RESULTS OF AN INTERNATIONAL PILE LOAD TESTING PREDICTION EVENT

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An international prediction event was carried out within the framework of a 30-pile testing program organized in a sandy soil in Belgium (Limelette). That program called upon several testing methods: static load tests, Statnamic testing, and dynamic testing. This paper provides a summary of received predictions and results obtained from the static pile load tests, which were carried up to failure of the instrumented piles. The comparison between predictions is made using load-settlement curves with reference to the results of the static load tests. The predictions are based on a geotechnical approach using an extensive soil investigation program and a dynamic approach using the dynamic load test data.

Introduction

Program Background

A national research project has been organized by the Belgian Building Research Institute with the financial support of the Belgian Ministry of Economic Affairs in order to establish the performance of different types of cast-in-place ground displacement screw piles set up in a sandy soil. The program included the installation and testing of 30 test piles that allowed the organization of a prediction event. That prediction effort was undertaken with the hope to document the profession's ability to estimate these new piles behavior based on standard investigation means as well as on dynamic testing.

Six different types of ground displacement piles were installed (five of each) and tested: one precast driven and five cast-in-place screwed types: Atlas, De Waal, Fundex, Olivier, and Omega. An extensive soil investigation was performed as part of the research project, including in situ tests (CPT, PMT, SPT, DMT, SASW) and laboratory tests on undisturbed samples.

A total of 30 loading tests could be performed at a site located in Limelette, some 25 km South-East of Brussels, according to the following schedule:

- 6 Statnamic tests took place in August 2001;
- 12 Static pile tests were performed between end of August and beginning of November 2001;
- 12 dynamic tests took place within the last week of October 2001.

A similar program was undertaken two years earlier to assess the capacity of soil displacement screw piles in stiff clay, and has been comprehensively documented in Holeyman, 2001.

Pile types

Six different types of ground displacement piles were installed and tested: one prefab and five cast-in-place screwed types:

- Atlas pile, installed by Franki Co. (Figure 1)
- De Waal pile, installed by De Waal Palen Co. (Figure 2)
- Fundex pile, installed by Fundex Co. (Figure 3)
- Olivier pile, installed by Olivier Co. (Figure 4)
- Omega pile, installed by Socofonda Co. (Figure 5)

Five piles of each type have been installed on the test site to accommodate the following conditions for each pile type:

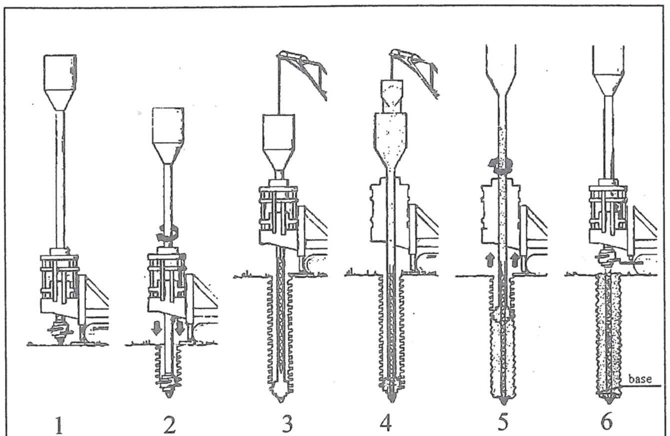
- Two piles for static load testing ;
- Two piles for dynamic load testing ;
- One pile for Statnamic testing.

The different pile types, their testing destination, their nominal shaft and base diameters for geotechnical bearing capacity calculations, and their measured pile base depths are listed in Table 1. The piles had an approximate depth of 9.5 m.

A total number of 30 test piles were installed according to the pile layout shown on Figure 6. The following load tests were to be performed on the following piles referenced according to their grid line locations :

- 12 static load tests on piles A1bis, A2, A3, A4, B1, B2, B3, B4, C1bis; C2, C3, and C4.
- 12 dynamic load tests on piles A6, A7, A8, A9, A10, B6, B7, B8, B9, B10, C9 and C10.
- 6 statnamic load tests on piles A5, B5, C5, C6, C7, and C8.

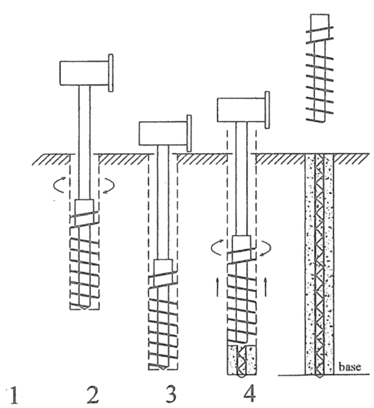
A1bis and C1bis were installed to replace Piles A1 and B1 of which that the delivered concrete did not fulfill the contractor's requirements.



1. Setting up rig.
2. Screwing in the displacement auger head.
3. Screwing until base level and bringing in reinforcement.
4. Filling tube and funnel with concrete.
5. Screwing out and concreting the pile. Lost point at pile base
6. Finished pile.

Toe level determined by the level of the top of the screw blade on the screw auger

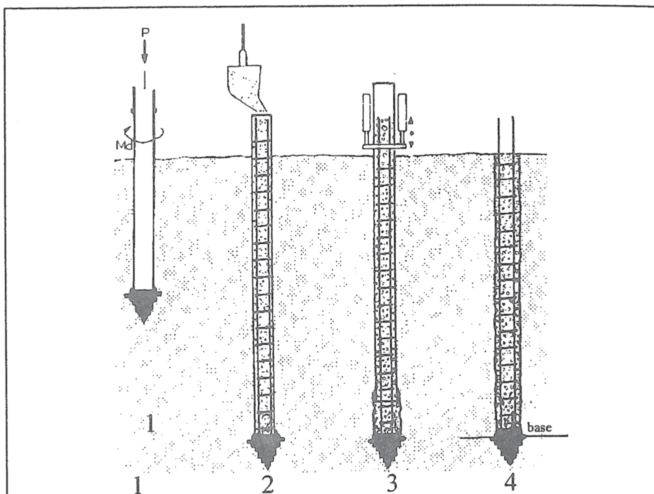
Figure 1. - Installation process of Atlas Pile



1. Screwing in displacement auger head.
2. Bringing in reinforcement
3. Injecting concrete and pulling out auger head, still rotating clockwise. Lost point at pile base.
4. Finished pile.

Pile toe determined by the level of the top of the lost bottom point

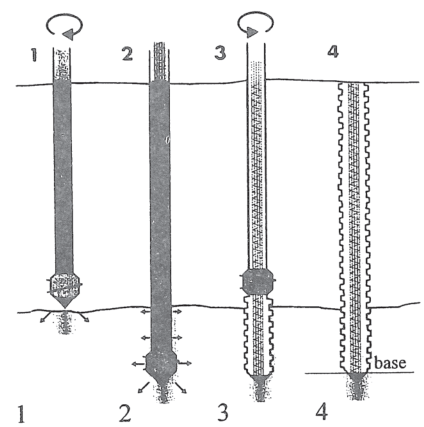
Figure 2. - Installation process of De Waal Pile



1. Screwing in tube, closed at the bottom with displacement auger tip.
2. Bringing in reinforcement and concreting.
3. Pulling out of tube under alternating rotations. Lost auger head forms enlarged base.
4. Finished pile.

Toe level determined by the level of the max. diameter of the screw blade on the lost auger head

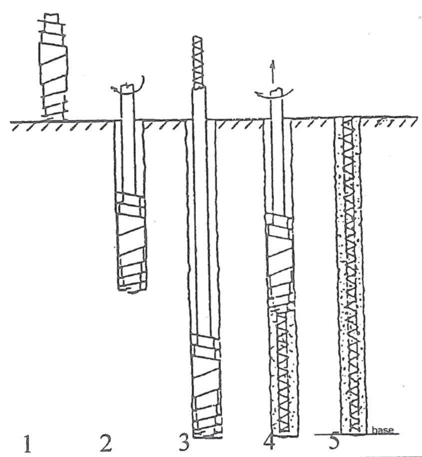
Figure 3. - Installation process of Fundex Pile



1. Screwing in displacement auger head.
2. Bringing in reinforcement.
3. Filling tube and funnel with concrete. Screwing out and concreting pile. Lost point at pile base.
4. Finished pile.

Toe level determined by the level of the top of the lost bottom point

Figure 4. - Installation process of Olivier Pile



1. Setting up rig.
2. Screwing in displacement auger tip.
3. Bringing in reinforcement (eventually after concreting).
4. Injecting concrete and pulling out auger head, while pursuing clockwise rotation. Lost point at pile base.
5. Finished pile.

