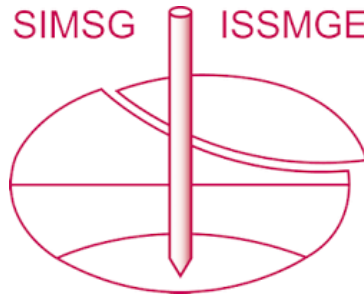


INTERNATIONAL SOCIETY FOR SOIL MECHANICS AND GEOTECHNICAL ENGINEERING



This paper was downloaded from the Online Library of the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE). The library is available here:

<https://www.issmge.org/publications/online-library>

This is an open-access database that archives thousands of papers published under the Auspices of the ISSMGE and maintained by the Innovation and Development Committee of ISSMGE.

DYNAMIC PILE TEST AND ITS CORRELATION WITH STATIC LOAD TEST

Sohail Kibria

Vice President, National Engineering Services Pakistan (NESPAK) Pvt. Ltd
(skibrias@yahoo.com)

Junaid Ahmad

General Manager, National Engineering Services Pakistan (NESPAK) Pvt. Ltd
(junaida70@yahoo.com)

Asim Masud–

Principal Engineer, National Engineering Services Pakistan (NESPAK) Pvt. Ltd
(masud_asim@yahoo.com)

Muhammad Ali

Senior Engineer, National Engineering Services Pakistan (NESPAK) Pvt. Ltd
(engineer.ma@hotmail.com)

ABSTRACT: High strain dynamic load tests (DLT) on piles for ascertaining the allowable load carrying capacity of piles in compression, are becoming common in Pakistan. The test is much quicker, cheaper and consumes less space than the traditional static load test (SLT). For these reasons, more dynamic load tests can be performed at a piling site than the static load tests in a given time; thereby increasing statistical reliability of the test results.

This paper is an outcome of a study where attention is focused on finding a correlation between the results of SLT and DLT, for various soil conditions in Pakistan. The research was carried out using the data of several ongoing mega power projects in the Punjab Province of Pakistan. The paper focuses on four case histories where both SLT and DLT were performed on the same piles. Subsoil characteristics at the referenced project sites were investigated and compared. The load-settlement response derived from DLT has been correlated with that observed in the conventional SLT. These correlations can be used for predicting the load-settlement behavior of the piles subjected to DLT alone for other projects in similar ground conditions.

INTRODUCTION:

Conventional static pile load tests using kentledge or reaction piles, are commonly used in Pakistan for evaluation of pile load carrying capacity in compression. Owing to increasing time and cost particularly the difficulties associated with transporting static load testing accessories into congested city centers and the lack of space on many sites, designers are seeking an alternative system for pile testing. The tendency is mainly for contractors to use dynamic techniques in order to supplement ordinary static tests.

Dynamic load test (DLT) is becoming a common pile test procedure for evaluating pile capacity in compression and pile integrity for cast-in-situ pile globally. The derived pile capacity generally shows satisfactory agreement with the static load carrying capacity. The DLT offers the following advantages:

- Piles can be tested in a day resulting time saving.
- Requires very little space.
- Structural integrity of the pile is verified.
- It is possible to broadly estimate the frictional and end bearing resistance of the piles

Many researchers reported the results of static and dynamic load tests (Davisson 1991; Gue and Chen 1998; Nayak et al. 2000; Uddin and Tungsanga 2001; Liew et al. 2004; Vaidya 2006; Long 2007; Basarkar et al. 2011). The results of static and dynamic load tests reported by above researchers are in good agreement. Therefore attempt is made in this study to correlate the results of static and dynamic load tests for bored cast in-situ R.C piles in term of ultimate load carrying capacity.

GENERAL SUB-SURFACE SOIL CONDITION:

The sub-surface lithology is almost consistent at all four sites i.e. top layer consists of soft to stiff cohesive stratum underlain by medium dense to dense non-cohesive stratum. However, the general subsurface soil conditions at four different project sites are described in the following paragraphs:

747 MW CCPP at Guddu: The overburden soil consists of firm to stiff Silty Clay from top of ground to a depth of 4 m below NSL. The above layer is underlain by medium dense to dense Silty Sand/Poorly graded Sand from 4 m to a maximum investigated depth of 50 m below NSL. The ground water table was encountered at a depth of 4 m below NSL. The variation in subsoil stratigraphy along with soil parameters are shown in Fig.1.

