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IN-SITU NONLINEAR SOIL PROPERTY MEASUREMENT

BY

PAUL IBÁÑEZ
DANIEL E. CHITTY

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ANCO ENGINEERS, INC.
9937 JEFFERSON BLVD.
CULVER CITY, CA 90230-3591

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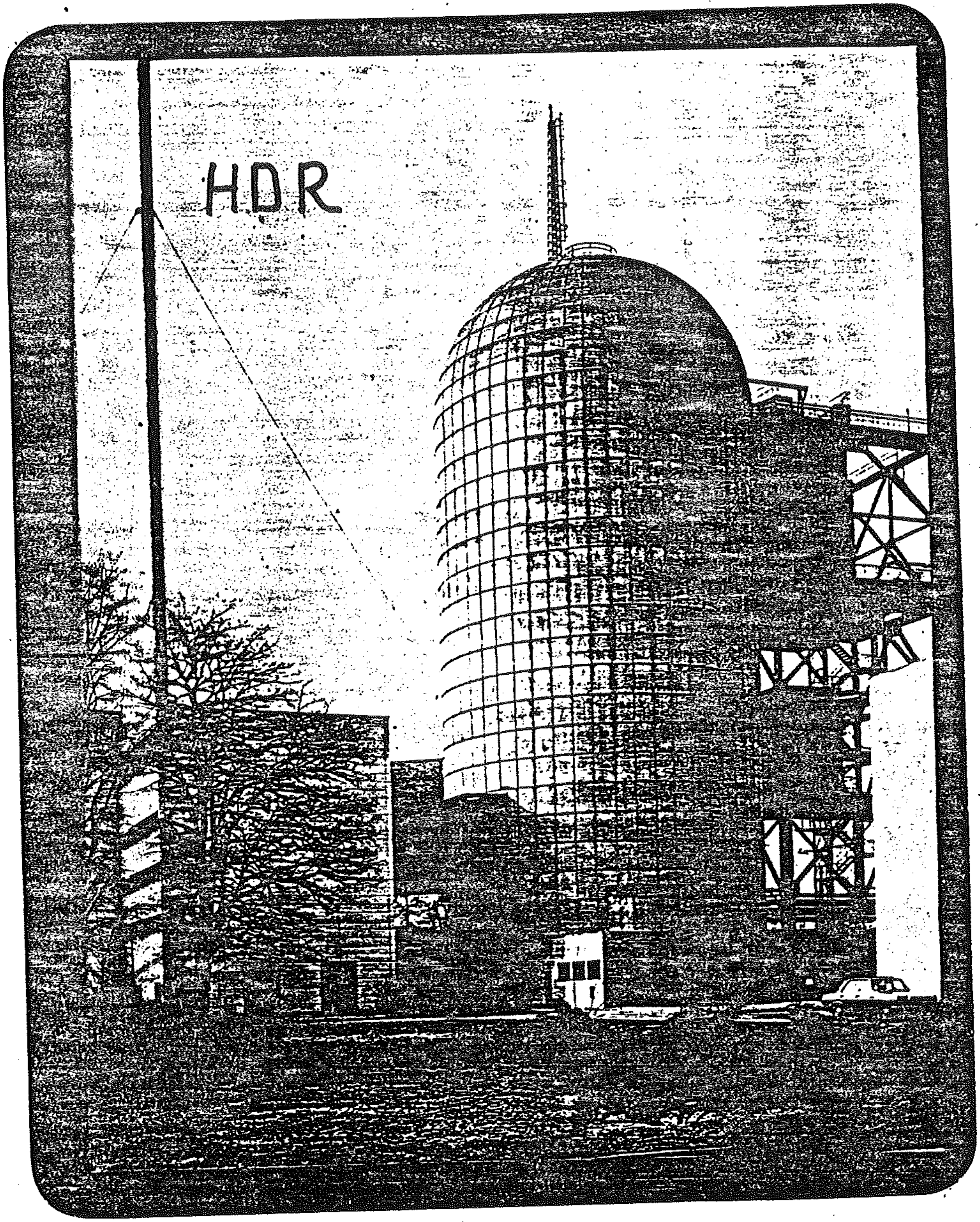
IN-SITU NONLINEAR SOIL PROPERTY MEASUREMENT

- NONLINEAR SOIL PROPERTIES SIGNIFICANTLY AFFECT THE SEISMIC RESPONSE OF LARGE STRUCTURES SUCH AS NUCLEAR POWER PLANTS AND OFF SHORE PLATFORMS

- THESE PROPERTIES ARE DISTORTED IN LAB TESTS AND DIFFICULT TO MEASURE IN-SITU WITH CURRENT METHODS

- A NEW APPROACH, USING A UNIQUE DOWNHOLE EXCITOR, SOPHISTICATED NONLINEAR MODELS, AND BAYESIAN PARAMETER IDENTIFICATION, IS BEING INVESTIGATED

- PRELIMINARY RESULTS ARE REPORTED HERE


HDR

TYPICAL SOIL-STRUCTURE FINITE ELEMENT GRID

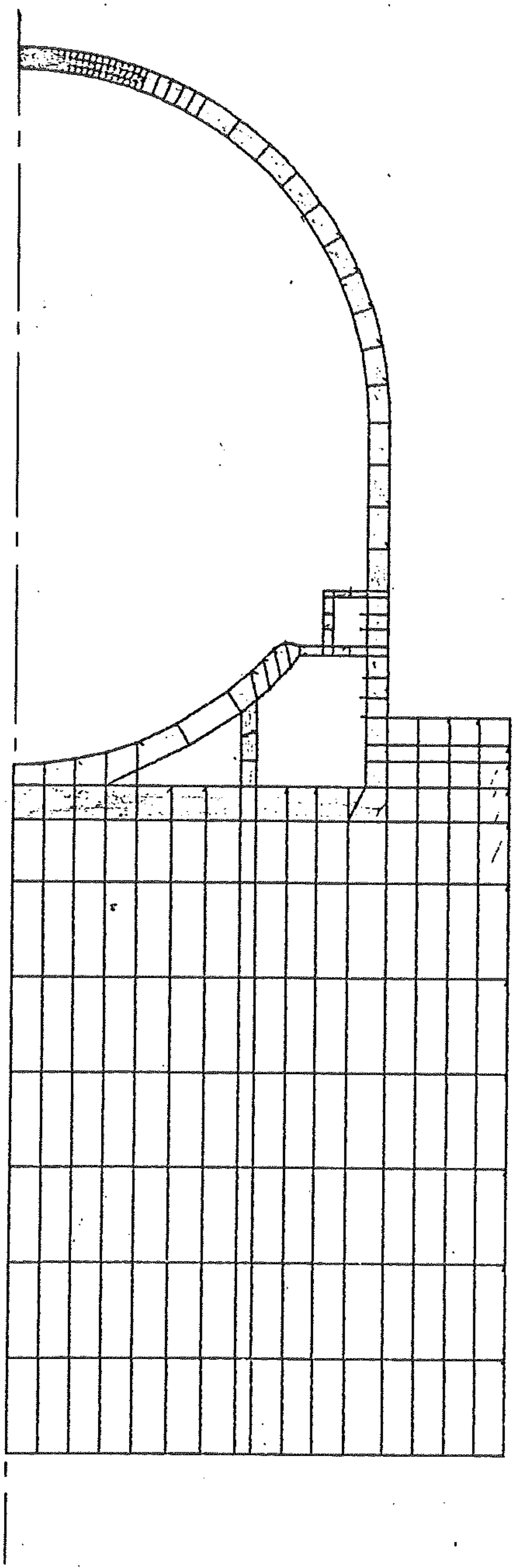
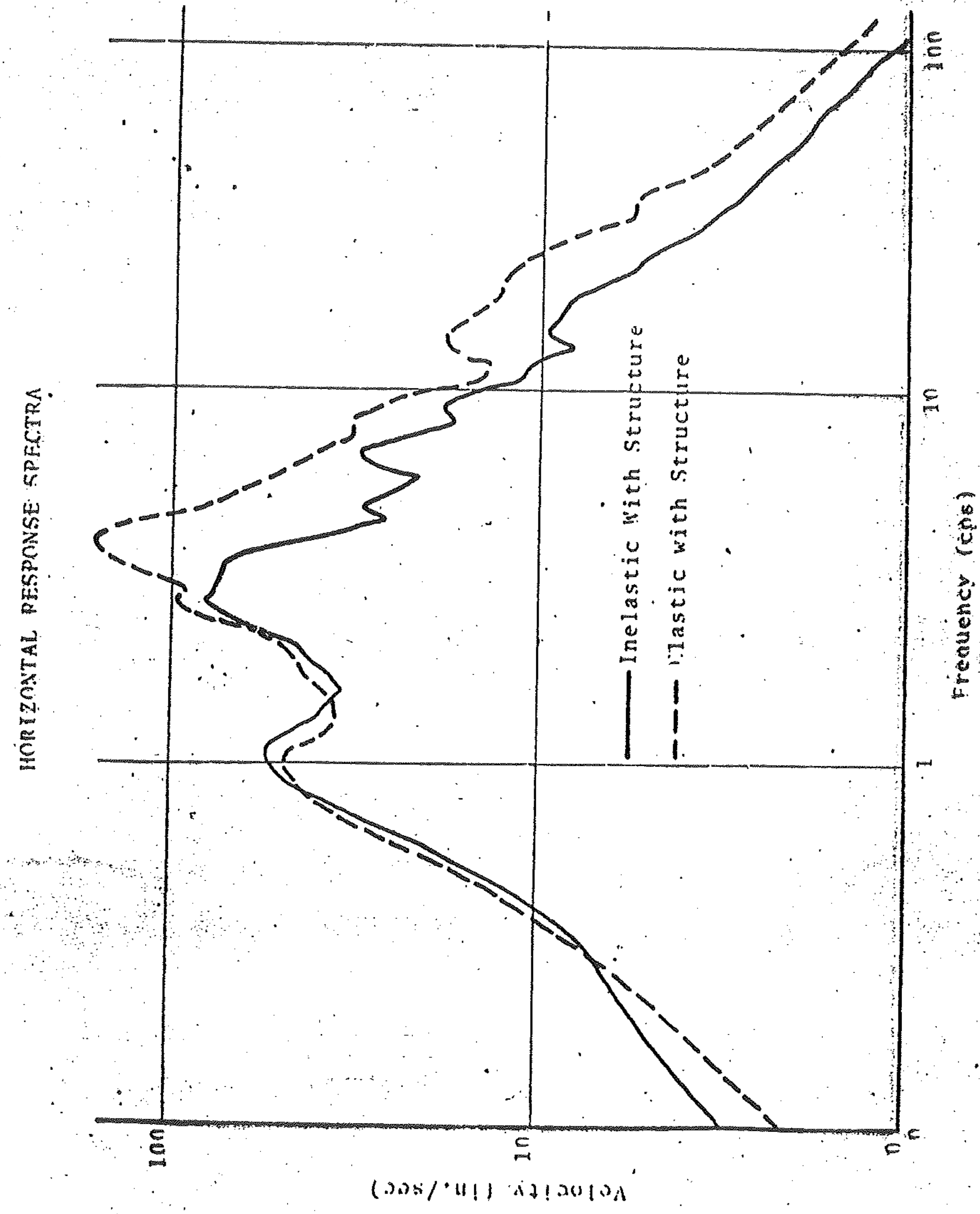
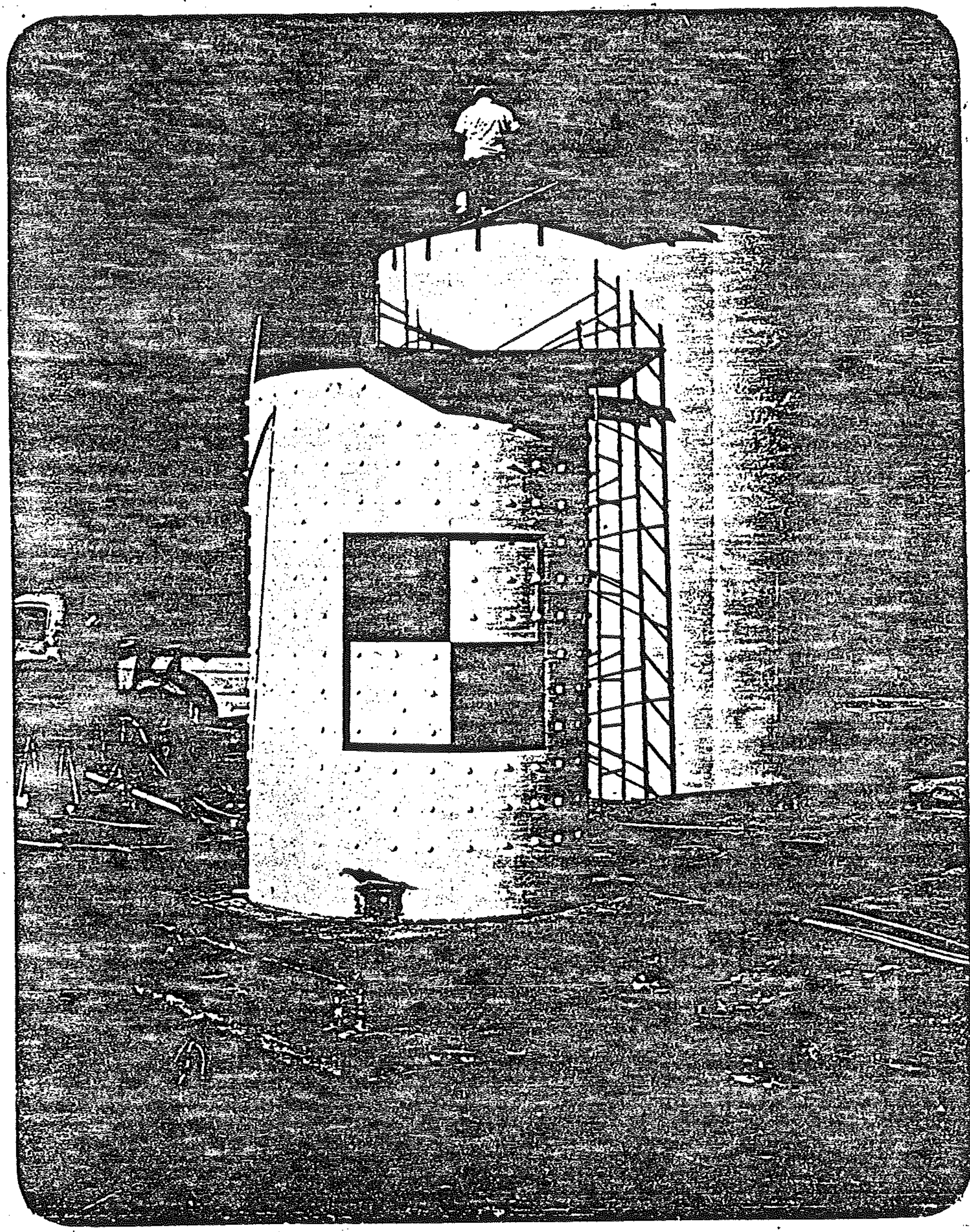


