's local practices, the results of RLT are typically interpreted by the Unloading Point Method (UPM) to subtract the inertia and damping effects, and deriving the equivalent static load displacement curves. However, there are concerns on the reliability of equivalent static pile behaviour derived from RLT to represent pile behaviour under static load, in view of the significant differences in loading duration. In view of this concern, the local Building & Construction Authority (BCA) of Singapore has requested that each project that intend to adopt RLT as part of the pile load test regime shall have at least one calibration test performed on the same site in similar ground conditions to demonstrate the reliability of equivalent static pile response derived from RLT, and to establish "Correction Factor" if any. Correction Factor is typically derived by methodology outlined in Annex A of ISO 22477-10:2016. This paper presents the results of correlation tests of cast in-situ bored piles embedded in Sedimentary Rock Formation (locally named as Jurong Formation) found in west southern side of Singapore Island. The comparisons of RLT and conventional results are discussed from the aspects of load displacement response and axial load distribution characteristics. At the end of the paper, the significant influence of percentage of end bearing contribution on correlation factor is highlighted.

A Review of International Standards' Guidance on High-Strain Dynamic Testing and Signal Matching of Pile Stress Wave Data. Presented by : D. Tara

ABSTRACT
High-strain stress wave data from vibratory or impact driving of a premanufactured pile or dynamic load testing of a premanufactured or cast-in-place pile can be subjected to signal matching. The term signal matching describes the process of "detailed matching of the stress wave data" (Fleming et al., 2009) typically performed using commercial software. The process involves discretizing the pile into a number of elements and the soil into layers, assigning initial values to the various parameters and iteratively adjusting the input parameters until an acceptable match is achieved with the measured signals. International standards such as Australian Standard AS2159 "Piling - design and installation", American Society for Testing and Materials ASTM D4945-17 "Standard method for high-strain dynamic testing of deep foundations" and International Standard ISO/FDIS 22477-4 "Geotechnical investigation and testing –testing of geotechnical structures – Part 4: Testing of piles dynamic load testing" address equipment requirements,the dynamic load test procedure and minimum reporting requirements. However, only ISO/FDIS 22477-4 provides discussion regarding the means of analysis, specifically signal matching. This paper will review the available guidanceprovided in the international standards on signal matching, and provide further considerations for signal matching, including the need for a sensitivity check and matching the signals to the displacement time history, and dynamic testing.

Static and Dynamic Load Tests of Driven Precast Piles. Presented by : C. Fernández Tadeo

ABSTRACT
Two test piles have been installed for the foundations of the future expansion of an infrastructure in Spain. The piles were precast reinforced concrete, installed by driving with a hydraulic hammer. A load test campaign has been carried out by various methods and on various dates, which has served to validate the design of the projected foundation system. The article analyzes the results of the load tests carried out on the two piles. On the one hand, the ultimate resistance obtained with the two test methods, static and dynamic, is compared, observing that they reach quite similar values. On the other hand, the evolution of the ultimate resistance is analyzed over the months after the drive, with no significant increases being observed. Changes are observed in the resistance distribution between base and shaft of the pile.

Hollow precast driven pile extended by a micropile: dynamic load tests and modelling. Presented by : Rafael Gil LaBlanca

ABSTRACT
The hollow precast driven pile (HCK) is a product developed by Rodio Kronsa. It consists of a concrete driven pile with a square cross section of 300, 350 or 400 mm side, and with a coaxial circular hole of variable diameters. This pile, just like any conventional precast pile, gets installed into the soil by driving the element until the hard material is reached at the toe. After that, we can take advantage of the inside hole for different purposes. One of the most frequent uses of hollow pile is to drill and install an inner micropile of a certain length below pile toe, through the resistant soil. The goal of this article is to show the results of dynamic load tests carried out on this compound element on a construction site. On site, some dynamic load tests were performed. After that, on the office, a CAPWAP analysis was also carried out, by making a discretization of the pile and the micropile, introducing the change of material at the pile toe. The compound pile was also modelled with finite elements and the results were compared.