Toe level determined by the level of the top lost bottom point

Figure 5. - Installation process of Omega Pile

Soil investigation

Overview

The extensive soil investigation performed as part of the research project included the following in situ tests and laboratory tests, the locations of which are shown on Figure 7:

In-situ tests

- 32 CPT-E with electric cone at the location of each test pile - (see example on Figure 8);
- 21 CPT-M1 with mechanical mantle cone (M1) – discontinuous penetration procedure;
- 7 CPT-M1 with mechanical M1 cone – continuous penetration procedure;
- 8 CPT-M4 with mechanical simple cone with closing nut (M4) – discontinuous penetration procedure;
- 6 DMT before pile installation and 5 DMT after pile installation near the pile shaft - (see example on Figure 13);
- 2 borings with PMT tests each 1 m (as shown on Figures 10 & 11);
- 3 borings with SPT tests each 1.5 m (see example on Figure 9);
- 1 boring allowing the recovery of disturbed and undisturbed soil samples;
- SASW tests;
- Seismic Cone tests.

Laboratory tests at several depths:

- Grain size distribution
- Plasticity Limits
- CU – Triaxial tests (consolidated, undrained)
- CD – Triaxial tests (consolidated, drained)
- Triaxial tests with Bender Elements

Subsurface geology and properties

Borings B1 revealed the following soil layers :

0 – 0.4 m : recent fill
0.4 – 8 m : Quaternary sandy silt (loam)
8 – 14 m : Tertiary Bruxellian / Ledian sand

The ground water level can be found at greater depth (approximately 40 meters).

Plasticity limits and other data for soil samples at depths 4.00 – 4.50 m , 7.00 – 7.50 m, and 10.00 – 10.50 m are summarized in Table 2a and 2b.

Dynamic load tests

Procedure for dynamic load tests

The loading device used to impact the 12 piles installed for that purpose was a 4 tons drop hammer operated by a crane. A sequence of several blows was applied to each pile. The drop height sequence most often applied was as follows: from 0.4m to 2m by increments of 0.4m with intermediate decreases to allow the use of the Simbat method.

Dynamic measurements of strain and acceleration were acquired for all 12 piles using a PDI PDA-PAL system. A 0.4m-diameter head was cast on top of the 10 cast-in-place piles. The transducers were attached generally 0.9 m from the top of the approximately 1.5 m high head. Displacements were acquired using a laser system monitored by Test-Consult ltd.

Other dynamic measurements of strain and acceleration were acquired (TNO-Profound and Test-Consult ltd) during the dynamic load tests but these data were not distributed to the predictors (except the displacement data of TestConsult).

Dynamic load tests caused in general a pile settlement of 10 – 20 mm per blow. In this case, the mean value was observed to reach about 10 mm which corresponded to approximately 2.5 % of the pile diameters.

Measurements nominal interpretation

It was emphasized that all files had been uniformly acquired using a nominal modulus of 40,000 MPa and a nominal wave speed of 4,000 m/s at the measurement section (i.e. in the concrete of the cast head). The pile heads were cylinders with a diameter of 0.4 m, except for the Prefab pile where the current 0.35x0.35m section prevailed. It was the predictor's responsibility to assess the adequate measurement section modulus for his prediction. It was also emphasized that the concrete of the tested pile below the added head had a different modulus and a different section. It was also the predictor's responsibility to assess the appropriate section and modulus for the shaft.

Peripheral information allowing the predictor to perform that important assessment included Table 1 of this paper and the digital signal themselves (e.g. impedance match or 2L/c check). Finally were made available strength and ultrasonic wave speed measurements on concrete samples cast at the times of both the installation of the piles and the concreting of the pile heads.

Static load tests

Procedure for static load tests

The static pile load tests were to comply with the following loading guidelines, referring to Q_{max}, the maximum anticipated test load, chosen with the aim to cause bearing failure:

- 10 maintained load steps with equal ΔQ until Q reaches Q_{max}
- No intermediate unloading cycles except when danger for structural pile failure existed and when the removal of the extensometers was necessary.
- Duration of maintained load-steps of 60 minutes
- Load test was performed until a pile head settlement $\geq$ 15% $\varnothing_{base}$ was reached
- When the pile head settlement has reached a value of 25 mm, subsequent load steps can be applied using a smaller increment ($\Delta Q/2$), in order to refine the pile load-settlement curve as it approaches failure,
- Unloading in 4 steps of 10 min. each, except for final unloading (30 min at least of monitoring).

The system used to apply the maintained loads on the piles called upon a sophisticated hydraulic regulation that guaranteed a tolerance of 5 KN. That system had just been developed by the BBRI. The 4.2 MN reaction was provided by a kentledge consisting of steel slabs. Besides load and settlement monitoring, extensometers provided longitudinal strains of 6 shaft segments along the pile length. The results provided by those more detailed measurements are to be reported elsewhere.

The maximum load (Q_{max}) to be applied for each pile during the test were estimated by the BBRI and the national experts using De Beer's method based on the CPT tests results (De Beer, 1971-1972). The load increments ΔQ were actually:

- $Q_{max}/10$ with a maximum of 360 KN because of the maximum reaction available.

The ultimate capacity was considered reached when the pile head settlement was equal to 10% $\varnothing_{base}$.

Prediction organization

Prediction preparation

On September 13th 2001, a reference document was distributed internationally among interested parties via e-mail, and in particular to members of ITC 18 (International Committee on Pile Foundations of ISSMGE) and APTLY (Association of Pile Testing Laboratory) to enable them to:

- Predict the static load-bearing behavior of the piles based on the results of the dynamic pile load tests, and
- Predict the static ultimate pile bearing capacity and the load-bearing behavior of the piles by means of the ground investigation results.

A project synopsis had been prepared to invite interested parties to make those predictions (Huybrechts et al, 2001a). It included a description of the pile types, site characterization, the static load test procedure, the dynamic load test procedure and the format of the prediction.

Interested predictors were asked to fill in an invitation document to accept the information release conditions associated with this prediction event. In particular any publication using part of the data herein and public release of any of the research measurements warranted the prior permission of the BBRI. Once this was done, they had access to the complete information available as laboratory and in situ investigation and dynamic load test results via the website of the BBRI (Huybrechts et al, 2001b).

All the information was downloadable from the website. It was organized into directories providing the dynamic measurements, the general information and the soil investigation data.

Prediction Format

It was requested that the prediction submittal include:

- A description of the used model(s), with a list of governing parameters,
- A detailed calculation methodology, with specific references (data provided, standards, publications, ...) and derivation of governing parameters,
- A separation between pile base resistance and shaft resistance;
- A criterion for the ultimate pile bearing capacity
- An allowable (or design) bearing capacity

The predicted static load-settlement behavior of the piles was to be summarized into a table providing the loads corresponding to the following settlements: 1, 2, 4, 6, 8, 10, 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 150, and 200 mm.

Predictions could be established based on dynamic load tests, detailed geotechnical information (boring+lab tests, CPT, PMT,...), experience, or a combination of the above.

The predictions are reported herein under an anonymous format in order not to stigmatize those with less accurate predictions. Each prediction is however labeled with a code corresponding to the prediction type. Each predictor is thus enabled to position his own prediction within the cluster of results and encouraged publishing his prediction procedure, using the present paper as a reference.

Predictions types and classes

13 predictions had been received by January 1st 2002, the ultimate submittal dead line. Contractors had also predicted the ultimate bearing capacity of their own piles (they were not asked to supply the load-settlement curves.)

According to the reference data used to cast those predictions, the following labels have been used:

- - "SLT" for the results of the actual Static Load Test.
- - "CPT" for predictors using the CPT results.
- - "Labo" for predictors using the laboratory results.
- - "DLT" for predictors using the Dynamic Load Test results.
- - "Statnamic" for predictors using the Statnamic Test results.
- - "Contractor" for the prediction made by the firms which install piles.
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The CPT predictors used different methods, including ultimate state design as well as load transfer curves. The LAB predictor used a load-transfer functions method based on plasticity indices.

The DLT predictors' methods included either CAPWAP, SIMBAT or another home-made method using the following logic: the soil parameters in a model are adjusted to get the best match between the measured and the predicted signals of a Dynamic Load Test. SIMBAT is an empirical method converting the dynamic reaction to a static reaction.

The Statnamic predictor used the Unloading Point Method (UPM) to predict the static load test.

Because of the organisation of the prediction event during the static load test session, it was not possible to achieve a true Class A prediction according Lambe's definition (Lambe, 1973). On the other hand, all results of the SLT tests were kept secret by the BBRI until the expiration of the prediction period.

The details of the predictions are summarized in Table 3 with for each predictor, the pile studied and the receiving prediction date.

Results and discussion

Overview

Figures 12a. to 17a. show the load-settlement curves of the static load test of the static piles and the calculated behavior for the predictions for static loaded piles. Figures 14b. to 19b. show the same for the dynamically loaded piles.

As all piles are approximately 9.5 m long, results can be presented per pile type in only one figure.

Some predictors give only the ultimate capacities (depending of their own definition of the ultimate capacity) without any detailed curves. In this case, the representation is plotted with a straight line for a pile head settlement of 80-100 mm for the predicted statically loaded piles and 5-10 mm for the predicted dynamically loaded piles. Those settlements are arbitrarily chosen for graphical representation.

