RAS 5640 72-22-ISFSI-State Exhibit 178 Rec'd 5/3/02

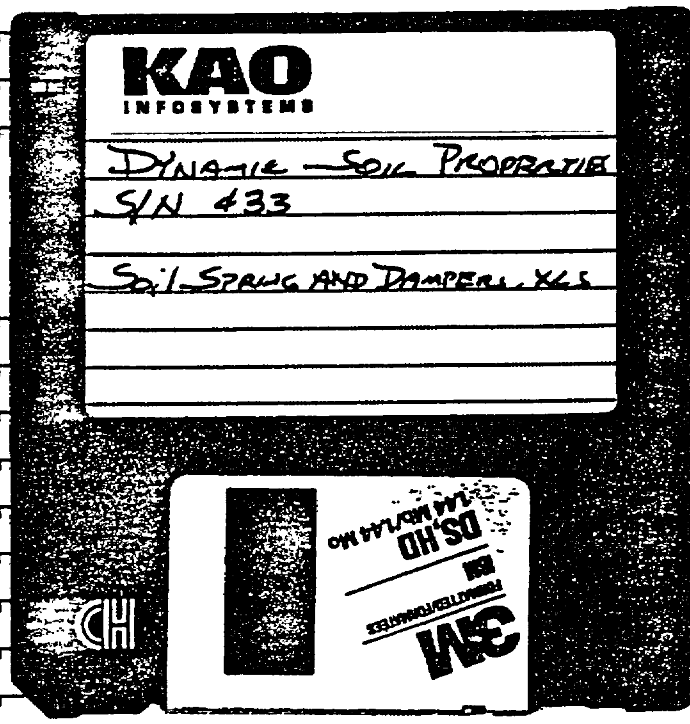
TITLE Review of PFSF SAR Book No. 433

From Page No.

11/19/01 Review of Dynamic soil properties from G(P018)-2

An Excel Spreadsheet was developed to verify the dynamic soil properties from Table 7 of G(P018)-2. This table was developed based on the equations identified in the SAR & supporting documentations.

FEB 4 2002



11/19/01

PRINTOUT ~~SF~~ DJP FOR THE CTB and STORAGE PADS ARE GIVEN ON PAGES 12 & 13 RESPECTIVELY.

THE RESULTS WERE FOUND TO BE CONSISTENT WITH THE DATA GIVEN IN G(P018)-2

To Page No.

Witnessed & Understood by me.	Date	Invented by / Recorded by	Date
		Recorded by D Pomerening	11/19/01

NRC-02083

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Project No: [illegible]
Book No. 433 TITLE REVIEW OF PFSF SAR...

Soil Calculations for PFS
For CTB

Dynamic Soil Properties from G(PO18)-2 Table 7

	Upper Range	Best Estimate	Lower Range
Vp	2205	1527	1157
Vs	1322	842	579
G (psf)	5015000	2027000	955000
beta S (%)	2.3	3.3	4.6
E (psf)	12236600	5193174	2546030
beta p (%)	2.3	3.3	4.6
Poisson's Ratio	0.220	0.281	0.333
Unit Wt. (pcf)	92.4	92.0	91.8

(new) RJP 12/05/01

L = Width (ft)	279.5
B = Breadth (ft)	240.0
Depth (ft)	5.0
Area (ft^2)	67080
I1 = L*B^3/12	321984000
I2 = B*L^3/12	436692198
J = L*B*(L^2+B^2)/12	758676198
Aspect Ratio	1.16

RJP 11/05/01
$\rho = \frac{\text{Unit weight}}{g}$
$g = 32.16\ ft/sec^2$

	Upper Range	Best Estimate	Lower Range
Cs	1.060	1.060	1.060
KappaT	0.936	0.881	0.840
KappaPhi	2.070	2.070	2.070

Vertical Mode	Upper Range	Best Estimate	Lower Range	
h = 0.27*(A)^0.5	69.93	69.93	69.93	ft
M = A*h*rho	13474565	13416234	13387068	lb-sec^2/ft
m = M/A	200.87	200.00	199.57	lb-sec^2/ft^3
Kv = E*(A)^0.5*Cs/(1-mu^2)	3530276507	1547951132	786158158	lb/ft
kv = Kv/A	52627.85	23076.19	11719.71	lb/ft^3
C = 5.42 *(KV*rho*h^3)^0.5	319172004	210890483	150127671	lb-sec/ft
c = C/A	4758.08	3143.87	2238.04	lb-sec/ft^3

