BAB VI

PENUTUP

6.1 Kesimpulan

Berdasarkan hasil analisis dan pembahasan yang telah dilakukan, dapat disimpulkan bahwa:

1. Hasil perhitungan daya dukung tiang dengan menggunakan empat metode pengujian, yaitu pengujian PDA, SPT, CPT, dan metode *alpha*, didapatkan nilai daya dukung tiang yang baik, jika dilihat dari besarnya nilai daya dukung dari keempat metode analisis.
2. Melihat dari kriteria penerimaan hasil *Ru* yaitu *Qu* (daya dukung ultimit tiang hasil CPT/SPT) ≤ *Ru* (daya dukung ultimit tiang hasil PDA), jadi pembangunan Cluster Flamingo Summarecon Serpong – Tangerang merupakan bangunan yang aman jika dilihat dari daya dukung pondasinya.

6.2 Saran

1. Dalam perhitungan analisis daya dukung tiang perlu ditinjau pula dari metode-metode yang lain sehingga lebih bisa membandingkan metode mana yang lebih efisien.

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LAMPIRAN

I

p.t. SOLEFOUND SAKTI

soil mechanics and engineering consultant

LAPORAN

PENYELIDIKAN - TANAH

Proyek : Rumah Tinggal 2 (dua) & 3 (tiga) Lantai

Cluster Flaminggo

Lokasi : Summarecon – Serpong, Tangerang

Jakarta , April 2015

DN/ FD

p.t. SOLEFOUND SAKTI
soil mechanics and engineering consultant
JAKARTA

alan Gading Putih Raya Blok KR. 15-17 Kelapa Gading Permai, Jakarta Utara, Phone: 4520808, Email: pt.solefoundsakti@yahoo.co.id

= DAFTAR ISI =

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LAPORAN PENYELIDIKAN TANAH

Proyek : Rumah Tinggal 2 (dua) & 3 (tiga) Lantai

Cluster Flaminggo

Lokasi : Summarecon - Serpong, Tangerang

PRA - KATA

Memenuhi permohonan penyelidikan tanah dari ***KSO Summarecon Serpong*** berdasarkan Surat Perintah Kerja No.SOL.K/KSLP/14/09/01, tertanggal 05 September 2014 dan Offerte No.24 A/SS/VIII/2014, tertanggal 28 Agustus 2014, untuk suatu proyek : ***Rumah Tinggal 2 (dua) & 3 (tiga) Lantai Cluster Flaminggo,*** **Lokasi :** ***Summarecon – Serpong, Tangerang,*** maka suatu regu dari PT.Solefound Sakti, Jakarta, mulai melaksanakan eksplorasi tanah Bangunan pada tanggal 02 Nopember 2014.

Penyelidikan Tanah tersebut terdiri dari :

PENYELIDIKAN DI LAPANGAN

1. **Penyondiran – Ringan** sebanyak : 18 (delapan belas) - titik dengan alat berkapasitas 2,5 tonf dilengkapi dengan "Adhesion Jacket Cone" dan yang dilaksanakan sampai mencapai lapisan "keras" dengan tekanan konus $q_c > 250$ kgf /cm^2.
2. **Pengeboran – Dalam** sebanyak : 7 (tujuh) - lubang sampai kedalaman 30.00 meter masing - masing
3. **Pengambilan contoh tanah dan core :** diambil contoh tanah "asli" (Undisturbed sample), contoh tanah "disturbed" maupun cores untuk lapisan – lapisan keras.

4. **Penentuan Konsistensi** : dari tiap contoh tanah yang "good undisturbed" ditentukan harga q_p-nya dengan "Pocket Penetrometer", harap lihat Boring Logs; hal 30 - 45
5. **Percobaan "Standard Penetration Test" (SPT)** : Pada pengeboran dilaksanakan SPT sebanyak 15 - 16 kali.
6. **Penentuan Muka Air Tanah (M.A.T.)** : Kedudukan M.A.T. didalam lobang bor diukur selama 24 jam setelah pengeboran mencapai 6.0 meter (hanya sebagai indikasi).

- Untuk letak titik - titik penyelidikan harap lihat : Gambar Situasi; hal 20
- Diagram Sondir dipersembahkan pada hal 21 - 38
- Profil Bor – Dalam yang bersangkutan; hal 39 - 45

II. PENYELIDIKAN - LABORATORIUM.

Ditentukan :

1. **Sifat – sifat Pengenal :**
   a. Berat jenis butir (G_s), berat volume massa (γ_m), kadar pori (e), derajat kejenuhan (S_r) dan kadar air alam (W_N)
   b. Gradasi dengan analisa hidrometer.
   c. Batas – batas Konsistensi (atterberg) :
   Batas cair dari contoh tanah Dengan dan / atau Tanpa pengeringan di dalam oven (W_L^*); batas plastis (W_P) dan batas susut (W_s)
   Juga : Indeks Plastisitas : $P.I = W_L - W_P$

Dan Liquidity Index : L.I = $\frac{W_N - W_P}{P.I}$

Aktivitas : A = $\frac{P.I.}{\% < 2\ \mu}$ (fraksi lempung menurut klassifikasi tekstur M.I.T.)

2. **Sifat – sifat Teknis** :

a. Kemampatan dengan percobaan konsolidasi di dalam oedometer.

b. Kekuatan terhadap geser :

i. "Unconfined Compressive Strength " (q_{uu}) dan derajat kepekaan :

$S_t = \frac{q_{uu}}{q_{ur}}$ dengan w – tetap.

ii. Parameter c dan ∅ (total, effektif) dengan percobaan pemampatan silinder geser triaksial dalam keadaan "Consolidated isotropic Undrained" dengan pengukuran tekanan air pori.

KEADAAN TANAH DASAR

Keadaan tanah pada lokasi ini dapat dijelaskan sebagai berikut:

Dari permukaan tanah sampai kedalaman 6.00 m-MT, terdapat lapisan SILT, MH, silt lempung pasir, merah coklat abu-abu, dengan konsistensi "lunak" sampai "stiff", dengan lensa pasir kerikil di DB III (4.00 ÷ 6.50 m-MT), hitam, dengan kepadatan "sedang".

Dari 6.00 ÷ 14.00 m-MT, terdapat lapisan SILT, MH, silt lempung pasir ÷ silt pasir lempung, abu-abu ÷ abu-abu coklat, organis, dengan konsistensi "lunak" sampai "stiff", dengan lensa pasir kerikil di DB VI (6.00 ÷ 12.00 m-MT), hitam, dengan kepadatan "sangat padat".

Dari 14.00 ÷ 19.00 m-MT, terdapat lapisan SILT, MH, silt lempung pasir ÷ silt pasir lempung, abu-abu coklat, dengan konsistensi "lunak" sampai "stiff".

Dari 19.00 ÷ 24.00 m-MT, terdapat lapisan SILT, MH, silt pasir lempung : silt lempung pasir, abu-abu, dengan konsistensi "sedang", diselingi lensa-lensa pasir di DB II (19.00 ÷ 24.00 m-MT) dan DB VII (20.00 ÷ 24.50 m-MT), hitam, dengan kepadatan "lepas" sampai "sedang".

Dari 24.00 ÷ 30.00 m-MT, terdapat lapisan SILT, MH, silt pasir lempung : silt lempung pasir / LEMPUNG, CH, lempung silt pasir, abu-abu ÷ coklat merah abu-abu, dengan konsistensi "sedang" sampai "sangat stiff", diselingi lensa cadas pasir di DB II (24.00 ÷ 28.50 m-MT), hitam, dengan kepadatan "sangat padat".

Muka air tanah yang diukur selama pengeboran tercatat pada kedalaman 4.80 ÷ 8.40 m-Muka Tanah.

DISKUSI

Dengan keadaan tanah tersebut diatas, dari perhitungan diperoleh:

1. **Daya Dukung Tiang Pancang.**

Dengan menggunakan fondasi tiang pancang penampang ⌷ 20 ÷ 35 cm, diperoleh daya dukung tiang sebagai berikut:

Lokasi	Panjang Tiang (m)	Penampang (cm^2)	$\overline{P_1}$ TIANG (tonf)
S1, DB VI	6 – 9	⌷ 20 x 20	27.3
		⌷ 25 x 25	39.9
		⌷ 30 x 30	54.8
		⌷ 35 x 35	72.0
S10, S11, S14	9 – 12	⌷ 20 x 20	30.7
		⌷ 25 x 25	42.9
		⌷ 30 x 30	56.9
		⌷ 35 x 35	72.7
S2, DB V, S3, S4, S5, DB IV, S6, S7, DB VII, S8, S9, DB III, S12, S13, S14, S16, S17, DB II, DB I, S18	24	⌷ 20 x 20	45.8
		⌷ 25 x 25	64.5
		⌷ 30 x 30	86.0
		⌷ 35 x 35	110.4

2. **Daya Dukung Tiang Bor.**

Dengan menggunakan fondasi tiang bor belled bottom Ø = 30 ÷ 50, panjang L = ± 15.00 : 30.00 m dengan dasar tiang pada lapisan cadas keras, panjang L = ± 15.00 – 24.00 m dan panjang L = ± 30.00 m apabila tidak ada cadas keras, diperoleh daya dukung tiang sebagai berikut:

L o k a s i	Panjang Tiang (cm)	Diameter Shaft (cm)	Diameter Dasar (cm)	$\overline{P}$ 1 tiang (tonf)
S 1, DB VI	6 – 9 m dengan Dasar tiang pada Lapisan cadas keras	$\varnothing_{shaft}$ = 30	$\varnothing_{base}$ = 50	44.3
		$\varnothing_{shaft}$ = 40	$\varnothing_{base}$ = 60	62.8
		$\varnothing_{shaft}$ = 50	$\varnothing_{base}$ = 70	83.8
S 10, S 11, S 14	9 – 12 m dengan dasar tiang pada lapisan cadas keras	$\varnothing_{shaft}$ = 30	$\varnothing_{base}$ = 50	45.4
		$\varnothing_{shaft}$ = 40	$\varnothing_{base}$ = 60	63.7
		$\varnothing_{shaft}$ = 50	$\varnothing_{base}$ = 70	84.6
S2, DB V, S3, S4 S5, DB IV, S6 S7, DB VII, S8, S9, DB III S12, S13 S16,S17, DB II, DB I, S 18	24 - 30	$\varnothing_{shaft}$ = 30	$\varnothing_{base}$ = 50	49.5
		$\varnothing_{shaft}$ = 40	$\varnothing_{base}$ = 60	69.9
		$\varnothing_{shaft}$ = 50	$\varnothing_{base}$ = 70	93.0

REKOMENDASI

Dengan data diskusi tersebut diatas untuk ***Bangunan Perumahan 2 (dua) lantai dan 3 (tiga) lantai***, dianjurkan menggunakan fondasi dengan alternatif sebagai berikut :

Alternatif 1

Dianjurkan menggunakan :

FONDASI TIANG PANCANG

Tiang pancang penampang ф 20 - 35 cm, dianjurkan menggunakan daya dukung tiang :

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Lokasi	Panjang Tiang (m)	Penampang (cm^2)	$\overline{P}$ 1 tiang (tonf)
S1 DB VI	6 - 9	ф 20 x 20	25
		ф 25 x 25	35
		ф 30 x 30	50
		ф 35 x 35	70
S10 S11, S14	9 - 12	ф 20 x 20	25
		ф 25 x 25	35
		ф 30 x 30	50
		ф 35 x 35	70
S2, DBV, S3, S4, S5, DB IV, S6, S7, DB VII, S8, S9, DB III, S12, S13, S16, S17, DB II, DBI, S18	24	ф 20 x 20	25
		ф 25 x 25	40
		ф 30 x 30	60
		ф 35 x 35	80

<u>Selanjutnya dianjurkan</u>

1. Pemancangan dengan menggunakan Drop Hammer.
2. Menghindar dari polusi getaran, bunyi, dan asap dianjurkan agar pemancangan dilaksanakan dengan alat pancang Hydraulic Tekan / Jack-in Pile.
3. Melaksanakan penge"check"an set untuk masing – masing tiang dengan beban 2 x design load.
4. Melaksanakan percobaan pembebanan tiang dengan beban 2 x design load.

Alternatif 2

Dianjurkan menggunakan

FONDASI TIANG BOR

Tiang Bor Belled Bottom diameter Ø = 30 – 50 cm, panjang L = ± 15.00 - 30.00 meter dengan dasar tiang pada lapisan cadas keras, panjang L = ± 15.00 - 24.00 meter dan Panjang L = ± 30.00 meter apabila tidak ada cadas keras, dianjurkan menggunakan daya dukung tiang :

Lokasi	Panjang Tiang (cm)	Diameter Shaft (cm)	Diameter Dasar (cm)	$\bar{P}$ 1 tiang (tonf)
S 1, DB VI	6 – 9 m dengan Dasar tiang pada Lapisan cadas keras	$Ø_{shaft}$ = 30	$Ø_{base}$ = 50	35
		$Ø_{shaft}$ = 40	$Ø_{base}$ = 60	50
		$Ø_{shaft}$ = 50	$Ø_{base}$ = 70	70
S 10, S 11, S 14	9 – 12 m dengan dasar tiang pada lapisan cadas keras	$Ø_{shaft}$ = 30	$Ø_{base}$ = 50	35
		$Ø_{shaft}$ = 40	$Ø_{base}$ = 60	50
		$Ø_{shaft}$ = 50	$Ø_{base}$ = 70	70
S2, DB V, S3, S4 S5, DB IV, S6 S7, DB VII, S8, S9, DB III S12, S13 S16,S17, DB II, DB I, S 18	24 - 30	$Ø_{shaft}$ = 30	$Ø_{base}$ = 50	40
		$Ø_{shaft}$ = 40	$Ø_{base}$ = 60	60
		$Ø_{shaft}$ = 50	$Ø_{base}$ = 70	80

Selanjutnya dianjurkan :

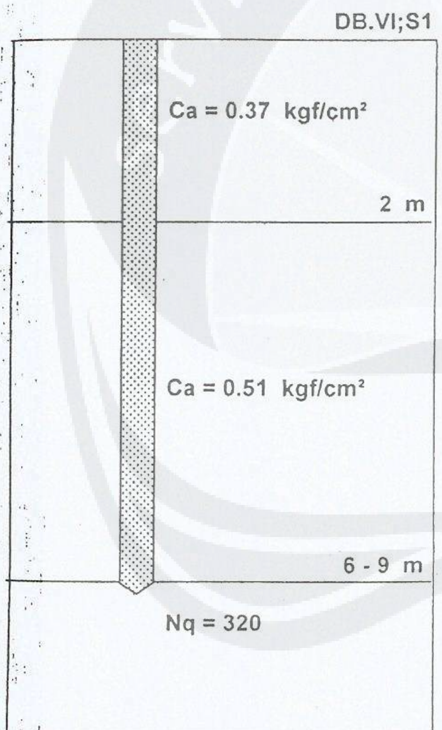
1. Pelaksanaan tiang bor dilakukan oleh yang berpengalaman dengan tiang bor belled bottom dibawah pengawasan Ahli fondasi.
2. Melaksanakan percobaan pembebanan tiang dengan beban rencana 2 x design load.

Oleh:

Direktur	Consulting Engineer
PT. SOLEFOUND SAKTI soil mechanics and engineering consultant JAKARTA	
Ir.Tjahja Husada	Ir.Soerjatmo Wreksoatmodjo

PERHITUNGAN DAYA DUKUNG TIANG

Proyek : PERUMAHAN CLUSTER FLAMINGGO 2 & 3 LANTAI
Lokasi : SUMMARECON , SERPONG - TANGERANG.



Pondasi Tiang Pancang (Jack in pile)

Penampang Φ = 20 - 25 cm
Panjang Tiang L = 6 - 9 m

A_b = 400 cm^2 O = 80 cm
= 625 cm^2 = 100 cm

Berezantsev :

Φ = 20 cm

P_u = 0.04 x (0.6 x 6 x 320) + 0.8 (2 x 3.7 + 4 x 5.1)

= 46.1 + 22.24
= 68.3 tonf

$\bar{P}_{1\ TIANG\ AXIAL\ TEKAN} = \dfrac{68.3}{2.5} =$ **27.3** tonf

$\bar{P}_{1\ TIANG\ AXIAL\ TARIK} = \dfrac{22.24}{2.5} =$ **8.9** tonf

Φ = 25 cm

P_u = 0.0625 x (0.6 x 6 x 320) + 1 (2 x 3.7 + 4 x 5.1)

= 72.0 + 27.8
= 99.8 tonf

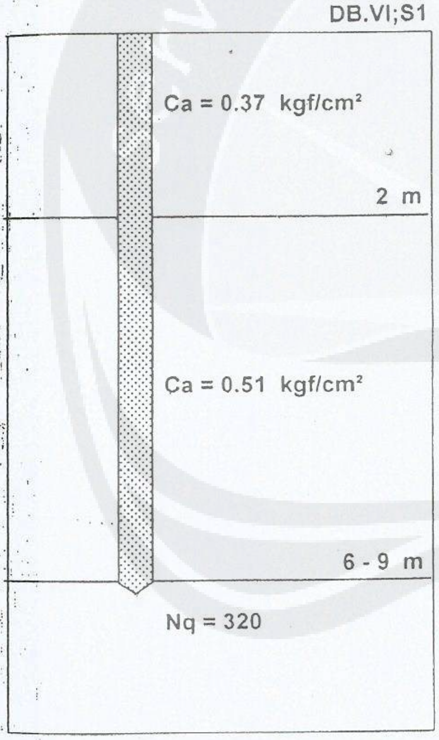
$\bar{P}_{1\ TIANG\ AXIAL\ TEKAN} = \dfrac{99.8}{2.5} =$ **39.9** tonf

$\bar{P}_{1\ TIANG\ AXIAL\ TARIK} = \dfrac{27.8}{2.5} =$ **11.1** tonf

PERHITUNGAN DAYA DUKUNG TIANG

Proyek : PERUMAHAN CLUSTER FLAMINGGO 2 & 3 LANTAI
Lokasi : SUMMARECON , SERPONG - TANGERANG.

DB.VI;S1



Pondasi Tiang Pancang (Jack in pile)

Penampang 中 = 30 - 35 cm
Panjang Tiang L = 6 - 9 m

A_b =	900 cm^2	O =	120 cm
=	1225 cm^2	=	140 cm

<u>Berezantsev :</u>

中 = 30 cm

P_u = 0.09 x (0.6 x 6 x 320) + 1.2 (2 x 3.7 + 4 x 5.1)

= 103.7 + 33.36
= 137.0 tonf

$\bar{P}_{1\ \text{TIANG AXIAL TEKAN}} = \frac{137.0}{2.5} =$ **54.8** tonf

$\bar{P}_{1\ \text{TIANG AXIAL TARIK}} = \frac{33.36}{2.5} =$ **13.3** tonf

中 = 35 cm

P_u = 0.1225 x (0.6 x 6 x 320) + 1.4 (2 x 3.7 + 4 x 5.1)

= 141.1 + 38.92
= 180.0 tonf

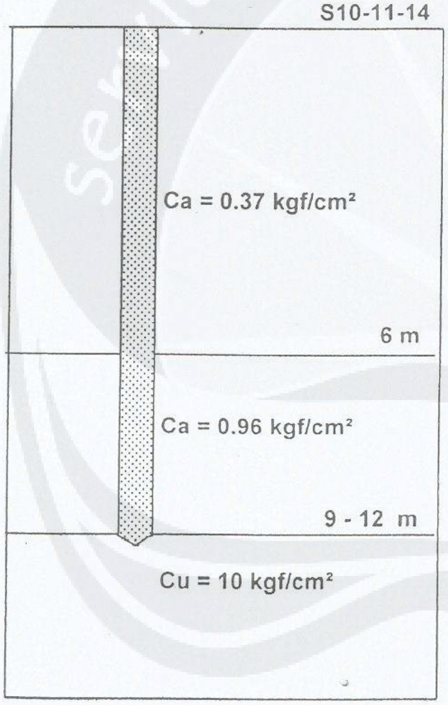
$\bar{P}_{1\ \text{TIANG AXIAL TEKAN}} = \frac{180.0}{2.5} =$ **72.0** tonf

$\bar{P}_{1\ \text{TIANG AXIAL TARIK}} = \frac{38.92}{2.5} =$ **15.6** tonf

PERHITUNGAN DAYA DUKUNG TIANG

Proyek : PERUMAHAN CLUSTER FLAMINGGO 2 & 3 LANTAI
Lokasi : SUMMARECON , SERPONG - TANGERANG.