Figures 12c and d to 17c and d give a histogram representation of the ultimate or mobilized capacities in comparison with the SLT result.

For each of these figures, the curves labels are followed by the identification code of the piles in order to allow the comparison of curves in detail.

Firstly, the SLT results reveal some dispersion between piles of each pair. The Atlas, De Waal, Olivier and Omega piles fit well for both static load test, unlike the Prefab and the Fundex ones. These difference can be explained by different reasons including the subsoil characteristic variations. A direct consequence is the spreading of the predictions. In this point of view, both Fundex pile give very different results, this is particularly due to an unexpected problem to the base of pile C1bis. The expected excavation will give more details about that. In consequence, the C1bis result is not included in the present analysis.

Analysis of the predictions based on the soil investigation results

Table 4 and 5 show the results of the predictions from either a predictor or a pile point of view. In these tables, the ultimate capacity predictions are compared with the conventional rupture load (load at pile settlement of 10% Db) deduced from SLT results.

Globally, Table 4 highlights that 4 predictions overestimate the results (CPT1, 5, 6 and Labo) and that 5 predictions underestimate (CPT 2, 3, 4 & 7 and Contractor) the SLT capacities.

The "Contractor" predictions can be considered as the fittest, 3 predictions have less than 10% of deviation, and 8 of 9 give less than 25 % of deviation. When the pile point of view is studied, it can be shown that the further prediction (CPT 2) influences extremely the average values. Without this prediction, the precision of the average prediction give 50% of the piles below 10% of deviation, and 11 piles of 12 under 25% of deviation.

Figures 12 to 17 show that the stiffness are generally well evaluated for all predictors at the beginning of the load test.

Analysis of the dynamic predictions

In order to allow comparison of predictions capacities and SLT results, the results of the dynamic predictions are presented for a pile head settlement corresponding to 10 mm (+/- 2.5% of pile diameter) in spite of the asked format. The companion SLT result is the average of loads mobilized for the same settlement during the static test for both static piles. When the exact load value for this settlement was unknown, an interpolated value was calculated. It will be called the " Reference Target".

As for the static pile analysis, Table 6 and 7 summarize the statistical analysis of predictions with a predictor or a pile point of view.

In spite of the small number of dynamic prediction per pile (between 2 and 5), following remarks can be formulated.

The predictions generally underestimate the results (except for the DLT 2 prediction that is more variable) and the DLT 1 can be considered as the best for all piles.

Table 7 shows approximately the same statistical conclusions than in section 5.2. : the average of prediction approach the SLT 10 mm mean value with less than 5% for 3 piles and less than 25% for 11 piles of 12. It also must be mentioned that the compared SLT results do not correspond to the tested piles and that the subsoil conditions can fluctuate.

The study of the Statnamic tests seems to be closer to the dynamic point of view than the static approach because of the specific testing procedure, but the mobilized pile resistance are more comparable to than the SLT result in term of reached settlement.

For the dynamic approach (2.5% diameter), it can be said that Statnamic interpretation surrounds the SLT '10 mm mean value' (3 under - and 3 over - estimations) and is globally 10% over estimated (what corresponds to a 0.9 coefficient which can be applied to the Statnamic results in order to take account of the load rate effect on pile behavior (from the Statnamic predictor report)).

Conclusions

Except for some predictors, most of predictions are in good agreement with the SLT result irrespective of the used method.

The static predictions show a scattered set around the real SLT values unlike the dynamic predictions that generally underestimate the pile capacities.

Acknowledgments

The authors would like to acknowledge the Belgian Ministry of Economic Affairs for its financial support of the testing program (Convention CC CI – 756). Contractors installed their own piles free of charge. Finally this exercise would not have been possible without countless hours accrued amongst the several prediction team that bravely took up the challenge.

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Table 1 : Features of installed piles

Pile number	Installation date	Pile type - $\varnothing_{shaft}/\varnothing_{base}$	$\varnothing_{shaft}$ (m)	$\varnothing_{base}$ (m)	Pile base depth (m)***	Test
A1	06/06/2001	Fundex 38/45	0.390*	0.450	9.50	(Static)
$A1_{bis}$	11/06/2001	Fundex 38/45	0.390*	0.450	9.59	Static
A2	12/06/2001	Olivier 36/51	0.550*	0.550*	9.45/9.20**	Static
A3	19/06/2001	Omega 41/41	0.410	0.410	9.45	Static
A4	26/06/2001	De Waal 41/41	0.410	0.410	9.53	Static
A5	07/06/2001	Fundex 38/45	0.390*	0.450	9.61	Statnamic
A6	19/06/2001	Omega 41/41	0.410	0.410	9.50	Dynamic
A7	11/06/2001	Olivier 36/51	0.550*	0.550*	9.24/8.99**	Dynamic
A8	07/06/2001	Fundex 38/45	0.390*	0.450	9.62	Dynamic
A9	11/06/2001	Olivier 36/51	0.550*	0.550*	9.25/9.00**	Dynamic
A10	07/06/2001	Fundex 38/45	0.390*	0.450	9.58	Dynamic
B1	20/06/2001	Prefab 35x35	0.446	0.395	9.51	Static
B2	20/06/2001	Prefab 35x35	0.446	0.395	9.57	Static
B3	29/06/2001	Atlas 36/51	0.510	0.510	9.58/9.43**	Static
B4	29/06/2001	Atlas 36/51	0.510	0.510	9.58/9.43**	Static
B5	28/06/2001	Atlas 36/51	0.510	0.510	9.33/9.18**	Statnamic
B6	28/06/2001	Atlas 36/51	0.510	0.510	9.33/9.18**	Dynamic
B7	26/06/2001	De Waal 41/41	0.410	0.410	9.72	Dynamic
B8	20/06/2001	Prefab 35x35	0.446	0.395	9.51	Dynamic
B9	20/06/2001	Prefab 35x35	0.446	0.395	9.50	Dynamic
B10	19/06/2001	Omega 41/41	0.410	0.410	9.45	Dynamic
C1	06/06/2001	Fundex 38/45	0.390*	0.450	9.44	(Static)
$C1_{bis}$	11/06/2001	Fundex 38/45	0.390*	0.450	9.65	Static
C2	12/06/2001	Olivier 36/51	0.550*	0.550*	9.38/9.13**	Static
C3	19/06/2001	Omega 41/41	0.410	0.410	9.45	Static

C4	26/06/2001	De Waal 41/41	0.410	0.410	9.52	Static
C5	26/06/2001	De Waal 41/41	0.410	0.410	9.53	Statnamic
C6	20/06/2001	Prefab 35x35	0.446	0.395	9.53	Statnamic
C7	19/06/2001	Omega 41/41	0.410	0.410	9.45	Statnamic
C8	12/06/2001	Olivier 36/51	0.550*	0.550*	9.65/9.40**	Statnamic
C9	26/06/2001	De Waal 41/41	0.410	0.410	9.45	Dynamic
C10	28/06/2001	Atlas 36/51	0.510	0.510	9.32/9.17**	Dynamic

* When measurement from the auger differed from the theoretical value, the measured values have been taken
** for piles with screw-shaped shaft : level top lost bottom plate / level one rotation above
***Measured pile base depth relative to soil surface level

Table 2a- Summary results triaxial tests

Depth	CU-triaxial		CD-triaxial	
	ϕ' [°]	c' [kPa]	ϕ' [°]	c' [kPa]
4.0 – 4.5 m	34	0	35	0
7.0 – 7.5 m	34	0	-	-
10.0 – 10.5 m	34	0	35	0

Table 2b- Plasticity limits and other data

	Depth soil sample		
Characteristics	4.0 – 4.5 m	7.0 – 7.5 m	10.0 – 10.5 m
γ_d (KN/m^3)	16.4	18.4	13.8
γ_n (KN/m^3)	18.8	20.8	15.0
w (%)	14.8	12.9	9.0
S_r (%)	67.6	82.3	27.0
w_L (%)	27.6	30.2	23.4
w_p (%)	18.7	15.0	20.7
I_p (%)	8.9	15.2	2.7

Table 3 : Prediction submission detail with number of predictions :

	PILE TYPE						SUBMITTAL	
type	**Prefab**	**Atlas**	**Fundex**	**Omega**	**De Waal**	**Olivier**	**electronic**	**report**
CPT 1	2	2	2	2	2	2	3/7/01	3/7/01
CPT 2	2	2	2	2	0	0	31/12/01	
CPT 3	2	2	2	2	2	2	21/12/01	
CPT 4	1	1	1	1	1	1	27/12/01	
CPT 5	2	2	2	2	2	2	24/8/01	
CPT 6	0	2	2	2	2	2	30/11/01	5/12/01
CPT 7	0	0	0	2	2	0	27/12/01	
DLT 1	2	2	2	2	2	2	30/12/01	
DLT 2	1	0	1	1	1	1	20/12/01	20/12/01
DLT 3	2	1	2	1	1	2	31/12/01	
DLT 4	2	0	0	0	0	0	27/12/01	
DLT 5	2	2	2	2	2	2	21/12/01	
Labo	2	2	2	2	2	2	31/12/01	

