Commonwealth Edison
One First National Plaza, Chicago, Illinois
Address Reply to: Post Office Box 767
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June 15, 1983

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: Byron Generating Station Units 1 and 2
River Screenhouse Seismic Design
NRC Docket Nos. 50-454 and 50-455

References (a): September 2, 1982, letter from T. R. Tramm to H. R. Denton.

(b): February 7, 1983, letter from B. J. Youngblood to L. O. DelGeorge.

Dear Mr. Denton:

This is to provide additional information regarding the seismic design basis for the river screenhouse at Byron Generating Station. NRC review of this information should help close Confirmatory Issue 1 of the Byron SER.

Reference (a) provided the justification for use of a 0.2 g Regulatory Guide 1.60 input for the design of the Byron river screenhouse. Reference (b) transmitted two FSAR questions requesting additional information r garding the seismic design basis for this structure. Question 241.8 requested additional information on soil properties below the river screenhouse.

Test data supporting the dynamic soil properties used in the seismic analyses were discussed with the NRC in a telephone conference on March 14, 1983. It was noted that the structure is founded on natural soil (as opposed to recompacted soil) and that the intact samples are representative of site conditions. Documentation of this information is provided in FSAR Figure 2.5-60, borings G23, R52, and R53. This letter provides further documentation of our evaluation of the soil data. A summary of this evaluation will be provided in response to Q241.8 in a forthcoming FSAR amendment.

Enclosed is a letter dated April 8, 1983 from Dames & Moore which presents a reevaluation of the dynamic testing performed on intact and reconstituted soils obtained at the site of the river screenhouse. For comparison purposes, shear moduli have been calculated from published geophysical data obtained from various sites across the United States. These moduli have been compared with those obtained at the Byron Station and with those predicted from empirical relationships. In addition, in-situ shear wave velocity versus depth of the river screenhouse have been calculated and compared to corresponding range of normalized shear modulus factors. This re-evaluation shows that the intact samples are representative for the soil underlying the river screenhouse.

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Agreement on proper characterization of the soil dynamic properties is essential to resolution of the river screenhouse seismic design confirmatory issue. Our response to Q362.1 will be provided as soon as the NRC indicates concurrence with the soil characterizations.

Please address further question regarding this matter to this office.

Very truly yours,

T. R. Tramm

T. R. Tramm
Nuclear Licensing Administrator

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Attachment

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Dames & Moore

1550 Northwest Highway
Park Ridge, Illinois 60068
(312) 297-6120
TWX: 910-253-4097 Cable address: DAMEMORE

April 8, 1983

Sargent & Lundy, Engineers
55 East Monroe Street
Chicago, Illinois 60603

Attention: Mr. R. J. Netzel DMO-35

Gentlemen:

Re: Dynamic Properties, River Screenhouse
Byron Station - Units 1 and 2
Commonwealth Edison Company

INTRODUCTION

This letter presents our reevaluation of the dynamic testing performed on intact and recompacted soils obtained at the site of the River Screenhouse at Byron Station, Units 1 and 2, in Ogle County, Illinois. We have also calculated shear moduli from published geophysical data obtained at different sites throughout the United States.[1] These moduli have been compared with those obtained at the site and with those predicted from empirical relationships.[2,3,4] In addition, we have calculated in-situ shear wave velocities versus depth under the River Screenhouse corresponding to a wide range of normalized shear modulus factors.

EVALUATION OF TEST RESULTS

Figure RS-1 shows the results of the cyclic triaxial tests on both intact and recompacted samples plotted in a normalized form. (It should be noted that the foundation for the River Screenhouse was placed on natural soils, and that the River Screenhouse, therefore, is not resting on recompacted material.) The points plotted on this figure were established by anchoring the shear modulus (G), at the lowest strain level obtained during the triaxial tests, on the Seed and Idriss[5] normalized shear modulus (G/G_{max}) strain degradation curve. By obtaining the normalized shear modulus value at this strain level, a G_{max} value for the tests was obtained based on the mean Seed and Idriss[5] strain degradation curve for strains smaller than the minimum shear strain for the tests. The other data points were then normalized based on the obtained G_{max} value.

The results show that the undisturbed samples exhibit strain degradation characteristics within the range postulated by Seed and Idriss[5]; however, the recompacted soil samples follow strain degradation curves unreasonably steep compared to the normalized curve. We believe these

characteristics are the result of the test procedures rather than actual soil properties. The tests on the recompacted samples, completed approximately 1 year prior to the tests on the intact samples, were performed on a machine that had not been calibrated for piston friction. A correction for piston friction is usually not necessary for property tests at high strain values, where high loads are required to obtain the desired deformation. At small strains, where smaller loads are required, the piston friction represents a significant portion of the recorded load. The calculated moduli at lower strains are, therefore, believed to be larger than the true values, which results in an apparent very steep strain degradation relationship from these incorrectly high shear moduli for low strains. In conclusion, it is our opinion that the curves for the reconstituted samples are probably in error at low strains and are not representative of the granular material underlying the River Screenhouse. This opinion is further supported by more recent test results[6], which show that the strain degradation curves for granular material may be flatter than those suggested by Seed and Idriss.

