CHAPTER IV

ANALYSIS OF RESULTS

The data obtained from the tests will now be presented.

4.1 Young's Modulus of Soil

BROMS (1964a) suggested that the modulus of elasticity of the soil (E_s) should be got from the stress-strain curve of unconfined compression test as follows:

$$E_s = E_{50} = \frac{q_u}{2 \text{ strain}} .$$

From unconfined compression tests in the laboratory we obtained:

Average q_u = 0.42 ksc,

Average E_{50} = 18.43 ksc.

From vane shear test in the field:-

$$c_u = 0.26 \text{ ksc.}$$

POULOS (1971a) has shown that good agreement is found between the measured load-deflection curves for a series of tests on model piles in clay and those predicted from the theoretical curves, using a value of Young's modulus of about 400 c_u in the analysis. Reasonable agreement is also found for a reported series of field tests on larger-scale piles.

From Eq. (21)

$$E_s = 400 \ c_u = 400 \times 0.26$$

$$= 104 \text{ ksc.}$$

4.2 Pile Classifications

(a) **Free headed pile:-**

i) Short pile : $\beta L < 1.5$

ii) Pile of medium length : $1.5 < \beta L < 2.5$

iii) Long pile : $\beta L > 2.5$

Based on research by VESIC (1961a)

$$K = kD = 1.30 \sqrt[12]{\frac{E_s D^4}{E_p I_p}} \times \frac{E_s}{1-\mu_s^2}$$

(b) **For E_s = 18.43 ksc.**

i) Short pile :-

$$E_p I_p = 6.06 \times 10^9 \text{ kg-cm}^2$$

$$L = 290 \text{ cm.}$$

Let assume $\mu_s = 0.50$

$$K = 1.30 \sqrt[12]{\frac{18.43 \times 18^4}{6.06 \times 10^9}} \times \frac{18.43}{1-(0.5)^2}$$

$$= 16.34 \text{ ksc.}$$

$$\beta = \sqrt[4]{\frac{K}{4 E_p I_p}} = \sqrt[4]{\frac{16.34}{4 \times 6.06 \times 10^9}}$$

$$= 5.10 \times 10^{-3} \text{ cm.}^{-1}$$

$$\beta L = 1.48 < 1.5$$

It is a short pile.

ii) Long pile :-

$$E_p I_p = 2.98 \times 10^9 \text{ kg-cm}^2$$

$$L = 600 \text{ cm.}$$

$$K_{\infty} = 1.30 \sqrt[12]{\frac{18.43 \times 18^4}{2.98 \times 10^9} \times \frac{18.43}{1 - (0.5)^2}}$$

$$= 17.33 \quad \text{ksc.}$$

$$\beta = \sqrt[4]{\frac{K}{4E_p I_p}} = \sqrt[4]{\frac{17.33}{4 \times 2.98 \times 10^9}}$$

$$= 6.17 \times 10^{-3} \text{ cm.}^{-1}$$

$$\beta L = 3.7 > 2.5$$

It is a long pile.

(c) <u>For E_s = 104 ksc.</u>

i) Pile of medium length :-

$$K = 1.30 \sqrt[12]{\frac{104 \times 18^4}{6.06 \times 10^9} \times \frac{104}{1 - (0.5)^2}}$$

$$= 106.47 \quad \text{ksc.}$$

$$\beta = \sqrt[4]{\frac{106.47}{4 \times 6.06 \times 10^9}} = 8.14 \times 10^{-3} \text{ cm.}^{-1}$$

$$\beta L = 2.36$$

It is a pile of medium length.

ii) Long pile :-

$$K = 1.30 \sqrt[12]{\frac{104 \times 18^4}{2.98 \times 10^9} \times \frac{104}{1 - (0.5)^2}}$$

$$= 112.96 \quad \text{ksc.}$$

$$\beta = \sqrt[4]{\frac{112.96}{4 \times 2.98 \times 10^9}} = 9.87 \times 10^{-3} \text{ cm.}^{-1}$$

$$\beta L = 5.92 > 2.5$$

It is a long pile.

4.3 Coefficient of Subgrade Reaction

4.3.1 Short Piles ($\beta L < 2.25$)

From Eq. (17)

$$k_p = \frac{E_s}{m(1-\mu_s^2)\sqrt{LD}}$$

Let assume $\mu_s = 0.5$ in the analysis.

$L = 290$ cm.

$D = 18$ cm.

$\frac{L}{D} = 16.11$

from Table 3 for $\frac{L}{D} = 16.11$, $m = 0.69$

$k_p = 2.69 \times 10^{-2}\ E_s$

From Eq. (18)

$$k_m = \frac{E_s}{m(1-\mu_s^2)\sqrt{L'D}}$$

where $L' = \frac{L}{10} = 29$ cm.

$\frac{L'}{D} = 1.61$

from Table 3, $m = 0.94$

$k_m = 6.23 \times 10^{-2}\ E_s$

Table 5 - Coefficient of Subgrade Reaction of Short Pile

E_s (ksc)	k_p (kg/cm^3)	k_m (kg/cm^3)
18.43	0.50	1.15
104	2.80	6.48

4.3.2 Long Piles ($\beta L > 2.25$)

From Eq. (14)

$$k_{\infty} = \frac{\alpha K_o}{D}$$

where $K_o = 1.67\ E_{50}$;

$\alpha = n_1 n_2$, from Tables 1 and 2 : $n_1 = 0.32, n_2 = 1.15$

$= 0.32 \times 1.15 = 0.37$

Table 6 - Coefficient of Subgrade Reaction of Long Pile

E_s (ksc.)	k_{∞} (kg/cm^3)
18.43	0.63
104	3.57

4.4 Load-Deflection Characteristics

4.4.1 Prediction of Load-Deflection Relationship at Working Load by Brom's Method

(a) Short piles ($\beta L < 1.5$)

Deflection at ground surface $y_o = y_p + y_m$

$$= \frac{P}{DLk_p} + \frac{12.35M}{DL^2\ k_m} ,$$

where $M = 191\ P$.

Let assume $P = 544$ kg.

$$\therefore \quad y_o = \frac{544}{18 \times 290 \times k_p} + \frac{12.35 \times 544 \times 191}{18\ (290)^2\ k_m}$$

$$= \frac{0.103}{k_p} + \frac{0.848}{k_m}$$

For $E_s = 18.43$ ksc.

$y_o = 0.943$ cm.

(b) Pile of medium length

From Eq. (11)

$$y_o = \frac{2P\beta}{K}\left(\frac{\sinh\beta L \cosh\beta L - \sin\beta L.\cos\beta L}{\sinh^2\beta L - \sin^2\beta L}\right) + \frac{2M\beta^2}{K}\left(\frac{\sinh^2\beta L + \sin^2\beta L}{\sinh^2\beta L - \sin^2\beta L}\right)$$

For $\beta = 8.14 \times 10^{-3}$ cm.$^{-1}$

$L = 290$ cm.

$\beta L = 2.36$

$e = 46$ cm.

Let $P = 544$ kg.

$\sinh\beta L = 5.25$

$\cosh\beta L = 5.34$

$\sin\beta L = 0.70$

$\cos\beta L = - 0.71$

$y_o = 0.120$ cm.

(c) Long piles - From Eq. (9)

Deflection at ground surface $y_o = \frac{2P\beta(e\beta + 1)}{k_\infty D}$

Let assume $P = 435$ kg.

$e = 90$ cm.

$L = 600$ cm.

SO $\beta = \sqrt[4]{\frac{k_\infty D}{4E_p I_p}}$.

For $E_s = 18.43$ ksc, $k_\infty = 0.63$ kg/cm^3

$$\beta = \sqrt[4]{\frac{0.63 \times 18}{4 \times 2.98 \times 10^9}} = 5.55 \times 10^{-3} \text{ cm.}^{-1}$$

$\beta L = 3.33 > 2.5$

It is a long pile.

$$y_o = \frac{2 \times 435 \times 5.55 \times 10^{-3}(90 \times 5.55 \times 10^{-3}+1)}{0.63 \times 18}$$

$= 0.64$ cm.

For E_s = 104 ksc , k_{∞} = 3.57 kg/cm^3

$$\beta = \sqrt[4]{\frac{3.57 \times 18}{4 \times 2.98 \times 10^9}} = 8.57 \times 10^{-3} \text{ cm.}^{-1}$$

$$\beta L = 5.14 > 2.5$$

It is a long pile.

$$y_o = \frac{2 \times 435 \times 8.57 \times 10^{-3}(90 \times 8.57 \times 10^{-3} + 1)}{3.57 \times 18}$$

$$= 0.210 \text{ cm.}$$

4.4.2 **Prediction of Load-Deflection Relationship at Working Load by Theory of Elasticity (Poulos's Method).**

Free headed piles (POULOS, 1971a)

$$y_o = I_{\rho P} \frac{P}{E_s L} + I_{\rho M} \frac{M}{E_s L^2}, \quad \ldots\ldots\ldots\ldots\ldots\ldots (29)$$

where $I_{\rho P}$ = displacement influence factors for constant E_s due to load P;

$I_{\rho M}$ = displacement influence factors for constant E_s due to moment M.

The pile flexibility factor (K_R) for constant E_s can be calculated from this equation:

$$K_R = \frac{E_P I_P}{E_s L^4}$$

POULOS (1971a) has plotted the displacement influence factors $I_{\rho P}$, $I_{\rho M}$ as the functions of pile flexibility factors K_R. The $I_{\rho P}$, $I_{\rho M}$ and K_R relationship curves were shown in Appendix C.

i) <u>Short piles</u>

For E_s = 18.43 ksc.

$$K_R = \frac{6.06 \times 10^9}{18.43 \times (290)^4} = 4.65 \times 10^{-2} > 10^{-2}$$

It is a relatively stiff pile.

$$\frac{L}{D} = 290/18 = 16.11$$

from Appendix C

$I_{\rho P} = 4$, $I_{\rho M} = 6.5$

Let assume P = 544 kg.

y_o = 0.512 cm.

For E_s = 104 ksc.

$$K_R = \frac{6.06 \times 10^9}{104 \times (290)^4} = 8.24 \times 10^{-3} < 10^{-2}$$

It is a relatively flexible pile.

$I_{\rho P} = 5$, $I_{\rho M} = 11$

y_o = 0.122 cm.

ii) <u>Long piles</u>

For E_s = 18.43 ksc.

$$K_R = \frac{2.98 \times 10^9}{18.43 \times (600)^4} = 1.25 \times 10^{-3} < 10^{-2}$$

It is a relatively flexible pile.

$$\frac{L}{D} = \frac{600}{18} = 33.33$$

From Appendix C

$I_{\rho P} = 7$, $I_{\rho M} = 22.2$

Let assume $P = 4\ 35$ kg.

$y_o = 0.406$ cm.

For $E_s = 104$ ksc.

$$K_R = \frac{2.98 \times 10^9}{104 \times (600)^4} = 2.21 \times 10^{-4}$$

$I_{\rho P} = 10.5, \quad I_{\rho M} = 60$

$y_o = 0.136$ cm.

