HYPERVIB1

AN ANALYTICAL MODEL-BASED COMPUTER PROGRAM TO EVALUATE THE PENETRATION SPEED OF VIBRATORY DRIVEN SHEET PILES

BBRI

Dr. Alain E. Holeyman

Irvine, June 1993

CONTENTS

OVER ALL APPROACH

1. Estimate amplitude of periodic motion by acceleration [$m\,s^{-2}$]

$$acc = \frac{F_v - Damp. \cdot Fsl}{M}$$

$F_v = me\omega^2$ centrifugal force of vibrator [kN]

Fsl = liquefied skin friction resistance [kN] (see 2.a)

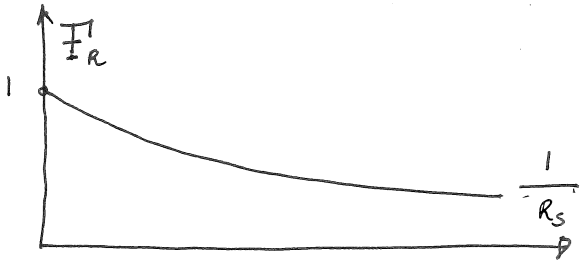
$Damp$ = Damping factor [-], {Program} default = 0.1}

M = total mass of moving parts [kg]

2. Estimate Soil Resistance during vibration, based on CPT data, liquefaction reduction factors, friction Ratio and level of vibration.

(2.a) Liquefied soil Resistance

Local Skin friction.



$$\tau_l = \tau_s F_R$$

$$\tau_l = \tau_s \left\{ \left(1 - \frac{1}{R_s}\right) \exp\left(-\frac{C_s}{FR}\right) + \frac{1}{R_s} \right\}^{\frac{C_s}{FR}}$$

Toe Resistance

$$q_l = q_s \cdot F_q$$

$$= q_s \left\{ \left(1 - \frac{1}{R_b}\right) Exp\left(-\frac{C_b}{FR}\right) + \frac{1}{R_b} \right\}$$

Qtot. $q_l \cdot \Omega$

Skin parameters			Toe parameters	
τ_s =	Taumx(i)	[MPa]	q_s =	Qptmx(i)
FR =	Qsakes(i)	[-]	FR =	Qtakep(i)
C_s =	.01	(Program)	C_b =	.01
R_s =	Sidamp(i)	[-]	R_b =	Ptdamp(i)

Total skin friction

$$F_{as} = \gamma \sum_{i=1}^{N} \tau_{s(i)} l_{(i)} \quad \text{(static)}$$

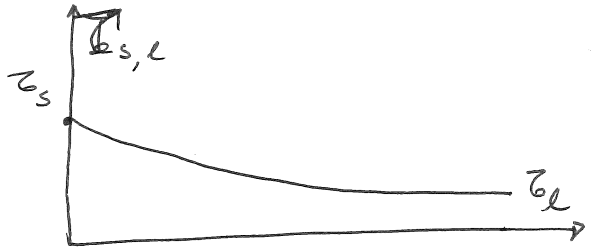
$$F_{RL} = \gamma \sum_{i=1}^{N} \tau_{l(i)} l_{(i)} \quad \text{(liquified)}$$

γ = perimeter of shaft pile

$l_{(i)}$: layer thicknesses

2.b Partially liquefied Soil Resistance

Local skin Friction.



$$\tau_{sl} = (\tau_s - \tau_l) \exp(-C_{sa} \cdot \alpha) + \tau_l$$

α = acceleration [in g's] calculated from 1.

C_{sa} = 1.0 (Program adjustable)

Toe Resistance

$$q_{sl} = (q_s - q_l) \exp(-C_{ba} \cdot \alpha) + q_l$$

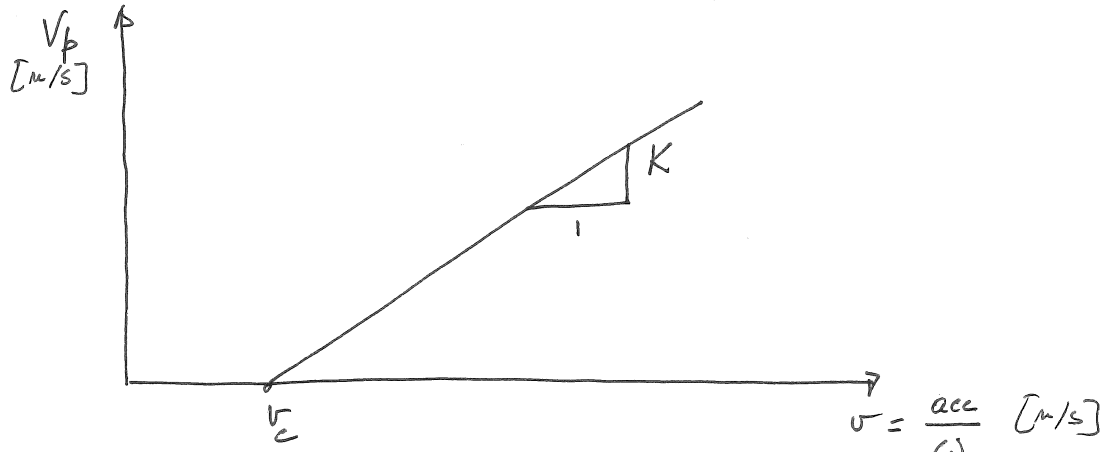
C_{sb} = 1.0 (Program adjustable)

Total skin Friction

$Q_{sl} = q_{sl} \cdot \Sigma$

$$F_{RL} = \gamma \sum \tau_{sl(i)} l_{(i)}$$

3. Estimate Penetration speed V_p, based on following relationship:



3.a. V_c = threshold amplitude of periodic velocity

$$= \frac{1}{\sqrt{\text{Mult} \cdot \rho_s \cdot \chi}} \cdot \sqrt{\frac{F_{RL}}{Z_i}}$$

Mult = Empirical factor by which Z_s must be multiplied to obtain shear modulus (G_i) of soil

ρ_s = Mass density (t à t/m³), not adjustable

χ = perimeter

F_{RL} = Partially liquefied total shear friction

Z_i = Embedment depth.

V_c is obtained by generalizing notion of acoustic impedance: $Z = v\sqrt{G\rho}$

3. b. $$K = Kap \cdot \left[(\alpha + \mu - \gamma - \beta)^{pow} - (\alpha - \mu - \gamma)^{pow} \right]$$

with $Kap = .15$ (program adjustable) / input)