S10-11-14



Pondasi Tiang Pancang (Jack in pile)

Penampang 中 = 20 - 25 cm
Panjang Tiang L = 9 - 12 m

A_b = 400 cm^2 ; O = 80 cm
A_b = 625 cm^2 ; O = 100 cm

中 = 20 cm

P_u = 9 x 10 x 400 + 80 (600 x 0.37 + 300 x 0.96)

= 36000 + 40800
= 76800 kg

$\bar{P}_{1\ \text{TIANG AXIAL TEKAN}} = \dfrac{76.80}{2.5} =$ **30.7** tonf

$\bar{P}_{1\ \text{TIANG AXIAL TARIK}} = \dfrac{40.80}{2.5} =$ **16.3** tonf

中 = 25 cm

P_u = 9 x 10 x 625 + 100 (600 x 0.37 + 300 x 0.96)

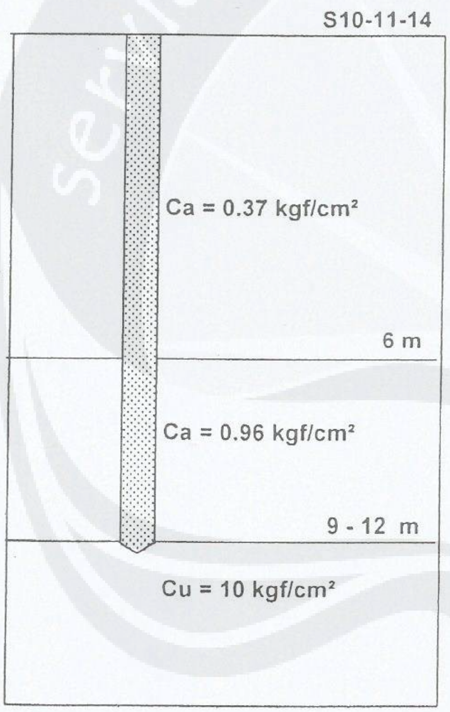
= 56250 + 51000
= 107250 kg

$\bar{P}_{1\ \text{TIANG AXIAL TEKAN}} = \dfrac{107.25}{2.5} =$ **42.9** tonf

$\bar{P}_{1\ \text{TIANG AXIAL TARIK}} = \dfrac{51.00}{2.5} =$ **20.4** tonf

PERHITUNGAN DAYA DUKUNG TIANG

Proyek : PERUMAHAN CLUSTER FLAMINGGO 2 & 3 LANTAI
Lokasi : SUMMARECON , SERPONG - TANGERANG.



Pondasi Tiang Pancang (Jack in pile)

Penampang ϕ = 30 - 35 cm
Panjang Tiang L = 9 - 12 m

A_b = 900 cm^2 ; O = 120 cm
A_b = 1225 cm^2 ; O = 140 cm

ϕ = 30 cm

P_u = 9 x 10 x 900 + 120 (600 x 0.37 + 300 x 0.96)

= 81000 + 61200
= 142200 kg

$\bar{P}_{1\ TIANG\ AXIAL\ TEKAN} = \frac{142.20}{2.5}$ = **56.9** tonf

$\bar{P}_{1\ TIANG\ AXIAL\ TARIK} = \frac{61.20}{2.5}$ = **24.5** tonf

ϕ = 35 cm

P_u = 9 x 10 x 1225 + 140 (600 x 0.37 + 300 x 0.96)

= 110250 + 71400
= 181650 kg

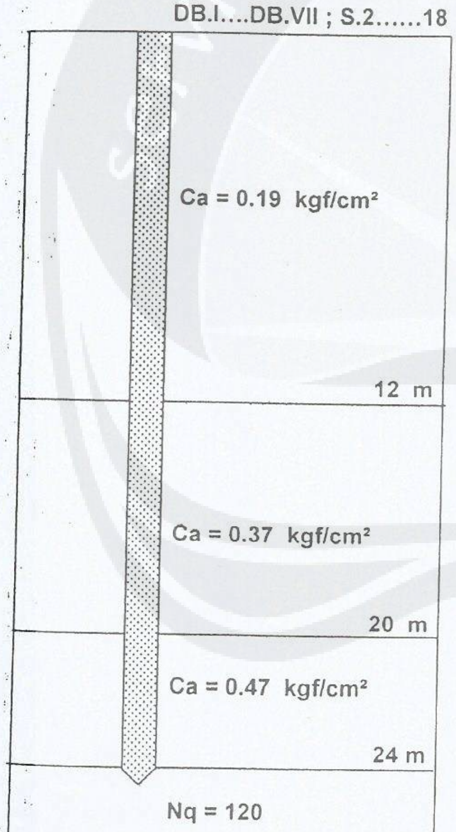
$\bar{P}_{1\ TIANG\ AXIAL\ TEKAN} = \frac{181.65}{2.5}$ = 72.7 tonf

$\bar{P}_{1\ TIANG\ AXIAL\ TARIK} = \frac{71.40}{2.5}$ = 28.6 tonf

PERHITUNGAN DAYA DUKUNG TIANG

Proyek : PERUMAHAN CLUSTER FLAMINGGO 2 & 3 LANTAI
Lokasi : SUMMARECON , SERPONG - TANGERANG.

DB.I....DB.VII ; S.2......18



Pondasi Tiang Pancang (Jack in pile)

Penampang ф = 20 - 25 cm
Panjang Tiang L = 24 m

A_b = 400 cm^2 O = 80 cm
A_b = 625 cm^2 O = 100 cm

<u>Berezantsev :</u>

ф = 20 cm

P_u = 0.04 x (0.5 x 24 x 120) + 0.8 (12 x 1.9 + 8 x 3.7 + 4 x 4.7)

= 57.6 + 56.96
= 114.6 tonf

$\bar{P}_{1\ TIANG\ AXIAL\ TEKAN} = \frac{114.6}{2.5} = 45.8$ tonf

$\bar{P}_{1\ TIANG\ AXIAL\ TARIK} = \frac{56.96}{2.5} = 22.8$ tonf

ф = 25 cm

P_u = 0.0625 x (0.5 x 24 x 120) + 1 (12 x 1.9 + 8 x 3.7 + 4 x 4.7)

= 90.0 + 71.2
= 161.2 tonf

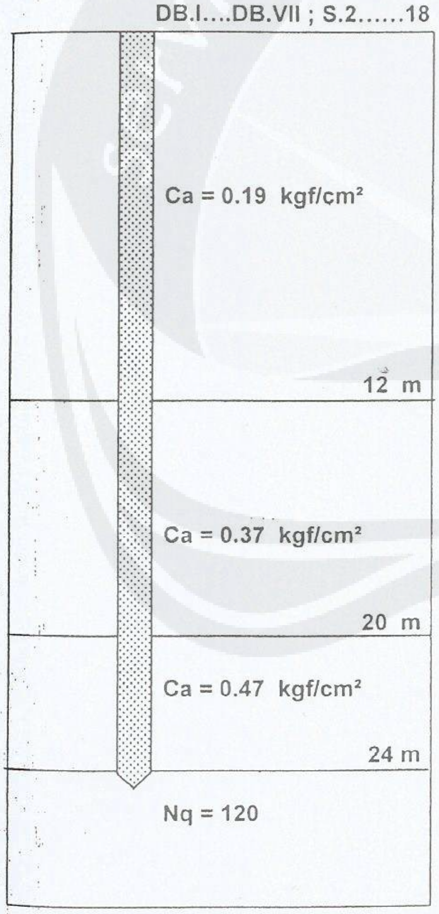
$\bar{P}_{1\ TIANG\ AXIAL\ TEKAN} = \frac{161.2}{2.5} = 64.5$ tonf

$\bar{P}_{1\ TIANG\ AXIAL\ TARIK} = \frac{71.2}{2.5} = 28.5$ tonf

PERHITUNGAN DAYA DUKUNG TIANG

Proyek : PERUMAHAN CLUSTER FLAMINGGO 2 & 3 LANTAI
Lokasi : SUMMARECON , SERPONG - TANGERANG.

DB.I....DB.VII ; S.2......18



Pondasi Tiang Pancang (Jack in pile)

Penampang ⌀ = 30 - 35 cm
Panjang Tiang L = 24 m

A_b = 900 cm^2 O = 120 cm
A_b = 1225 cm^2 O = 140 cm

<u>Berezantsev :</u>

⌀ = 30 cm

P_u = 0.09 x (0.5 x 24 x 120) + 1.2 (12 x 1.9 + 8 x 3.7 + 4 x 4.7)

= 129.6 + 85.44
= 215.0 tonf

$\bar{P}_{1\ \text{TIANG AXIAL TEKAN}} = \frac{215.0}{2.5} = 86.0$ tonf

$\bar{P}_{1\ \text{TIANG AXIAL TARIK}} = \frac{85.44}{2.5} = 34.2$ tonf

⌀ = 35 cm

P_u = 0.1225 x (0.5 x 24 x 120) + 1.4 (12 x 1.9 + 8 x 3.7 + 4 x 4.7)

= 176.4 + 99.68
= 276.1 tonf

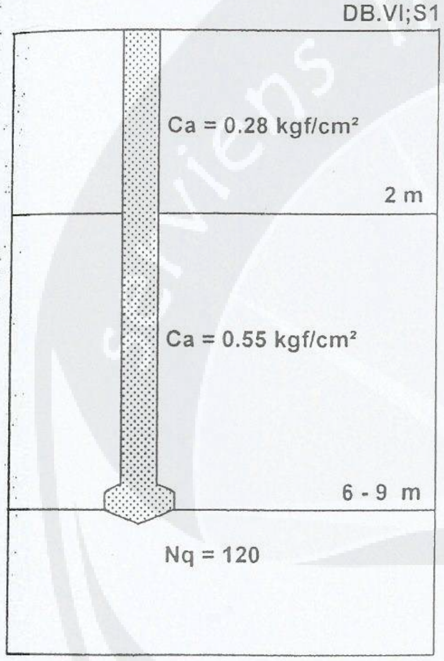
$\bar{P}_{1\ \text{TIANG AXIAL TEKAN}} = \frac{276.1}{2.5} = 110.4$ tonf

$\bar{P}_{1\ \text{TIANG AXIAL TARIK}} = \frac{99.68}{2.5} = 39.9$ tonf

PERHITUNGAN DAYA DUKUNG TIANG

Proyek : PERUMAHAN CLUSTER FLAMINGGO 2 & 3 LANTAI
Lokasi : SUMMARECON , SERPONG - TANGERANG.

DB.VI;S1



Pondasi Tiang Bor Bell Bottom

Diameter Φs = 30 - 50 cm ; Φb = 50 - 70 cm
Panjang Tiang L = 6 - 9 m

A_b = 1963 cm^2 O = 94 cm
A_b = 2827 cm^2 O = 126 cm
A_b = 3848 cm^2 O = 157 cm

<u>Berezantsev :</u>

Φs = 30 cm ; Φb = 50 cm

P_u = 0.1963 x (0.6 x 6 x 120) + 0.94 (2 x 2.8 + 4 x 5.5 + 0 x 0)
= 84.80 + 25.94
= 110.75 tonf

$\bar{P}_{1\ \text{TIANG AXIAL TEKAN}} = \frac{110.75}{2.5}$ = **44.3** tonf

$\bar{P}_{1\ \text{TIANG AXIAL TARIK}} = \frac{43.33}{2.5}$ = **17.3** tonf

Φs = 40 cm ; Φb = 60 cm

P_u = 0.2827 x (0.6 x 6 x 120) + 1.26 (2 x 2.8 + 4 x 5.5 + 0 x 0)
= 122.13 + 34.78
= 156.90 tonf

$\bar{P}_{1\ \text{TIANG AXIAL TEKAN}} = \frac{156.90}{2.5}$ = **62.8** tonf

$\bar{P}_{1\ \text{TIANG AXIAL TARIK}} = \frac{51.89}{2.5}$ = **20.8** tonf

Φs = 50 cm ; Φb = 70 cm

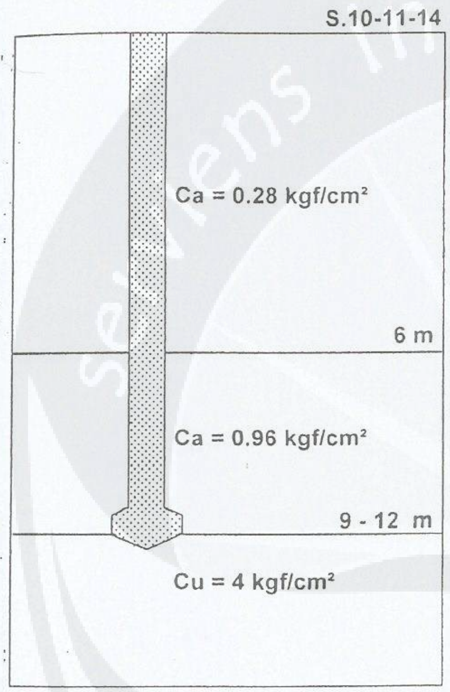
P_u = 0.3848 x (0.6 x 6 x 120) + 1.57 (2 x 2.8 + 4 x 5.5 + 0 x 0)
= 166.23 + 43.33
= 209.57 tonf

$\bar{P}_{1\ \text{TIANG AXIAL TEKAN}} = \frac{209.57}{2.5}$ = **83.8** tonf

$\bar{P}_{1\ \text{TIANG AXIAL TARIK}} = \frac{60.72}{2.5}$ = **24.3** tonf

PERHITUNGAN DAYA DUKUNG TIANG

Proyek : PERUMAHAN CLUSTER FLAMINGGO 2 & 3 LANTAI
Lokasi : SUMMARECON , SERPONG - TANGERANG.



Pondasi Tiang Bor Bell Bottom

Diameter Φs = 30 - 50 cm ; Φb = 50 - 70 cm
Panjang Tiang L = 9 - 12 m

A_b =	1963 cm^2	O =	94 cm
A_b =	2827 cm^2	O =	126 cm
A_b =	3848 cm^2	O =	157 cm

Φs = 30 cm ; Φb = 50 cm

P_u = 1 x 9 x 4 x 1963 + 94 (600 x 0.28 + 300 x 0.96)

= 70668 + 42864
= 113532 kg

$$\bar{P}_{1\ \text{TIANG AXIAL TEKAN}} = \frac{113.53}{2.5} = \mathbf{45.4}\ \text{tonf}$$

$$\bar{P}_{1\ \text{TIANG AXIAL TARIK}} = \frac{71.59}{2.5} = \mathbf{28.6}\ \text{tonf}$$

Φs = 40 cm ; Φb = 60 cm

P_u = 1 x 9 x 4 x 2827 + 126 (600 x 0.28 + 300 x 0.96)

= 101772 + 57456
= 159228 kg

$$\bar{P}_{1\ \text{TIANG AXIAL TEKAN}} = \frac{159.23}{2.5} = \mathbf{63.7}\ \text{tonf}$$

$$\bar{P}_{1\ \text{TIANG AXIAL TARIK}} = \frac{85.73}{2.5} = \mathbf{34.3}\ \text{tonf}$$

Φs = 50 cm ; Φb = 70 cm

P_u = 1 x 9 x 4 x 3848 + 157 (600 x 0.28 + 300 x 0.96)

= 138528 + 71592
= 210120 kg

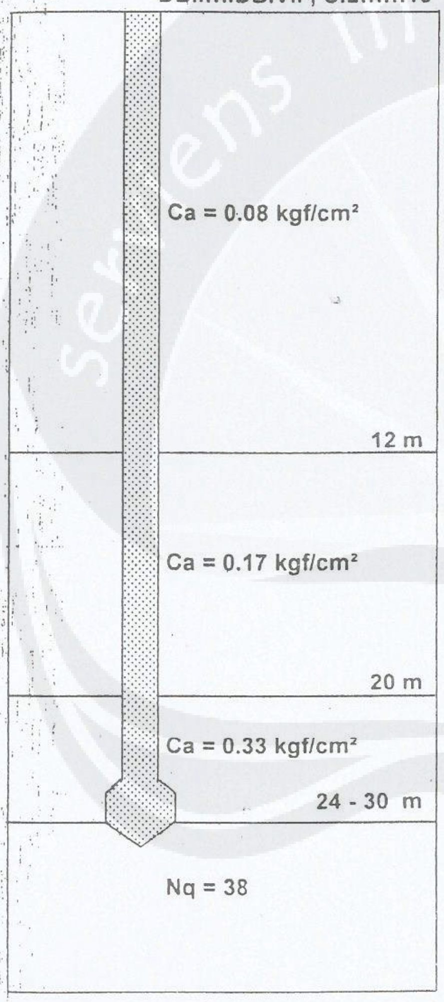
$$\bar{P}_{1\ \text{TIANG AXIAL TEKAN}} = \frac{210.12}{2.5} = \mathbf{84.0}\ \text{tonf}$$

$$\bar{P}_{1\ \text{TIANG AXIAL TARIK}} = \frac{100.32}{2.5} = \mathbf{40.1}\ \text{tonf}$$

PERHITUNGAN DAYA DUKUNG TIANG

Proyek : PERUMAHAN CLUSTER FLAMINGGO 2 & 3 LANTAI
Lokasi : SUMMARECON , SERPONG - TANGERANG.