SHEAR MODULUS FACTORS FROM EMPIRICAL RELATIONSHIPS

The test data on undisturbed samples are presented in the form of normalized shear modulus factor K_2 versus shear strain on Figure RS-2. The resonant column data were recorded at a shear strain on the order of 10^{-4} percent and, thus, represent anchor points. The data indicate normalized shear modulus factors in the range of 40 to 85.

The shear modulus factors for the deposits underlying the River Screenhouse were also evaluated using the empirical expression given by Hardin and Drnevich[2]. The average K_{2max} obtained using this procedure was 68 (Figure RS-3). However, Hardin[3] has proposed that the shear modulus for granular material is also a function of grain size, in particular the particle size at which 5 percent of the sample is finer (D_5). Using the procedure proposed by Hardin and a D_5 of 0.2 mm (see FSAR Figure 2.5-49), a shear modulus factor of 75 was obtained. Thus, the K_{2max} values obtained using the empirical relationships proposed by Hardin and Drnevich, and Hardin (68 to 75) fall within the range (65 to 90) given on FSAR Figure 2.5-89.

In addition to using the empirical relationship proposed by Hardin and Drnevich, the shear modulus factor for the deposits underlying the River Screenhouse were evaluated using the procedures proposed by Ohsaki and Iwasaki[4]. This procedure is based on an empirical relationship between dynamic shear modulus as determined from field measurements and standard split spoon resistance (SPT). Thus, using the SPT values at the River Screenhouse, shear modulus factors in the range of 57 to 122 were obtained, with a mean

shear modulus factor of 85 (Figure RS-3). It should be noted, however, that evaluation of field data[7] indicates that the procedure proposed by Ohsaki and Iwasaki generally overestimates the field shear modulus by approximately 25 percent.

DATA FROM FIELD GEOPHYSICAL MEASUREMENT

The shear modulus factors obtained for the materials underlying the River Screenhouse were also compared with those calculated from field data obtained at other sites[1]. The results, shown in Table RS-1 and on Figure RS-4, show shear modulus factors in the range of approximately 40 to 100 for sites with penetration resistance similar to those encountered under the River Screenhouse.

The shear wave velocities presented at other sites[1] were also plotted versus mean standard penetration resistance. The results are shown on Figure RS-5, together with the shear wave velocity calculated using the shear moduli obtained from the procedures of Ohsaki and Iwasaki. The data plotted on Figure RS-5 show that the procedures proposed by Ohsaki and Iwasaki are in good agreement, although close to an upper bound, with field data presented by Shannon and Wilson[1].

Figure RS-6 shows calculated shear wave velocities versus depth based on a wide range of normalized shear moduli. Also shown are the shear wave velocities corresponding to the shear moduli obtained using the empirical relationships proposed by Hardin and Drnevich[2], Hardin[3], and Ohsaki and Iwasaki[4]. Based on the empirical relationships, the shear wave velocity at the site of the River Screenhouse may vary between approximately 750 and 1600 feet per second. These velocities are in good agreement with the field data presented by Shannon and Wilson[1] (Figure RS-5), which show shear wave velocities in the same range for sites with similar standard split spoon penetration resistances to those encountered under the River Screenhouse at Byron.

CONCLUSIONS

In view of the results obtained of calculations based on empirical relationships[2,3,4], it is our opinion that the values presented on FSAR Figure 2.5-89 (K_2 in the range of 65 to 90) are reasonable for the materials underlying the River Screenhouse.

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Dames & Moore

If you have any questions regarding this letter, please do not hesitate to contact us.

Very truly yours,

DAMES & MOORE

Michael L. Kiefer

Michael L. Kiefer
Partner

Terje Preber
Senior Engineer

MLK/TP:lhk

Attachments: References

Table RS-1 - Geophysical and Normalized Shear Modulus Factors for Granular Material

Figure RS-1 - Normalized Shear Modulus versus Shear Strain

Figure RS-2 - Shear Modulus Factor K_2 versus Shear Strain

Figure RS-3 - Shear Modulus Factor K_2 versus Depth

Figure RS-4 - Shear Modulus Factor K_2 versus SPT Blow Count

Figure RS-5 - Shear Wave Velocity versus SPT Blow Count, Granular Material

Figure RS-6 - Calculated Shear Wave Velocities versus Depth

cc: Mr. L. L. Holish

Dames & Moore

REFERENCES

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4. Ohsaki, Y., and Iwasaki, R., 1973, On dynamic shear moduli and Poisson's ratios of soil deposits: Soils and Foundations, vol. 13, no. 4 (December).