FIGURE 3.2: Comparison of Response Spectra Obtained from Nonlinear and Linear Soil-Structure Interaction Models





Title FORCED VIBRATION TEST RESULTS ON SIMQUAKE MODELS

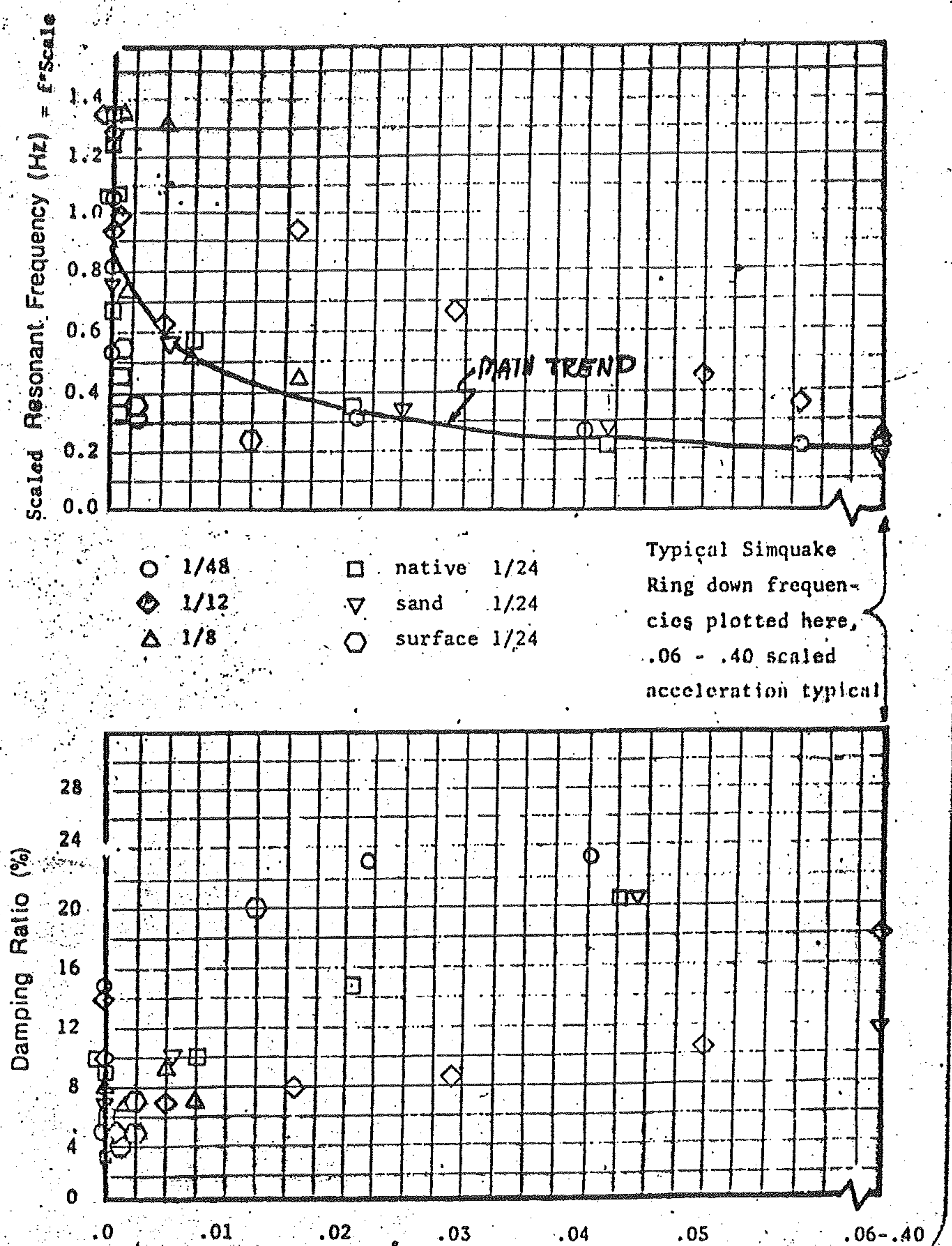
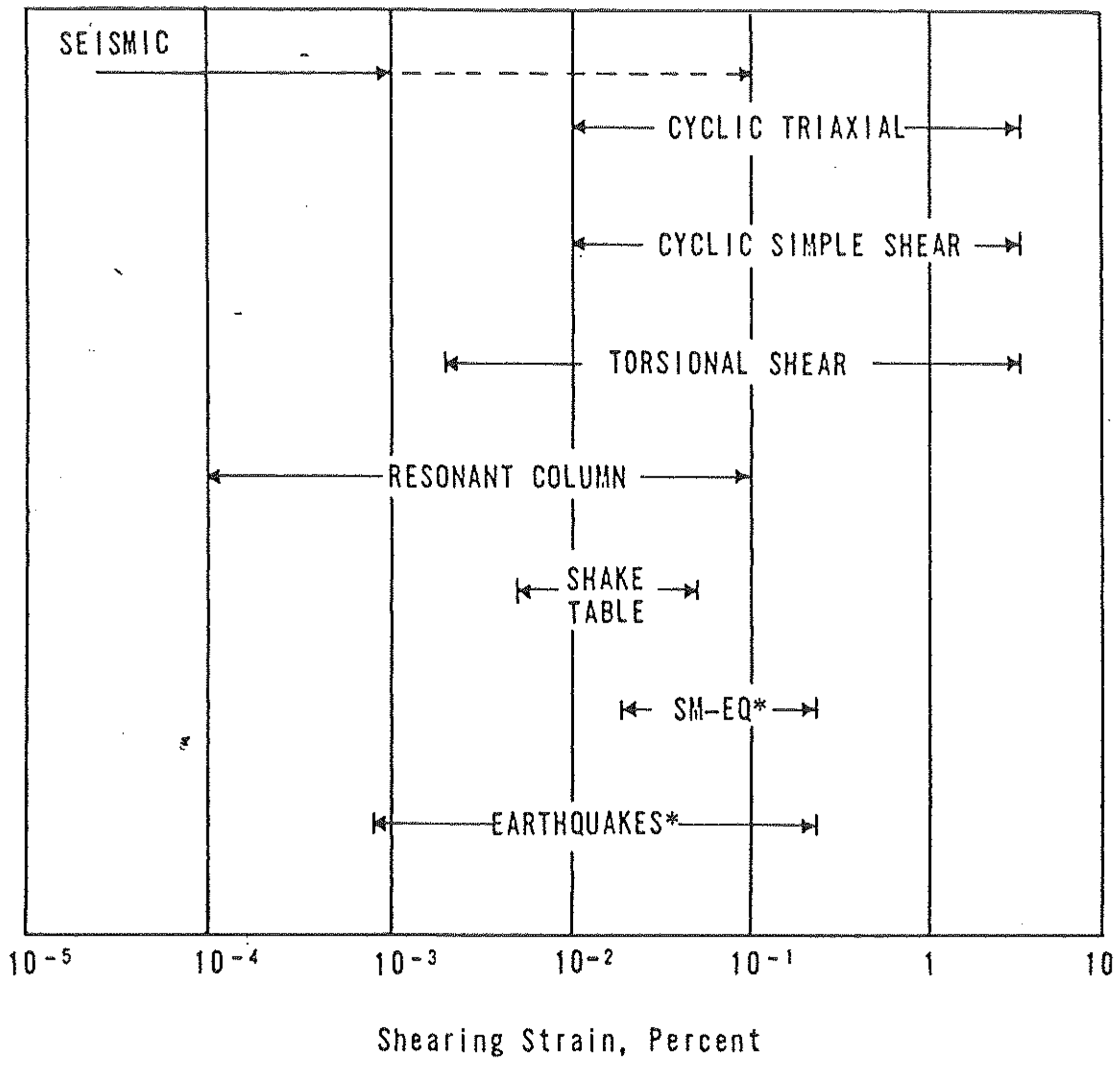