RJP

Horizontal Mode	Upper Range	Best Estimate	Lower Range	
h = 0.05*(A)^0.5	12.95	12.95	12.95	ft
M = A*h*rho	2495290	2484488	2479087	lb-sec^2/ft
m = M/A	37.20	37.04	36.96	lb-sec^2/ft^3
KH = E*(A)^0.5*kT/(1-mu^2)	3117300764	1286551837	622993257	lb/ft
kH = KH/A	46471	19179	9287	lb/ft^3
C = 41.1 *(KH*rho*h^3)^0.5	181243182	116183351	80760566	lb-sec/ft
c = C/A	2702	1732	1204	lb-sec/ft^3

Rocking Mode	Upper Range	Best Estimate	Lower Range	
h = 0.35*(A)^0.5	90.65	90.65	90.65	ft
M = A*h*rho	17467029	17391414	17353607	lb-sec^2/ft
m = M/A	260.39	259.26	258.70	lb-sec^2/ft^3
KR = E*I*ko/(A^0.5*(1-mu^2))	33091346575855	14509851368626	7369120244769	lb-ft
kR = KR/I	102773	45064	22887	lb/ft^3
C = 0.97 *(KR*rho*h^5)^0.5	739896697217	488881134556	348022277842	lb-sec-ft
c = C/I	2297.93	1518.34	1080.87	lb-sec/ft^3
KR = E*I*ko/(A^0.5*(1-mu^2))	44880282419140	19679048895485	9994401315997	lb-ft
kR = KR/I	102773	45064	22887	lb/ft^3
C = 0.97 *(KR*rho*h^5)^0.5	861671361967	569342821284	405300944404	lb-sec-ft
c = C/I	1973.18	1303.76	928.12	lb-sec/ft^3

RJP

Torsion	Upper Range	Best Estimate	Lower Range	
h = 0.25*(A)^0.5	64.75	64.75	64.75	ft
M = A*h*rho	12476449	12422439	12395433	lb-sec^2/ft
m = M/A	185.99	185.19	184.79	lb-sec^2/ft^3
KT= 1.5*E*J*kT/(A^0.5*(1-mu^2))	52885104883562	21826392125132	10569100080467	lb-ft
kT = KT/J	69707	28769	13931	lb/ft^3
C = 3.76 *(KT*rho*h^5)^0.5	1563423282214	1002210145451	696649372493	lb-sec-ft
c = C/J	2060.73	1321.00	918.24	lb-sec/ft^3

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essed & Understood by me,	Date	Invented by	Date
		Recorded by D Powering	11/19/01

NRC-02084

From Page

Soil Calculations for PFS
For Storage Pads

Dynamic Soil Properties from G(PO18)-2 Table 7

	Upper Range	Best Estimate	Lower Range
Vp	2205	1527	1157
Vs	1322	842	579
G (psf)	5015000	2027000	955000
beta S (%)	2.3	3.3	4.6
E (psf)	12236600	5193174	2546030
beta p (%)	2.3	3.3	4.6
Poisson's Ratio (mu) DJP 12/05/01	0.220	0.281	0.333
Unit Wt. (pcf)	92.4	92.0	91.8

L = Width (ft)	67.0
B = Breadth (ft)	30.0
Depth (ft)	3.0
Area (ft^2)	2010
I1 = L*B^3/12	150750
I2 = B*L^3/12	751908
J = L*B*(L^2+B^2)/12	902658
Aspect Ratio	2.23

rho = Unit Weight / g
g = 32.16 ft/sec^2
DJP 12/05/01

	Upper Range	Best Estimate	Lower Range
Cs	1.099	1.099	1.099
KappaT	0.937	0.892	0.760
KappaPhi	2.614	2.614	2.614

