FOUNDATION ENGINEERING – DYNAMIC PILE TESTING

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STATIC LOAD TESTS

Traditionally, static load tests are performed to evaluate the capacity and load-settlement behaviour of piles. Static loads are applied on the pile head and the corresponding pile movement is measured over a sustained period of time. The test results, which are presented as a plot of pile top load-movement versus settlement graph, are analysed for pile capacity and sometimes as an evaluation of the pile design. The cost involved, site space requirement and time taken for static testing limits the test to only very few piles on major projects and perhaps none on smaller jobs.

In 1964, a research program, sponsored by the U.S. Federal Highway Administration, was initiated at what is now Case Western Reserve University in Cleveland, Ohio. The research objective was to conceive an economical and practical method to estimate static pile bearing capacity. The successful research resulted in modern dynamic pile testing and evaluation methods. Application of the method was expanded to analyse the complete hammer-pile-soil system. Today, these procedures based on wave propagation theory are conveniently applied in the field by a dedicated piece of electronic equipment called the Pile Driving Analyzer (PDA).

Dynamic pile testing is different from static load testing, as it requires much less time to perform and the logistics involved are much less. As such, dynamic load testing is much more economical than static load tests. While simulated loads are applied to a test pile for a sustained period in a static load test, a dynamic load test will only require hammer strikes (re-strikes) of the pile under test. Sensors are attached to the pile during the re-strike and measurements are taken and analysed later to determine the ultimate load and the settlement pattern.

In fact, a dynamic load test can provide more information regarding the pile tested compared to static load test methods. Information such as pile integrity, pile length and load distribution are all additional information that a dynamic load test may yield. However, it must be noted that the use of dynamic load testing be made in conjunction with static load testing methods. Many countries in the world have adopted codes that permit replacement of static load tests with dynamic load tests.

In the wider picture of pile testing, there are certainly many internationally established standards and practices. The most significant of these include the British Standards and the American Society for Testing and Materials (ASTM) standards. Malaysia follows the British Standards due to tradition. However, there is currently no regulatory control on companies that perform pile testing, which includes dynamic pile testing.

The last British Standards revision was in the early 80s and considered a rather old standard, as European countries have not launched the Euro Code yet despite beginning to use it. The Euro Code is considered more updated with the use of more in-depth knowledge as to the behavior of foundations and incorporates a better understanding of how soil would behave.

A 30-metric tonne hammer that can be used to test in excess of 2500 tonnes! Normally, PDA tests can be tested using the piling hammer used to drive the piles in the case of pre-cast concrete and steel piles. However, in situations where the piling hammer is not available, drop hammers such as this one will be deployed.

"We refer to some of these established codes because we do not have one of our own. However, once you refer to a code, you try to refer to a newer code," said Richard Yu, Managing Director of Soil Dynamics (Malaysia) Sdn Bhd, a renowned and prominent pile tester specialising in advanced testing methods such as PDA (high-strain dynamic pile testing), cross-hole sonic logging, pile integrity test (low-strain dynamic pile testing) and the Segmented Maintained Load Test Method or better known as Bidirectional Static Load Test.

"Piles are the predominant mechanism for deep foundations. In Malaysia, nearly all deep foundations are based on piles of various types. For example, most housing projects would make use of driven piles for lower capacities and typically tall buildings in

A steel pile being tested using the PDA method

the city would consist of bored piles which can carry much higher capacities," said Yu.

According to Richard Yu, static load test is time consuming and costly. "If I have a pile here and use a maintained load test, it would take say, 3 days and 2 nights plus the time taken to move the concrete blocks to the site," he said.

He added many consultant engineers preferred using dynamic pile testing. He said PDA would cost as little as 1/20th compared to static load testing and the procedure would only take less than an hour to complete.

It should be noted that PDA is a complementary test to static load tests and should be correlated to static load tests. From the project timeline and costing point of view, static load tests can only be done on a very small fraction of piles in any project site and hence PDA is an ideal solution to increase the number of piles to be tested in the course of ensuring that the piling work is up to requirements.

Unfortunately, PDA is still an unregulated area. The government has no control nor guidelines set for testing. On the supply side, anyone who has the capital to acquire the equipment could proceed to establish a pile testing business. On the demand side, more education is needed to create an awareness on the need of having some form of control on the trade.

"Unlike other areas where the government has put their foot down, for example in the healthcare industry where only a trained doctor can practice medicine, where PDA is concerned, it is not regulated and is very much a free-for-all situation," said Wong Chun Wai, Director of Operations, Soil Dynamics (Malaysia) Sdn Bhd.

