# GEO DYNAMICS

*AN ISO 9001-2008 Company*
*Excellence in Testing*

*Quarterly Newsletter No.2 -September 2011* **Visit us at www.geodynamics.net**


## HIGH STRAIN DYNAMIC PILE TEST (HSDPT)

The use of Non Destructive Testing (NDT) in deep foundations has increased tremendously during the past few years but the most popular test worldwide is the HSDPT. This test is quite often used to replace or supplement conventional static testing after obtaining specific site correlation with conventional method or when data is available in the similar region and/or soil type. The test has been found to be reliable, quick and inexpensive compared to static test. It is standardized as per ASTM D4945 and various codes worldwide. It is now included in the MOST specifications and also finds a mention in the draft IS:2911 that is under revision. Currently it is one of the most widely used tests worldwide to ascertain pile static capacity and is particularly useful for large diameter bored piles. PDA test requires expert knowledge and understanding of the subject. Field data gathering also requires trained professional as data interpretation is the key for successful testing as well as analysis.

The test was developed in USA in 1976 by Dr. George Goble & his associates Frank Rausche & Garland Likins with active support from Ohio Department of Transportation (ODOT) and Federal Highway Administration (FHWA). The test involves application of an impact force equal to or more than the required pile capacity using a hammer whose weight is 1% to 3% of the test load. The Pile Driving Analyzer (PDA) and its associated strain transducers and accelerometers are used to record this force and the displacement caused under the force. Since the impact created by such a hammer from a height of normally 1m to 3m induces high strains or stresses in the pile, the method is known as High Strain Test Method. It is also more commonly known as Dynamic Pile Testing or Pile Driving Analyzer Test. The field test results are then further processed using CAPWAP – a Signal Matching Procedure to determine damping factor, estimate soil resistance distribution, pile profile and to confirm pile capacity. For bored piles, it is mandatory to do CAPWAP analysis on every pile else results can be misleading. Subsequent Newsletters will focus more on this method. The test and subsequent analysis can be used to evaluate various parameters, important of these are mentioned below.

- Static capacity of the pile at the time of testing
- Simulated static load test curve
- Total skin friction and end bearing of the pile
- Skin friction variation along the length of the pile
- Compressive and tensile stresses developed in the pile during testing
- Net and total displacement of the pile
- Pile integrity and changes in cross-section if any

The method involves attaching a minimum of two pairs of strain transducers and accelerometers on diagonally opposite sides of the pile. These are fixed generally at a distance equal to 1.5 times the pile diameter below pile top. Almost any pile type (bored, concrete, steel pipe, H type, timber, spun etc.) can be tested with slightly different pile preparation. Following Figure shows the PDA equipment as well as the transducers. Pile preparation typically requires about 20 to 30 minutes for a single pile.


**PDA Equipment and Sensors**

In order to fully mobilize pile static capacity, a pile set in excess of 3-4mm per blow is required. If the pile set is less than 3-4mm, then not all the static pile resistance will be mobilized during any one blow and the subsequent CAPWAP and PDA analysis will under-predict the true ultimate static capacity of the pile. In other words, the ultimate capacity of the pile will be still higher than that indicated after field testing/CAPWAP analysis. This provides some in-built conservatism to the capacities indicated by the PDA and CAPWAP system in the event of small set being recorded.

## GEO DYNAMICS IS PLEASED TO ANNOUNCE OPENING OF KOLKATA REGIONAL OFFICE!

Geo Dynamics is glad to announce opening of its regional office in Kolkata to cater to projects in East and NE India. All low strain integrity testing (PIT) shall be done locally. HSDPT shall be done locally and/or from Baroda HO based on specific project requirements. All reports and commercial shall be managed by our HO only. Contact Neeti Patel or Dhananjay (Mobile: 08000861666) or Rakesh Patel (Mobile: 09327226084) for your testing requirements).