	Upper Range	Best Estimate	Lower Range	Units
Vertical Mode				
h = 0.27*(A)^0.5	12.10	12.10	12.10	ft
M = A*h*rho	69891	69588	69437	lb-sec^2/ft
m = M/A	34.77	34.62	34.55	lb-sec^2/ft^3
Kv = E*(A)^0.5*Cs/(1-mu^2)	633580863	277811728	141092281	lb/ft
kv = Kv/A	315214.36	138214.79	70195.16	lb/ft^3
C = 5.42 *(KV*rho*h^3)^0.5	9738088	6434368	4580466	lb-sec/ft
c = C/A	4844.82	3201.18	2278.84	lb-sec/ft^3
Horizontal Mode				
h = 0.05*(A)^0.5	2.24	2.24	2.24	ft
M = A*h*rho	12943	12887	12859	lb-sec^2/ft
m = M/A	6.44	6.41	6.40	lb-sec^2/ft^3
KH = E*(A)^0.5*kT/(1-mu^2)	540186778	225485042	97570640	lb/ft
kH = KH/A	268750	112182	48543	lb/ft^3
C = 41.1 *(KH*rho*h^3)^0.5	5433711	3503010	2301810	lb-sec/ft
c = C/A	2703	1743	1145	lb-sec/ft^3
Rocking Mode				
h = 0.35*(A)^0.5	15.69	15.69	15.69	ft
M = A*h*rho	90599	90207	90011	lb-sec^2/ft
m = M/A	45.07	44.88	44.78	lb-sec^2/ft^3
KR = E*I*ko/(A^0.5*(1-mu^2))	113024138569	49558679879	25169373684	lb-ft
kR = KR/I	749746	328747	166961	lb/ft^3
C = 0.97 *(KR*rho*h^5)^0.5	539080008	356193029	253564927	lb-sec-ft
c = C/I	3575.99	2362.81	1682.02	lb-sec/ft^3
KR = E*I*ko/(A^0.5*(1-mu^2))	563739286707	247187682194	125539242742	lb-ft
kR = KR/I	749746	328747	166961	lb/ft^3
C = 0.97 *(KR*rho*h^5)^0.5	1203945350	795497765	566295004	lb-sec-ft
c = C/I	1601.19	1057.97	753.14	lb-sec/ft^3
Torsion				
h = 0.25*(A)^0.5	11.21	11.21	11.21	ft
M = A*h*rho	64714	64433	64293	lb-sec^2/ft
m = M/A	32.20	32.06	31.99	lb-sec^2/ft^3
KT= 1.5*E*J*kT/(A^0.5*(1-mu^2))	363883318373	151892361306	65726022466	lb-ft
kT = KT/J	403124	168272	72814	lb/ft^3
C = 3.76 *(KT*rho*h^5)^0.5	1616756880	1042292324	684885032	lb-sec-ft
c = C/J	1791.11	1154.69	758.74	lb-sec/ft^3

DJP

DJP

Witnessed & Understood by me.	Date	Invented by	Date 11/14/01
		Recorded by D Pomerening	

Project No. 20-01405-071
Book No. 433 TITLE REVIEW OF PFSF SAR

From Page No.____ 11/19/01

REVIEW OF STORAGE PAD ANALYSIS

To support the conclusion drawn associated with the pad analysis presented in the SAR a series of calculations was performed

1) Determination of stress in soil under various load conditions

Dead & Live load
Weight of slab = (150 lb/ft3)(67 ft × 30 ft × 3 ft)
= 904,500 lbs
Weight of Cask = 360,000 lbs

(1.4)(Dead) + 1.7(8)(360,000) lbs = 1,266,300 + 4,896,000 lbs
(904,500) = 6,162,300 lbs

Soil Stress = 6,162,300 / (67×30)
= 3.07 ksf DJP

For case of seven casks and one cask on transporter

(1.4)(904,500) + (1.7)(7)(360,000) + (1.7)(2)(360,000 + 145,000)

= 1,266,300 + 4,284,000 + 1,717,000 = 7267,300 lbs

Soil Stress = 7,267,300 / (67×30)
= 3.61 ksf

This is the same as the 3.6 ksf identified in the SAR
DJP 11/19/01

2) Calculation of Vertical Mode of Pad Storage Pad
Based on Table 11-4 Robert Blevins, Formulas for Natural Frequencies and mode Shape, 1979

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NRC-02086

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$$f_{ij} = \frac{\lambda_{ij}^2}{2\pi (a)^2} \left[\frac{E h^3}{12 \gamma (1-\nu^2)} \right]^{1/2}$$

DJP 11/19/01

$$\frac{a}{b} = \frac{~~67~~ \; 67}{30} = 2.23 \Rightarrow \lambda_{ij}^2 = 21.64 \text{ to } a/b = 2.5$$