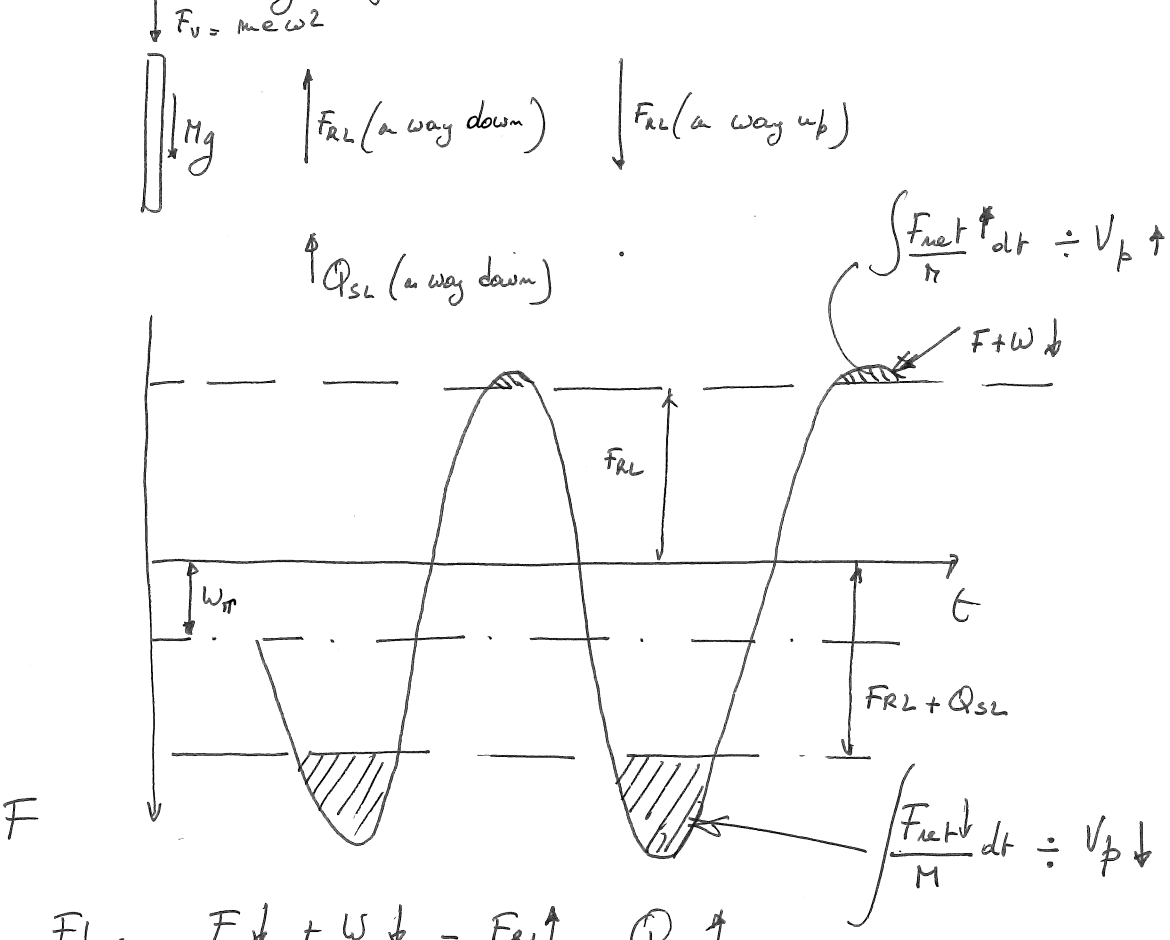
$$\alpha = \frac{acc}{g}$$

$$\mu = \frac{M_T}{M} = \frac{\text{total weight (mass)}}{\text{Vibrating weight (mass)}} = \frac{W_T}{W} = \frac{W_T}{Mg}$$

$$\gamma = \frac{F_{RL}}{W} = \frac{F_{RL}}{Mg}$$

$$\beta = \frac{Q_{SL}}{W} = \frac{Q_{SL}}{Mg}$$

K is obtained based on consideration that penetration speed is the result of acceleration exceedance over that corresponding to resistance during cycle:



$F_{down} = F\downarrow + W\downarrow - F_{RL}\uparrow - Q_{SL}\uparrow$

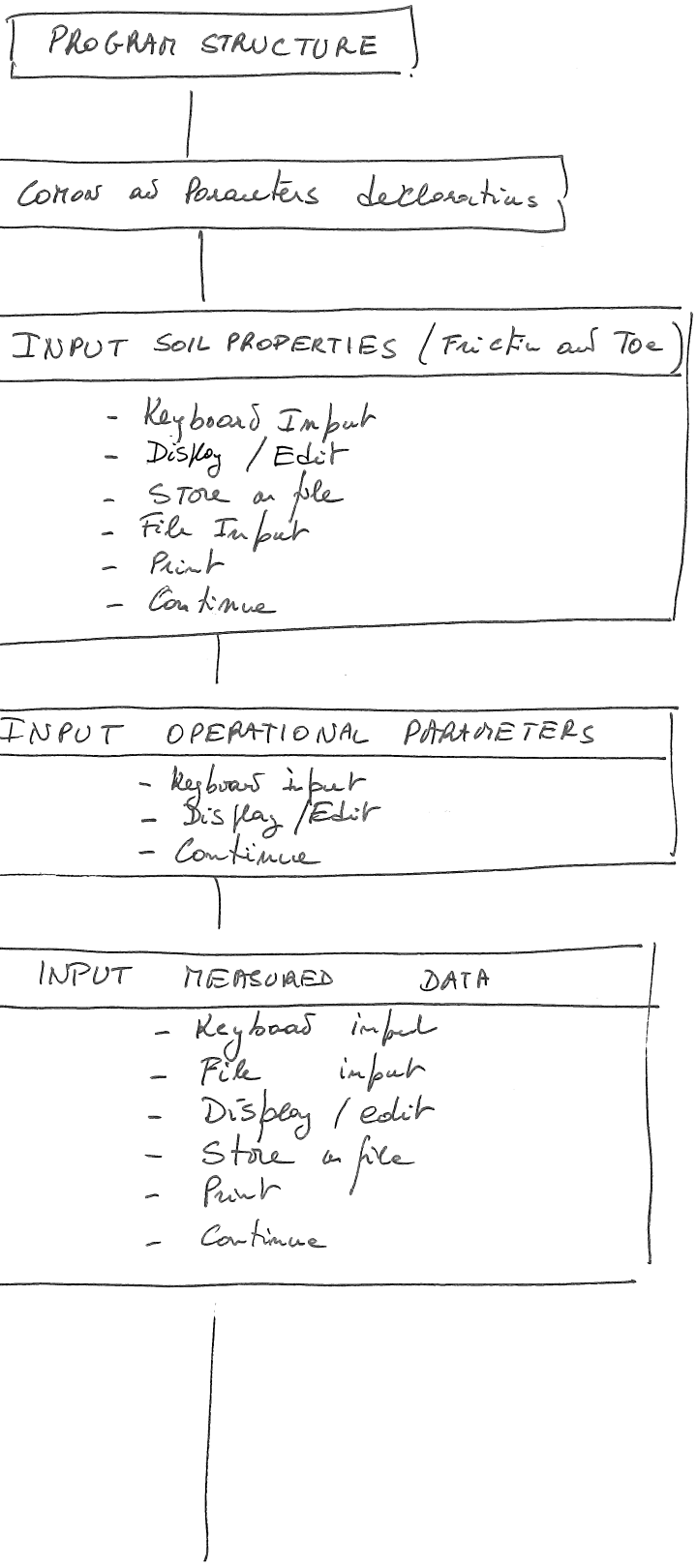
$F_{up} = F\uparrow - W\downarrow - F_{RL}\downarrow$

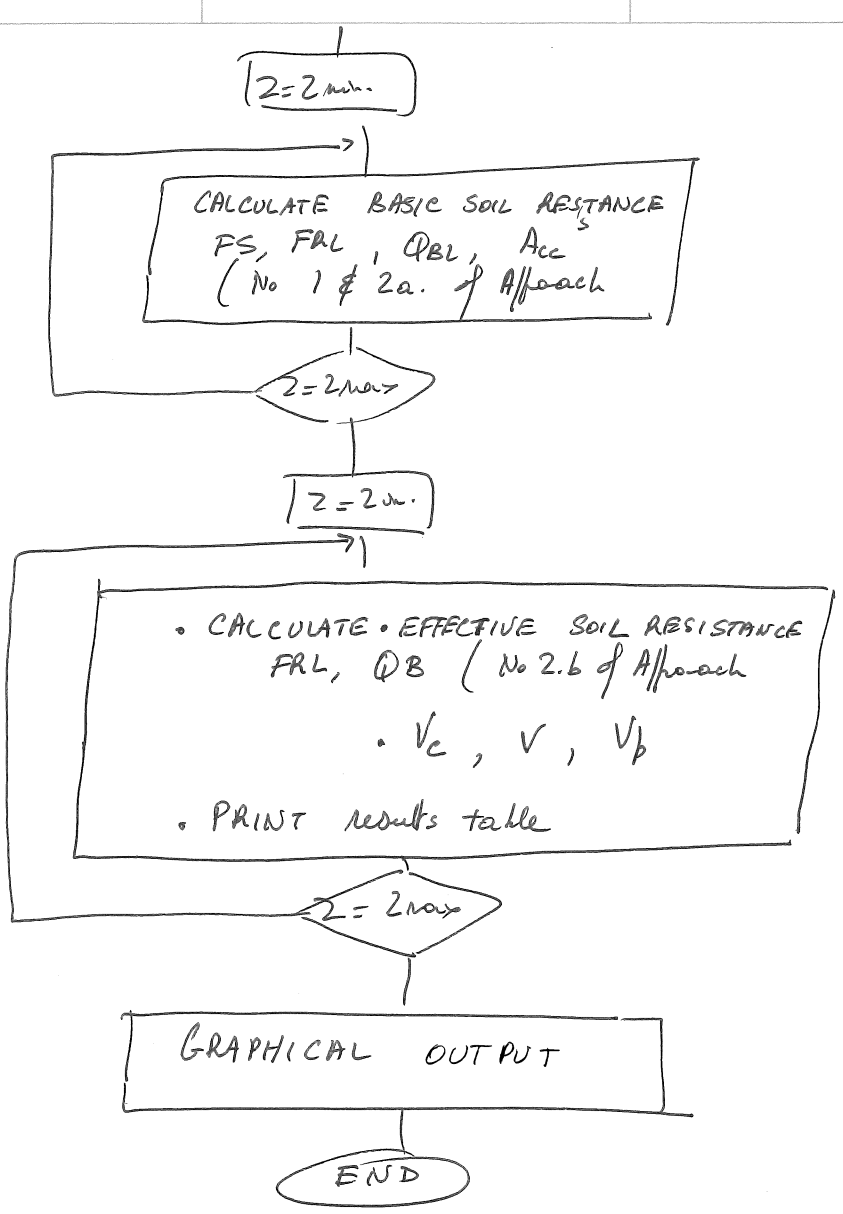
$V_p = V_p\downarrow - V_p\uparrow$

4. Repeat Stk/s 1 → 3 at various depths

5. Compare to measured data in graph of

{ Time required to penetrate 1 meter [i.e. min/m]
vs. depth




Z=Z min.
CALCULATE BASIC SOIL RESISTANCE
FS, FRL, QBL, Acc
(No 1 & 2a. of Approach
Z=Z max
Z=Z in.
• CALCULATE • EFFECTIVE SOIL RESISTANCE
FRL, QB (No 2.6 of Approach
• Vc , V , Vp
• PRINT results table
Z= Z max
GRAPHICAL OUTPUT
END