4.4.3 <u>Prediction of Deflections and Bending Moments - along the Long Pile below the Ground Surface</u>

From Eq. (A-13a)

$$y_{(x)} = \frac{e^{-\beta x}}{2\beta^3 E I}\left(P\cos\beta x + \beta M(\cos\beta x - \sin\beta x)\right)$$

For $P = 435$ kg.

Let $X = 100$ cm.

$E_s = 18.43$ ksc.

$\beta = 6.17 \times 10^{-3}$ cm.$^{-1}$

$\beta X = 0.62$

$EI = 2.98 \times 10^9$ kg-cm^2

$y_{(x)} = 0.16$ cm.

From Eq. (A-13c)

$$M_{(x)} = \frac{-e^{-\beta x}}{\beta}\left(P\sin\beta x + \beta M(\cos\beta x + \sin\beta x)\right)$$

Let $X = 100$ cm.

$\beta X = 0.62$

$M_{(x)} = -51218$ kg-cm.

4.4.4 Load-Deflection at Ground Surface The relationships of load-deflection at ground surface of all piles are shown from Figs. 11 to 24 and summary of all relationships are collected in Tables 7 to 8.

4.4.5 Effect of Repeated Loading The effect of repeated loading on laterally loaded piles are shown in Figs. 25 to 26.

4.5 Ultimate Lateral Resistance

4.5.1 Prediction of Ultimate Lateral Resistance of Piles by Brom's Method

(a) Short Piles

$L = 290$ cm , $D = 18$ cm , $e = 46$ cm.

From Eqs. (25) to (28)