$a = 67$

DJP 11/19/01

$E =$ ~~3.7~~ ~~003~~ $3,700,000$ psi $= 23,694$ psf

DJP 11/19/01

$h =$ ~~3/12~~ 3 ft

$$\gamma = \left(\frac{150 \text{ lb/ft}^3}{32.167 \text{ ft/sec}^2} \right) (3 \text{ ft}) = 14.01$$

$\nu = 0.17$

$$f_{ij} = \frac{21.64}{(2\pi)(67)^2} \left[\frac{(23,694)(3)^3}{12(14.01)(1-.17^2)} \right]^{1/2}$$

$$= \frac{21.64}{2\pi (67)^2} (9394)$$

$$= 7.21 \text{ Hz}$$

This assumes a free-free-free-free plate. The support of the soil will have an influence on the natural frequency of the system. In addition the loading of the storage pad will influence the natural frequency.

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3) Estimation of onload storage pad vertical mode on soil spring

Mass of storage pad

$$(150\ lb/ft^3)(67\ ft \times 30\ ft \times 3\ ft) / 32.17\ ft/sec^2$$

$$= \frac{(150)(67)(30)(3)}{32.167} = 28,120\ lb\ sec^2/ft$$

$$\omega_n = \sqrt{\frac{K}{m}} = \sqrt{\frac{277811728}{28,120}}$$ ← Best Est page 13 of this Book

$$= 99.4\ rad/sec$$

$$= 15.8\ Hz$$

4) Determination of important parameters for cask drop tip-over events.

Review of NUREG/CR-6608

from NUREG/CR-6608

The test results were plotted using Microsoft Excel. The resulting data indicates that the peak deceleration is proportional to the square root of the drop height. ~~The~~ This corresponds to the fact that the deceleration is proportional to the energy at impact and the stiffness of the system. DJP 11/19/01

~~½ W~~ DJP 11/19/01 $\frac{1}{2} mV^2 = mgh$

$$V = \sqrt{2gh} \qquad a_m \propto V \propto \sqrt{K}/\sqrt{m}$$

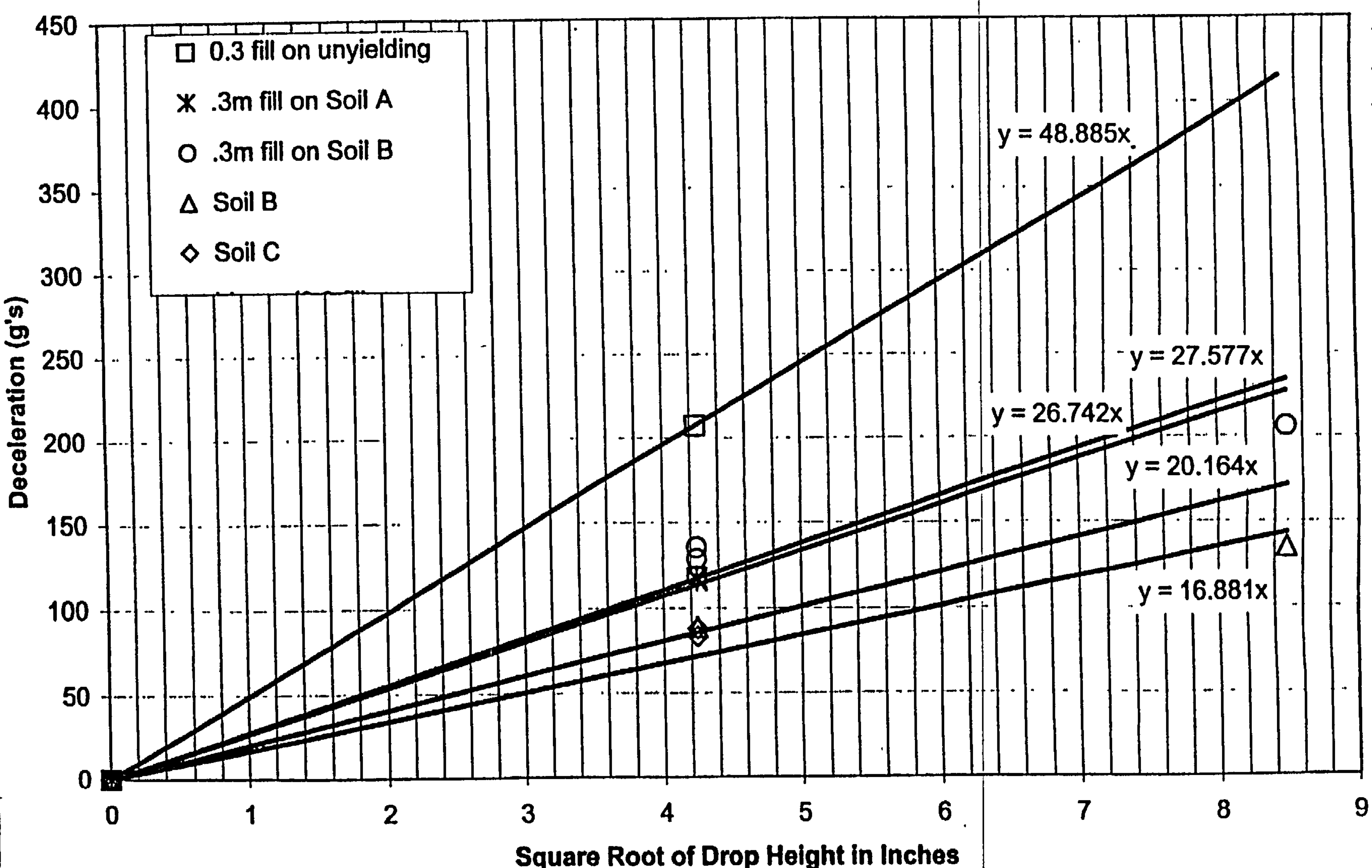
A linear regression analysis of the data in NUREG/CR-6608 was performed and plotted (see page 17)