DB.I....DB.VII ; S.2......18



Pondasi Tiang Bor Bell Bottom

Diameter Φs = 30 - 50 cm ; Φb = 50 - 70 cm
Panjang Tiang L = 24 - 30 m

A_b =	1963 cm^2	O = 94 cm
A_b =	2827 cm^2	O = 126 cm
A_b =	3848 cm^2	O = 157 cm

<u>Berezantsev :</u>

Φs = 30 cm ; Φb = 50 cm

P_u = 0.1963 x (0.5 x 24 x 38) + 0.94 (12 x 0.8 + 8 x 1.7 + 4 x 3.3)
= 89.51 + 34.22
= 123.73 tonf

$\bar{P}_{1\ \text{TIANG AXIAL TEKAN}} = \dfrac{123.73}{2.5} = \mathbf{49.5}$ tonf

$\bar{P}_{1\ \text{TIANG AXIAL TARIK}} = \dfrac{57.15}{2.5} = \mathbf{22.9}$ tonf

Φs = 40 cm ; Φb = 60 cm

P_u = 0.2827 x (0.5 x 24 x 38) + 1.26 (12 x 0.8 + 8 x 1.7 + 4 x 3.3)
= 128.91 + 45.86
= 174.78 tonf

$\bar{P}_{1\ \text{TIANG AXIAL TEKAN}} = \dfrac{174.78}{2.5} = \mathbf{69.9}$ tonf

$\bar{P}_{1\ \text{TIANG AXIAL TARIK}} = \dfrac{68.43}{2.5} = \mathbf{27.4}$ tonf

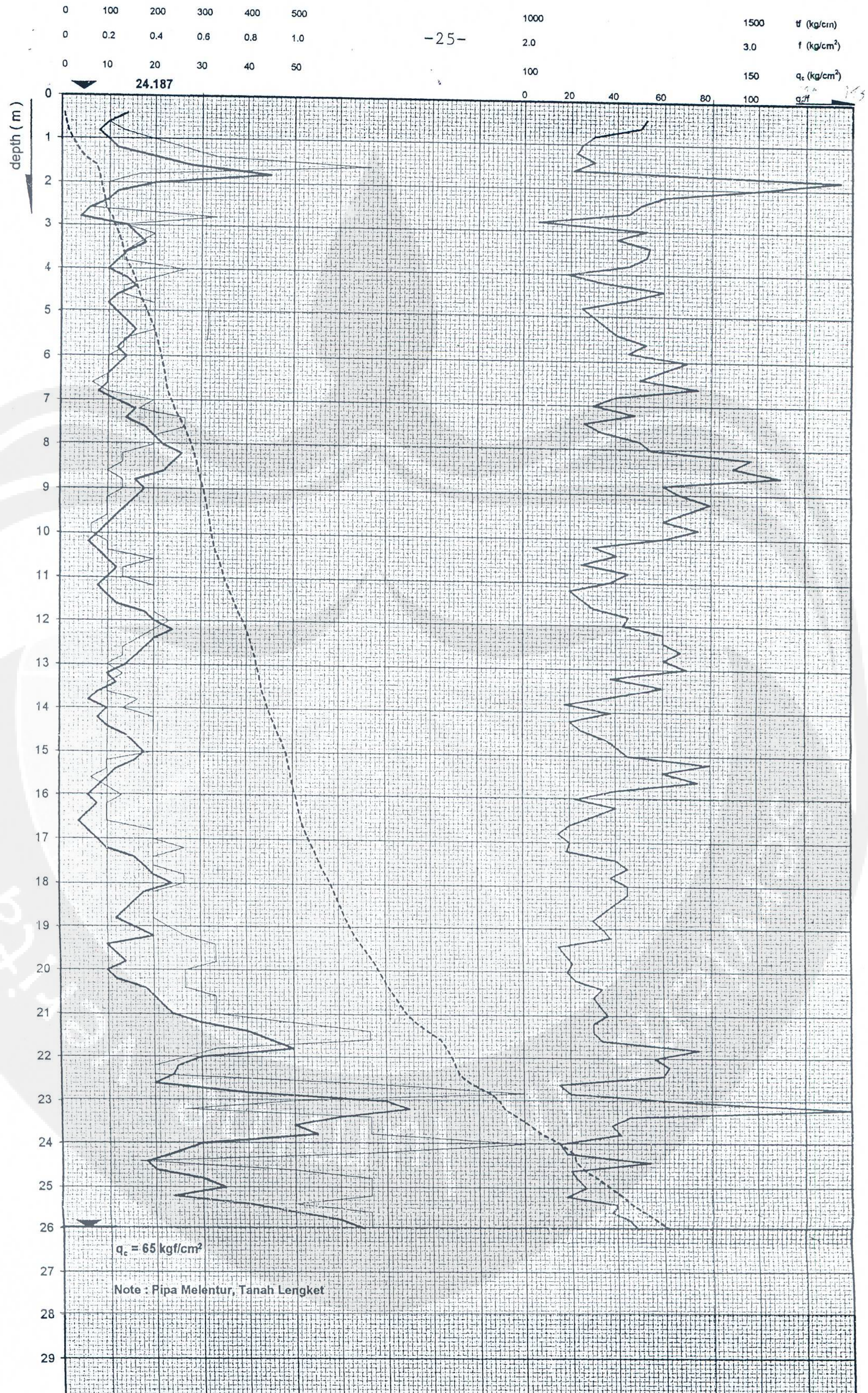
Φs = 50 cm ; Φb = 70 cm

P_u = 0.3848 x (0.5 x 24 x 38) + 1.57 (12 x 0.8 + 8 x 1.7 + 4 x 3.3)
= 175.47 + 57.15
= 232.62 tonf

$\bar{P}_{1\ \text{TIANG AXIAL TEKAN}} = \dfrac{232.62}{2.5} = \mathbf{93.0}$ tonf

$\bar{P}_{1\ \text{TIANG AXIAL TARIK}} = \dfrac{80.08}{2.5} = \mathbf{32.0}$ tonf

LAYOUT SCALE	PROJECT : RUMAH TINGGAL 2 & 3 LT CLUSTER FLAMINGGO	LEGEND : ▼ : TITIK SONDIR (S) ⌖ : TITIK BOR DALAM (DB)
	LOCATION : SUMMARECON SERPONG TANGERANG	p.t. SOLEFOUND SAKTI soil mechanics and engineering consultans JAKARTA



PROJECT	RUMAH TINGGAL 2 & 3 LT CLUSTER FLAMINGGO	SOUNDING No 5	S_5
LOCATION	SUMMARECON SERPONG - TANGERANG	DATE of TEST	03 DES 2014

Raymond Hadianto, B.Eng., M.Eng.
IR. Soerjatmo Wreksoatmodjo (2003)

q_c ——— tf - - - - -
f ——— q_c/f ———

P.T. SOLEFOUND SAKTI
JAKARTA

LOCATION : SUMMARECON SERPONG - TANGERANG
HOLE : DB IV
DATE of TEST : 29 JANUARI - 01 PEBRUARI 2015

▼ 24.187

DEPTH (M)	LAYER THICKNESS (M)	ELEVATION (M)	SOIL CLASSIFICATION	q_p (kgf/cm^2)	SAMPLE ELEVATION (M)	SAMPLE SYMBOL	% RECOVERED	N VALUE EVERY 15 + 10 CM				N VALUE 30 CM
1			SILT, MH, coklat,merah,abu2, silt lempung dengan pasir halus konsistensi medium ÷ soft ÷ medium, aktivitas sedang.			Core	65					
2						Core	90					
					1.50	SPT	100	2	2	1	1	4
3						Core	70					
4				2.90		UDS	75					
					3.50	SPT	100	2	1	1	1	3
5						Core	70					
6						Core	100					
					5.50	SPT	100	2	2	1	1	4
7						Core	65					
	7.50	7.50										
8			SILT, MH, abu-abu, coklat, silt pasir halus dengan lempung sedikit organis, konsistensi medium ÷ soft ÷ medium, aktivitas aktive, kepekaan tidak peka.			Core	90					
					7.50	SPT	100	2	2	2	2	6
9						Core	70					
10				2.30		UDS	75					
					9.50	SPT	100	2	2	2	3	7
11						Core	70					
12						Core	90					
					11.50	SPT	100	3	4	2	2	8
13						Core	70					
14				2.00		UDS	83					
					13.50	SPT	100	1	1	1	1	3
15						Core	70					
16						Core	100					
	8.50	16.00			15.50	SPT	89	2	2	2	3	7
17			SILT, abu-abu, silt lempung dengan pasir halus, stiff.			Core	70					
18						Core	90					
					17.50	SPT	89	3	3	3	4	10
19						Core	70					
20						Core	90					
	4.00	20.00			19.50	SPT	100	3	3	3	3	9
21			SILT, MH, abu2, silt pasir halus dengan lempung, konsistensi medium, aktivitas aktive.			Core	70					
22				1.60		UDS	75					
					21.50	SPT	100	2	1	1	2	4
23						Core	70					
24						Core	90					
					23.50	SPT	100	2	2	2	2	6
25						Core	70					
26						Core	90					
					25.50	SPT	100	2	1	1	2	4
27						Core	70					
28				4.25		UDS	75					
					27.50	SPT	89	2	2	2	2	6
29						Core	70					
30						Core	100					
	10.00	30.00			29.50	SPT	100	2	3	3	2	8

N VALUE STANDARD PENETRATION TEST: 0 10 20 30 40 50 60 70 80

PT.SOLEFOUND SAKTI, JAKARTA

Raymond Harianto M.Eng.

UNDISTURBED SAMPLE
STANDARD PENETRATION TEST
CORE SAMPLE
DISTURBED SAMPLE

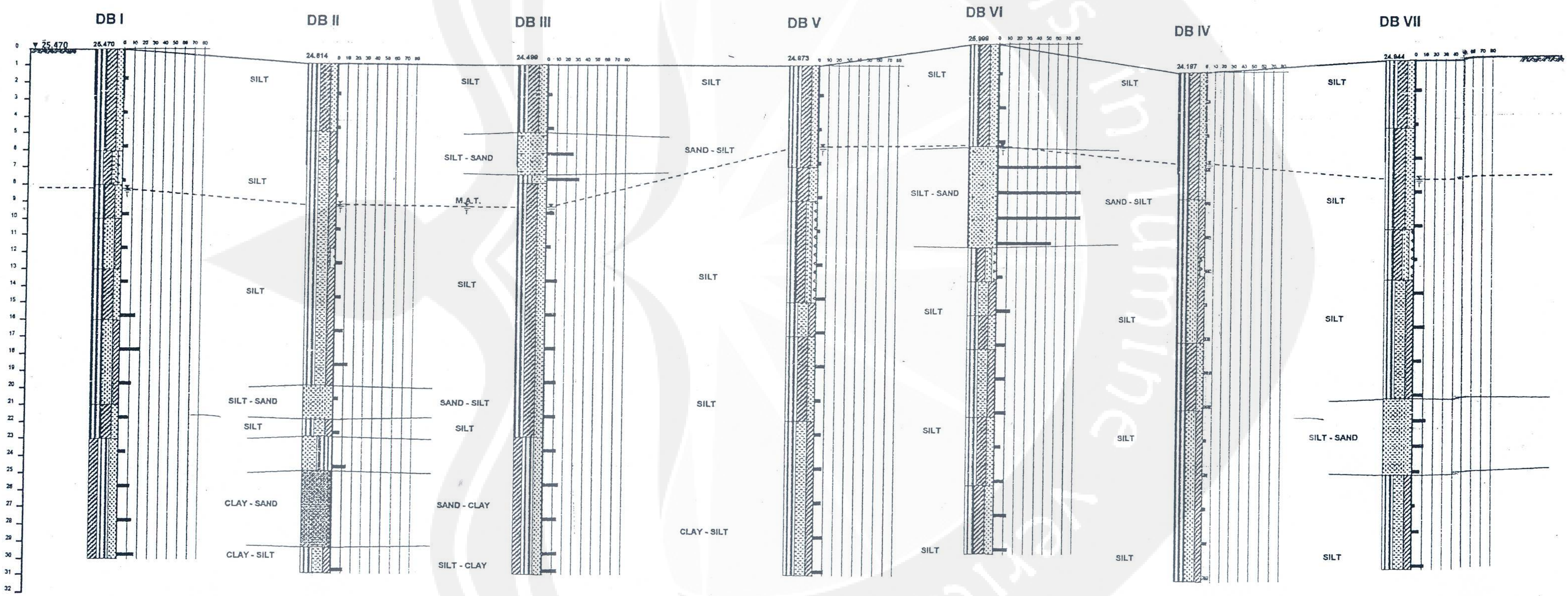
SILT
LEMPUNG
PASIR
CEMENTED
PUING
KEMBANG KARANG

KULIT KERANG
KARANG
ORGANIC
GUMPALAN CADAS
KERIKIL
KORAL

MUKA AIR TANAH = - 5.40 M

GEOLOGICAL PROFILE

PROJECT : RUMAH TINGGAL 2 & 3 LANTAI CLUSTER FLAMINGGO
LOCATION : SUMMARECON SERPONG - TANGERANG
SECTION : I - I



LIST OF RESULTS OF LABORATORY TESTING

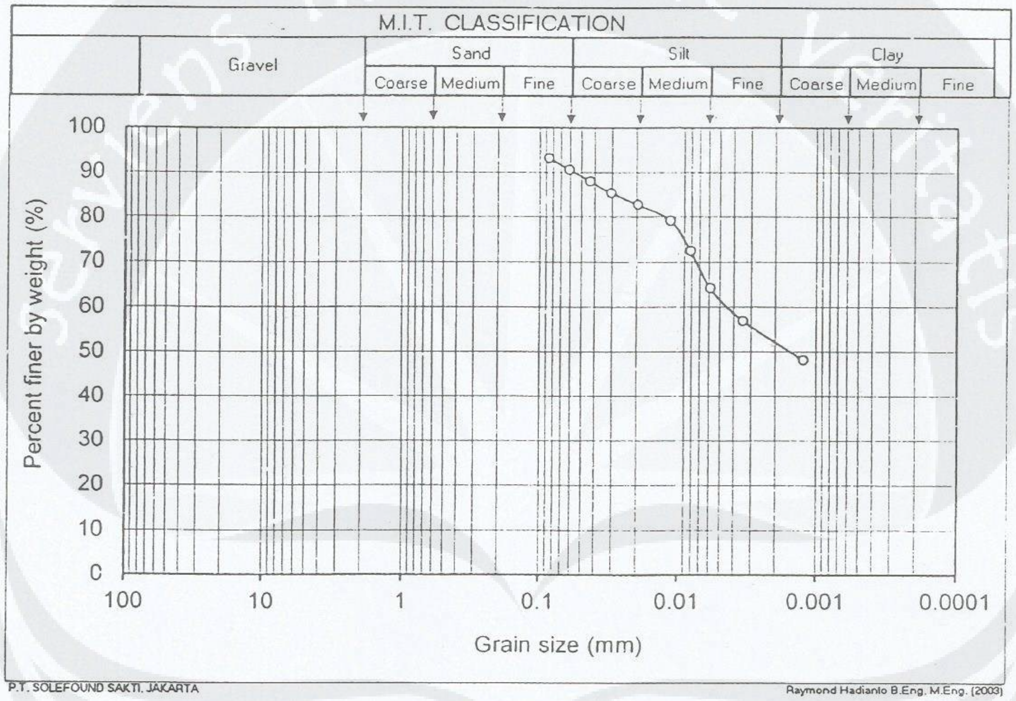
PROJECT: " RUMAH TINGGAL 2 LANTAI & 3 LANTAI CLUSTER FLAMINGGO " - SUMMARECON SERPONG - TANGERANG

BORING			INDEX PROPERTIES												ENGINEERING PROPERTIES								
								ANALYSIS CONSISTENCY							Swelling Potential	Swelling Pressure	COMPRESSIBILITY			SHEARING STRENGTH			
NO.	ELEVATION (M)	TYPE OF SOIL	G_s	γ_m (ton/m³)	e	S_r (%)	W_N (%)	SIEVE (%)	HIDRO (%)	W_L (%)	P.I (%)	L.I	W_S (%)	Activity	SP (%)	σ_{SP} (kgf/cm²)	C_c C_e	P_c (kgf/cm²)	O.C.R	C , C' (kN/m²)	ϕ , ϕ' (°)	q_{uu} (kgf/cm²)	S_t
DB IV	3.00 - 3.50	SILT,MH,coklat,abuabu,silt lempung dengan pasir halus,soft,aktivitas sedang	2.589	1.698	1.421	100.00	58.76	-	S=9.6 C=51.0	79.01 *68.06	42.81	0.53	38.15	0.84	19.23	-	-	-	-	C =34.0 C'=47.0	ϕ = 25.5 ϕ'= 30.5	-	-
	9.00 - 9.50	SILT,MH,abuabu,coklat,silt pasir halus dengan lempung ,konsistensi medium, kepekaan tidak peka	2.526	1.594	1.522	98.23	59.21	-	-	75.67	21.07	0.22	-	-	-	-	-	-	-	-	-	0.61	1.75
	13.00 - 13.50	SILT,MH,coklat,silt pasir halus dengan lempung, soft, aktivitas aktive, kepekaan tidak peka	2.588	1.708	1.334	100.00	54.00	-	S=36.3 C=14.0	72.54	21.92	0.15	-	1.57	-	-	-	-	-	-	-	0.36	1.48
	21.00 - 21.50	SILT,MH,abuabu,silt pasir halus dengan lempung, konsistensi medium	2.554	1.403	2.313	90.50	81.98	-	-	70.28	15.88	1.74	-	-	-	-	-	-	-	C =61.3	ϕ = 0.00	1.23	-
	27.00 - 27.50	SILT,MH,abuabu,silt pasir halus dengan lempung,konsistensi medium,aktivitas aktive	2.547	1.473	1.543	77.71	47.07	-	S=26.8 C=19.0	73.63	24.89	-0.07	-	1.31	-	-	0.063 0.006	3.68	1.73	C =46.9	ϕ = 0.00	0.94	-
DB V	5.00 - 5.50	SILT,MH,coklat,silt lempung dengan pasir halus, soft, aktivitas sedang	2.590	1.403	2.206	86.50	73.67	-	S=12.2 C=40.4	79.51 *69.27	36.31	0.84	38.05	0.90	11.11	-	-	-	-	C =23.0 C'=35.0	ϕ = 26.5 ϕ'= 32.5	-	-
	9.00 - 9.50	SILT,MH,abuabu,silt lempung dengan pasir halus dan organis,soft,kepekaan tidak peka	2.307	1.408	1.980	95.46	81.93	-	-	83.36	17.29	0.92	-	-	-	-	-	-	-	-	-	0.61	1.56
	15.00 - 15.50	SILT,MH,abuabu,silt pasir halus dengan lempung, stif,aktivitas aktive, kepekaan tidak peka	2.509	1.440	2.079	92.58	76.74	-	S=29.7 C=14.8	73.60	19.34	1.16	-	1.31	-	-	-	-	-	-	-	0.32	1.47
	21.00 - 21.50	SILT,MH,abuabu,silt pasir halus dengan lempung ,konsistensi medium	2.538	1.443	2.098	92.15	76.16	-	-	69.25	19.03	1.36	-	-	-	-	-	-	-	C =34.3	ϕ = 0.00	0.69	-
	25.00 - 25.50	SILT,MH,abuabu,silt pasir halus dengan lempung, konsistensi medium , aktivitas sedang	2.520	1.494	1.771	91.52	64.32	-	S=39.3 C=11.4	56.09	13.55	1.61	-	1.19	-	-	0.196 0.018	3.95	2.01	C =18.3	ϕ = 0.00	0.37	-
DB VI	1.00 - 1.50	SILT,MH,merah kecoklatan bintik putih, silt lempung dan pasir halus,soft, aktivitas sedang	2.588	1.553	1.464	84.55	47.81	-	S=28.9 C=39.9	91.04 *81.62	47.67	0.09	28.14	1.23	18.99	-	-	-	-	C =48.0 C'=55.0	ϕ = 22.0 ϕ'= 28.0	-	-
	13.00 - 13.50	SILT,MH,abuabu,coklat,silt lempung dengan pasir halus dan organis,konsist. medium,kepekaan tidak peka	2.389	1.198	3.424	85.08	121.96	-	-	138.44	40.58	0.59	-	-	-	-	-	-	-	-	-	0.46	1.34
	17.00 - 17.50	SILT,MH,abuabu,silt lempung dengan pasir halus, stiff,aktivitas tidak aktive, kepekaan tidak peka	2.522	1.408	2.193	90.02	78.26	-	S=17.4 C=29.3	72.94	21.31	1.25	-	0.73	-	-	-	-	-	-	-	0.44	1.37
	23.00 - 23.50	SILT,MH,abuabu,silt lempung dengan pasir halus, konsistensi medium	2.511	1.368	2.269	86.43	78.09	-	-	84.91	27.43	0.75	-	-	-	-	-	-	-	C =73.7	ϕ = 0.00	1.47	-
	27.00 - 27.50	SILT,MH,abuabu,silt lempung dan pasir halus, stiff, aktivitas sedang	2.527	1.475	1.775	88.20	61.95	-	S=25.9 C=23.9	69.09	24.57	0.71	-	1.05	-	-	0.051 0.006	3.50	1.37	C =49.0	ϕ = 0.00	0.98	-

*AFTER 24 HOURS DRIED IN THE OVEN

HIDROMETER ANALYSIS

PROJECT : RUMAH TINGGAL 2 & 3 LANTAI CLUSTER FLAMINGGO
LOCATION : SUMMARECON SERPONG - TANGERANG
BORING : DB IV
DEPTH : 3.00 - 3.50 M