FIGURE 1.1 APPROXIMATE SHEARING STRAIN RANGES OF FIELD AND LABORATORY DYNAMIC TEST (MODIFIED FROM SW-AJA, 1972)



*NOTE: RANGE OF SHEAR STRAIN DENOTED AS " EARTHQUAKES" REPRESENTS AN EXTREME RANGE FOR MOST EARTHQUAKES " SM-EQ" DENOTES STRAINS INDUCED BY STRONG MOTION EARTHQUAKES.

Figures and Tables from reference A: " Evaluation of In-Situ Methods for High-Amplitude, Dynamic Property Determination ", EPRI Report NP-920 November 1978, By Fugro, Inc.

FIGURE 1.2 TYPICAL MODULUS AND DAMPING RATIO CURVES (FUGRO, 1977) - Reference A

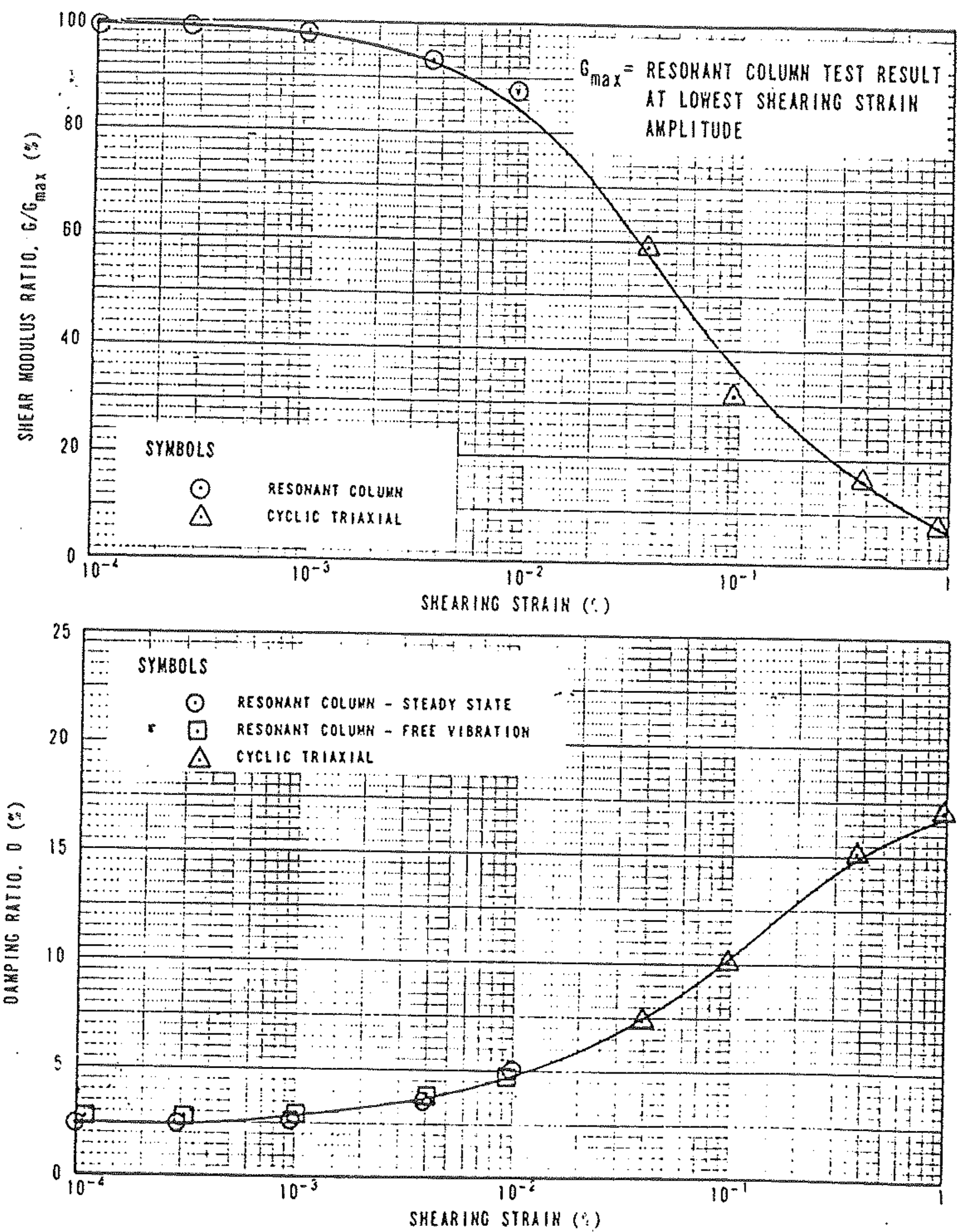


FIGURE 1.3 LOW AMPLITUDE SHEAR MODULUS (FUGRO, 1977) - Ref. A

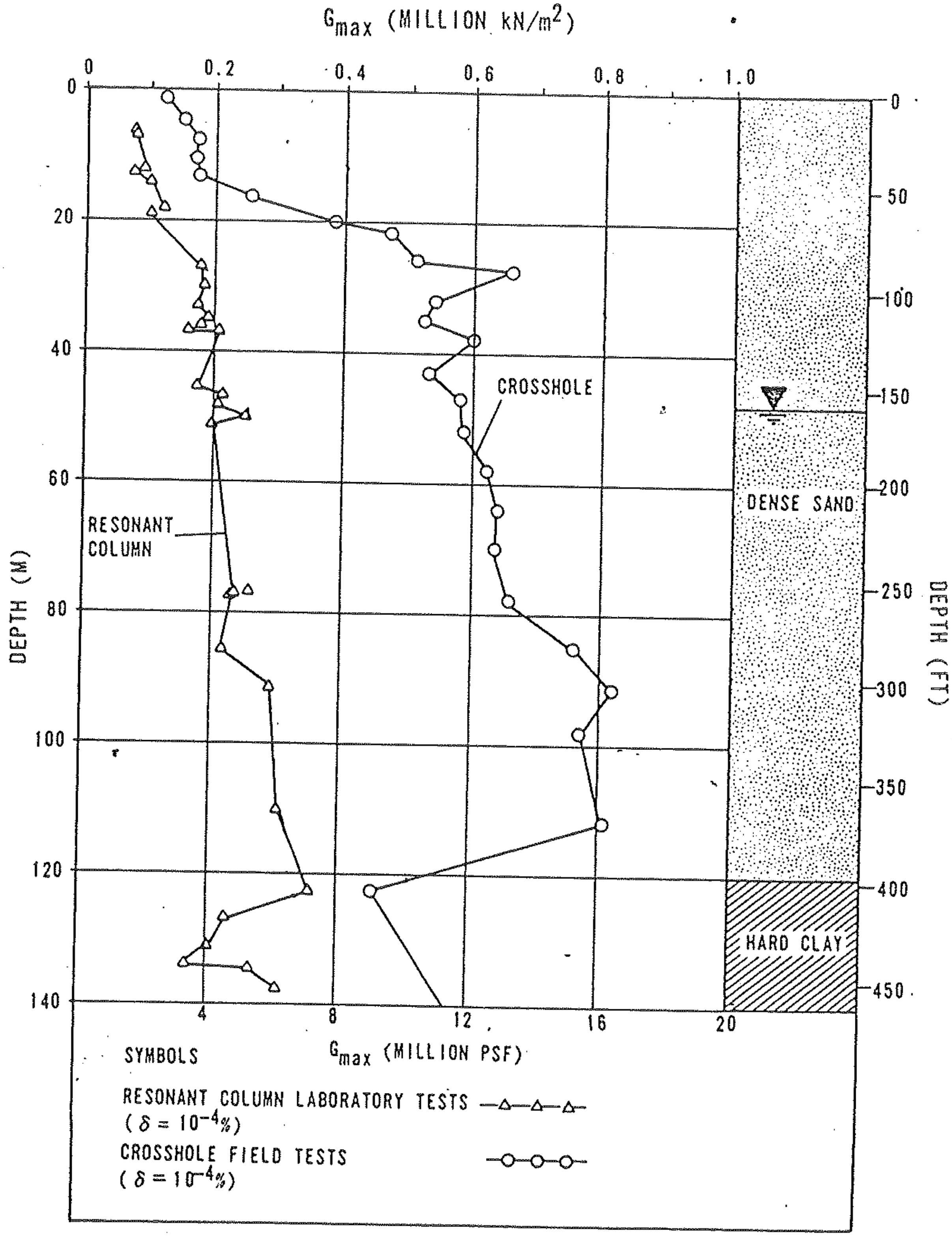
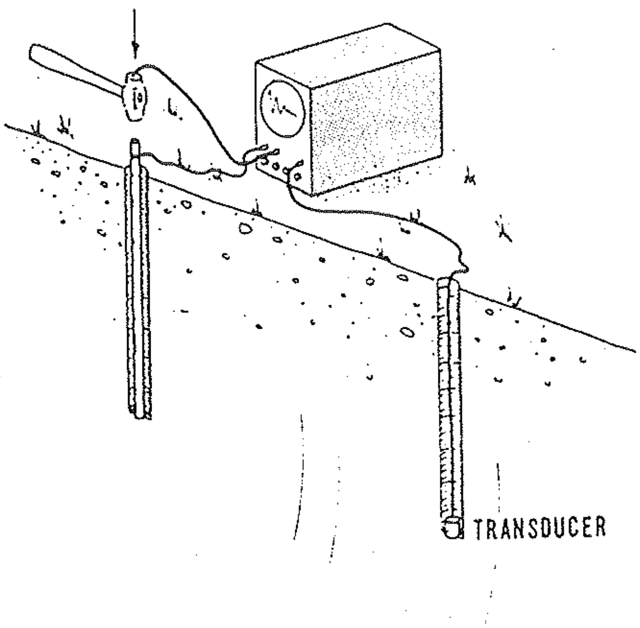
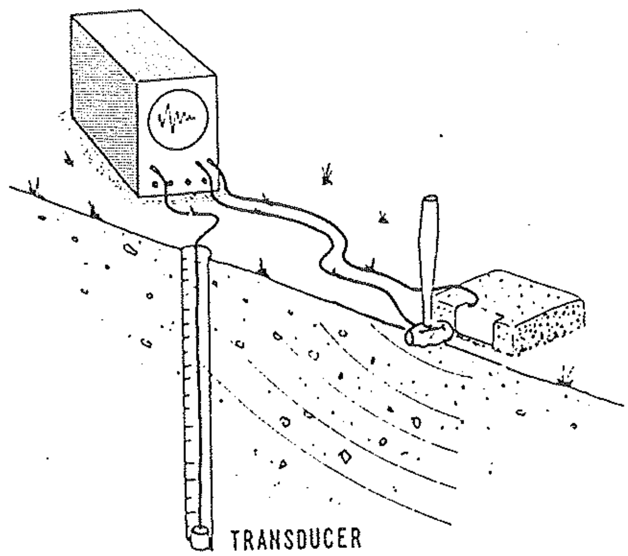