1223 MW CCPP at Balloki: The overburden soil consists of soft to firm Silty Clay from top of ground to a depth of 13 m below NSL. The above layer is underlain by medium dense to dense Silty Sand/Poorly graded Sand from 13 m to a maximum investigated depth of 40 m below NSL. The ground water table was encountered at a depth of 4 m below NSL. The variation in subsoil stratigraphy along with soil parameters are shown in Fig.2.

1180 MW CCPP at Bhikki: The overburden soil consists of soft to firm Silty Clay from top of ground to a depth of 5 m below NSL. The above layer is underlain by medium dense Silty Sand from 5 m to a maximum depth of 18.5 m below NSL. Below this layer, firm to stiff Silty Clay is present from 18.5 m to 25.5 m below NSL. Below this layer, medium dense to dense Silty Sand is present from 25.5 m to a maximum investigated depth of 40 m below NSL. The ground water table was encountered at

a depth of 2.0 m below NSL. The variation in subsoil stratigraphy along with soil parameters are shown in Fig.3

1230 MW CCPP at Haveli Bahadur Shah (HBS): The overburden soil consists of soft to firm Silty Clay/Silt from top of ground to a depth of 2 m below NSL. The above layer is underlain by medium dense to dense Silty Sand/Poorly graded Sand from 2 m to a maximum investigated depth of 40 m below NSL. The ground water table was encountered at a depth of 2.5 m below NSL. The variation in subsoil stratigraphy along with soil parameters are shown in Fig.4.

TESTING METHODOLOGY:

Dynamic load test (DLT) was carried out using 8 tons hammer falling from a height of 0.8 to 1.2 m as per ASTM D-4945. Cushion system consisting of plywood sheets of 50 mm thickness was used for transferring impact load to pile top. The displacement after each impact was measured to assess the load carrying capacity. Two types of sensors, namely vibrating wire strain gauges and accelerometer were installed at 2 times the pile diameter below the top of the pile. Pile Driving Analyzer (PDA) was used for recording forces and motion after each drop of hammer. Finally, a computer program, CAPWAP software was used to compute the pile capacity, based on the recorded data.

For static load test (SLT), kentledge reaction system was used as per ASTM D-1143. The load is applied through a hydraulic jack resting under the kentledge girder. The applied load was measured by a pressure gauge. The load is applied in a series of vertical downward increments, each increment being about 25 percent of design load on the pile. Settlement of the pile was recorded with four dial gauges, each positioned at equal distance around the pile and normally held by datum bars resting on immovable supports at a distance of five time pile diameter from the edge of the pile.