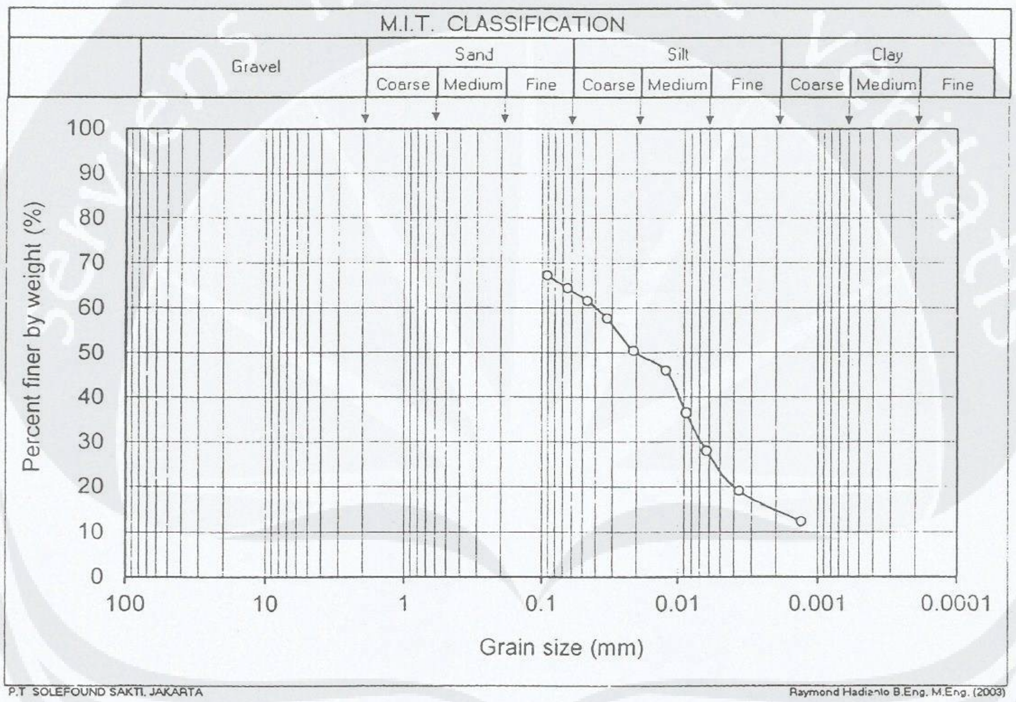
M.I.T. CLASSIFICATION									
Gravel	Sand			Silt			Clay		
	Coarse	Medium	Fine	Coarse	Medium	Fine	Coarse	Medium	Fine
			9.6%	7.5%	18.4%	13.5%	51.0%		
	9.6%			39.4%			51.0%		

D_{60}	0.0043 mm
D_{30}	
D_{10}	

C_u	
C_c	

HIDROMETER ANALYSIS

PROJECT : RUMAH TINGGAL 2 & 3 LANTAI CLUSTER FLAMINGGO
LOCATION : SUMMARECON SERPONG - TANGERANG
BORING : DB IV
DEPTH : 13.00 - 13.50 M



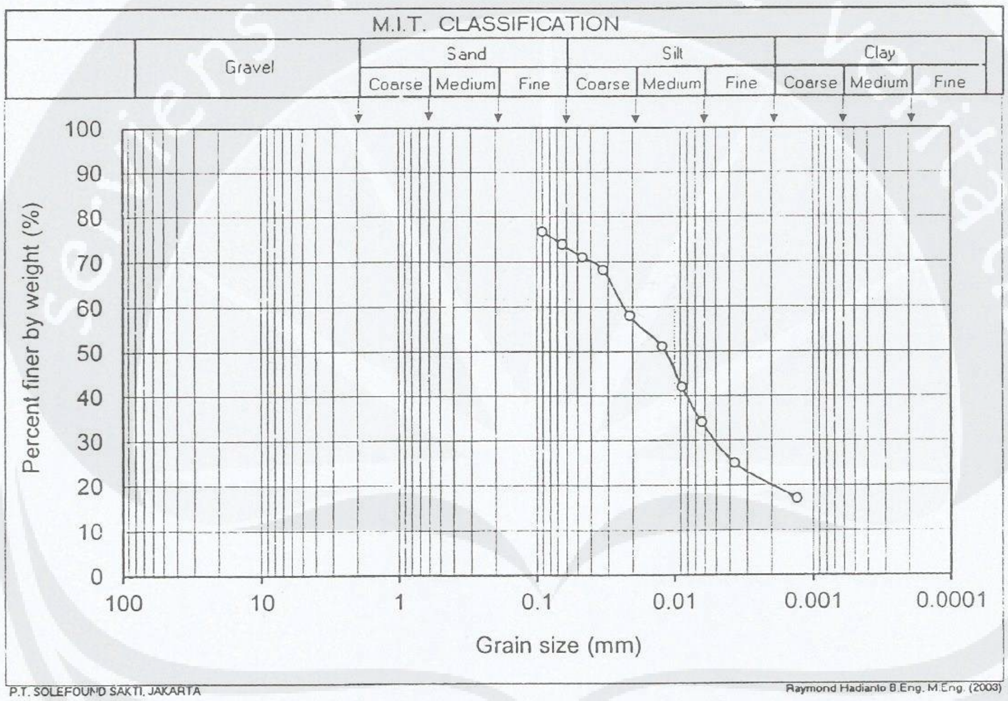
M.I.T. CLASSIFICATION									
Gravel	Sand			Silt			Clay		
	Coarse	Medium	Fine	Coarse	Medium	Fine	Coarse	Medium	Fine
			36.3%	13.8%	23.1%	12.8%	14.0%		
	36.3%			49.7%			14.0%		

D_{60}	0.0401 mm
D_{30}	0.0068 mm
D_{10}	

C_u	
C_c	

HIDROMETER ANALYSIS

PROJECT	:	RUMAH TINGGAL 2 & 3 LANTAI CLUSTER FLAMINGGO
LOCATION	:	SUMMARECON SERPONG - TANGERANG
BORING	:	DB IV
DEPTH	:	27.00 - 27.50 M



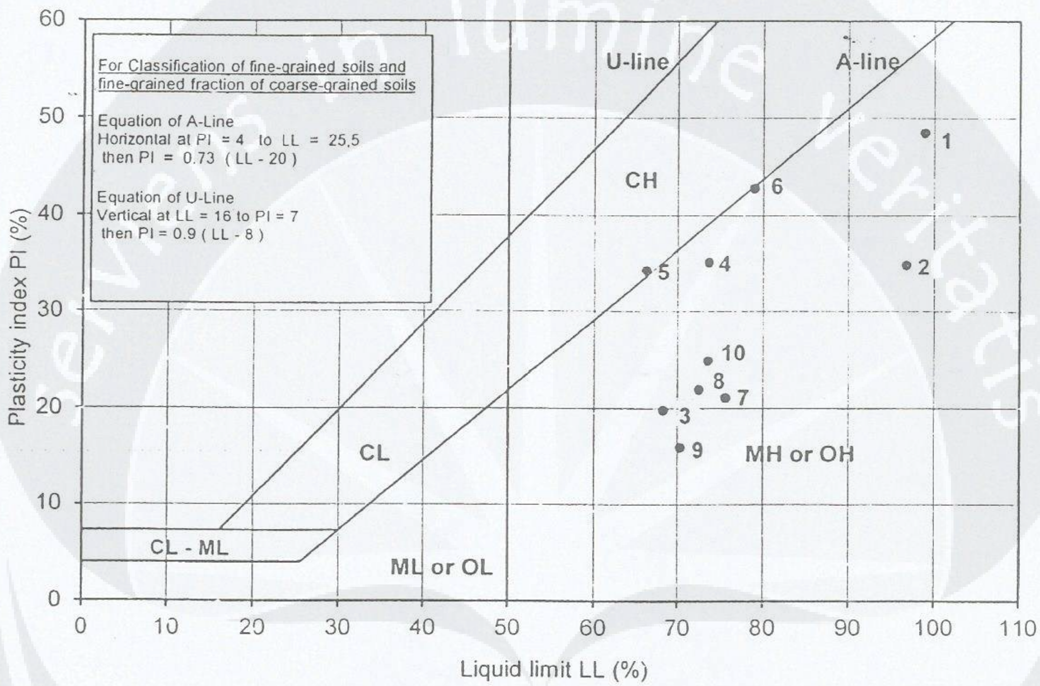
M.I.T. CLASSIFICATION									
Gravel	Sand			Silt			Clay		
	Coarse	Medium	Fine	Coarse	Medium	Fine	Coarse	Medium	Fine
			26.8%	16.1%	24.3%	13.8%	19.0%		
	26.8%			54.2%			19.0%		

D_{60}	0.0229 mm
D_{30}	0.0050 mm
D_{10}	

C_u	
C_c	

PLASTICITY CHART

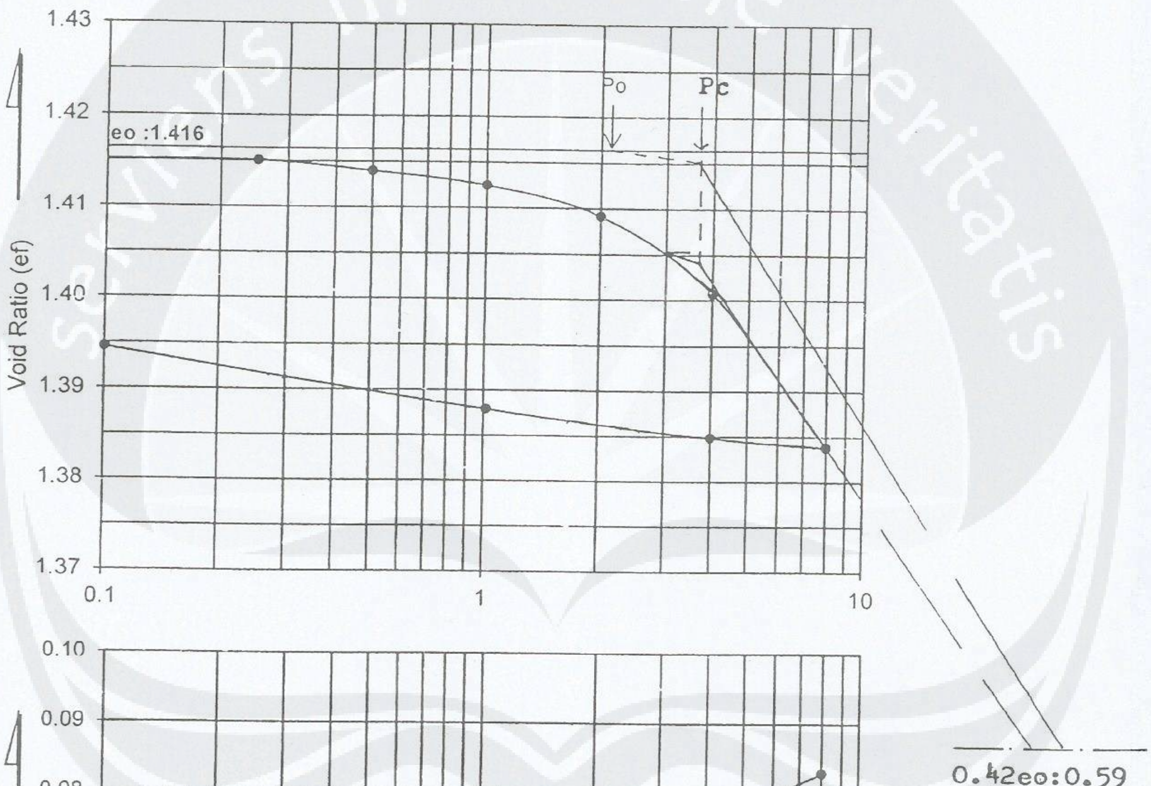
PROJECT : RUMAH TINGGAL 2 & 3 LANTAI CLUSTER FLAMINGGO
LOCATION: SUMMARECON SERPONG - TANGERANG

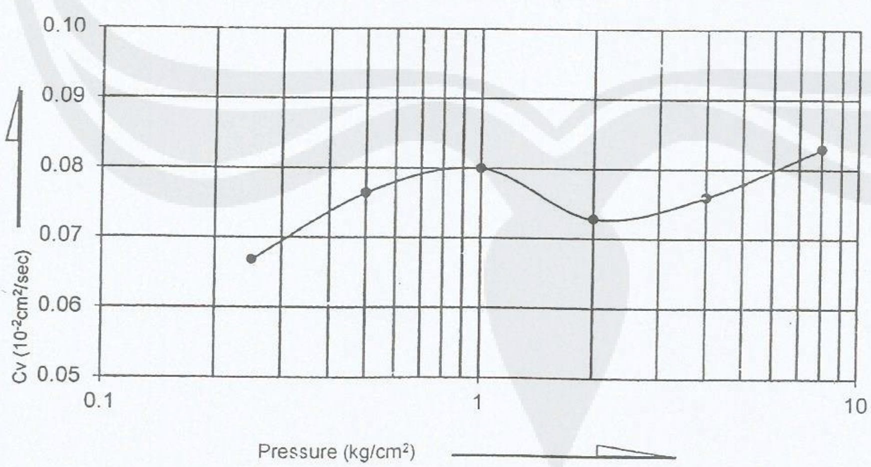


BORING (DB) III				BORING (DB) IV		
1.	1.00 - 1.50 M	(MH)	6.	3.00 - 3.50 M	(MH)
2.	8.00 - 8.50 M	(MH)	7.	9.00 - 9.50 M	(MH)
3.	12.00 - 12.50 M	(MH)	8.	13.00 - 13.50 M	(MH)
4.	18.00 - 18.50 M	(MH)	9.	21.00 - 21.50 M	(MH)
5.	22.00 - 22.50 M	(CH)	10.	27.00 - 27.50 M	(MH)

CONSOLIDATION TEST

PROJECT : RUMAH TINGGAL 2 & 3 LANTAI CLUSTER FLAMINGGO
LOCATION : SUMMARECON SERPONG - TANGERANG
BORING NO : DB IV
DEPTH : 27.00 - 27.50 M

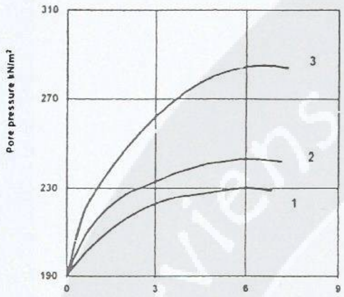


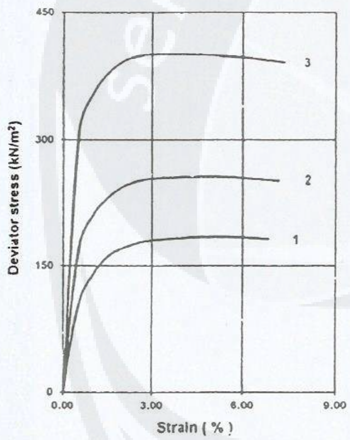


COMPRESSION CURVE				
C_c	C_e	P_c (kgf/cm^2)	O.C.R	W (%)
0.063	0.006	3.68	1.73	47.97%

TRIAXIAL TEST C.U

PROJECT : RUMAH TINGGAL CLUSTER FLAMINGGO
LOCATION : SUMMARECON SERPONG - TANGERANG
BORING No : DB IV
DEPTH : 3.00 - 3.50 M

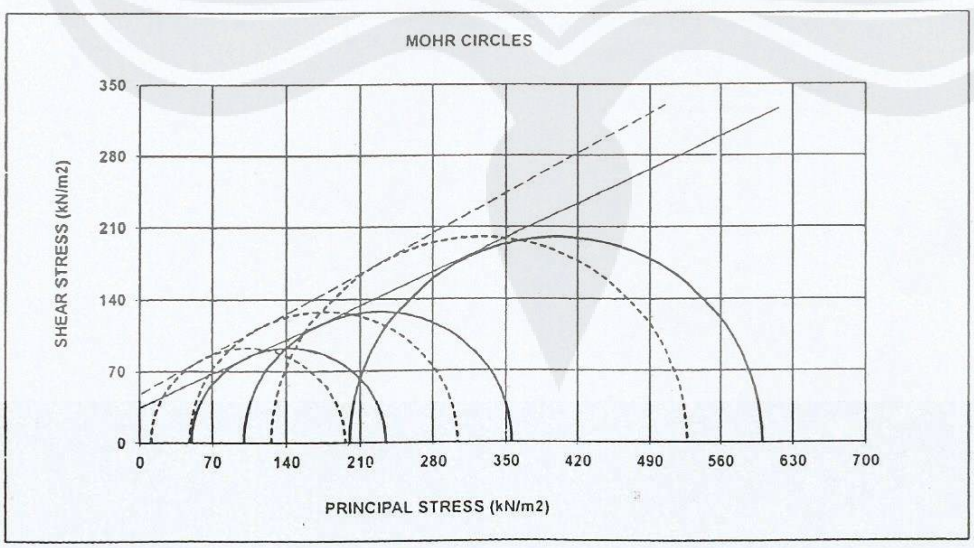




SPECIMEN			1	2	3
INITIAL	Wet density	Mg/m³	1.60		
	Moisture content	%	58		
	Dry density	Mg/m³	1.01		
CONSOLIDATION STAGE	Cell pressure	kN/m²	240	290	390
	Back pressure	kN/m²	190	190	190
	Initial pwp	kN/m²	230	265	360
	Final pwp	kN/m²	0	0	0
COMPRESSION STAGE	Cell pressure	kN/m²	240	290	390
	Initial pwp	kN/m²	190	190	190
	Initial σ'3	kN/m²	50	100	200
	Rate of strain	% / hour	4.1	4.1	4.1
FAILURE CONDITION	Strain	%	5.26	5.26	3.16
	σ1 - σ3	kN/m²	185	256	401
	U	kN/m²	229	242	264
	σ'3	kN/m²	11	48	126
	σ'1	kN/m²	196	304	527

STRENGTH PARAMETERS

C	kN/m²	34
ø	°	25.5
C'	kN/m²	47
ø'	°	30.5



CU - TRIAXIAL COMPRESSION TEST

PROJECT : RUMAH TINGGAL CLUSTER FLAMINGGO
LOCATION : SUMMARECON SERPONG - TANGERANG
BORING No : DB IV
DEPTH : 3.00 - 3.50 M

Sample type : UDS
Soil description : Lempung silt, coklat kuning
Sample no. : 1

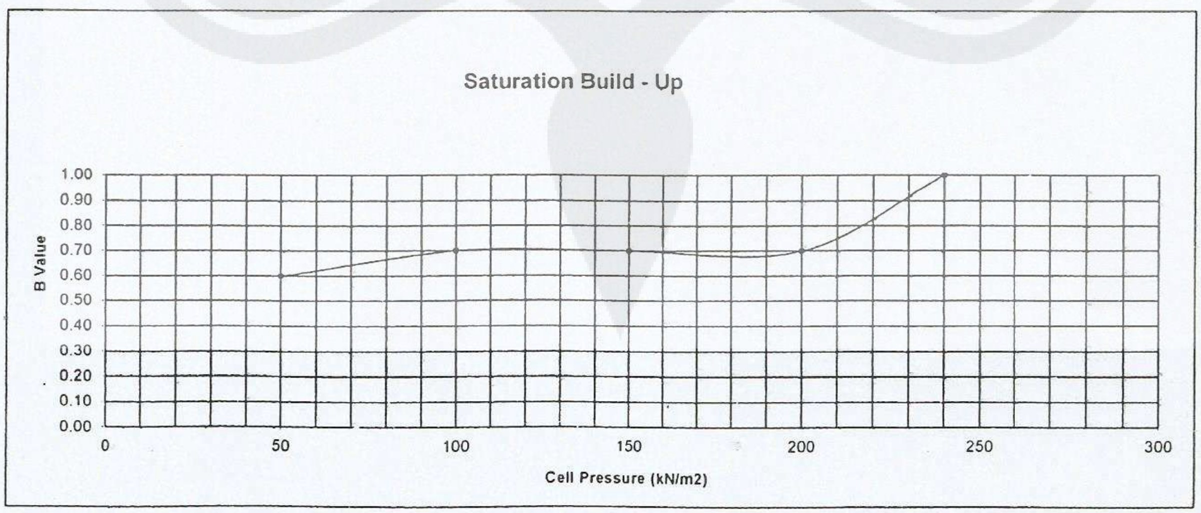
SPECIMEN

MEASUREMENT			
Length (mm)		Diameter (mm)	
76		38.0	
76		38.0	
76		38.0	
Mean *Lo*	76.0	Mean *Do*	38.0
INITIAL CONDITIONS			
Area, Ao		mm2	1134.11
Volume, Vo		cm3	86.19
Wet density		kg/cm^3	1.60
Moisture content		%	57.85
Dry density		kg/cm^3	1.01

WEIGHINGS		Specimen initially	Specimen after test
Container no		14	14
Weight of wet specimen + container	gr	144.59	142.36
Weight of dry specimen + container	gr	94.02	94.02
Weight of container	gr	6.61	6.61
Weight of wet soil		137.98	135.75
Weight of dry soil		87.41	87.41
Weight of water	gr	50.57	48.34
Moisture content	%	57.85	55.30