An Improved Efficiency of Free Fall Hammer in High Strain Dynamic Load Test. Presented by : Z. Eng

ABSTRACT
High strain dynamic load test (HSDLT) is commonly used in testing for displacement piles. Recently, it has also increasingly used as an economy method to evaluate the capacity and integrity of cast-in-situ foundation system. To get a reliable pile analysis, a good quality stress-wave signal in HSDLT is utmost important. Secondly, an adequate stresses mobilization along the pile shaft and the toe is also very critical for the capacity determination. A proper selection of drop weight system for HSDLT on drilled shaft is one of the key components so as a uniform and sufficiently large impulse can be impacted on the pile head to sufficiently mobilize the pile-soil interaction behaviour. The typical conventional drop weight system in HSDLT engages a free-fall ram with a rigid guide frame. However, several studies reported a large variation of energy transfer efficiency (ETR) from the free-fall ram onto the drilled shaft. The ETR can be ranged from 3%-98% due to varies reasons. An uneven ram impact could be one of the possible reasons that causes a low ETR even with the best practice to align the verticality of the rigid guide frame with the pile head. Paikowsky (2004) conducted a series of numerical simulation to study the effect of a tilted ram impact, at very small angle of 1o, onto the pile capacity determination. The study suggested that the induced stress-wave can only become uniform after a distance of 2 to 3 times of pile diameter (D) below the pile top. This paper presents a new dropweight system for HSDLT that was innovatively designed with a hydraulic-lifted modular ram built on four independent automatic self-adjusted outrigger system. It enables the almost perfect vertical alignment of the ram to the axial direction of the pile head. Based on the compiled case histories, the conventional drop weight system registers an averaged ETR of 39% associated with a standard deviation of 19.9%. As a comparison, this new drop weight system shows a remarkable y improved ETR of 56% associated with standard deviation of 8.2% after minimizing the effect of uneven ram impact.

Load-transfer curves from field data to engineering values. Presented by : R. van der Salm

ABSTRACT
The load-transfer method is an efficient and practical tool for the analysis of single piles. Load-settlement behaviour analyses of piles are getting more and more important, compared to solely bearing capacity analyses. This tendency is reflected in the European standard for geotechnics Euro-code 7. The axial load-transfer or 't-z' method describes the pile shaft and pile tip local resistance mobilization as a function of the pile axial displacement at the corresponding depth. It represents a very straightforward and practical method for isolated piles. The load-transfer curves can be defined in different ways from different soil parameters and they are based on theory and on experience. The estimation of the ultimate value of the friction and the tip resistance depends mostly on regional ground properties and on local practice. The load-transfer method is thus an intermediate tool between fundamental soil mechanics and empirical approaches. Results from a static pile load test can be very erratic and seemingly uncorrelated. With a load-transfer curve, a best fit through the data points can be created and an estimate of required geotechnical parameters can be obtained. A simple spreadsheet can be used to assess the test results. This paper describes how to create a model for basic geotechnical and structural parameters that will match the acquired data from a pile load test.

Rapid Load Testing on piles instrumented with glass fibre optics in Rotterdam. Presented by : R. van Dorp

ABSTRACT
In Rotterdam Harbour a series of Rapid Load Tests (RLT) has been executed on precast concrete piles that were instrumented with optical fibres (FBG). The same piles had been subjected to Static Load Tests (SLT) a couple of weeks earlier. The results of these static load tests were presented and discussed at the ECSMGE conference in Reykjavik in 2019 [2]. The Rapid Load Tests have been performed in order to (a) test feasibility of fibre optics for capturing strain data at the high sample rate required for Rapid Load Testing, (b) use the opportunity to be able to distinguish the contributions of toe resistance and shaft friction (per layer) during a Rapid Load Test and (c) check and establish the correlation between results of Rapid Load Testing and Static Load Testing, including a break down between the soil layers contributing to toe resistance (only sand) and the soil layers contributing to shaft friction (dominated by stiff clay). In international codes and guidelines, the correlation between Rapid Load Testing and static pile behaviour is accounted for by applying the so-called loading rate factor on the results. For piles in rock and granular soils this loading rate factor is pretty well known, but for piles in cohesive soils this correlation is less conclusive and subject to a larger variation. This paper discusses the comparison of results of RLT and SLT and the soil dependent loading rate factor that could be derived from the tests.

Validated Signal Matching. Presented by : N. Moscoso

ABSTRACT
In 1979 the Beta Method of pile integrity was published. The basic idea behind this method is that stress waves propagating through a foundation pile will be reflected on cracks in concrete piles. As the crack becomes more extensive, so do the reflections. In the ultimate situation of a fully cracked pile, no waves will travel through the crack and the stress wave will be fully reflected. The Beta Method is then calculating the reflection rate (reflected as percentage of the original peak force) and the outcome is presented as a reliable integrity indicator. However, from both theory and practical experience it can be shown that applying the beta method to indicate pile damage will give false negative and false positive results. The former is unwanted because sound piles will be rejected, which will cause grief to the piling contractor. The latter will result in the fact that damaged piles are accepted as sound, where that shouldn't be the case, obviously increasing the risk of failure. The paper will once again illustrate this, through theory as well as practical examples, and then conclude by making suggestions for a practical pile damage assessment on a job site using low strain dynamic testing.