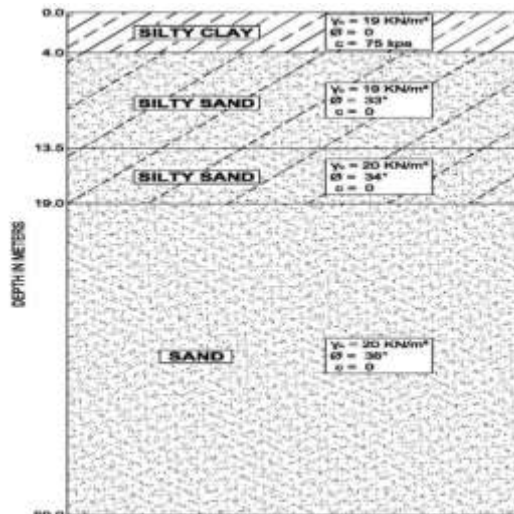


Fig. 1: Sub-Soil Conditions at 747 MW CCPP at Guddu

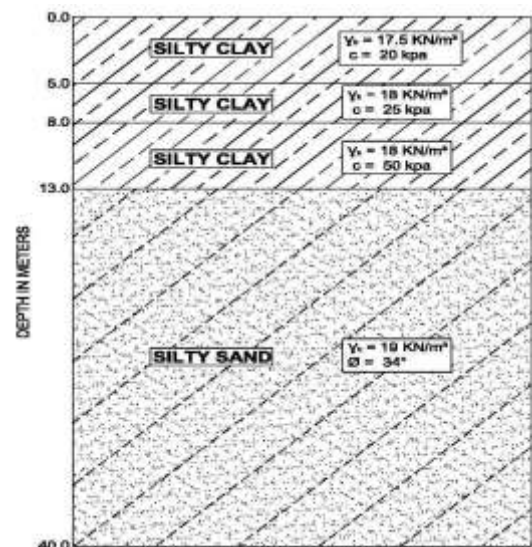


Fig. 2: Sub-Soil Conditions at 1223 MW CCPP at Balloki

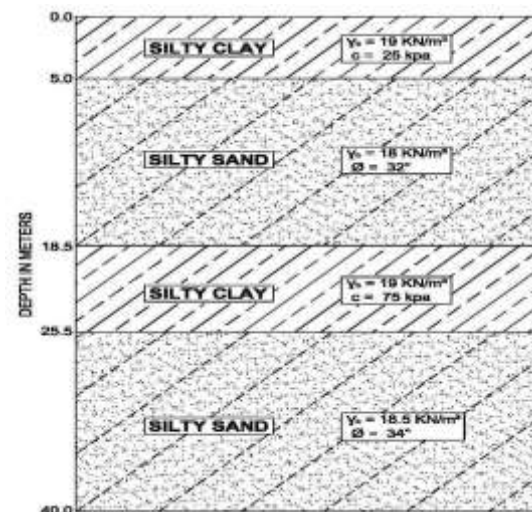


Fig. 3: Sub-Soil Conditions at 1180 MW CCPP at Bhikki

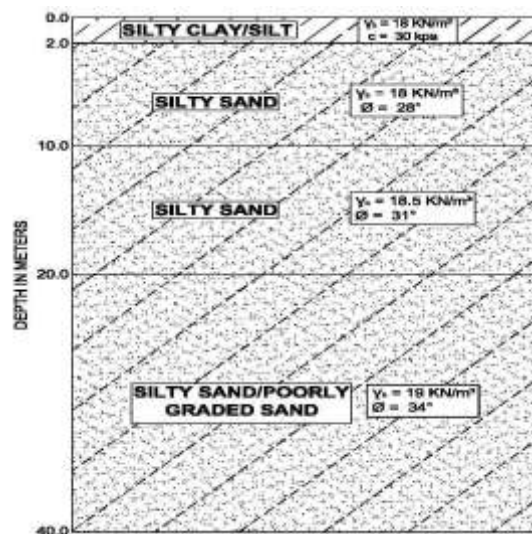


Fig. 4: Soil Conditions at 1230 MW CCPP at HBS



Fig. 5: Setup for Dynamic Load Test (DLT)



Fig. 6: Setup for Static Load Test (SLT)

DISCUSSIONS AND RESULTS:

DLT is commonly carried out as an alternative to ordinary SLT owing to high cost and time required on the SLT. Also, pile integrity assessment is an additional advantage of DLT.

Table-1 shows test results of the aforementioned test piles subjected to DLT prior to SLT. However, Fig.7 indicates a strong correlation between pile load carrying capacity evaluated from SLT & DLT performed on test piles at aforementioned project sites. The average DLT/SLT ratio is 0.95, showing DLT to be slightly conservative.

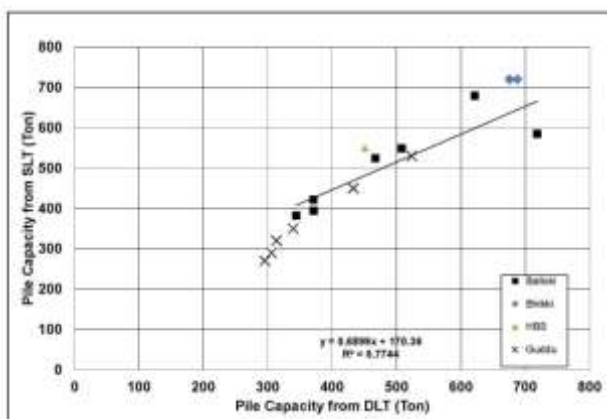


Fig. 7: Ultimate Load Predicted from SLT & DLT

The comparison of load settlement response from SLT & DLT for each project site is given in Fig. 8, Fig.9, Fig.10 & Fig. 11.