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7. Anderson, D.G., Espana, C., and McLamore, V.R., 1978, Estimating in-situ shear moduli at competent sites: Proceedings of the ASCE Geotechnical Engineering Division Specialty Conference on Earthquake Engineering and Soil Dynamics, Pasadena, California (June).

8. Gibbs, H.J., and Holtz, W.G., 1957, Research on determining the density of sand by spoon penetration test: Proceedings, Fourth International Conference on Soil Mechanics and Foundation Engineering, vol. I, pp. 35-39.

9. Mayne, P.W., and Kulhawy, F.H., 1982, K_0-OCR relationships in soil: Journal of the ASCE Geotechnical Engineering Division, vol. 108, no. GT6 (June).

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TABLE RS-1

GEOPHYSICAL PROPERTIES AND NORMALIZED SHEAR MODULUS FACTOR FOR GRANULAR MATERIAL

SITE	SOIL CONDITIONS	MEAN BLOW COUNT SPT	DEPTH (ft)	SHEAR WAVE VELOCITY (ft/sec)	DEPTH TO WATER TABLE (ft)	K_o*	K_2
Cholame-Shandon Array California (In-situ Impulse/ Downhole, 1975)	SM Alluvium (Holocene)	81 56	135 165	900 1,100	26	1.0 1.0	31 43
Terminal Substation El Centro, California (Downhole, 1975)	SM Lake Deposit (Quaternary)	88	95	850	33	1.0	31
Highway Test Lab Olympia, Washington (Crosshole, 1974)	SP-SM Glaciolacustrine Deposit	29	25	750	12	0.6	53
Cit Millikan Library Pasadena, California (Downhole, 1975)	SM Alluvium (Pleistocene)	126 180 155/5"	40 80 120	1,550 1,550 1,950	238	1.0 1.0 1.0	132 93 121
4800 Oak Grove Pasadena, California (Downhole, 1978)	SW-GW SM-SW SM-SW SM-SW-GW Alluvium (Pleistocene)	42 103 (very dense) (very dense)	20 40 80 140	1,100 1,600 1,600 2,000	225	0.8 1.0 1.0 1.0	103 143 101 120
State Building San Francisco, California (Downhole, 1978)	SP (Quaternary Sediments)	36 49 122	25 55 80	1,000 1,100 1,600	20	0.6 1.0 1.0	87 70 127

*Estimated based on Gibbs and Holtz, 1957 (Ref. 8); Marcuson and Bieganousky, 1976 (Ref. 10); and Mayne and Kulhawy, 1982 (Ref. 9).

TABLE RS-1 (continued)

GEOPHYSICAL PROPERTIES AND NORMALIZED SHEAR MODULUS FACTOR FOR GRANULAR MATERIAL

SITE	SOIL CONDITIONS	MEAN BLOW COUNT SPT	DEPTH (ft)	SHEAR WAVE VELOCITY (ft/sec)	DEPTH TO WATER TABLE (ft)	K_o*	K_2
Lincoln School Tunnel	SM	71	25	1,200	>200	1.0	98
Taft, California	Alluvium	121	50	1,200		1.0	69
(Downhole, 1976)	(Quaternary)	103	80	1,600		1.0	97
Noranda Aluminum Plant	SP/SP-SM	23	25	850	11	0.4	77
New Madrid, Missouri	Alluvium	32	75	900		0.9	45
(Downhole, 1979)	(Quaternary)	69	120	1,000		1.0	43
MSU Roberts Hall	GW	35	14	750	8	1.0	60
Bozeman, Montana	Alluvium	85/6"	25	1,300		1.0	146
(In-situ Impulse, 1976)	(Quaternary)						
PSU Cramer Hall	GW	106/6"	105	1,800	133	1.0	112
Portland, Oregon							
(Downhole, 1978)							
USU Old Main Building	SW-GW	23	15	900	150	0.6	86
Logan, Utah	Alluvium	-	50	1,300		0.5	103
(Downhole, 1976)	(Quaternary)	66	90	1,600		1.0	96
1900 Avenue of the Stars	SP/SM	102/6"	80	1,300	64	1.0	70
Los Angeles, California	Pleistocene	124	120	1,800		1.0	119
(Downhole, 1975)	(Some Cementation)						
Hollywood Storage Bldg.	SM w/Gravel	61	120	1,400	40	1.0	77
Los Angeles, California	Alluvium						
(Downhole, 1979)	(Quaternary)						