$$f = \frac{P}{9c_u D} \quad \text{.....................(a)}$$

$$M_{max}^{pos} = P(e + 1.5D + 0.5f) = 2.25\, c_u D g^2 \text{....(b)}$$

$$L = (1.5D + f + g) \quad \text{............(c)}$$

Substituting Eq. (a) and Eq. (c) into Eq. (b) yields

$$9c_u D\, f(e + 1.5D + 0.5f) = 2.25\, c_u D(L - 1.5\, D - f)^2$$

$$0.25\, f^2 + 205\, f - 17292 = 0$$

$$f = \frac{-205 \pm\sqrt{205^2 + 4 \times 0.25 \times 17292}}{2 \times 0.25}$$

$$= 77.10 \text{ cm.}$$

$$P_{ult} = 9c_u Df$$

$$= 3247 \text{ kg.}$$

$$M_{max}^{pos} = 3247(46 + 1.5 \times 18 + 0.5 \times 77.10)$$

$$= 362{,}203 \text{ kg-cm.}$$

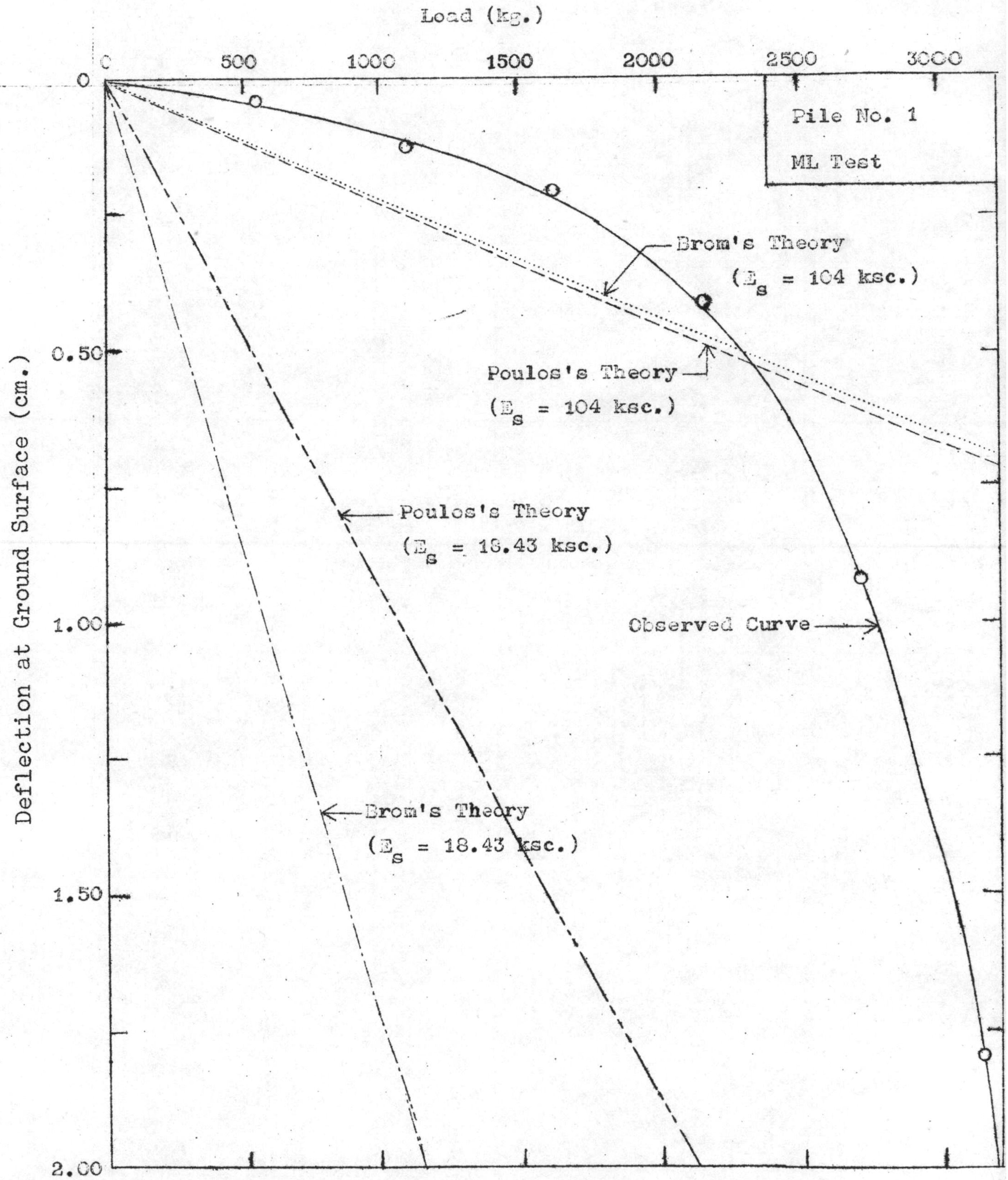

Fig. 11 - Comparisons Between Observed and Computed Load-Deflection Curves