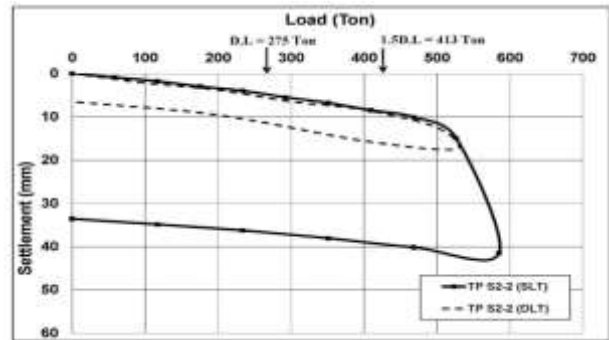


Fig. 8: Load Settlement Response for Guddu

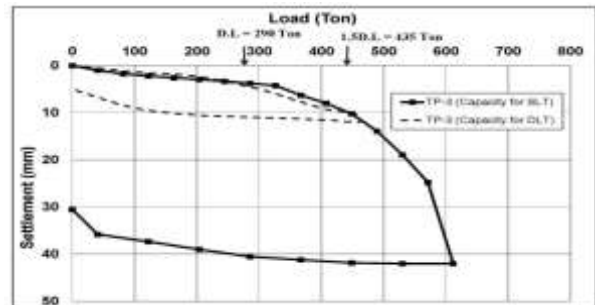


Fig. 9: Load Settlement Response for Balloki

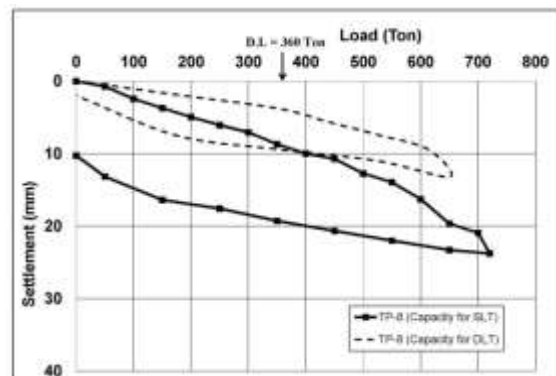


Fig. 10: Load Settlement Response for Bhikki

Fig.8, 9 & 11 indicates that at the initial stage of loading (i.e. up to 1.5xdesign load), the settlement measured from static load test is consistent with the settlement predicted by dynamic load test.

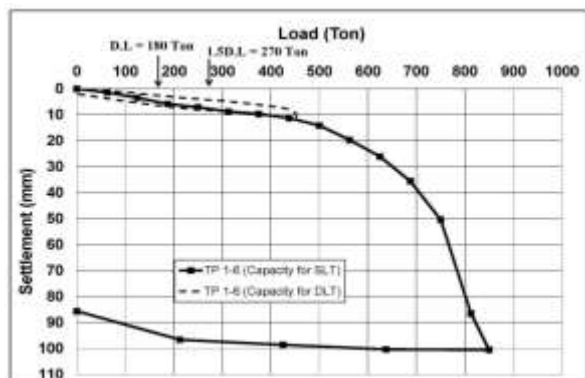


Fig. 11: Load Settlement Response for HBS

Berserker et al. (2011) also reported that the static and dynamic load tests are well compare up to 1.5 times the design load

Table – 1: Summary of DLT & SLT Results

Site Location	Pile No.	Pile Dia (mm)	Pile Length (m)	Static Capacity (Ton)	Dynamic Capacity (Ton)	Gross Sett. Static Test (mm)	Gross Sett. Dynamic Test (mm)	Weight of Hammer (Tons)
Balloki	TP-1	760	31.7	585	718	11	3	8
	TP-3	760	21.8	525	467	30.5	2.4	8
	TP-5	760	31.7	680	621	74	4	8
	TP-10	760	31.75	422	371	109.6	2.1	8
	TP-11	760	32	549	508	66.7	2.1	8
	TP-12	760	22	383	344	104.2	2.3	8
	TP-4	760	22	395	371	104.9	2.2	8
Bhikki	TP - 8	760	32.8	720	675	10.3	2	8
	TP - 9	760	32.5	720	687	11.4	2.5	8
Haveli	TP 1 -6	760	30	550	450	100.6	7	8
Guddu	S2-1	600	25.9	350	340	39	4	8
	S2-2	600	26	530	524	33.6	4.5	8
	S2-3	600	25.8	450	433	34.7	3	8
	S3-1	600	20.4	320	314	35.1	2.5	8
	S3-2	600	20.4	270	295	35.9	4.7	8
	S3-3	600	21.4	290	306	34.8	3.5	8

