EARTHQUAKE ENGINEERING RESEARCH CENTER

A P O L L O

A COMPUTER PROGRAM FOR THE ANALYSIS OF PORE PRESSURE GENERATION AND DISSIPATION IN HORIZONTAL SAND LAYERS DURING CYCLIC OR EARTHQUAKE LOADING

by

Philippe P. Martin

H. Bolton Seed

Report No. UCB/EERC-78/21

October 1978

A Report on Research Sponsored by
the National Science Foundation

College of Engineering

University of California

Berkeley, California

A P O L L O
A COMPUTER PROGRAM FOR THE ANALYSIS OF PORE PRESSURE GENERATION AND DISSIPATION IN HORIZONTAL SAND LAYERS DURING CYCLIC OR EARTHQUAKE LOADING

by Philippe P. Martin[1] and H. Bolton Seed[2]

1. INTRODUCTION

The evaluation of pore pressure generation in soils due to earthquakes or other types of cyclic loading conditions has been given considerable attention in recent years.

Laboratory test procedures have been developed to obtain quantitative measures of the stress conditions which lead to soil pore pressure development. In addition, analytical methods which use these test results have been developed to evaluate the liquefaction or cyclic mobility potential of soil deposits in the field (Seed and Idriss, 1967, 1971).

The improved understanding of the mechanisms involved in pore pressure generation under cyclic loading conditions has also led to advances in the analysis of ground response taking into account the effects of pore water pressure generation under dynamic loading conditions (Finn et. al., 1977; Ghaboussi and Dikmen, 1978; Liou et. al., 1977; Zienkiewicz et. al., 1978; Martin and Seed, 1978), and on the significance of dissipation and internal redistribution of pore water pressures in a soil mass subjected to dynamic loading (Seed and Lee, 1966; Ambraseys and Sarma, 1969; Yoshimi and Kuwabara, 1973; Seed et. al., 1975).

Effective stress ground response analyses can only be performed with the knowledge of the pore pressure distribution in the soil and its variation with time

---

[1]Project Engineer, Engineering and Ouvrages D'Art, Clamart, France.

[2]Professor of Civil Engineering, University of California, Berkeley, CA.

Several methods of expressing the rate of build-up of pore water pressures in a sand deposit subjected to earthquake shaking have been developed in recent years. They generally fall into one of two categories:

1. By referring to the fundamentals of the behavior of granular materials under cyclic shear stress applications, it has been possible to isolate the factors and the soil properties which determine the rate of pore water pressure generation. Then these data and mechanisms have been incorporated into methods of effective stress ground response analysis (Finn et. al., 1977, 1978). Yet, unless these soil characteristics can be measured with the required degree of accuracy, predicted pore pressures may be somewhat in error.
2. Use can be made of actual measurements of pore water pressure build-up in cyclic loading tests. The only criteria then required to evaluate pore pressure development in any soil element is the evaluation of the number of uniform stress cycles (N_ℓ) which will produce a condition of initial liquefaction under undrained conditions. This can readily be determined from undrained cyclic simple shear tests or other appropriate tests on representative samples.

A method of liquefaction analysis of horizontal sand deposits using these principles has been developed by Seed et. al. (1975). This report describes the computer program APOLLO in which the method has been incorporated and gives a typical example of its application.

2. Derivation of the Basic Equation

The basic assumption involved in a pore pressure generation and dissipation analysis is that the excess pore water pressure change, Δu, in a soil element is the sum of the pore pressure increment generated by the dynamic excitation, Δu_g, and of the pore pressure change due to the flow of pore water in and out of the soil element, Δu_d:

$$\Delta u = \Delta u_d + \Delta u_g \tag{1}$$

The pore water flow is related to the volume change of the element. Assuming vertical flow and constrained soil deformations in the horizontal direction:

$$\Delta u_d = -\Delta\sigma' = -\frac{1}{m_v}\Delta\varepsilon_v \tag{2}$$

where m_v is the coefficient of volume compressibility. Darcy's law relates the volume change, $\Delta\varepsilon_v$, occurring in the time Δt to the vertical gradient of excess pore water pressures:

$$\Delta\varepsilon_v = -\frac{\partial}{\partial z}\left(\frac{k}{\gamma_w}\frac{\partial u}{\partial z}\right)\cdot\Delta t \tag{3}$$

where k is the soil permeability and γ_w the unit weight of water. Using equations 1 through 3, the basic differential equation of the simultaneous generation and redistribution of pore pressures within a deposit may be written:

$$\frac{\partial u}{\partial t} = \frac{1}{m_v\gamma_w}\frac{\partial}{\partial z}\left(k\frac{\partial u}{\partial z}\right) + \frac{\partial u_g}{\partial t} \tag{4}$$

3. Soil Properties and Liquefaction Characteristics

The solution of equation (4) requires the knowledge of the undrained rate of pore pressure generation, $\frac{\partial u_g}{\partial t}$, the coefficient of volume compressibility, m_v, and the coefficient of permeability, k.

3.1. Undrained Rate of Pore Pressure Build-up

This method of analysis is based on the empirical finding that the development of pore water pressure in granular soils under cyclic loading conditions is of the form:

$$u_g = \sigma'_o \cdot F\left(\frac{N}{N_\ell}\right) \tag{5}$$

where σ'_o is the effective overburden pressure, N is the number of uniform stress cycles undergone by the soil sample and N_ℓ , the accumulative number of cycles at the same stress level required to reach initial liquefaction under undrained conditions.

For many soils, the function F may be expressed as

$$F\left(\frac{N}{N_\ell}\right) = \frac{2}{\pi} \text{ arc sin } \left(\frac{N}{N_\ell}\right)^{\frac{1}{2\alpha}} \tag{6}$$

where α is an empirical constant which depends on the soil type and test conditions. The relationship given in equation (6) is plotted in Figure 1 for different values of α. A value of $\alpha = 0.7$ has been found to represent the average curve for many soils.

The undrained rate of pore water pressure build-up may then be expressed as

$$\frac{\partial u_g}{\partial t} = \frac{\partial u_g}{\partial N} \cdot \frac{dN}{dt} \tag{7}$$

and equation (7) becomes according to equation (5)

$$\frac{\partial u_g}{\partial t} = \frac{\sigma'_o}{N_\ell} \cdot \frac{dF}{dN}\left(\frac{N}{N_\ell}\right) \cdot \frac{dN}{dt} \tag{8}$$

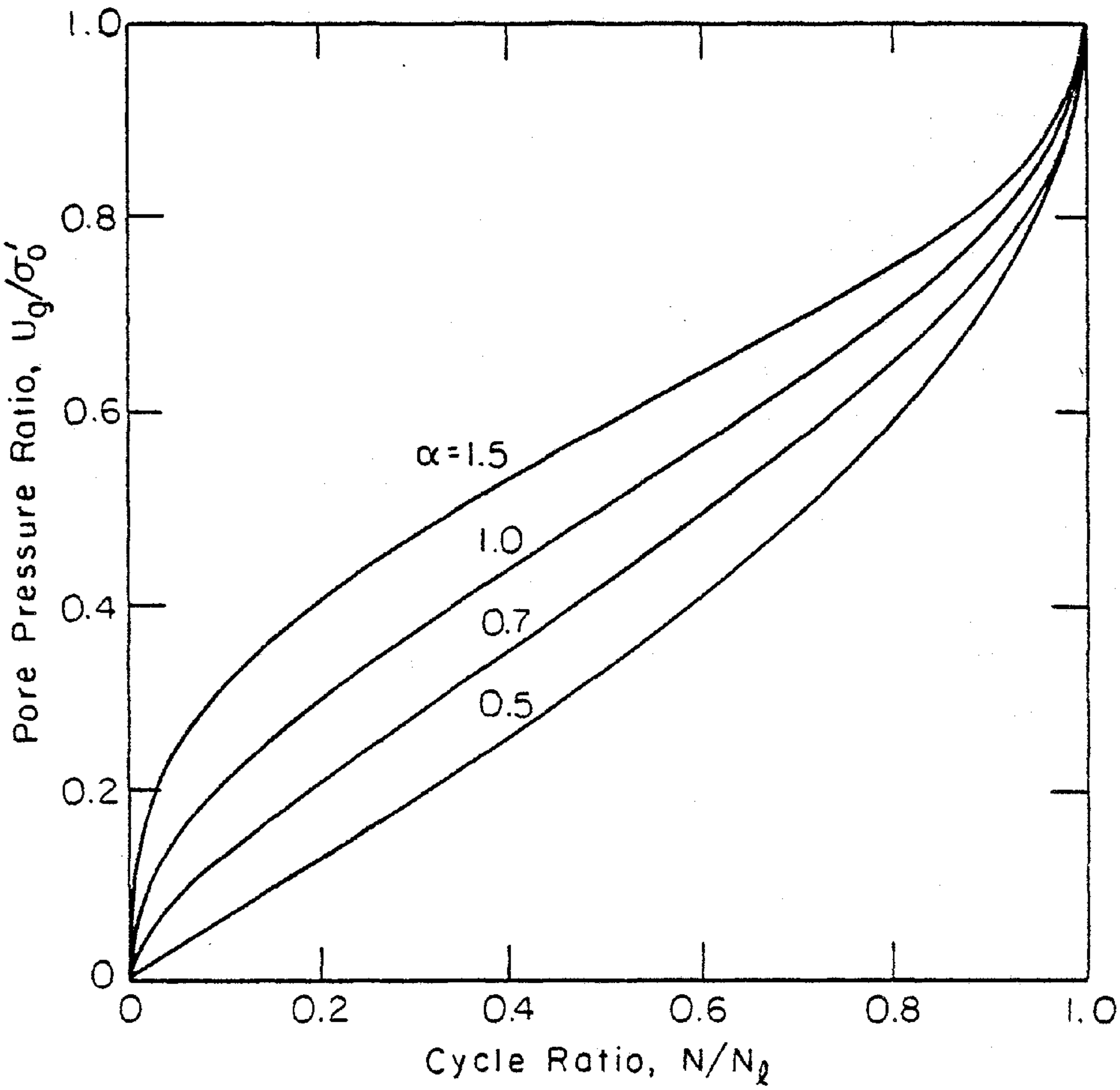


FIG. 1 RATE OF PORE PRESSURE GENERATION

It may then be noted that the only criterion required to evaluate the rate of pore water pressure build-up per applied uniform stress cycle, $\frac{\partial u_g}{\partial N}$, is the determination of the value of N_ℓ.

This can readily be obtained from undrained cyclic simple shear tests or any other appropriate test providing curves of the type shown in Figure 2. In a cyclic loading test, the cyclic loading frequency $\frac{dN}{dt}$ is a selected constant of the test. In the case of irregular dynamic loading patterns, the number of uniform stress cycles over which an equivalent shear stress amplitude is applied, may be evaluated either by adopting a representative number of cycles from studies of different magnitude earthquakes as shown in Table 1 or by using an appropriate weighting procedure as shown in Figure 3.

Whenever cyclic stresses are applied consistently at an equivalent level throughout the earthquake duration, t_D, the rate of uniform cyclic loading, $\frac{dN}{dt}$, may be taken as a constant determined by

$$\frac{dN}{dt} = \frac{N_{eq}}{t_D} \tag{9}$$

However when a specified earthquake motion induces phases of high stress intensity followed by significant phases of little activity, it may be desirable to evaluate the number of stress cycles, N_{eq_i}, over which the uniform equivalent cyclic stress is applied for each phase (see Figure 4). If there are k phases in the earthquake motion, then

$$N_{eq} = \sum_{i=1}^{k} N_{eq_i} \tag{10}$$

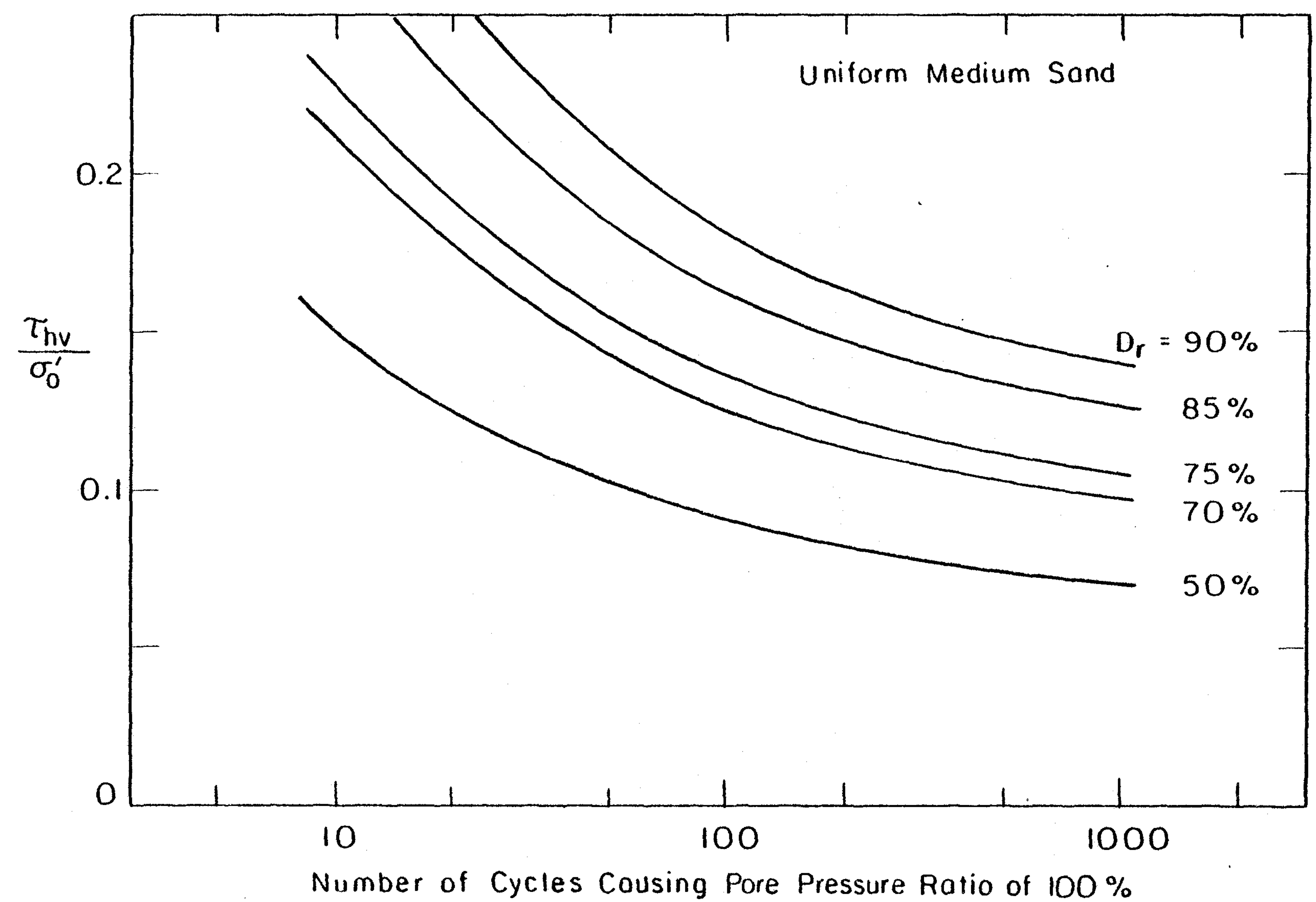


FIG. 2 TYPICAL CYCLIC LOADING TEST DATA

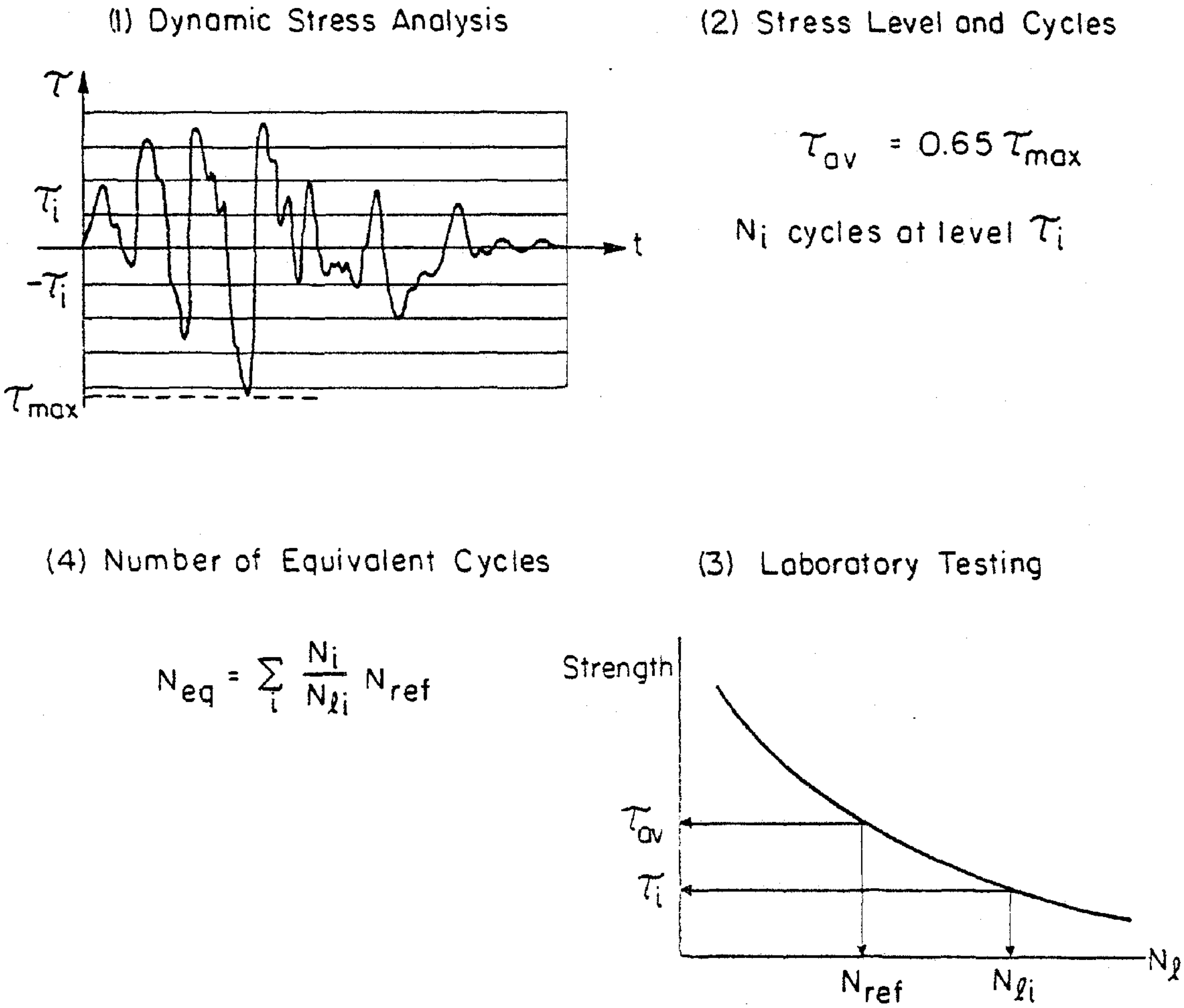
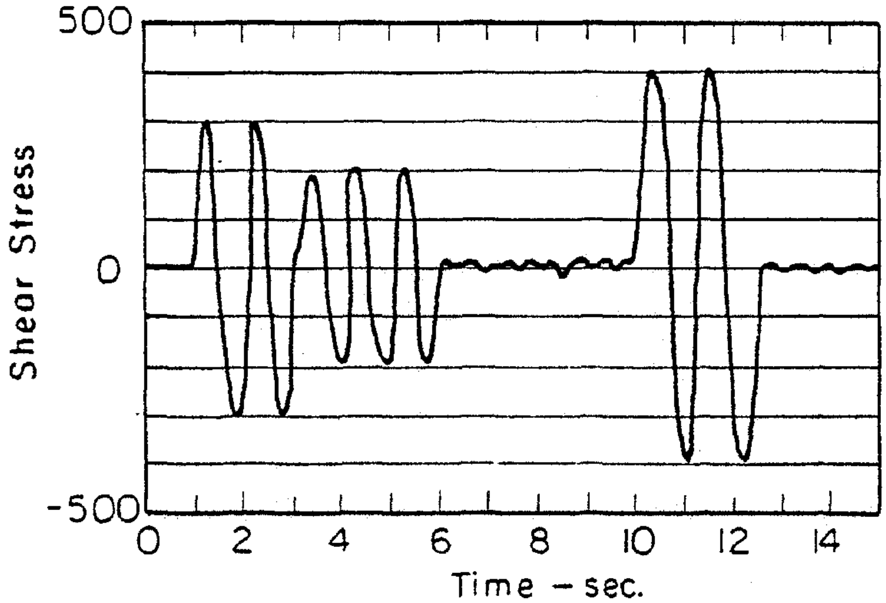
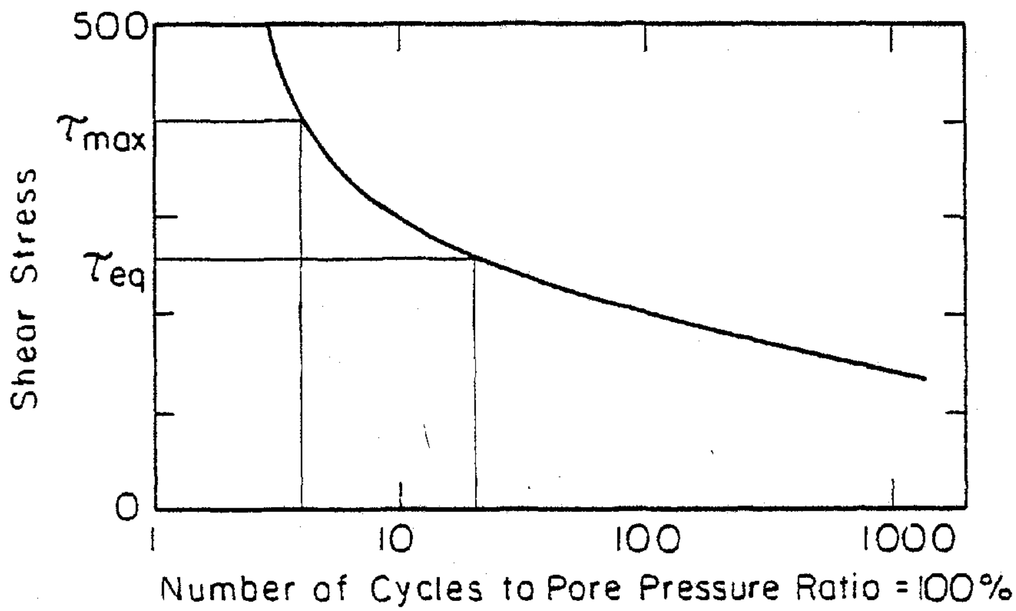


FIG. 3 DETERMINATION OF EQUIVALENT NUMBER OF CYCLES





Phase 1	0-1	sec	0 cycles @ τ = 0	=	0	cycles @ τ_{eq}
Phase 2	1-3	secs	2 cycles @ τ = 300	=	4	cycles @ τ_{eq}
Phase 3	3-6	secs	3 cycles @ τ = 200	=	0.6	cycles @ τ_{eq}
Phase 4	6-10	secs	n cycles @ τ = 0	=	0	cycles @ τ_{eq}
Phase 5	10-13	secs	2 cycles @ τ = 400	=	10	cycles @ τ_{eq}

FIG. 4 MOTION WITH PHASES AT DIFFERENT STRESS INTENSITIES

Table 1. Approximate Relationships between Earthquake Magnitude, Strong Shaking duration and Equivalent Number of Uniform Cycles

Earthquake Magnitude	N_{eq} Number of Uniform Stress Cycles @ 0.65 τ_{max}	Duration of Strong Shaking	Rate of Uniform Cycling
5 1/2-6	5	8 sec	0.6 cy/sec
6 1/2	8	14 sec	0.6 cy/sec
7	12	20 sec	0.6 cy/sec
7 1/2	20	40 sec	0.5 cy/sec
8	30	60 sec	0.5 cy/sec

3.2. Coefficient of Volume Compressibility

For low values of the pore pressure ratio, $r_u = u/\sigma'_o$, it is found that neither grain size nor relative density have a large influence on the coefficient of volume compressibility m_v (Figure 5). For such low pore pressure ratios, values of m_v typically range between 1×10^{-6} and 2×10^{-6} ft^2/lb (2×10^{-5} and 4×10^{-5} m^2/kN) for average densities and grain sizes of sandy soils.