***For all technical queries contact us at info@geodynamics.net***


**For all testing queries**
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Strains induced under the impact of a heavy falling from a pre-determined height are measured with the help of strain transducers attached to the pile, whereas accelerometers record the accelerations generated in the pile. The PDA records this strain and then converts this strain to force by multiplying with elastic modulus and the area of the pile. Similarly acceleration records are converted to velocities by integration. The resistance developed by the pile is then a function of force and velocity along the pile length and includes few assumed factors such as soil damping as inputs based on the soil type.

A more accurate value of these parameters is then obtained from CAPWAP analysis conducted on field data. There are various methods available in PDA for capacity determinations: RMX, RSP, RSU, RA2, RAU etc. However, RMX (Case Method Resistance) and RSU at an assumed Jc value for a particular soil type are the important and explained below briefly.

The RMX method searches for the maximum resistance during the entire blow. The method uses the following basic equation to compute pile capacity although actually it is a complete finite element analysis program that uses the force and velocity values along the entire pile length after discretizing the pile into series of elements.

$$R_s = (1 - J_c)(P_1 + Z.v_1)/2 + (1 + J_c)(P_2 - Z.v_2)/2$$

Here ,

| | | |
|---|---|---|
| $R_s$ | = | Static Pile Capacity |
| $P_1$, $P_2$ | = | Force at time t1 & t2 respectively |
| $v_1$, $v_2$ | = | Velocity at times t1 and t2 respectively |
| $t_1$ | = | Time of first peak of force / velocity |
| $t_2$ | = | $t_1+2L/c$ |
| $L$ | = | Pile Length |
| $c$ | = | Wave speed |
| $J_c$ | = | Soil damping factor (0.5 is a good starting solution) |
| $Z$ | = | Pile Impedance |

For longer piles with high friction, the velocity may become negative before 2L/c and the upper soil layers begin unloading even prior to the loading of the lower soil layers. For such situation, RSU may be applicable rather than RMX method. RSU method estimates the amount of friction unloaded and adds it back to total resistance as a correction factor.

The PDA tries to compute impedance change in the following fashion. Force is proportional to velocity at any point in the pile and is defined by the equation

$$F = v.Z$$

Note that we can compute force and velocities at any point in the pile once we have measured them near the pile top. Thus proportionality between F & v will be maintained by varying impedance Z, which indicates change in cross-section, material properties or soil resistance. For uniform piles, impedance reduction represents pile damage. The degree of damage can be evaluated by the term BETA. Particularly for bored piles BETA may not be 100% due to inherent nature of installation. A BETA factor less than 60% indicates a shaft with poor integrity. Such shaft may require remedial action in the form of reduced loads, redesigning the cap or installation of additional pile.

Here, $Z = E.A/c$

Where, c = Wave speed of the pile
E = elastic modulus of pile
A = cross-sectional area of pile
L = Length of pile from sensors to pile bottom

The wave speed c can either be obtained from a pile integrity test using Low Strain Test Method or after the first blow of a High Strain Dynamic Testing if toe is evident. The value of 'c' varies from 3300m/sec to 4200m/sec and it depends on density, strength, age of concrete, percent reinforcement, presence of permanent liners etc.

Today the test method is standardized in USA, UK, Canada, Brazil, Germany, Netherlands, China, & used in 50 countries. Historically it is seen that PDA results match well with the Davisson's criterion which generally estimates conservative pile capacities. In India also Geo Dynamics has popularized and extensively used PDA at most major projects and sectors. Geo Dynamics has conducted numerous co-relation studies in various regions and soil stratums for all commonly used pile types. It has been demonstrated that with good knowledge and proper use, the technology can ensure safe and reliable foundations at much reduced cost and time compared to static load testing.

## PIT TRAINING FOR AL HOTY STANGER LTD.

A 2 day training course was conducted by Mr. Vaidya at Abu Dhabi Dubai for Al Hoty Stanger Ltd. Mr. Vaidya trained the attendees on PIT. The training covered procedure for field testing as well as analysis using PIT-W software. Information regarding Profile and PIT-S software was also provided.