Witnessed & Understood by me,	Date	Invented by	Date
		Recorded by D Pomerening	11/14/01

TITLE Review of PFSF SAR

From Page

Summary of Results from NUREG/CR-6608



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Date

Invented by

Recorded by D Pomerening 11/14/01

Date 11/14/01

Book No. 433

NRC-02089

Project No. 20-1405-041
Book No. 133 TITLE Review of PFSF SAR

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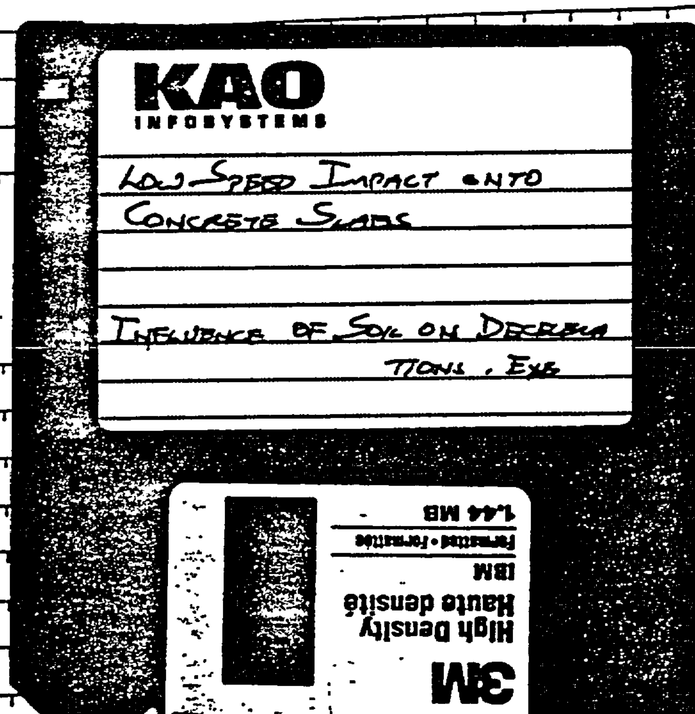
11/19/01

The data indicates that the deceleration for a specific impact condition ~~that the~~ is proportional to the square root of the drop height. This correlates to the information provided on page 12 of Holtec HI-2012653 Revision 2.

DJP 11/19/01

There is a slight dependence on the type of soil.

There is more change due to the addition of engineered fill



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NRC-02090

NUCLEAR REGULATORY COMMISSION

Docket No. ____________ Official Exh. No. 178

In the matter of ____________

Staff ____________ IDENTIFIED ✓

Applicant ____________ RECEIVED ✓

Intervenor ✓ REJECTED ____________

Other ____________ WITHDRAWN ____________

DATE 5/3/02 Witness ____________

Clerk ____________

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