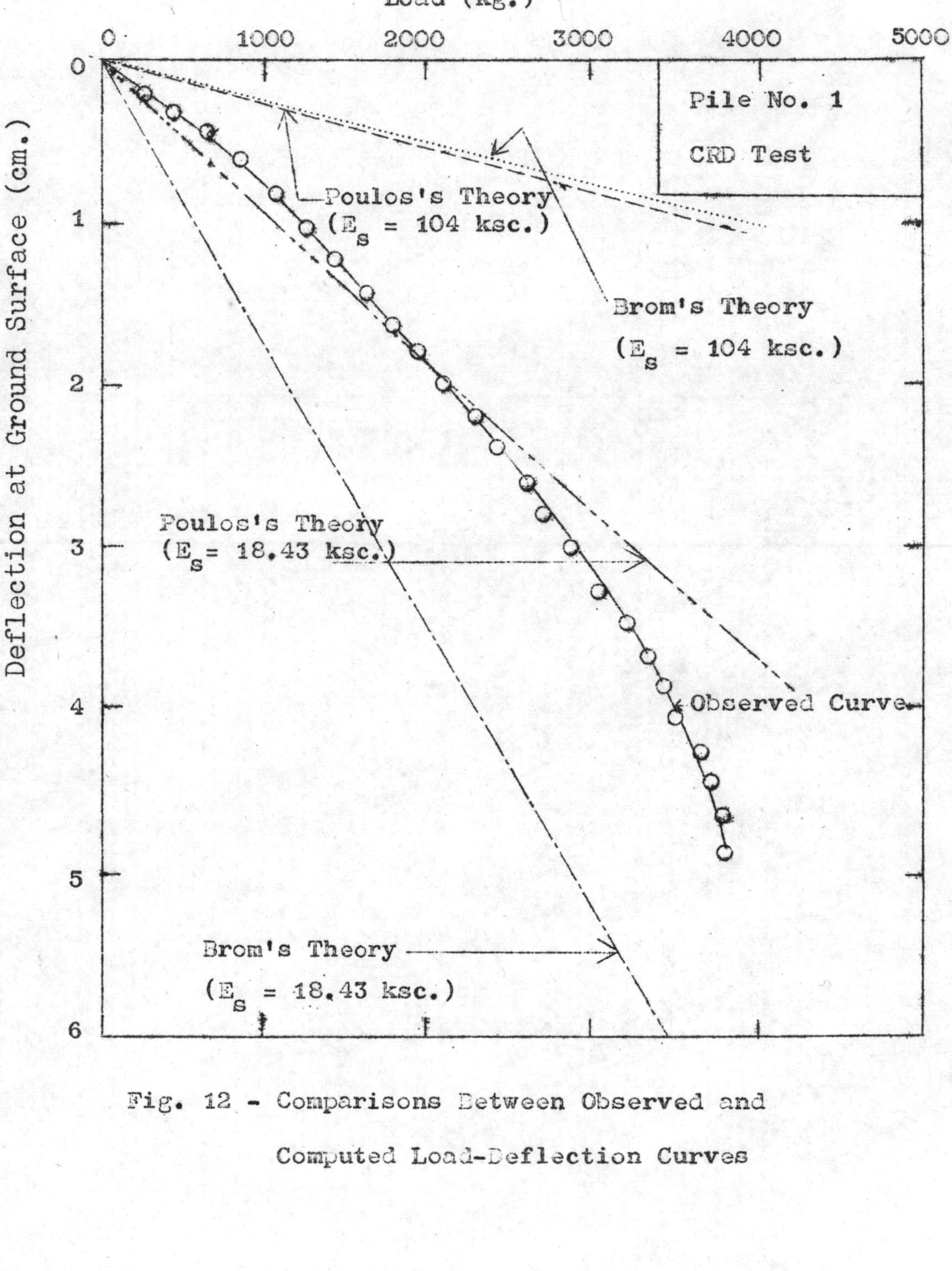

Fig. 12 - Comparisons Between Observed and Computed Load-Deflection Curves

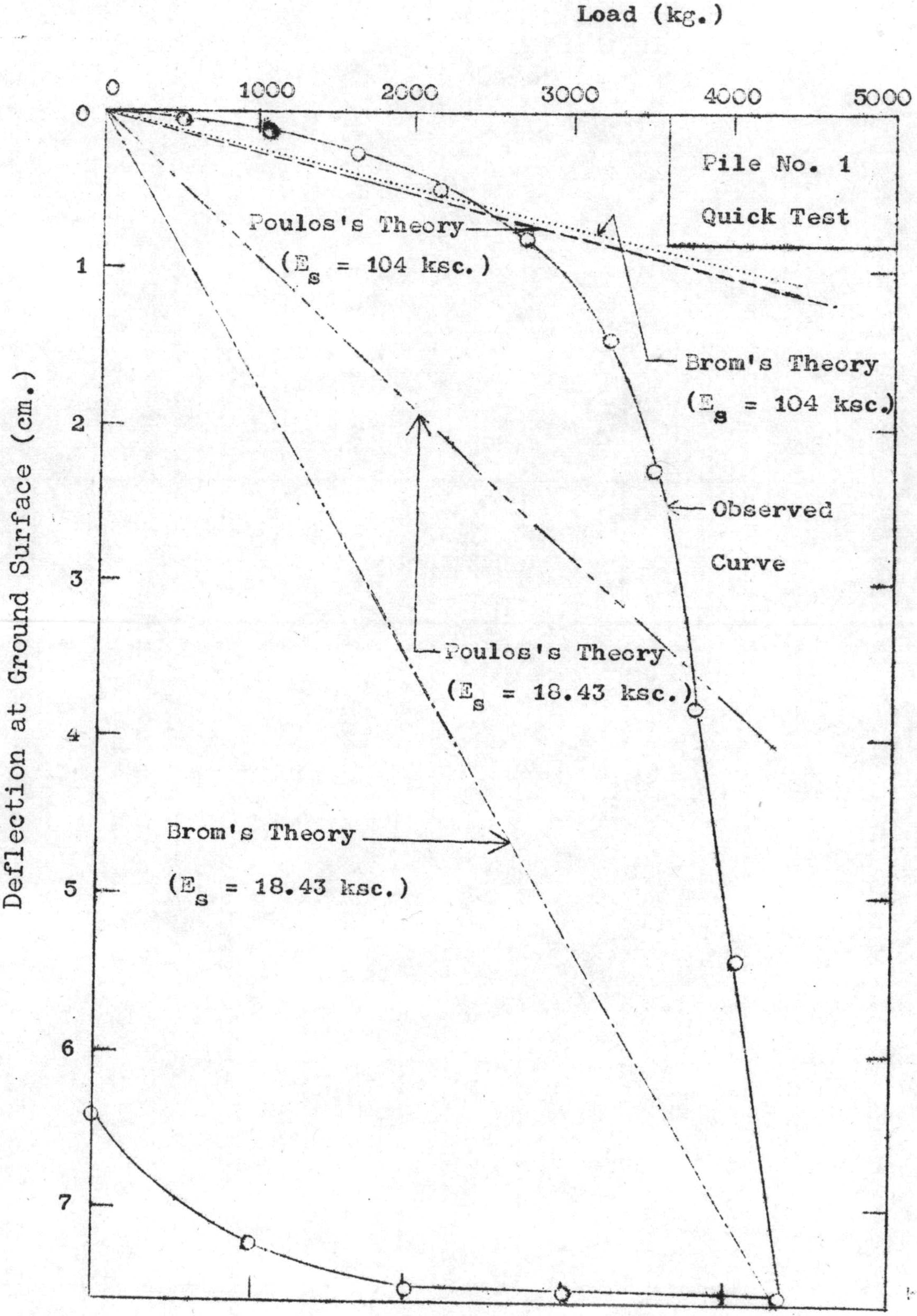

Fig. 13 - Comparisons Between Observed and Computed Load-Deflection Curves

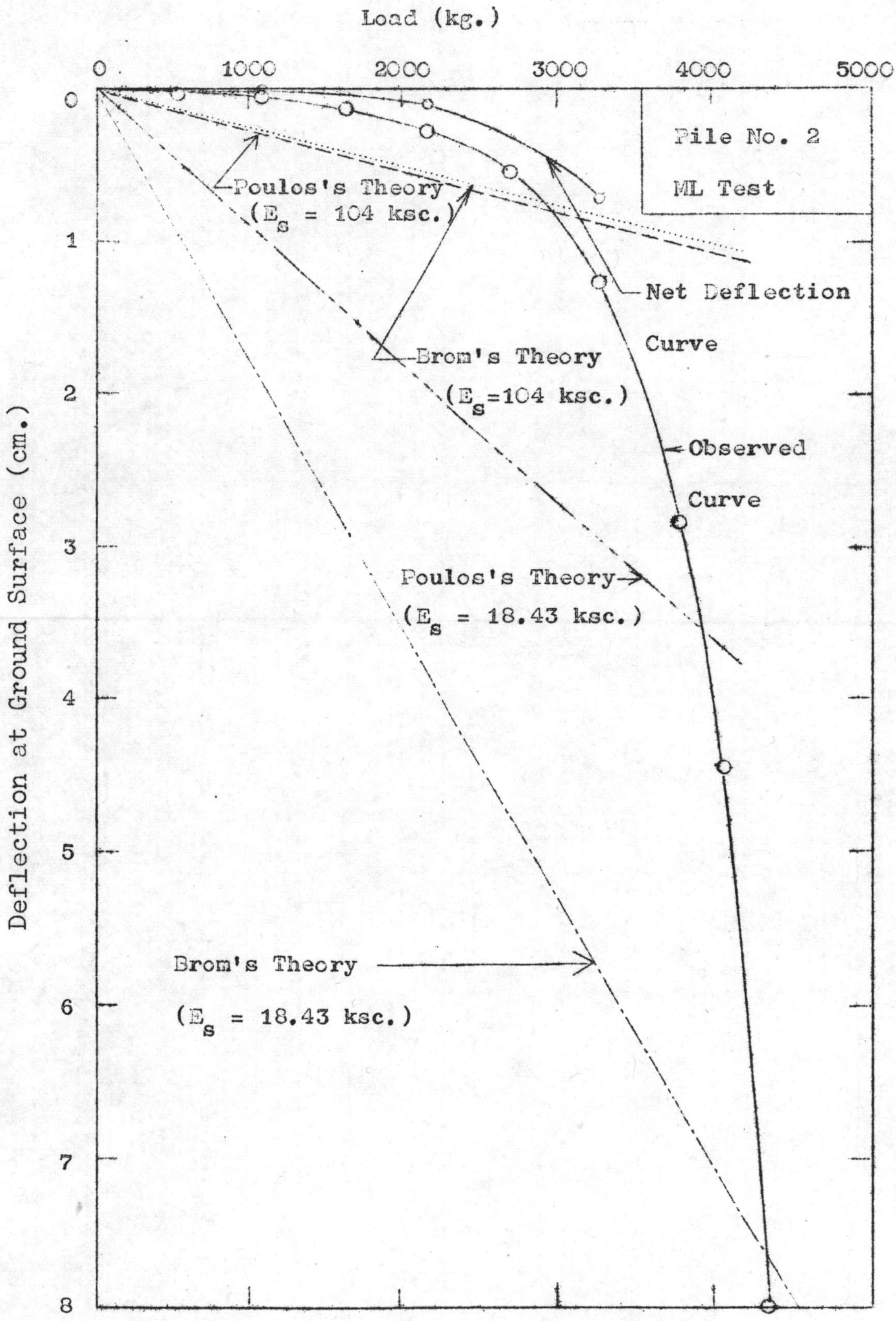

Fig. 14 - Comparisons Between Observed and Computed Load-Deflection Curves

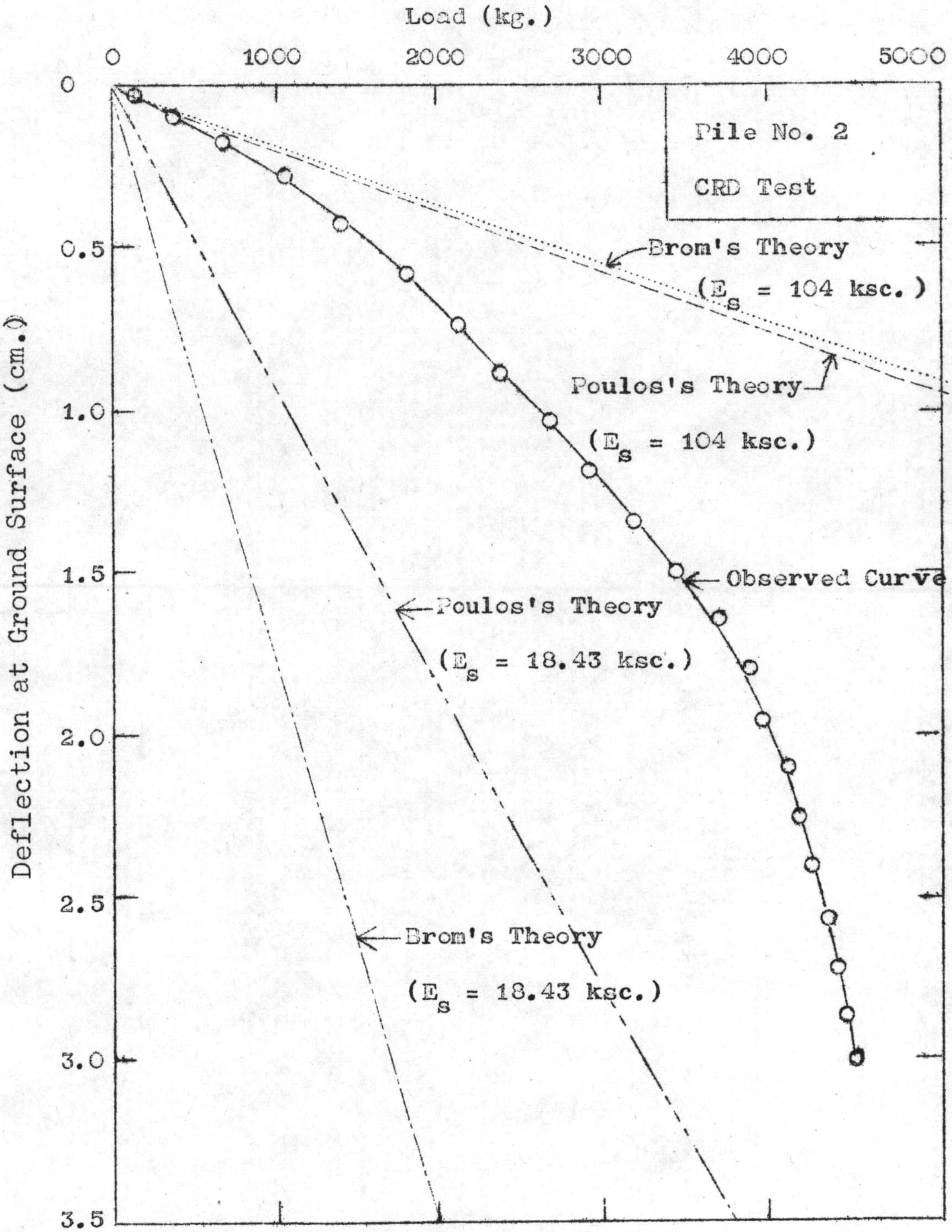

Fig. 15 - Comparisons Between Observed and Computed Load-Deflection Curves

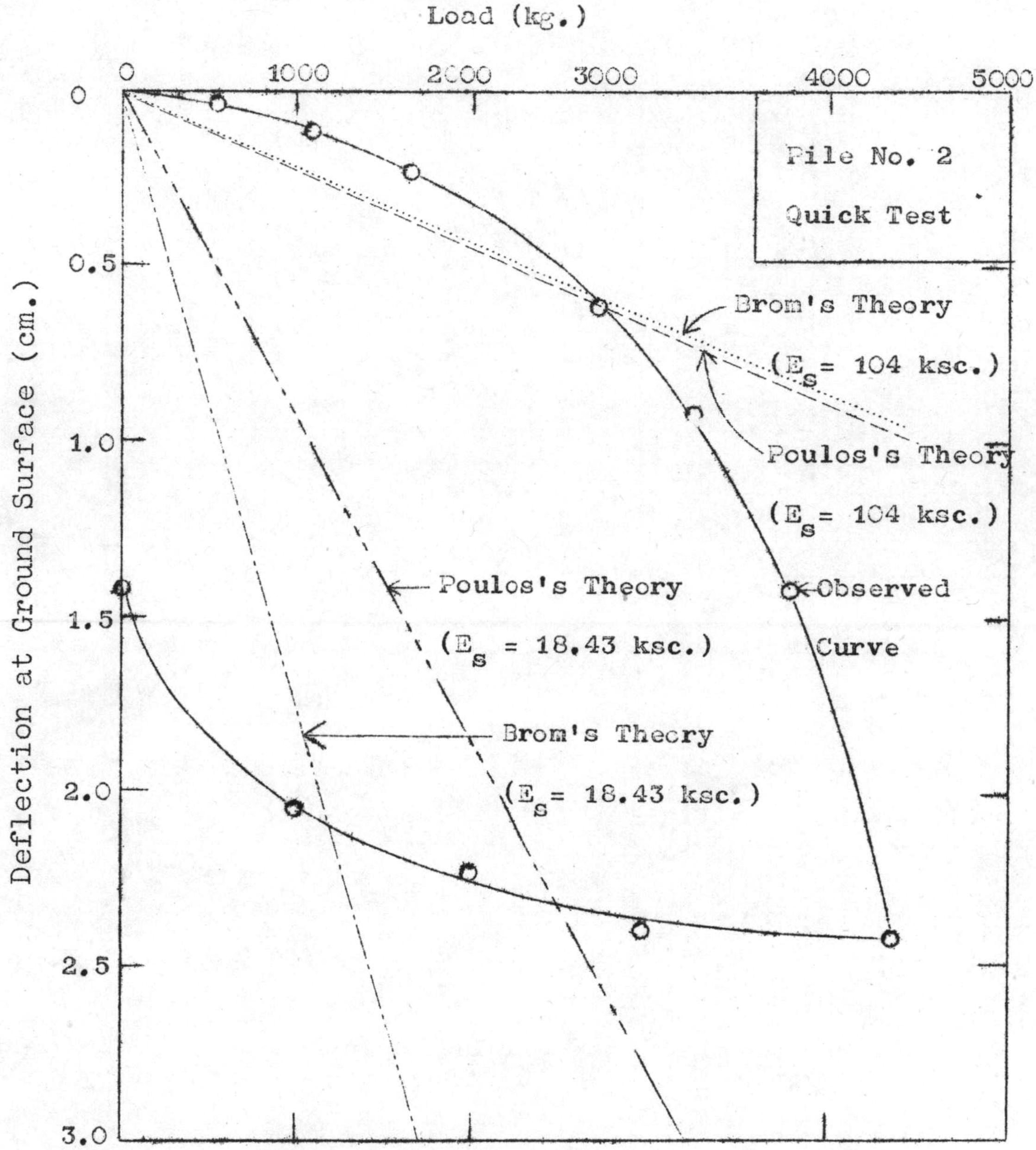

Fig. 16 - Comparisons Between Observed and Computed Load-Deflection Curves

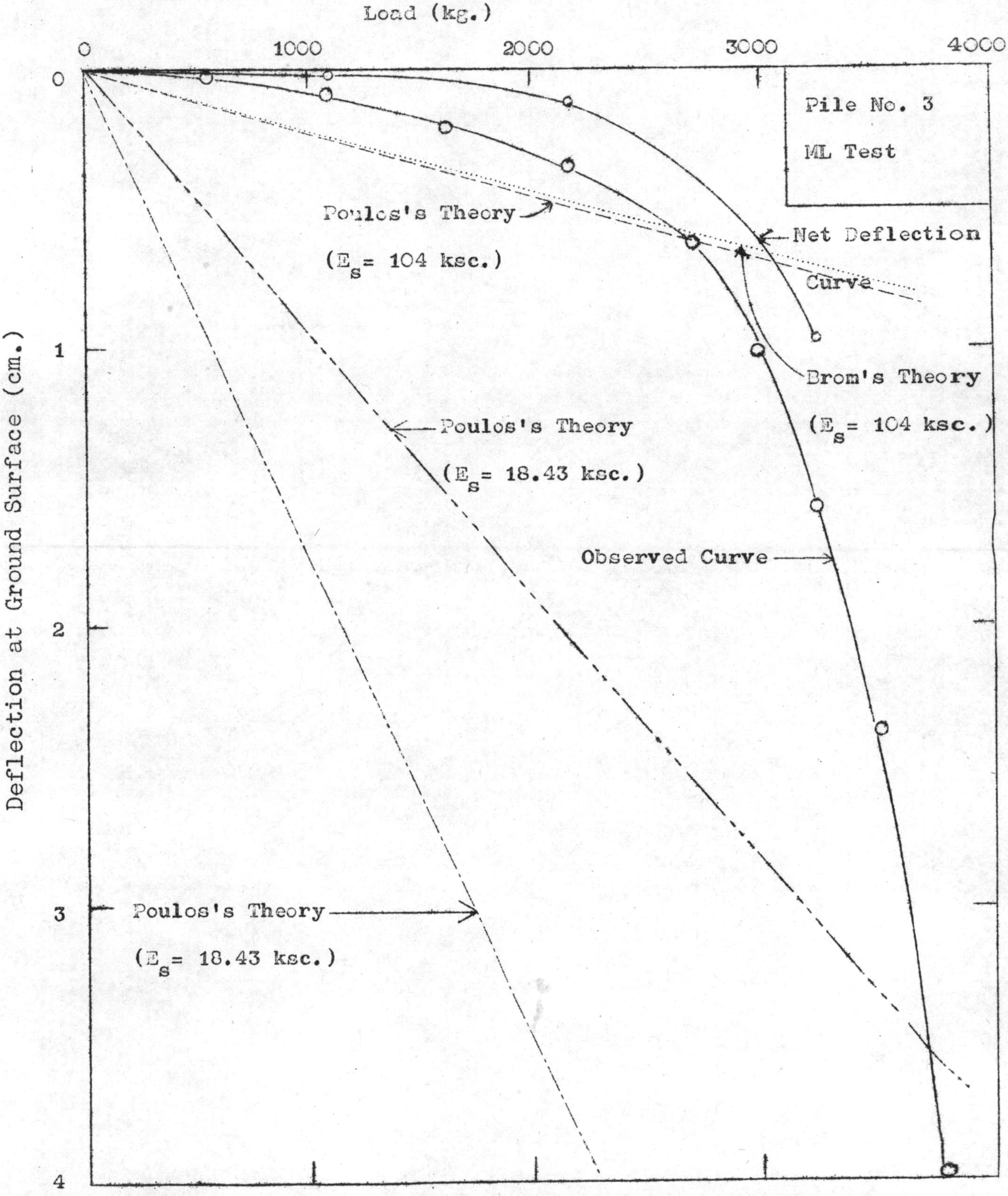

Fig. 17 - Comparisons Between Observed and Computed