FIGURE 2.1 TYPICAL WAVE PROPAGATION TEST METHODS
- Reference A -

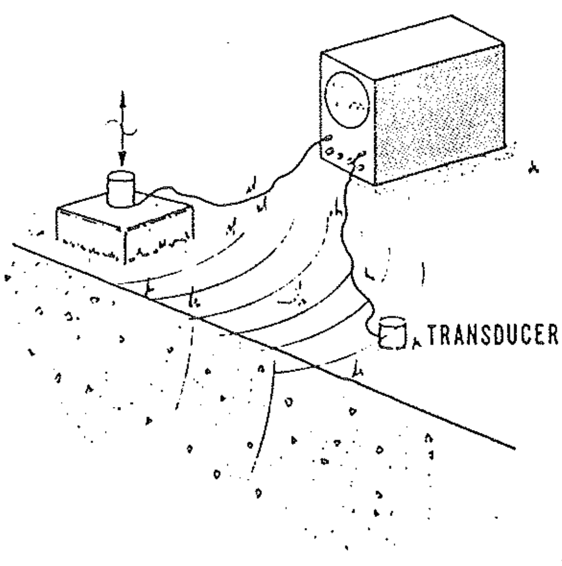
1. CROSSHOLE



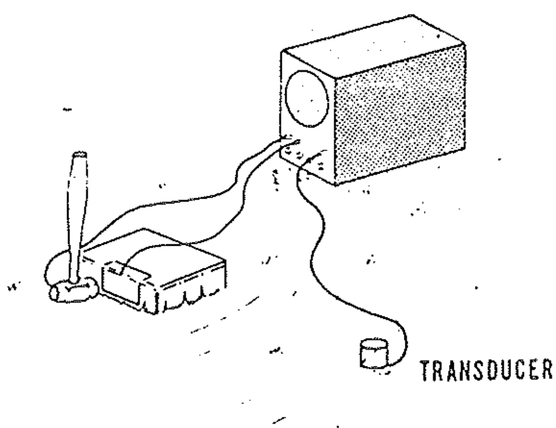
2. DOWNHOLE



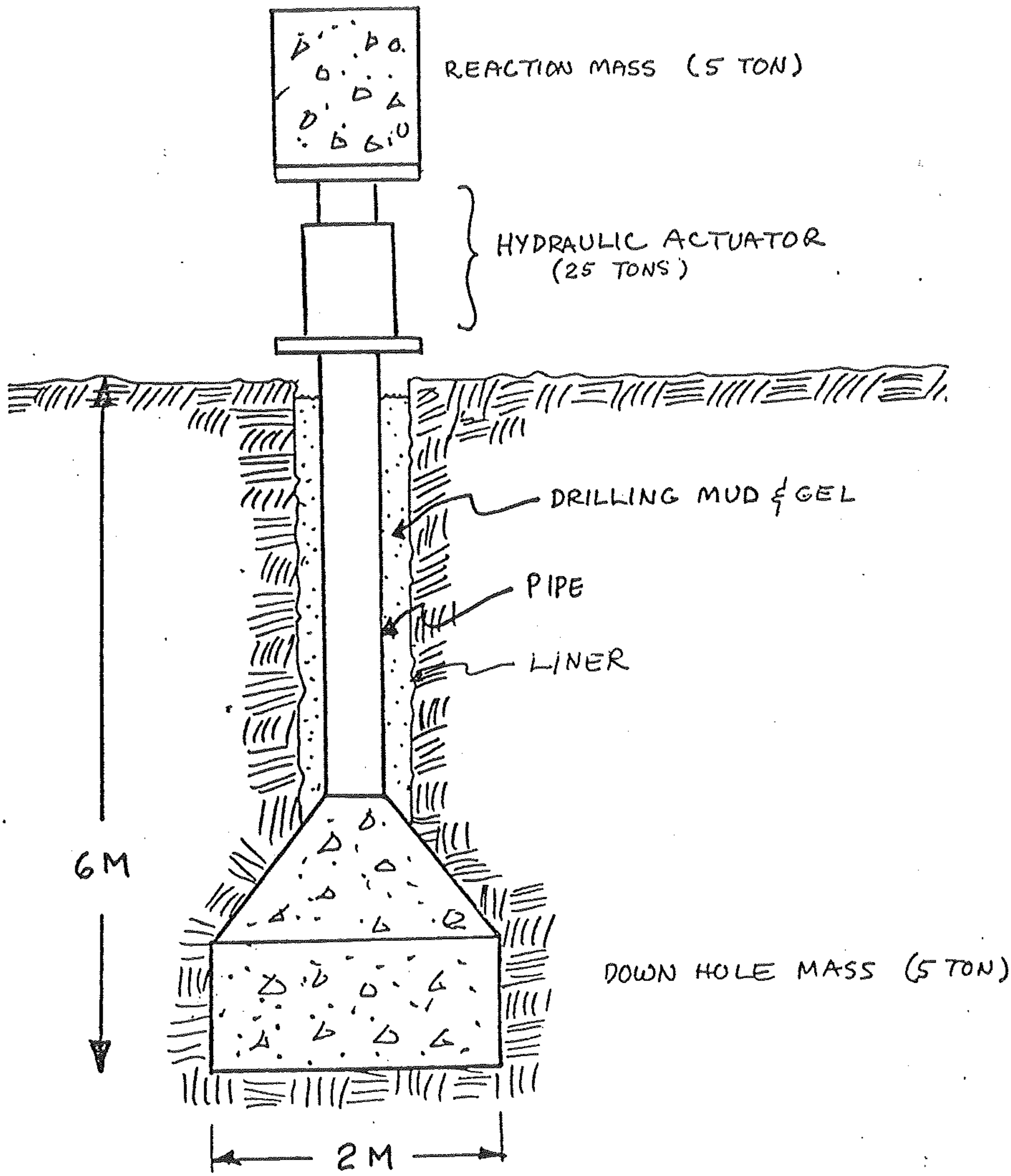
3. STEADY STATE VIBRATION



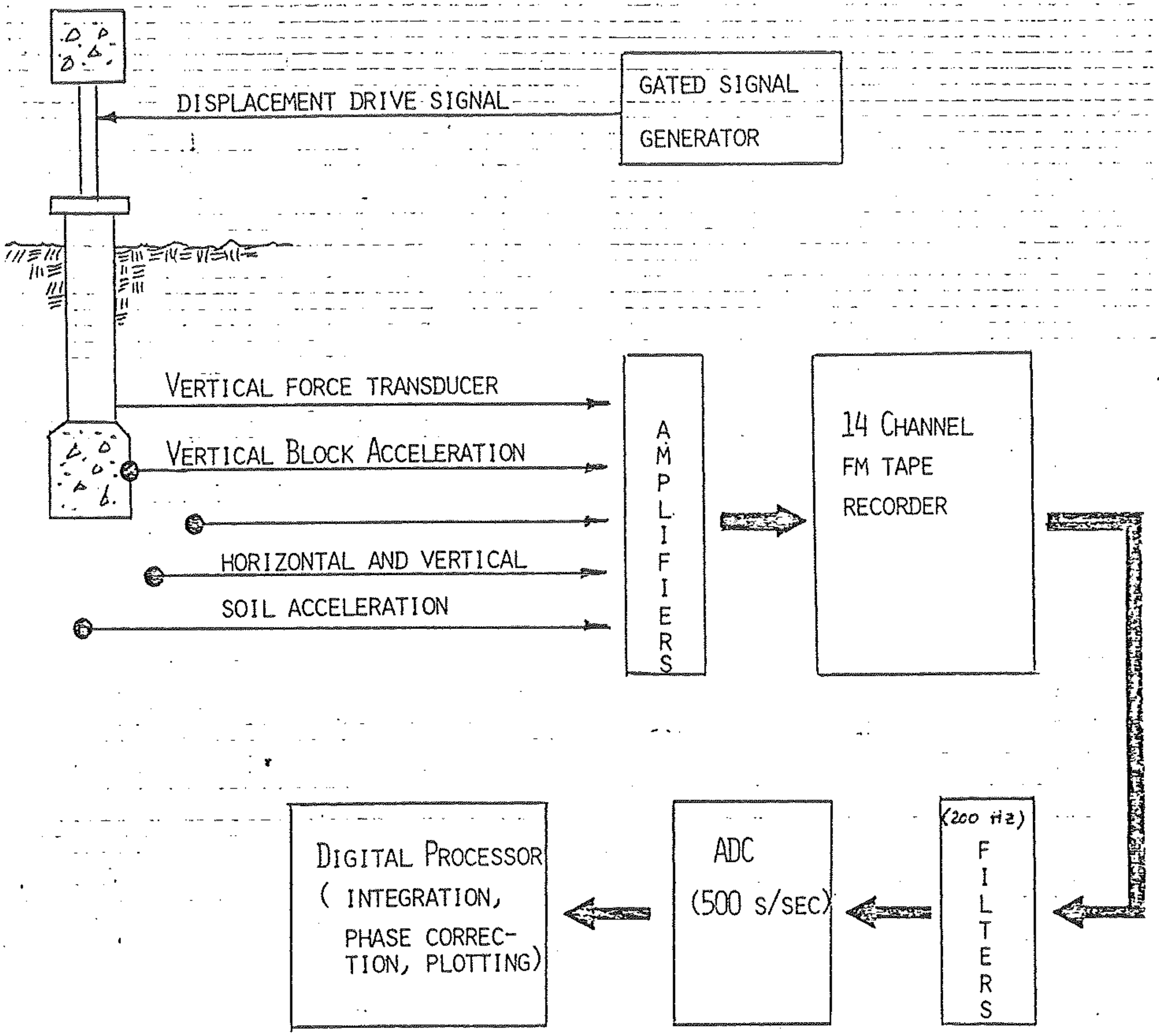
4. SHEAR WAVE REFRACTION



EXPERIMENTAL DEVICE SCHEMATIC



INSTRUMENTATION DIAGRAM



IN TRIAXIAL COMPRESSION TEST

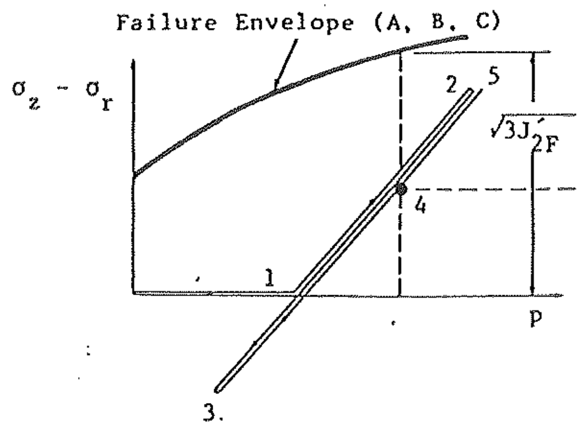


Figure 1-1

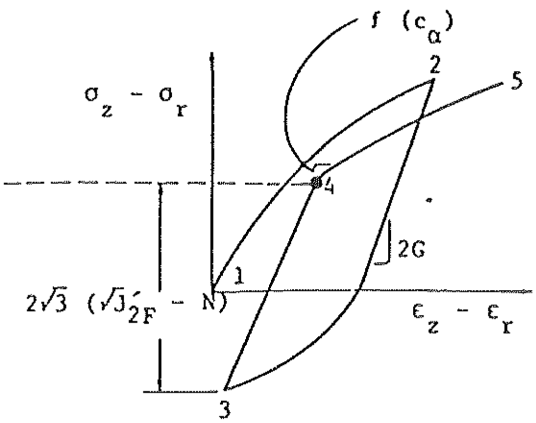


Figure 1-2

IN UNIAXIAL STRAIN TEST

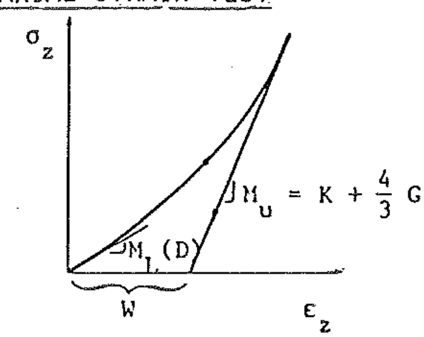


Figure 1-3

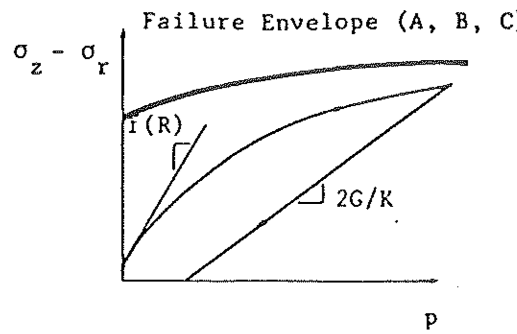
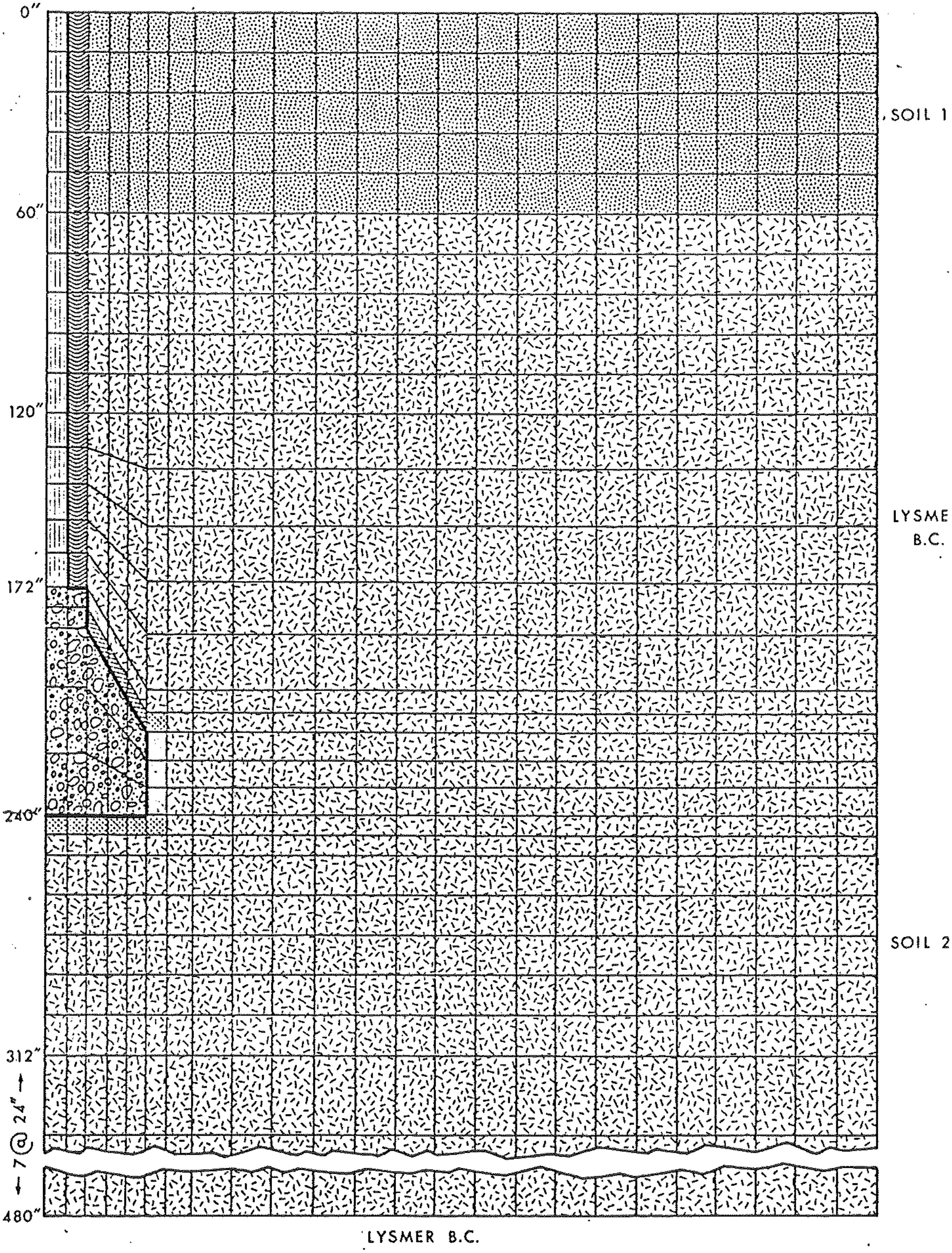


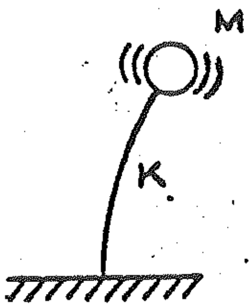
Figure 1-4

Parameter	Role in Model	Effect on Behavior
K	Elastic bulk modulus	Controls volumetric behavior during unloading
G	Elastic shear modulus	Controls shear behavior during unloading
A	Mises failure limit	Maximum shear stress which can be supported by material
B	Rate at which failure envelope approaches maximum	Controls angle of friction at low pressures
C	Shear strength at zero pressure	Cohesion
W	Maximum plastic volumetric strain	Locking strain-unfilled voids
D	Rate at which compaction occurs with pressure	Controls initial loading moduli
R	Shape factor for cap	Controls loading stress path in uniaxial strain
c_α	Inelastic shear modulus	Controls inelastic stiffness and hysteresis in cyclic loading
N	Defines size of elastic region in cyclic loading	Controls proportion of elastic to plastic strain in cyclic loading

Figure 1. Illustration of physical meaning of cap parameters in simple laboratory test.