USING TIPS

- In HP-Instrument basic, (obey) load "HYPERVIB1.IBW"
- Click Run
- For soil properties input, pay attention to [units]

Zl(i)	friction	Zp(i)	Toe [m]
Taumax(i)		Qptmax(i)	[MPa]
Qsoftk(i)		Qsoftp(i)	[-]
Sidamp(i)		Ptdamp(i)	[-]

Note that Zl(i) can have ≠ structure from that of Zp(i)
FRatios . . . . .

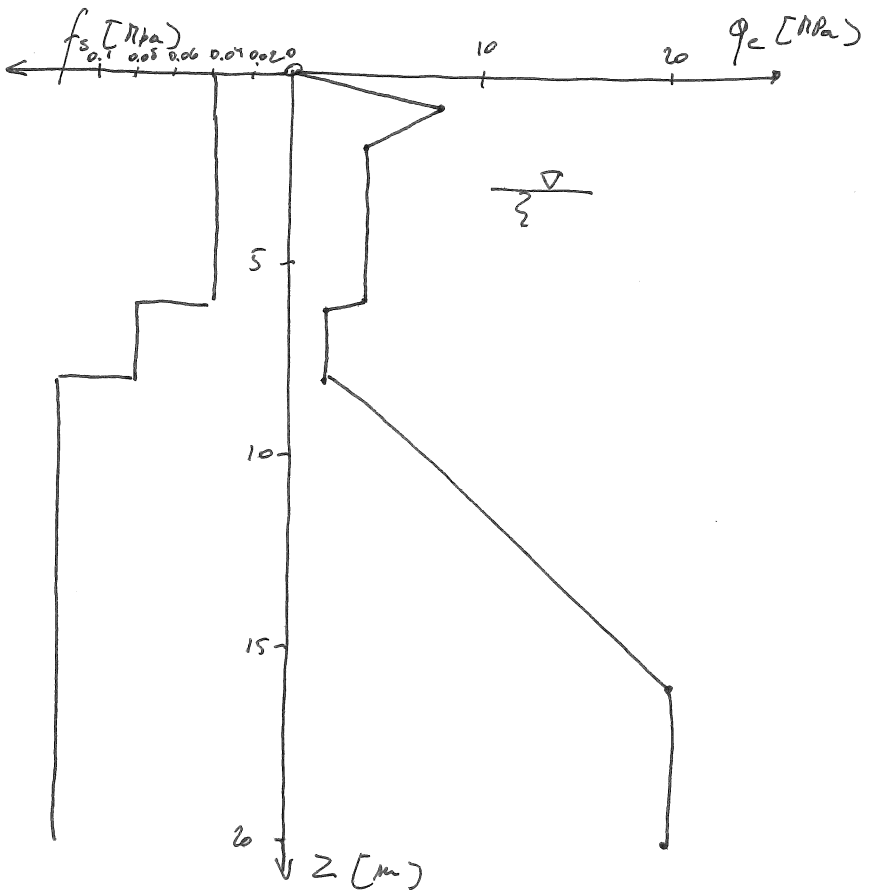
- Because parameters are in COM declarations, "display" will show current values and avoid re-entering data upon successive runs.
- For vibration & pile parameters, no storage (use display), after initial input)
- For measured data, will not go through display, etc when Nm = 0
  Thus, Nm is an option.
  If not data, click continue.
- If formats error occurs during printing, chances are that parameters are unrealistic. Typically too high a skin friction or Sidamp, Ptdamp < 1.0
- At End of run, pull down "Print graph" in graphics window to get hard copy of display. - Minimize after print is complete & click on "RUN" for next problem.
- Practice with simple cases first. (e.g constant friction and qc increasing linearly between two levels) to develop "feel" for influence of parameters.
- Program is not "idiot proof", ie it can detect under specific set of parameters. Make a list of such instances, with error message copied on data input.

SUMMARY OF VARIABLES

Run Input (= Variable)	Program Adjustable (= Parameter)
Mechanical • me • M_v • ω • n_s	
Sheet pile • A • ℓ • y	
	Soil - General. • Damp : influence of soil friction in reducing amplitude • Mult : regulates V_c • Kap, low : regulates K
Soil - Skin friction. • τ_s • FR • R : Reduction fa liquefaction	• C_s : regulates partial liquefaction dependent on FR • C_{sa} ——— ——— acceleration
Soil - Base Resistance • q_b • FR • R	• C_b • C_{ba}

SAMPLE PROBLEM

File "a:\sa1" for SOIL DATA.



Note that fs are constant values over depth range (step function)
while qc are linearly varying between anchor points.

This allows speedy schematization of CPT results with limited input.

Note that Sidump/Pt damp above water table should be lower than below.

SAMPLE PROBLEM

File "a:\oa1" for observed parameters

Initial input based on time versus depth observations:

z (m)	t (min)	t (sec)	
0	0	0	) VPA(1)
6	12 min	720	) VPA(2)
10	28 min.	1,680	) VPA(3).
12	50 min.	3,000	

VPA (s/m) is calculated for initial data for storage and graphical reformatting

version 'HYPERVIB1' 30 Jun 1993 08:38:51

.0015 2 150 .01 1 .01 1 .1

****

Sample Problem

Parametric Analysis

****

SOIL PARAMETERS

****

DATA FILE:

SKIN FRICTION

xxxxxxxxxxxxxxxxxxx

I	Zl [m]	Taumx [MPa]	Quakes [-]	Sidamp [-]
1	2.000	.0400	.0150	5.0000
2	3.000	.0400	.0100	5.0000
3	6.000	.0400	.0100	8.0000
4	8.000	.0800	.0400	8.0000
5	20.000	.1200	.0050	8.0000

TOE RESISTANCE

xxxxxxxxxxxxxxxxxxxxx

I	Zp [m]	Qptmx [MPa]	Quakep [-]	Ptdamp [-]
1	1.000	8.0000	.0150	3.0000
2	2.000	4.0000	.0100	5.0000
3	6.000	4.0000	.0100	5.0000
4	6.100	2.0000	.0400	5.0000
5	8.000	2.0000	.0400	5.0000
6	16.000	20.0000	.0050	5.0000
7	20.000	20.0000	.0050	5.0000