"With PDA, with one strike of the pile head, the data is then used to perform various analyses. In fact, only 0.2 seconds of data is used for the purpose of CASE Method and CAPWAP analyses (these are the two dominant analysis methods used in PDA testing), thus it is a test that is of high technology in nature and much care has to be taken to ensure that the measurement sensors and equipment, competency of operators and analysts are subject to some degree of control and scrutiny," he said stating that determining the strength of a pile is of utmost importance as it ensures a solid and secure foundation. Any failings in this task may have economic and safety implications.

He said PDA is a method that involves electronic measurements using advanced dedicated computer systems and unlike measurements using human-read instruments, the accuracy of electronic measurements depends on the condition of sensors, the accuracy of calibration sensors, the accuracy of the electronic equipment that converts electrical signals from sensors into engineering quantities and the quality of the installation procedure, reinforcing a point made earlier about the need for regulation and control.

Several consultant engineers that use PDA testing stressed that the availability of an independent body to ensure that all of the above were complied by PDA testers would be much desired. Fortunately but seemingly unknown to many, such bodies do exist in most countries, including here in Malaysia, charged with the responsibility of administrating laboratory accreditation schemes (LAS).

In Malaysia, there is the Malaysian Laboratory Accreditation Scheme (formally known as Skim Akreditasi Makmal Malaysia or SAMM) that provides the internationally recognised ISO/IEC 17025 accreditation to qualified laboratories which includes PDA testing as pile testing is technically a measurement laboratory activity.

Wong added that authorities in many countries have required PDA testers to be accredited under the ISO/IEC 17025 accreditation scheme in order for their test reports and certificates to be officially recognised. Countries such as Singapore and Hong Kong are examples. In countries where PDA testing is not required to be accredited under this scheme, the

A static load test

onus is on the consultant engineer to make a decision on the quality and competency of the PDA tester.

While the absence of ISO/IEC 17025 accreditation does not imply incompetence, the onus is on the consultant engineer to determine the tester's competency as incompetent testers and/or the use of uncalibrated sensors or equipment may lead to erroneous measurements which in turn may result in inaccurate reporting of pile capacity and load-settlement characteristics.

From the industry governance and professional risk management points of view, consultant engineers and contractors would be most interested in PDA being regulated or accredition of testers made compulsory and it would be in their interest to have their piles tested by a reliable tester or a tester that has been accredited.

A consultant engineer who declined to be named said if PDA testers were regulated or accredited there would be a reference point for any complaints or a place to obtain more information on the reliability and credentials of a tester.

"Unfortunately, consultant engineers sometimes do not know the ramifications of erroneous measurements due to uncalibrated electronic sensors," the consultant said adding that most of the time, consultant engineers relied on the judgment of the PDA tester on face value.

Any device for measurement must be calibrated. In electronic devices, usually you can't see anything visually, unlike a ruler. Therefore, you must check and calibrate to ensure the output is correct, he said.

He added that if a PDA tester was accredited, he would be subject to the scrutiny of the Department of Standards and thus consultant engineers would be ensured a level of standard.

According to Harry Khor, General Manager of Industrial Concrete Products Berhad, a leader in the manufacture of pretensioned spun concrete piles in Malaysia,

PDA Testing has been accepted in the industry as a tool to get quick estimates on the geotechnical capacity of driven piles.

"It is useful in determining the integrity of driven piles. Usually it is used as a supplement to the more accurate and reliable maintained static load test," he said adding that the government needs to regulate dynamic pile testing.

"The government should set standards or regulate the usage of dynamic pile testing. This is to prevent people who are not very strong in geotechnical engineering interpreting the results wrongly. Also, the credibility of the test results might be questionable because of commercial reasons," he said.

Khoo Kay Ong, Technical Director of Petro-Pipe Concrete Piles Sdn Bhd, a pioneer manufacturer of prestressed concrete piles said, according to the British Standards, PDA was accepted as a means to test the strength of piles.

"In Malaysia, most consultant engineers use PDA as it is very fast and precise," he said adding that PDA was common in Malaysia as not only it would indicate the strength of the pile but would also indicate if there was any section in the pile which had fractures.

He said that as for PDA standards, Malaysia mostly followed the American Society of Testing Material (ASTM) as there were no standards for PDA in Malaysia.

"Our local engineers are very well versed with this method of testing piles. We need to draw a Malaysian standard on this procedure," he said. To this point, Wong of Soil Dynamics resonated in agreement and added that "while local engineers are aware of the benefits, there is a pressing need for them to be aware of the high-tech nature of PDA which may pose some degree of risk to the engineers themselves if the operators and analysts are not up to mark," he said.

Wong said more work needed to be done in this area to educate the engineers in the areas of risk management while engaging PDA testers.

"You either know the tester well and put your trust in him or look for a trusted organisation behind the tester. In this respect, PDA testing is truly laggard in adopting some form of regulation and control compared to many other professions," he said. ■