SATURATION

Cell pressure kN/m^2	Back pressure kN/m^2	Pore pressure kN/m^2	pwp difference kN/m^2	B value	Back pressure volume change before	after	diff.	Cell volume change LHS/ RHS before	after	diff	+ consol cm^3	- exp. cm^3
0	0	0										
50	-	30	30	0.60				19.0	21.0	2.0	2.0	
50	40	40			29.0	29.4	0.4					0.4
100	-	75	35	0.70				21.5	24.7	3.2	3.2	
100	90	90			29.4	29.9	0.5					0.5
150	-	125	35	0.70				25.0	27.5	2.5	2.5	
150	140	140			29.9	30.6	0.7					0.7
200	-	175	35	0.70				27.8	29.8	2.0	2.0	
200	190	190			30.6	31.5	0.9					0.9
240	-	230	40	1.00				30.0	21.5	-8.5	-8.5	
										Total	1.20	2.50



OLEFOUND SAKTI
hanics and engineering
JAKARTA

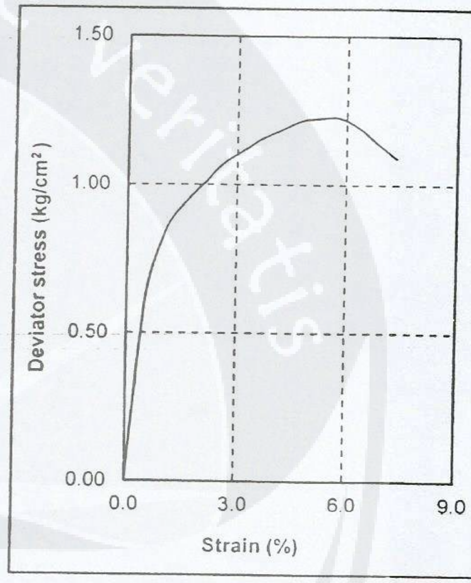
pt. SOLEFOUND SAKTI

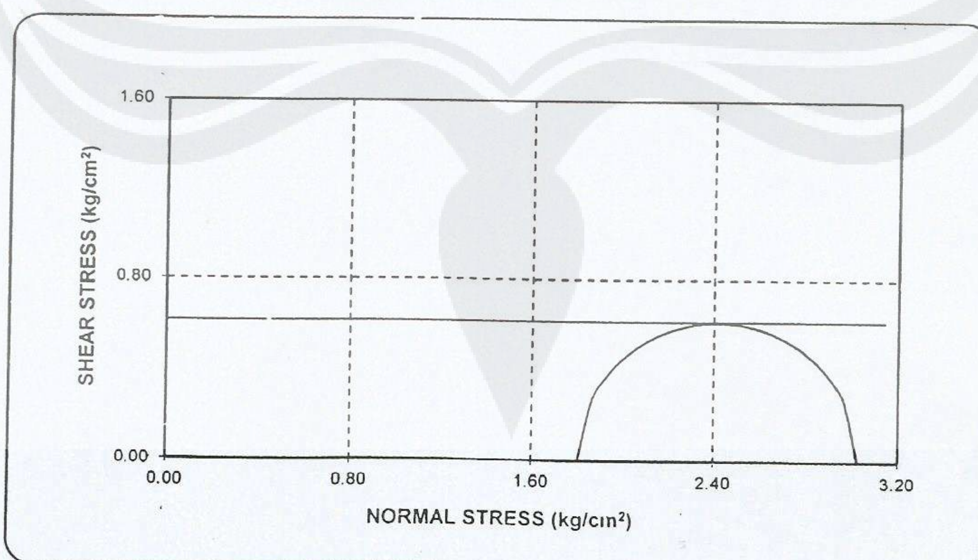
TRIAXIAL COMPRESSION TEST UU

PROJECT : RUMAH TINGGAL CLUSTER FLAMINGGO
LOCATION : SUMMARECON SERPONG - TANGERANG
BORING NO. : DB IV
DEPTH : 21.00 - 21.50 M

SPECIMEN DATA		
Number Of Specimen		1
Specimen Diameter	cm	3.800
Specimen Height	cm	7.600
Specimen Area	cm^2	11.335
Dial Gauge Subdevision	mm/div	0.001
Load Rate	kg/min	0.760
Load Ring Constant	kg/div	0.284
Lateral Pressure	kg/cm^2	1.800
Maximum Deviator Stress	kg/cm^2	1.226
Maximum Value Of Vertical Stress	kg/cm^2	3.026

C	0.613 kg/cm^2
Ø	0 °
quu	1.23 kg/cm^2
Wn	70.43 %





pt. SOLEFOUND SAKTI

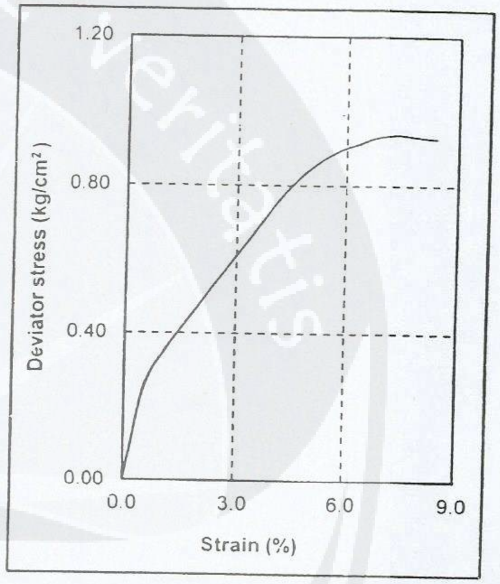
TRIAXIAL COMPRESSION TEST UU

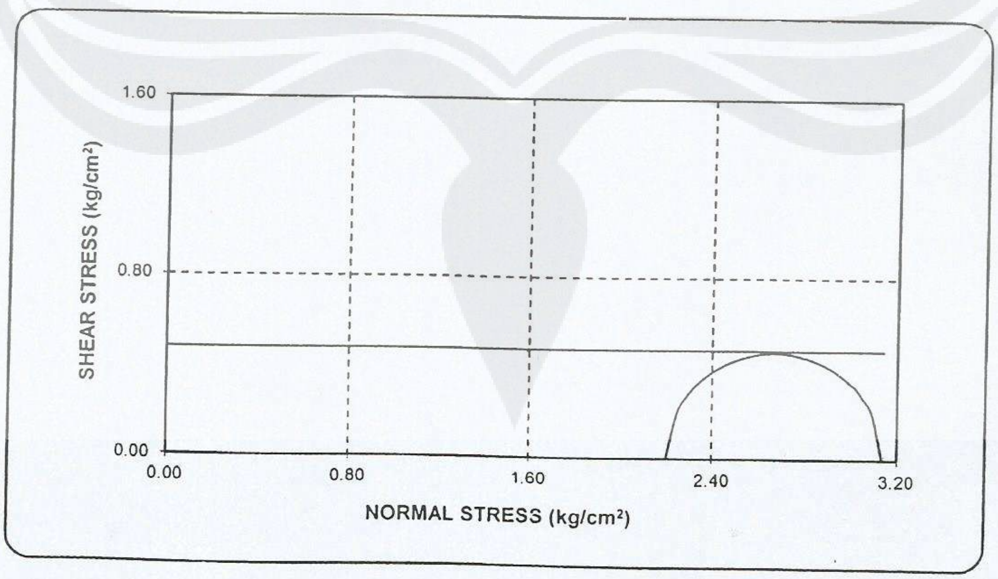
PROJECT : RUMAH TINGGAL CLUSTER FLAMINGGO
LOCATION : SUMMARECON SERPONG - TANGERANG
BORING NO. : DB IV
DEPTH : 27.00 - 27.50 M

-103

SPECIMEN DATA		
Number Of Specimen		1
Specimen Diameter	cm	3.800
Specimen Height	cm	7.600
Specimen Area	cm^2	11.335
Dial Gauge Subdevision	mm/div	0.001
Load Rate	kg/min	0.760
Load Ring Constant	kg/div	0.284
Lateral Pressure	kg/cm^2	2.200
Maximum Deviator Stress	kg/cm^2	0.939
Maximum Value Of Vertical Stress	kg/cm^2	3.139

C	0.469 kg/cm^2
Ø	0 °
quu	0.94 kg/cm^2
Wn	51.98 %

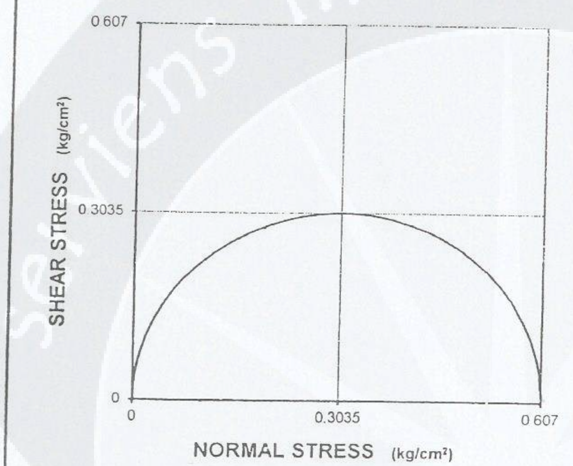




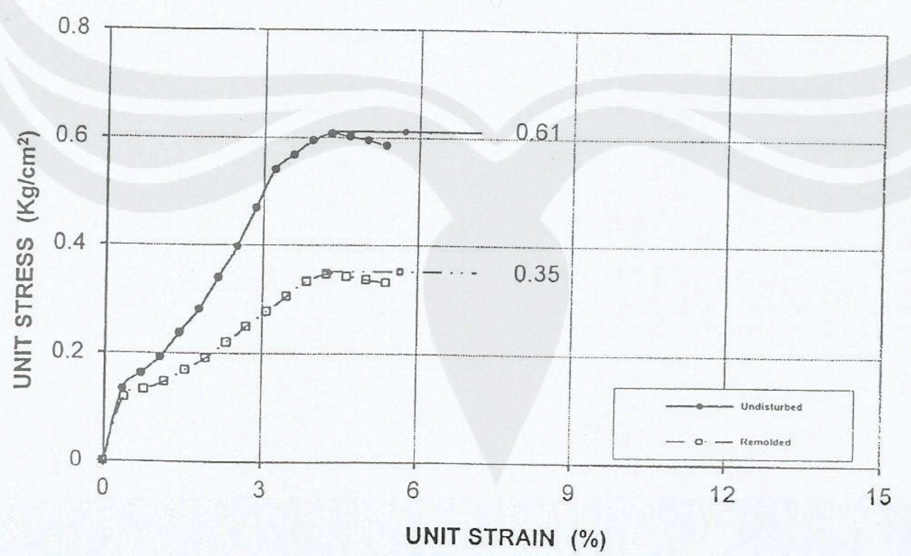
p.t. SOLEFOUND SAKTI
soil mechanics and engineering consultant
JAKARTA

UNCONFINED COMPRESSION TEST

PROJECT : RUMAH TINGGAL 2 & 3 LANTAI CLUSTER FLAMINGGO
LOCATION : SUMMARECON SERPONG - TANGERANG
BORING NO : DB IV
DEPTH : 9.00 - 9.50 M



UNDISTURBED	REMOLDED	SENSITIVITY
w(%)	w(%)	S_t
54.51%	53.46%	1.75

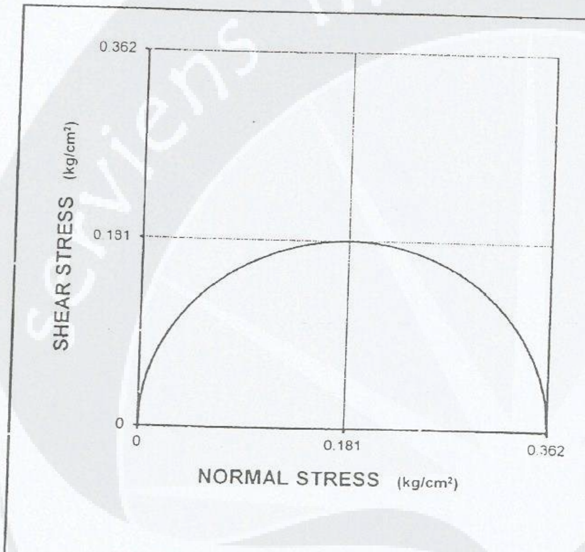


PT. SOLEFOUND SAKTI, JAKARTA

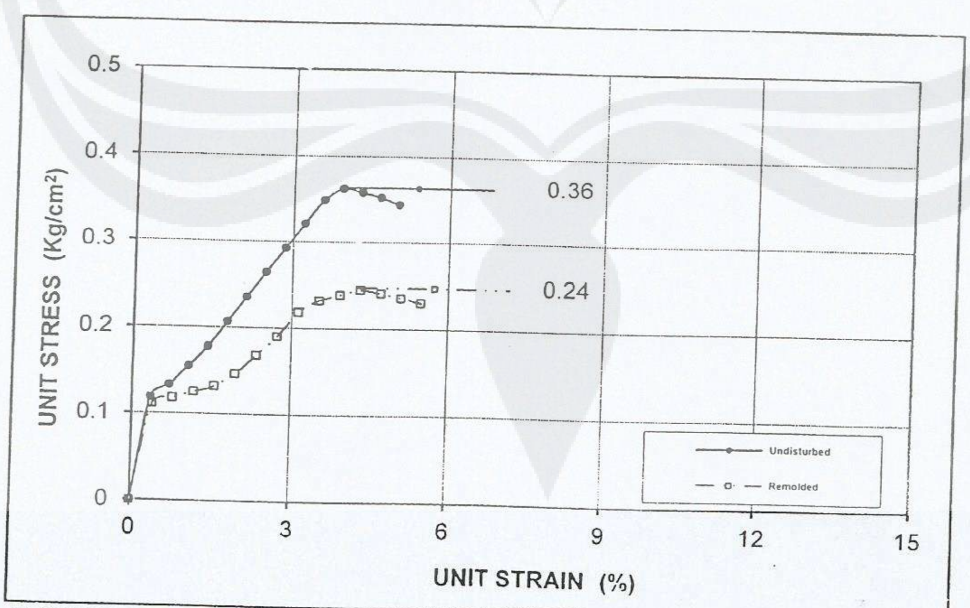
Raymond Hadianto M. Eng (2003)

UNCONFINED COMPRESSION TEST

PROJECT : RUMAH TINGGAL 2 & 3 LANTAI CLUSTER FLAMINGGO
LOCATION : SUMMARECON SERPONG - TANGERANG
BORING NO : DB IV
DEPTH : 13.00 - 13.50 M



UNDISTURBED	REMOLDED	SENSITIVITY
w(%)	w(%)	S_t
53.24%	48.98%	1.48



PT. SOLEFOUND SAKTI, JAKARTA

Raymond Hadianto M. Eng (2003)

LAMPIRAN II

2015

LAPORAN PELAKSANAAN PENGUJIAN DINAMIS PONDASI TIANG PANCANG SQUARE DENGAN METODA PILE DRIVING ANALYZER (PDA) TEST

Doc. No. 034/PDA-SS/TNG/III/2015

PROYEK PEMBANGUNAN CLUSTER FLAMINGO SUMMARECON
BERLOKASI DI KOMPLEK PERUMAHAN SUMMARECON
SERPONG – TANGERANG

KLIEN : PT. SUMMARECON SERPONG

PT. Geotesting Utama Engineering
Jl. Cendana 3 Blok S1 No. 27, Pondok Bahar, Karang Tengah, Tangerang
Telp/Fax : (021) 5574 2947 Email : geotestingutama@yahoo.com
16/03/2015

Jakarta, 16 Maret 2015

Kepada Yth. **PT. Summarecon Serpong**
Proyek Pembangunan Cluster Flamingo Summarecon
Komplek Perumahan Summarecon, Serpong – Tangerang

Dengan hormat,

Sesuai permintaan **PT. Summarecon Serpong**, bersama ini kami sampaikan hasil pengujian **Pondasi Tiang Pancang Square** dengan metode Pile Driving Analyzer (PDA Test) yang dilaksanakan pada **Proyek Pembangunan Cluster Flamingo Summarecon** yang berlokasi di **Komplek Perumahan Summarecon, Serpong – Tangerang.**

Hasil pengujian dari **Pondasi Tiang Pancang Square** dengan PDA kami sajikan dalam laporan ini. Kapasitas yang diperoleh dari pengujian PDA adalah kapasitas tiang tunggal; dalam menentukan kapasitas ijin tiang perlu diperhatikan faktor lainnya seperti variasi panjang tiang dan kondisi tanah, pengaruh kelompok tiang, kualitas pelaksanaan piling maupun gaya down-drag (jika ada). Hasil pengujian ini dapat mewakili pondasi lainnya yang dikerjakan dengan metode yang sama dan dalam kondisi tanah yang menyerupai.

Demikian hasil pengujian ini kami sajikan. Jika ada pertanyaan, dapat hubungi kami.

PT. Geotesting Utama Engineering

Didik Haryadi, ST
Direktur
(Certified PDA Engineer)

DAFTAR ISI

I. PENDAHULUAN

Sesuai permintaan **PT. Summarecon Serpong,** pada **tanggal 13 Maret 2015** telah kami laksanakan pengujian terhadap **Pondasi Tiang Pancang Square** dengan metode Pile Driving Analyzer (PDA) untuk **Proyek Pembangunan Cluster Flamingo Summarecon** yang berlokasi di **Komplek Perumahan Summarecon, Serpong – Tangerang.**

Tujuan pengujian PDA adalah untuk memperoleh kapasitas ultimate dari tiang.

II. PILE DRIVING ANALYZER (PDA)

Pile Driving Analyzer (PDA) adalah suatu sistem pengujian dengan menggunakan data digital komputer yang diperoleh dari strain transducer dan accelerometer untuk memperoleh kurva gaya dan kecepatan ketika tiang dipukul menggunakan palu dengan berat tertentu. Hasil dari pengujian PDA terdiri dari kapasitas tiang, penurunan, energi palu,dll.

Pada umumnya, pengujian dengan metode PDA dilaksanakan setelah tiang mempunyai kekuatan yang cukup untuk menahan tumbukan palu. Metode lain yang dapat digunakan untuk menahan tumbukan adalah dengan menggunakan cushion, merendahkan tinggi jatuh palu & menggunakan palu yang lebih berat.

II. 1. Data Tiang Uji

Data tiang uji disajikan dalam Tabel 1 dibawah ini:

No.	No. Tiang	Ukuran Tiang (cm)	Jenis Tiang	Panjang Total Tiang (m)	Panjang Tiang Dibawah Instrumen (m)	Panjang Tertanam (m)	Berat Hammer (ton)
1.	Jl. Flamingo Timur 6 Kav. 18 No. 129	□ 25 X 25	Square	24.00	23.60	23.35	1.0
2.	Jl. Flamingo Timur 5 Kav. 19 No. 357	□ 25 X 25	Square	24.00	23.60	23.35	1.0
3.	Jl. Flamingo Timur 5 Kav. 28 No. 188	□ 25 X 25	Square	24.00	23.55	23.35	1.0
4.	Jl. Flamingo Timur 3 Kav. 17 No. 461	□ 25 X 25	Square	24.00	23.50	23.30	1.0
5.	Jl. Flamingo Timur 3 Kav. 6 No. 28	□ 25 X 25	Square	24.00	23.55	23.35	1.0
6.	Jl. Flamingo Timur 2 Kav. S-3 No. 540	□ 25 X 25	Square	14.00	13.55	13.35	1.0
7.	Jl. Flamingo Timur 2 Kav. 28 No. 181	□ 25 X 25	Square	24.00	23.55	23.35	1.0
8.	Jl. Flamingo Timur 1 Kav. R-31 No. 353	□ 25 X 25	Square	24.00	23.55	23.35	1.0
9.	Jl. Flamingo Timur 1 Kav. 38 No. 271	□ 25 X 25	Square	8.00	7.55	7.35	1.0
10.	Jl. Flamingo Timur Kav. 09 No. 67	□ 25 X 25	Square	24.00	23.55	23.35	1.0

II. 2. Perlengkapan Pengujian PDA

- PDA-PAX
- Dua (2) strain transducer
- Dua (2) accelerometer
- Peralatan tambahan; antara lain bor tangan, gerinda, dan perlengkapan safety

II. 3. Metode Kerja

Pengujian PDA dilaksanakan berdasarkan ASTM D4945 - 96.