Observed pentration rates

I,	ZM(I),	VPM(I)
0	0	0
1	6	120
2	10	240
3	12	660

PTC 2A2

Eccentric Moment = 2.65 kg.m

Frequency = 48 Hz

Vibrating Mass of Vibrator = 1165 kg

Stationary mass of Vibrator = 1500 kg

Section of Sheet pile = 100 cm2

Perimeter of Sheet pile = 1.4 m

Length of Sheet pile = 16 m

Range and resolution depth [m] of analysis .2 16 79

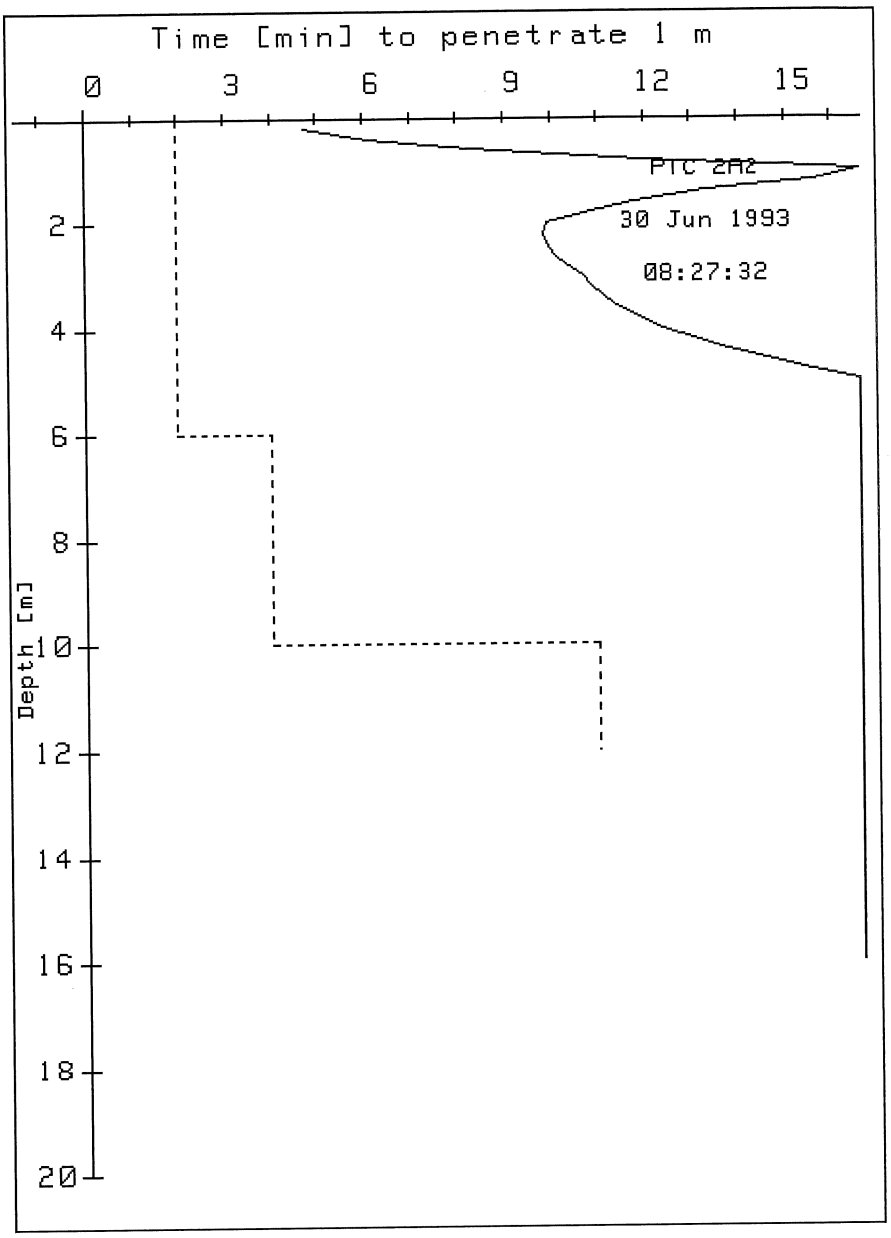
ESTIMATED RESULTS

No	Depth	Frs	Frl	Qbs	QBl	accel	vit	Vc	Ampl	Fr	Qb	Vpi

	[m]	[kN]	[Kn]	[kN]	[Kn]	m/s2	[mm/s]		[mm]	kN	kN	s/m
0	.20	11	7	16	11	99.3	329	285	1.1	7	11	284
1	.40	22	14	32	22	99.0	328	285	1.1	14	22	368
2	.60	34	21	48	32	98.7	327	285	1.1	21	32	498
3	.80	45	27	64	43	98.4	326	285	1.1	27	43	719
4	1.00	56	34	80	54	98.1	325	285	1.1	34	54	999
5	1.20	67	41	72	47	97.9	324	285	1.1	41	47	938
6	1.40	78	48	64	40	97.6	324	285	1.1	48	40	800
7	1.60	90	55	56	33	97.3	323	285	1.1	55	33	708
8	1.80	101	62	48	27	97.0	322	285	1.1	62	27	643
9	2.00	112	68	40	20	96.7	321	285	1.1	68	20	596
10	2.20	123	74	40	20	96.5	320	283	1.1	74	20	592
11	2.40	134	79	40	20	96.3	319	281	1.1	79	20	595
12	2.60	146	85	40	20	96.1	318	279	1.1	85	20	606
13	2.80	157	91	40	20	95.8	318	277	1.1	91	20	622
14	3.00	168	96	40	20	95.6	317	276	1.1	96	20	643
15	3.20	179	101	40	20	95.4	316	274	1.0	101	20	653
16	3.40	190	106	40	20	95.2	316	273	1.0	106	20	668
17	3.60	202	111	40	20	95.0	315	271	1.0	111	20	689
18	3.80	213	116	40	20	94.8	314	270	1.0	116	20	715
19	4.00	224	121	40	20	94.6	314	269	1.0	121	20	746
20	4.20	235	126	40	20	94.4	313	267	1.0	126	20	783
21	4.40	246	131	40	20	94.1	312	266	1.0	131	20	827
22	4.60	258	136	40	20	93.9	311	265	1.0	136	20	878
23	4.80	269	141	40	20	93.7	311	265	1.0	141	20	938
24	5.00	280	146	40	20	93.5	310	264	1.0	146	20	999
25	5.20	291	151	40	20	93.3	309	263	1.0	151	20	999
26	5.40	302	156	40	20	93.1	309	262	1.0	156	20	999
27	5.60	314	161	40	20	92.9	308	262	1.0	161	20	999
28	5.80	325	166	40	20	92.7	307	261	1.0	166	20	999
29	6.00	336	171	40	20	92.5	307	261	1.0	171	20	999
30	6.20	358	189	20	16	91.7	304	270	1.0	189	16	999
31	6.40	381	207	20	16	91.0	302	278	1.0	207	16	999
32	6.60	403	225	20	16	90.3	299	285	1.0	225	16	999
33	6.80	426	243	20	16	89.5	297	292	1.0	243	16	999
34	7.00	448	261	20	16	88.8	294	298	1.0	262	16	999
35	7.20	470	280	20	16	88.0	292	304	1.0	280	16	999
36	7.40	493	298	20	16	87.3	289	309	1.0	298	16	999
37	7.60	515	316	20	16	86.5	287	314	1.0	316	16	999
38	7.80	538	334	20	16	85.8	284	319	.9	334	16	999
39	8.00	560	352	20	16	85.0	282	324	.9	352	16	999
40	8.20	594	360	25	18	84.7	281	323	.9	360	18	999
41	8.40	627	368	29	19	84.4	280	323	.9	368	19	999
42	8.60	661	376	34	20	84.0	279	323	.9	376	20	999
43	8.80	694	385	38	21	83.7	277	323	.9	385	21	999
44	9.00	728	393	43	22	83.3	276	322	.9	393	22	999
45	9.20	762	401	47	23	83.0	275	322	.9	401	23	999
46	9.40	795	409	52	24	82.7	274	322	.9	409	24	999
47	9.60	829	417	56	25	82.3	273	322	.9	417	26	999
48	9.80	862	425	60	27	82.0	272	322	.9	426	27	999
49	10.00	896	434	65	28	81.7	271	321	.9	434	28	999
50	10.20	930	442	69	29	81.3	270	321	.9	442	29	999
51	10.40	963	450	74	30	81.0	268	321	.9	450	30	999
52	10.60	997	458	78	31	80.6	267	321	.9	458	31	999
53	10.80	1030	466	83	32	80.3	266	321	.9	466	32	999
54	11.00	1064	474	87	33	80.0	265	321	.9	475	33	999
55	11.20	1098	483	92	35	79.6	264	320	.9	483	35	999
56	11.40	1131	491	96	36	79.3	263	320	.9	491	36	999
57	11.60	1165	499	101	37	78.9	262	320	.9	499	37	999

58	11.80	1198	507	106	38	78.6	261	320	.9	507	38	999
59	12.00	1232	515	110	39	78.3	260	320	.9	516	39	999
60	12.20	1266	524	115	40	77.9	258	320	.9	524	40	999
61	12.40	1299	532	119	41	77.6	257	320	.9	532	41	999
62	12.60	1333	540	124	42	77.3	256	320	.8	540	42	999
63	12.80	1366	548	128	44	76.9	255	319	.8	548	44	999
64	13.00	1400	556	133	45	76.6	254	319	.8	557	45	999
65	13.20	1434	564	137	46	76.2	253	319	.8	565	46	999
66	13.40	1467	573	142	47	75.9	252	319	.8	573	47	999
67	13.60	1501	581	146	48	75.6	251	319	.8	581	48	999
68	13.80	1534	589	151	49	75.2	249	319	.8	589	49	999
69	14.00	1568	597	155	50	74.9	248	319	.8	598	50	999
70	14.20	1602	605	160	51	74.6	247	319	.8	606	52	999
71	14.40	1635	614	164	53	74.2	246	319	.8	614	53	999
72	14.60	1669	622	169	54	73.9	245	319	.8	622	54	999
73	14.80	1702	630	173	55	73.5	244	318	.8	630	55	999
74	15.00	1736	638	178	56	73.2	243	318	.8	639	56	999
75	15.20	1770	646	182	57	72.9	242	318	.8	647	57	999
76	15.40	1803	654	186	58	72.5	240	318	.8	655	58	999
77	15.60	1837	663	191	59	72.2	239	318	.8	663	59	999
78	15.80	1870	671	195	61	71.9	238	318	.8	672	61	999
79	16.00	1904	679	200	62	71.5	237	318	.8	680	62	999