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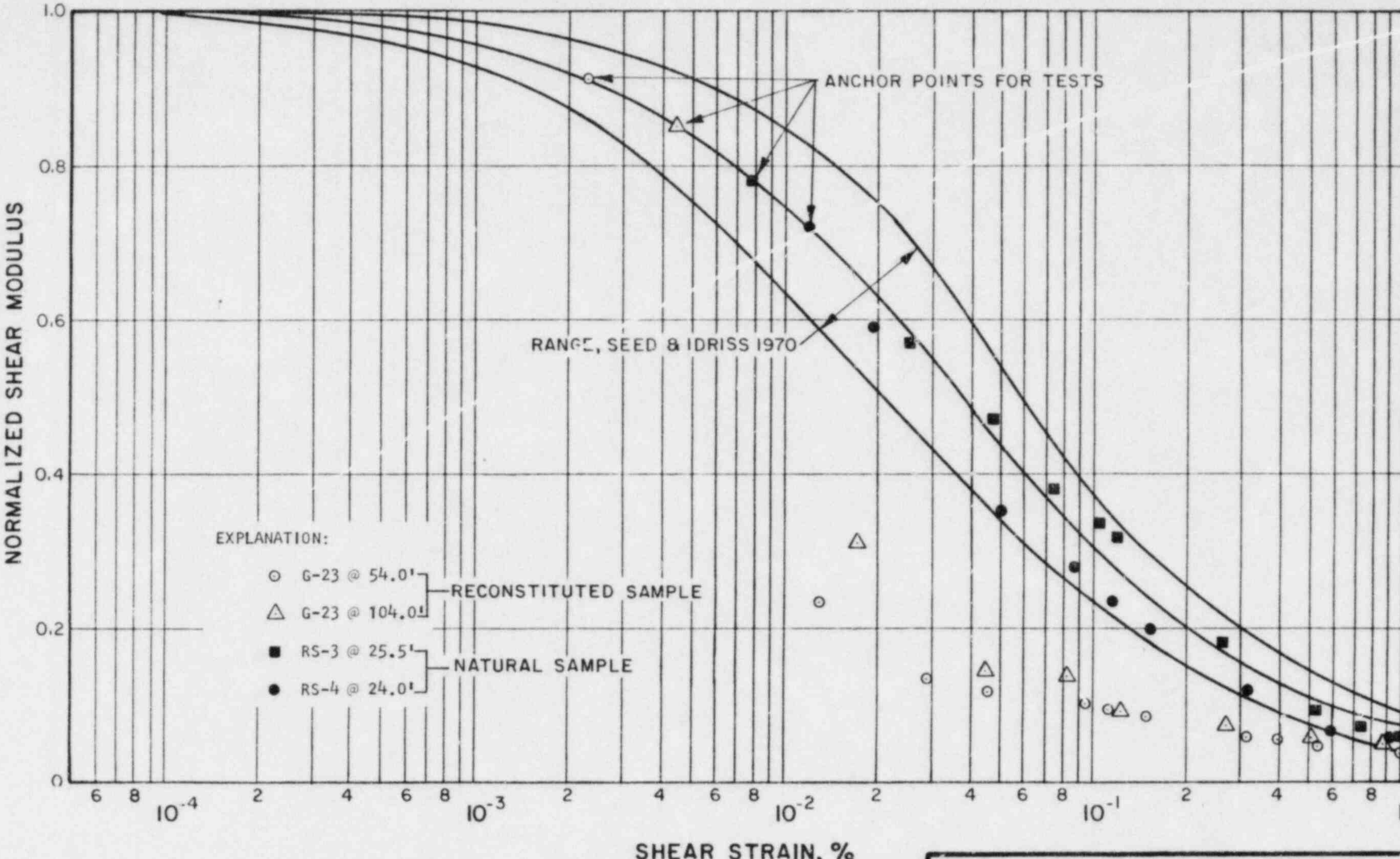