However for pore pressure ratios larger than about 60%, the values of compressibility have been found to be influenced by both relative density and pore pressure ratio. Seed et. al. (1975) found that the variation of m_v could be expressed by

$$\frac{m_v}{m_{vo}} = \frac{e^y}{1 + y + \frac{1}{2}y^2} \tag{11}$$

where m_{vo} is the compressibility for low pore pressure,

$$y = A(r_u)^B$$

$$A = 5(1.5 - D_r)$$

$$B = 3(2)^{-2D_r}$$

and D_r is the relative density. Expression (11) is shown in graphical form in Figure 6 for different values of the relative density D_r.

Cyclic tests performed by Lee and Albeisa (1974) beyond the point where the cyclic pore pressure ratio (r_u) reached a value of 100% developed volumetric strains which were much larger than the strains measured on samples which were merely loaded to the point where r_u = 100% was first developed. These findings were included in a qualitative form in the analysis by assuming that under a decrease in pore pressure, the value of m_v would remain constant and equal to the maximum value reached during pore pressure build-up.

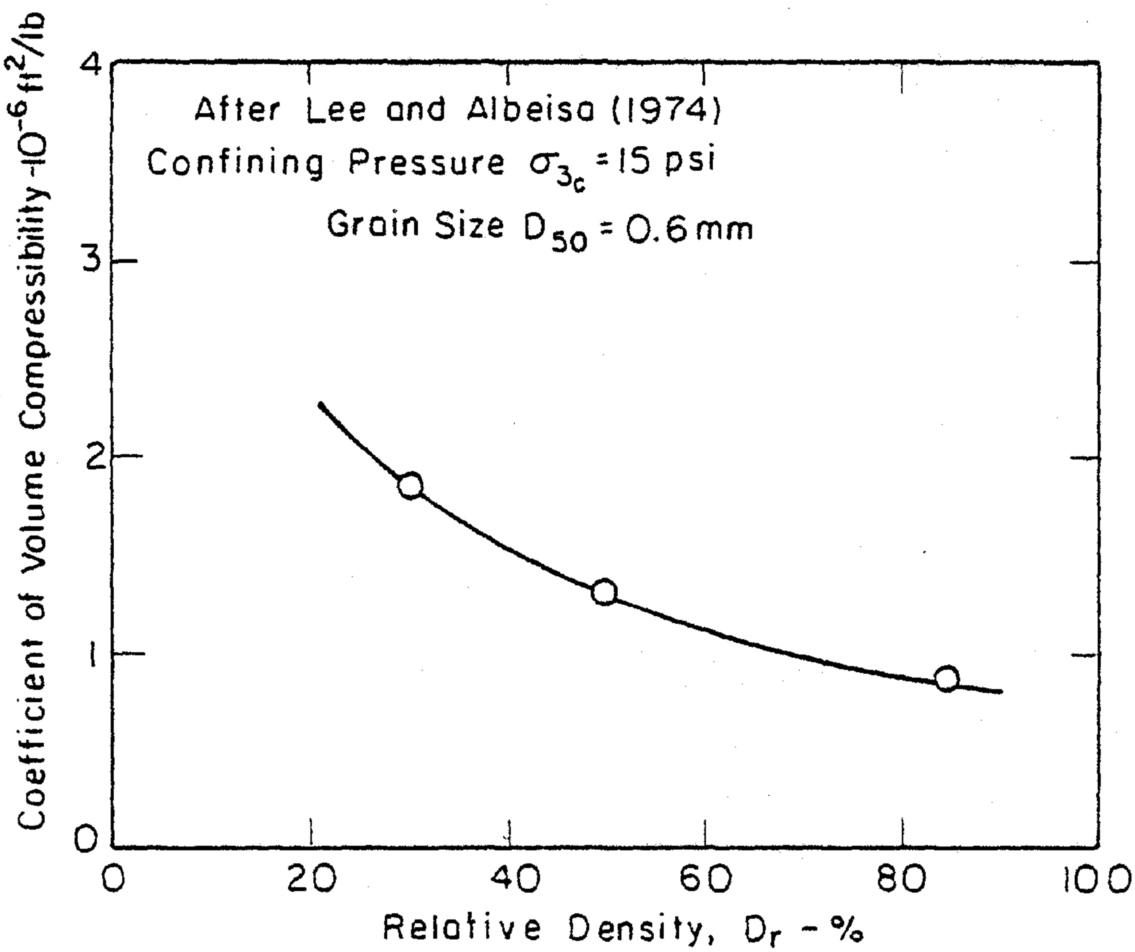


FIG. 5a EFFECT OF DENSITY ON COMPRESSIBILITY STATIC LOADING OR CYCLIC LOADING AT LOW EXCESS PORE PRESSURE

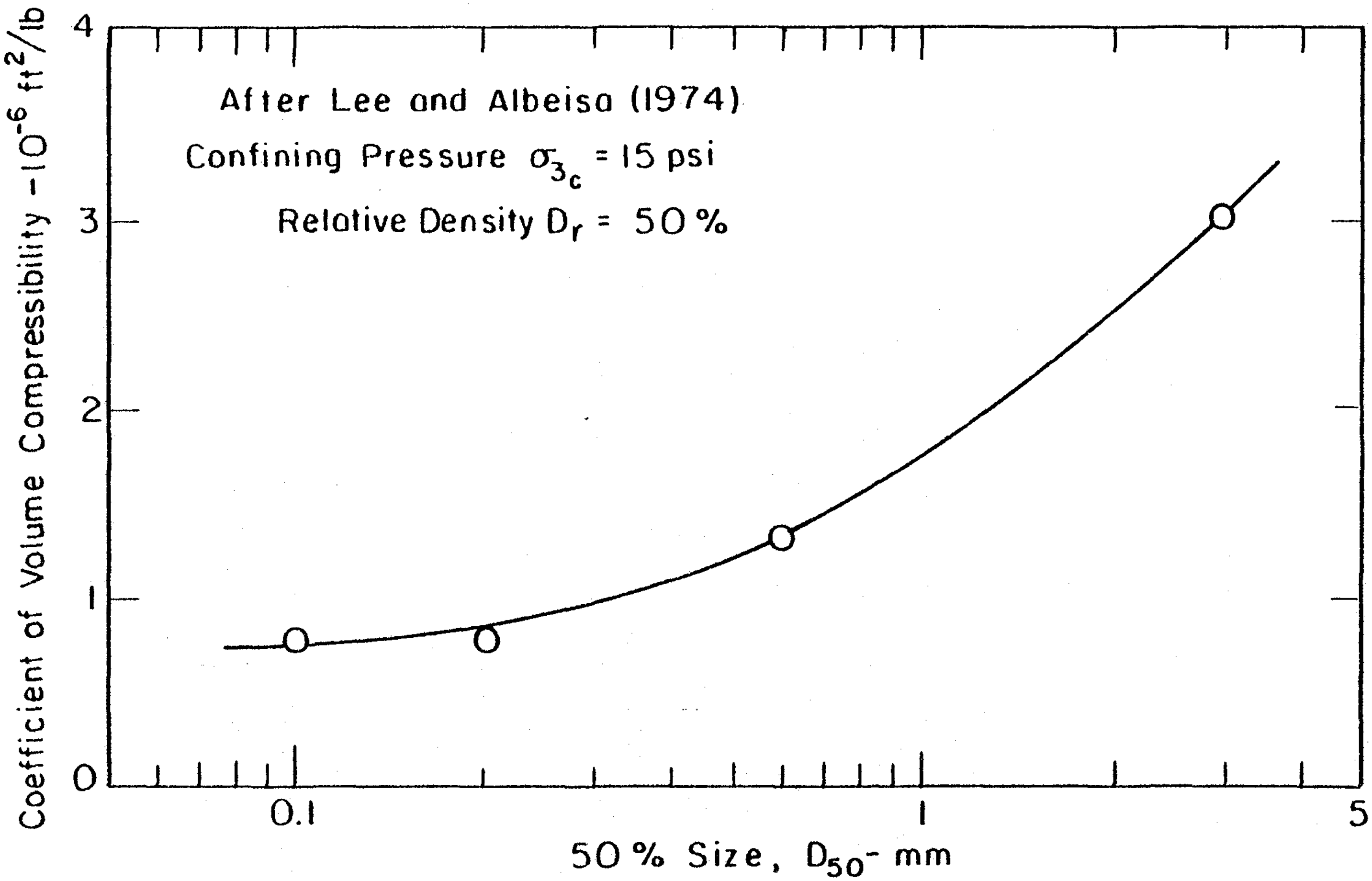


FIG. 5b EFFECT OF GRAIN SIZE ON COMPRESSIBILITY. STATIC LOADING OR CYCLIC LOADING AT LOW EXCESS PORE PRESSURE

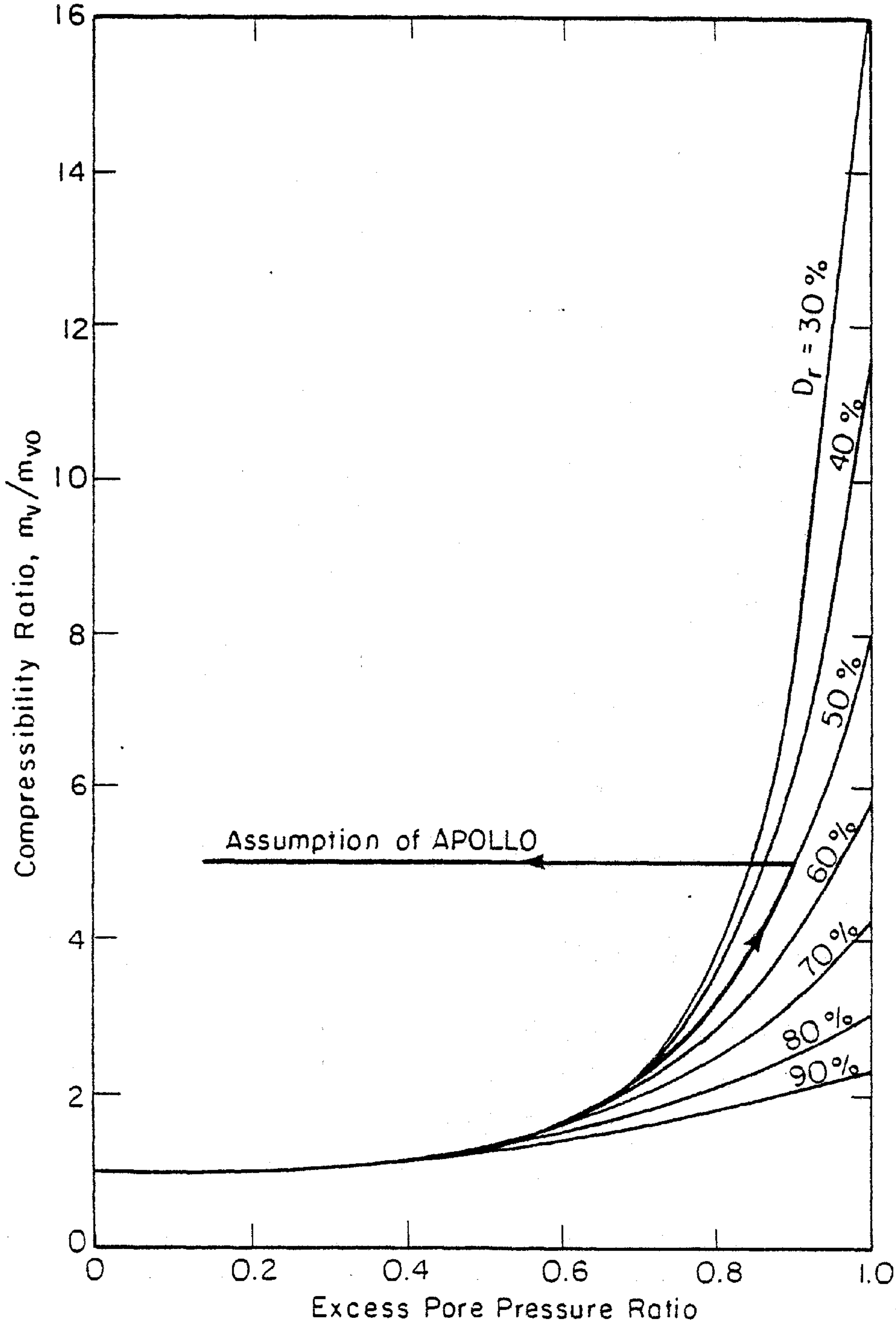


FIG. 6 EFFECT OF PORE PRESSURE AND RELATIVE DENSITY ON THE COMPRESSIBILITY OF SATURATED SANDS

3.3. Permeability Characteristics

Permeability is a soil characteristic which covers a wide range of values. The best available means to evaluate the permeability coefficient for a soil mass is by means of a pumping test in the field but they may also be estimated from a knowledge of the grain size characteristics of the soil. It is considered that the range of values shown in Figure 7 provide a reasonable guide to the range of permeabilities which might be expected for granular materials of different grain sizes.

4. Boundary Conditions

Since the problem under consideration is one-dimensional and the water table is the only drainage boundary, it is to be expected that the consolidation of the layers in the soil profile will lead to an upward flow of pore water resulting in a rise in the water table.

The quantity, Q, of water flowing upward per unit area through the water table elevation, d, in a time interval Δt is

$$Q = -k\left(\frac{\partial u}{\partial z}\right)_{z=d} \cdot \Delta t \tag{12}$$

Two situations may occur:

a) <u>The saturation line is at the water table elevation.</u>

If the saturation line is at the water table elevation it is necessary to adopt the concept of an effective porosity, n_e, for the overlying soil, i.e. the fraction of a unit volume of unsaturated soil which is filled by air, to determine the change in water table elevation. The volume filled by the flow of water crossing the water table during the interval Δt may be expressed as

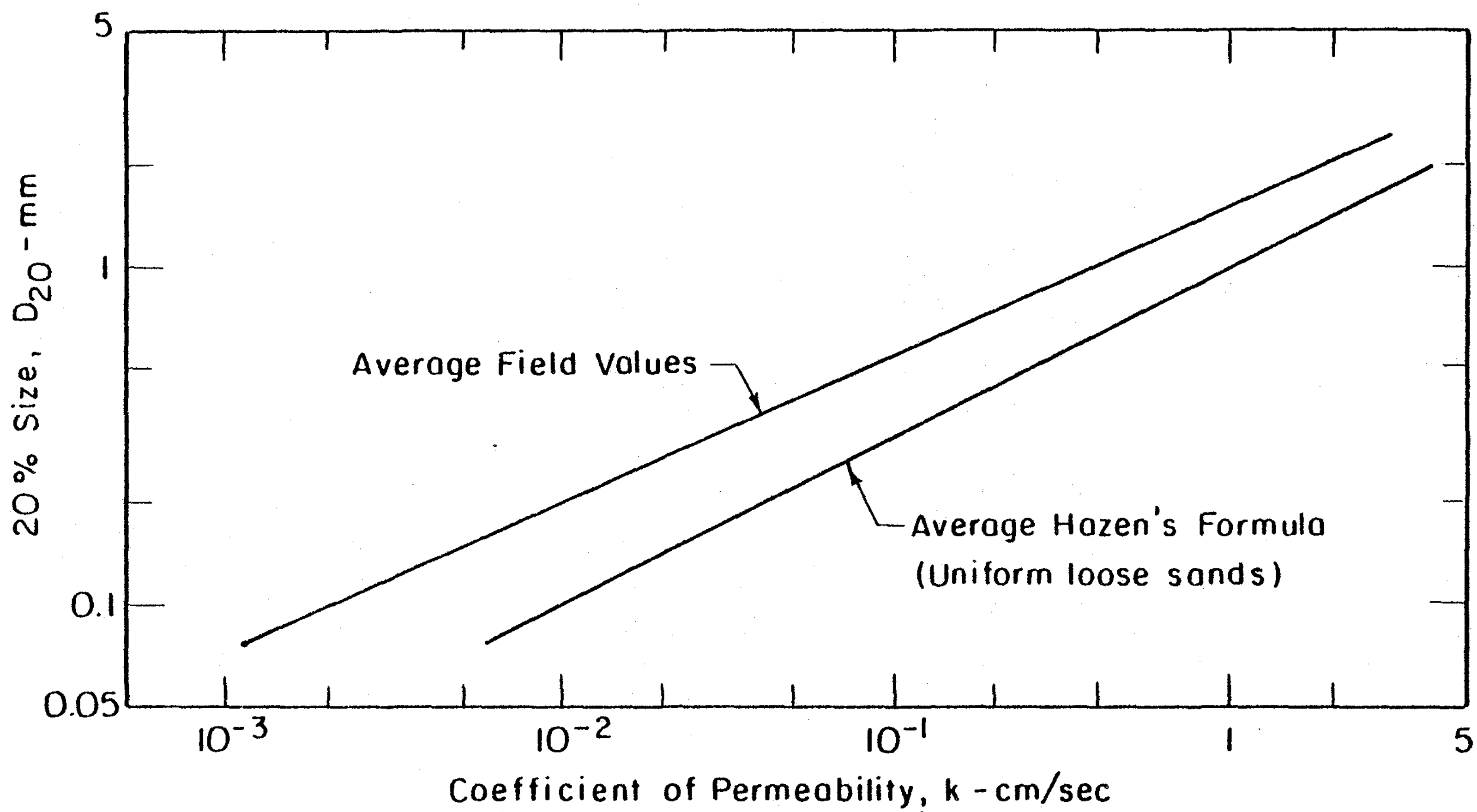


FIG. 7 RELATIONSHIPS BETWEEN GRAIN SIZE AND PERMEABILITY

$$\Delta H \cdot 1 = Q/n_e \tag{13}$$

and the corresponding rise in water table over the time interval Δt will be equal to ΔH.

b) <u>The saturation line is above the water table.</u>

Let H be the height of saturated soil above the water table. Then

$$H = s - d \tag{14}$$

where s is the saturation line elevation.

The flow of water, Q, through the water table induces a volume change, ΔH, of the saturated zone such as

$$\Delta H \cdot 1 = Q \tag{15}$$

The resulting change of effective stress, $\Delta\sigma'$, occurring in the saturated soil above the water table may be expressed as

$$\Delta\sigma' = -\frac{1}{m_R}\frac{\Delta H}{H} \tag{16}$$

where m_R is the coefficient of volume rebound. Finally, the resulting rise in water table over the time interval Δt is

$$\Delta d = \frac{\Delta\sigma'}{\gamma_w} \tag{17}$$

Experience gained from several case studies indicates that the rise of the water table through the saturated zone is very rapid. It was therefore concluded that the coefficient of volume compressibility, m_v, could be substituted for m_R in equation (16) without affecting the nature of the phenomenon.

5. Solution of Basic Equation

The computer program APOLLO (Analysis of Potential Liquefaction of Layers for One-Dimensional Flow) has been written to solve the basic equation with the appropriate boundary conditions through a finite difference scheme using an implicit formulation.

5.1. Discretized Equations

The pore pressures, u_i, are computed at line levels i, separating layer i above from layer i+1 below. The finite difference equations are obtained by the usual techniques, with the assumption that pore pressures are continuous throughout the profile and that there is continuity of flow through the interface separating two layers.

The basic equations of the algorithm are

$$u_{i,t+\Delta t} = \frac{2\Theta(\alpha_i u_{i-1} + \alpha_{i+1} u_{i+1})_{t+\Delta t} + b_i}{2\Theta(\alpha_i + \alpha_{i+1}) + \frac{\alpha_i}{\beta_i} + \frac{\alpha_{i+1}}{\beta_{i+1}}} \tag{18}$$

where Θ is a convergence parameter, usually set equal to 0.5 (Crank-Nicholsen Method).

$$\alpha_i = \frac{k_i}{\Delta z_i} = \frac{\text{permeability of layer } i}{\text{thickness of layer } i}$$

$$\beta_i = \alpha_i \frac{\Delta t}{m_{vi}\gamma_w \Delta z_i}$$

m_{vi} being the coefficient of volume compressibility of layer i, γ_w the unit weight of water and Δt the time increment chosen in the analysis.

The expression of b_i is

$$\begin{aligned} b_i = {} & 2(1-\Theta)(\alpha_i u_{i-1} + \alpha_{i+1} u_{i+1})_t \\ & -[2(1-\Theta)(\alpha_i + \alpha_{i+1}) - \frac{\alpha_i}{\beta_i} \\ & - \frac{\alpha_{i+1}}{\beta_{i+1}}]\, u_{i,t} + q_i \end{aligned} \tag{19}$$

b_i is completely determined at time t, q_i refers to the source term in equation (18). Its expression is

$$q_i = \sigma_{oi}(F_i \frac{\alpha_i}{\beta_i} + F_{i+1} \frac{\alpha_{i+1}}{\beta_{i+1}}) - u_{i,t} (\frac{\alpha_i}{\beta_i} + \frac{\alpha_{i+1}}{\beta_{i+1}}) \qquad (20)$$

where σ_{oi} is the hydrostatic vertical effective stress at level i. F_i and F_{i+1} are the excess pore pressure ratios just above level i and just below, respectively, which would exist at time $t = t + \Delta t$ if the system were undrained.

5.2. Structure of the Program

The program APOLLO consists of a main program, 18 subroutines and 3 function subprograms.

APOLLO, the main program, includes the user's manual in the form of comment cards. Also, it fixes arbitrarily the values of the following constants:

THETA = convergence parameter of the implicit formulation (set as $\Theta = 0.5$),

PCT = the termination criterion for the iterations within one time interval, set 0.001% error on the excess pore pressures,

ITMAX = maximum number of iterations in the solution procedure (Implicit Finite Difference), set as ITMAX = 100

MASTER reads the constants of the problem necessary to set up the dynamic storage.

ADJUST contains the calls to the system dependent routines, e.g. LOCF and MEM, which return the memory location of a variable and allocate the required amount of central memory within the limits of the system.

EQKDIV reads the information concerning the phases at different stress intensity within an earthquake motion.

SETTIN reads the information concerning each time period of analysis. Indeed, the analysis may be performed with a sequence of increasing time steps. Shorter time steps should be affected to the period of pore pressure build-up, longer time steps to the period of pressure dissipation.

INPT is the tree of the program. It calls the different operations in sequence.

UNIT reads the system of units in which the data are input and in which the results are given. The computations within the program are done in dimensionless units.

PROPYL reads the soil properties of the profile.

OPTIONL reads the output options selected for each period of analysis.

INITL performs the initializations at the start of each period of analysis.

SOLVER is the tree of the solution block.

PROUTL prints out the maxima of pore pressures and the minima of effective stresses at the bottom of each layer for each of the time periods of analysis.

OUTPTL treats the optional output.

PLT and PLOTL are used for printer-plotting optional output.

PCH is used to punch optional output on cards.

ITR is part of the solution block; it performs the iterations of the implicit formulation for each time step.

MOBILE is part of the solution block; it computes the water table rise within each time step.

NVA is part of the solution block; it computes at the end of each time step the new values of the variable coefficients of the discretized equations, i.e., b_i and q_i of equations (19) and (20).

FUNCTION F is the normalized function which expresses the undrained excess pore pressure ratio as a function of the cycle ratio (see equation 6).

FUNCTION FINV is the inverse function of F; that is, it expresses the cycle ratio as a function of pore pressure ratio.

FUNCTION CHANGE is the normalized function which expresses the compressibility ratio, m_v/m_{vo}, as a function of pore pressure ratio and relative density (see equation 11).

The subprograms of APOLLO are listed in Table 2 with the relationship between the programs.

5.3. User's Manual

Input Data

1. Job card (3I5, F5.0, 10A6)

1-8	NTS	Number of soils with different properties
6-10	NTL	Number of layers (and of lines within the profile where excess pore pressures are computed)
11-15	NUM	Number of different time periods of analysis (maximum of 7). The shortest periods (generation) with the shorter time step, the largest periods (diffusion) with the larger time step. Note: The maximum of 7 periods can be waived by adding disk storage on the program card, e.g. TAPE 8 for period no. 8, etc.