Load-Deflection Curves

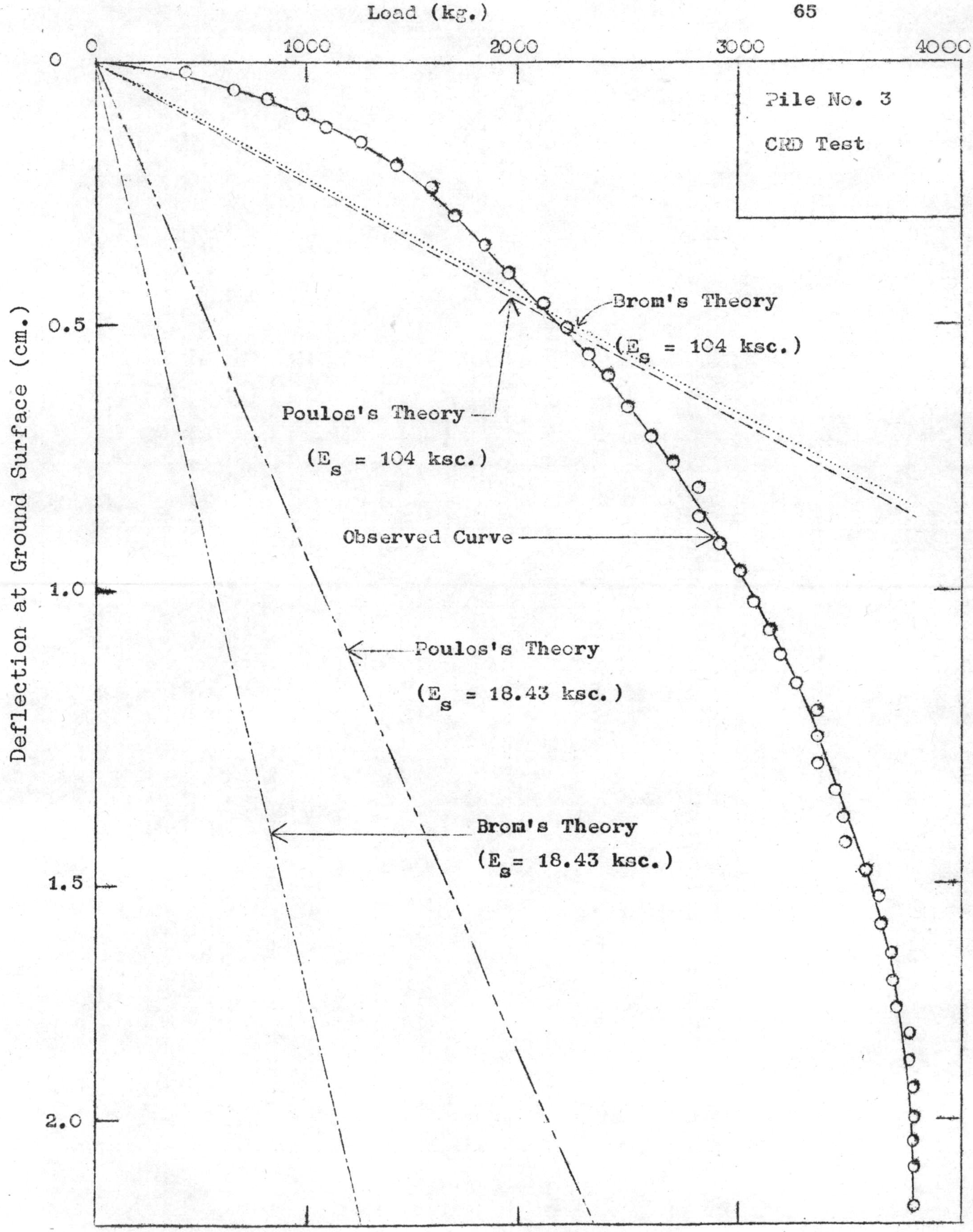

Fig. 18 - Comparisons Between Observed and Computed Load-Deflection Curves

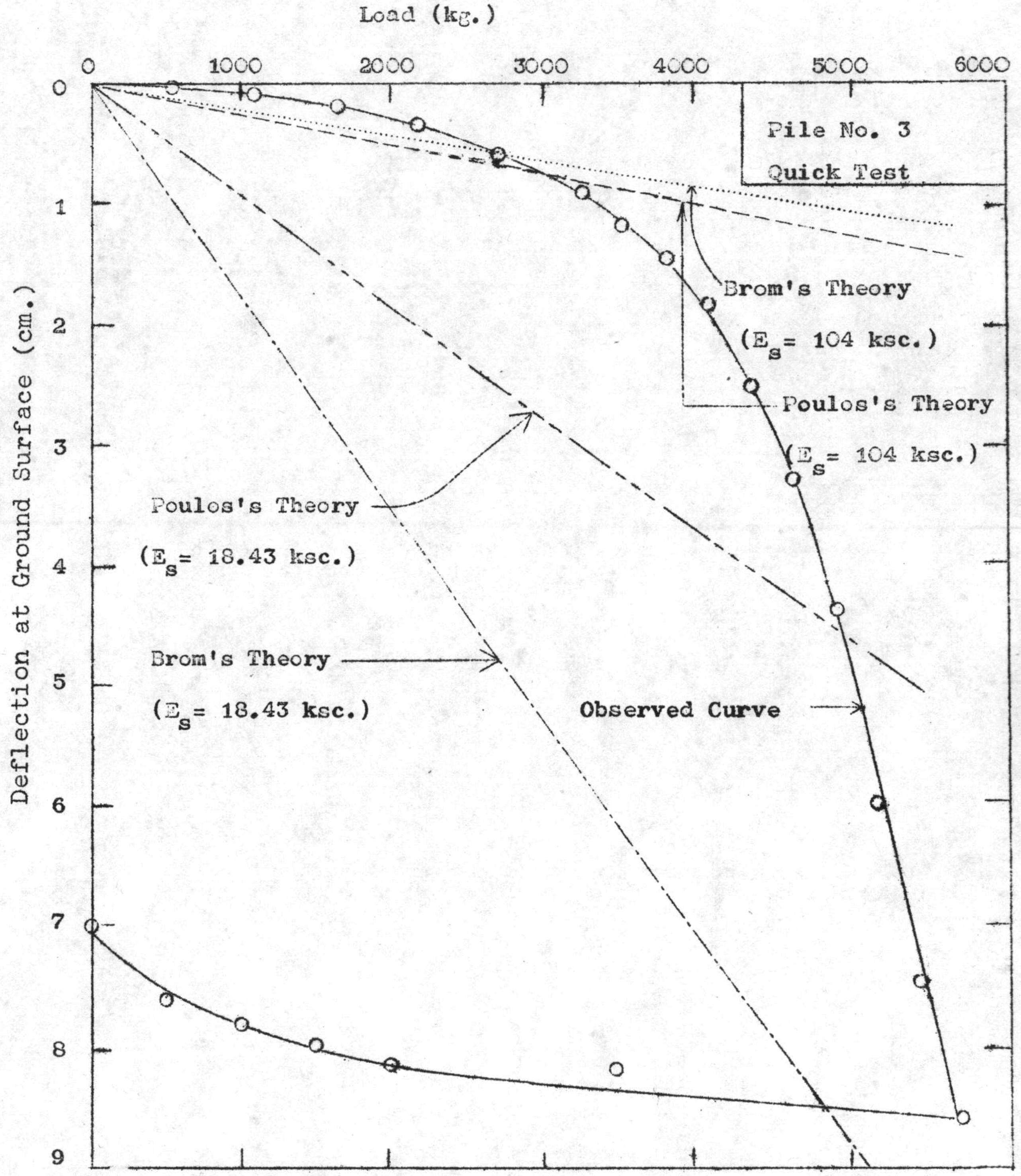

Fig. 19 - Comparisons Between Observed and Computed Load-Deflection Curves

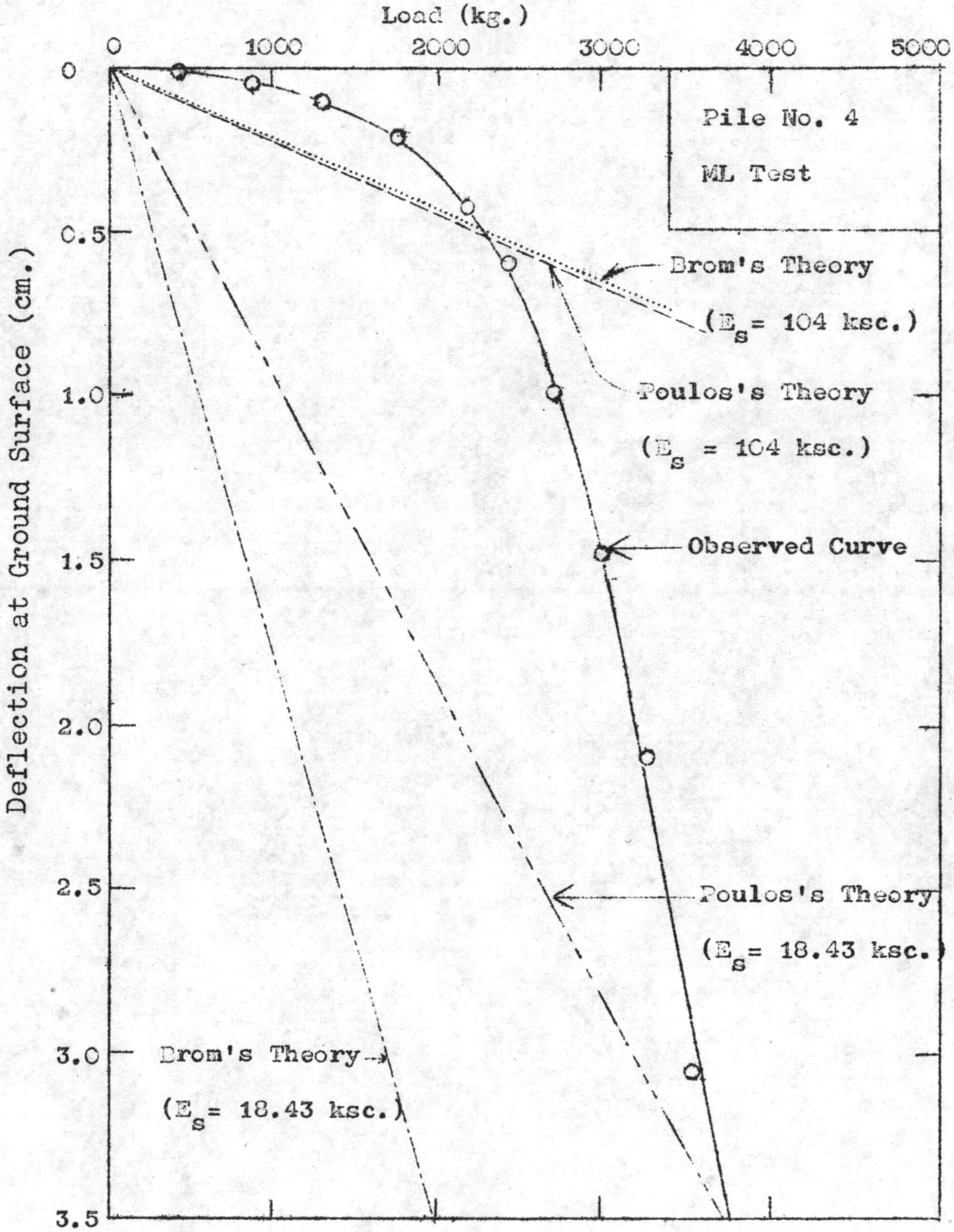

Fig. 20 - Comparisons Between Observed and Computed Load-Deflection Curves

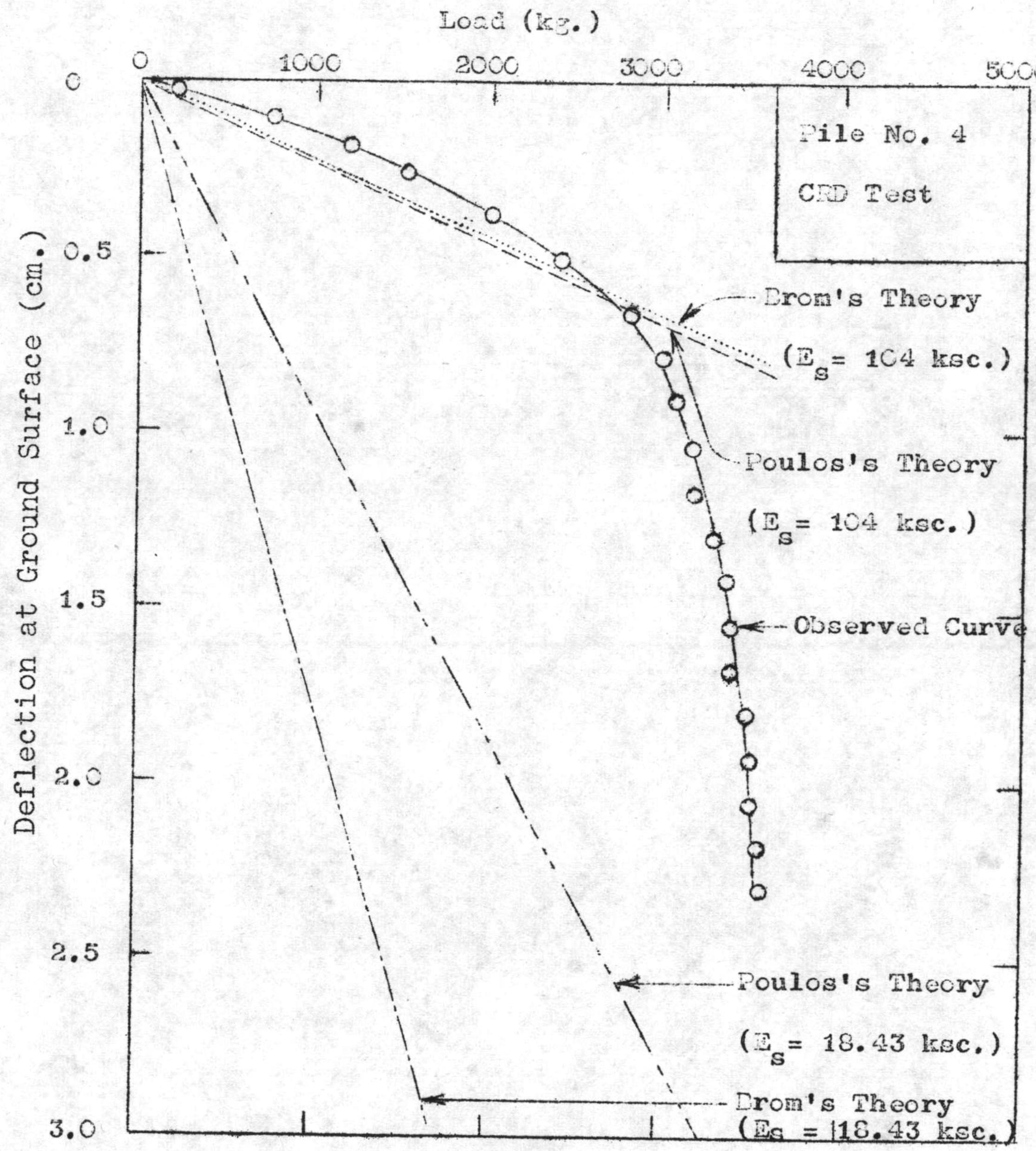

Fig. 21 - Comparisons Between Observed and Computed Load-Deflection Curves

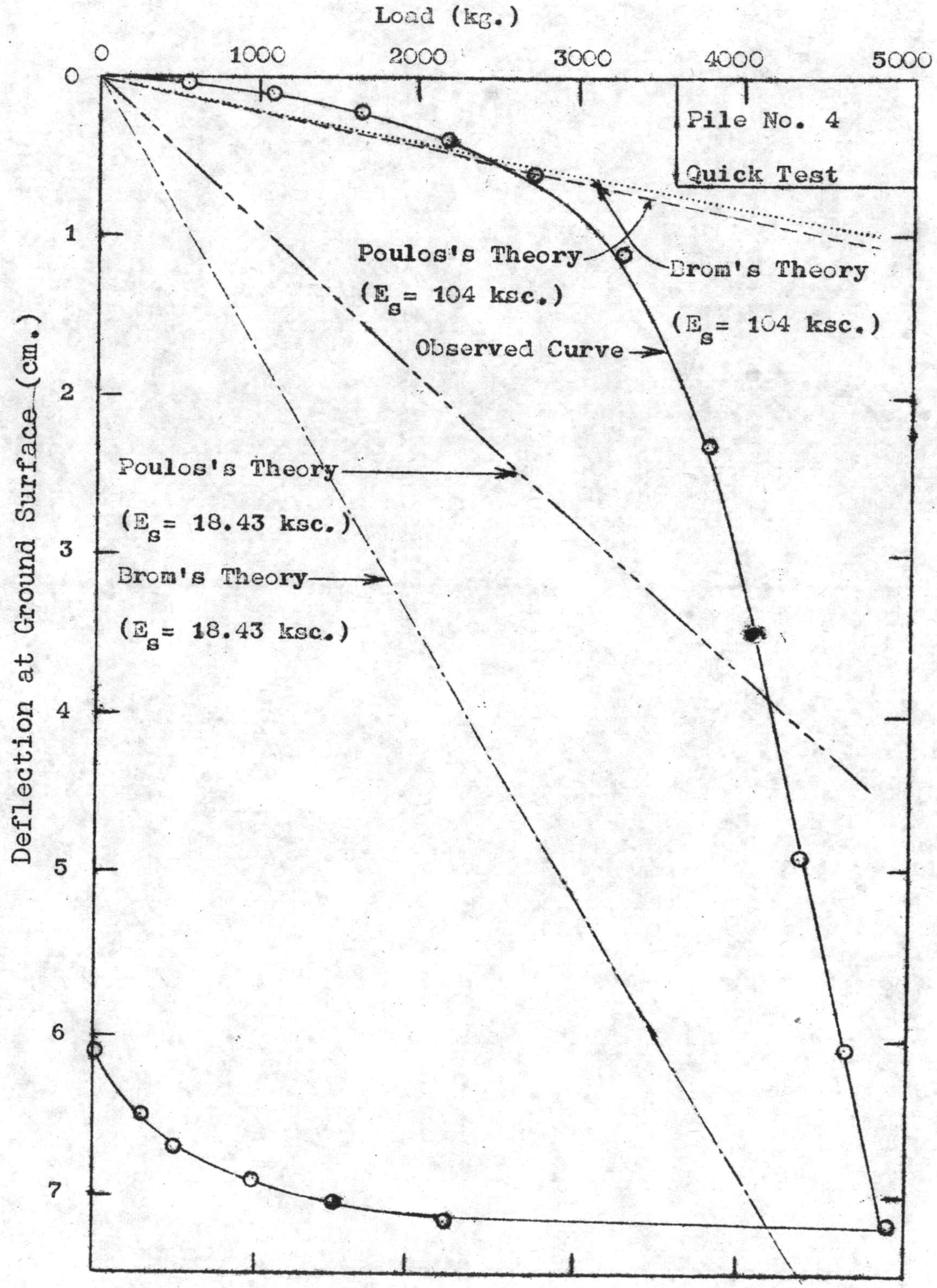

Fig. 22 - Comparisons Between Observed and Computed Load-Deflection Curves

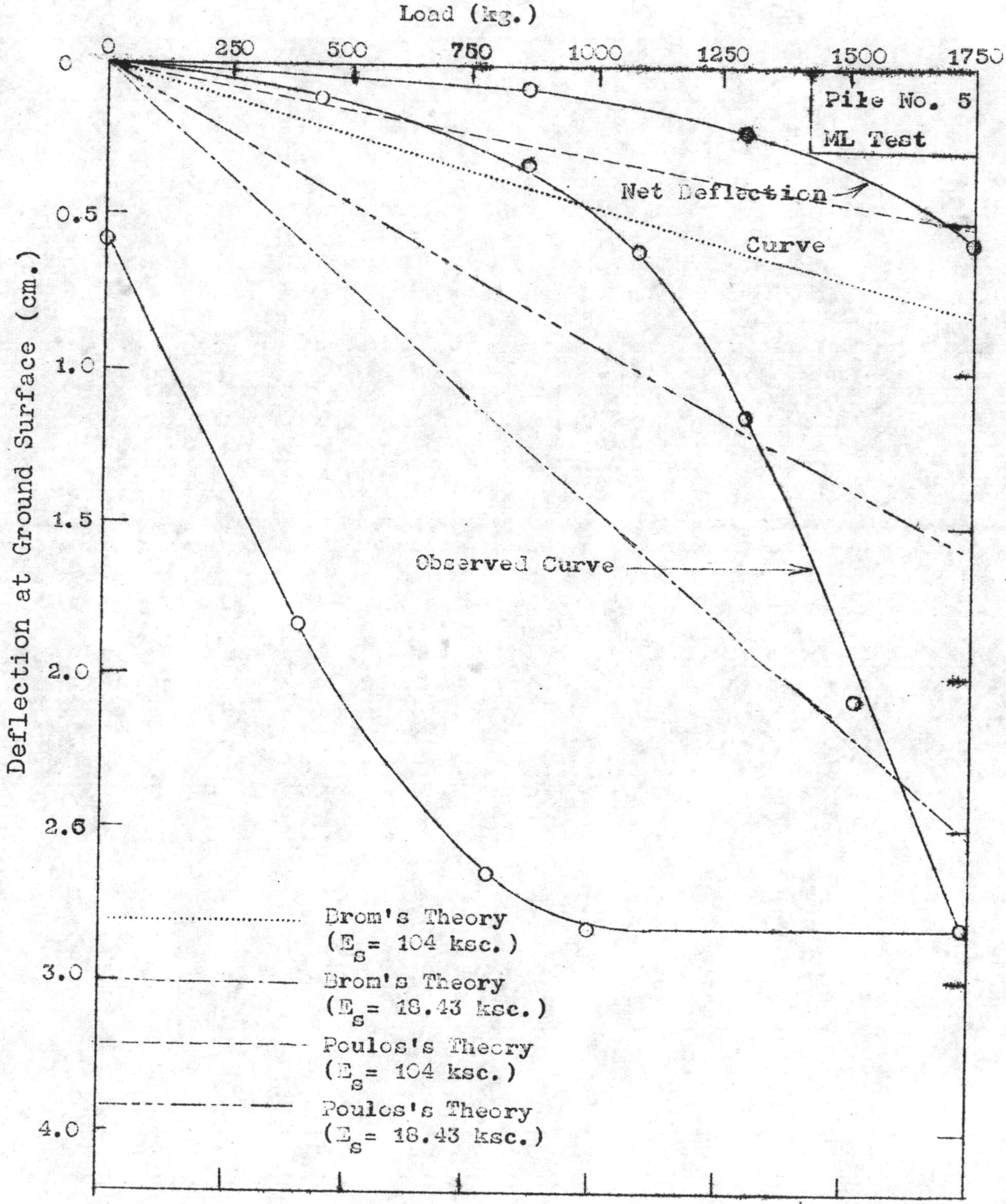