SOIL TEST GRID



CALCULATED

$M = 1.0 \pm .32$ Kg

$K = 1.0 \pm .55$ N/M

PREDICTED

$\omega = 1.0$ R/S

MEASURED

$\omega = 0.9 \pm .22$ R/S

WHAT IS BEST ESTIMATE OF

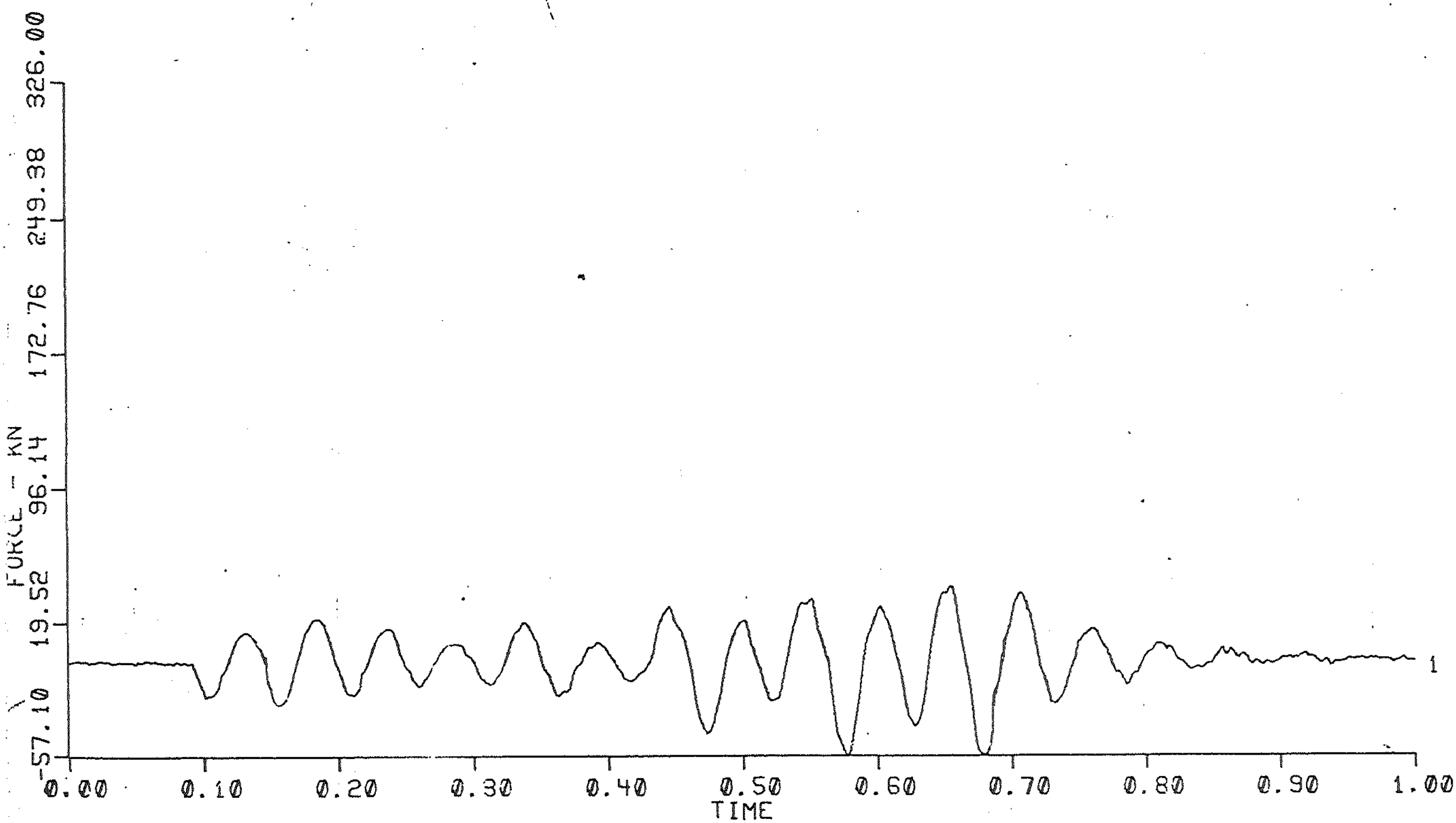
M, K, AND ω ?

$$E(M_0, K_0) \equiv \frac{(K-K_0)^2}{\sigma_K^2} + \frac{(M-M_0)^2}{\sigma_M^2} + \frac{(\omega_0 - \omega_m)^2}{\sigma_\omega^2}$$

$$\omega_0 = \sqrt{\frac{K_0}{M_0}}$$

MINIMIZE E TO FIND BEST ESTIMATES

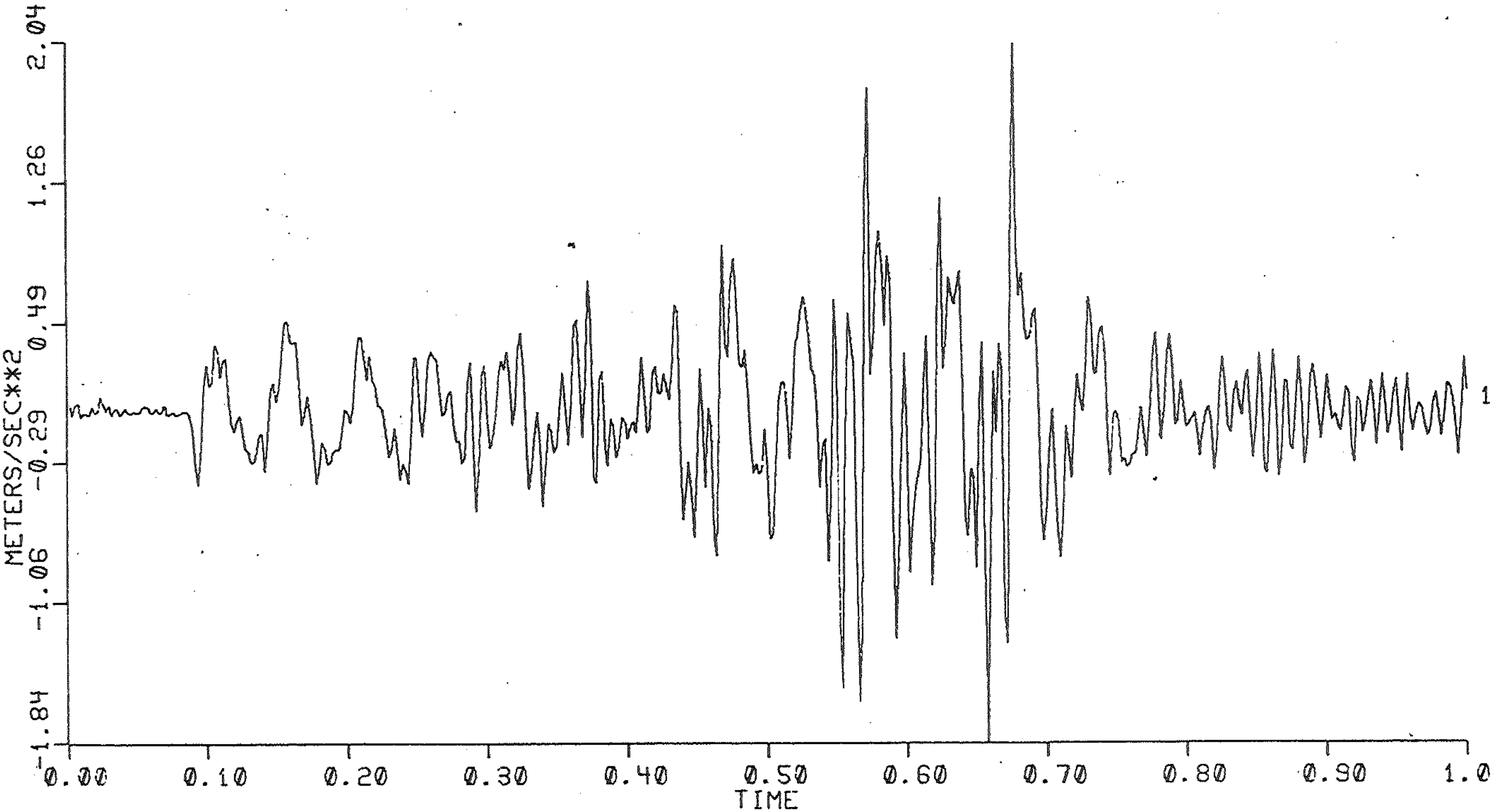
Parameter	A Priori or Measured Value	Optimal Value	% Difference
Mass	1.00 ± 0.32	1.030	3.0
Stiffness	1.00 ± 0.55	0.895	11.0
Resonant Frequency	0.90 ± 0.22	0.932	3.6



NSF SOILS TEST (T1RS) 0.1 SPAN, 10 CYCLES, 20 HERTZ

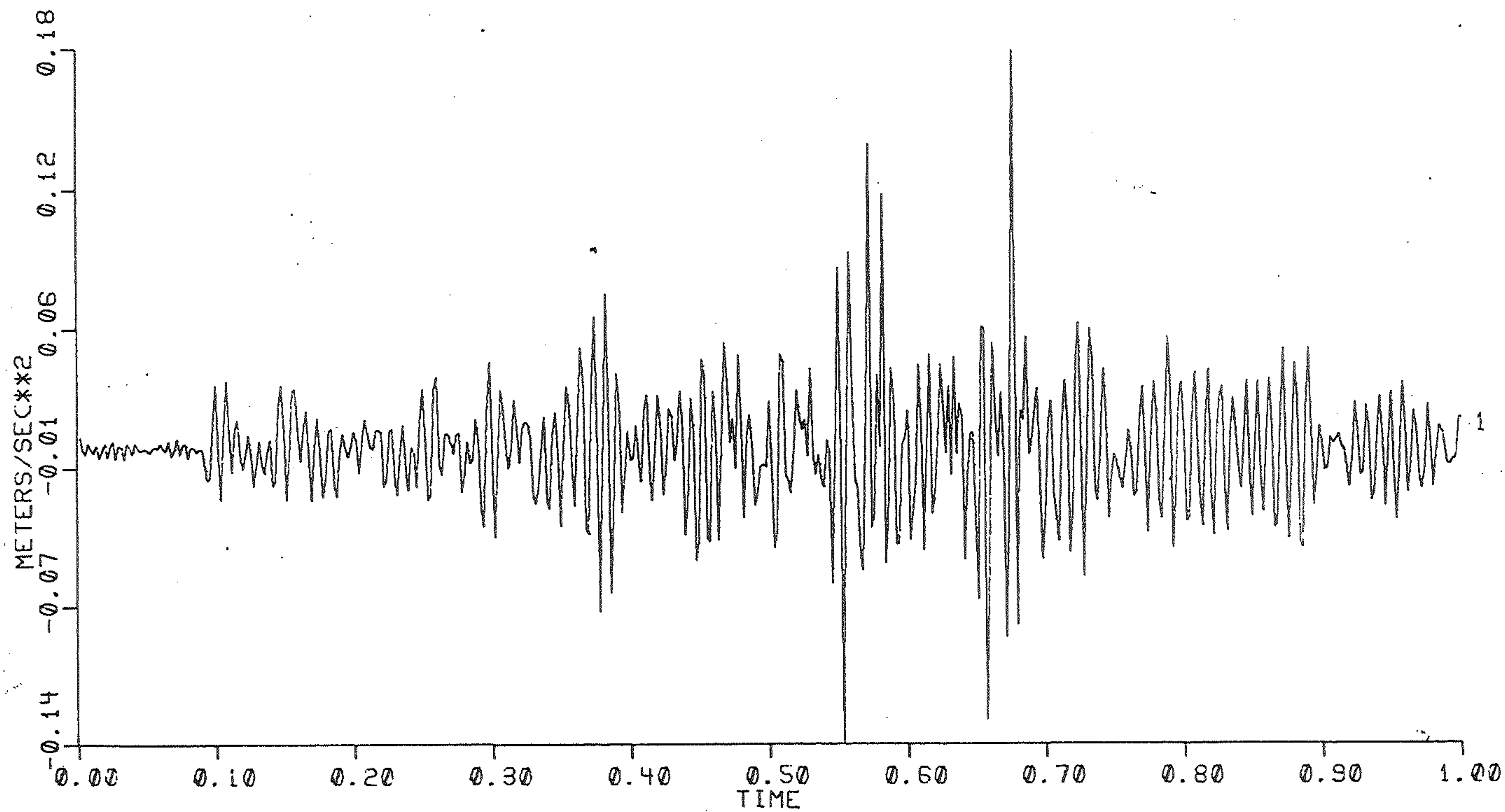
F1 UPWARDS FORCE ON BLOCK (#1)