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FIGURE RS-1
NORMALIZED SHEAR MODULUS VERSUS SHEAR STRAIN

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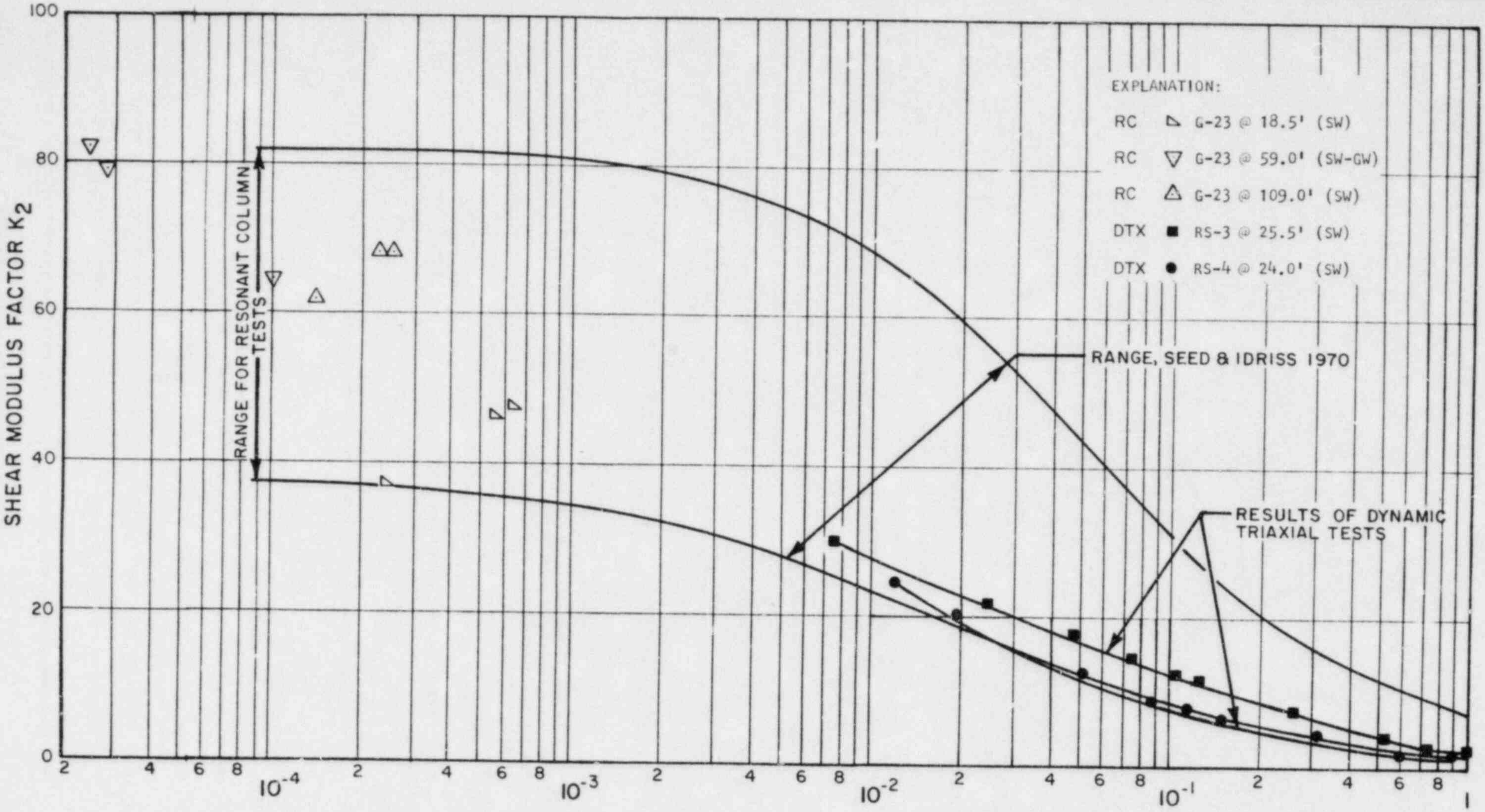

$$K_2 = \frac{G}{1000\,(\bar{\sigma})^{1/2}}$$

RC = RESONANT COLUMN TEST
DTX = DYNAMIC TRIAXIAL TEST

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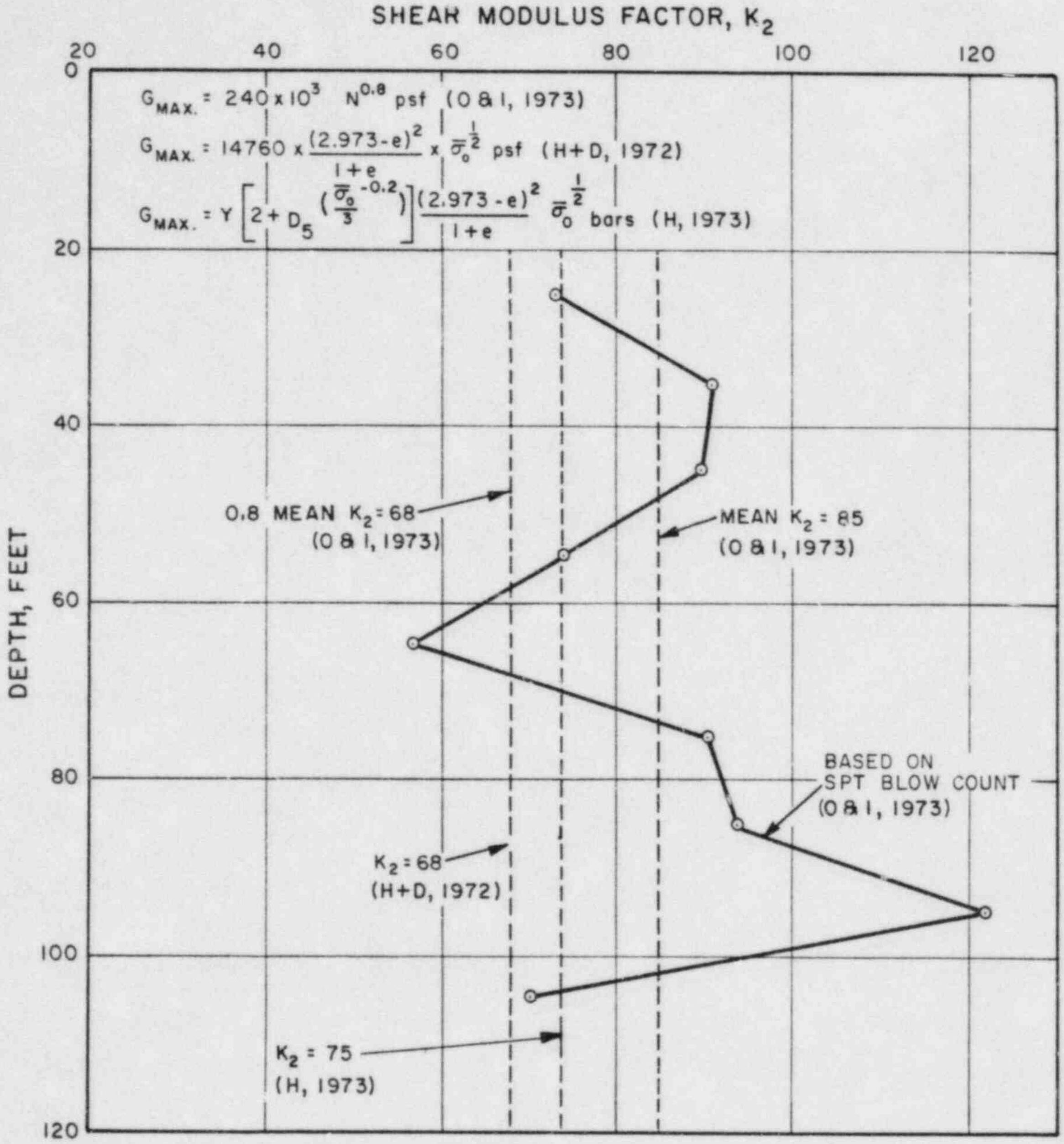
FIGURE RS-2