Pekerjaan persiapan dilaksanakan sebelum pengujian dilakukan. Persiapan ini antara lain :

- Kondisi kepala tiang sebaiknya rata, simetris dan tegak lurus.
- Pasang strain transducer dan accelerometer disisi tiang saling tegak lurus dengan jarak minimal 1.5 X Diameter (D) dari kepala tiang.
- Persiapkan palu dan cushion pada kepala tiang.
- Masukkan kalibrasi strain transducer dan accelerometer kemudian periksa konesitas peralatan pengujian secara keseluruhan.
- Masukkan data tiang dan palu dalam PDA PAK.
- Setelah semua tampak siap, selalu lakukan pengecekan ulang untuk memastikan pengujian telah siap dilaksanakan.

Sesudah persiapan, pengujian dilakukan dengan menjatuhkan palu ke kepala tiang hingga diperoleh energi yang cukup dan tegangan tidak terlampaui agar kepala tiang tidak rusak. Saat pemukulan, beberapa variable tiang uji termonitor, seperti kapasitas tiang, penurunan, maupun integritas tiang. Setelah pengujian PDA dilaksanakan, dilakukan analisa lebih lanjut dengan CAPWAP untuk memperoleh load transfer tiang dan perilaku tanah disekelilingnya, kapasitas friksi dan ujung tiang serta penurunan tiang.

III. MONITORING TIANG UJI

III. 1. Tegangan Material Tiang

Hasil **Pengujian PDA di Lapangan dan Analisa CAPWAP** untuk **Ke – Sepuluh** titik tersebut kami diskusikan dengan hasil selengkapnya dapat dilihat pada tabel dibawah ini.

Tegangan Tekan Maksimum dan Tegangan Tarik Maksimum Pada Tiang

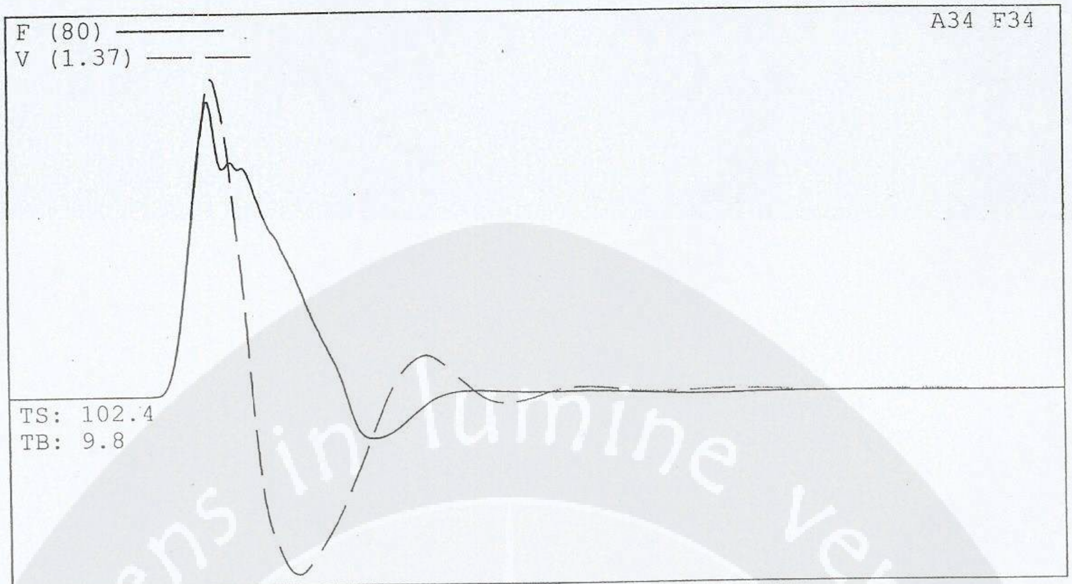
No.	No. Tiang	Tegangan Tekan Maksimum (Mpa)	Tegangan Tarik Maksimum (Mpa)
1.	Jl. Flamingo Timur 6 Kav. 18 No. 129	11.3	2.0
2.	Jl. Flamingo Timur 5 Kav. 19 No. 357	6.8	2.9
3.	Jl. Flamingo Timur 5 Kav. 28 No. 188	9.7	2.7
4.	Jl. Flamingo Timur 3 Kav. 17 No. 461	12.9	2.5
5.	Jl. Flamingo Timur 3 Kav. 6 No. 28	8.6	2.1
6.	Jl. Flamingo Timur 2 Kav. S-3 No. 540	14.1	3.0
7.	Jl. Flamingo Timur 2 Kav. 28 No. 181	13.3	5.6
8.	Jl. Flamingo Timur 1 Kav. R-31 No. 353	8.5	4.5
9.	Jl. Flamingo Timur 1 Kav. 38 No. 271	16.6	0.7
10.	Jl. Flamingo Timur Kav. 09 No. 67	13.6	4.8

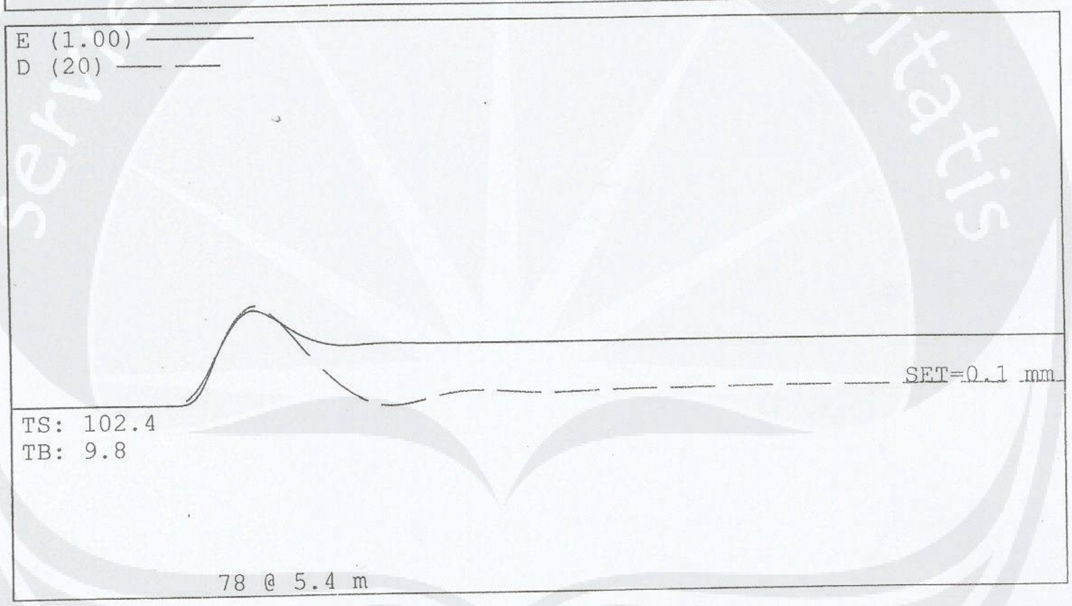
III. 2. Energi Tumbukan dan Efisiensi Hammer

No.	No. Tiang	Tinggi Jatuh (m)	Energi Tumbukan (m)	Efisiensi Hammer (%)	Jenis Hammer
1.	Jl. Flamingo Timur 6 Kav. 18 No. 129	0.8	0.36	45.00	Drop Hammer 1.0 Ton
2.	Jl. Flamingo Timur 5 Kav. 19 No. 357	0.8	0.25	31.25	Drop Hammer 1.0 Ton
3.	Jl. Flamingo Timur 5 Kav. 28 No. 188	0.8	0.25	31.25	Drop Hammer 1.0 Ton
4.	Jl. Flamingo Timur 3 Kav. 17 No. 461	0.8	0.50	62.50	Drop Hammer 1.0 Ton
5.	Jl. Flamingo Timur 3 Kav. 6 No. 28	0.8	0.27	33.75	Drop Hammer 1.0 Ton
6.	Jl. Flamingo Timur 2 Kav. S-3 No. 540	0.8	0.47	58.75	Drop Hammer 1.0 Ton
7.	Jl. Flamingo Timur 2 Kav. 28 No. 181	0.8	0.47	58.75	Drop Hammer 1.0 Ton
8.	Jl. Flamingo Timur 1 Kav. R-31 No. 353	0.8	0.28	35.00	Drop Hammer 1.0 Ton
9.	Jl. Flamingo Timur 1 Kav. 38 No. 271	0.8	0.26	32.50	Drop Hammer 1.0 Ton
10.	Jl. Flamingo Timur Kav. 09 No. 67	0.8	0.49	61.25	Drop Hammer 1.0 Ton

EH = Efisiensi Hammer = [Energi Tumbukan / (Tinggi Jatuh Hammer x Berat Hammer)] x 100 %

LAMPIRAN A
DATA PDA DAN ANALISA CAPWAP





Project Information

PROJECT: CLUSTER FLAMINGO JL FLAMINGO TI
PILE NAME: KAV. 28 No. 188
DESCR: SQUARE 25X25
OPERATOR: SDMN
FILE: KAV 28 No 188_3
13/03/2015 11:51:57
Blow Number 2/3

Pile Properties

LE	23.6 m
AR	625.00 cm^2
EM	354 t/cm2
SP	2.40 t/m3
WS	3800.0 m/s
EA/C	58.2 tn-s/m
2L/C	11.70 ms
JC	0.90 []
LP	23.4 m

Quantity Results

CSX	59.7 MPa
TSX	2.7 MPa
EMX	0.25 tn-m
BTA	78.0 (%)
DMX	5 mm
RSU	107 tn
RMX	39 tn
RA2	31 tn
DFN	0 mm

Sensors

F3: [J736] 92.7 (1)
F4: [I 498] 102.7 (1)
A3: [K4210] 365 mv/5000g's (1)
A4: [K4209] 372 mv/5000g's (1)
CLIP: OK
F3/F4: LOW -5.23
V3/V4: OK 1.17

CLUSTER FLAMINGO JL FLAMINGO TIMUR 5; Pile: KAV. 28 No. 188 Test: 13-Mar-2015 11:51:
SQUARE 25X25; Blow: 3 CAPWAP(R) 2006-3
PT. Geotesting Utama Eng OP: SDMN

CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 107.2; along Shaft 87.2; at Toe 20.0 tons

Soil Sgmnt No.	Dist. Below Gages m	Depth Below Grade m	Ru tons	Force in Pile tons	Sum of Ru tons	Unit Resist. (Depth) tons/m	Unit Resist. (Area) tons/m^2	Smith Damping Factor s/m	Quake mm
				107.2					
1	3.1	2.9	0.7	106.6	0.7	0.23	0.23	1.291	1.951
2	5.1	4.9	5.6	101.0	6.3	2.74	2.74	1.291	1.951
3	7.2	7.0	5.8	95.1	12.1	2.84	2.84	1.291	1.951
4	9.2	9.0	5.8	89.3	17.9	2.84	2.84	1.291	1.841
5	11.3	11.1	7.1	82.2	25.0	3.47	3.47	1.291	1.550
6	13.3	13.1	8.4	73.8	33.4	4.10	4.10	1.291	1.303
7	15.4	15.2	11.0	62.8	44.5	5.38	5.38	1.291	1.093
8	17.4	17.2	11.7	51.1	56.1	5.69	5.69	1.291	0.923
9	19.5	19.3	11.3	39.8	67.4	5.53	5.53	1.291	0.759
10	21.5	21.3	10.2	29.6	77.6	4.97	4.97	1.291	0.517
11	23.5	23.3	9.6	20.0	87.2	4.70	4.70	1.291	0.339
Avg. Shaft			7.9			3.74	3.74	1.291	1.103
Toe			20.0				320.00	1.313	0.362

Soil Model Parameters/Extensions		Shaft	Toe
Case Damping Factor		1.935	0.451
Unloading Quake	(% of loading quake)	48	128
Reloading Level	(% of Ru)	100	100
Unloading Level	(% of Ru)	42	
Resistance Gap (included in Toe Quake) (mm)			0.078
Soil Plug Weight	(tons)		0.46

CAPWAP match quality = 4.18 (Wave Up Match) ; RSA = 0
Observed: final set = 0.100 mm; blow count = 10000 b/m
Computed: final set = 0.100 mm; blow count = 9999 b/m

max. Top Comp. Stress = 0.105 tons/cm^2 (T= 29.4 ms, max= 1.121 x Top)
max. Comp. Stress = 0.118 tons/cm^2 (Z= 5.1 m, T= 30.7 ms)
max. Tens. Stress = -0.023 tons/cm^2 (Z= 5.1 m, T= 44.5 ms)
max. Energy (EMX) = 0.24 tonne-m;max. Measured Top Displ. (DMX)= 5.17 mm

 Analysis: 15-Mar-2015

EXTREMA TABLE

Pile Sgmnt No.	Dist. Below Gages m	max. Force tons	min. Force tons	max. Comp. Stress tons/cm²	max. Tens. Stress tons/cm²	max. Trnsfd. Energy tonne-m	max. Veloc. m/s	max. Displ. mm
1	1.0	65.9	-12.6	0.105	-0.020	0.24	1.0	4.599
2	2.0	67.7	-13.7	0.108	-0.022	0.24	1.0	4.398
4	4.1	71.2	-14.5	0.114	-0.023	0.22	0.9	3.961
5	5.1	73.9	-14.6	0.118	-0.023	0.22	0.9	3.719
6	6.1	65.3	-11.1	0.104	-0.018	0.18	0.8	3.493
7	7.2	68.0	-11.6	0.109	-0.018	0.18	0.8	3.251
8	8.2	60.3	-9.2	0.096	-0.015	0.15	0.8	3.021
9	9.2	63.2	-9.8	0.101	-0.016	0.14	0.7	2.779
10	10.2	56.6	-7.3	0.091	-0.012	0.11	0.7	2.547
11	11.3	59.7	-7.7	0.096	-0.012	0.11	0.6	2.307
12	12.3	52.0	-4.7	0.083	-0.008	0.08	0.6	2.085
13	13.3	55.2	-5.4	0.088	-0.009	0.08	0.5	1.855
14	14.3	46.6	-2.7	0.075	-0.004	0.06	0.5	1.651
15	15.4	49.6	-3.4	0.079	-0.005	0.05	0.4	1.441
16	16.4	39.0	-0.0	0.062	-0.000	0.04	0.4	1.268
17	17.4	41.7	-0.0	0.067	-0.000	0.03	0.3	1.084
18	18.4	32.2	-0.0	0.051	-0.000	0.02	0.3	0.937
19	19.5	34.0	-0.0	0.054	-0.000	0.02	0.2	0.783
20	20.5	26.2	-0.0	0.042	-0.000	0.01	0.2	0.670
21	21.5	27.5	-0.0	0.044	-0.000	0.01	0.2	0.550
22	22.5	21.6	-0.0	0.034	-0.000	0.01	0.2	0.462
23	23.5	23.2	-0.0	0.037	-0.000	0.00	0.1	0.362
Absolute	5.1			0.118			(T =	30.7 ms)
	5.1				-0.023		(T =	44.5 ms)

CASE METHOD

J =	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
RP	77.5	72.8	68.1	63.4	58.7	54.0	49.4	44.7	40.0	35.3
RX	77.5	72.8	68.1	63.4	58.7	54.0	49.4	44.7	40.0	35.3
RU	108.4	106.8	105.2	103.6	102.0	100.4	98.8	97.2	95.6	94.0

RAU = 0.3 (tons); RA2 = 27.3 (tons)

Current CAPWAP Ru = 107.2 (tons); Corresponding J(RP)= 0.00; J(RX) = 0.00

VMX m/s	TVP ms	VT1*Z tons	FT1 tons	FMX tons	DMX mm	DFN mm	SET mm	EMX tonne-m	QUS tons
1.14	29.37	66.1	58.2	60.9	5.168	0.619	0.100	0.2	94.1

PILE PROFILE AND PILE MODEL

Depth m	Area cm^2	E-Modulus $tons/cm^2$	Spec. Weight $tons/m^3$	Perim. m
0.00	625.00	353.8	2.403	1.000
23.55	625.00	353.8	2.403	1.000

Toe Area 0.063 m^2

Top Segment Length 1.02 m, Top Impedance 58.19 tons/m/s

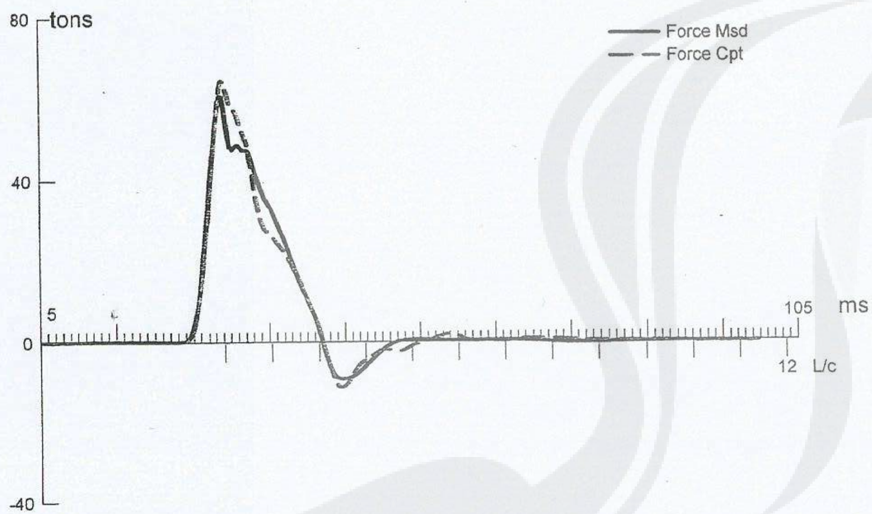
Pile Damping 2.0 %, Time Incr 0.269 ms, Wave Speed 3800.0 m/s, 2L/c 12.4 ms

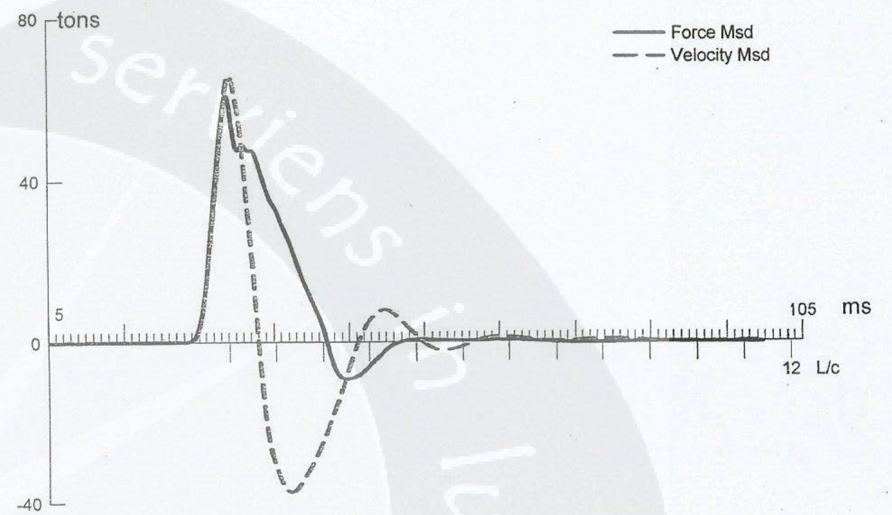
CLUSTER FLAMINGO JL FLAMINGO TIMUR 5; Pile: KAV. 28 No. 188; SQUARE 25X25; Blow: 3 (Test: 13-Mar-2015 11:51:)

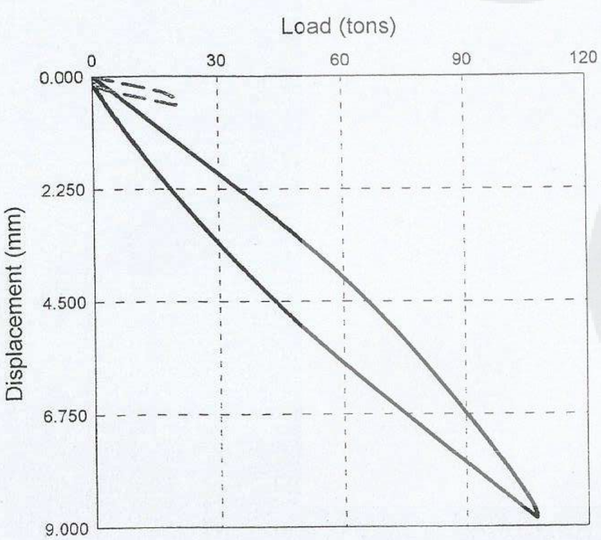
PT. Geotesting Utama Eng

15-Mar-2015

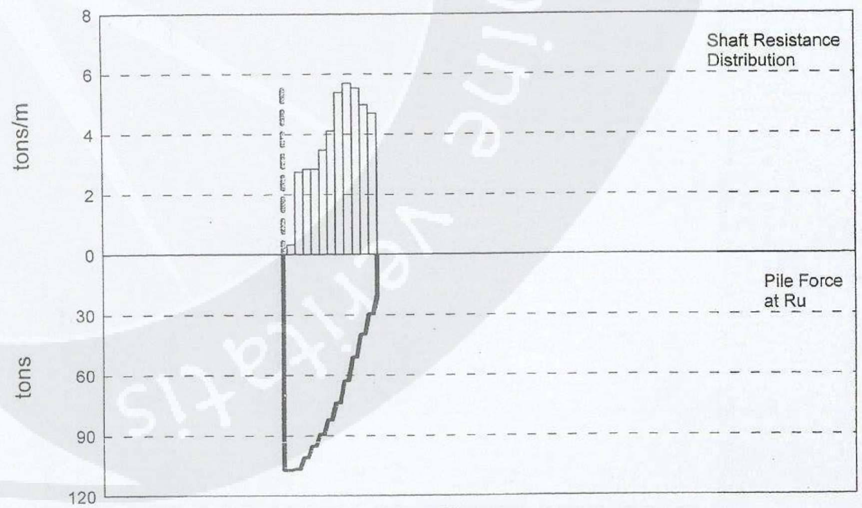
CAPWAP(R) 2006-3







Ru = 107.2 tons
Rs = 87.2 tons
Rb = 20.0 tons
Dy = 8.7 mm
Dx = 8.8 mm



LAMPIRAN B
PENGANTAR KE METODA PENGUJIAN DINAMIS TIANG PONDASI

AN INTRODUCTION INTO DYNAMIC PILE TESTING METHODS

BACKGROUND

Since the mid-1960s research has been conducted at Case Institute of Technology in Cleveland Ohio with the objective of improving pile installation and construction control methods using electronic measurement and modern analysis methods. This work had been supported by the Ohio Department of Transportation and the Federal Highway Administration.