1 TEST 1 RUN 5 CHANNEL 1



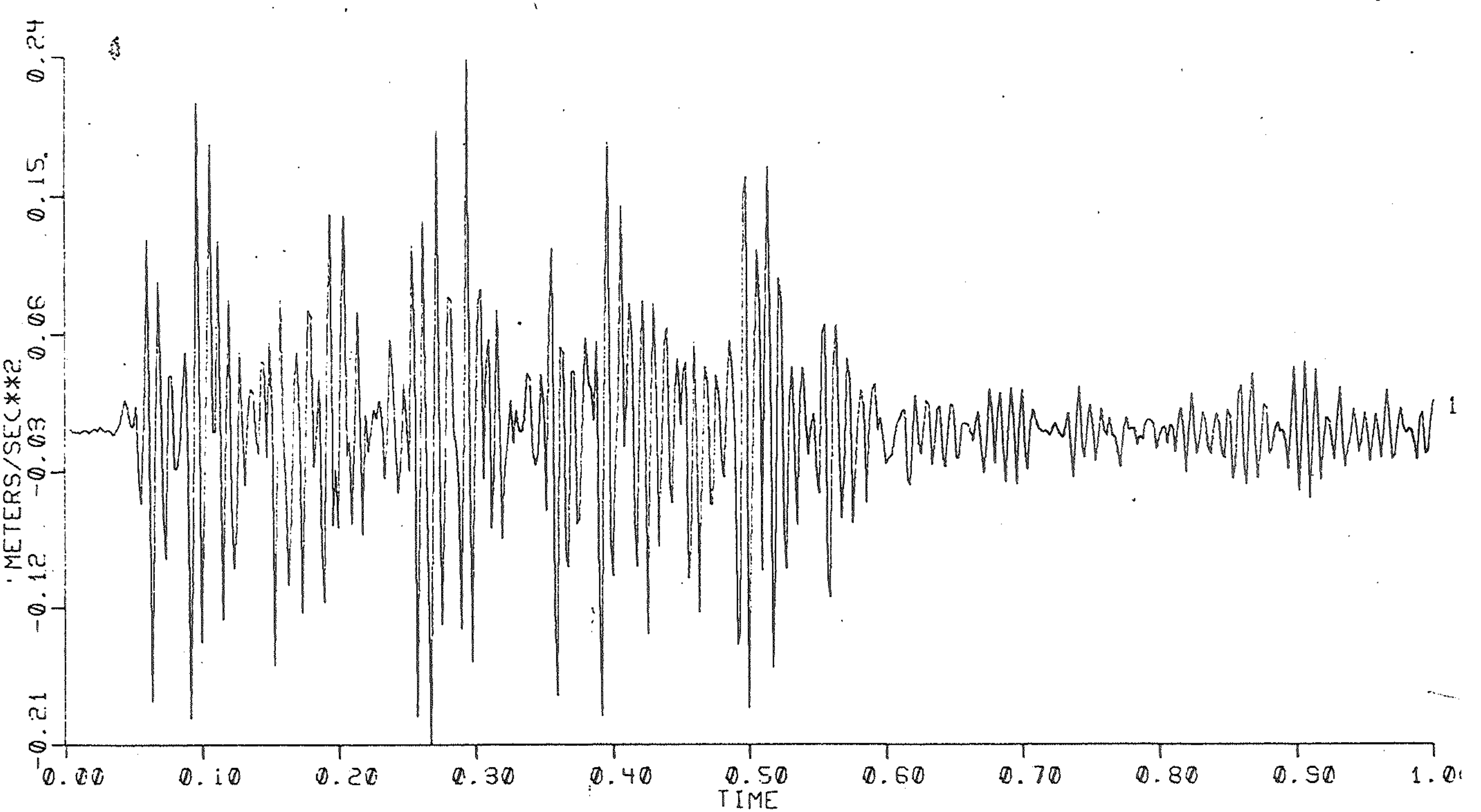
NSF SOILS TEST (T1RS) 0.1 SPAN, 10 CYCLES, 20 HERTZ
S1 UPWARDS MOTION OF BLOCK (10 G STATHAM)

1 TEST 1 RUN 5 CHANNEL 3



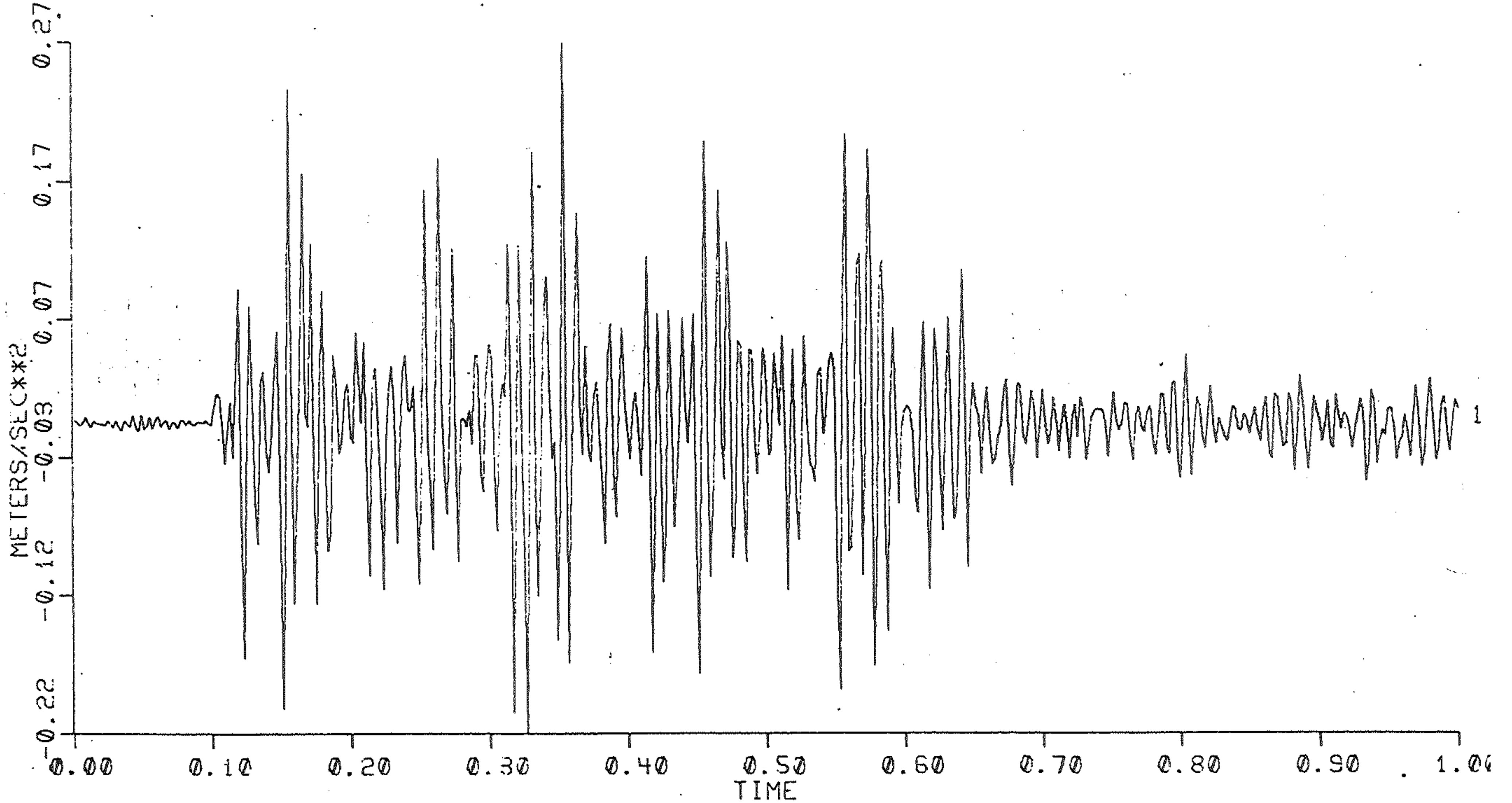
NSF SOILS TEST (T1RS) 0.1 SPAN, 10 CYCLES, 20 HERTZ
AF04 UP AT 60" RADIUS, 15' DEEP

1 TEST 1 RUN 5 CHANNEL 5



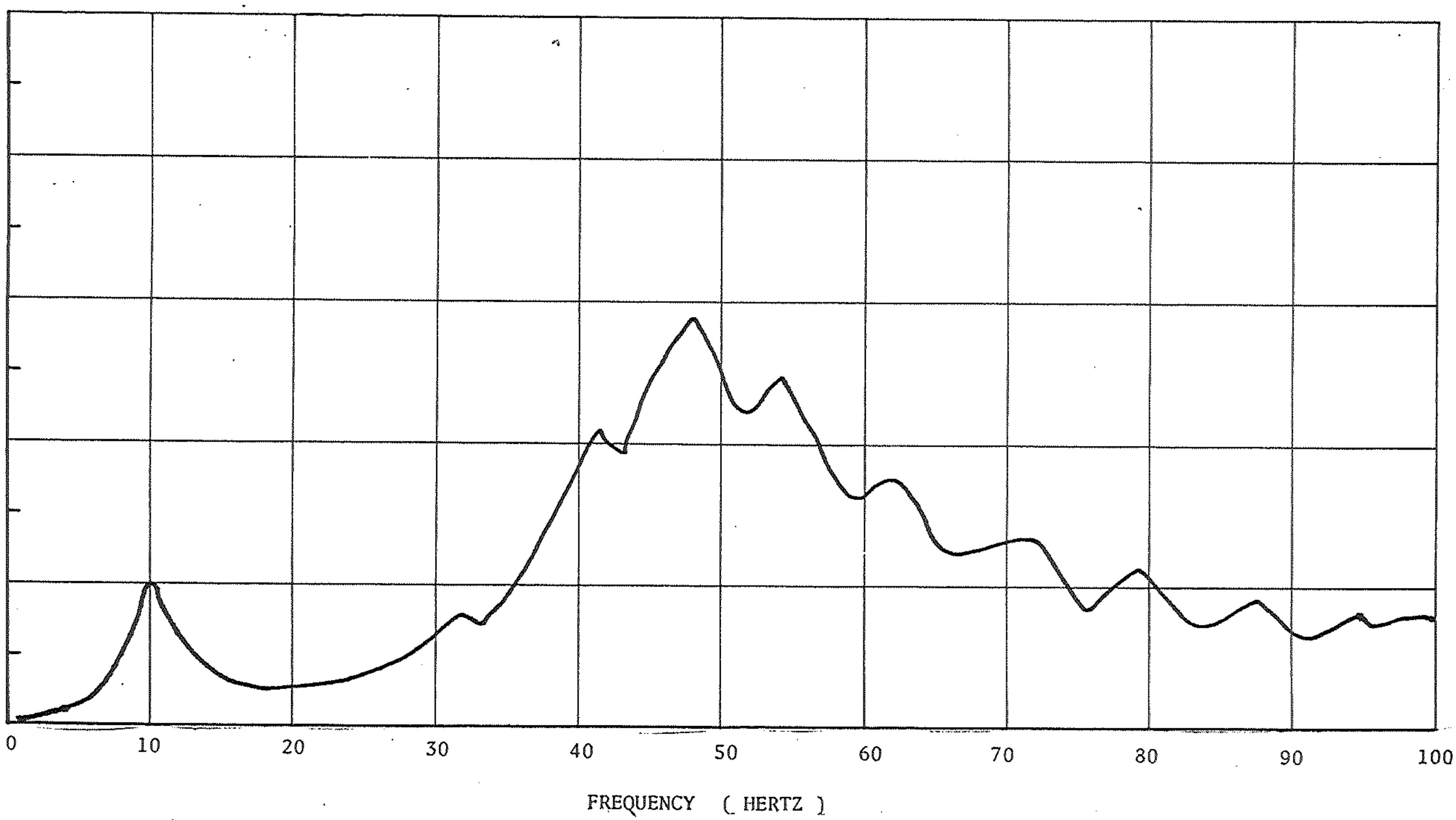
NSF SOIL TEST (T3R1) .3 SPAN. 5 CYCLES. 10 HERTZ
AF04 UP AT 60" RADIUS. 15' DEEP