Fig. 23 - Comparisons Between Observed and Computed Load-Deflection Curves

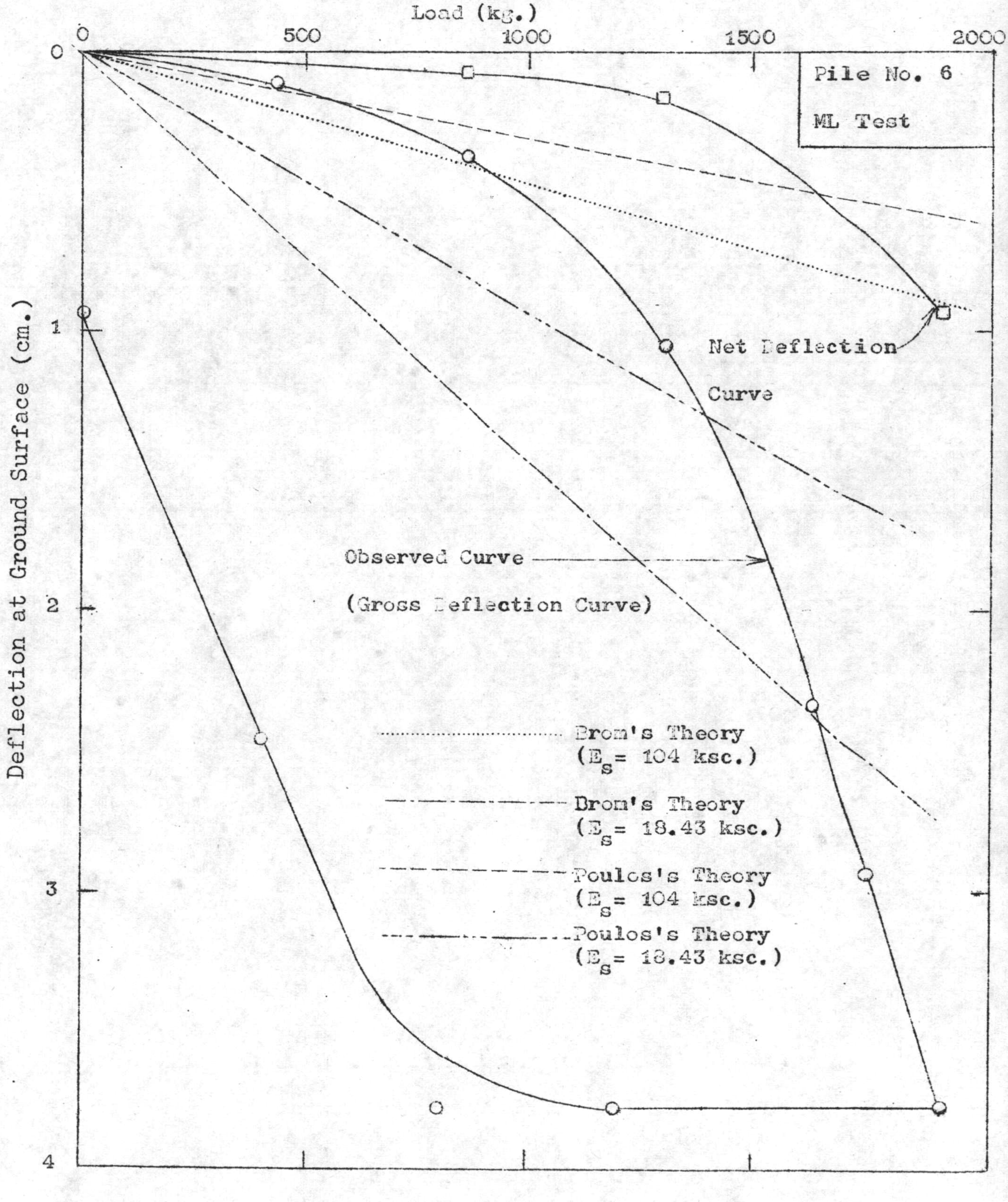

Fig. 24 - Comparisons Between Observed and Computed Load-Deflection Curves

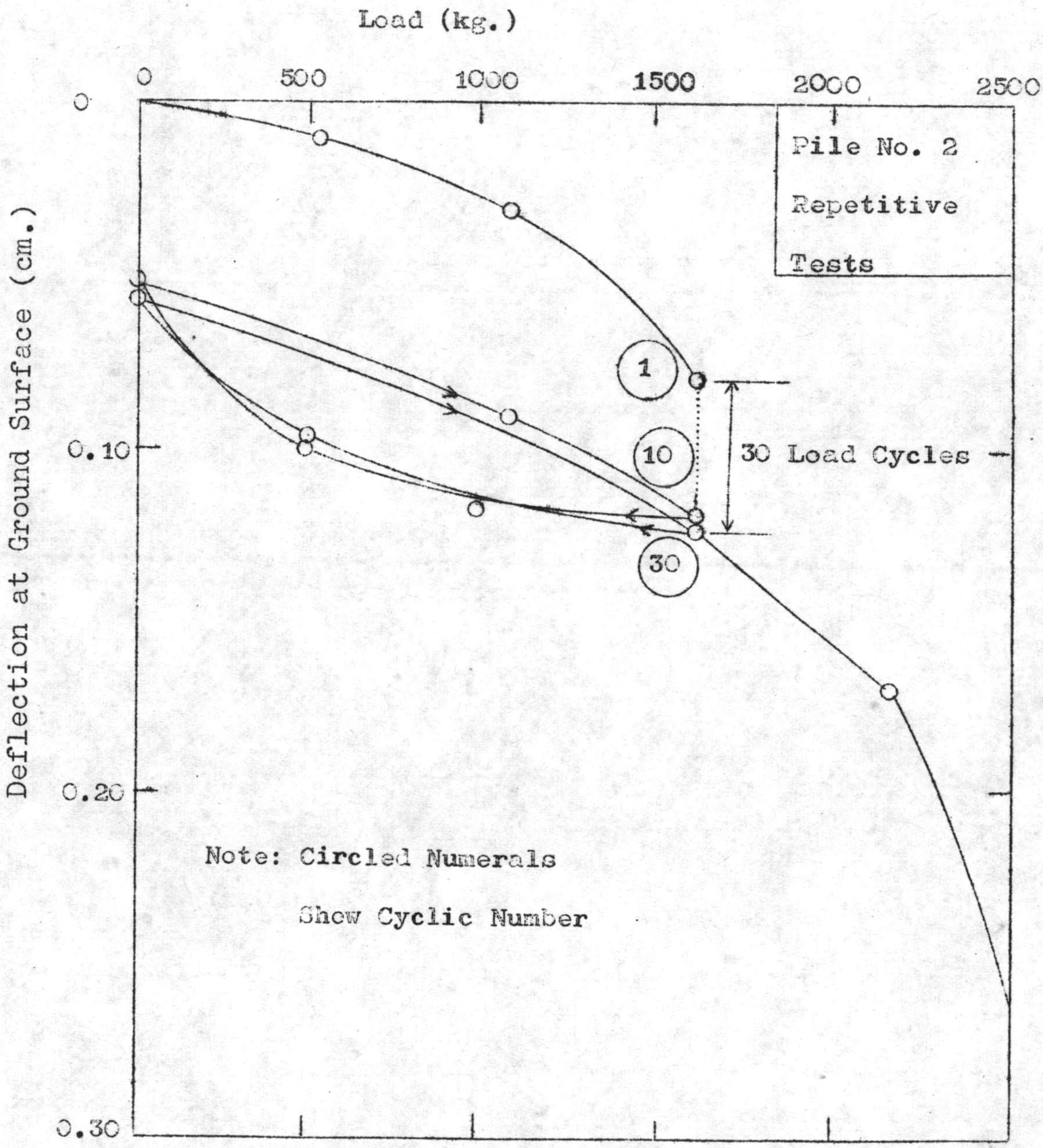

Fig. 25 - Load-Deflection Relationship from

Repeated Loading Test

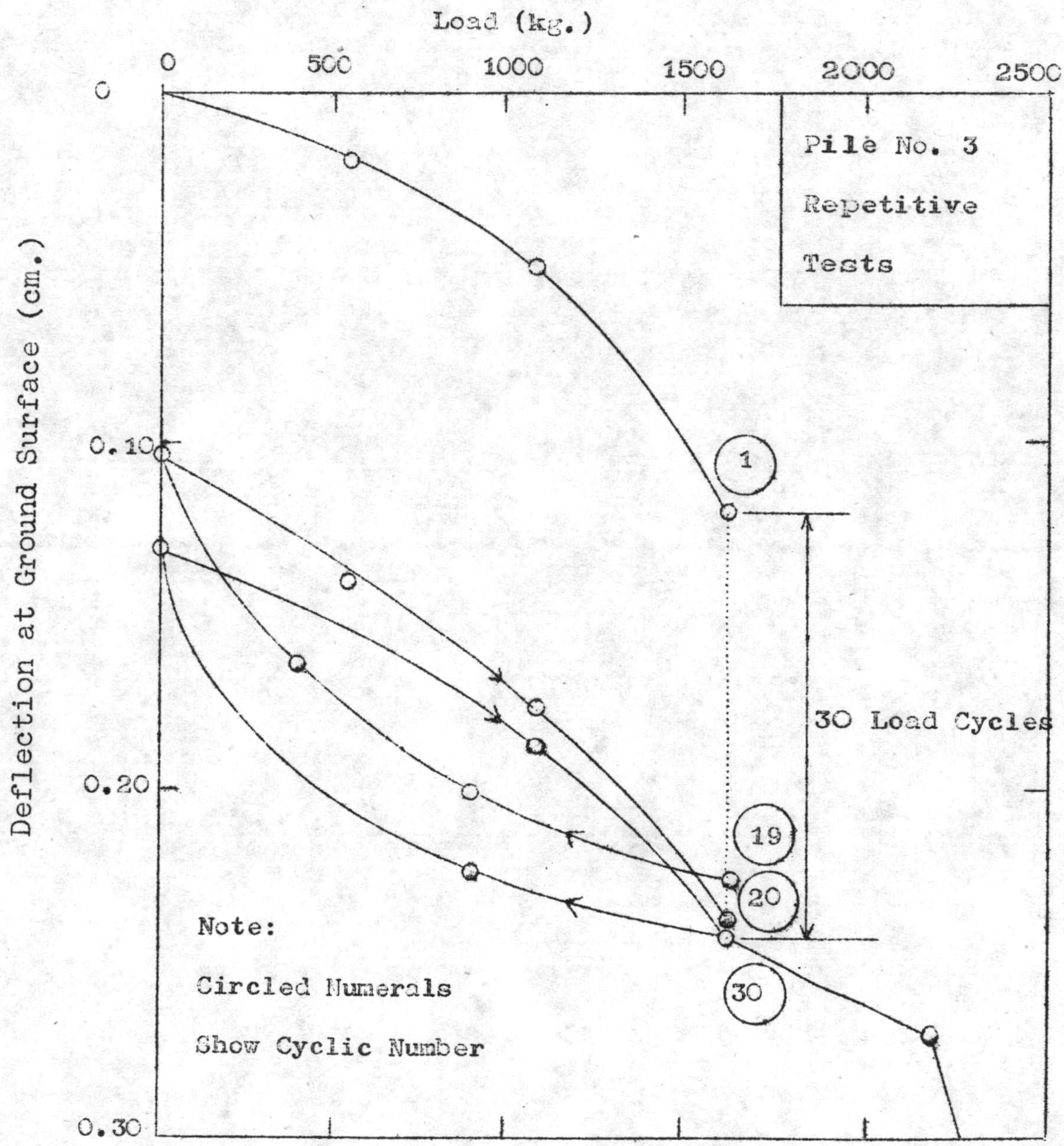

Fig. 26 - Load-Deflection Relationship from Repeated Loading Test

Table 7 - Lateral Deflection for E_s = 18.43 ksc.

Pile No.	Testing Methods	Applied Load P, in kg.	Measured Lateral Deflection y_{test}, in cm.	Brom's Approach		Poulos's Approach	
				y_{calc} in cm.	Ratio y_{calc}/y_{test}	y_{calc} in cm.	Ratio y_{calc}/y_{test}
1	ML	544	0.047	0.943	20.06	0.512	10.89
	ML	1088	0.129	1.886	14.62	1.024	7.94
	ML	1631	0.212	2.827	13.33	1.535	7.24
	CRD	544	0.250	0.943	3.77	0.512	2.05
	CRD	1088	0.690	1.886	2.73	1.024	1.48
	CRD	1631	1.310	2.827	2.16	1.535	1.17
	Quick	544	0.045	0.943	20.96	0.512	11.38
	Quick	1088	0.130	1.886	14.51	1.024	7.88
	Quick	1631	0.267	2.827	10.59	1.535	5.75
2	ML	544	0.017	0.943	55.47	0.512	30.12
	ML	1088	0.041	1.886	46.00	1.024	24.98
	ML	1631	0.126	2.827	22.44	1.535	12.18
	CRD	544	0.140	0.943	6.74	0.512	3.66
	CRD	1088	0.300	1.886	6.29	1.024	3.41
	CRD	1631	0.500	2.827	5.65	1.535	3.07
	Quick	544	0.039	0.943	24.18	0.512	13.13
	Quick	1088	0.119	1.886	15.85	1.024	8.61
	Quick	1631	0.234	2.827	12.08	1.535	6.56

Table 7 - Lateral Deflection for E_s = 18.43 ksc.