*Geo Dynamics completed 13 years of services to the deep foundation industry. We thank you for the continued support and encouragement.*

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## GEO DYNAMICS NOW ALSO OFFERS CORING SERVICES!

Geo Dynamics purchased Hilti's DD130 equipment – a diamond coring system to offer independent coring services as well as use it in conjunction with NDT of superstructures. 50mm, 75mm and 100mm diameter core samples can be obtained. Now coring slabs, foundations, or any other concrete element is possible by contacting us.

## GEO DYNAMICS CONDUCTED TECHNICAL FORUM AT GANDHINAGAR

Geo Dynamics conducted a half day informative technical forum at Gandhinagar on June 23, 2011. More than 100 professionals were present for the event from various government departments. Mr. Ravikiran Vaidya started the session by delivering a talk on "Innovative Non Destructive Testing Practices for Deep Foundations" This session was followed by "Non Destructive Testing for Super Structures". These sessions covered various techniques and tools available including PIT, CHA, PDA, Schmidt Hammer, Pundit Lab, Rebar Locators, Canin, Dyna, Hygropin, Resipod etc. The last session was conducted by Mr. Sujan Kulkarni who provided information regarding Ground Penetrating Radar and its application in Civil Engineering. A booth was also set up where variety of equipments was available for demonstration including PDA, PIT, Rebound Hammer, Pundit Lab etc.

## TECHNICAL LECTURES

Mr. Vaidya delivered a technical lecture for the MSU Civil Engineering Alumni Association (MSUCEAA) on July 24, 2011 at the M. S. University, Baroda. Dhargalkar Technoesis Pvt. Ltd. and Gammon India also invited Mr. Vaidya to deliver a lecture on Innovative NDT applications for Super Structure and Deep Foundation Testing at Mumbai. Mr. Vaidya also presented a corporate presentation on Testing of Pile Foundations at National Seminar arranged by Indian Geotechnical Society, Kolkata Chapter Held on 9th & 10th September 2011.

## CLIENT FEEDBACK

We received a very warm welcome from the industry for the launch of our quarterly newsletter. Here are some of the responses we received from our well wishers.

***Dr. Sunil Basarkar (GM, ITD Cementation India Ltd.)*** - "Your GD quarterly Newsletter is another feather to Geo Dynamics profusely decorated cap. I congratulate entire Geo Dynamics family on this prestigious launch. I expect that some of the important findings of your field tests, which can be of great importance to the piling fraternity, are reported in the coming editions. Wishing this Newsletter and Geo Dynamics a long and rewarding days ahead."

***Dr. K.S. Ramakrishna (GM, FGEC L&T)*** – "I am very glad to see your first newsletter. Dr.N.V.Nayak wrote the foreword and it gives me immense pleasure as he is one of the foremost pioneers in Indian Foundation Industry and is still actively pursuing his profession, i.e., foundation engineering practice. I have gone through the newsletter and it looked to me very impressive. I wish you and the newsletter every success in disseminating the knowledge gained through your various pile testing techniques."

## WHAT'S HAPPENING IN 2011?

- Mr. Ravikiran Vaidya will present at National Seminar on Advances in Geotechnical Engineering, Surat, India. (8-9 October)
- Recent Advances in Civil Engineering, RACE-2011 Varanasi, India. (14-16 October)
- 36th Annual Conference on Deep Foundations (DFI), Boston, USA. (18-21 October)
- International Journal Conference in Recent Trends in Civil Engineering IJCRTCE 2011 Proc. Published by Academy Publishers Trivandrum, India. (30 October)
- PROCEQ – Geo Dynamics Joint Seminar on PROCEQ Products for Non Destructive Testing of Concrete, Ahmadabad, India. (22 November).
- Indian Geotechnical Conference organized by IGS-Kochi Chapter and Cochin University of Science and Technology (CUSAT), Kochi. Theme of the Conferences 'Geochallenges', Kochi, India. (15-17 December). Visit Geo Dynamics' booth.

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