Estimated driving time between .2 and .8 m. is 5 minutes


Time [min] to penetrate 1 m
0
3
6
9
12
15
PTC 2A2
30 Jun 1993
08:27:32
Depth [m]
2
4
6
8
10
12
14
16
18
20

version 'HYPERVIB1' 30 Jun 1993 09:26:26

.0015 2 150 .01 1 .01 1 .1

****

Sample Problem

Parametric Analysis

****

PTC 2A2

Eccentric Moment = 2.65 kg.m

Frequency = 48 Hz

Vibrating Mass of Vibrator = 1165 kg

Stationary mass of Vibrator = 1500 kg

Section of Sheet pile = 70 cm2

Perimeter of Sheet pile = 1.4 m

Length of Sheet pile = 16 m

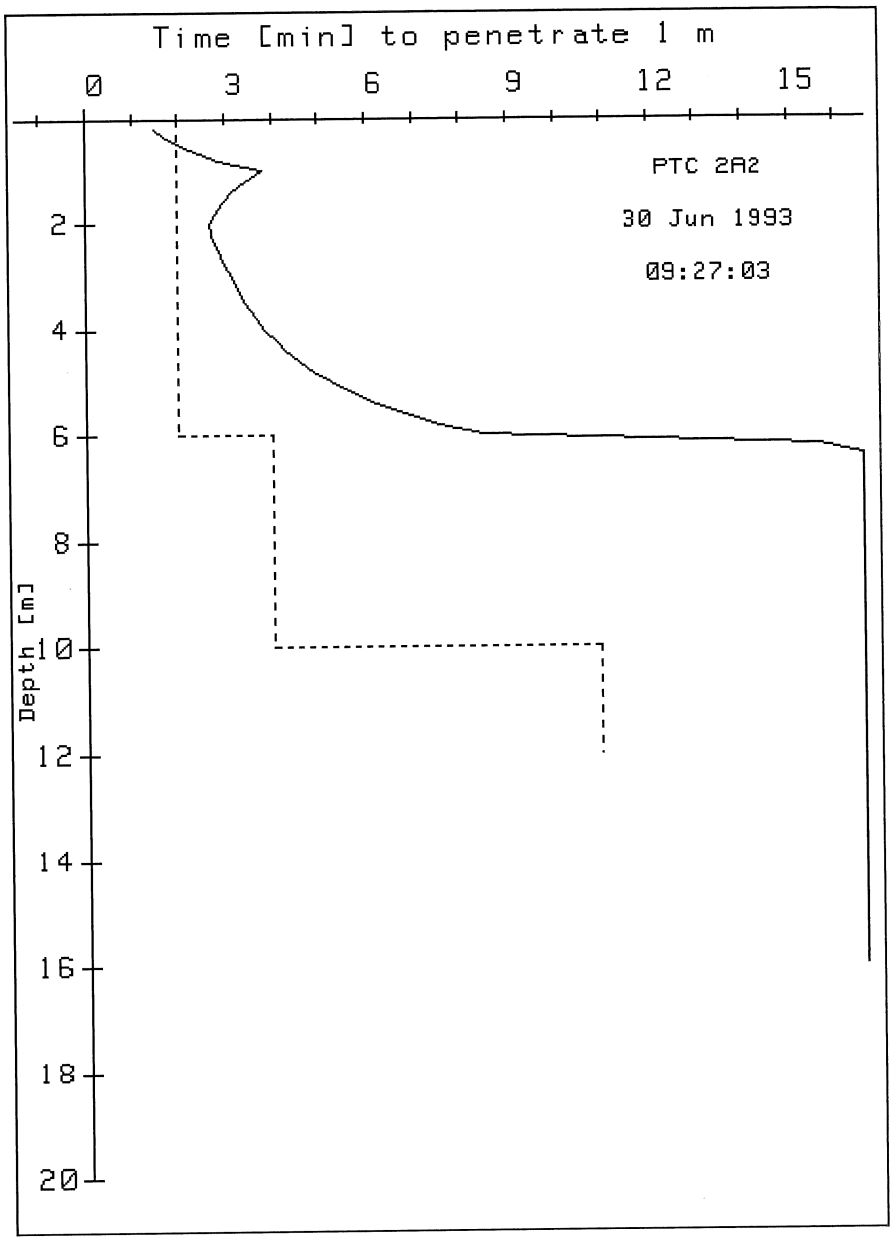
Range and resolution depth [m] of analysis .2 16 79

ESTIMATED RESULTS

No	Depth [m]	Frs [kN]	Frl [Kn]	Qbs [kN]	QBl [Kn]	accel m/s2	vit Vc [mm/s]		Ampl [mm]	Fr kN	Qb kN	Vpi s/m
0	.20	11	7	11	8	117.6	390	285	1.3	7	8	90
1	.40	22	14	22	15	117.2	389	285	1.3	14	15	109
2	.60	34	21	34	23	116.9	388	285	1.3	21	23	135
3	.80	45	27	45	30	116.6	387	285	1.3	27	30	172
4	1.00	56	34	56	38	116.2	385	285	1.3	34	38	229
5	1.20	67	41	50	33	115.9	384	285	1.3	41	33	207
6	1.40	78	48	45	28	115.6	383	285	1.3	48	28	190
7	1.60	90	55	39	23	115.2	382	285	1.3	55	23	178
8	1.80	101	62	34	19	114.9	381	285	1.3	62	19	168
9	2.00	112	68	28	14	114.6	380	285	1.3	68	14	160
10	2.20	123	74	28	14	114.3	379	283	1.3	74	14	164
11	2.40	134	79	28	14	114.0	378	281	1.3	79	14	169
12	2.60	146	85	28	14	113.8	377	279	1.3	85	14	174
13	2.80	157	91	28	14	113.5	376	277	1.2	91	14	181
14	3.00	168	96	28	14	113.2	375	276	1.2	96	14	189
15	3.20	179	101	28	14	113.0	375	274	1.2	101	14	195
16	3.40	190	106	28	14	112.7	374	273	1.2	106	14	203
17	3.60	202	111	28	14	112.5	373	271	1.2	111	14	211
18	3.80	213	116	28	14	112.2	372	270	1.2	116	14	221
19	4.00	224	121	28	14	112.0	371	268	1.2	121	14	232
20	4.20	235	126	28	14	111.7	371	267	1.2	126	14	245
21	4.40	246	131	28	14	111.5	370	266	1.2	131	14	259
22	4.60	258	136	28	14	111.3	369	265	1.2	136	14	276
23	4.80	269	141	28	14	111.0	368	265	1.2	141	14	295
24	5.00	280	146	28	14	110.8	367	264	1.2	146	14	317
25	5.20	291	151	28	14	110.5	366	263	1.2	151	14	343
26	5.40	302	156	28	14	110.3	366	262	1.2	156	14	374
27	5.60	314	161	28	14	110.0	365	262	1.2	161	14	411
28	5.80	325	166	28	14	109.8	364	261	1.2	166	14	456
29	6.00	336	171	28	14	109.5	363	261	1.2	171	14	512
30	6.20	358	189	14	12	108.7	360	270	1.2	189	12	939
31	6.40	381	207	14	12	107.8	357	278	1.2	207	12	999
32	6.60	403	225	14	12	106.9	354	285	1.2	225	12	999
33	6.80	426	243	14	12	106.0	351	292	1.2	243	12	999
34	7.00	448	261	14	12	105.1	349	298	1.2	261	12	999
35	7.20	470	280	14	12	104.2	346	304	1.1	280	12	999
36	7.40	493	298	14	12	103.4	343	309	1.1	298	12	999