Table 2. Calling Sequence for Subprograms of APOLLO

Program	Section			Calls	Called by
	Input	Solution	Output		
APOLLO	x			MASTER	
MASTER	x			SETTIN,INPT,EQKDIV,ADJUST	APOLLO
SETTIN	x				MASTER
INPT	x	x	x	UNIT,PROPYL,OPTIONL,INITL, SOLVER,PROUTL,OUTPTL	MASTER
UNIT	x				INPT
PROPYL	x				INPT
OPTIONL	x				INPT
EQKDIV	x				MASTER
ADJUST	x				MASTER,OPTIONL
INITL		x		F,FINV,CHANGE	INPT
SOLVER		x		ITR,MOBILE,NVA	INPT
ITR		x			SOLVER
MOBILE		x			SOLVER
NVA		x		F,FINV,CHANGE	SOLVER
F		x			INITL,NVA
FINV		x			INITL,NVA
CHANGE		x			INITL,NVA
PROUTL			x		INPT
OUTPTL			x	PCH,PLT	INPT
PLT			x	PLOTL	OUTPTL
PCH			x		OUTPTL
PLOTL			x		PLT

16-20 ALPHA Parameter for the pore water pressure generation function. Mean α-value = 0.7

21-80 IDENT Job identification

2. Earthquake motion card (F10.0, F5.0, I5)

   1-10 EQK Earthquake motion duration in seconds

   11-15 NCYC Number of equivalent stress cycles for the entire duration of the motion (required if NDiV = 1)

   16-20 NDiV Number of phases within the earthquake motion at different constant rate of cycling. If NDiV = 1, leave blank

3. Earthquake motion phases cards (only if NDiV is greater than 1) Two cards

   8F10.0 EQKP(NDiV) - Durations of all the phases in the motion defined by a constant rate of cycling

   8F10.0 NCYCP(NDiV) - Numbers of equivalent stress cycles for each one of the phases in the motion

4. Time Periods of analysis cards (Three cards)

   8F10.0 DURATN(NUM) - Durations of each period of analysis starting from the beginning of the earthquake motion

   8F10.0 DT(NUM) - Time steps to be used in each period of analysis. Restriction = the time step value for a given period of analysis must not be smaller than the one used in the previous period

   16I5 NA(NUM) - Maximum number of curves to be plotted on a single graph for each time period of analysis (maximum of 9). If blank, NA = 9 for each time period

5. Unit system card (10A6, 2F10.0)

1-60	IDT	Identification of system of units
61-70	GW	Unit Weight of Water in the particular system of units
71-80	GR	Acceleration of Gravity in the particular system of units

6. Water level card (8F10.0)

1-20	WT	Depth of Water Table
11-20	SAT	Depth of Line of Saturation

7. Soil cards (total of NTS cards) (I5, 5F10.0)

1-5	I	Soil number
6-15	DY	Humid Unit Weight of Soil
16-25	K	Coefficient of Permeability in cm/sec
26-35	MV	Coefficient of Volume Compressibility
36-45	DR	Relative density (fractional)
46-55	PORES	Air porosity of the soil. By definition, the air void volume divided by the total volume

8. Layer cards (total of NTL cards) (2I5, 3F10.0)

1-5	I	Layer number
6-10	NS	Soil number
11-20	NFT	Number of equivalent cycles to liquefaction in an undrained state at top of layer
21-30	NFB	Number of cycles to liquefaction in an undrained state at bottom of layer
31-40	DZ	Thickness of layer

9. Optional output cards

16I5 KEY(NUM) - Number of layers for which optional output is requested for each time period of analysis

The following information must appear on a set of two cards per time period for which output is requested =

16I5 LINES - Numbers of the layers with output

16I5 CODE - Requested output code starting from the righthand end of a I5 field =

Column 1 Pore Pressures

Column 2 Effective Stress

Code 0 No Action Taken

1 Print-Plot

2 Punch Only

3 Print-Plot and Punch

End of Input Data

6. Example Problem

In order to illustrate the use of the program, an analysis of the generation of pore water pressures in the soil profile shown in Figure 8 was performed for a 10-second earthquake motion scaled to 0.1g maximum acceleration and consisting of the first 10 seconds of the El Centro N-S component record.

The anticipated profile of equivalent stress ratios determined by say a total stress ground response analyses such as obtained by the SHAKE program is shown in Figure 8, together with the distribution with depth of the numbers of cycles required to reach a pore pressure ratio of 100% under undrained conditions. The profile was divided into 2 soils

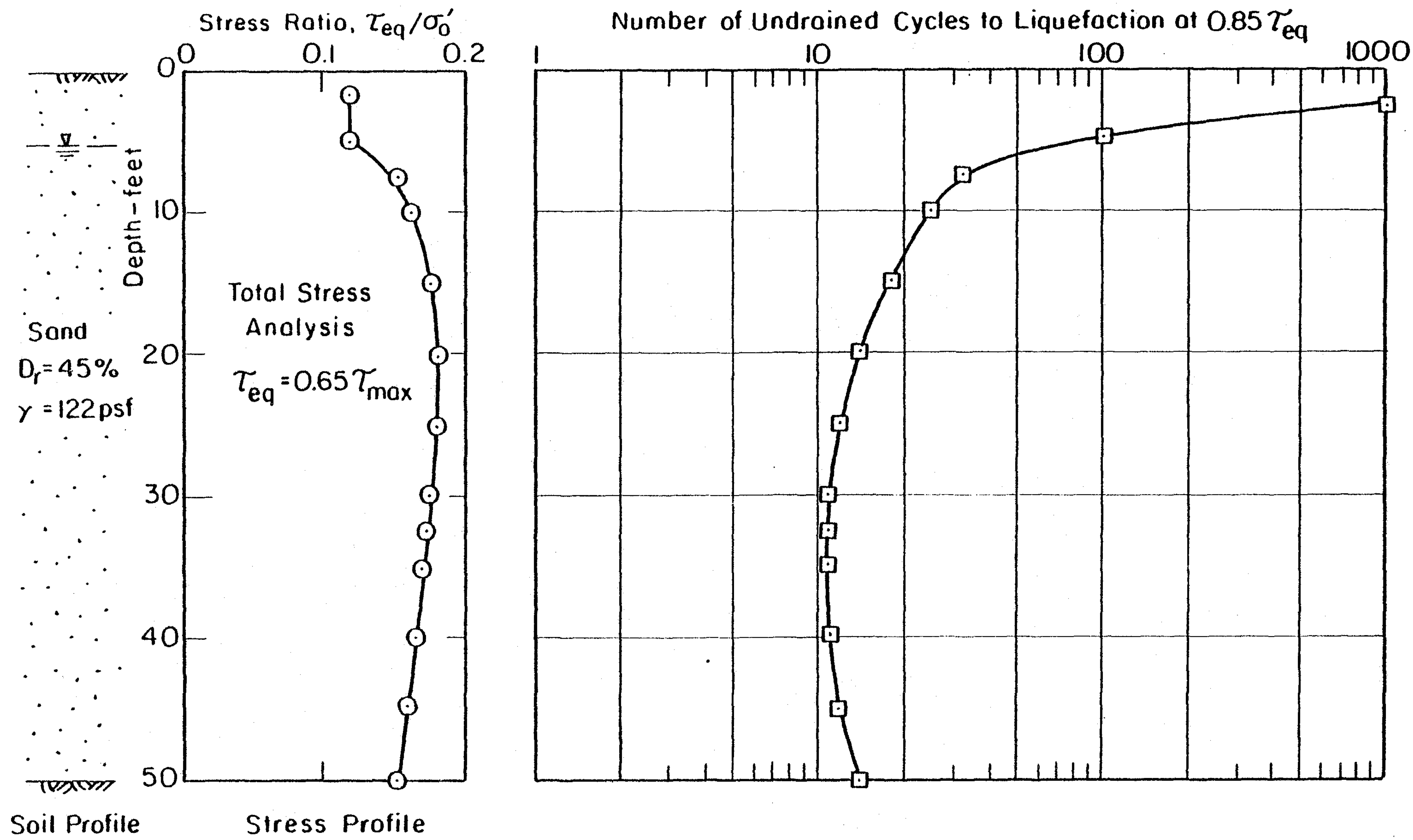


FIG. 8 EXAMPLE PROBLEM - TOTAL STRESS ANALYSIS AND INPUT TO LIQUEFACTION ANALYSIS

and 13 layers. Soil No. 1 is 4 feet deep; it is a non-saturated superficial sand layer at 45% relative density, with

$$k = 0.01 \text{ cm/sec},$$

$$m_v = 1 \times 10^{-6} \text{ ft}^2/\text{lb},$$

$$n_e = 0.20 \quad \text{air porosity = air volume/total volume}$$

Soil No. 2 consists of a saturated sand at 45% relative density with

$$k = 0.1 \text{ cm/sec},$$

$$m_v = 1 \times 10^{-6} \text{ ft}^2/\text{lb}$$

As shown in Figure 9, the stress history computed by a total stress analysis at a depth of 22.5 feet is very irregular. Accordingly, the number of uniform stress cycles at 65% of the maximum stress equivalent to the earthquake motion was computed by the usual procedure and the rate of cycling was found to vary considerably during that motion.

The motion was thus decomposed into six phases:

0-1 second	0 cycle
1-2 seconds	1 cycle
2-3 seconds	5 cycles
3-6 seconds	4½ cycles
6-8 seconds	½ cycle
8-10 seconds	1½ cycles

Three time periods of analysis were selected: the first period covers the earthquake response with a duration of 10 seconds. The second and third periods analyze the pore water pressure response in the soil profile during the 10 and 30 minutes following the earthquake, respectively.

The necessary input data cards and the output data in the form of pore pressure distribution as a function of time for different depths

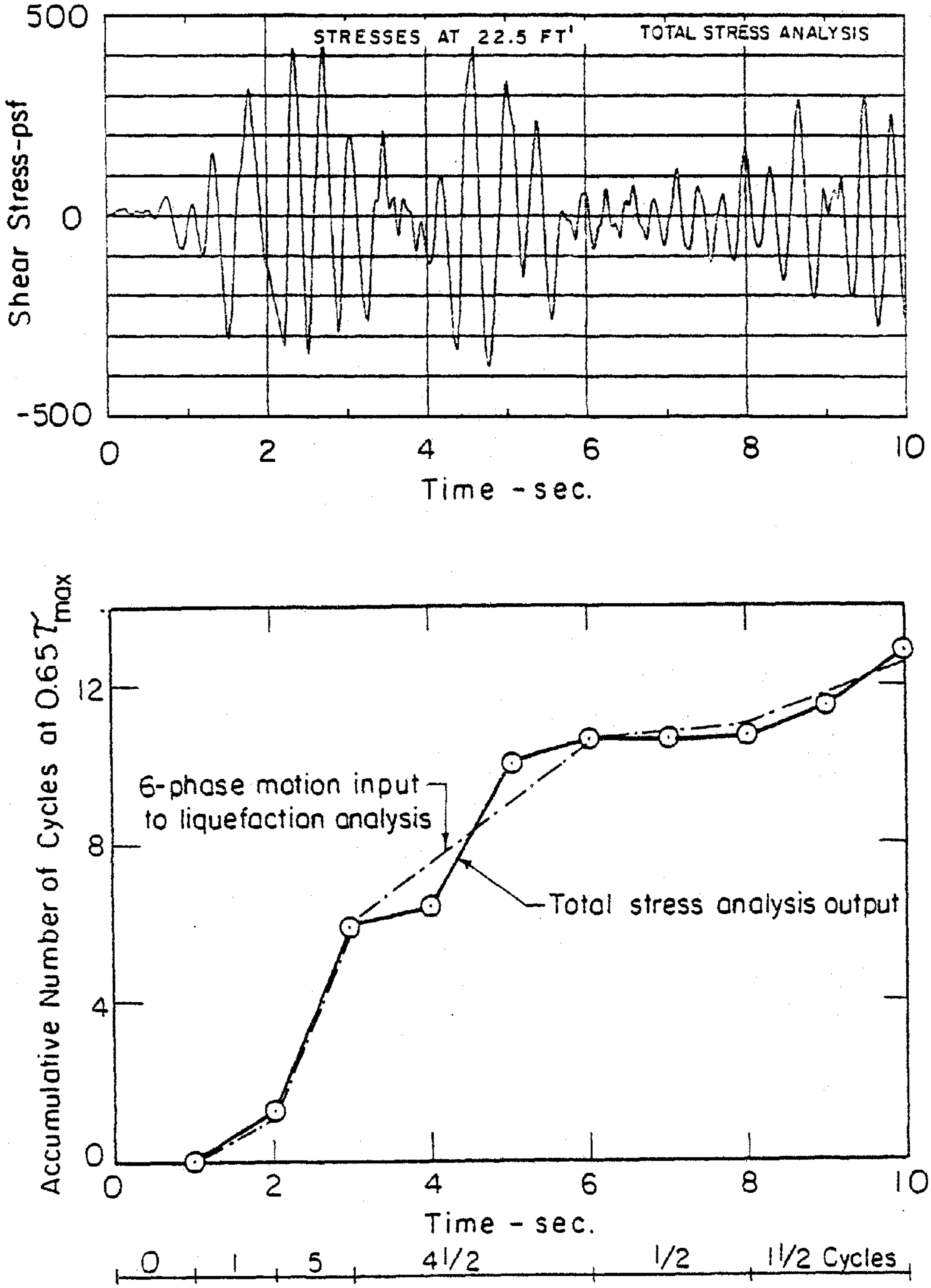


FIG. 9 EVALUATION OF NUMBER OF EQUIVALENT UNIFORM CYCLES FROM TOTAL STRESS ANALYSIS

in the profile are shown in Appendix A.

7. Run time

On the CDC 6400 computer, run time is about 5 seconds of central processor per layer and per thousand time steps.

ACKNOWLEDGMENT

The studies described in the preceding pages were conducted as part of a study of the response of earth dams and deeply embedded structures during earthquakes under Grants GI-43104 and ENV75-21875 from the National Science Foundation. This support is gratefully acknowledged. The contribution of Engineering and Ouvrages d'Art and Dames and Moore towards the publication of the studies described in this report is also greatly appreciated.

REFERENCES

Ambraseys, N. and Sarma, S. (1969) "Liquefaction of Soils Induced by Earthquakes," Bulletin of Seismological Society of America, Vol. 59, No. 2.

Finn, W. D. L., Lee, K. W. and Martin, G. R. (1977) "An Effective Stress Model for Liquefaction," ASCE, Vol. 103, No. GT6, June.

Finn, W. D. L., Martin, G. R. and Lee, M. R. W. (1978) "Comparison of Dynamic Analyses for Saturated Sands," Conference on Earthquake Engineering and Soil Dynamics, Pasadena, June.

Ghaboussi, J. and Dikmen, S. U. (1978) "Liquefaction Analysis of Horizontally Layered Sands," ASCE, Vol. 104, No. GT3, March.

Lee, K. L. and Albeisa, A. (1974) "Earthquake Induced Settlements in Saturated Sands," Journal of the Geotechnical Engineering Division, ASCE, Vol. 100, No. GT4, April.

Liou, C. P., Streeter, V. L. and Richart, F. E., Jr. (1977) "Numerical Model for Liquefaction," ASCE, Vol. 103, No. GT6, June.

Martin, P. P. and Seed, H. B. (1978) "A Simplified Procedure for Stress Analysis of Ground Response," In press.

Seed, H. B. and Idriss, I. M. (1967) "Analysis of Soil Liquefaction: Niigata Earthquake," ASCE, Vol. 93, No. SM3, May.

Seed, H. B. and Idriss, I. M. (1971) "Simplified Procedure for Evaluating Soil Liquefaction Potential," ASCE, Vol. 97, No. SM9, September.

Seed, H. B. and Lee, K. L. (1966) "Liquefaction of Saturated Sands During Cyclic Loading," ASCE, Vol. 92, No. SM6, November.

Seed, H. B., Martin, P. P. and Lysmer, J. (1975) "The Generation and Dissipation of Pore Water Pressures During Soil Liquefaction," Earthquake Engineering Research Center, University of California, Berkeley, August.

Yoshimi, Y. and Kuwabara, F. (1973) "Effects of Subsurface Liquefaction on the Strength of Surface Soil," Soils and Foundations, Japanese Society of Soil Mechanics and Foundation Engineering, Vol. 13, No. 2, June.

Zienkiewicz, O. C., Chang, C. T. and Hinton, E. (1978) "Non-linear Seismic Response and Liquefaction," Submitted for publication in the International Journal for Numerical and Analytical Methods in Geomechanics.

APPENDIX A

A.1 INPUT DATA

A.1 Input Data

```
  2   13    3  0.7APOLLO--EXAMPLE PROBLEM--CDC 6400
 10.      12.5    6
 1.        1.         1.        3.         2.         2.
 0.0       1.0        5.        4.5        0.5        1.5
 10.       600.       1800.
 .05       1.0        10.0
  9    9    7
SYSTEM OF UNITS FEET AND POUNDS                                        62.        32.2
 5.        4.
  1  122.          1.-03      1.-06   .45        .20
  2  122.      0.01           1.-06   .45
  1    1   1000.      1000.     2.0
  2    1   1000.      100.      2.0
  3    2   100.       32.       3.0
  4    2   32.        25.       3.0
  5    2   25.        18.       5.0
  6    2   18.        14.       5.0
  7    2   14.        12.       5.0
  8    2   12.        11.       5.0
  9    2   11.        11.       2.5
 10    2   11.        11.       2.5
 11    2   11.        12.       5.0
 12    2   12.        12.       5.0
 13    2   12.        14.       5.0
  9    9   13
  5    6    7    8    9   10   11   12   13
 21   21   21   21   23   21   21   21   21
  5    6    7    8    9   10   11   12   13
  1    1    1    1    1    1    1    1    1
  1    2    3    4    5    6    7    8    9   10   11   12   13
  1    1    1    1    1    1    1    1    1    1    1    1    1
```

APPENDIX A

A.2 APOLLO--EXAMPLE PROBLEM OUTPUT

SYSTEM OF UNITS FEET AND POUNDS
UNIT WEIGHT OF WATER 62.0000
ACCELERATION OF GRAVITY 32.2000

ACCEL. OF GRAVITY	M/SEC2	CM/SEC2	FT/SEC2	FT/SEC2
UNIT WT. OF WATER	KN/M3	KGF/CM3	KIPS/CUFT	LBS/CUFT
LENGTH	M	CM	FT	FT
FORCE	KN	KGF	KIPS	LBS
STRESS	KN/M2	KGF/CM2	KIPS/SQFT	LBS/SQFT

OVE

SOIL NUMBER	TOTAL UNIT WEIGHT	COEFFT. OF PERMEABILITY (CM/SEC)	COEFFT. OF VOLUME COMPRESSIBILITY	RELATIVE DENSITY (IN PCT.)	DRY POROSITY
1	122.000	.10E-02	.10E-05	45.0	.200
2	122.000	.10E-01	.10E-05	45.0	--

LINE NUMBER	SOIL NUMBER	DEPTH	INITIAL EFFECTIVE VERTICAL STRESS	UNDRAINED NUMBER OF CYCLES TO LIQUEFACTION ABOVE LINE	BELOW LINE
1	1	2.0	244.000	1000.0	1000.0
2	1	4.0	550.000	100.0	100.0
3	2	7.0	730.000	32.0	32.0
4	2	10.0	910.000	25.0	25.0
5	2	15.0	1210.000	18.0	18.0
6	2	20.0	1510.000	14.0	14.0
7	2	25.0	1810.000	12.0	12.0
8	2	30.0	2110.000	11.0	11.0
9	2	32.5	2260.000	11.0	11.0
10	2	35.0	2410.000	11.0	11.0
11	2	40.0	2710.000	12.0	12.0
12	2	45.0	3010.000	12.0	12.0
13	2	50.0	3310.000	14.0	14.0

APOLLO--EXAMPLE PROBLEM--CDC 6400	
ALPHA COEFFICIENT FOR SOIL	.7
THETA COEFFICIENT FOR CONVERGENCE	.50
MAXIMUM ERROR IN ITERATIONS (PCT)	.0010
MAXIMUM NUMBER OF ITERATIONS	100
DEPTH OF WATER TABLE	5.00
DEPTH OF LINE OF SATURATION	4.00
DURATION OF EXCITATION (SECS.)	10.00
NUMBER OF EQUIVALENT CYCLES	12.5

EARTHQUAKE LEVEL DECOMPOSITION	0. - 1.0 SECS	0. CYCLES
	1.0- 2.0 SECS	1.0 CYCLES
	2.0- 3.0 SECS	5.0 CYCLES
	3.0- 6.0 SECS	4.5 CYCLES
	6.0- 8.0 SECS	.5 CYCLES
	8.0- 10.0 SECS	1.5 CYCLES

OVF

OPTIONAL OUTPUT

TIME STEP NO 1
TOTAL DURATION FROM START OF EXCITATION .05 SECS.
10.00 SECS.

LINE NUMBER	DEPTH	PORE PRESSURE CODE	EFFECTIVE STRESS CODE
5	15.00	1	2
6	20.00	1	2
7	25.00	1	2
8	30.00	1	2
9	32.50	3	2
10	35.00	1	2
11	40.00	1	2
12	45.00	1	2
13	50.00	1	2

TIME STEP NO 2
TOTAL DURATION FROM START OF EXCITATION 1.00 SECS.
600.00 SECS.

LINE NUMBER	DEPTH	PORE PRESSURE CODE	EFFECTIVE STRESS CODE
5	15.00	1	0
6	20.00	1	0
7	25.00	1	0
8	30.00	1	0

9	32.50	1	0
10	35.00	1	0
11	40.00	1	0
12	45.00	1	0
13	50.00	1	0

TIME STEP NO 3 10.00 SECS.
TOTAL DURATION FROM START OF EXCITATION 1800.00 SECS.

LINE NUMBER	DEPTH	PORE PRESSURE CODE	EFFECTIVE STRESS CODE
1	2.00	1	0
2	4.00	1	0
3	7.00	1	0
4	10.00	1	0
5	15.00	1	0
6	20.00	1	0
7	25.00	1	0
8	30.00	1	0
9	32.50	1	0
10	35.00	1	0
11	40.00	1	0
12	45.00	1	0
13	50.00	1	0

CODE IDENTIFICATION = 0 NO ACTION TAKEN
= 1 PRINT-PLOT ONLY
= 2 PUNCH ONLY
= 3 PRINT-PLOT AND PUNCH

MAXIMUM AVAILABLE SYSTEM FIELD LENGTH =0000120000
MAXIMUM REQUIRED FIELD LENGTH =0000066100
REQUIRED CAPACITY FOR TRANSFER ARRAY = 12020

QVE

TIME PERIOD NO 1
STARTING AT TIME 0. SECS
DURATION 10.00 SECS

LINE NUMBER	DEPTH	MAXIMUM PORE PRESSURE RATIO	TIME OF OCCURENCE	MINIMUM EFFECTIVE STRESS RATIO	TIME OF OCCURENCE
1	2.0	0.	0.	1.0000	0.
2	4.0	.0128	10.00	.8746	10.00
3	7.0	.2589	10.00	.6775	10.00
4	10.0	.4044	10.00	.5545	10.00
5	15.0	.5595	10.00	.4177	10.00
6	20.0	.6851	10.00	.3018	10.00
7	25.0	.8118	10.00	.1816	10.00
8	30.0	.9565	8.40	.0422	8.40
9	32.5	1.0000	8.40	0.	8.40
10	35.0	1.0000	8.50	0.	8.50
11	40.0	1.0000	9.30	0.	9.30
12	45.0	.9598	10.00	.0403	10.00
13	50.0	.7743	10.00	.2214	10.00

OVE

TIME PERIOD NO 2
STARTING AT TIME 10.00 SECS
DURATION 590.00 SECS

LINE NUMBER	DEPTH	MAXIMUM PORE PRESSURE RATIO	TIME OF OCCURENCE	MINIMUM EFFECTIVE STRESS RATIO	TIME OF OCCURENCE
1	2.0	0.	0.	1.0000	0.
2	4.0	.8425	600.00	.1244	600.00
3	7.0	.8031	600.00	.1657	600.00
4	10.0	.7820	600.00	.1902	600.00
5	15.0	.7884	334.00	.1949	349.00
6	20.0	.8309	185.00	.1600	190.00
7	25.0	.8792	108.00	.1159	110.00
8	30.0	.9532	11.00	.0454	11.00
9	32.5	.9925	11.00	.0073	11.00
10	35.0	.9996	11.00	.0004	11.00
11	40.0	1.0000	11.00	0.	11.00
12	45.0	1.0000	11.00	0.	11.00
13	50.0	.8848	22.00	.1130	22.00