In 1973 the research results were introduced into practice. Professor G. G. Goble, who had been the principal investigator at Case, founded Pile Dynamics, Inc. a company which manufactures – among other devices – the Pile Driving Analyzer™ (PDA). Together with his former research assistants he also founded Goble Rausche Likins and Associates, Inc. (GRL) a consulting engineering firm specialized in the dynamic measurement and analysis methods of piles.

Pile Dynamics gradually improved the PDA technology, always searching for and utilizing advances in electronic and computer technology. In addition, new devices were built and introduced into the market. GRL, on the other hand, developed methods and software for the analysis of the measured quantities. It is the intent of this paper to summarize both analytical and measurement tools available to the civil engineer.

RESULTS FROM DYNAMIC TESTING

The following are the main objectives of dynamic pile testing (or monitoring):

- Bearing Capacity at the time of testing. For the prediction of a pile's long term bearing capacity, measurements are taken during testing.
- Dynamic Pile Stresses during pile driving. In order to limit the possibility of pile damage, stresses must be kept within certain bounds. For concrete piles both tension and compression stresses are important.
- Pile integrity often must be checked both during and after pile installation.
- Hammer performance must be checked for productivity and construction control.

MEASUREMENTS

The basis for the results calculated by the PDA are pile top force and velocity signals obtained using piezoelectric accelerometers and bolt-on strain transducers attached to the pile near its top. The PDA conditions and calibrates these signals and velocity. Using Case Method solutions, the PDA calculates the results described in the following section.

Other measurements are sometimes also required. The ram velocity may be directly obtained using radar technology in the Hammer Performance Analyzer™ (HPA). For open end diesel hammers, the time between two impacts indicates the magnitude of the fall height. This information is measured and calculated by the Saximeter™. Furthermore, the combustion pressure may be measured in diesels for proper wave equation modeling. Acceleration measurements taken on a helmet in addition to standard pile top force and velocity measurements yield pile top cushion stiffness information.

The Pile Integrity Tester (P.I.T.) can be used to evaluate damage to piles which may have occurred during driving or casting. It should also be mentioned that this so called "Low Strain Method" of integrity testing requires only the measurement of acceleration at a pile top. The stress wave producing impact is then generated by a small hand-held hammer.

ANALYTICAL SOLUTIONS

BERAING CAPACITY

Wave Equation

GRL has prepared a program, GRLWEAP, which provides for a truly analytical solution, *i.e.* it does not require measurements and provides the user with a functional relationship between both bearing capacity and pile stress and the blow count. These results can be adjusted or calibrated if measurements of pile top quantities are available. However, the real strength of the traditional wave equation approach lies in a prediction of driving behavior and in the selection of an optimal driving system.

Case Method

The Case Method is a closed form solution based on a few simplifying assumptions such as ideal plastic soil behavior and an ideally elastic and uniform pile. Given the measured pile top force F(t) and pile top velocity v(t), the total soil resistance is

$$R(t) = \frac{1}{2} \{ [F(t) + F(t_2)] + Z[v(t) + v(t_2)] \} \quad (1)$$

where

- Z EA/c is the pile impedance.
- t_2 time t + 2L/c
- L pile length below gages
- C $(E/\rho)^{1/2}$ is the speed of the stress wave
- E elastic modulus of the pile
- ρ pile mass density
- A pile cross sectional area

The total resistance consists of a dynamic and a static component. Thus

$$R_s(t) = R(t) - R_d(t) \quad (2)$$

The static resistance component is, of course, the desired pile bearing capacity. The dynamic component may be computed from a soil damping factor, J, and a pile toe velocity $v_t(t)$ which is, conveniently calculated for the pile toe. Using wave considerations this approach leads immediately to the dynamic resistance

$$R_d(t) = J[F(t) + Zv(t) - R(t)] \quad (3)$$

and finally to static resistance by means of Equation 2. This solution is simple enough to be evaluated "in real time", *i.e.* between hammer blows, using the PDA. However, the assumption of a soil damping constant must be made and the time, t, has to be selected. Often, t is selected such that the maximum static resistance, RMX, is calculated. The damping constant, J, may not be needed if the time t is chosen such that the $R_d(t)$ term vanishes. One calls the resulting capacity value *RA2*.

CAPWAP

This method (Case Pile Wave Analysis Program) combines the wave equation pile and soil model with the Case Method measurements. Thus, the solution includes not only the total and static bearing capacity values but also the skin friction, end bearing, damping factors and soil stiffness. The method iteratively determines a number of unknowns by signal matching. While it is necessary to make hammer performance assumptions for a GRLWEAP analysis, the CAPWAP program works with the pile top measurements. Furthermore, while GRLWEAP and Case Method require certain assumptions regarding the soil behavior, CAPWAP calculates these soil parameters.

STREESSES

The wave equation and CAPWAP solutions include stresses along the pile. For the PDA field results include the pile top stress directly from the measurement and, for concentrated end bearing, the stress at the pile toe from Equation 1.

For concrete piles the maximum tension stress is also of great importance. It occurs at some point below the pile top. The maximum tension stress can be computed from the pile top measurements by considering the magnitude of both upward and downward traveling waves. W_u and W_d.

$$W_u = ½[F(t) – Zv(t)] \quad (4)$$

$$W_d = ½[F(t) + Zv(t)] \quad (5)$$

If any one of these waves is negative, a tension wave exists. It must be checked whether the wave traveling in the opposite direction is sufficiently compressive to reduce the net tension to allowable levels. The PDA also performs this calculation.

PILE INTEGRITY

High Strain Tests

Stress waves in a pile are reflected wherever the impedance (Z=EA/c) changes. The reflected waves arrive at the pile top at a time which depends on the location of the change. The reflected waves cause changes in both pile top force and velocity. The magnitude relative change of the pile top variables allows to determine the extent of the cross sectional change. Thus, with β_i being a relative integrity factor which is unity for no impedance change and zero for the pile end, the following can be calculated by the PDA

$$\beta_i = (1 - \alpha_i)/(1 + \alpha_i) \quad (6)$$

with

$$\alpha_i = ½(W_{ur} – W_{ud})/(W_{di} – W_{ur}) \quad (7)$$

where

W_{ur} is the upward traveling wave at the onset of the reflected wave. It is caused by resistance

W_{ud} is the upward traveling wave due to the damage reflection.

W_{di} is the maximum downward traveling wave due to impact

Low Strain Tests (P.I.T.)

The pile top is struck with a held hand hammer and the resulting pile top velocity is measured, displayed and interpreted for signs of wave reflections. In general, a comparison of the reflected acceleration leads to a relative measure of extent of damage, again the location of the problem is indicated by the arrival time of the reflection. An approximate pile profile can be calculated from low strain records using the P.I.T.WAP.

HAMMER PERFORMANCE

The PDA can very simply calculate the energy transferred to the pile top

$$E(t) = \int F(t)v(t)dt \quad (8a)$$

The maximum of the E_t curve is the most important information for an overall evaluation of the performance of a driving system. This EMX or ENTHRU value allows for a classification of the hammer's performance, using

$$E_t = EMX/E_r \quad (8b)$$

where E_r is the hammer's rated energy

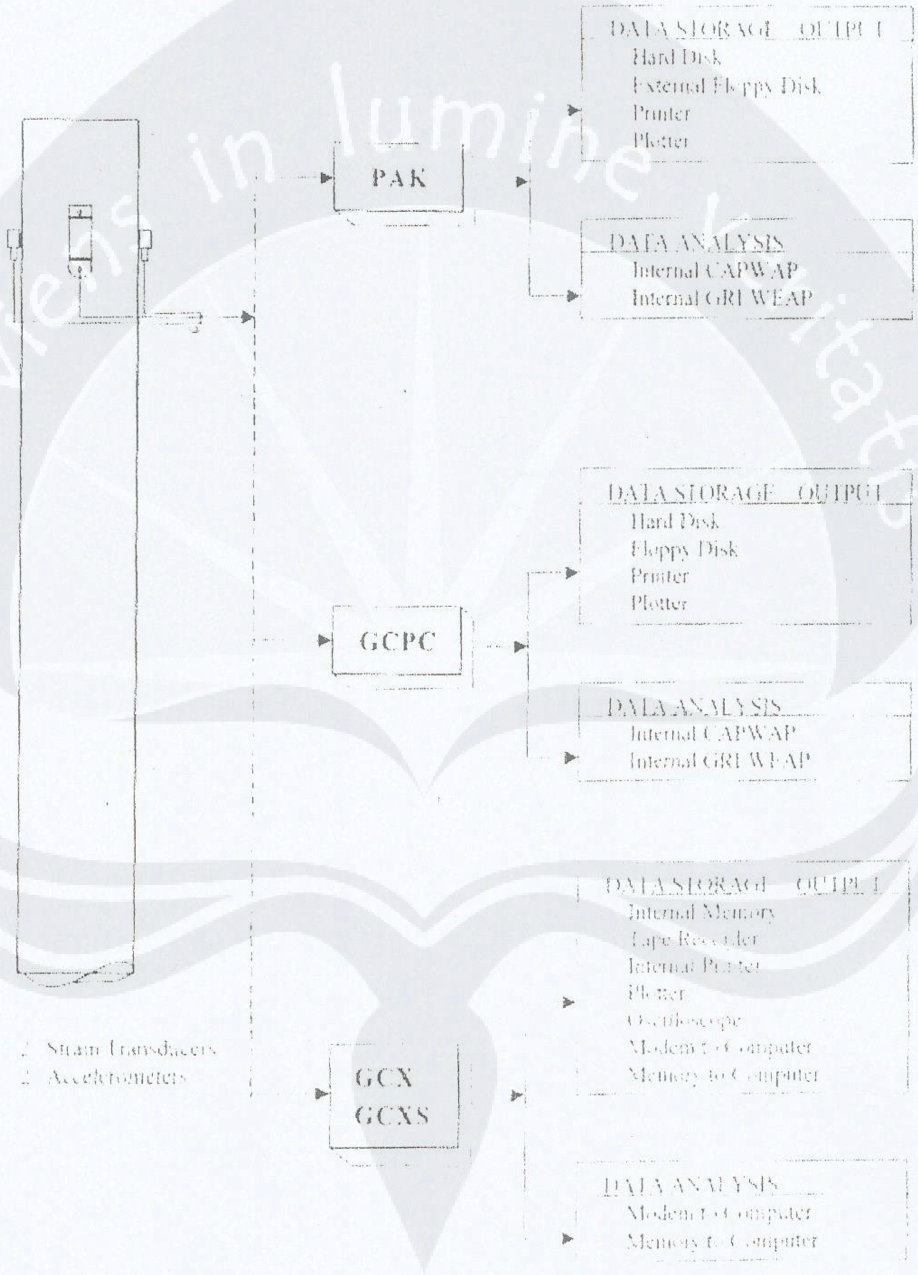
The Saximeter™ calculates the stroke from an open end diesel using

$$H = (g/8) T^2 – h_l \quad (9)$$

Where

- g earth gravitational acceleration,
- T time between two blows
- h_l a stroke loss value due to gas compression and time losses during impact (usually 0.3 ft or 0.1 m)

Pile Driving Analyzer System



B-4

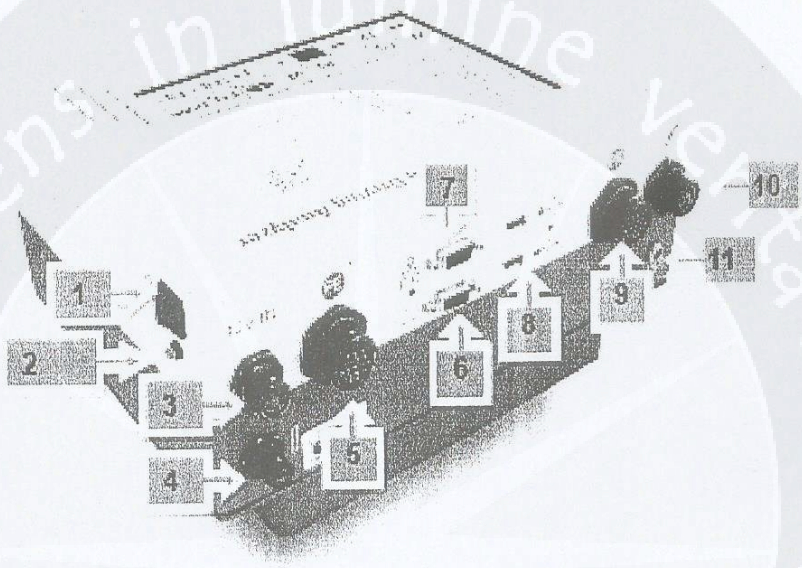
LAMPIRAN C
SPESIFIKASI PERALATAN PDA

Appendix E

Specifications

Physical:
Size: 150 X 220 X 290 mm (5.9 x 8.7 x 11.4 inches)
Weight: 5 Kg (11 lbs)
Temperature range: 0 to 40°C (32 to 104° F) operating; -20 to 65°C (-4 to 149 °F) storage
High visibility color VGA backlit LCD display optically enhanced for outdoor viewing
High contrast touch screen doubles as keyboard
Built in VGA external monitor port
Power: built-in 8 hour duration battery, 12 VDC car battery, or 100-240 VAC w/12 VDC converter
Fast charger recharges built-in battery in 4 hours
Electronic:
PC compatible processor, running Microsoft Windows XP Home Edition
40 GB hard disk minimum
512 KB DRAM minimum
Ethernet port
2 USB ports
Analog signal frequency response 5 KHZ (-3 dB)
24-bit A/D converter with sampling frequency of 5.12 MHz
8 channels with effective digitizing frequency of 40 KHZ per channel (2500 – 40000 HZ selectable)
Resolution: 24 bit A/D
Transducer signals digitally recorded
1Kbyte, 2Kbyte, or 4Kbyte data record sizes available
Built in calibration test function
Basic unit accuracy 2%
Functional:
Two or four channels of strain data acquisition
Two or four channels of acceleration data acquisition
Automatic balancing of signals and signal conditioning
Signal conditioning for force and acceleration have similar frequency response
Internal calibration check of strain and acceleration
Signal amplification capability
Automatically triggers on any attached strain transducers
High speed internet data transmission through broadband phone or other network device
Dial up data transmission through data capable mobile phone connected via USB
Other:
Optional external USB keyboard, mouse, memory stick, and WiFi (802.11x) available
Operates in English, SI, or Metric units
Includes both soft side carry-on luggage case and hard transit case

Setting up the PAX



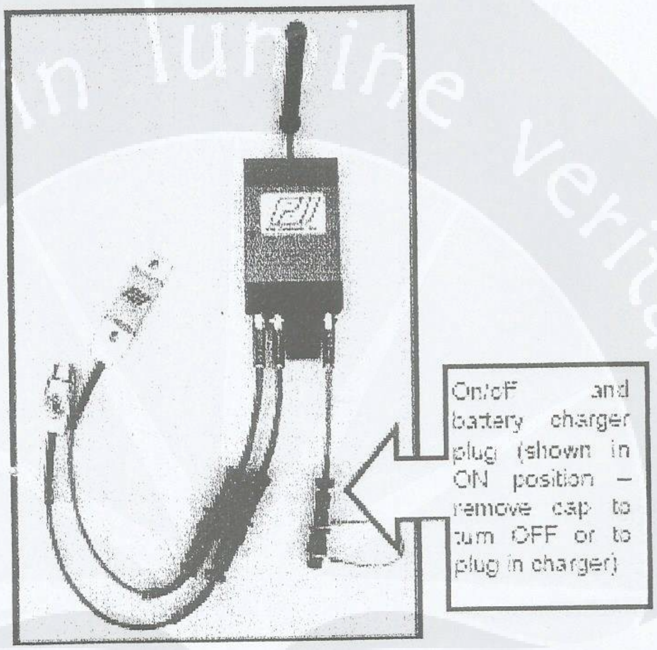
1 On-off switch (on newer models the rocker switch is inside the plastic casing)
2 Pilot lamp
3 12 Volt DC input
4 Blow count extension cord input
5 Piezoelectric (PE) main cable input
6 External monitor output
7 Network input
8 USB inputs (2)
9 Piezoresistive (PR) main cable input
10 Battery charger input
11 12 Volt DC output

To turn the unit on flip the toggle switch (1) on the side of the PAX. The pilot lamp (2) will illuminate. The PAX comes equipped with an internal battery good for a full day of operation. If the battery runs low, you can run the PAX connected to a 12 Volt car battery with the car power adapter connected to the 12 Volt input (3). The PAX also comes with an external power supply that connects to the mains supply (100 to 250 Volts AC, 50 to 60 Hz). The output of this power supply should be connected to the 12 Volt input (3). However, using a car battery instead of the external power supply is the recommended procedure in the field.

It is always recommended to fully charge the PAX the day before testing using the provided battery charger. To charge the PAX connect the charger to the Battery charger input (10). Full charge should take about 5 hours. A LED on the charger will indicate when charging is

Introduction

This feature requires the purchase of wireless transmitters, like the one shown below:



Charging the battery

You should charge the battery before using the transmitter. It should run for 8 hours after it has been fully charged. Full charge should normally take about 2 hours, or a maximum of 3.5 hours if the batteries are totally dead. Each transmitter comes with its own "Smart Li-Ion Battery Charger". To charge the battery proceed as follows:

1. Make sure that the cap shown on the picture above is removed, so that the transmitter is powered off.
2. Plug in the connector from the charger to the battery charger plug.
3. Connect the charger to the AC mains (100 to 240 Volts AC – 50-60 Hz), using the power cord provided.
4. When the charger is connected to the AC mains, its LED will flash the sequence RED-GREEN-RED-GREEN. This is a self-check procedure that ensures that the internal circuitry is functioning properly.
5. The RED LED will then come on to indicate that the battery is charging in the high rate.
6. After the battery is charged the LED will change to GREEN to indicate that the battery is charged and ready to use. After some period of inactivity, the LED will start to cycle back and forth between red and green.