37	7.60	515	316	14	12	102.5	340	314	1.1	316	12	999
38	7.80	538	334	14	12	101.6	337	319	1.1	334	12	999
39	8.00	560	352	14	12	100.7	334	324	1.1	352	12	999
40	8.20	594	360	17	12	100.3	333	323	1.1	360	12	999
41	8.40	627	368	20	13	99.9	331	323	1.1	368	13	999
42	8.60	661	376	23	14	99.5	330	323	1.1	376	14	999
43	8.80	694	385	27	15	99.1	329	323	1.1	385	15	999
44	9.00	728	393	30	15	98.7	327	322	1.1	393	15	999
45	9.20	762	401	33	16	98.3	326	322	1.1	401	16	999
46	9.40	795	409	36	17	97.9	325	322	1.1	409	17	999
47	9.60	829	417	39	18	97.5	323	322	1.1	417	18	999
48	9.80	862	425	42	19	97.1	322	321	1.1	425	19	999
49	10.00	896	434	45	19	96.7	321	321	1.1	434	19	999
50	10.20	930	442	49	20	96.3	319	321	1.1	442	20	999
51	10.40	963	450	52	21	95.9	318	321	1.1	450	21	999
52	10.60	997	458	55	22	95.5	317	321	1.0	458	22	999
53	10.80	1030	466	58	23	95.1	315	321	1.0	466	23	999
54	11.00	1064	474	61	23	94.7	314	320	1.0	475	23	999
55	11.20	1098	483	64	24	94.3	313	320	1.0	483	24	999
56	11.40	1131	491	68	25	93.9	311	320	1.0	491	25	999
57	11.60	1165	499	71	26	93.5	310	320	1.0	499	26	999
58	11.80	1198	507	74	27	93.1	309	320	1.0	507	27	999
59	12.00	1232	515	77	27	92.7	307	320	1.0	515	27	999
60	12.20	1266	524	80	28	92.3	306	320	1.0	524	28	999
61	12.40	1299	532	83	29	91.9	305	320	1.0	532	29	999
62	12.60	1333	540	86	30	91.5	303	319	1.0	540	30	999
63	12.80	1366	548	90	31	91.1	302	319	1.0	548	31	999
64	13.00	1400	556	93	31	90.7	301	319	1.0	556	31	999
65	13.20	1434	564	96	32	90.3	299	319	1.0	565	32	999
66	13.40	1467	573	99	33	89.9	298	319	1.0	573	33	999
67	13.60	1501	581	102	34	89.5	297	319	1.0	581	34	999
68	13.80	1534	589	105	34	89.1	295	319	1.0	589	34	999
69	14.00	1568	597	109	35	88.7	294	319	1.0	597	35	999
70	14.20	1602	605	112	36	88.3	293	319	1.0	605	36	999
71	14.40	1635	614	115	37	87.9	291	319	1.0	614	37	999
72	14.60	1669	622	118	38	87.5	290	318	1.0	622	38	999
73	14.80	1702	630	121	38	87.1	289	318	1.0	630	38	999
74	15.00	1736	638	124	39	86.7	287	318	1.0	638	39	999
75	15.20	1770	646	127	40	86.3	286	318	.9	646	40	999
76	15.40	1803	654	131	41	85.9	285	318	.9	655	41	999
77	15.60	1837	663	134	42	85.5	283	318	.9	663	42	999
78	15.80	1870	671	137	42	85.1	282	318	.9	671	42	999
79	16.00	1904	679	140	43	84.7	281	318	.9	679	43	999

Estimated driving time between .2 and 6.2 m. is 26 minutes


Time [min] to penetrate 1 m
0
3
6
9
12
15
PTC 2A2
30 Jun 1993
09:27:03
Depth [m]
2
4
6
8
10
12
14
16
18
20

version 'HYPERVIB1' 30 Jun 1993 09:20:17

.0015 2 150 .01 1 .01 1 .1

****

Sample Problem

Parametric Analysis

****

PTC 2A2

Eccentric Moment = 2.65 kg.m

Frequency = 72 Hz

Vibrating Mass of Vibrator = 1165 kg

Stationary mass of Vibrator = 1500 kg

Section of Sheet pile = 70 cm2

Perimeter of Sheet pile = 1.4 m

Length of Sheet pile = 16 m

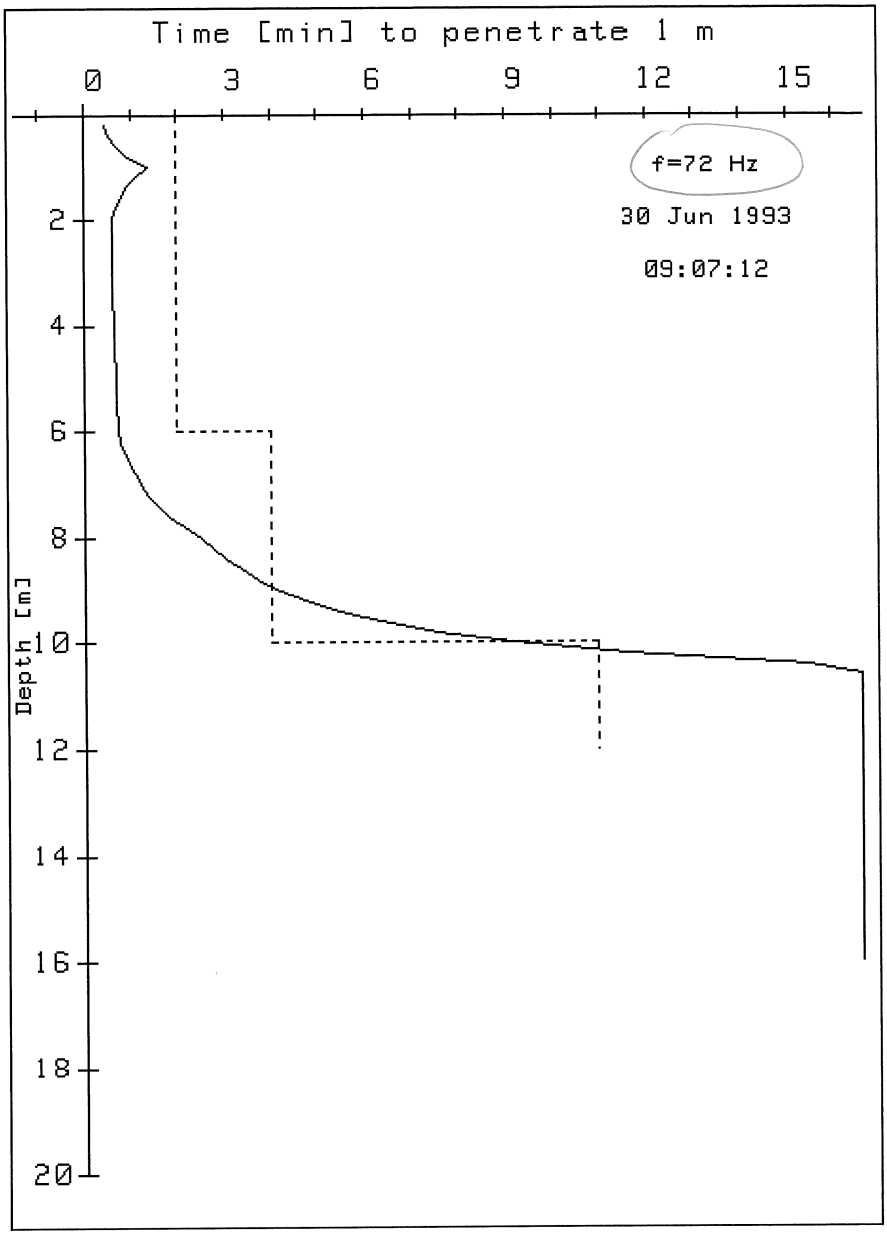
Range and resolution depth [m] of analysis .2 16 79