OVE

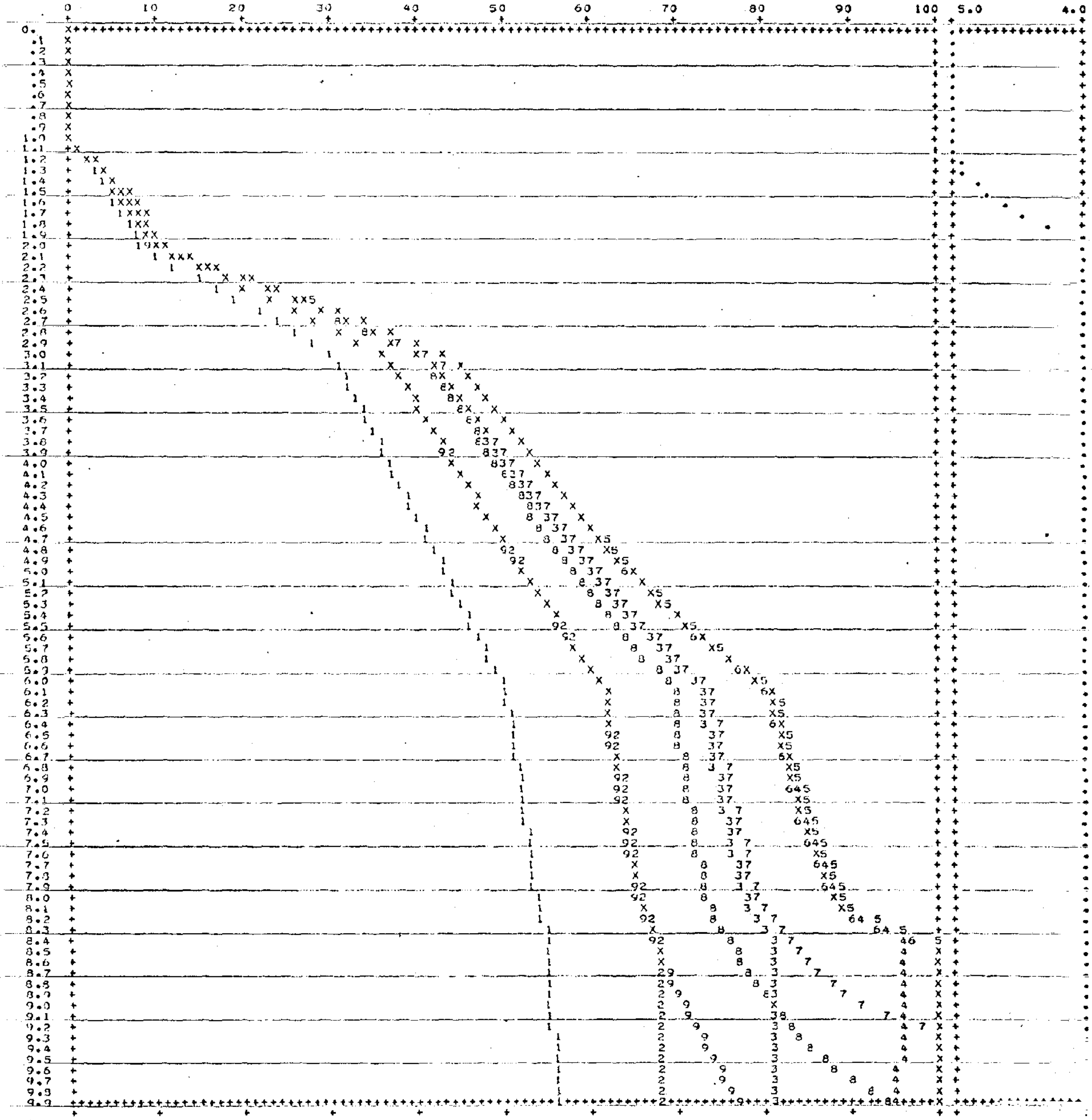
TIME PERIOD NO 3
STARTING AT TIME 600.00 SECS
DURATION 1200.00 SECS

LINE NUMBER	DEPTH	MAXIMUM PORE PRESSURE RATIO	TIME OF OCCURENCE	MINIMUM EFFECTIVE STRESS RATIO	TIME OF OCCURENCE
1	2.0	0.	0.	1.0000	0.
2	4.0	.9581	1160.00	.0306	1170.00
3	7.0	.8243	860.00	.1437	890.00
4	10.0	.7820	610.00	.1901	610.00
5	15.0	.7602	610.00	.2167	610.00
6	20.0	.7452	610.00	.2352	610.00
7	25.0	.7308	610.00	.2519	610.00
8	30.0	.7135	610.00	.2707	610.00
9	32.5	.7019	610.00	.2828	610.00
10	35.0	.6874	610.00	.2975	610.00
11	40.0	.6511	610.00	.3339	610.00
12	45.0	.6058	610.00	.3789	610.00
13	50.0	.5533	610.00	.4310	610.00

1	-	BOTTOM OF LAYER NO 5	DEPTH	15.0	INITIAL EFFECTIVE STRESS	1210.000
2	-	BOTTOM OF LAYER NO 6	DEPTH	20.0	INITIAL EFFECTIVE STRESS	1510.000
3	-	BOTTOM OF LAYER NO 7	DEPTH	25.0	INITIAL EFFECTIVE STRESS	1810.000
4	-	BOTTOM OF LAYER NO 8	DEPTH	30.0	INITIAL EFFECTIVE STRESS	2110.000
5	-	BOTTOM OF LAYER NO 9	DEPTH	32.5	INITIAL EFFECTIVE STRESS	2260.000
6	-	BOTTOM OF LAYER NO 10	DEPTH	35.0	INITIAL EFFECTIVE STRESS	2410.000
7	-	BOTTOM OF LAYER NO 11	DEPTH	40.0	INITIAL EFFECTIVE STRESS	2710.000
8	-	BOTTOM OF LAYER NO 12	DEPTH	45.0	INITIAL EFFECTIVE STRESS	3010.000
9	-	BOTTOM OF LAYER NO 13	DEPTH	50.0	INITIAL EFFECTIVE STRESS	3310.000

PORE PRESSURE RATIO = EXCESS PORE PRESSURE / HYDROSTATIC EFFECTIVE STRESS
100 PER CENT CORRESPONDS TO 1.0000

WATER TABLE DEPTH



****** TIME IN SECONDS

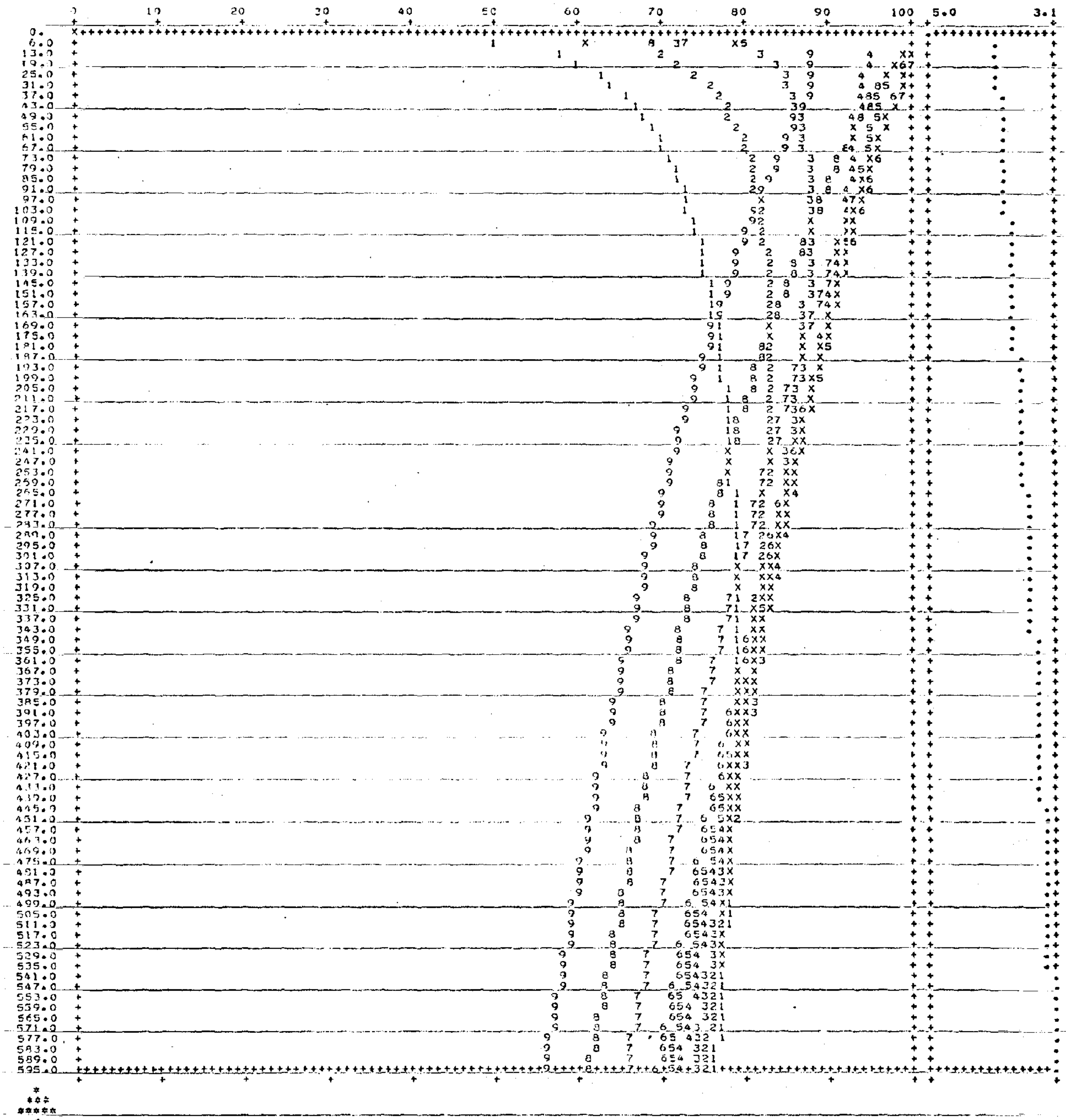
CURVE | TABLE OF PLOTTED VALUES

0.	1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	4	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	5	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	6	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	7	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	8	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	9	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.05	1	0.	.9514E-02	.2090E-01	.3020E-01	.3854E-01	.4631E-01	.5373E-01	.6093E-01	.6811E-01	.7541E-01
	2	0.	.1138E-01	.2497E-01	.3604E-01	.4594E-01	.5514E-01	.6387E-01	.7231E-01	.8065E-01	.8904E-01
	3	0.	.1270E-01	.2787E-01	.4020E-01	.5121E-01	.6143E-01	.7111E-01	.8043E-01	.8960E-01	.9875E-01
	4	0.	.1351E-01	.2962E-01	.4270E-01	.5437E-01	.6517E-01	.7538E-01	.8519E-01	.9480E-01	.1043E+00
	5	0.	.1352E-01	.2965E-01	.4276E-01	.5446E-01	.6529E-01	.7554E-01	.8537E-01	.9499E-01	.1045E+00
	6	0.	.1351E-01	.2961E-01	.4267E-01	.5431E-01	.6507E-01	.7524E-01	.8499E-01	.9451E-01	.1039E+00
	7	0.	.1271E-01	.2789E-01	.4023E-01	.5127E-01	.6149E-01	.7115E-01	.8043E-01	.8948E-01	.9842E-01
	8	0.	.1266E-01	.2781E-01	.4005E-01	.5095E-01	.6100E-01	.7048E-01	.7954E-01	.8835E-01	.9700E-01
	9	0.	.1138E-01	.2496E-01	.3600E-01	.4584E-01	.5495E-01	.6354E-01	.7177E-01	.7977E-01	.8762E-01
2.05	1	.8142E-01	.9834E-01	.1244E+00	.1486E+00	.1717E+00	.1938E+00	.2153E+00	.2363E+00	.2569E+00	.2772E+00
	2	.9617E-01	.1166E+00	.1477E+00	.1769E+00	.2047E+00	.2314E+00	.2574E+00	.2829E+00	.3081E+00	.3330E+00
	3	.1067E+00	.1294E+00	.1645E+00	.1973E+00	.2286E+00	.2588E+00	.2883E+00	.3174E+00	.3461E+00	.3749E+00
	4	.1127E+00	.1369E+00	.1749E+00	.2093E+00	.2427E+00	.2750E+00	.3066E+00	.3378E+00	.3688E+00	.3999E+00
	5	.1110E+00	.1372E+00	.1747E+00	.2098E+00	.2433E+00	.2757E+00	.3075E+00	.3389E+00	.3701E+00	.4013E+00
	6	.1123E+00	.1365E+00	.1739E+00	.2089E+00	.2422E+00	.2745E+00	.3060E+00	.3372E+00	.3681E+00	.3991E+00
	7	.1065E+00	.1293E+00	.1646E+00	.1976E+00	.2290E+00	.2595E+00	.2893E+00	.3186E+00	.3477E+00	.3768E+00
	8	.1048E+00	.1275E+00	.1625E+00	.1951E+00	.2261E+00	.2560E+00	.2851E+00	.3137E+00	.3419E+00	.3701E+00
	9	.9479E-01	.1152E+00	.1466E+00	.1758E+00	.2036E+00	.2304E+00	.2565E+00	.2820E+00	.3072E+00	.3322E+00
3.05	1	.2973E+00	.3106E+00	.3169E+00	.3233E+00	.3297E+00	.3360E+00	.3424E+00	.3487E+00	.3551E+00	.3614E+00
	2	.3579E+00	.3741E+00	.3817E+00	.3893E+00	.3969E+00	.4045E+00	.4121E+00	.4198E+00	.4275E+00	.4353E+00
	3	.4037E+00	.4225E+00	.4311E+00	.4398E+00	.4486E+00	.4574E+00	.4662E+00	.4751E+00	.4841E+00	.4931E+00
	4	.4312E+00	.4516E+00	.4608E+00	.4702E+00	.4795E+00	.4890E+00	.4985E+00	.5082E+00	.5179E+00	.5277E+00
	5	.4329E+00	.4534E+00	.4628E+00	.4723E+00	.4818E+00	.4914E+00	.5010E+00	.5107E+00	.5206E+00	.5305E+00
	6	.4303E+00	.4506E+00	.4598E+00	.4691E+00	.4784E+00	.4879E+00	.4973E+00	.5069E+00	.5166E+00	.5264E+00
	7	.4059E+00	.4251E+00	.4341E+00	.4431E+00	.4522E+00	.4613E+00	.4704E+00	.4796E+00	.4889E+00	.4982E+00
	8	.3982E+00	.4164E+00	.4244E+00	.4325E+00	.4406E+00	.4488E+00	.4570E+00	.4653E+00	.4737E+00	.4821E+00
	9	.3570E+00	.3733E+00	.3808E+00	.3884E+00	.3960E+00	.4036E+00	.4112E+00	.4188E+00	.4265E+00	.4341E+00
4.05	1	.3679E+00	.3741E+00	.3805E+00	.3868E+00	.3932E+00	.3996E+00	.4060E+00	.4124E+00	.4189E+00	.4253E+00
	2	.4430E+00	.4508E+00	.4587E+00	.4666E+00	.4746E+00	.4826E+00	.4906E+00	.4988E+00	.5070E+00	.5152E+00
	3	.5022E+00	.5114E+00	.5206E+00	.5300E+00	.5395E+00	.5491E+00	.5588E+00	.5686E+00	.5786E+00	.5888E+00
	4	.5377E+00	.5478E+00	.5580E+00	.5684E+00	.5789E+00	.5896E+00	.6006E+00	.6117E+00	.6231E+00	.6347E+00
	5	.5406E+00	.5507E+00	.5611E+00	.5715E+00	.5822E+00	.5930E+00	.6040E+00	.6153E+00	.6268E+00	.6386E+00
	6	.5364E+00	.5464E+00	.5566E+00	.5670E+00	.5775E+00	.5882E+00	.5991E+00	.6102E+00	.6215E+00	.6331E+00
	7	.5075E+00	.5170E+00	.5265E+00	.5362E+00	.5459E+00	.5557E+00	.5657E+00	.5758E+00	.5861E+00	.5965E+00
	8	.4906E+00	.4992E+00	.5078E+00	.5166E+00	.5254E+00	.5343E+00	.5434E+00	.5526E+00	.5618E+00	.5713E+00
	9	.4418E+00	.4495E+00	.4572E+00	.4651E+00	.4729E+00	.4808E+00	.4888E+00	.4968E+00	.5049E+00	.5130E+00
5.05	1	.4318E+00	.4383E+00	.4449E+00	.4515E+00	.4581E+00	.4647E+00	.4714E+00	.4781E+00	.4849E+00	.4917E+00
	2	.5236E+00	.5320E+00	.5405E+00	.5492E+00	.5579E+00	.5669E+00	.5757E+00	.5848E+00	.5941E+00	.6035E+00
	3	.5991E+00	.6096E+00	.6204E+00	.6313E+00	.6426E+00	.6541E+00	.6659E+00	.6781E+00	.6906E+00	.7037E+00
	4	.6466E+00	.6589E+00	.6715E+00	.6846E+00	.6981E+00	.7122E+00	.7268E+00	.7423E+00	.7586E+00	.7760E+00
	5	.6506E+00	.6631E+00	.6759E+00	.6891E+00	.7028E+00	.7172E+00	.7321E+00	.7479E+00	.7646E+00	.7824E+00
	6	.6450E+00	.6572E+00	.6698E+00	.6828E+00	.6962E+00	.7102E+00	.7247E+00	.7401E+00	.7562E+00	.7734E+00
	7	.6072E+00	.6180E+00	.6290E+00	.6403E+00	.6518E+00	.6637E+00	.6759E+00	.6885E+00	.7015E+00	.7150E+00
	8	.5808E+00	.5906E+00	.6005E+00	.6106E+00	.6209E+00	.6314E+00	.6421E+00	.6532E+00	.6645E+00	.6761E+00
	9	.5213E+00	.5296E+00	.5380E+00	.5465E+00	.5551E+00	.5638E+00	.5727E+00	.5817E+00	.5908E+00	.6001E+00
6.05	1	.4984E+00	.5030E+00	.5048E+00	.5065E+00	.5083E+00	.5101E+00	.5119E+00	.5136E+00	.5154E+00	.5171E+00
	2	.6130E+00	.6189E+00	.6209E+00	.6229E+00	.6249E+00	.6269E+00	.6290E+00	.6310E+00	.6331E+00	.6351E+00
	3	.7172E+00	.7254E+00	.7278E+00	.7303E+00	.7327E+00	.7352E+00	.7377E+00	.7403E+00	.7428E+00	.7454E+00
	4	.7947E+00	.8063E+00	.8094E+00	.8126E+00	.8159E+00	.8192E+00	.8225E+00	.8260E+00	.8295E+00	.8331E+00
	5	.8019E+00	.8137E+00	.8170E+00	.8203E+00	.8237E+00	.8272E+00	.8307E+00	.8343E+00	.8380E+00	.8418E+00
	6	.7920E+00	.8033E+00	.8064E+00	.8095E+00	.8127E+00	.8159E+00	.8192E+00	.8226E+00	.8260E+00	.8295E+00
	7	.7290E+00	.7376E+00	.7401E+00	.7427E+00	.7453E+00	.7479E+00	.7505E+00	.7531E+00	.7558E+00	.7585E+00
	8	.6882E+00	.6952E+00	.6969E+00	.6986E+00	.7004E+00	.7021E+00	.7039E+00	.7057E+00	.7076E+00	.7094E+00
	9	.6099E+00	.6153E+00	.6172E+00	.6191E+00	.6210E+00	.6229E+00	.6249E+00	.6268E+00	.6287E+00	.6306E+00
7.05	1	.5189E+00	.5206E+00	.5224E+00	.5241E+00	.5259E+00	.5276E+00	.5294E+00	.5311E+00	.5328E+00	.5346E+00
	2	.6372E+00	.6393E+00	.6413E+00	.6434E+00	.6455E+00	.6477E+00	.6498E+00	.6519E+00	.6541E+00	.6562E+00
	3	.7481E+00	.7507E+00	.7534E+00	.7561E+00	.7589E+00	.7616E+00	.7644E+00	.7673E+00	.7702E+00	.7731E+00
	4	.8368E+00	.8406E+00	.8445E+00	.8485E+00	.8526E+00	.8568E+00	.8612E+00	.8658E+00	.8705E+00	.8754E+00
	5	.8456E+00	.8496E+00	.8537E+00	.8579E+00	.8623E+00	.8668E+00	.8715E+00	.8763E+00	.8814E+00	.8867E+00
	6	.8331E+00	.8368E+00	.8406E+00	.8445E+00	.8484E+00	.8526E+00	.8568E+00	.8611E+00	.8657E+00	.8704E+00
	7	.7612E+00	.7639E+00	.7667E+00	.7695E+00	.7723E+00	.7752E+00	.7781E+00	.7810E+00	.7839E+00	.7869E+00
	8	.7113E+00	.7132E+00	.7151E+00	.7171E+00	.7190E+00	.7210E+00	.7230E+00	.7251E+00	.7271E+00	.7292E+00
	9	.6325E+00	.6344E+00	.6363E+00	.6382E+00	.6401E+00	.6420E+00	.6439E+00	.6458E+00	.6477E+00	.6496E+00
8.05	1	.5363E+00	.5391E+00	.5430E+00	.5470E+00	.5493E+00	.5500E+00	.5507E+00	.5514E+00	.5521E+00	.5527E+00
	2	.6384E+00	.6623E+00	.6679E+00	.6736E+00	.6768E+00	.6774E+00	.6779E+00	.6784E+00	.6790E+00	.6795E+00
	3	.7761E+00	.7820E+00	.7910E+00	.8005E+00	.8057E+00	.8061E+00	.8066E+00	.8070E+00	.8074E+00	.8078E+00
	4	.8805E+00	.8918E+00	.9117E+00	.9379E+00	.9564E+00	.9563E+00	.9562E+00	.9561E+00	.9559E+00	.9558E+00
	5	.8922E+00	.9049E+00	.9282E+00	.9646E+00	.1000E+01	.9998E+00	.9995E+00	.9991E+00	.9988E+00	.9984E+00
	6	.8752E+00	.8860E+00	.9049E+00	.9283E+00	.9653E+00	.1000E+01	.1000E+01	.1000E+01	.1000E+01	.1000E+01
	7	.7900E+00	.7961E+00	.8056E+00	.8156E+00	.8262E+00	.8376E+00	.8498E+00	.8628E+00	.8770E+00	.8925E+00
	8	.7313E+00	.7359E+00	.7430E+00	.7503E+00	.7578E+00	.7656E+00	.7736E+00	.7819E+00	.7906E+00	.7996E+00
	9	.6516E+00	.6552E+00	.6605E+00	.6659E+00	.6714E+00	.6770E+00	.6827E+00	.6885E+00	.6945E+00	.7005E+00
9.05	1	.5534E+00	.5541E+00	.5547E+00	.5554E+00	.5560E+00	.5567E+00	.5573E+00	.5579E+00	.5586E+00	.5592E+00
	2	.6801E+00	.6806E+00	.6811E+00	.6817E+00	.6822E+00	.6827E+00	.6833E+00	.6838E+00	.6843E+00	.6848E+00
	3	.8082E+00	.8086E+00	.8090E+00	.8094E+00	.8098E+00	.8101E+00	.8105E+00	.8109E+00	.8113E+00	.8116E+00
	4	.9557E+00	.9556E+00	.9554E+00	.9553E+00	.9552E+00	.9550E+00	.9549E+00	.9548E+00	.9547E+00	.9545E+00
	5	.9981E+00	.9978E+00	.9975E+00	.9971E+00	.9968E+00	.9965E+00	.9962E+00	.9959E+00	.9956E+00	.9953E+00
	6	.1000E+01	.1000E+01	.1000E+01	.1000E+01	.1000E+01	.1000E+01	.1000E+01	.9999E+00	.9999E+00	.9999E+00
	7	.9115E+00	.9351E+00	.9753E+00	.1000E+01	.1000E+01	.1000E+01	.1000E+01	.1000E+01	.1000E+01	.1000E+01
	8	.8090E+00	.8190E+00	.8255E+00	.8409E+00	.8530E+00	.8661E+00	.8825E+00	.8967E+00	.9155E+00	.9409E+00
	9	.7066E+00	.7129E+00	.7194E+00	.7260E+00	.7328E+00	.7397E+00	.7469E+00	.7544E+00	.7621E+00	.7701E+00

1	-	BOTTOM OF LAYER NO	5	DEPTH	15.0	INITIAL EFFECTIVE STRESS	1210.000
2	-	BOTTOM OF LAYER NO	6	DEPTH	20.0	INITIAL EFFECTIVE STRESS	1510.000
3	-	BOTTOM OF LAYER NO	7	DEPTH	25.0	INITIAL EFFECTIVE STRESS	1810.000
4	-	BOTTOM OF LAYER NO	8	DEPTH	30.0	INITIAL EFFECTIVE STRESS	2110.000
5	-	BOTTOM OF LAYER NO	9	DEPTH	32.5	INITIAL EFFECTIVE STRESS	2260.000
6	-	BOTTOM OF LAYER NO	10	DEPTH	35.0	INITIAL EFFECTIVE STRESS	2410.000
7	-	BOTTOM OF LAYER NO	11	DEPTH	40.0	INITIAL EFFECTIVE STRESS	2710.000
8	-	BOTTOM OF LAYER NO	12	DEPTH	45.0	INITIAL EFFECTIVE STRESS	3010.000
9	-	BOTTOM OF LAYER NO	13	DEPTH	50.0	INITIAL EFFECTIVE STRESS	3310.000