Table 4 : CPT and labo predictions : predictors analysis (Qpredicted/Qmeasured)

	CPT 1	**CPT 2**	**CPT 3**	**CPT 4**	**CPT 5**	**CPT 6**	**CPT 7**	**Labo**	**Contractor**
average [%]	118%	29%	75%	90%	109%	122%	78%	114%	95%
Standard deviation [%]	14%	2%	10%	13%	13%	27%	6%	14%	12%
COV [%]	12%	8%	13%	15%	12%	22%	8%	12%	13%
Number	11	7	11	6	11	9	4	9	7

Table 5 : CPT and labo predictions : pile analysis

		SLT [KN] (10% Db)	Prediction Average [KN]	Av. / SLT Result [%]	Pred. Av.* [KN]	Av./SLT Result * [%]
B3	Atlas 36/51	3586	3 493	97%	3 833	107%
B4	Atlas 36/51	3463	3 340	96%	3 789	109%

A4	De Waal 41/41	2441	2 595	106%	2 595	106%
C4	De Waal 41/41	2267	2 520	111%	2 520	111%
A1bis	Fundex 38/45	3012	2 693	89%	2 942	98%
C1bis	Fundex 38/45	- - - -	2 518	- - - -	2 786	- - - -
A2	Olivier 36/51	3368	3 725	111%	3 725	111%
C2	Olivier 36/51	2910	3 547	122%	3 547	122%
A3	Omega 41/41	2826	2 341	83%	2 533	90%
C3	Omega 41/41	2751	2 131	77%	2 360	86%
B1	Prefab 35x35	2660	2 354	88%	2 664	100%
B2	Prefab 35x35	3535	2 518	71%	2 923	83%

* : without CPT 2 prediction

Table 6 : DLT predictions : predictors analysis

	DLT 1	DLT 2	DLT 3	DLT 4	DLT 5	Statnamic
average [%]	91%	122%	78%	72%	63%	111%
standard deviation [%]	18%	42%	19%	7%	10%	23%
COV [%]	19%	34%	24%	10%	16%	21%
Number	12	5	9	2	12	6

Table 7 : DLT predictions : pile analysis

		Reference Target [KN] (10 mm)	Prediction Average [KN]	Av. / Ref. Target [%]
B6	Atlas 36/51	1992	2090	105%
C10	Atlas 36/51	1992	1707	86%
B7	De Waal 41/41	1477	1525	103%
C9	De Waal 41/41	1477	1380	93%
A8	Fundex 38/45	2288	1687	74%
A10	Fundex 38/45	2288	1360	59%
A7	Olivier 36/51	2009	2068	103%
A9	Olivier 36/51	2009	1746	87%
A6	Omega 41/41	1775	1479	83%
B10	Omega 41/41	1775	1332	75%
B8	Prefab 35x35	2228	1924	86%
B9	Prefab 35x35	2228	1720	77%

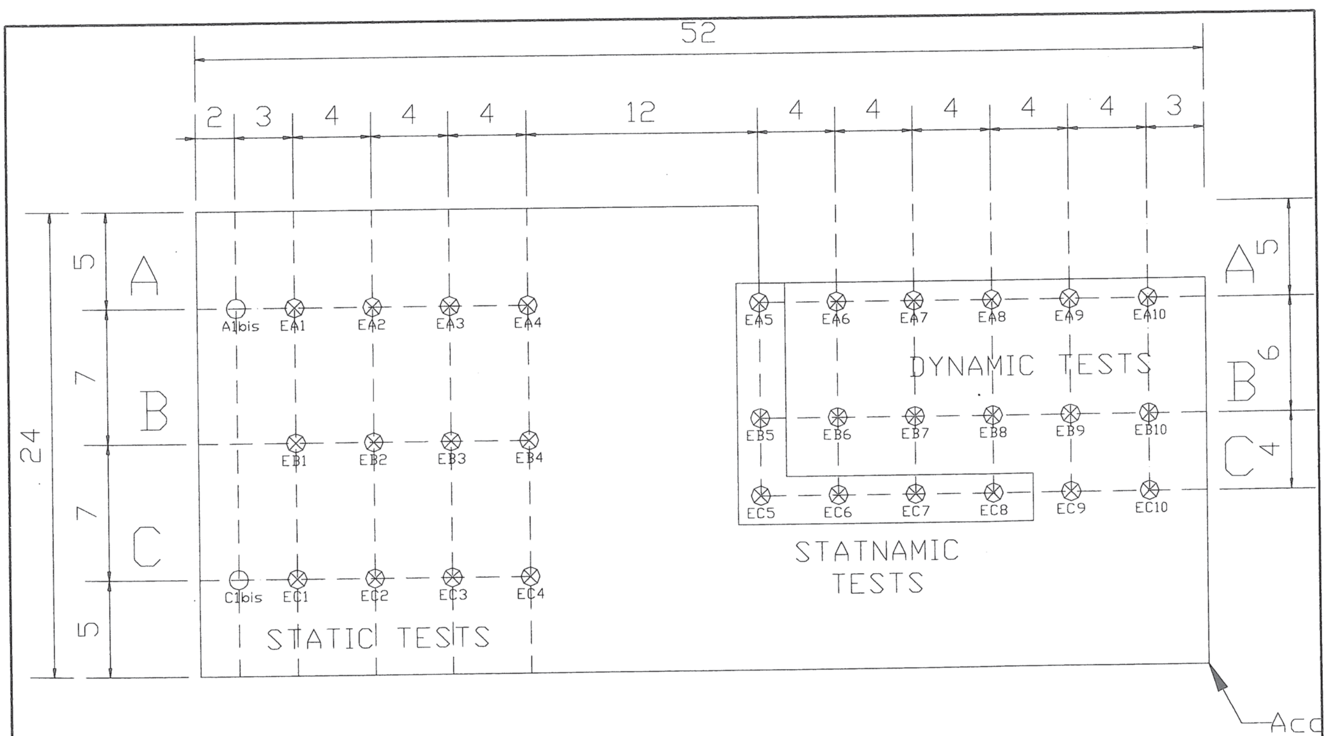
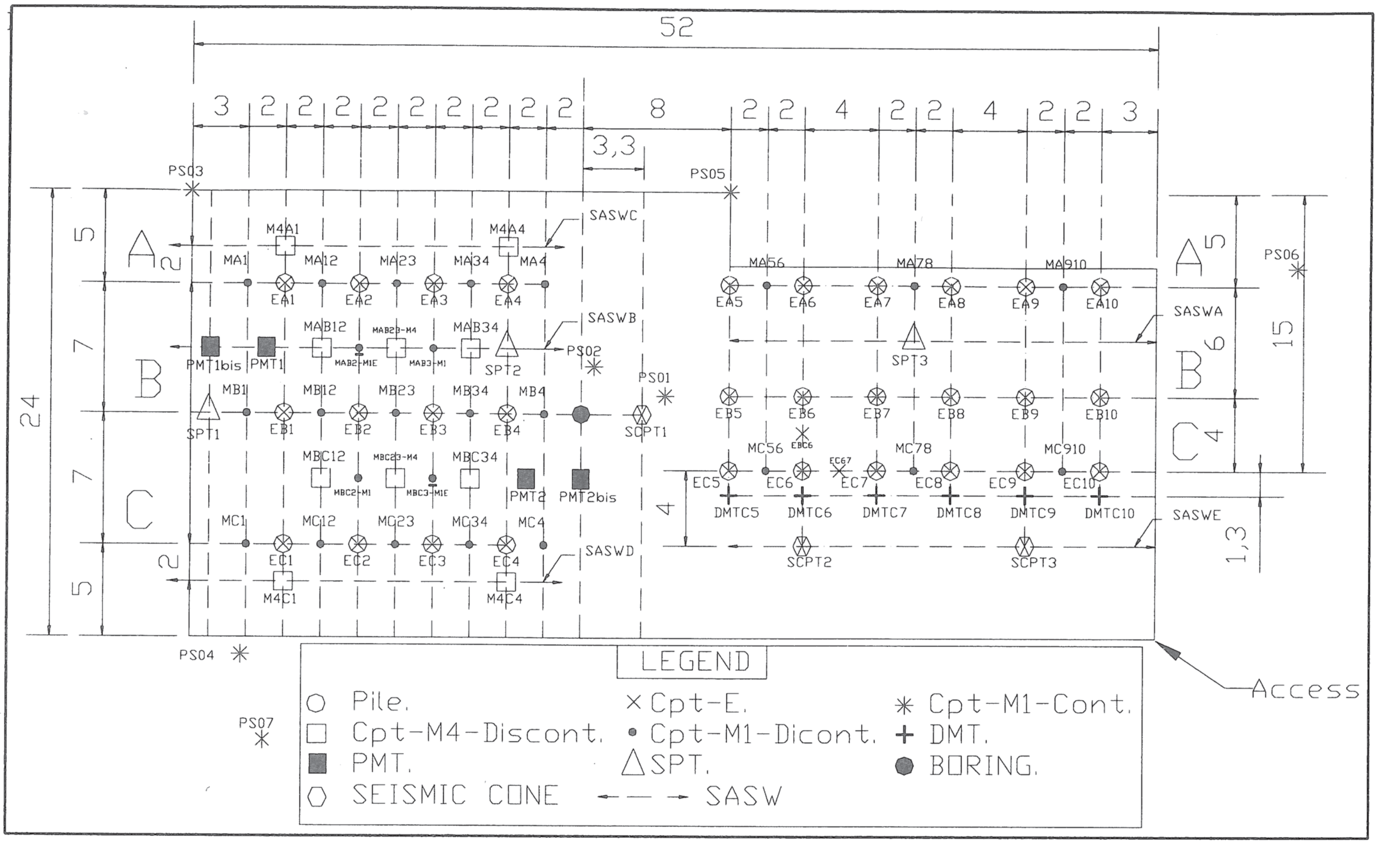