ESTIMATED RESULTS

No	Depth [m]	Frs [kN]	Frl [Kn]	Qbs [kN]	QBl [Kn]	accel m/s2	vit Vc [mm/s]		Ampl [mm]	Fr kN	Qb kN	Vpi s/m
0	.20	11	7	11	8	265.0	586	285	1.3	7	8	14
1	.40	22	14	22	15	264.6	585	285	1.3	14	15	16
2	.60	34	21	34	23	264.3	584	285	1.3	21	23	19
3	.80	45	27	45	30	264.0	583	285	1.3	27	30	23
4	1.00	56	34	56	38	263.6	583	285	1.3	34	38	29
5	1.20	67	41	50	33	263.3	582	285	1.3	41	33	26
6	1.40	78	48	45	28	263.0	581	285	1.3	48	28	23
7	1.60	90	55	39	23	262.6	581	285	1.3	55	23	21
8	1.80	101	62	34	19	262.3	580	285	1.3	62	19	19
9	2.00	112	68	28	14	262.0	579	285	1.3	68	14	18
10	2.20	123	74	28	14	261.7	578	283	1.3	74	14	18
11	2.40	134	79	28	14	261.4	578	281	1.3	79	14	18
12	2.60	146	85	28	14	261.1	577	279	1.3	85	14	18
13	2.80	157	91	28	14	260.9	577	277	1.3	91	14	18
14	3.00	168	96	28	14	260.6	576	276	1.3	96	14	19
15	3.20	179	101	28	14	260.4	576	274	1.3	101	14	19
16	3.40	190	106	28	14	260.1	575	273	1.3	106	14	19
17	3.60	202	111	28	14	259.9	574	271	1.3	111	14	19
18	3.80	213	116	28	14	259.6	574	270	1.3	116	14	19
19	4.00	224	121	28	14	259.4	573	268	1.3	121	14	20
20	4.20	235	126	28	14	259.1	573	267	1.3	126	14	20
21	4.40	246	131	28	14	258.9	572	266	1.3	131	14	20
22	4.60	258	136	28	14	258.6	572	265	1.3	136	14	20
23	4.80	269	141	28	14	258.4	571	265	1.3	141	14	21
24	5.00	280	146	28	14	258.2	571	264	1.3	146	14	21
25	5.20	291	151	28	14	257.9	570	263	1.3	151	14	21
26	5.40	302	156	28	14	257.7	570	262	1.3	156	14	22
27	5.60	314	161	28	14	257.4	569	262	1.3	161	14	22
28	5.80	325	166	28	14	257.2	568	261	1.3	166	14	22
29	6.00	336	171	28	14	256.9	568	261	1.3	171	14	23
30	6.20	358	189	14	12	256.0	566	270	1.3	189	12	24
31	6.40	381	207	14	12	255.2	564	278	1.2	207	12	26
32	6.60	403	225	14	12	254.3	562	285	1.2	225	12	29
33	6.80	426	243	14	12	253.4	560	292	1.2	243	12	32
34	7.00	448	261	14	12	252.5	558	298	1.2	261	12	36
35	7.20	470	280	14	12	251.6	556	304	1.2	280	12	40
36	7.40	493	298	14	12	250.7	554	309	1.2	298	12	45

37	7.60	515	316	14	12	249.9	552	314	1.2	316	12	51
38	7.80	538	334	14	12	249.0	550	319	1.2	334	12	59
39	8.00	560	352	14	12	248.1	548	324	1.2	352	12	69
40	8.20	594	360	17	12	247.7	548	323	1.2	360	12	75
41	8.40	627	368	20	13	247.3	547	323	1.2	368	13	81
42	8.60	661	376	23	14	246.9	546	323	1.2	376	14	89
43	8.80	694	385	27	15	246.5	545	323	1.2	385	15	98
44	9.00	728	393	30	15	246.1	544	322	1.2	393	15	109
45	9.20	762	401	33	16	245.7	543	322	1.2	401	16	122
46	9.40	795	409	36	17	245.3	542	322	1.2	409	17	138
47	9.60	829	417	39	18	244.9	541	322	1.2	417	18	159
48	9.80	862	425	42	19	244.5	540	321	1.2	425	19	185
49	10.00	896	434	45	19	244.1	540	321	1.2	434	19	220
50	10.20	930	442	49	20	243.7	539	321	1.2	442	20	270
51	10.40	963	450	52	21	243.3	538	321	1.2	450	21	345
52	10.60	997	458	55	22	242.9	537	321	1.2	458	22	473
53	10.80	1030	466	58	23	242.5	536	321	1.2	466	23	732
54	11.00	1064	474	61	23	242.1	535	320	1.2	474	23	999
55	11.20	1098	483	64	24	241.7	534	320	1.2	483	24	999
56	11.40	1131	491	68	25	241.3	533	320	1.2	491	25	999
57	11.60	1165	499	71	26	240.9	532	320	1.2	499	26	999
58	11.80	1198	507	74	27	240.5	532	320	1.2	507	27	999
59	12.00	1232	515	77	27	240.1	531	320	1.2	515	27	999
60	12.20	1266	524	80	28	239.7	530	320	1.2	524	28	999
61	12.40	1299	532	83	29	239.3	529	320	1.2	532	29	999
62	12.60	1333	540	86	30	238.9	528	319	1.2	540	30	999
63	12.80	1366	548	90	31	238.5	527	319	1.2	548	31	999
64	13.00	1400	556	93	31	238.1	526	319	1.2	556	31	999
65	13.20	1434	564	96	32	237.7	525	319	1.2	564	32	999
66	13.40	1467	573	99	33	237.3	525	319	1.2	573	33	999
67	13.60	1501	581	102	34	236.9	524	319	1.2	581	34	999
68	13.80	1534	589	105	34	236.5	523	319	1.2	589	34	999
69	14.00	1568	597	109	35	236.1	522	319	1.2	597	35	999
70	14.20	1602	605	112	36	235.7	521	319	1.2	605	36	999
71	14.40	1635	614	115	37	235.3	520	319	1.1	614	37	999
72	14.60	1669	622	118	38	234.9	519	318	1.1	622	38	999
73	14.80	1702	630	121	38	234.5	518	318	1.1	630	38	999
74	15.00	1736	638	124	39	234.1	517	318	1.1	638	39	999
75	15.20	1770	646	127	40	233.7	517	318	1.1	646	40	999
76	15.40	1803	654	131	41	233.3	516	318	1.1	654	41	999
77	15.60	1837	663	134	42	232.9	515	318	1.1	663	42	999
78	15.80	1870	671	137	42	232.5	514	318	1.1	671	42	999
79	16.00	1904	679	140	43	232.1	513	318	1.1	679	43	999

Estimated driving time between .2 and 10.8 m. is 13 minutes


Time [min] to penetrate 1 m
0
3
6
9
12
15
f=72 Hz
30 Jun 1993
09:07:12
Depth [m]
2
4
6
8
10
12
14
16
18
20

version 'HYPERVIB1' 30 Jun 1993 09:41:40

.0015 2 250 .01 1 .01 1 .1

****

Sample Problem

Parametric Analysis

****

PTC 2A2

Eccentric Moment = 2.65 kg.m

Frequency = 48 Hz

Vibrating Mass of Vibrator = 1165 kg

Stationary mass of Vibrator = 1500 kg

Section of Sheet pile = 70 cm2

Perimeter of Sheet pile = 1.4 m

Length of Sheet pile = 16 m

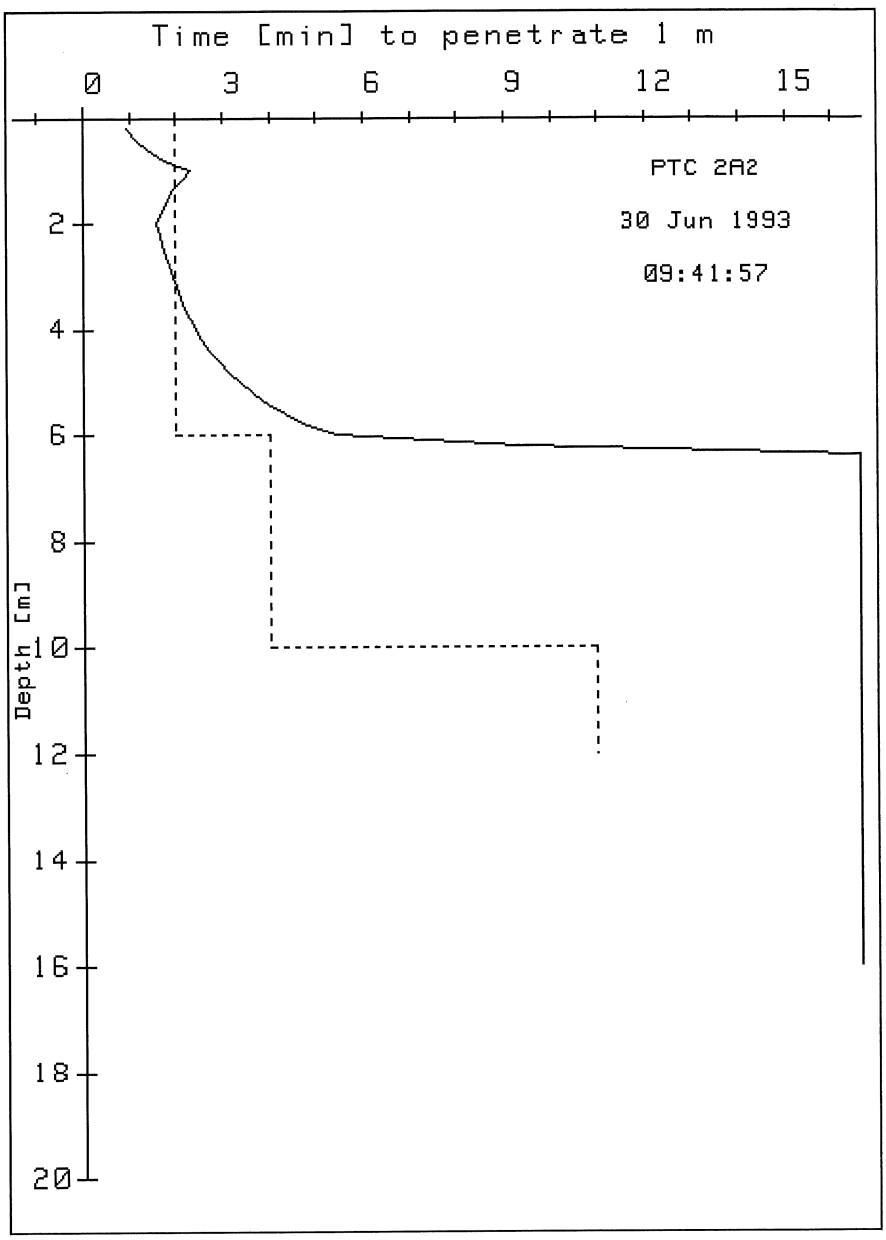
Range and resolution depth [m] of analysis .2 16 79