PORE PRESSURE RATIO = EXCESS PORE PRESSURE / HYDROSTATIC EFFECTIVE STRESS
100 PER CENT CORRESPONDS TO 1.0000

WATER TABLE DEPTH



****** TIME IN SECONDS

TABLE OF PLOTTED VALUES

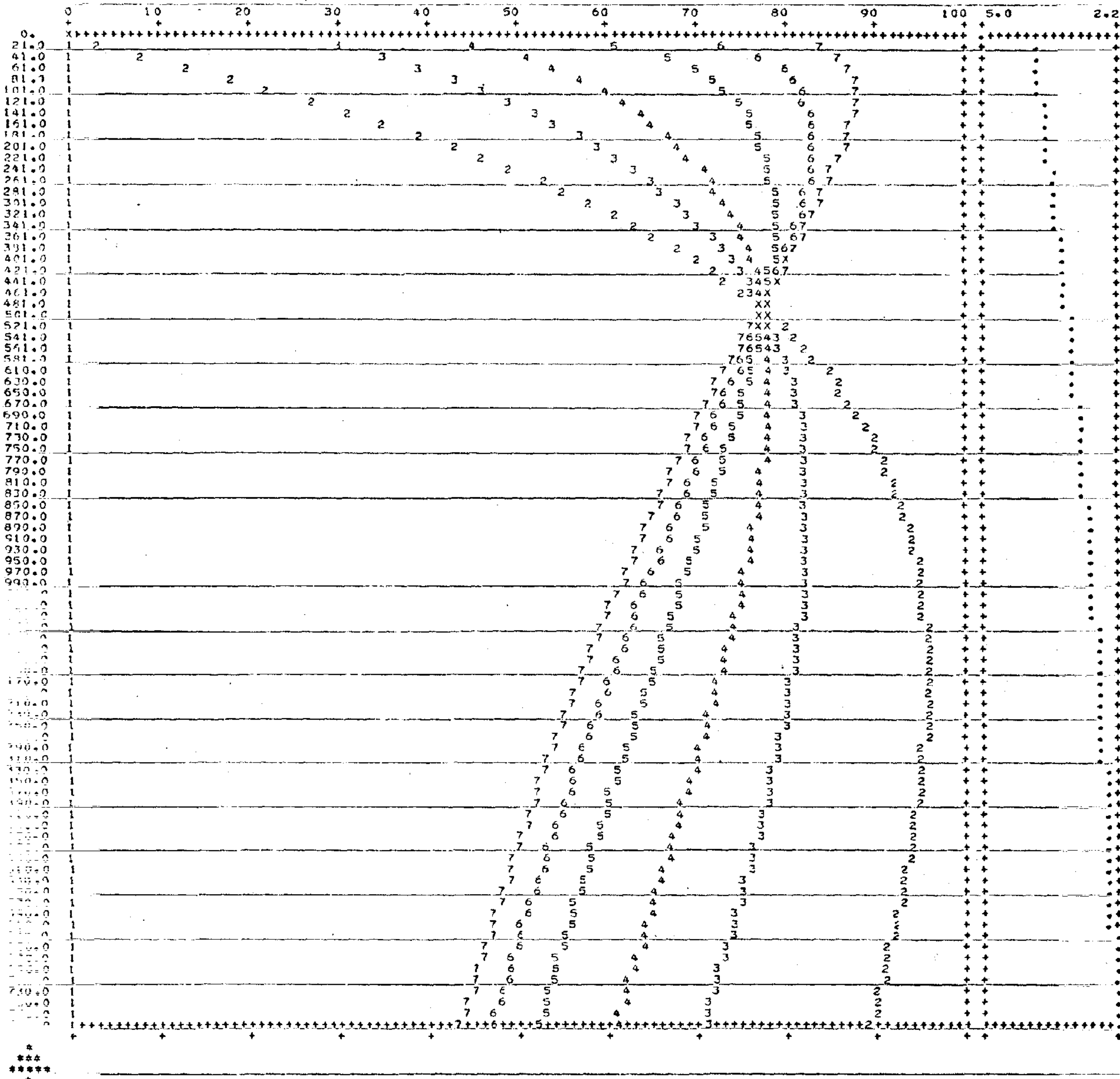
	CURVE										
0.	1	0.	.4986E+00	.5765E+00	.6041E+00	.6258E+00	.6433E+00	.6576E+00	.6697E+00	.6799E+00	.6889E+00
	2	0.	.6130E+00	.6999E+00	.7238E+00	.7420E+00	.7561E+00	.7674E+00	.7766E+00	.7843E+00	.7907E+00
	3	0.	.7172E+00	.8217E+00	.8359E+00	.8456E+00	.8528E+00	.8585E+00	.8629E+00	.8666E+00	.8695E+00
	4	0.	.7947E+00	.9509E+00	.9452E+00	.9414E+00	.9388E+00	.9369E+00	.9354E+00	.9340E+00	.9327E+00
	5	0.	.8018E+00	.9880E+00	.9787E+00	.9726E+00	.9679E+00	.9640E+00	.9606E+00	.9575E+00	.9546E+00
	6	0.	.7920E+00	.9987E+00	.9948E+00	.9901E+00	.9854E+00	.9809E+00	.9765E+00	.9722E+00	.9682E+00
	7	0.	.7290E+00	.9998E+00	.9980E+00	.9945E+00	.9901E+00	.9852E+00	.9800E+00	.9747E+00	.9693E+00
	8	0.	.6882E+00	.9940E+00	.9800E+00	.9694E+00	.9606E+00	.9529E+00	.9458E+00	.9390E+00	.9325E+00
	9	0.	.6095E+00	.8767E+00	.8541E+00	.8842E+00	.8809E+00	.8760E+00	.8703E+00	.8644E+00	.8585E+00
61.00	1	.6967E+00	.7037E+00	.7101E+00	.7159E+00	.7210E+00	.7259E+00	.7304E+00	.7345E+00	.7384E+00	.7420E+00
	2	.7962E+00	.8010E+00	.8052E+00	.8088E+00	.8120E+00	.8148E+00	.8172E+00	.8194E+00	.8213E+00	.8230E+00
	3	.8720E+00	.8739E+00	.8755E+00	.8768E+00	.8777E+00	.8784E+00	.8789E+00	.8791E+00	.8792E+00	.8791E+00
	4	.9314E+00	.9301E+00	.9287E+00	.9273E+00	.9257E+00	.9241E+00	.9224E+00	.9207E+00	.9188E+00	.9169E+00
	5	.9518E+00	.9490E+00	.9463E+00	.9437E+00	.9410E+00	.9383E+00	.9356E+00	.9329E+00	.9301E+00	.9274E+00
	6	.9642E+00	.9603E+00	.9565E+00	.9528E+00	.9491E+00	.9455E+00	.9418E+00	.9383E+00	.9347E+00	.9311E+00
	7	.9639E+00	.9586E+00	.9534E+00	.9482E+00	.9430E+00	.9380E+00	.9330E+00	.9281E+00	.9233E+00	.9185E+00
	8	.9262E+00	.9201E+00	.9141E+00	.9082E+00	.9024E+00	.8968E+00	.8913E+00	.8859E+00	.8805E+00	.8753E+00
	9	.8526E+00	.8468E+00	.8411E+00	.8355E+00	.8301E+00	.8247E+00	.8195E+00	.8143E+00	.8093E+00	.8043E+00
121.00	1	.7454E+00	.7485E+00	.7515E+00	.7543E+00	.7569E+00	.7594E+00	.7617E+00	.7639E+00	.7659E+00	.7679E+00
	2	.8245E+00	.8258E+00	.8269E+00	.8278E+00	.8286E+00	.8293E+00	.8298E+00	.8303E+00	.8306E+00	.8308E+00
	3	.8788E+00	.8784E+00	.8779E+00	.8772E+00	.8765E+00	.8756E+00	.8747E+00	.8736E+00	.8725E+00	.8713E+00
	4	.9149E+00	.9129E+00	.9108E+00	.9086E+00	.9064E+00	.9042E+00	.9019E+00	.8996E+00	.8972E+00	.8948E+00
	5	.9246E+00	.9218E+00	.9189E+00	.9161E+00	.9132E+00	.9103E+00	.9074E+00	.9045E+00	.9016E+00	.8986E+00
	6	.9276E+00	.9241E+00	.9206E+00	.9171E+00	.9136E+00	.9101E+00	.9067E+00	.9032E+00	.8998E+00	.8964E+00
	7	.9139E+00	.9092E+00	.9047E+00	.9002E+00	.8958E+00	.8914E+00	.8871E+00	.8828E+00	.8786E+00	.8744E+00
	8	.8702E+00	.8652E+00	.8602E+00	.8554E+00	.8506E+00	.8459E+00	.8412E+00	.8367E+00	.8322E+00	.8278E+00
	9	.7995E+00	.7947E+00	.7900E+00	.7855E+00	.7809E+00	.7765E+00	.7721E+00	.7679E+00	.7636E+00	.7595E+00
181.00	1	.7697E+00	.7714E+00	.7730E+00	.7745E+00	.7758E+00	.7771E+00	.7784E+00	.7795E+00	.7805E+00	.7815E+00
	2	.8309E+00	.8309E+00	.8308E+00	.8306E+00	.8304E+00	.8301E+00	.8297E+00	.8293E+00	.8288E+00	.8282E+00
	3	.8701E+00	.8687E+00	.8674E+00	.8659E+00	.8644E+00	.8629E+00	.8613E+00	.8597E+00	.8581E+00	.8564E+00
	4	.8924E+00	.8899E+00	.8874E+00	.8849E+00	.8824E+00	.8799E+00	.8773E+00	.8747E+00	.8721E+00	.8695E+00
	5	.8957E+00	.8927E+00	.8898E+00	.8868E+00	.8838E+00	.8808E+00	.8779E+00	.8749E+00	.8719E+00	.8689E+00
	6	.8930E+00	.8895E+00	.8862E+00	.8828E+00	.8794E+00	.8761E+00	.8727E+00	.8694E+00	.8661E+00	.8628E+00
	7	.8703E+00	.8662E+00	.8622E+00	.8582E+00	.8543E+00	.8504E+00	.8465E+00	.8427E+00	.8389E+00	.8352E+00
	8	.8235E+00	.8192E+00	.8150E+00	.8108E+00	.8067E+00	.8026E+00	.7986E+00	.7947E+00	.7908E+00	.7870E+00
	9	.7554E+00	.7514E+00	.7474E+00	.7435E+00	.7396E+00	.7359E+00	.7321E+00	.7284E+00	.7248E+00	.7212E+00
241.00	1	.7824E+00	.7832E+00	.7839E+00	.7846E+00	.7852E+00	.7858E+00	.7863E+00	.7867E+00	.7871E+00	.7874E+00
	2	.8276E+00	.8270E+00	.8263E+00	.8255E+00	.8247E+00	.8239E+00	.8230E+00	.8221E+00	.8211E+00	.8201E+00
	3	.8547E+00	.8529E+00	.8511E+00	.8493E+00	.8475E+00	.8456E+00	.8437E+00	.8418E+00	.8399E+00	.8380E+00
	4	.8669E+00	.8643E+00	.8617E+00	.8591E+00	.8564E+00	.8538E+00	.8512E+00	.8485E+00	.8459E+00	.8432E+00
	5	.8660E+00	.8630E+00	.8600E+00	.8571E+00	.8541E+00	.8512E+00	.8482E+00	.8453E+00	.8423E+00	.8394E+00
	6	.8595E+00	.8562E+00	.8530E+00	.8497E+00	.8465E+00	.8433E+00	.8401E+00	.8370E+00	.8338E+00	.8307E+00
	7	.8315E+00	.8278E+00	.8242E+00	.8205E+00	.8170E+00	.8134E+00	.8099E+00	.8064E+00	.8030E+00	.7996E+00
	8	.7832E+00	.7794E+00	.7757E+00	.7720E+00	.7684E+00	.7648E+00	.7613E+00	.7578E+00	.7543E+00	.7508E+00
	9	.7176E+00	.7141E+00	.7106E+00	.7072E+00	.7038E+00	.7005E+00	.6972E+00	.6939E+00	.6907E+00	.6875E+00
301.00	1	.7877E+00	.7880E+00	.7881E+00	.7883E+00	.7883E+00	.7884E+00	.7884E+00	.7884E+00	.7883E+00	.7882E+00
	2	.8191E+00	.8180E+00	.8170E+00	.8159E+00	.8147E+00	.8136E+00	.8124E+00	.8112E+00	.8099E+00	.8087E+00
	3	.8361E+00	.8341E+00	.8321E+00	.8301E+00	.8281E+00	.8261E+00	.8241E+00	.8221E+00	.8200E+00	.8180E+00
	4	.8406E+00	.8379E+00	.8353E+00	.8327E+00	.8300E+00	.8274E+00	.8248E+00	.8222E+00	.8195E+00	.8169E+00
	5	.8365E+00	.8336E+00	.8307E+00	.8278E+00	.8250E+00	.8221E+00	.8193E+00	.8164E+00	.8136E+00	.8108E+00
	6	.8275E+00	.8244E+00	.8213E+00	.8182E+00	.8152E+00	.8121E+00	.8091E+00	.8061E+00	.8031E+00	.8001E+00
	7	.7962E+00	.7929E+00	.7895E+00	.7862E+00	.7829E+00	.7796E+00	.7764E+00	.7732E+00	.7700E+00	.7668E+00
	8	.7474E+00	.7441E+00	.7407E+00	.7374E+00	.7342E+00	.7309E+00	.7277E+00	.7246E+00	.7214E+00	.7183E+00
	9	.6843E+00	.6812E+00	.6781E+00	.6750E+00	.6720E+00	.6690E+00	.6660E+00	.6630E+00	.6601E+00	.6572E+00
361.00	1	.7880E+00	.7878E+00	.7876E+00	.7873E+00	.7870E+00	.7867E+00	.7864E+00	.7860E+00	.7856E+00	.7852E+00
	2	.8074E+00	.8061E+00	.8048E+00	.8035E+00	.8021E+00	.8008E+00	.7994E+00	.7980E+00	.7966E+00	.7952E+00
	3	.8160E+00	.8139E+00	.8118E+00	.8098E+00	.8077E+00	.8056E+00	.8036E+00	.8015E+00	.7994E+00	.7973E+00

	4	.8143E+00	.8117E+00	.8091E+00	.8066E+00	.8040E+00	.8014E+00	.7988E+00	.7963E+00	.7937E+00	.7912E+00
	5	.8079E+00	.8052E+00	.8024E+00	.7996E+00	.7968E+00	.7941E+00	.7913E+00	.7886E+00	.7859E+00	.7832E+00
	6	.7972E+00	.7942E+00	.7913E+00	.7884E+00	.7855E+00	.7826E+00	.7797E+00	.7768E+00	.7740E+00	.7712E+00
	7	.7637E+00	.7606E+00	.7575E+00	.7544E+00	.7514E+00	.7484E+00	.7454E+00	.7424E+00	.7395E+00	.7365E+00
	8	.7152E+00	.7121E+00	.7091E+00	.7061E+00	.7031E+00	.7001E+00	.6972E+00	.6943E+00	.6914E+00	.6885E+00
	9	.6544E+00	.6515E+00	.6487E+00	.6459E+00	.6431E+00	.6404E+00	.6377E+00	.6350E+00	.6323E+00	.6296E+00
421.00	1	.7847E+00	.7842E+00	.7837E+00	.7832E+00	.7826E+00	.7820E+00	.7814E+00	.7808E+00	.7801E+00	.7795E+00
	2	.7938E+00	.7923E+00	.7909E+00	.7894E+00	.7879E+00	.7865E+00	.7850E+00	.7835E+00	.7820E+00	.7805E+00
	3	.7953E+00	.7932E+00	.7911E+00	.7890E+00	.7869E+00	.7849E+00	.7828E+00	.7807E+00	.7786E+00	.7766E+00
	4	.7887E+00	.7861E+00	.7836E+00	.7811E+00	.7786E+00	.7761E+00	.7736E+00	.7712E+00	.7687E+00	.7663E+00
	5	.7805E+00	.7778E+00	.7752E+00	.7725E+00	.7699E+00	.7672E+00	.7646E+00	.7620E+00	.7594E+00	.7568E+00
	6	.7684E+00	.7656E+00	.7628E+00	.7601E+00	.7573E+00	.7546E+00	.7519E+00	.7492E+00	.7465E+00	.7438E+00
	7	.7336E+00	.7307E+00	.7279E+00	.7250E+00	.7222E+00	.7194E+00	.7166E+00	.7138E+00	.7111E+00	.7083E+00
	8	.6857E+00	.6828E+00	.6800E+00	.6772E+00	.6745E+00	.6717E+00	.6690E+00	.6663E+00	.6637E+00	.6610E+00
	9	.6270E+00	.6244E+00	.6218E+00	.6192E+00	.6167E+00	.6141E+00	.6116E+00	.6091E+00	.6066E+00	.6042E+00
451.00	1	.7789E+00	.7781E+00	.7773E+00	.7766E+00	.7758E+00	.7751E+00	.7743E+00	.7735E+00	.7726E+00	.7718E+00
	2	.7789E+00	.7774E+00	.7759E+00	.7743E+00	.7728E+00	.7713E+00	.7697E+00	.7681E+00	.7666E+00	.7650E+00
	3	.7745E+00	.7724E+00	.7704E+00	.7683E+00	.7662E+00	.7642E+00	.7621E+00	.7601E+00	.7580E+00	.7560E+00
	4	.7638E+00	.7614E+00	.7590E+00	.7565E+00	.7541E+00	.7517E+00	.7493E+00	.7470E+00	.7446E+00	.7422E+00
	5	.7542E+00	.7517E+00	.7491E+00	.7466E+00	.7441E+00	.7416E+00	.7391E+00	.7366E+00	.7341E+00	.7316E+00
	6	.7412E+00	.7385E+00	.7359E+00	.7333E+00	.7307E+00	.7281E+00	.7255E+00	.7230E+00	.7204E+00	.7179E+00
	7	.7056E+00	.7029E+00	.7002E+00	.6975E+00	.6949E+00	.6923E+00	.6897E+00	.6871E+00	.6845E+00	.6819E+00
	8	.6584E+00	.6557E+00	.6531E+00	.6506E+00	.6480E+00	.6454E+00	.6429E+00	.6404E+00	.6379E+00	.6354E+00
	9	.6017E+00	.5993E+00	.5969E+00	.5945E+00	.5922E+00	.5898E+00	.5875E+00	.5852E+00	.5829E+00	.5806E+00
541.00	1	.7710E+00	.7701E+00	.7692E+00	.7683E+00	.7674E+00	.7665E+00	.7656E+00	.7646E+00	.7637E+00	.7627E+00
	2	.7634E+00	.7619E+00	.7603E+00	.7587E+00	.7571E+00	.7555E+00	.7539E+00	.7523E+00	.7507E+00	.7491E+00
	3	.7539E+00	.7519E+00	.7499E+00	.7478E+00	.7458E+00	.7438E+00	.7418E+00	.7398E+00	.7378E+00	.7357E+00
	4	.7399E+00	.7375E+00	.7352E+00	.7329E+00	.7306E+00	.7283E+00	.7260E+00	.7237E+00	.7214E+00	.7191E+00
	5	.7292E+00	.7263E+00	.7243E+00	.7219E+00	.7195E+00	.7171E+00	.7147E+00	.7124E+00	.7100E+00	.7076E+00
	6	.7154E+00	.7129E+00	.7104E+00	.7079E+00	.7054E+00	.7030E+00	.7005E+00	.6981E+00	.6957E+00	.6933E+00
	7	.6794E+00	.6768E+00	.6743E+00	.6718E+00	.6693E+00	.6663E+00	.6644E+00	.6619E+00	.6595E+00	.6571E+00
	8	.6333E+00	.6305E+00	.6281E+00	.6257E+00	.6233E+00	.6209E+00	.6185E+00	.6162E+00	.6139E+00	.6115E+00
	9	.5783E+00	.5761E+00	.5738E+00	.5716E+00	.5694E+00	.5672E+00	.5650E+00	.5628E+00	.5607E+00	.5585E+00

1	- BOTTOM OF LAYER NO	1	DEPTH 2.0	INITIAL EFFECTIVE STRESS	244.000
2	- BOTTOM OF LAYER NO	2	DEPTH 4.0	INITIAL EFFECTIVE STRESS	550.000
3	- BOTTOM OF LAYER NO	3	DEPTH 7.0	INITIAL EFFECTIVE STRESS	730.000
4	- BOTTOM OF LAYER NO	4	DEPTH 10.0	INITIAL EFFECTIVE STRESS	910.000
5	- BOTTOM OF LAYER NO	5	DEPTH 15.0	INITIAL EFFECTIVE STRESS	1210.000
6	- BOTTOM OF LAYER NO	6	DEPTH 20.0	INITIAL EFFECTIVE STRESS	1510.000
7	- BOTTOM OF LAYER NO	7	DEPTH 25.0	INITIAL EFFECTIVE STRESS	1810.000