Figure 6 : Tests Piles Layout



52
3 2 2 2 2 2 2 2 2 2 8 2 2 4 2 2 4 2 2 3
3,3
PS03
PS05
PS06
PS01
PS02
PS04
PS07
SASWC
SASWB
SASWA
SASWD
SASWE
M4A1
M4A4
MA1
MA12
MA23
MA34
MA4
EA1
EA2
EA3
EA4
MA56
MA78
MA910
EA5
EA6
EA7
EA8
EA9
EA10
MAB12
MAB34
SPT2
SPT3
PMT1bis
PMT1
MB1
MB12
MB23
MB34
MB4
SPT1
EB1
EB2
EB3
EB4
SCPT1
EB5
EB6
EB7
EB8
EB9
EB10
MBC12
MBC34
PMT2
PMT2bis
MC56
MC78
MC910
EC5
EC6
EC7
EC8
EC9
EC10
DMTC5
DMTC6
DMTC7
DMTC8
DMTC9
DMTC10
SCPT2
SCPT3
MC1
MC12
MC23
MC34
MC4
EC1
EC2
EC3
EC4
M4C1
M4C4
A
B
C
24
5
7
2
15
6
4
1,3
Access
LEGEND
Pile.
Cpt-M4-Discont.
PMT.
SEISMIC CONE
Cpt-E.
Cpt-M1-Dicont.
SPT.
SASW
Cpt-M1-Cont.
DMT.
BORING.

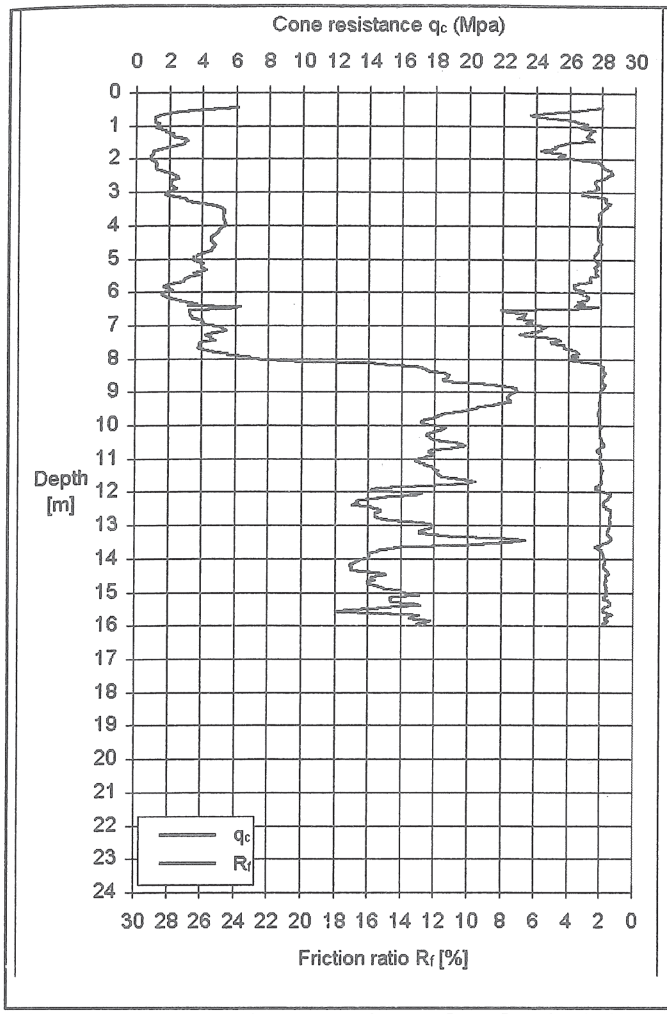


Figure 8 : CPT-E Result : cone resistance [Mpa] and Friction Ratio [%]

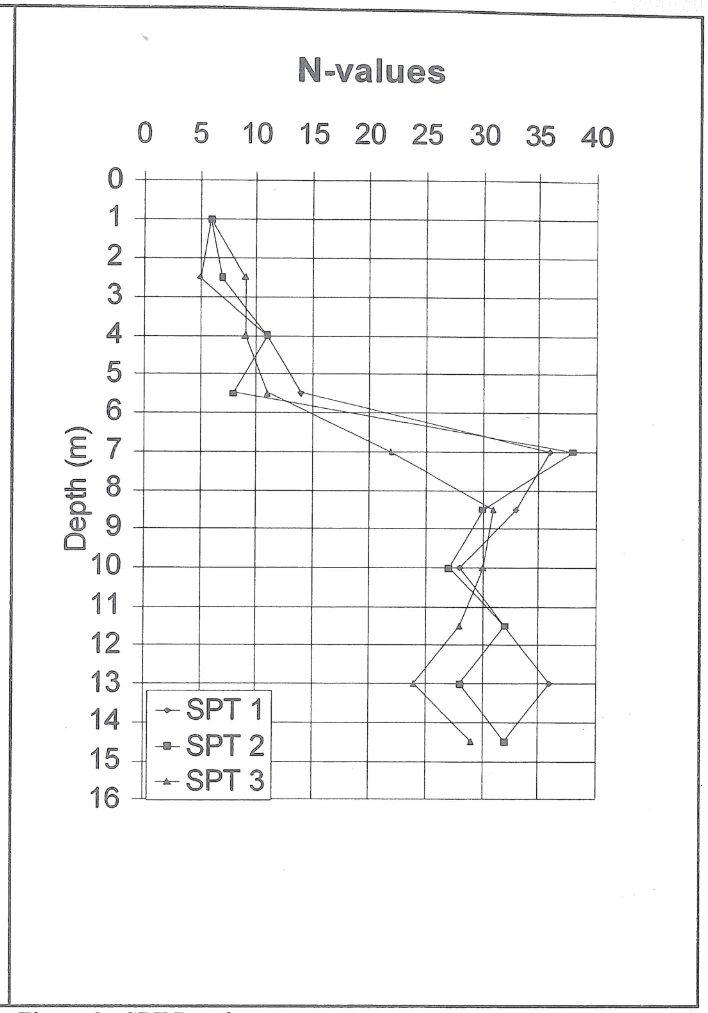


Figure 9 : SPT Result

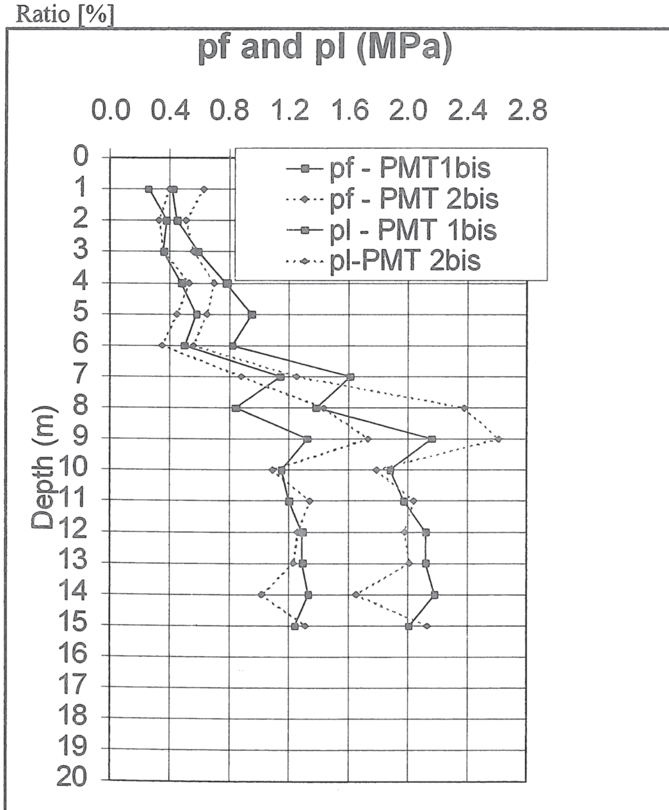


Figure 10 : PMT Result : Pressures pf & pl [Mpa]