CONCLUSIONS:

This paper discusses the reliability of dynamic tests by comparing the results of dynamic and static tests on piles from the same site. The following conclusions are drawn.

- ❖ The load-settlement behavior of piles shows good agreement between SLT and DLT for the test load up to 1.5 times the design load.
- ❖ The average DLT/SLT ratio is 0.95. Since the ratio is less than unity and the often used Davisson based evaluation of SLT is less than the average failure definition, DLT results are statistically, generally conservative.
- ❖ Dynamic load test could play an important role for predicting the pile capacity and pile integrity.
- ❖ Dynamic load test could be cost effective and also less time consuming for larger diameter bored piles as compared to static load test. Therefore, SLT can be safely replaced with DLT at piling sites.
- ❖ The results of this research can be adopted for similar ground conditions elsewhere.

REFERENCES

1. C. Rajagopal, C.H. Solanki and Y.K. Tandel (2012) "Comparison of Static and Dynamic Load Test of Pile". Electronic Journal of Geotechnical Engineering
2. ASTM D-1143 "Standard Test Methods for DEEP Foundations under Static Axial Compressive Load".
3. ASTM D-4945 "Standard Test Method for High Strain Dynamic Testing of Piles"
4. Basarkar, S.S., Manish, K. and Vaidya, R. (2011) "High Strain Dynamic Pile Testing Practices in India-Favourable Situations and Correlation Studies," Proceedings of Indian Geotechnical Conference, AhmedKochi, India, 1039-1042.
5. Davisson, M. T. (1991). "Reliability of Pile Prediction Methods," Proceedings of Deep Foundation Institute Conference, Chicago.
6. Gue, S. S. and Chen, C.S. (1998) "A Comparison of Dynamic and Static Load Tests on Reinforced Concrete Driven Pile," Proceedings of the 13th Southeast Asian Geotechnical Conference, Taipei, Taiwan, 497-501.
7. Hussein, M., Likins, G. and Rausche, F. (1996) "Selection of a Hammer for HighStrain Dynamic Testing of Cast-in-Place Shafts," Proceedings of Fifth International Conference on the Applications of Stress-Wave Theory to Piles, Orlando, Florida, USA
8. Liew, S. S., Ng, H. B. & Lee, K. K. (2004) "Comparison of High Strain Dynamic Pile Test Results, Pile Designs and Static Load Test Results of Driven Concrete Pile at Residual Soils in Malaysia," Malaysian Geotechnical Conference, Sheraton Subang, Petaling Jaya, Malaysia.
9. Likins, G. Rausche, F. And Goble, G. (2000) "High Strain Dynamic Pile Testing, Equipment and Practice," Proceedings of the Sixth International Conference on the Application of Stress-wave Theory to Piles, Sao Paulo, Brazil.
10. Long, M. (2007), "Comparing Dynamic and Static Test Results of Bored Piles," Proceedings of the Institution of Civil Engineers Geotechnical Engineering 160, Issue GE1, 43-49.
11. Nayak, N. V., Kanhere, D.K. and Vaidya, R. (2000) "Static and High Strain Dynamic Test Co-relation Studies on Cast-in-situ Concrete Bored Piles," Proceedings of Deep Foundation Institute 2000, New York, USA.
12. Rausche, F., Goble, G. and Likins, G. (1985) "Dynamic Determination of Pile Capacity," Journal of Geotechnical Engineering, ASCE, 111 (3), 367-383. Vol. 17 [2012], Bund. M 1914
13. Uddin, M. K. and Tungsanga, K. (2001) "Dynamic Pile Testing and its Correlation with Static Load Test," journal of Civil Engineering, The Institution of Engineers, Bangladesh, 29 (1), 2001