SHEAR MODULUS FACTOR K_2 VERSUS SHEAR STRAIN



N = STANDARD PENETRATION TEST BLOW COUNT

e = VOID RATIO

$\bar{\sigma}_0$ = MEAN EFFECTIVE CONFINING STRESS = $\frac{\bar{\sigma}_v}{3}(1+2K_0)$

$\bar{\sigma}_v$ = EFFECTIVE VERTICAL STRESS

K_0 = AT-REST COEFFICIENT OF LATERAL EARTH PRESSURE

D_5 = GRAIN SIZE (mm) FROM GRADATION CURVE AT 5% FINER THAN

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FIGURE RS-3

SHEAR MODULUS FACTOR K_2 VERSUS DEPTH

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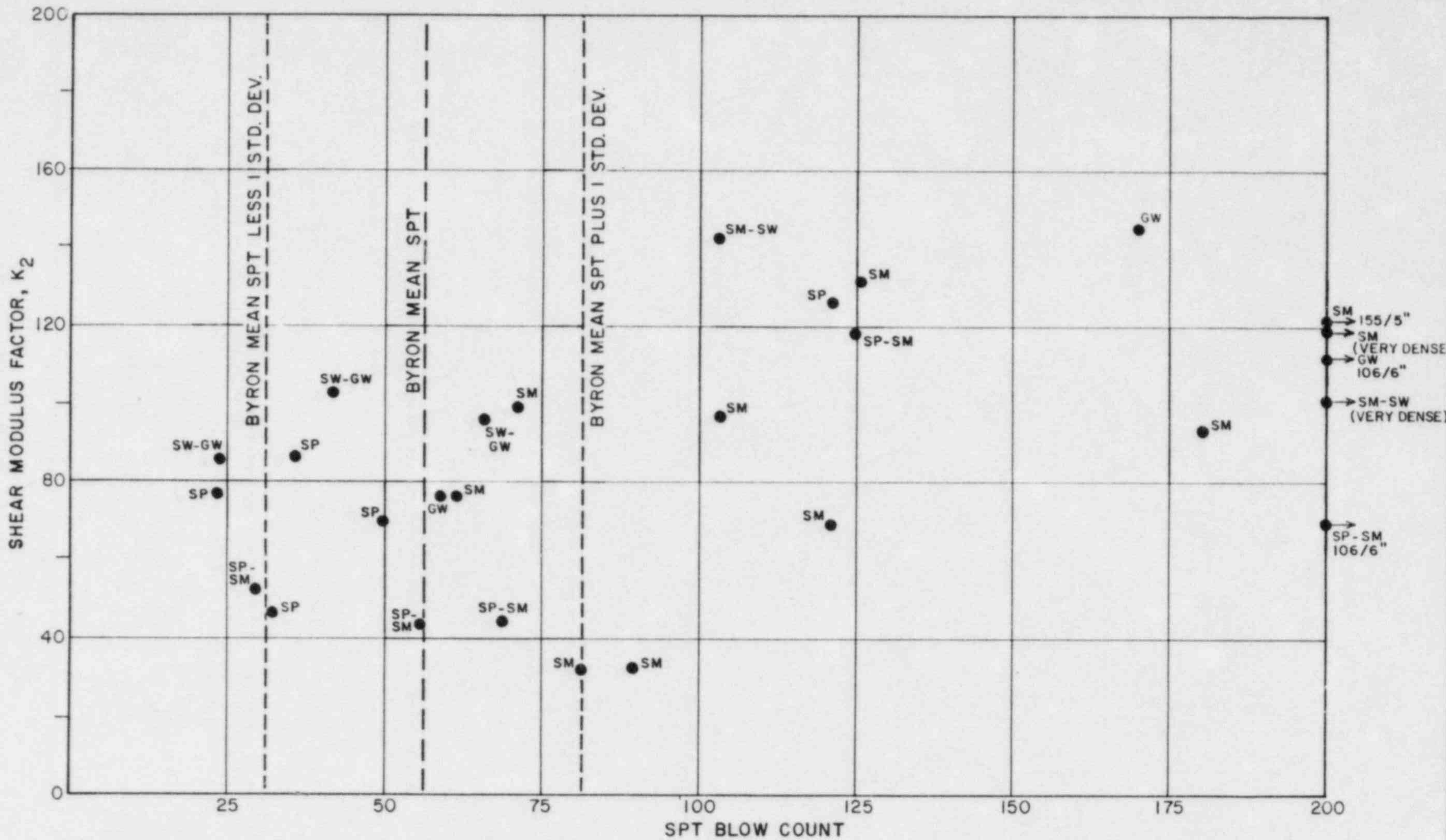