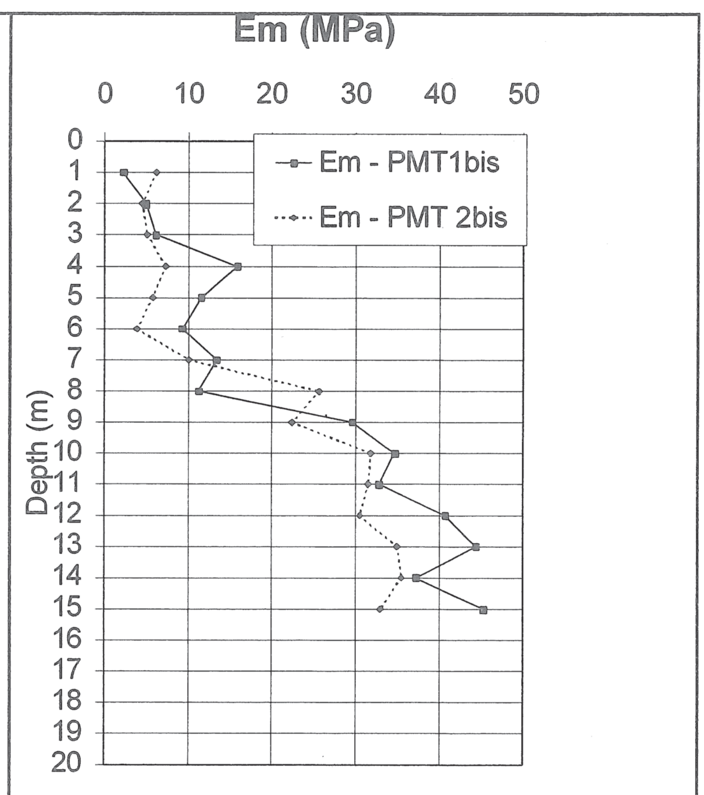


Figure 11 : PMT Result : module Em [Mpa]

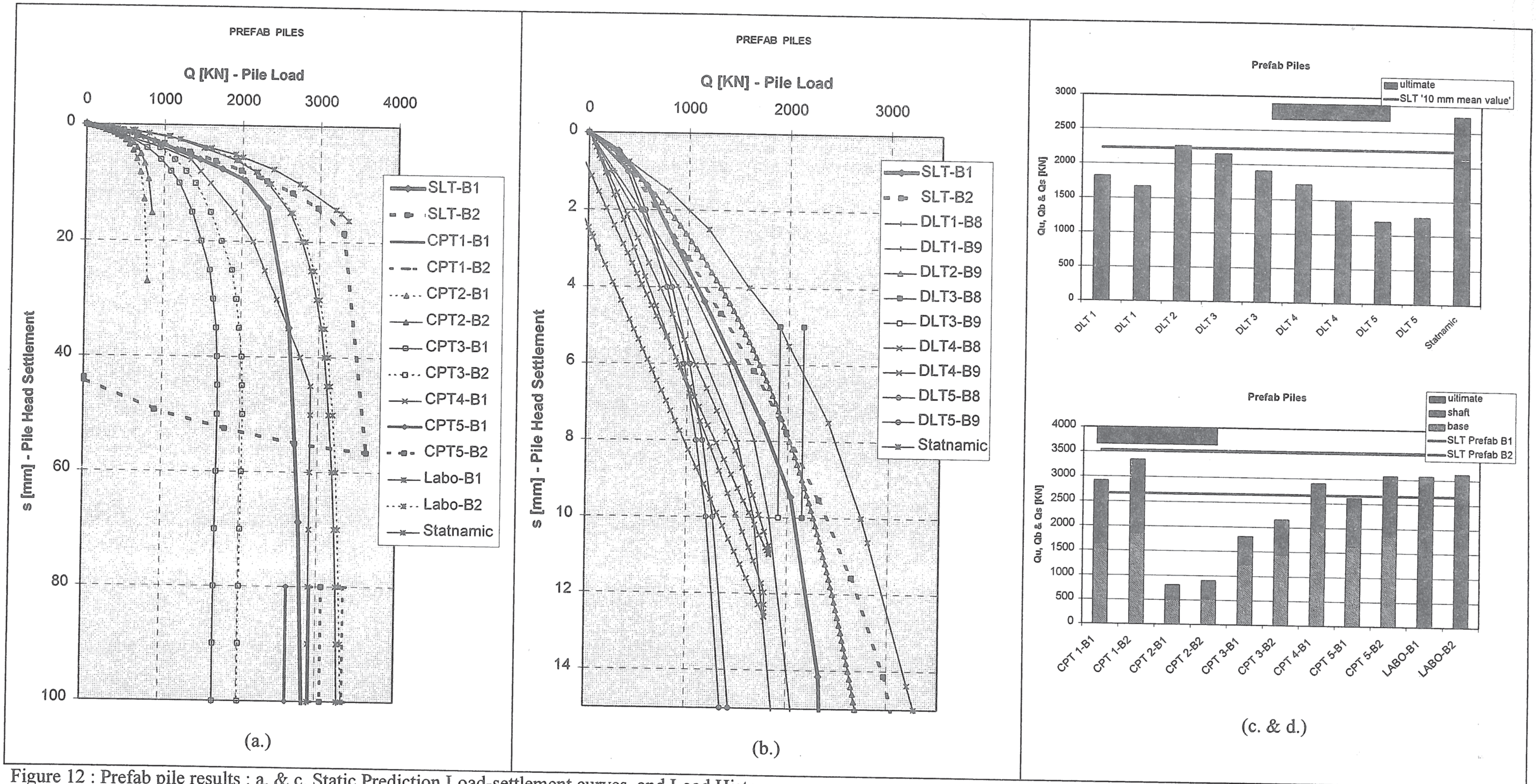


Figure 12 : Prefab pile results : a. & c. Static Prediction Load-settlement curves and Load Histogram
b. & d. Dynamic Prediction Load-settlement curves and Load Histogram