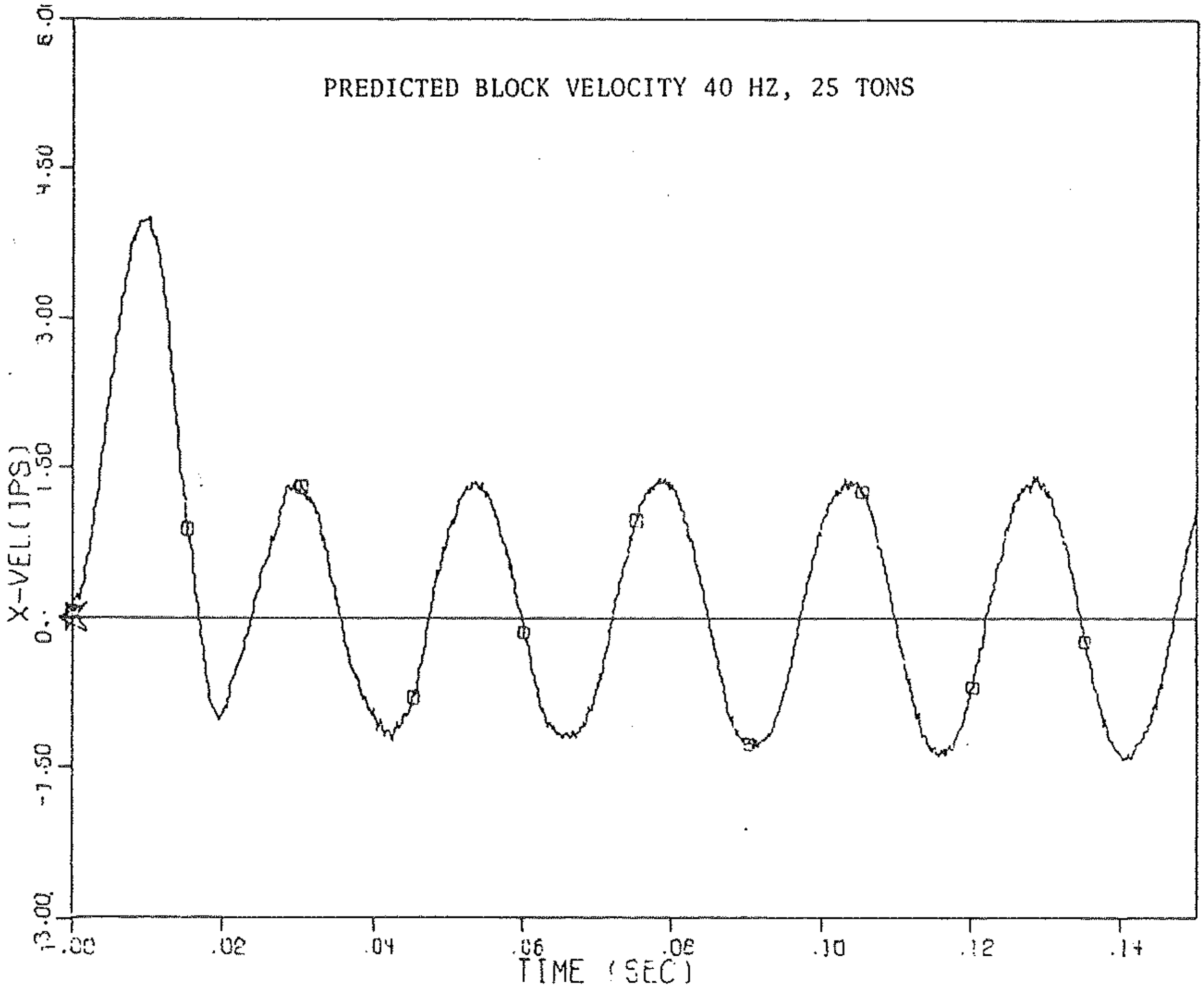
1. TEST 3 RUN 1 CHANNEL 5

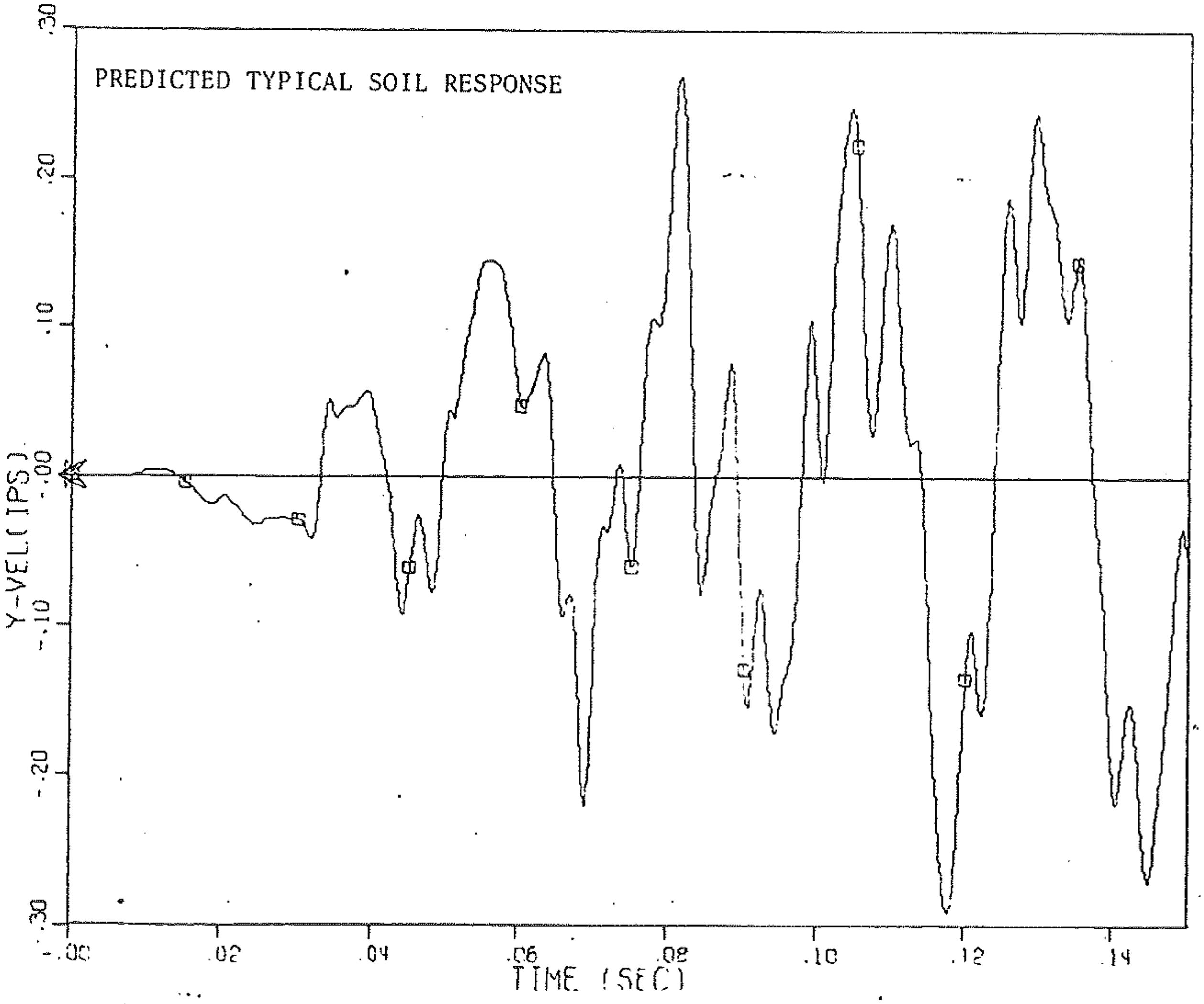


NSF SOIL TEST (TSR1) 0.3 SPAN. 5 CYCLES. 10 HERTZ
AF04 UP AT 60" RADIUS. 15' DEEP

TYPICAL SPECTRA OF SOIL RESPONSE TO 10 HZ FORCING




PREDICTED BLOCK VELOCITY 40 HZ, 25 TONS
X-VEL(IPS)
6.00
4.50
3.00
1.50
0.
-1.50
-3.00
.00
.02
.04
.06
.08
.10
.12
.14
TIME (SEC)


PREDICTED TYPICAL SOIL RESPONSE
Y-VEL(IPS)
.30
.20
.10
.00
-.10
-.20
-.30
.00
.02
.04
.06
.08
.10
.12
.14
TIME (SEC)

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FUTURE WORK

- INTEGRATION AND BANDPASS FILTERING OF SOIL ACCELERATION RESPONSE
- COMPARISON OF TEST AND ANALYSIS
- APPLICATION OF BAYESIAN ALGORITHM, IF FEASIBLE
- PUBLICATION OF RESULTS (circa March 1981)