Caution:

- The charger is designed for indoor use only.
- Do not use the charger in wet areas.
- Do not use the charger near flammable substances or explosive fumes.

LAMPIRAN D
KALIBRASI TRANSDUCER & ACCELEROMETER

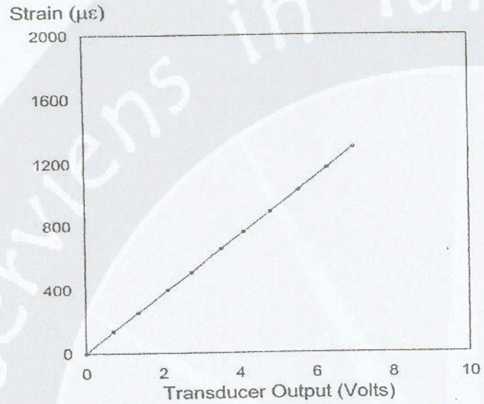
Strains Transducer

Pile Dynamics, Inc.

Pile Dynamics, Inc.

Transducer J736

PDA Cal Factor (5.0 V) 92.7με/V



Applied Strain (με)	Transducer Output (Volts)
0	0.00
135	0.71
252	1.35
398	2.13
503	2.74
654	3.53
761	4.12
892	4.82
1030	5.56
1173	6.31
1300	7.01

Shunt (60.4 KΩ) 2.5 V
General Factor 321.7με/mV/V

Traceable to N.I.S.T.

Strain Transducer Calibrator System 2011 Version 1.5

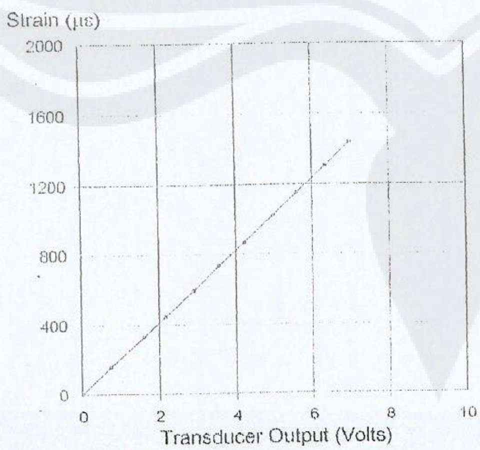
Calibrated by: [illegible]
Calibrated on: 10-Dec-2013

Smart Sensor? ✓ Yes ____ No Smart Chip Programmed by: KT Date: [illegible] CRC value [illegible]

GEOTECH CALIBRATION

Transducer I498

PDA Cal Factor (5.0 V) 102.7με/V



Applied Strain (με)	Transducer Output (Volts)
0	0.00
161	0.75
333	1.60
446	2.16
594	2.90
738	3.56
869	4.23
1025	4.97
1154	5.59
1307	6.35
1440	6.99

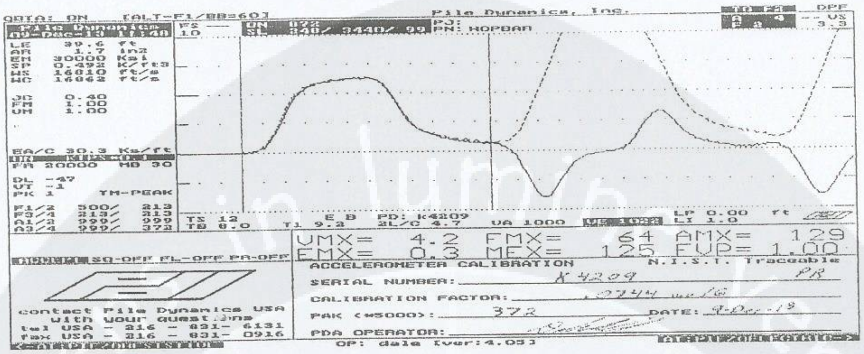
Shunt (60.4 KΩ) 2.5 V
General Factor 356.7με/mV/V

Traceable to N.I.S.T.

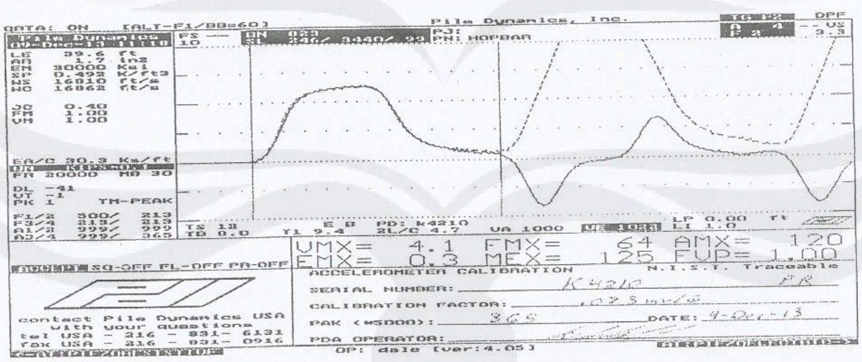
Strain Transducer Calibrator System 2004 Version 1.2

Calibrated by: Ricky Setiawan
Calibrated on: 15-Jan-2015

Accelerometer



Smart Sensor
Smart Chip Programmed By DB on 9-Dec-13 CRC Value 4067



Smart Sensor
Smart Chip Programmed By DB on 9-Dec-13 CRC Value 2820

LAMPIRAN E
SERTIFIKAT KOMPUTER PDA
SN 4369 LA

Certificate of Calibration

Pile Dynamics, Inc. certifies that the

Pile Driving Analyzer®, Model PAX

Serial Number: 4369 LA

was calibrated on 20 Dec 20[illegible]
using a PDA Calibration Box whose output was calibrated with test equipment traceable to NIST.
This certificate is valid for 2 years from above date.

Tested by: [illegible]

PDI
Pile Dynamics, Inc.
30725 Aurora Road
Cleveland, Ohio 44139 USA

Certificate of Compliance

Pile Dynamics, Inc. certifies that the

Pile Driving Analyzer®, Model PAX

Serial Number: 4369 LA

has been tested and passed all final test procedures on [illegible]

and complies with the criteria as set forth in ASTM Standard D-4945

Tested by: [illegible]

PDI
Pile Dynamics, Inc.
30725 Aurora Road
Cleveland, Ohio 44139 USA

LAMPIRAN F
ASTM D-4945-96

D 4945

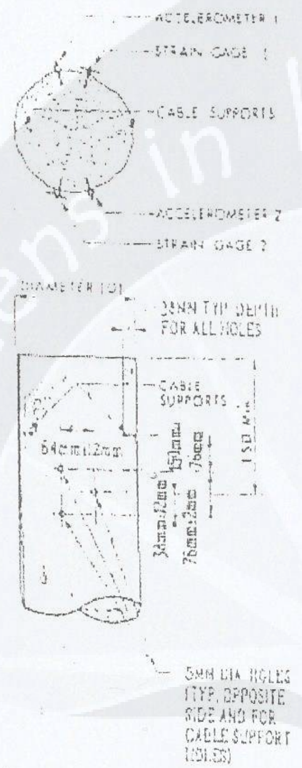
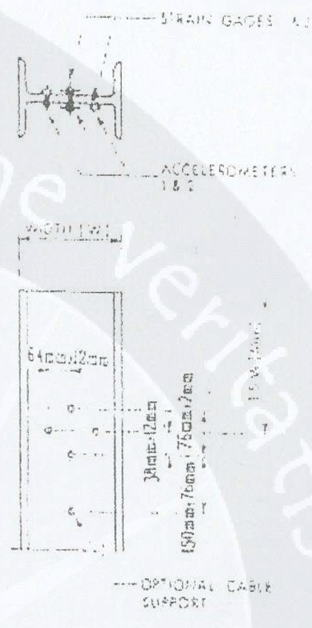


FIG. 6 Typical Arrangement for Attaching Transducers to Wood Piles



NOTE All holes at 5mm diameter.

FIG. 7 Typical Arrangement for Attaching Transducers to H-Piles

To limit electronic or other interferences. The signals arriving at the apparatus shall be linearly proportional to the measurements at the pile over the frequency range of the equipment.

5.4 *Apparatus for Recording, Reducing and Displaying Data*

5.4.1 *General*—The signals from the transducers (see 5.2) during the impact event shall be transmitted to an apparatus for recording, reducing, and displaying data to allow determination of the force and velocity versus time. It may be desirable to also determine the acceleration and displacement of the pile head, and the energy transferred to the pile. The apparatus shall include an oscilloscope, oscillograph, or LCD graphics screen. For displaying the force and velocity traces, a tape recorder, digital disk or equivalent for obtaining a record for future analysis, and a means to reduce the data. The apparatus for recording, reducing, and displaying data shall have the capability of making an internal calibration check of strain, acceleration, and time scale. No error shall exceed 2 % of the maximum signal expected. A typical schematic arrangement for this apparatus is illustrated in Fig. 3.

5.4.2 *Recording Apparatus*—Signals from the transducers shall be recorded electronically in either analog or digital form so that frequency components have a low pass cut-off frequency of 1500 Hz (-3dB). When digitizing, the sample frequency shall be at least 5000 Hz for each data channel.

5.4.3 *Apparatus for Reducing Data*—The apparatus for reducing signals from the transducers shall be an analog or digital computer capable of at least the following functions.

5.4.3.1 *Force Measurements*—The apparatus shall provide signal conditioning, amplification and calibration for the force measurement system. If strain transducers are used (see 5.2.1), the apparatus shall be able to compute the force. The force output shall be continuously balanced to zero except during the impact event.

5.4.3.2 *Velocity Data*—If accelerometers are used (see 5.2.2), the apparatus shall integrate the acceleration overtime to obtain velocity. If displacement transducers are used the apparatus, shall differentiate the displacement overtime to obtain velocity. If required, the apparatus shall zero the velocity between impact events and shall adjust the velocity record to account for transducers zero drift during the impact event.

D 4945

5.4.3.5 *Signal Conditioning*—The signal conditioning for velocity shall have equal frequency response curves to avoid relative phase shifts and relative amplitude differences.

5.4.4 Display Apparatus—Signals from the transducers specified in 4.2.1 and 4.2.2 shall be displayed by means of an apparatus, such a, an oscilloscope, oscillograph, or LCD graphic screen on which the force and velocity versus time can be observed for each hammer blow. This apparatus may receive the signals from the transducers directly or after they have been processed by the apparatus for reducing the data. The apparatus shall be adjustable to reproduce a signal having a range of duration of between 5 and 160 ms. Both the force and velocity data can be reproduced for each blow and the apparatus shall be capable of holding and displaying the signal from each selected blow for a minimum period of 30 s.

6. Procedure

6.1 General—Record applicable project information (Section 7). Attach the transducers (see 5.2) to the pile, perform the internal calibration check, and take the dynamic measurements for the impacts during the interval to be monitored together with routine observations of penetration resistance. Determine properties from a minimum of ten impact records during initial driving and, when used for soil resistance computations, normally from one or two representative blows at the beginning of restriking. The force and velocity versus time signals shall be reduced by the apparatus for reducing data, computer, or manually to calculate the developed force, velocity, acceleration, displacement, and energy over the impact event.

6.2 *Determination of Strain Wave Speed for Concrete or Wood Piles*—The wave speed should be determined from the impact event if a tensile reflection wave from the pile toe is clearly identified. Alternatively, place the pile on supports or level ground free and clear from neighboring piles and obstructions. Attach accelerometer to one end of the pile and strike the other end of the pile with a sledge hammer of suitable weight. Take care not to damage or dent the pile. Record (see 5.4.2) and display (5.4.4) the accelerometer signal. Measure the time between acceleration peaks for as many cycles of reflection as possible. Divide this time by the appropriate travel length of the strain waves, during this interval to determine the wave speed.

6.3 *Preparation*—Mark the piles clearly at appropriate intervals. Attach the transducers securely to the piles by bolting, gluing, or welding. For pile material other than steel, determine the wave speed (see 6.2). Position the apparatus for applying the impact force so that the force is applied axially and concentrically with the pile. Set up the apparatus for recording, reducing, and displaying data so that it is operational and the force and velocity signals are zeroed.

6.4 *Taking Measurements*—Record the number of impacts for a specific penetration. For drop hammer and single acting diesel and air/steam/hydraulic hammers, record the drop of the ram travel length. For double acting diesel hammers, measure the bounce pressure, and for double acting steam or compressed air hammers, measure the steam or air pleasure in the pressure line to the hammer. For hydraulic hammer, record the kinetic energy from the hammer readout when available. Record the number of blows per minute delivered by the hammer. Take, record, and display a series of force and velocity measurements. Compare the force and the product of velocity and impedance (see 6.5) at the moment of impact.

NOTE 4—If the dynamic measurements are to be used for bearing capacity computations, take the dynamic measurements during restriking of the pile at the time periods sufficiently long after the end of initial driving to allow pore water pressure and soil strength changes to occur. Further geotechnical conditions, such as underlying compressible layers, need always be considered, as they should be in any type of bearing capacity computations.

NOTE 5. Warning—Before approaching a pile being driven, ensure that no material or other appurtenances can break free and jeopardize the safety of persons in the vicinity.

6.5 *Data Quality Checks*— For confirmation of data quality, periodically compare the force and the product of the velocity and pile impedance at the moment of impact for proportionality agreement and the force and velocity versus little over a series of selected and generally consecutive impact events for consistency. Consistent and proportional signals from the force or strain transducers and acceleration, velocity or displacement transducers are the result of the transducers systems performing property and the apparatus for recording, reducing and displaying data being properly calibrated. If the signals are not in proportionality agreement, investigate the cause and correct the situation if necessary. If the cause is determined to be a transducers, it must be repaired or recalibrated, or both, before further use. Perform internal calibration checks for the apparatus for recording, reducing, and displaying data at least once for each test day; if found to be out of manufacturer's tolerance, the apparatus for recording, reducing, and displaying must be recalibrated before further use.

NOTE 6—It is generally recommended that all components of the apparatus for obtaining dynamics measurements and the apparatus for recording, reducing and displaying data be calibrated at least once every two years to the standards of the manufacturer.

6.6 *Analysis of Measurements*

6.6.1 Obtain force and velocity from the readout of the apparatus for reducing data (see 5.4.3) or from the display apparatus (see 5.4.4). Record the impact force and velocity and the maximum and minimum forces for the selected representative blows. Obtain the maximum acceleration directly from the accelerometer signal or by differentiation of the velocity versus time record. Obtain the displacement from the pile driving record, and from the displacement transducer, if used in accordance with 5.2.2 or by integration of the velocity versus time record. Obtain the maximum energy transferred to the location of the transducers.

6.6.2 The recorded data may be subjected to analysis by a computer. The results of the analysis may include in, assessment of integrity of the pile, the driving system performance, and the maximum dynamic driving stresses.

14

ASTM D 4945

The results may also be used for evaluation of static soil resistance and its distribution on the pile at the time of the testing. Such further use of the data is a matter of proper engineering judgment.

NOTE 7—Normally, there is better correlation between mobilized resistance and bearing capacity where there is a measurable net penetration per impact of at least 3 mm.

NOTE 8—Evaluation of static soil resistance and its distribution can be based on a variety of analytical methods and is the subject of individual engineering judgement. The input into the analytical methods may or may not result in the dynamic evaluation matching static load test data. It is desirable and sometimes necessary to calibrate the result of the dynamic analysis with those of a static pile load test carried out according to Test Method D 1143.

7 Report

7.1 The testing report should include all information, indicated below, as applicable to the type of pile being tested. Any required information that could not be obtained should be indicated in the testing report as being not available.

7.1.1 *General*

7.1.1.1 Project identification/location, and

7.1.1.2 Log of nearby or typical test borings)

7.1.2 *Pile Installation Equipment:*

7.1.2.1 Description of pile installation equipment used for either driving piles or drilling piles or the testing of these piles or combination thereof, as appropriate, including size (ram, weight and stroke) and manufacturer's energy rating, capabilities, and type, operating performance levels or pressure, fuel settings, hammer cushion and pile cushion descriptions, and description or lead type and any special installation equipment such as for use of a follower or mandrel, predrilling or jetting.

7.1.3 *Test Piles:*

7.1.3.1 Identification (name and designation) of test pile(s),

7.1.3.2 Working load and safety factor (or required ultimate capacity) of the pile(s),

7.1.3.3 Type and dimensions of pile(s) including nominal or actual cross sectional area, or both, length and diameter (as a function of pile length for timber or composite piles),

7.1.3.4 For concrete piles, cast-in-place pipe piles, or drilled shafts: date test piles made, cast, or installed, design concrete cylinder strength, density, effective prestress, or reinforcement details (size, length, of longitudinal bars), description of internal and external reinforcement used in test pile (size, length, number and arrangement of longitudinal bars, casing or shell size and length),

7.1.3.5 For steel piles: steel grade, yield strength, and type of pile (for example, seamless or spiral weld pipe, H section designation),

7.1.3.6 For timber piles: length, straightness, preservative treatment, tip and butt dimensions (and area as a function of length), and measured density for each pile,

7.1.3.7 Description and location of splices, if applicable,

7.1.3.8 Description of special pile tip protection, if applicable,

7.1.3.9 Description of any special coatings applied, if applicable,

7.1.3.10 Inclination angle from vertical or all test piles, and

7.1.3.11 Observations of piles including spalled area, cracks, head surface of piles.

7.1.4 *Pile Installation*

7.1.4.1 Date of installation and pile embedment below reference,

7.1.4.2 For drilled shafts, include the nominal size of the auger, volume of concrete or grout placed in pile (volume versus depth, if available), and a description of special installation procedures used, such as pile casing installation or extraction, or both,

7.1.4.3 For driven piles, include hammer cushion and to cushion exchange information; include driving records, including blow count and hammer stroke or operating level for unit penetration,

7.1.4.4 Cause and duration of interruptions in pile installation, if applicable and related to the investigation, and

7.1.4.5 Notation of any unusual occurrences during installation or excavation, or both, which may relate to the investigation.

7.1.5 *Dynamic Testing:*

7.1.5.1 Description of all components of the apparatus for obtaining dynamic measurements and apparatus for recording, reducing and displaying data, and test procedure including description and location of the sensor attachment,

7.1.5.2 Date tested and sequence of test pile such as "end of driving" or "beginning of restrike" (restrikes referenced with time since end of driving) or embedment depth,

7.1.5.3 Test pile identification,

7.1.5.4 The length below sensors, cross sectional area density, wave speed, and dynamic modulus of elasticity of the test pile,

7.1.5.5 Penetration resistance (number of blows per unit penetration) during the test,

7.1.5.6 Graphical presentation of velocity and force measurements in the time domain for representative blow of each pile tested,

7.1.5.7 Method(s) and one-dimensional wave propagation theory used (give reference) to evaluate data (particularly for the capacity evaluation, if applicable),

7.1.5.8 Comments on the capacity of the pile at the time of testing; mention shall be made as to if capacity is a remolded state as at end of driving or from a restrike, with sufficient wait after driving. When applicable, summarize variables describing the soil model, including damping factors, quakes, and resistance distribution,

7.1.5.9 Comments on the hammer performance as measured by the energy transferred into the pile (with comparison to manufacturer's rating),

7.1.5.10 Comments on the driving stresses in the pile,

7.1.5.11 Comments on the integrity of the pile, and

7.1.5.12 Results of testing shall be summarized and presented numerically, with notation of time testing such as "end of driving" or "beginning of restrike" and noted of

D 4945

[illegible] depth; also standard deviation and range when, statistically significant.

8. Precision and Bias

8.1 *Precision*—The precision of this test method for [illegible] measurement of strain and acceleration in a pile by means of high-strain dynamic testing has not been determined. The precision cannot be determined due to the variability of the pile, pile driving hammer, and the soil surrounding the pile.

8.2 *Bias*—There is no accepted reference value for this test method, therefore bias cannot be determined.

9. Keywords

9.1 dynamic testing; pile bearing capacities; pile foundations

LAMPIRAN G
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