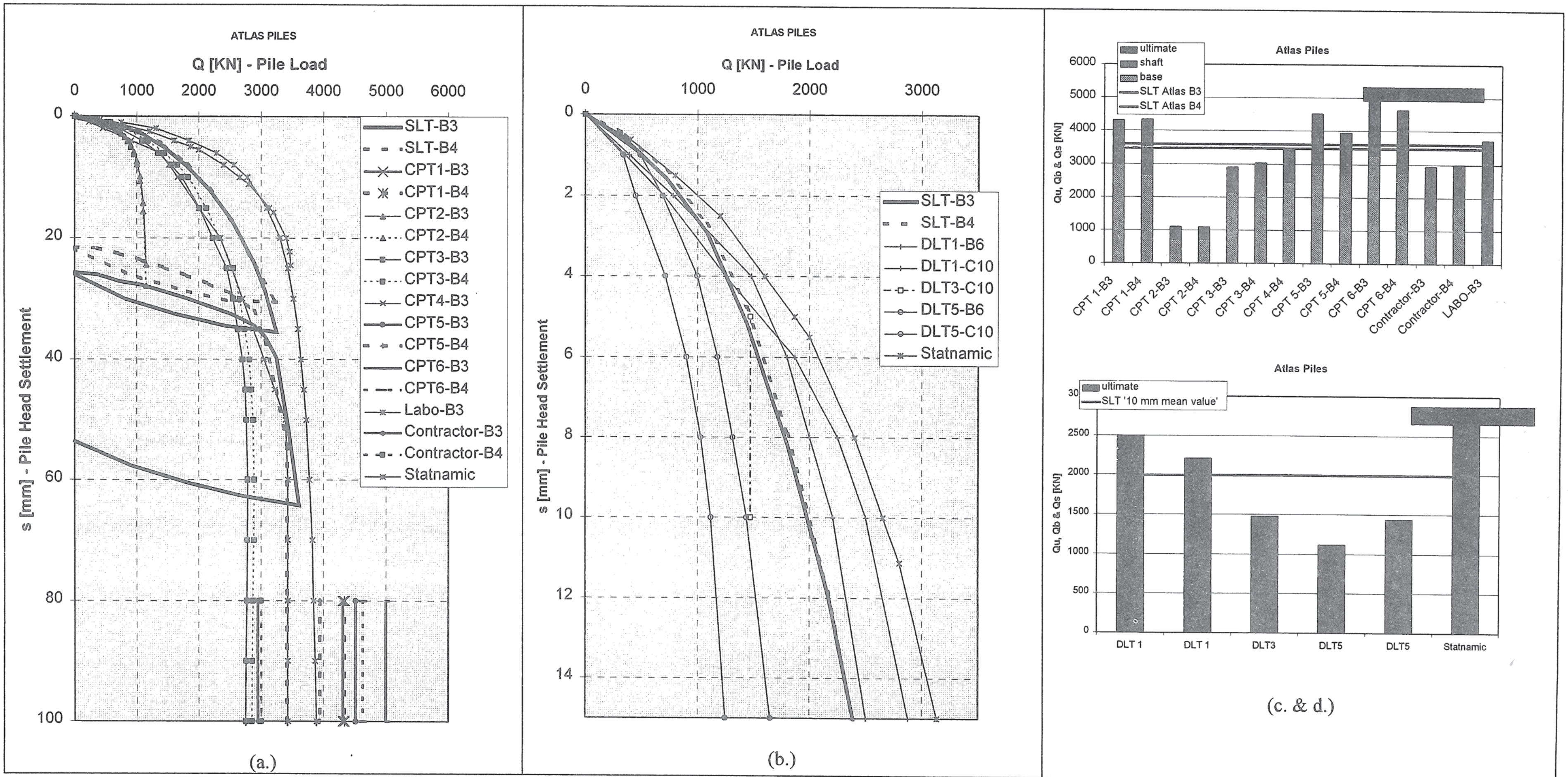


Figure 13 : Atlas pile results : a. & c. Static Prediction Load-settlement curves and Load Histogram
b. & d. Dynamic Prediction Load-settlement curves and Load Histogram

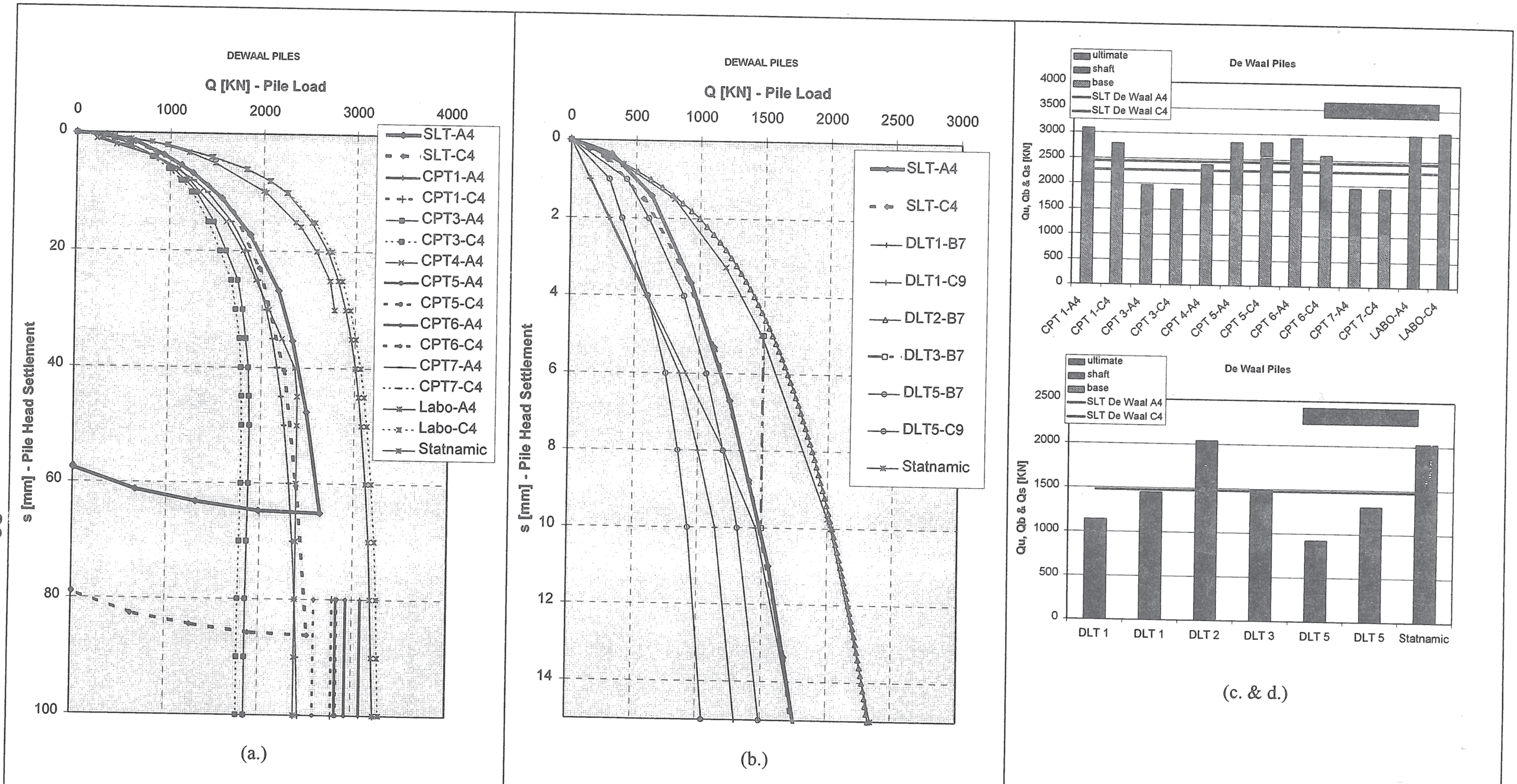


Figure 14 : De Waal pile results : a. & c. Static Prediction Load-settlement curves and Load Histogram
b. & d. Dynamic Prediction Load-settlement curves and Load Histogram

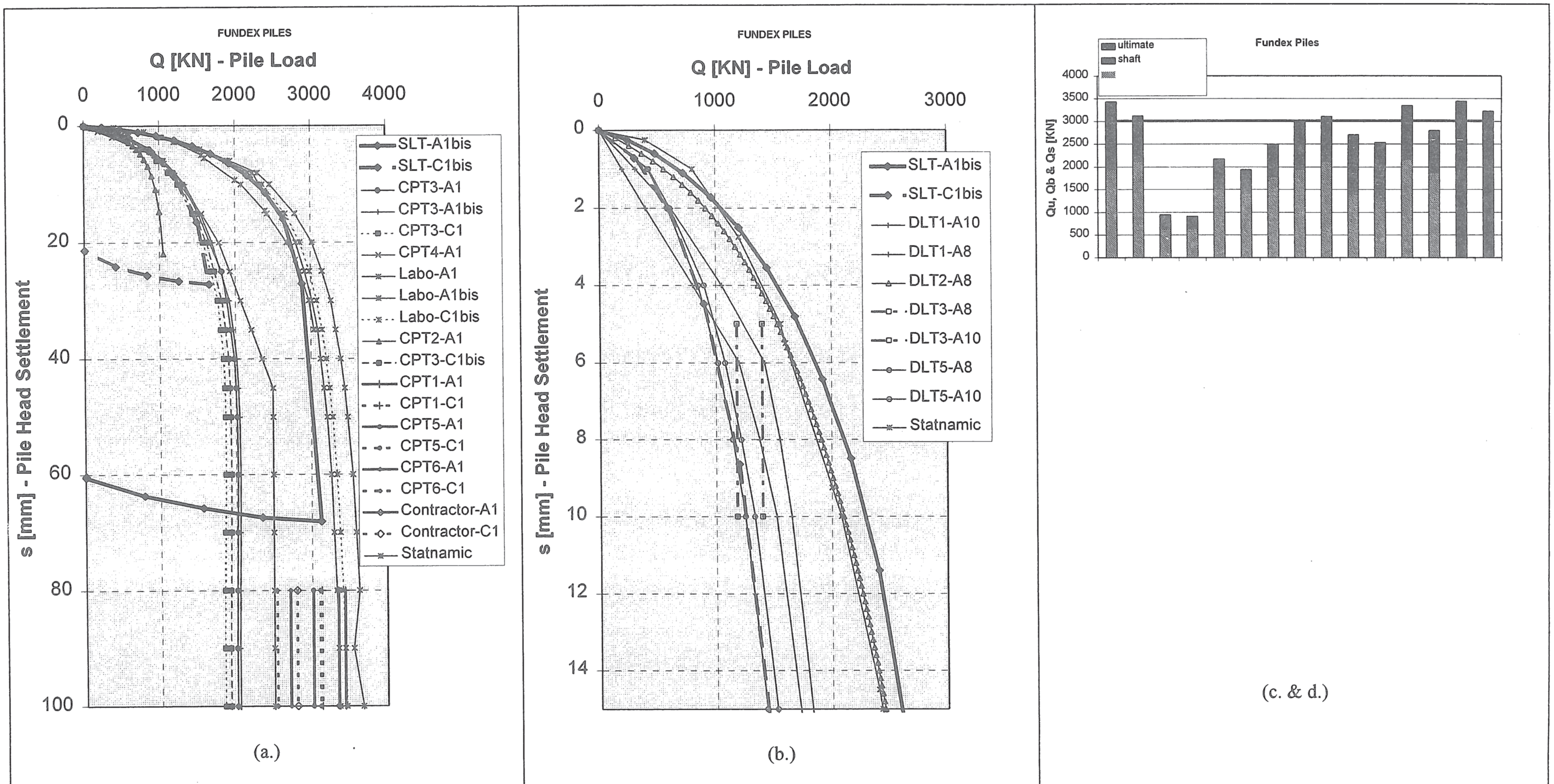


Figure 15 : Fundex pile results : a. & c. Static Prediction Load-settlement curves and Load Histogram
b. & d. Dynamic Prediction Load-settlement curves and Load Histogram