NOTE: DATA FROM SHANNON AND WILSON, INC. AND AGBABIAN ASSOCIATES (REF 1).

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FIGURE RS-4

SHEAR MODULUS FACTOR K_2 VERSUS SPT BLOW COUNT, GRANULAR MATERIAL

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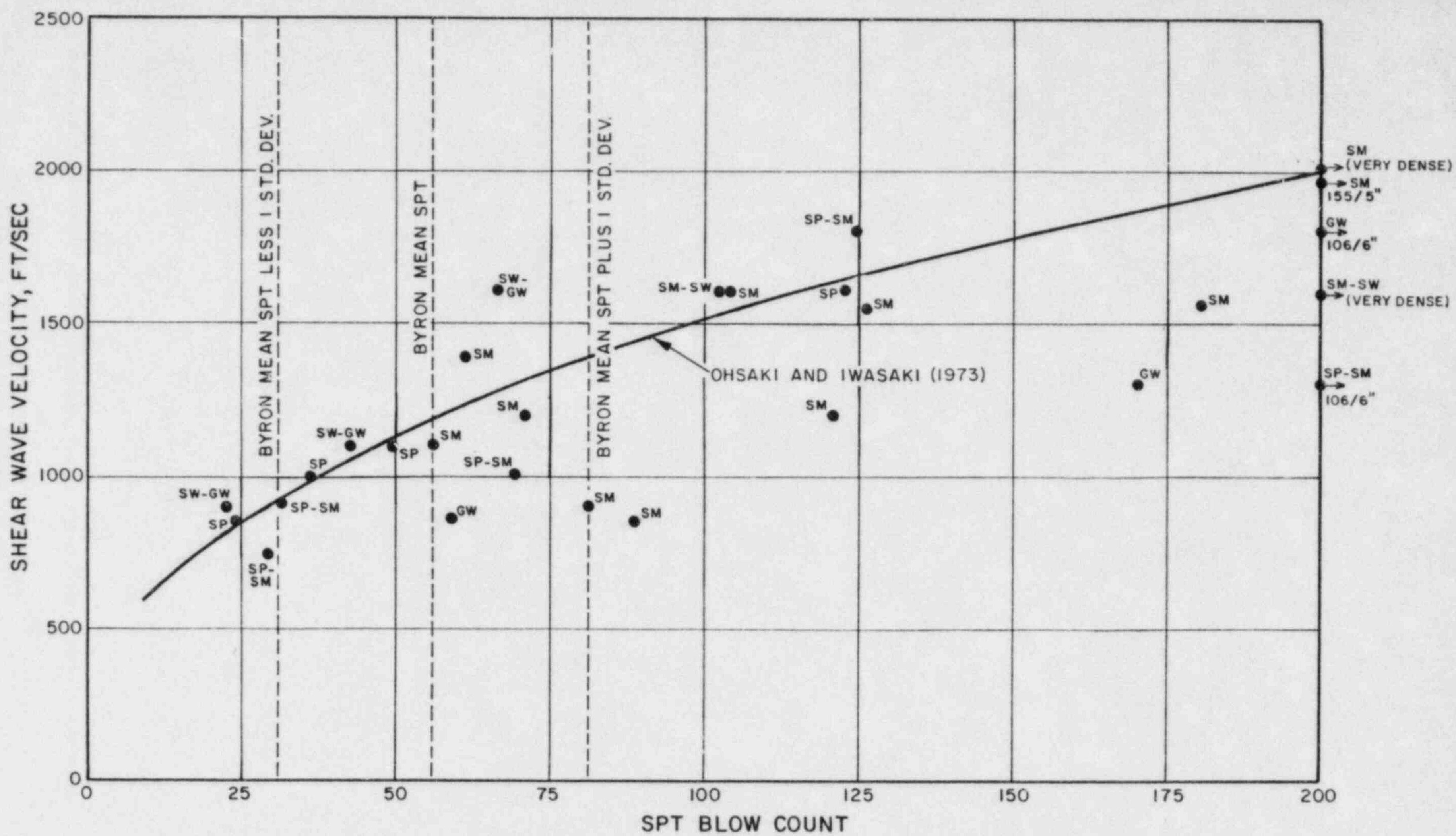