ESTIMATED RESULTS

No	Depth [m]	Frs [kN]	Frl [Kn]	Qbs [kN]	QBl [Kn]	accel m/s2	vit Vc [mm/s]	Ampl [mm]	Fr kN	Qb kN	Vpi s/m
0	.20	11	7	11	8	117.6	390 221	1.3	7	8	56
1	.40	22	14	22	15	117.2	389 221	1.3	14	15	67
2	.60	34	21	34	23	116.9	388 221	1.3	21	23	83
3	.80	45	27	45	30	116.6	387 221	1.3	27	30	105
4	1.00	56	34	56	38	116.2	385 221	1.3	34	38	139
5	1.20	67	41	50	33	115.9	384 221	1.3	41	33	125
6	1.40	78	48	45	28	115.6	383 221	1.3	48	28	115
7	1.60	90	55	39	23	115.2	382 221	1.3	55	23	107
8	1.80	101	62	34	19	114.9	381 221	1.3	62	19	100
9	2.00	112	68	28	14	114.6	380 221	1.3	68	14	95
10	2.20	123	74	28	14	114.3	379 219	1.3	74	14	99
11	2.40	134	79	28	14	114.0	378 218	1.3	79	14	102
12	2.60	146	85	28	14	113.8	377 216	1.3	85	14	106
13	2.80	157	91	28	14	113.5	376 215	1.2	91	14	111
14	3.00	168	96	28	14	113.2	375 214	1.2	96	14	116
15	3.20	179	101	28	14	113.0	375 212	1.2	101	14	121
16	3.40	190	106	28	14	112.7	374 211	1.2	106	14	126
17	3.60	202	111	28	14	112.5	373 210	1.2	111	14	132
18	3.80	213	116	28	14	112.2	372 209	1.2	116	14	139
19	4.00	224	121	28	14	112.0	371 208	1.2	121	14	146
20	4.20	235	126	28	14	111.7	371 207	1.2	126	14	154
21	4.40	246	131	28	14	111.5	370 206	1.2	131	14	164
22	4.60	258	136	28	14	111.3	369 206	1.2	136	14	175
23	4.80	269	141	28	14	111.0	368 205	1.2	141	14	187
24	5.00	280	146	28	14	110.8	367 204	1.2	146	14	201
25	5.20	291	151	28	14	110.5	366 204	1.2	151	14	218
26	5.40	302	156	28	14	110.3	366 203	1.2	156	14	238
27	5.60	314	161	28	14	110.0	365 203	1.2	161	14	261
28	5.80	325	166	28	14	109.8	364 202	1.2	166	14	290
29	6.00	336	171	28	14	109.5	363 202	1.2	171	14	325
30	6.20	358	189	14	12	108.7	360 209	1.2	189	12	562
31	6.40	381	207	14	12	107.8	357 215	1.2	207	12	999
32	6.60	403	225	14	12	106.9	354 221	1.2	225	12	999
33	6.80	426	243	14	12	106.0	351 226	1.2	243	12	999
34	7.00	448	261	14	12	105.1	349 231	1.2	261	12	999
35	7.20	470	280	14	12	104.2	346 236	1.1	280	12	999
36	7.40	493	298	14	12	103.4	343 240	1.1	298	12	999

37	7.60	515	316	14	12	102.5	340	244	1.1	316	12	999
38	7.80	538	334	14	12	101.6	337	247	1.1	334	12	999
39	8.00	560	352	14	12	100.7	334	251	1.1	352	12	999
40	8.20	594	360	17	12	100.3	333	250	1.1	360	12	999
41	8.40	627	368	20	13	99.9	331	250	1.1	368	13	999
42	8.60	661	376	23	14	99.5	330	250	1.1	376	14	999
43	8.80	694	385	27	15	99.1	329	250	1.1	385	15	999
44	9.00	728	393	30	15	98.7	327	250	1.1	393	15	999
45	9.20	762	401	33	16	98.3	326	250	1.1	401	16	999
46	9.40	795	409	36	17	97.9	325	249	1.1	409	17	999
47	9.60	829	417	39	18	97.5	323	249	1.1	417	18	999
48	9.80	862	425	42	19	97.1	322	249	1.1	425	19	999
49	10.00	896	434	45	19	96.7	321	249	1.1	434	19	999
50	10.20	930	442	49	20	96.3	319	249	1.1	442	20	999
51	10.40	963	450	52	21	95.9	318	249	1.1	450	21	999
52	10.60	997	458	55	22	95.5	317	248	1.0	458	22	999
53	10.80	1030	466	58	23	95.1	315	248	1.0	466	23	999
54	11.00	1064	474	61	23	94.7	314	248	1.0	475	23	999
55	11.20	1098	483	64	24	94.3	313	248	1.0	483	24	999
56	11.40	1131	491	68	25	93.9	311	248	1.0	491	25	999
57	11.60	1165	499	71	26	93.5	310	248	1.0	499	26	999
58	11.80	1198	507	74	27	93.1	309	248	1.0	507	27	999
59	12.00	1232	515	77	27	92.7	307	248	1.0	515	27	999
60	12.20	1266	524	80	28	92.3	306	248	1.0	524	28	999
61	12.40	1299	532	83	29	91.9	305	248	1.0	532	29	999
62	12.60	1333	540	86	30	91.5	303	247	1.0	540	30	999
63	12.80	1366	548	90	31	91.1	302	247	1.0	548	31	999
64	13.00	1400	556	93	31	90.7	301	247	1.0	556	31	999
65	13.20	1434	564	96	32	90.3	299	247	1.0	565	32	999
66	13.40	1467	573	99	33	89.9	298	247	1.0	573	33	999
67	13.60	1501	581	102	34	89.5	297	247	1.0	581	34	999
68	13.80	1534	589	105	34	89.1	295	247	1.0	589	34	999
69	14.00	1568	597	109	35	88.7	294	247	1.0	597	35	999
70	14.20	1602	605	112	36	88.3	293	247	1.0	605	36	999
71	14.40	1635	614	115	37	87.9	291	247	1.0	614	37	999
72	14.60	1669	622	118	38	87.5	290	247	1.0	622	38	999
73	14.80	1702	630	121	38	87.1	289	247	1.0	630	38	999
74	15.00	1736	638	124	39	86.7	287	247	1.0	638	39	999
75	15.20	1770	646	127	40	86.3	286	246	.9	646	40	999
76	15.40	1803	654	131	41	85.9	285	246	.9	655	41	999
77	15.60	1837	663	134	42	85.5	283	246	.9	663	42	999
78	15.80	1870	671	137	42	85.1	282	246	.9	671	42	999
79	16.00	1904	679	140	43	84.7	281	246	.9	679	43	999

Estimated driving time between .2 and 6.2 m. is 16 minutes


Time [min] to penetrate 1 m
0
3
6
9
12
15
PTC 2A2
30 Jun 1993
09:41:57
Depth [m]
2
4
6
8
10
12
14
16
18
20