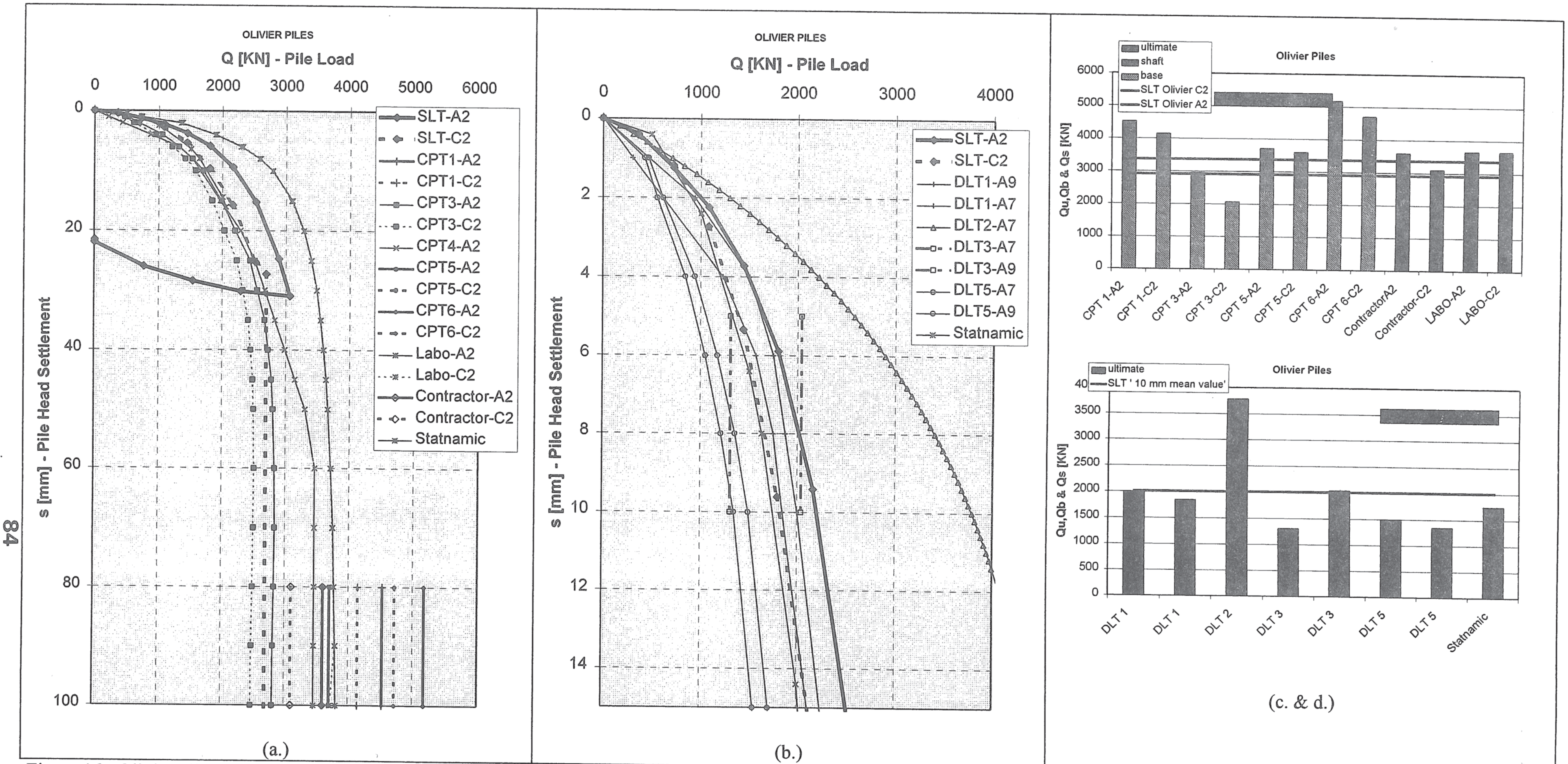


Figure 16 : Olivier pile results : a. & c. Static Prediction Load-settlement curves and Load Histogram
b. & d. Dynamic Prediction Load-settlement curves and Load Histogram

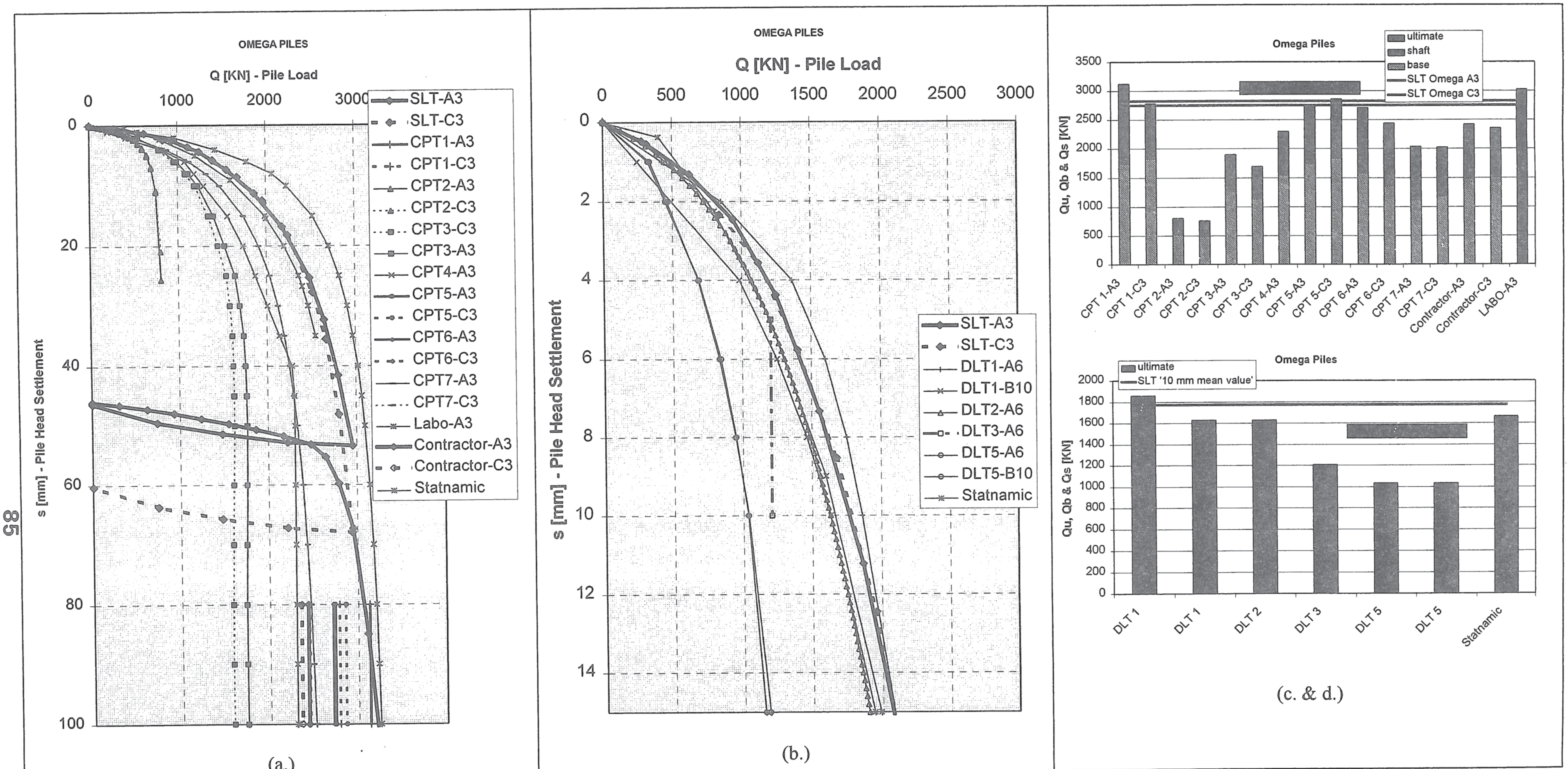


Figure 17 : Omega pile results : a. & c. Static Prediction Load-settlement curves and Load Histogram
b. & d. Dynamic Prediction Load-settlement curves and Load Histogram