PORE PRESSURE RATIO = EXCESS PORE PRESSURE / HYDROSTATIC EFFECTIVE STRESS
100 PER CENT CORRESPONDS TO 1.0000

WATER TABLE DEPTH



TIME IN SECONDS

TABLE OF PLOTTED VALUES

	CURVE										
0.	1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	2	0.	.3445E-01	.2128E-01	.1295E+00	.1779E+00	.2245E+00	.2692E+00	.3119E+00	.3525E+00	.3911E+00
	3	0.	.2958E+00	.3492E+00	.3911E+00	.4273E+00	.4599E+00	.4898E+00	.5175E+00	.5431E+00	.5669E+00
	4	0.	.4502E+00	.5061E+00	.5433E+00	.5723E+00	.5966E+00	.6178E+00	.6366E+00	.6534E+00	.6686E+00
	5	0.	.6119E+00	.6659E+00	.6967E+00	.7176E+00	.7332E+00	.7454E+00	.7552E+00	.7632E+00	.7697E+00
	6	0.	.7304E+00	.7737E+00	.7962E+00	.8099E+00	.8187E+00	.8245E+00	.8281E+00	.8301E+00	.8309E+00
	7	0.	.8394E+00	.8616E+00	.8720E+00	.8771E+00	.8790E+00	.8788E+00	.8770E+00	.8740E+00	.8701E+00
201.00	1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	2	.4276E+00	.4621E+00	.4947E+00	.5254E+00	.5545E+00	.5818E+00	.6076E+00	.6318E+00	.6547E+00	.6762E+00
	3	.5890E+00	.6094E+00	.6284E+00	.6461E+00	.6624E+00	.6775E+00	.6915E+00	.7045E+00	.7164E+00	.7275E+00
	4	.6822E+00	.6946E+00	.7057E+00	.7157E+00	.7249E+00	.7329E+00	.7401E+00	.7466E+00	.7524E+00	.7575E+00
	5	.7749E+00	.7791E+00	.7824E+00	.7848E+00	.7866E+00	.7877E+00	.7883E+00	.7884E+00	.7880E+00	.7872E+00
	6	.8306E+00	.8295E+00	.8276E+00	.8252E+00	.8224E+00	.8191E+00	.8155E+00	.8116E+00	.8074E+00	.8030E+00
	7	.8654E+00	.8603E+00	.8547E+00	.8487E+00	.8425E+00	.8361E+00	.8295E+00	.8228E+00	.8160E+00	.8091E+00
401.00	1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	2	.6964E+00	.7155E+00	.7334E+00	.7502E+00	.7661E+00	.7810E+00	.7950E+00	.8082E+00	.8205E+00	.8321E+00
	3	.7377E+00	.7471E+00	.7558E+00	.7638E+00	.7711E+00	.7778E+00	.7839E+00	.7895E+00	.7946E+00	.7992E+00
	4	.7620E+00	.7660E+00	.7694E+00	.7724E+00	.7749E+00	.7770E+00	.7787E+00	.7800E+00	.7810E+00	.7817E+00
	5	.7861E+00	.7847E+00	.7830E+00	.7810E+00	.7788E+00	.7764E+00	.7737E+00	.7710E+00	.7680E+00	.7649E+00
	6	.7935E+00	.7938E+00	.7889E+00	.7840E+00	.7789E+00	.7738E+00	.7687E+00	.7634E+00	.7582E+00	.7529E+00
	7	.8022E+00	.7953E+00	.7883E+00	.7814E+00	.7745E+00	.7676E+00	.7608E+00	.7539E+00	.7472E+00	.7404E+00
610.00	1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	2	.8460E+00	.8554E+00	.8645E+00	.8731E+00	.8812E+00	.8887E+00	.8958E+00	.9024E+00	.9085E+00	.9142E+00
	3	.8046E+00	.8075E+00	.8104E+00	.8131E+00	.8154E+00	.8175E+00	.8192E+00	.8207E+00	.8219E+00	.8229E+00
	4	.7820E+00	.7816E+00	.7812E+00	.7806E+00	.7798E+00	.7789E+00	.7777E+00	.7765E+00	.7750E+00	.7734E+00
	5	.7602E+00	.7567E+00	.7531E+00	.7494E+00	.7457E+00	.7419E+00	.7381E+00	.7342E+00	.7303E+00	.7263E+00
	6	.7452E+00	.7399E+00	.7344E+00	.7289E+00	.7235E+00	.7181E+00	.7128E+00	.7074E+00	.7021E+00	.6968E+00
	7	.7308E+00	.7242E+00	.7176E+00	.7111E+00	.7046E+00	.6982E+00	.6919E+00	.6856E+00	.6794E+00	.6732E+00
810.00	1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	2	.9194E+00	.9242E+00	.9287E+00	.9328E+00	.9365E+00	.9398E+00	.9429E+00	.9456E+00	.9480E+00	.9502E+00
	3	.8236E+00	.8240E+00	.8243E+00	.8243E+00	.8241E+00	.8237E+00	.8232E+00	.8224E+00	.8215E+00	.8205E+00
	4	.7717E+00	.7699E+00	.7678E+00	.7657E+00	.7634E+00	.7611E+00	.7586E+00	.7561E+00	.7534E+00	.7507E+00
	5	.7223E+00	.7182E+00	.7142E+00	.7100E+00	.7059E+00	.7017E+00	.6976E+00	.6933E+00	.6891E+00	.6849E+00
	6	.6915E+00	.6852E+00	.6809E+00	.6757E+00	.6705E+00	.6653E+00	.6602E+00	.6551E+00	.6500E+00	.6450E+00
	7	.6671E+00	.6611E+00	.6552E+00	.6493E+00	.6434E+00	.6376E+00	.6319E+00	.6263E+00	.6207E+00	.6151E+00
1010.00	1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	2	.9520E+00	.9536E+00	.9549E+00	.9560E+00	.9569E+00	.9575E+00	.9579E+00	.9581E+00	.9581E+00	.9579E+00
	3	.8193E+00	.8179E+00	.8164E+00	.8148E+00	.8130E+00	.8111E+00	.8091E+00	.8070E+00	.8048E+00	.8025E+00
	4	.7479E+00	.7450E+00	.7421E+00	.7390E+00	.7360E+00	.7328E+00	.7296E+00	.7264E+00	.7231E+00	.7197E+00
	5	.6807E+00	.6764E+00	.6722E+00	.6679E+00	.6636E+00	.6594E+00	.6551E+00	.6509E+00	.6466E+00	.6424E+00
	6	.6399E+00	.6349E+00	.6300E+00	.6251E+00	.6202E+00	.6153E+00	.6105E+00	.6057E+00	.6009E+00	.5962E+00
	7	.6096E+00	.6042E+00	.5989E+00	.5935E+00	.5883E+00	.5831E+00	.5779E+00	.5728E+00	.5678E+00	.5628E+00
1210.00	1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	2	.9575E+00	.9569E+00	.9562E+00	.9553E+00	.9542E+00	.9530E+00	.9517E+00	.9502E+00	.9486E+00	.9468E+00
	3	.8001E+00	.7976E+00	.7951E+00	.7924E+00	.7897E+00	.7869E+00	.7840E+00	.7811E+00	.7781E+00	.7751E+00
	4	.7164E+00	.7129E+00	.7095E+00	.7060E+00	.7025E+00	.6989E+00	.6953E+00	.6917E+00	.6881E+00	.6844E+00
	5	.6381E+00	.6339E+00	.6296E+00	.6254E+00	.6212E+00	.6170E+00	.6128E+00	.6087E+00	.6045E+00	.6004E+00
	6	.5915E+00	.5869E+00	.5822E+00	.5776E+00	.5731E+00	.5686E+00	.5641E+00	.5596E+00	.5552E+00	.5508E+00
	7	.5579E+00	.5530E+00	.5482E+00	.5434E+00	.5386E+00	.5340E+00	.5293E+00	.5247E+00	.5202E+00	.5157E+00
1410.00	1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	2	.9450E+00	.9430E+00	.9409E+00	.9387E+00	.9364E+00	.9340E+00	.9316E+00	.9290E+00	.9263E+00	.9236E+00
	3	.7720E+00	.7688E+00	.7656E+00	.7624E+00	.7591E+00	.7558E+00	.7524E+00	.7490E+00	.7456E+00	.7421E+00
	4	.6808E+00	.6771E+00	.6734E+00	.6697E+00	.6660E+00	.6622E+00	.6585E+00	.6547E+00	.6510E+00	.6472E+00
	5	.5962E+00	.5921E+00	.5880E+00	.5839E+00	.5799E+00	.5758E+00	.5718E+00	.5678E+00	.5638E+00	.5598E+00
	6	.5465E+00	.5421E+00	.5379E+00	.5336E+00	.5294E+00	.5252E+00	.5211E+00	.5169E+00	.5129E+00	.5088E+00
	7	.5112E+00	.5068E+00	.5025E+00	.4981E+00	.4939E+00	.4896E+00	.4854E+00	.4813E+00	.4772E+00	.4731E+00
1610.00	1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

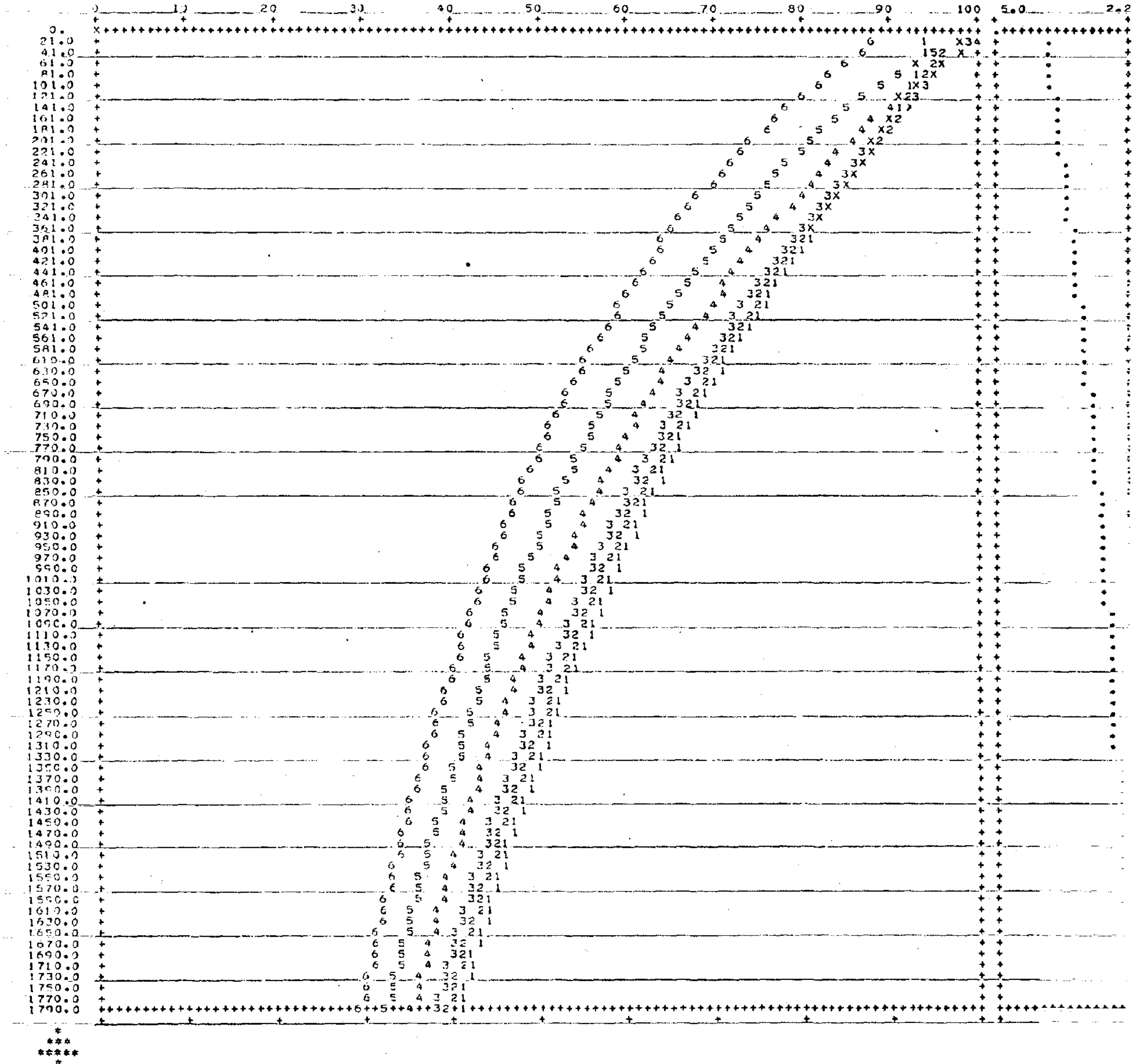
2	.9208E+00	.9179E+00	.9149E+00	.9119E+00	.9088E+00	.9057E+00	.9025E+00	.8992E+00	.8959E+00	.8926E+00
3	.7386E+00	.7351E+00	.7316E+00	.7290E+00	.7244E+00	.7208E+00	.7172E+00	.7136E+00	.7099E+00	.7063E+00
4	.6435E+00	.6397E+00	.6359E+00	.6322E+00	.6284E+00	.6247E+00	.6209E+00	.6172E+00	.6134E+00	.6097E+00
5	.5559E+00	.5519E+00	.5480E+00	.5441E+00	.5403E+00	.5364E+00	.5326E+00	.5288E+00	.5250E+00	.5213E+00
6	.5049E+00	.5008E+00	.4968E+00	.4929E+00	.4890E+00	.4852E+00	.4813E+00	.4775E+00	.4738E+00	.4700E+00
7	.4691E+00	.4651E+00	.4611E+00	.4572E+00	.4534E+00	.4495E+00	.4457E+00	.4420E+00	.4383E+00	.4346E+00

*CURVES

CURVE 1 - BOTTOM OF LAYER NO 8 DEPTH 30.0 INITIAL EFFECTIVE STRESS 2110.000
CURVE 2 - BOTTOM OF LAYER NO 9 DEPTH 32.5 INITIAL EFFECTIVE STRESS 2260.000
CURVE 3 - BOTTOM OF LAYER NO 10 DEPTH 35.0 INITIAL EFFECTIVE STRESS 2410.000
CURVE 4 - BOTTOM OF LAYER NO 11 DEPTH 40.0 INITIAL EFFECTIVE STRESS 2710.000
CURVE 5 - BOTTOM OF LAYER NO 12 DEPTH 45.0 INITIAL EFFECTIVE STRESS 3010.000
CURVE 6 - BOTTOM OF LAYER NO 13 DEPTH 50.0 INITIAL EFFECTIVE STRESS 3310.000

PORE PRESSURE RATIO = EXCESS PORE PRESSURE / HYDROSTATIC EFFECTIVE STRESS
100 PER CENT CORRESPONDS TO 1.0000

WATER TABLE DEPTH



****** TIME IN SECONDS

TABLE OF PLOTTED VALUES

	CURVE										
0.	1	0.	.9438E+00	.9358E+00	.9314E+00	.9268E+00	.9213E+00	.9149E+00	.9079E+00	.9003E+00	.8924E+00
	2	0.	.9764E+00	.9617E+00	.9518E+00	.9428E+00	.9338E+00	.9246E+00	.9151E+00	.9055E+00	.8957E+00
	3	0.	.9933E+00	.9779E+00	.9642E+00	.9515E+00	.9394E+00	.9276E+00	.9159E+00	.9044E+00	.8930E+00
	4	0.	.9969E+00	.9818E+00	.9639E+00	.9464E+00	.9297E+00	.9139E+00	.8987E+00	.8842E+00	.8703E+00
	5	0.	.9762E+00	.9481E+00	.9262E+00	.9063E+00	.8877E+00	.8702E+00	.8538E+00	.8382E+00	.8235E+00
	6	0.	.8847E+00	.8722E+00	.8526E+00	.8337E+00	.8160E+00	.7995E+00	.7839E+00	.7693E+00	.7554E+00
201.00	1	.8841E+00	.8756E+00	.8669E+00	.8582E+00	.8494E+00	.8406E+00	.8318E+00	.8230E+00	.8143E+00	.8057E+00
	2	.8858E+00	.8759E+00	.8660E+00	.8561E+00	.8463E+00	.8365E+00	.8269E+00	.8174E+00	.8075E+00	.7987E+00
	3	.8817E+00	.8705E+00	.8595E+00	.8487E+00	.8380E+00	.8275E+00	.8172E+00	.9071E+00	.7972E+00	.7874E+00
	4	.8569E+00	.8440E+00	.8315E+00	.8193E+00	.8076E+00	.7962E+00	.7851E+00	.7742E+00	.7637E+00	.7534E+00
	5	.8394E+00	.7960E+00	.7832E+00	.7708E+00	.7589E+00	.7474E+00	.7364E+00	.7256E+00	.7152E+00	.7051E+00
	6	.7422E+00	.7296E+00	.7176E+00	.7061E+00	.6950E+00	.6843E+00	.6740E+00	.6640E+00	.6544E+00	.6450E+00
401.00	1	.7971E+00	.7887E+00	.7803E+00	.7720E+00	.7638E+00	.7557E+00	.7478E+00	.7399E+00	.7321E+00	.7244E+00
	2	.7895E+00	.7805E+00	.7716E+00	.7629E+00	.7542E+00	.7458E+00	.7374E+00	.7292E+00	.7211E+00	.7131E+00
	3	.7778E+00	.7684E+00	.7591E+00	.7501E+00	.7412E+00	.7324E+00	.7238E+00	.7154E+00	.7071E+00	.6989E+00
	4	.7434E+00	.7336E+00	.7241E+00	.7147E+00	.7056E+00	.6967E+00	.6879E+00	.6794E+00	.6710E+00	.6628E+00
	5	.6952E+00	.6857E+00	.6763E+00	.6672E+00	.6584E+00	.6497E+00	.6412E+00	.6330E+00	.6249E+00	.6170E+00
	6	.6359E+00	.6270E+00	.6184E+00	.6099E+00	.6017E+00	.5937E+00	.5859E+00	.5783E+00	.5708E+00	.5636E+00
[illegible]10.00	1	.7135E+00	.7061E+00	.6988E+00	.6916E+00	.6844E+00	.6774E+00	.6705E+00	.6636E+00	.6569E+00	.6502E+00
	2	.7018E+00	.6942E+00	.6866E+00	.6792E+00	.6719E+00	.6647E+00	.6576E+00	.6506E+00	.6437E+00	.6369E+00
	3	.6874E+00	.6796E+00	.6719E+00	.6643E+00	.6569E+00	.6496E+00	.6424E+00	.6354E+00	.6284E+00	.6216E+00
	4	.6511E+00	.6433E+00	.6356E+00	.6281E+00	.6207E+00	.6135E+00	.6063E+00	.5993E+00	.5925E+00	.5857E+00
	5	.6058E+00	.5983E+00	.5909E+00	.5837E+00	.5767E+00	.5697E+00	.5629E+00	.5563E+00	.5497E+00	.5433E+00
	6	.5533E+00	.5463E+00	.5396E+00	.5329E+00	.5264E+00	.5200E+00	.5138E+00	.5077E+00	.5016E+00	.4957E+00
[illegible]10.00	1	.6437E+00	.6372E+00	.6308E+00	.6245E+00	.6183E+00	.6122E+00	.6062E+00	.6002E+00	.5943E+00	.5885E+00
	2	.6302E+00	.6236E+00	.6172E+00	.6108E+00	.6045E+00	.5983E+00	.5922E+00	.5861E+00	.5802E+00	.5743E+00
	3	.6149E+00	.6082E+00	.6017E+00	.5953E+00	.5890E+00	.5828E+00	.5766E+00	.5706E+00	.5647E+00	.5588E+00
	4	.5791E+00	.5726E+00	.5662E+00	.5599E+00	.5537E+00	.5476E+00	.5416E+00	.5357E+00	.5299E+00	.5242E+00
	5	.5370E+00	.5308E+00	.5247E+00	.5187E+00	.5129E+00	.5071E+00	.5014E+00	.4958E+00	.4904E+00	.4850E+00
	6	.4899E+00	.4842E+00	.4786E+00	.4732E+00	.4679E+00	.4625E+00	.4572E+00	.4521E+00	.4471E+00	.4421E+00
1010.00	1	.5828E+00	.5771E+00	.5716E+00	.5660E+00	.5606E+00	.5552E+00	.5499E+00	.5447E+00	.5395E+00	.5344E+00
	2	.5685E+00	.5629E+00	.5572E+00	.5517E+00	.5462E+00	.5408E+00	.5355E+00	.5303E+00	.5251E+00	.5200E+00
	3	.5530E+00	.5474E+00	.5417E+00	.5362E+00	.5308E+00	.5254E+00	.5201E+00	.5149E+00	.5098E+00	.5047E+00
	4	.5186E+00	.5130E+00	.5076E+00	.5022E+00	.4969E+00	.4917E+00	.4866E+00	.4816E+00	.4766E+00	.4717E+00
	5	.4796E+00	.4744E+00	.4693E+00	.4642E+00	.4593E+00	.4544E+00	.4495E+00	.4448E+00	.4401E+00	.4355E+00
	6	.4373E+00	.4325E+00	.4277E+00	.4231E+00	.4185E+00	.4140E+00	.4096E+00	.4053E+00	.4010E+00	.3966E+00
1210.00	1	.5294E+00	.5244E+00	.5195E+00	.5146E+00	.5098E+00	.5051E+00	.5004E+00	.4957E+00	.4912E+00	.4866E+00
	2	.5149E+00	.5100E+00	.5051E+00	.5002E+00	.4954E+00	.4907E+00	.4860E+00	.4814E+00	.4769E+00	.4724E+00
	3	.4997E+00	.4948E+00	.4899E+00	.4851E+00	.4803E+00	.4757E+00	.4710E+00	.4665E+00	.4620E+00	.4576E+00
	4	.4669E+00	.4621E+00	.4574E+00	.4528E+00	.4482E+00	.4437E+00	.4393E+00	.4349E+00	.4306E+00	.4264E+00
	5	.4310E+00	.4265E+00	.4221E+00	.4177E+00	.4135E+00	.4092E+00	.4051E+00	.4010E+00	.3969E+00	.3930E+00
	6	.3926E+00	.3885E+00	.3845E+00	.3805E+00	.3766E+00	.3727E+00	.3689E+00	.3652E+00	.3615E+00	.3578E+00
1410.00	1	.4822E+00	.4778E+00	.4734E+00	.4691E+00	.4648E+00	.4606E+00	.4564E+00	.4523E+00	.4482E+00	.4442E+00
	2	.4679E+00	.4635E+00	.4592E+00	.4549E+00	.4507E+00	.4465E+00	.4424E+00	.4383E+00	.4343E+00	.4303E+00
	3	.4532E+00	.4489E+00	.4446E+00	.4404E+00	.4362E+00	.4321E+00	.4280E+00	.4240E+00	.4200E+00	.4161E+00
	4	.4222E+00	.4180E+00	.4139E+00	.4099E+00	.4059E+00	.4020E+00	.3981E+00	.3943E+00	.3905E+00	.3868E+00
	5	.3890E+00	.3852E+00	.3813E+00	.3776E+00	.3739E+00	.3702E+00	.3666E+00	.3630E+00	.3595E+00	.3560E+00
	6	.3542E+00	.3507E+00	.3472E+00	.3437E+00	.3403E+00	.3370E+00	.3337E+00	.3304E+00	.3272E+00	.3240E+00
1610.00	1	.4402E+00	.4363E+00	.4324E+00	.4285E+00	.4247E+00	.4210E+00	.4172E+00	.4136E+00	.4099E+00	.4063E+00
	2	.4264E+00	.4225E+00	.4186E+00	.4148E+00	.4111E+00	.4074E+00	.4037E+00	.4001E+00	.3965E+00	.3929E+00
	3	.4123E+00	.4084E+00	.4047E+00	.4009E+00	.3972E+00	.3936E+00	.3900E+00	.3864E+00	.3829E+00	.3795E+00
	4	.3831E+00	.3795E+00	.3759E+00	.3723E+00	.3688E+00	.3654E+00	.3620E+00	.3586E+00	.3553E+00	.3520E+00
	5	.3526E+00	.3492E+00	.3458E+00	.3425E+00	.3393E+00	.3360E+00	.3328E+00	.3297E+00	.3266E+00	.3235E+00
	6	.3208E+00	.3177E+00	.3147E+00	.3117E+00	.3087E+00	.3057E+00	.3028E+00	.3000E+00	.2971E+00	.2943E+00

APPENDIX A

A.3 PUNCHED OUTPUT TO BE USED IN EFFECTIVE STRESS ANALYSIS

APOLLO--EXAMPLE PROBLEM--CDC 6400 -- PERIOD NO. 1

TIME IN SECONDS

0.	.10000	.25000	.35000	.45000	.55000	.65000	.75000
.85000	.95000	1.05000	1.15000	1.25000	1.35000	1.45000	1.55000
1.65000	1.75000	1.85000	1.95000	2.05000	2.15000	2.25000	2.35000
2.45000	2.55000	2.65000	2.75000	2.85000	2.95000	3.05000	3.15000
3.25000	3.35000	3.45000	3.55000	3.65000	3.75000	3.85000	3.95000
4.05000	4.15000	4.25000	4.35000	4.45000	4.55000	4.65000	4.75000
4.85000	4.95000	5.05000	5.15000	5.25000	5.35000	5.45000	5.55000
5.65000	5.75000	5.85000	5.95000	6.05000	6.15000	6.25000	6.35000
6.45000	6.55000	6.65000	6.75000	6.85000	6.95000	7.05000	7.15000
7.25000	7.35000	7.45000	7.55000	7.65000	7.75000	7.85000	7.95000
8.05000	8.15000	8.25000	8.35000	8.45000	8.55000	8.65000	8.75000
8.85000	8.95000	9.05000	9.15000	9.25000	9.35000	9.45000	9.55000
9.65000	9.75000	9.85000	9.95000				

WATER TABLE RISE HISTORY

5.00000	5.00000	5.00000	5.00000	5.00000	5.00000	5.00000	5.00000
5.00000	5.00000	5.00000	4.99035	4.95404	4.89904	4.82668	4.73598
4.62320	4.47895	4.27470	3.99995	3.99990	3.99980	3.99969	3.99957
3.99944	3.99931	3.99917	3.99902	3.99887	3.99872	3.99856	3.99843
3.99830	3.99817	3.99804	3.99792	3.99779	3.99766	3.99753	3.99740
3.99727	3.99713	3.99700	3.99687	3.99673	3.99659	3.99646	3.99632
3.99618	3.99604	3.99590	3.99575	3.99561	3.99546	3.99532	3.99517
3.99502	3.99487	3.99472	3.99457	3.99441	3.99427	3.99412	3.99398
3.99384	3.99369	3.99355	3.99341	3.99326	3.99312	3.99298	3.99283
3.99269	3.99255	3.99240	3.99226	3.99211	3.99197	3.99182	3.99168
3.99153	3.99139	3.99124	3.99108	3.99094	3.99079	3.99064	3.99050
3.99035	3.99020	3.99006	3.98991	3.98977	3.98962	3.98947	3.98933
3.98918	3.98903	3.98889	3.98874				

BOTTOM OF LAYER NO 9 DEPTH 32.5 INITIAL EFFECTIVE STRESS 2260.000

PORE PRESSURE RATIO = EXCESS PORE PRESSURE / HYDROSTATIC EFFECTIVE STRESS

0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	.01352	.02965	.04276	.05446	.06529
.07551	.08537	.09499	.10452	.11297	.13720	.17469	.20977
.24328	.27573	.30750	.33887	.37006	.40130	.43281	.46341
.46282	.47228	.48179	.49136	.50101	.51074	.52057	.53051
.54056	.55074	.56105	.57153	.58217	.59300	.60403	.61529
.62679	.63857	.65065	.66307	.67588	.68912	.70285	.71715
.73211	.74786	.76456	.78241	.80176	.81374	.81700	.82032
.82371	.82716	.83069	.83430	.83799	.84177	.84565	.84963
.85373	.85795	.86230	.86680	.87147	.87632	.88138	.88667
.89224	.90186	.92813	.96455	1.00000	.99982	.99947	.99912
.99878	.99844	.99811	.99778	.99746	.99714	.99683	.99652
.99621	.99591	.99562	.99532				