Pile No.	Testing Methods	Applied Load P, in kg.	Measured Lateral Deflection y_{test}, in cm.	Brom's Approach		Poulos's Approach	
				y_{calc} in cm.	Ratio y_{calc}/y_{test}	y_{calc} in cm.	Ratio y_{calc}/y_{test}
3	ML	544	0.031	0.943	30.42	0.512	16.52
	ML	1088	0.093	1.886	20.28	1.024	11.01
	ML	1631	0.210	2.827	13.46	1.535	7.31
	CRD	544	0.040	0.943	23.58	0.512	12.80
	CRD	1088	0.125	1.886	15.09	1.024	8.19
	CRD	1631	0.270	2.827	10.47	1.535	5.69
	Quick	544	0.036	0.943	26.19	0.512	14.22
	Quick	1088	0.099	1.886	19.05	1.024	10.34
	Quick	1631	0.206	2.827	13.72	1.535	7.45
4	ML	435	0.022	0.754	34.27	0.409	18.59
	ML	870	0.059	1.508	25.56	0.819	13.88
	ML	1305	0.110	2.262	20.56	1.228	11.16
	ML	1631	0.170	2.827	16.63	1.535	9.03
	CRD	435	0.060	0.754	12.57	0.409	6.82
	CRD	870	0.120	1.508	12.57	0.819	6.83
	CRD	1305	0.210	2.262	10.77	1.228	5.85
	CRD	1631	0.280	2.827	10.10	1.535	5.48
	Quick	544	0.045	0.943	20.96	0.512	11.38
	Quick	1088	0.114	1.886	16.53	1.024	8.98
	Quick	1631	0.218	2.827	12.97	1.535	7.04
5	ML	435	0.119	0.640	5.378	0.406	3.412
	ML	750	0.240	1.103	4.596	0.700	2.917
	ML	435	0.120	0.640	5.333	0.406	3.383
6	ML	750	0.300	1.103	3.677	0.700	2.333

Table 8 - Lateral Deflection for E_s = 104 ksc.

Pile No.	Testing Methods	Applied Load P, in kg.	Measured Lateral Deflection y_{test}, in cm.	Brom's Approach		Poulos's Approach	
				y_{calc} in cm.	Ratio y_{calc}/y_{test}	y_{calc} in cm.	Ratio y_{calc}/y_{test}
1	ML	544	0.047	0.120	2.55	0.122	2.60
	ML	1088	0.129	0.240	1.86	0.244	1.89
	ML	1631	0.212	0.360	1.70	0.366	1.73
	CRD	544	0.250	0.120	0.48	0.122	0.49
	CRD	1088	0.690	0.240	0.35	0.244	0.35
	CRD	1631	1.310	0.360	0.27	0.366	0.28
	Quick	544	0.045	0.120	2.67	0.122	2.71
	Quick	1088	0.130	0.240	1.85	0.244	1.88
	Quick	1631	0.267	0.360	1.35	0.366	1.37
2	ML	544	0.017	0.120	7.06	0.122	7.18
	ML	1088	0.041	0.240	5.85	0.244	5.95
	ML	1631	0.126	0.360	2.86	0.366	2.90
	CRD	544	0.140	0.120	0.86	0.122	0.87
	CRD	1088	0.300	0.240	0.80	0.244	0.81
	CRD	1631	0.500	0.360	0.72	0.366	0.73
	Quick	544	0.039	0.120	3.08	0.122	3.13
	Quick	1088	0.119	0.240	2.02	0.244	2.05
	Quick	1631	0.234	0.360	1.54	0.366	1.56
3	ML	544	0.031	0.120	3.87	0.122	3.94
	ML	1088	0.093	0.240	2.58	0.244	2.62
	ML	1631	0.210	0.360	1.71	0.366	1.74
	CRD	544	0.040	0.120	3.00	0.122	3.05
	CRD	1088	0.125	0.240	1.92	0.244	1.95

Table 8 - Lateral Deflection for E_s = 104 ksc.

Pile No.	Testing Methods	Applied Load P, in kg.	Measured Lateral Deflection y_{test}, in cm.	Brom's Approach		Poulos's Approach	
				y_{calc} in cm.	Ratio y_{calc}/y_{test}	y_{calc} in cm.	Ratio y_{calc}/y_{test}
3	CRD	1631	0.270	0.360	1.33	0.366	1.36
	Quick	544	0.036	0.120	3.33	0.122	3.39
	Quick	1088	0.099	0.240	2.42	0.244	2.46
	Quick	1631	0.206	0.360	1.75	0.366	1.78
4	ML	435	0.022	0.096	4.36	0.098	4.45
	ML	870	0.059	0.192	3.25	0.195	3.31
	ML	1305	0.110	0.288	2.62	0.293	2.66
	ML	1631	0.170	0.360	2.12	0.366	2.15
	CRD	435	0.060	0.096	1.60	0.098	1.63
	CRD	870	0.120	0.192	1.60	0.195	1.63
	CRD	1305	0.210	0.288	1.37	0.293	1.40
	CRD	1631	0.280	0.360	1.29	0.366	1.31
	Quick	544	0.045	0.120	2.67	0.122	2.71
	Quick	1088	0.114	0.240	2.11	0.244	2.14
	Quick	1631	0.218	0.360	1.65	0.366	1.68
5	ML	250	0.060	0.121	2.02	0.078	1.30
	ML	435	0.119	0.210	1.76	0.136	1.14
	ML	750	0.240	0.362	1.51	0.234	0.98
6	ML	250	0.060	0.121	2.02	0.078	1.30
	ML	435	0.120	0.210	1.75	0.136	1.13
	ML	750	0.300	0.362	1.21	0.234	0.78

(b) Long piles

$L = 600$ cm., $D = 18$ cm , $e = 90$ cm.

$$d' = \frac{2 \times 2 + 2 \times 3.5}{4} = 2.75 \text{ cm.}$$

$$d = 18 - 2.75 \times 2 = 12.5 \text{ cm.}$$

$$A_s = 4 \times 0.13 = 0.52 \text{ cm.}$$

$$f_y = 17{,}500 \text{ ksc} , f'_c = 448 \text{ ksc.}$$

i) Ultimate moment of piles

$$M_u = \phi \left[A_s f_y \left(d - ½ \frac{A_s f_y}{0.85 f'_c b} \right) \right]$$

$$= 107{,}708 \text{ kg-cm.}$$

Let $M_u = M_{yield}$ of the long pile.

From Eq. (26)

$$M^{Pos}_{max} = P(e + 1.5D + 0.5f)$$

$$107{,}708 = P(90 + 1.5 \times 18 + 0.5xf)$$

From Eq. (25) $f = \dfrac{P}{9c_u D}$

Substituting Eq. (25) into Eq. (26) yields

$$P_{ult} = 847 \text{ kg.}$$

$$f = 20.11 \text{ cm.}$$

ii) Cracking moment of piles

Cracking stress = $0.1\ f'_c$ = 44.80 ksc.

Prestressing stress = $\frac{8 \times 1350}{18 \times 18}$ = 33.33 ksc.

External stress at cracking = 78.13 ksc.

I = 8,748 cm^4.

S = $\frac{I}{c}$ = 972 cm^3.

External moment = 75,942 kg-cm.

For pile No. 5

Cracking load = 1196 kg.

Cracking moment = 1196 x 90 = 107,640 kg-cm.

$$\frac{\text{Observed cracking moment}}{\text{Calculated cracking moment}} = \frac{107,640}{75,942} = 1.42$$

For pile No. 6

Cracking load = 1305 kg.

Cracking moment = 117,450 kg-cm.

$$\frac{\text{Observed cracking moment}}{\text{Calcalated cracking moment}} = \frac{117,450}{75,942} = 1.55$$

It should be noted that the cracking was started about 10 cm. above ground surface and made 45° with vertical direction. It is shown in Appendix D.

4.5.2 Ultimate Lateral Resistance All of the ultimate lateral resistances determined from load-deflection curves (Figs. 11 to 24) are tabulated in Tables 9 to 13.

The details of ultimate load and deflection criteria are shown on pp. 35 - 36.

Table 9 - Ultimate Load for Pile No. 1

Criteria	ML Test		CRD Test		Quick Test	
No.	Ultimate Load (kg.)	Ratio P_{test}/P_{calc}	Ultimate Load (kg.)	Ratio P_{test}/P_{calc}	Ultimate Load (kg.)	Ratio P_{test}/P_{calc}
1	2650	0.82	3540	1.09	3340	1.03
2	1800	0.55	3440	1.06	1680	0.52
3	1800	0.55	3440	1.06	1680	0.52
4	1800	0.55	3440	1.06	1680	0.52
5	500	0.15	-	-	1000	0.31
6	1000	0.31	-	-	1100	0.34
7	-	-	-	-	-	-
8	-	-	-	-	-	-
9	2480	0.76	860	0.26	2500	0.77
10	3120	0.96	1980	0.61	3400	1.05

Table 10 - Ultimate Load for Pile No. 2

Criteria No.	ML Test		CRD Test		Quick Test	
	Ultimate Load (kg.)	Ratio P_{test}/P_{calc}	Ultimate Load (kg.)	Ratio P_{test}/P_{calc}	Ultimate Load (kg.)	Ratio P_{test}/P_{calc}
1	3660	1.13	4100	1.26	3260	1.00
2	1640	0.51	3700	1.14	1640	0.51
3	1640	0.51	3700	1.14	1640	0.51
4	1640	0.51	3700	1.14	1640	0.51
5	1075	0.33	-	-	-	-
6	1450	0.45	-	-	800	0.25
7	1000	0.31	-	-	-	-
8	2800	0.86	-	-	-	-
9	2840	0.87	1920	0.59	2800	0.86
10	3500	1.08	3840	1.18	4040	1.24

Table 11 - Ultimate Load for Pile No. 3

Criteria No.	ML Test		CRD Test		Quick Test	
	Ultimate Load (kg.)	Ratio P_{test}/P_{calc}	Ultimate Load (kg.)	Ratio P_{test}/P_{calc}	Ultimate Load (kg.)	Ratio P_{test}/P_{calc}
1	3225	0.99	3525	1.09	4240	1.31
2	2175	0.67	2400	0.74	2000	0.62
3	2175	0.67	2400	0.74	2000	0.62
4	2175	0.67	2400	0.74	2000	0.62
5	625	0.19	-	-	1200	0.37
6	900	0.28	750	0.23	1800	0.55
7	-	-	-	-	-	-
8	2500	0.77	-	-	-	-
9	2700	0.83	2500	0.77	2900	0.89
10	3325	1.02	3750	1.15	4100	1.26

Table 12 - Ultimate Load for Pile No. 4

Criteria No.	ML Test		CRD Test		Quick Test	
	Ultimate Load (kg.)	Ratio P_{test}/P_{calc}	Ultimate Load (kg.)	Ratio P_{test}/P_{calc}	Ultimate Load (kg.)	Ratio P_{test}/P_{calc}
1	2560	0.79	3300	1.02	3460	1.07
2	1300	0.40	2000	0.62	2080	0.64
3	1300	0.40	2000	0.62	2080	0.64
4	1300	0.40	2000	0.62	2080	0.64
5	800	0.25	-	-	1000	0.31
6	1100	0.34	-	-	1100	0.34
7	-	-	-	-	-	-
8	-	-	-	-	-	-
9	24[illegible]0	0.75	2740	0.84	2760	0.85
10	3120	0.96	3460	1.07	3600	1.11

Table 13 - Ultimate Load for Pile No. 5 and No. 6

Criteria No.	Pile No. 5(ML Test)		Pile No. 6 (ML Test)	
	Ultimate Load (kg.)	Ratio P_{test}/P_{calc}	Ultimate Load (kg.)	Ratio P_{test}/P_{calc}
1	1110	1.31	1325	1.56
2	430	0.51	440	0,52
3	430	0.51	440	0.52
4	430	0.51	440	0.52
5	-	-	-	-
6	-	-	-	-
7	-	-	-	-
8	1300	1.53	1375	1.62
9	1100	1.30	1083	1.28
10	1490	1.76	1540	1.82