NOTE: DATA FROM SHANNON AND WILSON, INC. AND AGBABIAN ASSOCIATES (REF 1).

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FIGURE RS-5

SHEAR WAVE VELOCITY VERSUS SPT BLOW COUNT GRANULAR MATERIAL

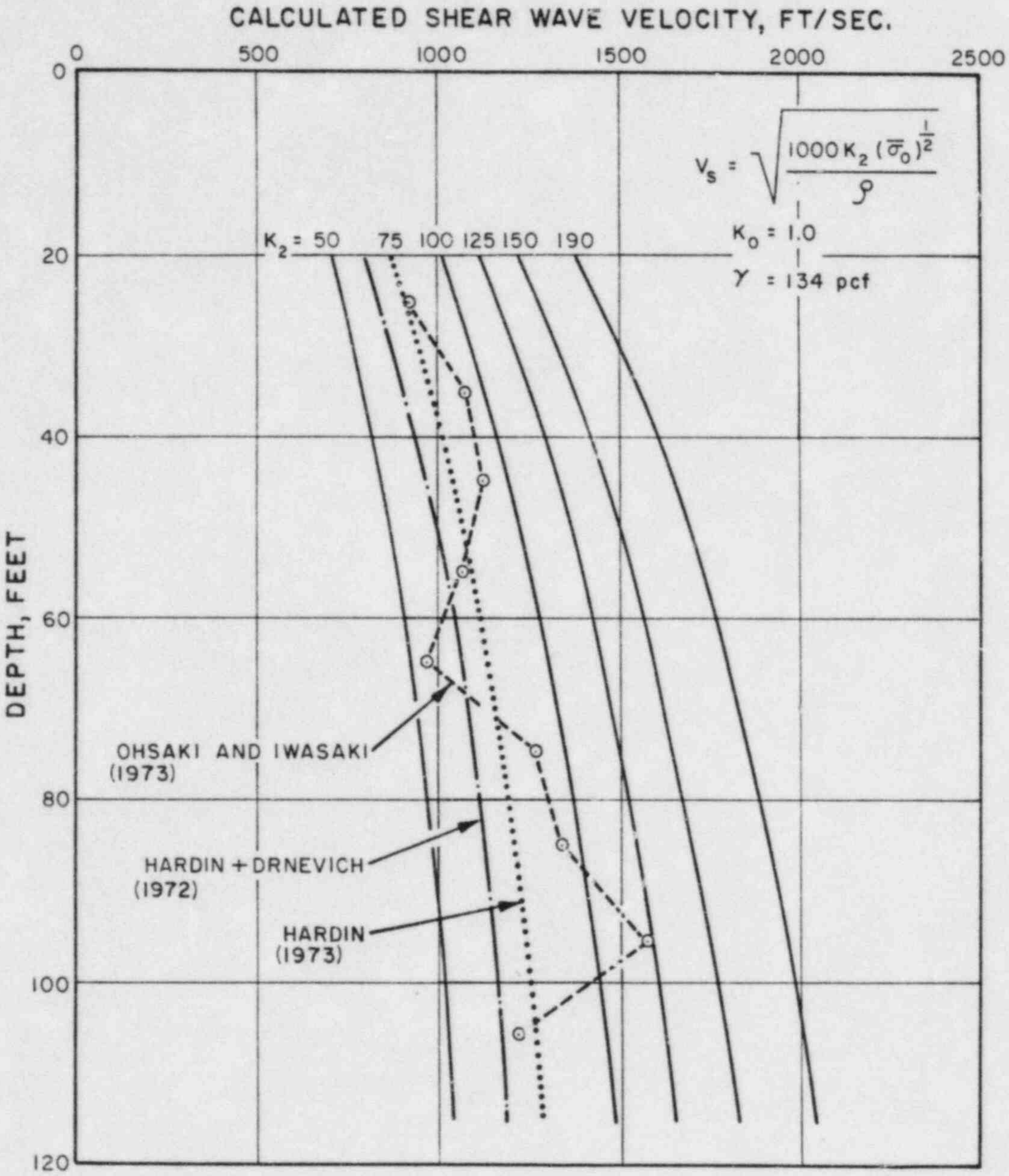

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FIGURE RS-6

CALCULATED SHEAR WAVE VELOCITIES VERSUS DEPTH