Evaluation of penetration resistance and bearing capacity of a small-diameter spiral pile by similitude model tests using seepage force. Presented by : K. Yoshida

ABSTRACT
In recent years, with application to soft ground with poor conditions in mind, the development of techniques to build foundation types using spiral piles has been progressing. However, there have been few examples of experiments conducted under strict control and conditions closer to real phenomena. Therefore, in this study, we performed a scale similar model experiment that reproduced the stress state of the actual scale ground by loading the seepage force and clarified the vertical bearing capacity characteristics of the spiral pile in the saturated sandy ground. This paper reports the results of penetration and vertical loading experiments on the saturated ground using straight and spiral piles. The experiment results clarify the differences in the support mechanisms of the two types of piles in a full scale saturated ground.

Understanding the Trends behind Load-Displacement Results from Rapid Load Tests. Presented by : Chew

ABSTRACT
The Rapid Load Testing (RLT) of foundation piles has been applied worldwide since 1984. Several international and national codes are available. For checking the performance of piles, they are more economical, faster and environmentally friendly than Static Load Testing (SLT), while yielding good correlations with SLT results through an objective analysis method. In Singapore, most of the foundation piles in Singapore are usually socketed into competent soil material (SPT N>100) or hard rock. In addition to the usual pile bearing capacity with adequate factor of safety, local regulation stipulates that the pile has to satisfy the serviceability criteria, which is pile top settlement less than 15 mm for 1.5 times working load, or less than 25 mm for 2 times working load. To date (January 2022), over one thousand RLT (by StatRapid Load Test method) have been successfully tested in Singapore. It was observed that the load-settlement pattern of the multiple cycles of StatRapid test actually gives useful indication of the performance of the pile – from very elastic behavior to near geotechnical failure case. If the pile is undergoing structure failure (i.e. material yielded or cracked) during the loading stage, the multiple cycle load-settlement result will also show unique patterns. Hence, the StatRapid load-settlement results can also be used to “indicate” the health of the pile. This paper aims to introduce five unique patterns of the StatRapid multiple cycle load-settlement responses, with correlation to their actual pile performance. Actual case studies representing several common scenarios will be presented and discussed.

CORRELATING RAPID AND STATIC LOAD TEST RESULTS OF BORED PILES IN SINGAPORE. Presented by : Nagatie

ABSTRACT
Rapid Load Test (RLT) has become a common and standard method of testing in Singapore for bored pile as it is generally easier and faster to set-up than conventional Static Load Test, and is less complex to analyse than Dynamic Load Test. Recently Singapore is seeing greater use of Rapid Load Test for verification of pile design parameters and pile geotechnical capacity, in ultimate load tests, as well as, for verification of pile head settlement criteria in working load tests. This paper summarizes results of many correlation tests conducted on bored pile, where both static load test and rapid load test were conducted, for high-rise buildings developed by public housing agency, Housing & Development Board (HDB), Singapore. Based on tests carried out in HDB projects, Rapid Load Test generally provides good correlation with Static Load Test in various soil types in Singapore. This paper focus on the correlation between Rapid Load test and Static Load Test especially in pile head load-settlement behaviour, mobilized skin friction and mobilized end bearing.

Finite element simulation of the high-strain dynamic test and the static load test performed on the test pile of the George Massey Tunnel Replacement project. Presented by : Carvajal / Tara

ABSTRACT
High-strain dynamic and static loading tests were performed on a 2.0 m diameter, 67 m embedment, open-toe, steel pipe pile driven in a deltaic deposit comprised of compact sand and stiff clayey silt. Dynamic tests were carried out at 1 day, 7 days, and 29 days after pile installation, and a static test at 80 days after pile installation. Axisymmetric finite element analyses were performed with PLAXIS2D to determine the soil properties that control the shaft and the toe resistance of the pile using both dynamic and static load testing data. The geotechnical properties of the PLAXIS model were obtained by matching the work time history in the time interval of maximum energy transfer with that obtained from the dynamic test. The analysis indicates that the estimation of the pile resistance using high-strain dynamic testing is mainly associated with the shaft resistance due to the very small mobilization of the toe displacement during the dynamic test. The ultimate geotechnical resistance is obtained by simulating a static load test with the calibrated PLAXIS model with a pile head displacement equal to 200 mm, which is equivalent to 10% of the pile diameter.