BOTTOM OF LAYER NO 5 DEPTH 15.0 INITIAL EFFECTIVE STRESS 1210.000

EFFECTIVE STRESS RATIO = EFFECTIVE STRESS / INITIAL EFFECTIVE STRESS

1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1.00000	1.00000	1.00000	.99000	.97679	.96478	.95292	.94078
.92800	.91400	.89726	.87722	.87151	.85545	.83075	.80772
.78586	.76483	.74443	.72452	.70497	.68569	.66661	.65409
.64802	.64197	.63593	.62989	.62386	.61784	.61181	.60579
.59976	.59373	.58769	.58165	.57559	.56952	.56344	.55734
.55123	.54509	.53893	.53275	.52654	.52030	.51402	.50772
.50137	.49498	.48855	.48207	.47555	.47141	.46971	.46802
.45633	.46465	.46297	.46129	.45962	.45795	.45628	.45462
.45296	.45130	.44964	.44799	.44633	.44468	.44302	.44137
.43971	.43704	.43334	.42961	.42740	.42673	.42607	.42542
.42477	.42412	.42349	.42285	.42223	.42161	.42099	.42038
.41977	.41917	.41857	.41798				

BOTTOM OF LAYER NO 6 DEPTH 20.0 INITIAL EFFECTIVE STRESS 1510.000

EFFECTIVE STRESS RATIO = EFFECTIVE STRESS / INITIAL EFFECTIVE STRESS

1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

1.00000	1.00000	1.00000	.98823	.97319	.95997	.94727	.93462
.92165	.90785	.89197	.87356	.86672	.84726	.81726	.78928
.76266	.73701	.71205	.68758	.66345	.63953	.61571	.60017
.59290	.58562	.57833	.57101	.56367	.55631	.54891	.54149
.53403	.52654	.51900	.51142	.50380	.49611	.48838	.48058
.47272	.46478	.45677	.44868	.44050	.43223	.42386	.41537
.40677	.39804	.38917	.38016	.37098	.36536	.36344	.36151
.35958	.35764	.35569	.35373	.35176	.34979	.34781	.34582
.34382	.34181	.33979	.33777	.33573	.33368	.33163	.32956
.32748	.32376	.31835	.31285	.30980	.30928	.30875	.30823
.30771	.30719	.30667	.30616	.30564	.30513	.30462	.30411
.30360	.30309	.30259	.30209				

BOTTOM OF LAYER NO 7 DEPTH 25.0 INITIAL EFFECTIVE STRESS 1810.000

EFFECTIVE STRESS RATIO = EFFECTIVE STRESS / INITIAL EFFECTIVE STRESS

1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1.00000	1.00000	1.00000	.98697	.97060	.95649	.94315	.93008
.91690	.90315	.88778	.87036	.86270	.84076	.80686	.77519
.74499	.71580	.68729	.65924	.63143	.60370	.57589	.55772
.54935	.54094	.53250	.52401	.51547	.50688	.49823	.48951
.48072	.47186	.46290	.45385	.44470	.43544	.42606	.41655
.40689	.39708	.38710	.37693	.36656	.35597	.34513	.33402
.32260	.31085	.29873	.28613	.27306	.26515	.26231	.26044
.25806	.25565	.25322	.25076	.24828	.24578	.24325	.24069
.23810	.23548	.23283	.23014	.22743	.22467	.22189	.21905
.21618	.21049	.20174	.19256	.18757	.18717	.18676	.18636
.18596	.18557	.18518	.18479	.18441	.18403	.18366	.18328
.18292	.18255	.18219	.18183				

BOTTOM OF LAYER NO 8 DEPTH 30.0 INITIAL EFFECTIVE STRESS 2110.000

EFFECTIVE STRESS RATIO = EFFECTIVE STRESS / INITIAL EFFECTIVE STRESS

1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1.00000	1.00000	1.00000	.98621	.96907	.95446	.94082	.92758
.91438	.90080	.88591	.86935	.86119	.83771	.80139	.76745
.73505	.70369	.67391	.64273	.61262	.58247	.55209	.53227
.52329	.51425	.50514	.49596	.48669	.47734	.46790	.45834
.44868	.43889	.42897	.41890	.40867	.35826	.38766	.37685
.36591	.35451	.34293	.33103	.31877	.30610	.29298	.27934
.26508	.25011	.23428	.21740	.19920	.18798	.18495	.18186
.17871	.17550	.17222	.16337	.16545	.16195	.15836	.15468
.15091	.14703	.14303	.13892	.13467	.13027	.12570	.12095
.11600	.10499	.08564	.06030	.04226	.04235	.04251	.04263
.04276	.04288	.04301	.04313	.04325	.04338	.04350	.04362
.04375	.04387	.04399	.04412				

BOTTOM OF LAYER NO 9 DEPTH 32.5 INITIAL EFFECTIVE STRESS 2260.000

EFFECTIVE STRESS RATIO = EFFECTIVE STRESS / INITIAL EFFECTIVE STRESS

1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1.00000	1.00000	1.00000	.98622	.96913	.95459	.94104	.92794
.91491	.90155	.88700	.87092	.86270	.83912	.80266	.76854
.73595	.70438	.67348	.64298	.61264	.58225	.55161	.53157
.52241	.51322	.50397	.49466	.48527	.47580	.46624	.45658
.44680	.43690	.42687	.41668	.40633	.39580	.38507	.37412
.36293	.35148	.33973	.32764	.31519	.30232	.28896	.27505
.26050	.24519	.22895	.21159	.19277	.18112	.17795	.17472
.17143	.16806	.16463	.16112	.15753	.15386	.15009	.14621
.14223	.13813	.13389	.12952	.12498	.12026	.11534	.11019
.10478	.09251	.06984	.03446	0.	.00017	.00052	.00085
.00119	.00151	.00184	.00216	.00247	.00278	.00308	.00339
.00368	.00397	.00426	.00455				

BOTTOM OF LAYER NO 10 DEPTH 35.0 INITIAL EFFECTIVE STRESS 2410.000

EFFECTIVE STRESS RATIO = EFFECTIVE STRESS / INITIAL EFFECTIVE STRESS

1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1.00000	1.00000	1.00000	.98624	.96524	.95485	.94147	.92858
.91580	.90274	.88859	.87302	.86484	.84126	.80481	.77077
.73829	.70685	.67611	.64577	.61562	.58543	.55501	.53520
.52625	.51723	.50813	.49896	.48970	.48034	.47089	.46134
.45166	.44187	.43193	.42185	.41161	.40120	.39059	.37977
.36873	.35742	.34584	.33394	.32169	.30905	.29595	.28234
.26813	.25323	.23748	.22071	.20267	.19158	.18860	.18557
.18243	.17933	.17612	.17284	.16949	.16606	.16256	.15897

```
  .15529    .15151    .14762    .14363    .13951    .13525    .13084    .12627
  .12152    .11100    .09276    .06987    .03383   0.        0.        0.
 0.        0.        0.        0.        0.         .00001    .00002    .00003
  .00005    .00006    .00009    .00010
BOTTOM OF LAYER NO   11   DEPTH     40.0   INITIAL EFFECTIVE STRESS    2710.000
     EFFECTIVE STRESS RATIO = EFFECTIVE STRESS / INITIAL EFFECTIVE STRESS
 1.00000   1.00000   1.00000   1.00000   1.00000   1.00000   1.00000   1.00000
 1.00000   1.00000   1.00000    .98708    .97109    .95755    .94497    .93284
  .92084    .90861    .89541    .88095    .87308    .85075    .81630    .78408
  .75331    .72354    .69444    .66577    .63733    .60895    .58046    .56173
  .55292    .54409    .53524    .52635    .51742    .50844    .49941    .49032
  .48116    .47193    .46261    .45320    .44368    .43406    .42431    .41442
  .40439    .39419    .38382    .37325    .36247    .35144    .34016    .32857
  .31666    .30438    .29168    .27849    .26475    .25640    .25391    .25140
  .24988    .24633    .24377    .24115    .23858    .23596    .23331    .23063
  .22793    .22520    .22244    .21965    .21683    .21397    .21108    .20815
  .20518    .19919    .18989    .18011    .16974    .15862    .14678    .13405
  .12015    .10459    .08642    .06341    .02409   0.        0.        0.
 0.        0.        0.        0.
BOTTOM OF LAYER NO   12   DEPTH     45.0   INITIAL EFFECTIVE STRESS    3010.000
     EFFECTIVE STRESS RATIC = EFFECTIVE STRESS / INITIAL EFFECTIVE STRESS
 1.00000   1.00000   1.00000   1.00000   1.00000   1.00000   1.00000   1.00000
 1.00000   1.00000   1.00000    .98711    .97127    .95795    .94567    .93389
  .92231    .91058    .89803    .88440    .87673    .85452    .82024    .78832
  .75796    .72870    .70019    .67219    .64450    .61694    .58935    .57158
  .56371    .55579    .54783    .53982    .53175    .52363    .51544    .50719
  .49887    .49048    .48200    .47344    .46479    .45603    .44717    .43820
  .42910    .41987    .41049    .40096    .39126    .38138    .37130    .36100
  .35046    .33966    .32857    .31715    .30537    .29851    .29683    .29514
  .29343    .29169    .28994    .28816    .28636    .28454    .28270    .28084
  .27895    .27705    .27512    .27317    .27120    .26921    .26719    .26516
  .26310    .25864    .25166    .24450    .23713    .22952    .22167    .21353
  .20507    .19625    .18700    .17726    .16691    .15579    .14392    .13111
  .11704    .10116    .08238    .05796
BOTTOM OF LAYER NO   13   DEPTH     50.0   INITIAL EFFECTIVE STRESS    3310.000
     EFFECTIVE STRESS RATIC = EFFECTIVE STRESS / INITIAL EFFECTIVE STRESS
 1.00000   1.00000   1.00000   1.00000   1.00000   1.00000   1.00000   1.00000
 1.00000   1.00000   1.00000    .98344    .97420    .96218    .95106    .94038
  .92985    .91917    .90773    .89529    .89825    .86826    .83746    .80876
  .78147    .75517    .72960    .70453    .67982    .65532    .63091    .61498
  .60753    .60009    .59264    .58519    .57773    .57026    .56276    .55524
  .54770    .54012    .53251    .52486    .51716    .50941    .50161    .49375
  .48582    .47782    .46974    .46158    .45333    .44499    .43654    .42797
  .41929    .41047    .40151    .39240    .38312    .37747    .37558    .37370
  .37182    .36994    .36807    .36620    .36434    .36247    .36060    .35874
  .35687    .35500    .35314    .35126    .34939    .34751    .34563    .34374
  .34185    .33832    .33307    .32775    .32235    .31685    .31126    .30557
  .29976    .29385    .28780    .28163    .27531    .26883    .26218    .25533
  .24828    .24098    .23341    .22551
```

EARTHQUAKE ENGINEERING RESEARCH CENTER REPORTS

NOTE: Numbers in parenthesis are Accession Numbers assigned by the National Technical Information Service; these are followed by a price code. Copies of the reports may be ordered from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia, 22161. Accession Numbers should be quoted on orders for reports (PB --- ---) and remittance must accompany each order. Reports without this information were not available at time of printing. Upon request, EERC will mail inquirers this information when it becomes available.

EERC 67-1 "Feasibility Study Large-Scale Earthquake Simulator Facility," by J. Penzien, J.G. Bouwkamp, R.W. Clough and D. Rea - 1967 (PB 187 905)A07

EERC 68-1 Unassigned

EERC 68-2 "Inelastic Behavior of Beam-to-Column Subassemblages Under Repeated Loading," by V.V. Bertero - 1968 (PB 184 888)A05

EERC 68-3 "A Graphical Method for Solving the Wave Reflection-Refraction Problem," by H.D. McNiven and Y. Mengi - 1968 (PB 187 943)A03

EERC 68-4 "Dynamic Properties of McKinley School Buildings," by D. Rea, J.G. Bouwkamp and R.W. Clough - 1968 (PB 187 902)A07

EERC 68-5 "Characteristics of Rock Motions During Earthquakes," by H.B. Seed, I.M. Idriss and F.W. Kiefer - 1968 (PB 188 338)A03

EERC 69-1 "Earthquake Engineering Research at Berkeley," - 1969 (PB 187 906)A11

EERC 69-2 "Nonlinear Seismic Response of Earth Structures," by M. Dibaj and J. Penzien - 1969 (PB 187 904)A08

EERC 69-3 "Probabilistic Study of the Behavior of Structures During Earthquakes," by R. Ruiz and J. Penzien - 1969 (PB 187 886)A06

EERC 69-4 "Numerical Solution of Boundary Value Problems in Structural Mechanics by Reduction to an Initial Value Formulation," by N. Distefano and J. Schujman - 1969 (PB 187 942)A02

EERC 69-5 "Dynamic Programming and the Solution of the Biharmonic Equation," by N. Distefano - 1969 (PB 187 941)A03

EERC 69-6 "Stochastic Analysis of Offshore Tower Structures," by A.K. Malhotra and J. Penzien - 1969 (PB 187 903)A09

EERC 69-7 "Rock Motion Accelerograms for High Magnitude Earthquakes," by H.B. Seed and I.M. Idriss - 1969 (PB 187 940)A02

EERC 69-8 "Structural Dynamics Testing Facilities at the University of California, Berkeley," by R.M. Stephen, J.G. Bouwkamp, R.W. Clough and J. Penzien - 1969 (PB 189 111)A04

EERC 69-9 "Seismic Response of Soil Deposits Underlain by Sloping Rock Boundaries," by H. Dezfulian and H.B. Seed 1969 (PB 189 114)A03

EERC 69-10 "Dynamic Stress Analysis of Axisymmetric Structures Under Arbitrary Loading," by S. Ghosh and E.L. Wilson 1969 (PB 189 026)A10

EERC 69-11 "Seismic Behavior of Multistory Frames Designed by Different Philosophies," by J.C. Anderson and V. V. Bertero - 1969 (PB 190 662)A10

EERC 69-12 "Stiffness Degradation of Reinforcing Concrete Members Subjected to Cyclic Flexural Moments," by V.V. Bertero, B. Bresler and H. Ming Liao - 1969 (PB 202 942)A07

EERC 69-13 "Response of Non-Uniform Soil Deposits to Travelling Seismic Waves," by H. Dezfulian and H.B. Seed - 1969 (PB 191 023)A03

EERC 69-14 "Damping Capacity of a Model Steel Structure," by D. Rea, R.W. Clough and J.G. Bouwkamp - 1969 (PB 190 663)A06

EERC 69-15 "Influence of Local Soil Conditions on Building Damage Potential during Earthquakes," by H.B. Seed and I.M. Idriss - 1969 (PB 191 036)A03

EERC 69-16 "The Behavior of Sands Under Seismic Loading Conditions," by M.L. Silver and H.B. Seed - 1969 (AD 714 982)A07

EERC 70-1 "Earthquake Response of Gravity Dams," by A.K. Chopra - 1970 (AD 709 640)A03

EERC 70-2 "Relationships between Soil Conditions and Building Damage in the Caracas Earthquake of July 29, 1967," by H.B. Seed, I.M. Idriss and H. Dezfulian - 1970 (PB 195 762)A05

EERC 70-3 "Cyclic Loading of Full Size Steel Connections," by E.P. Popov and R.M. Stephen - 1970 (PB 213 545)A04

EERC 70-4 "Seismic Analysis of the Charaima Building, Caraballeda, Venezuela," by Subcommittee of the SEAONC Research Committee: V.V. Bertero, P.F. Fratessa, S.A. Mahin, J.H. Sexton, A.C. Scordelis, E.L. Wilson, L.A. Wyllie, H.B. Seed and J. Penzien, Chairman - 1970 (PB 201 455)A06

EERC 70-5 "A Computer Program for Earthquake Analysis of Dams," by A.K. Chopra and P. Chakrabarti - 1970 (AD 723 994)A05

EERC 70-6 "The Propagation of Love Waves Across Non-Horizontally Layered Structures," by J. Lysmer and L.A. Drake 1970 (PB 197 896)A03

EERC 70-7 "Influence of Base Rock Characteristics on Ground Response," by J. Lysmer, H.B. Seed and P.B. Schnabel 1970 (PB 197 897)A03

EERC 70-8 "Applicability of Laboratory Test Procedures for Measuring Soil Liquefaction Characteristics under Cyclic Loading," by H.B. Seed and W.H. Peacock - 1970 (PB 198 016)A03

EERC 70-9 "A Simplified Procedure for Evaluating Soil Liquefaction Potential," by H.B. Seed and I.M. Idriss - 1970 (PB 198 009)A03

EERC 70-10 "Soil Moduli and Damping Factors for Dynamic Response Analysis," by H.B. Seed and I.M. Idriss - 1970 (PB 197 869)A03

EERC 71-1 "Koyna Earthquake of December 11, 1967 and the Performance of Koyna Dam," by A.K. Chopra and P. Chakrabarti 1971 (AD 731 496)A06

EERC 71-2 "Preliminary In-Situ Measurements of Anelastic Absorption in Soils Using a Prototype Earthquake Simulator," by R.D. Borcherdt and P.W. Rodgers - 1971 (PB 201 454)A03

EERC 71-3 "Static and Dynamic Analysis of Inelastic Frame Structures," by F.L. Porter and G.H. Powell - 1971 (PB 210 135)A06

EERC 71-4 "Research Needs in Limit Design of Reinforced Concrete Structures," by V.V. Bertero - 1971 (PB 202 943)A04

EERC 71-5 "Dynamic Behavior of a High-Rise Diagonally Braced Steel Building," by D. Rea, A.A. Shah and J.G. Bouwkamp 1971 (PB 203 584)A06

EERC 71-6 "Dynamic Stress Analysis of Porous Elastic Solids Saturated with Compressible Fluids," by J. Ghaboussi and E. L. Wilson - 1971 (PB 211 396)A06

EERC 71-7 "Inelastic Behavior of Steel Beam-to-Column Subassemblages," by H. Krawinkler, V.V. Bertero and E.P. Popov 1971 (PB 211 335)A14

EERC 71-8 "Modification of Seismograph Records for Effects of Local Soil Conditions," by P. Schnabel, H.B. Seed and J. Lysmer - 1971 (PB 214 450)A03

EERC 72-1 "Static and Earthquake Analysis of Three Dimensional Frame and Shear Wall Buildings," by E.L. Wilson and H.H. Dovey - 1972 (PB 212 904)A05

EERC 72-2 "Accelerations in Rock for Earthquakes in the Western United States," by P.B. Schnabel and H.B. Seed - 1972 (PB 213 100)A03

EERC 72-3 "Elastic-Plastic Earthquake Response of Soil-Building Systems," by T. Minami - 1972 (PB 214 868)A08

EERC 72-4 "Stochastic Inelastic Response of Offshore Towers to Strong Motion Earthquakes," by M.K. Kaul - 1972 (PB 215 713)A05

EERC 72-5 "Cyclic Behavior of Three Reinforced Concrete Flexural Members with High Shear," by E.P. Popov, V.V. Bertero and H. Krawinkler - 1972 (PB 214 555)A05

EERC 72-6 "Earthquake Response of Gravity Dams Including Reservoir Interaction Effects," by P. Chakrabarti and A.K. Chopra - 1972 (AD 762 330)A08

EERC 72-7 "Dynamic Properties of Pine Flat Dam," by D. Rea, C.Y. Liaw and A.K. Chopra - 1972 (AD 763 928)A05

EERC 72-8 "Three Dimensional Analysis of Building Systems," by E.L. Wilson and H.H. Dovey - 1972 (PB 222 438)A06

EERC 72-9 "Rate of Loading Effects on Uncracked and Repaired Reinforced Concrete Members," by S. Mahin, V.V. Bertero, D. Rea and M. Atalay - 1972 (PB 224 520)A08

EERC 72-10 "Computer Program for Static and Dynamic Analysis of Linear Structural Systems," by E.L. Wilson, K.-J. Bathe, J.E. Peterson and H.H.Dovey - 1972 (PB 220 437)A04

EERC 72-11 "Literature Survey - Seismic Effects on Highway Bridges," by T. Iwasaki, J. Penzien and R.W. Clough - 1972 (PB 215 613)A19

EERC 72-12 "SHAKE-A Computer Program for Earthquake Response Analysis of Horizontally Layered Sites," by P.B. Schnabel and J. Lysmer - 1972 (PB 220 207)A06

EERC 73-1 "Optimal Seismic Design of Multistory Frames," by V.V. Bertero and H. Kamil - 1973

EERC 73-2 "Analysis of the Slides in the San Fernando Dams During the Earthquake of February 9, 1971," by H.B. Seed, K.L. Lee, I.M. Idriss and F. Makdisi - 1973 (PB 223 402)A14

EERC 73-3 "Computer Aided Ultimate Load Design of Unbraced Multistory Steel Frames," by M.B. El-Hafez and G.H. Powell 1973 (PB 248 315)A09

EERC 73-4 "Experimental Investigation into the Seismic Behavior of Critical Regions of Reinforced Concrete Components as Influenced by Moment and Shear," by M. Celebi and J. Penzien - 1973 (PB 215 884)A09

EERC 73-5 "Hysteretic Behavior of Epoxy-Repaired Reinforced Concrete Beams," by M. Celebi and J. Penzien - 1973 (PB 239 568)A03

EERC 73-6 "General Purpose Computer Program for Inelastic Dynamic Response of Plane Structures," by A. Kanaan and G.H. Powell - 1973 (PB 221 260)A08

EERC 73-7 "A Computer Program for Earthquake Analysis of Gravity Dams Including Reservoir Interaction," by P. Chakrabarti and A.K. Chopra - 1973 (AD 766 271)A04

EERC 73-8 "Behavior of Reinforced Concrete Deep Beam-Column Subassemblages Under Cyclic Loads," by O. Küstü and J.G. Bouwkamp - 1973 (PB 246 117)A12

EERC 73-9 "Earthquake Analysis of Structure-Foundation Systems," by A.K. Vaish and A.K. Chopra - 1973 (AD 766 272)A07

EERC 73-10 "Deconvolution of Seismic Response for Linear Systems," by R.B. Reimer - 1973 (PB 227 179)A08

EERC 73-11 "SAP IV: A Structural Analysis Program for Static and Dynamic Response of Linear Systems," by K.-J. Bathe, E.L. Wilson and F.E. Peterson - 1973 (PB 221 967)A09

EERC 73-12 "Analytical Investigations of the Seismic Response of Long, Multiple Span Highway Bridges," by W.S. Tseng and J. Penzien - 1973 (PB 227 816)A10

EERC 73-13 "Earthquake Analysis of Multi-Story Buildings Including Foundation Interaction," by A.K. Chopra and J.A. Gutierrez - 1973 (PB 222 970)A03

EERC 73-14 "ADAP: A Computer Program for Static and Dynamic Analysis of Arch Dams," by R.W. Clough, J.M. Raphael and S. Mojtahedi - 1973 (PB 223 763)A09

EERC 73-15 "Cyclic Plastic Analysis of Structural Steel Joints," by R.B. Pinkney and R.W. Clough - 1973 (PB 226 843)A08

EERC 73-16 "QUAD-4: A Computer Program for Evaluating the Seismic Response of Soil Structures by Variable Damping Finite Element Procedures," by I.M. Idriss, J. Lysmer, R. Hwang and H.B. Seed - 1973 (PB 229 424)A05

EERC 73-17 "Dynamic Behavior of a Multi-Story Pyramid Shaped Building," by R.M. Stephen, J.P. Hollings and J.G. Bouwkamp - 1973 (PB 240 718)A06

EERC 73-18 "Effect of Different Types of Reinforcing on Seismic Behavior of Short Concrete Columns," by V.V. Bertero, J. Hollings, O. Küstü, R.M. Stephen and J.G. Bouwkamp - 1973

EERC 73-19 "Olive View Medical Center Materials Studies, Phase I," by B. Bresler and V.V. Bertero - 1973 (PB 235 986)A06

EERC 73-20 "Linear and Nonlinear Seismic Analysis Computer Programs for Long Multiple-Span Highway Bridges," by W.S. Tseng and J. Penzien - 1973

EERC 73-21 "Constitutive Models for Cyclic Plastic Deformation of Engineering Materials," by J.M. Kelly and P.P. Gillis 1973 (PB 226 024)A03

EERC 73-22 "DRAIN - 2D User's Guide," by G.H. Powell - 1973 (PB 227 016)A05

EERC 73-23 "Earthquake Engineering at Berkeley - 1973," (PB 226 033)A11

EERC 73-24 Unassigned

EERC 73-25 "Earthquake Response of Axisymmetric Tower Structures Surrounded by Water," by C.Y. Liaw and A.K. Chopra 1973 (AD 773 052)A09

EERC 73-26 "Investigation of the Failures of the Olive View Stairtowers During the San Fernando Earthquake and Their Implications on Seismic Design," by V.V. Bertero and R.G. Collins - 1973 (PB 235 106)A13

EERC 73-27 "Further Studies on Seismic Behavior of Steel Beam-Column Subassemblages," by V.V. Bertero, H. Krawinkler and E.P. Popov - 1973 (PB 234 172)A06

EERC 74-1 "Seismic Risk Analysis," by C.S. Oliveira - 1974 (PB 235 920)A06

EERC 74-2 "Settlement and Liquefaction of Sands Under Multi-Directional Shaking," by R. Pyke, C.K. Chan and H.B. Seed 1974

EERC 74-3 "Optimum Design of Earthquake Resistant Shear Buildings," by D. Ray, K.S. Pister and A.K. Chopra - 1974 (PB 231 172)A06

EERC 74-4 "LUSH - A Computer Program for Complex Response Analysis of Soil-Structure Systems," by J. Lysmer, T. Udaka, H.B. Seed and R. Hwang - 1974 (PB 236 796)A05

EERC 74-5 "Sensitivity Analysis for Hysteretic Dynamic Systems: Applications to Earthquake Engineering," by D. Ray 1974 (PB 233 213)A06

EERC 74-6 "Soil Structure Interaction Analyses for Evaluating Seismic Response," by H.B. Seed, J. Lysmer and R. Hwang 1974 (PB 236 519)A04

EERC 74-7 Unassigned

EERC 74-8 "Shaking Table Tests of a Steel Frame - A Progress Report," by R.W. Clough and D. Tang - 1974 (PB 240 869)A03

EERC 74-9 "Hysteretic Behavior of Reinforced Concrete Flexural Members with Special Web Reinforcement," by V.V. Bertero, E.P. Popov and T.Y. Wang - 1974 (PB 236 797)A07

EERC 74-10 "Applications of Reliability-Based, Global Cost Optimization to Design of Earthquake Resistant Structures," by E. Vitiello and K.S. Pister - 1974 (PB 237 231)A06

EERC 74-11 "Liquefaction of Gravelly Soils Under Cyclic Loading Conditions," by R.T. Wong, H.B. Seed and C.K. Chan 1974 (PB 242 042)A03

EERC 74-12 "Site-Dependent Spectra for Earthquake-Resistant Design," by H.B. Seed, C. Ugas and J. Lysmer - 1974 (PB 240 953)A03

EERC 74-13 "Earthquake Simulator Study of a Reinforced Concrete Frame," by P. Hidalgo and R.W. Clough - 1974 (PB 241 944)A13

EERC 74-14 "Nonlinear Earthquake Response of Concrete Gravity Dams," by N. Pal - 1974 (AD/A 006 583)A06

EERC 74-15 "Modeling and Identification in Nonlinear Structural Dynamics - I. One Degree of Freedom Models," by N. Distefano and A. Rath - 1974 (PB 241 548)A06

EERC 75-1 "Determination of Seismic Design Criteria for the Dumbarton Bridge Replacement Structure, Vol. I: Description, Theory and Analytical Modeling of Bridge and Parameters," by F. Baron and S.-H. Pang - 1975 (PB 259 407)A15

EERC 75-2 "Determination of Seismic Design Criteria for the Dumbarton Bridge Replacement Structure, Vol. II: Numerical Studies and Establishment of Seismic Design Criteria," by F. Baron and S.-H. Pang - 1975 (PB 259 408)A11 (For set of EERC 75-1 and 75-2 (PB 259 406))

EERC 75-3 "Seismic Risk Analysis for a Site and a Metropolitan Area," by C.S. Oliveira - 1975 (PB 248 134)A09

EERC 75-4 "Analytical Investigations of Seismic Response of Short, Single or Multiple-Span Highway Bridges," by M.-C. Chen and J. Penzien - 1975 (PB 241 454)A09

EERC 75-5 "An Evaluation of Some Methods for Predicting Seismic Behavior of Reinforced Concrete Buildings," by S.A. Mahin and V.V. Bertero - 1975 (PB 246 306)A16

EERC 75-6 "Earthquake Simulator Study of a Steel Frame Structure, Vol. I: Experimental Results," by R.W. Clough and D.T. Tang - 1975 (PB 243 981)A13

EERC 75-7 "Dynamic Properties of San Bernardino Intake Tower," by D. Rea, C.-Y. Liaw and A.K. Chopra - 1975 (AD/A008 406) A05

EERC 75-8 "Seismic Studies of the Articulation for the Dumbarton Bridge Replacement Structure, Vol. I: Description, Theory and Analytical Modeling of Bridge Components," by F. Baron and R.E. Hamati - 1975 (PB 251 539)A07

EERC 75-9 "Seismic Studies of the Articulation for the Dumbarton Bridge Replacement Structure, Vol. 2: Numerical Studies of Steel and Concrete Girder Alternates," by F. Baron and R.E. Hamati - 1975 (PB 251 540)A10

EERC 75-10 "Static and Dynamic Analysis of Nonlinear Structures," by D.P. Mondkar and G.H. Powell - 1975 (PB 242 434)A08

EERC 75-11 "Hysteretic Behavior of Steel Columns," by E.P. Popov, V.V. Bertero and S. Chandramouli - 1975 (PB 252 365)A11

EERC 75-12 "Earthquake Engineering Research Center Library Printed Catalog," - 1975 (PB 243 711)A26

EERC 75-13 "Three Dimensional Analysis of Building Systems (Extended Version)," by E.L. Wilson, J.P. Hollings and H.H. Dovey - 1975 (PB 243 989)A07

EERC 75-14 "Determination of Soil Liquefaction Characteristics by Large-Scale Laboratory Tests," by P. De Alba, C.K. Chan and H.B. Seed - 1975 (NUREG 0027)A08

EERC 75-15 "A Literature Survey - Compressive, Tensile, Bond and Shear Strength of Masonry," by R.L. Mayes and R.W. Clough - 1975 (PB 246 292)A10

EERC 75-16 "Hysteretic Behavior of Ductile Moment Resisting Reinforced Concrete Frame Components," by V.V. Bertero and E.P. Popov - 1975 (PB 246 388)A05

EERC 75-17 "Relationships Between Maximum Acceleration, Maximum Velocity, Distance from Source, Local Site Conditions for Moderately Strong Earthquakes," by H.B. Seed, R. Murarka, J. Lysmer and I.M. Idriss - 1975 (PB 248 172)A03

EERC 75-18 "The Effects of Method of Sample Preparation on the Cyclic Stress-Strain Behavior of Sands," by J. Mulilis, C.K. Chan and H.B. Seed - 1975 (Summarized in EERC 75-28)

EERC 75-19 "The Seismic Behavior of Critical Regions of Reinforced Concrete Components as Influenced by Moment, Shear and Axial Force," by M.B. Atalay and J. Penzien - 1975 (PB 258 842)A11

EERC 75-20 "Dynamic Properties of an Eleven Story Masonry Building," by R.M. Stephen, J.P. Hollings, J.G. Bouwkamp and D. Jurukovski - 1975 (PB 246 945)A04

EERC 75-21 "State-of-the-Art in Seismic Strength of Masonry - An Evaluation and Review," by R.L. Mayes and R.W. Clough 1975 (PB 249 040)A07

EERC 75-22 "Frequency Dependent Stiffness Matrices for Viscoelastic Half-Plane Foundations," by A.K. Chopra, P. Chakrabarti and G. Dasgupta - 1975 (PB 248 121)A07

EERC 75-23 "Hysteretic Behavior of Reinforced Concrete Framed Walls," by T.Y. Wong, V.V. Bertero and E.P. Popov - 1975

EERC 75-24 "Testing Facility for Subassemblages of Frame-Wall Structural Systems," by V.V. Bertero, E.P. Popov and T. Endo - 1975

EERC 75-25 "Influence of Seismic History on the Liquefaction Characteristics of Sands," by H.B. Seed, K. Mori and C.K. Chan - 1975 (Summarized in EERC 75-28)

EERC 75-26 "The Generation and Dissipation of Pore Water Pressures during Soil Liquefaction," by H.B. Seed, P.P. Martin and J. Lysmer - 1975 (PB 252 648)A03

EERC 75-27 "Identification of Research Needs for Improving Aseismic Design of Building Structures," by V.V. Bertero 1975 (PB 248 136)A05

EERC 75-28 "Evaluation of Soil Liquefaction Potential during Earthquakes," by H.B. Seed, I. Arango and C.K. Chan - 1975 (NUREG 0026)A13

EERC 75-29 "Representation of Irregular Stress Time Histories by Equivalent Uniform Stress Series in Liquefaction Analyses," by H.B. Seed, I.M. Idriss, F. Makdisi and N. Banerjee - 1975 (PB 252 635)A03

EERC 75-30 "FLUSH - A Computer Program for Approximate 3-D Analysis of Soil-Structure Interaction Problems," by J. Lysmer, T. Udaka, C.-F. Tsai and H.B. Seed - 1975 (PB 259 332)A07

EERC 75-31 "ALUSH - A Computer Program for Seismic Response Analysis of Axisymmetric Soil-Structure Systems," by E. Berger, J. Lysmer and H.B. Seed - 1975

EERC 75-32 "TRIP and TRAVEL - Computer Programs for Soil-Structure Interaction Analysis with Horizontally Travelling Waves," by T. Udaka, J. Lysmer and H.B. Seed - 1975

EERC 75-33 "Predicting the Performance of Structures in Regions of High Seismicity," by J. Penzien - 1975 (PB 248 130)A03

EERC 75-34 "Efficient Finite Element Analysis of Seismic Structure - Soil - Direction," by J. Lysmer, H.B. Seed, T. Udaka, R.N. Hwang and C.-F. Tsai - 1975 (PB 253 570)A03

EERC 75-35 "The Dynamic Behavior of a First Story Girder of a Three-Story Steel Frame Subjected to Earthquake Loading," by R.W. Clough and L.-Y. Li - 1975 (PB 248 841)A05

EERC 75-36 "Earthquake Simulator Study of a Steel Frame Structure, Volume II - Analytical Results," by D.T. Tang - 1975 (PB 252 926)A10

EERC 75-37 "ANSR-I General Purpose Computer Program for Analysis of Non-Linear Structural Response," by D.P. Mondkar and G.H. Powell - 1975 (PB 252 386)A08

EERC 75-38 "Nonlinear Response Spectra for Probabilistic Seismic Design and Damage Assessment of Reinforced Concrete Structures," by M. Murakami and J. Penzien - 1975 (PB 259 530)A05

EERC 75-39 "Study of a Method of Feasible Directions for Optimal Elastic Design of Frame Structures Subjected to Earthquake Loading," by N.D. Walker and K.S. Pister - 1975 (PB 257 781)A06

EERC 75-40 "An Alternative Representation of the Elastic-Viscoelastic Analogy," by G. Dasgupta and J.L. Sackman - 1975 (PB 252 173)A03

EERC 75-41 "Effect of Multi-Directional Shaking on Liquefaction of Sands," by H.B. Seed, R. Pyke and G.R. Martin - 1975 (PB 258 781)A03

EERC 76-1 "Strength and Ductility Evaluation of Existing Low-Rise Reinforced Concrete Buildings - Screening Method," by T. Okada and B. Bresler - 1976 (PB 257 906)A11

EERC 76-2 "Experimental and Analytical Studies on the Hysteretic Behavior of Reinforced Concrete Rectangular and T-Beams," by S.-Y.M. Ma, E.P. Popov and V.V. Bertero - 1976 (PB 260 843)A12

EERC 76-3 "Dynamic Behavior of a Multistory Triangular-Shaped Building," by J. Petrovski, R.M. Stephen, E. Gartenbaum and J.G. Bouwkamp - 1976

EERC 76-4 "Earthquake Induced Deformations of Earth Dams," by N. Serff and H.B. Seed - 1976

EERC 76-5 "Analysis and Design of Tube-Type Tall Building Structures," by H. de Clercq and G.H. Powell - 1976 (PB 252 220) A10

EERC 76-6 "Time and Frequency Domain Analysis of Three-Dimensional Ground Motions, San Fernando Earthquake," by T. Kubo and J. Penzien (PB 260 556)A11

EERC 76-7 "Expected Performance of Uniform Building Code Design Masonry Structures," by R.L. Mayes, Y. Omote, S.W. Chen and R.W. Clough - 1976

EERC 76-8 "Cyclic Shear Tests on Concrete Masonry Piers," Part I - Test Results," by R.L. Mayes, Y. Omote and R.W. Clough - 1976 (PB 264 424)A06

EERC 76-9 "A Substructure Method for Earthquake Analysis of Structure - Soil Interaction," by J.A. Gutierrez and A.K. Chopra - 1976 (PB 257 783)A08

EERC 76-10 "Stabilization of Potentially Liquefiable Sand Deposits using Gravel Drain Systems," by H.B. Seed and J.R. Booker - 1976 (PB 258 820)A04

EERC 76-11 "Influence of Design and Analysis Assumptions on Computed Inelastic Response of Moderately Tall Frames," by G.H. Powell and D.G. Row - 1976

EERC 76-12 "Sensitivity Analysis for Hysteretic Dynamic Systems: Theory and Applications," by D. Ray, K.S. Pister and E. Polak - 1976 (PB 262 859)A04

EERC 76-13 "Coupled Lateral Torsional Response of Buildings to Ground Shaking," by C.L. Kan and A.K. Chopra - 1976 (PB 257 907)A09

EERC 76-14 "Seismic Analyses of the Banco de America," by V.V. Bertero, S.A. Mahin and J.A. Hollings - 1976

EERC 76-15 "Reinforced Concrete Frame 2: Seismic Testing and Analytical Correlation," by R.W. Clough and J. Gidwani - 1976 (PB 261 323)A08

EERC 76-16 "Cyclic Shear Tests on Masonry Piers, Part II - Analysis of Test Results," by R.L. Mayes, Y. Omote and R.W. Clough - 1976

EERC 76-17 "Structural Steel Bracing Systems: Behavior Under Cyclic Loading," by E.P. Popov, K. Takanashi and C.W. Roeder - 1976 (PB 260 715)A05

EERC 76-18 "Experimental Model Studies on Seismic Response of High Curved Overcrossings," by D. Williams and W.G. Godden - 1976

EERC 76-19 "Effects of Non-Uniform Seismic Disturbances on the Dumbarton Bridge Replacement Structure," by F. Baron and R.E. Hamati - 1976

EERC 76-20 "Investigation of the Inelastic Characteristics of a Single Story Steel Structure Using System Identification and Shaking Table Experiments," by V.C. Matzen and H.D. McNiven - 1976 (PB 258 453)A07

EERC 76-21 "Capacity of Columns with Splice Imperfections," by E.P. Popov, R.M. Stephen and R. Philbrick - 1976 (PB 260 378)A04

EERC 76-22 "Response of the Olive View Hospital Main Building during the San Fernando Earthquake," by S. A. Mahin, R. Collins, A.K. Chopra and V.V. Bertero - 1976

EERC 76-23 "A Study on the Major Factors Influencing the Strength of Masonry Prisms," by N.M. Mostaghel, R.L. Mayes, R. W. Clough and S.W. Chen - 1976

EERC 76-24 "GADFLEA - A Computer Program for the Analysis of Pore Pressure Generation and Dissipation during Cyclic or Earthquake Loading," by J.R. Booker, M.S. Rahman and H.B. Seed - 1976 (PB 263 947)A04

EERC 76-25 "Rehabilitation of an Existing Building: A Case Study," by B. Bresler and J. Axley - 1976

EERC 76-26 "Correlative Investigations on Theoretical and Experimental Dynamic Behavior of a Model Bridge Structure," by K. Kawashima and J. Penzien - 1976 (PB 263 388)A11

EERC 76-27 "Earthquake Response of Coupled Shear Wall Buildings," by T. Srichatrapimuk - 1976 (PB 265 157)A07

EERC 76-28 "Tensile Capacity of Partial Penetration Welds," by E.P. Popov and R.M. Stephen - 1976 (PB 262 899)A03

EERC 76-29 "Analysis and Design of Numerical Integration Methods in Structural Dynamics," by H.M. Hilber - 1976 (PB 264 410)A06

EERC 76-30 "Contribution of a Floor System to the Dynamic Characteristics of Reinforced Concrete Buildings," by L.J. Edgar and V.V. Bertero - 1976

EERC 76-31 "The Effects of Seismic Disturbances on the Golden Gate Bridge," by F. Baron, M. Arikan and R.E. Hamati - 1976

EERC 76-32 "Infilled Frames in Earthquake Resistant Construction," by R.E. Klingner and V.V. Bertero - 1976 (PB 265 892)A13

UCB/EERC-77/01 "PLUSH - A Computer Program for Probabilistic Finite Element Analysis of Seismic Soil-Structure Interaction," by M.P. Romo Organista, J. Lysmer and H.B. Seed - 1977

UCB/EERC-77/02 "Soil Structure Interaction Effects at the Humboldt Bay Power Plant in the Ferndale Earthquake of June 7, 1975," by J.E. Valera, H.B. Seed, C.F. Tsai and J. Lysmer - 1975

UCB/EERC-77/03 "Influence of Sample Disturbance on Sand Response to Cyclic Loading," by K. Mori, H.B. Seed and C.K. Chan - 1977 (PB 267 352)A04

UCB/EERC-77/04 "Seismological Studies of Strong Motion Records," by J. Shoja-Taheri - 1977 (PB 269 655)A10

UCB/EERC-77/05 "Testing Facility for Coupled-Shear Walls," by L. Li-Hyung, V.V. Bertero and E.P. Popov - 1977

UCB/EERC-77/06 "Developing Methodologies for Evaluating the Earthquake Safety of Existing Buildings," No. 1 - B. Bresler; No. 2 - B. Bresler, T. Okada and D. Zisling; No. 3 - T. Okada and B. Bresler; No. 4 - V.V. Bertero and B. Bresler - 1977 (PB 267 354)A08

UCB/EERC-77/07 "A Literature Survey - Transverse Strength of Masonry Walls," by Y. Omote, R.L. Mayes, S.W. Chen and R.W. Clough 1977

UCB/EERC-77/08 "DRAIN-TABS: A Computer Program for Inelastic Earthquake Response of Three Dimensional Buildings," by R. Guendelman-Israel and G.H. Powell - 1977

UCB/EERC-77/09 "SUBWALL: A Special Purpose Finite Element Computer Program for Practical Elastic Analysis and Design of Structural Walls with Substructure Option," by D.Q. Le, H. Peterson and E.P. Popov - 1977

UCB/EERC-77/10 "Experimental Evaluation of Seismic Design Methods for Broad Cylindrical Tanks," by D.P. Clough - 1977

UCB/EERC-77/11 "Earthquake Engineering Research at Berkeley - 1976," - 1977

UCB/EERC-77/12 "Automated Design of Earthquake Resistant Multistory Steel Building Frames," by N.D. Walker, Jr. - 1977

UCB/EERC-77/13 "Concrete Confined by Rectangular Hoops Subjected to Axial Loads," by D. Zallnas, V.V. Bertero and E.P. Popov - 1977

UCB/EERC-77/14 "Seismic Strain Induced in the Ground During Earthquakes," by Y. Sugimura - 1977

UCB/EERC-77/15 "Bond Deterioration under Generalized Loading," by V.V. Bertero, E.P. Popov and S. Viwathanatepa - 1977

UCB/EERC-77/16 "Computer Aided Optimum Design of Ductile Reinforced Concrete Moment Resisting Frames," by S.W. Zagajeski and V.V. Bertero - 1977

UCB/EERC-77/17 "Earthquake Simulation Testing of a Stepping Frame with Energy-Absorbing Devices," by J.M. Kelly and D.F. Tsztoo 1977

UCB/EERC-77/18 "Inelastic Behavior of Eccentrically Braced Steel Frames under Cyclic Loadings," by C.W. Roeder and E.P. Popov 1977

UCB/EERC-77/19 "A Simplified Procedure for Estimating Earthquake-Induced Deformations in Dams and Inbankments, by F.I. Makdisi and H.B. Seed - 1977

UCB/EERC-77/20 "The Performance of Earth Dams during Earthquakes," by H.B. Seed, F. I. Makdisi and P. de Alba - 1977

UCB/EERC-77/21 "Dynamic Plastic Analysis Using Stress Resultant Finite Element Formulation," by P. Lukkunapvasit and J.M. Kelly 1977

UCB/EERC-77/22 "Preliminary Experimental Study of Seismic Uplift of a Steel Frame," by R.W. Clough and A.A. Huckelbridge - 1977

UCB/EERC-77/23 "Earthquake Simulator Tests of a Nine-Story Steel Frame with Columns Allowed to Uplift," by A.A. Huckelbridge - 1977

UCB/EERC-77/24 "Nonlinear Soil-Structure Interaction of Skew Highway Bridges," by M.-C. Chen and Joseph Penzien - 1977

UCB/EERC-77/25 "Seismic Analysis of an Offshore Structure Supported on Pile Foundations," by D.D.-N. Liou - 1977

UCB/EERC-77/26 "Dynamic Stiffness Matrices for Homogeneous Viscoelastic Half-Planes," by G. Dasgupta and A.K. Chopra - 1977

UCB/EERC-77/27 "A Practical Soft Story Earthquake Isolation System," by J.M. Kelly and J.M. Eidinger - 1977

UCB/EERC-77/28 "Seismic Safety of Existing Buildings and Incentives for Hazard Mitigation in San Francisco: An Exploratory Study," by A.J. Meltsner - 1977

UCB/EERC-77/29 "Dynamic Analysis of Electrohydraulic Shaking Tables," by D. Rea, S. Abedi-Hayati and Y. Takahashi - 1977

UCB/EERC-77/30 "An Approach for Improving Seismic-Resistant Behavior of Reinforced Concrete Interior Joints," by B. Galunic, V.V. Bertero and E.P. Popov - 1977

UCB/EERC-78/01 "The Development of Energy-Absorbing Devices for Aseismic Base Isolation Systems," by J. M. Kelly and D.F. Tsztoo - 1978

UCB/EERC-78/02 "Effect of Tensile Prestrain on the Cyclic Response of Structural Steel Connections," by J.G. Bouwkamp and A. Mukhopadhyay - 1978

UCB/EERC-78/03 "Experimental Results of an Earthquake Isolation System using Natural Rubber Bearings," by J.M. Eidinger and J.M. Kelly - 1978

UCB/EERC-78/04 "Seismic Behavior of Tall Liquid Storage Tanks," by A. Niwa - 1978

UCB/EERC-78/05 "Hysteretic Behavior of Reinforced Concrete Columns Subjected to High Axial and Cyclic Shear Forces," by S.W. Zagajeski, V.V. Bertero and J.G. Bouwkamp - 1978

UCB/EERC-78/06 "Inelastic Beam-Column Elements for the ANSR-I Program," by A. Riahi, D.G. Row and G.H. Powell - 1978

UCB/EERC-78/07 "Studies of Structural Response to Earthquake Ground Motion," by O. A. Lopez and A.K. Chopra - 1978

UCB/EERC-78/08 "A Laboratory Study of the Fluid-Structure Interaction of Submerged Tanks and Caissons in Earthquakes," by R.C. Byrd - 1978

UCB/EERC-78/09 "Models for Evaluating Damageability of Structures," by I. Sakamoto and B. Bresler - 1978

UCB/EERC-78/10 "Seismic Performance of Secondary Structural Elements," by I. Sakamoto - 1978

UCB/EERC-78/11 Case Study--Seismic Safety Evaluation of a Reinforced Concrete School Building," by J.Axley and B. Bresler - 1978

UCB/EERC-78/12 "Potential Damageability in Existing Buildings," by T. Blejwas and B. Bresler - 1978

UCB/EERC-78/13 "Dynamic Behavior of a Pedestal Base Multistory Building," by R. M. Stephen, E. L. Wilson, J.G. Bouwkamp and M. Button - 1978

UCB/EERC-78/14 "Seismic Response of Bridges - Case Studies," by R.A. Imbsen, V. Nutt and J. Penzien - 1978

UCB/EERC-78/15 "A Substructure Technique for Nonlinear Static and Dynamic Analysis," by D.G. Row and G.H. Powell - 1978

UCB/EERC-78/16 "Seismic Performance of Nonstructural and Secondary Structural Elements," by Isao Sakamoto - 1978

UCB/EERC-78/17 "Model for Evaluating Damageability of Structures," by Isao Sakamoto and B. Bresler - 1978

UCB/EERC-78/18 "Response of K-Braced Steel Frame Models to Lateral Loads," by J. G. Bouwkamp, R. M. Stephen and E. P. Popov - 1978

UCB/EERC-78/19 "Rational Design Methods for Light Equipment in Structures Subjected to Ground Motion," by J. L. Sackman and J. M. Kelly - 1978

UCB/EERC-78/20 "Testing of a Wind Restraint for Aseismic Base Isolation," by J. M. Kelly and D. E. Chitty - 1978