Exhibit A
to
Declaration of Dr. Farhang Ostadan
dated January 21, 2000
in support of State's Response to Applicant's Motion
for Summary Disposition of Utah Contention GG

FOUNDATION ANALYSIS AND DESIGN

Fourth Edition

Joseph E. Bowles, P.E., S.E.
Consulting Engineer/Software Consultant
Engineering Computer Software
Peoria, Illinois

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9-7 CLASSICAL SOLUTION OF BEAM ON ELASTIC FOUNDATION

When flexural rigidity of the footing is taken into account, a solution is used that is based on some form of a beam on an elastic foundation. This may be of the classical Winkler solution of about 1867 in which the foundation is considered as a bed of springs ("Winkler foundation") or a finite-element procedure of the next section.

The classical solutions, being of closed form, are not as general in application as the finite-element method. The basic differential equation is (see Fig. 9-10)

$$EI\frac{d^4y}{dx^4} = q = -K_s y \qquad (9\text{-}11)$$

TABLE 9-2 Closed-form solutions of infinite beam on elastic foundation (Fig. 9-10a)

Concentrated load at end	Moment at end
$y = \dfrac{2V_1\lambda}{k'_s} D_{\lambda x}$	$y = \dfrac{-2M_1\lambda^2}{k'_s} C_{\lambda x}$
$\theta = \dfrac{-2V_1\lambda^2}{k'_s} A_{\lambda x}$	$\theta = \dfrac{4M_1\lambda^3}{k'_s} D_{\lambda x}$
$M = \dfrac{-V_1}{\lambda} B_{\lambda x}$	$M = M_1 A_{\lambda x}$
$Q = -V_1 C_{\lambda x}$	$Q = -2M_1\lambda B_{\lambda x}$
Concentrated load at center	**Moment at center**
$y = \dfrac{P\lambda}{2k'_s} A_{\lambda x}$	$y = \dfrac{M_0\lambda^2}{k'_s} B_{\lambda x}$ deflection
$\theta = \dfrac{-P\lambda^2}{k'_s} B_{\lambda x}$	$\theta = \dfrac{M_0\lambda^3}{k'_s} C_{\lambda x}$ slope
$M = \dfrac{P}{4\lambda} C_{\lambda x}$	$M = \dfrac{M_0}{2} D_{\lambda x}$ moment
$Q = \dfrac{-P}{2} D_{\lambda x}$	$Q = \dfrac{-M_0}{2} A_{\lambda x}$ shear

The A, B, C, and D coefficients are:

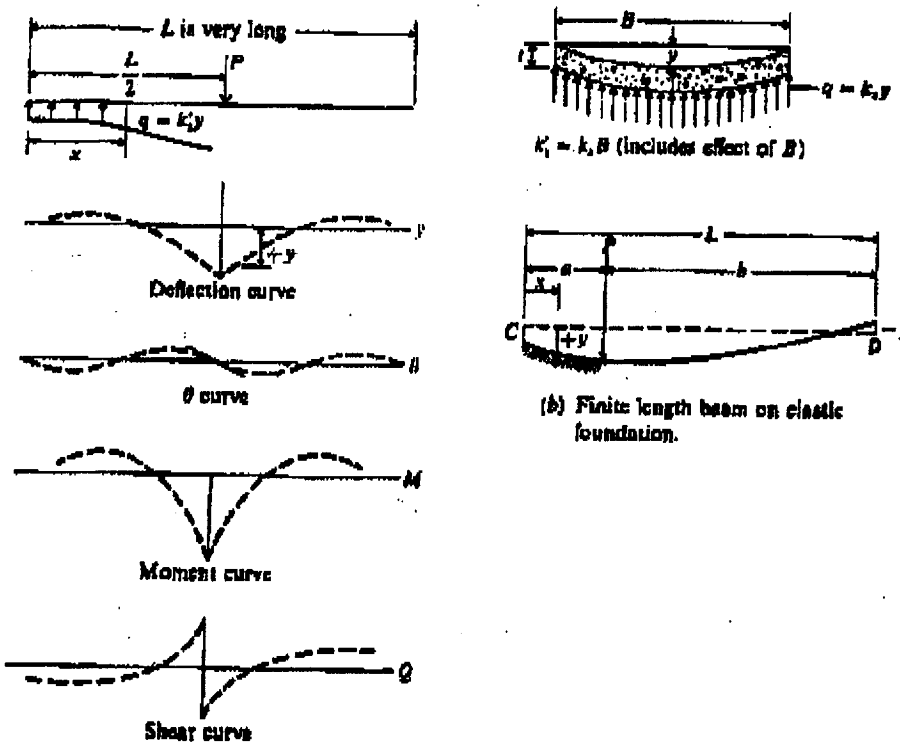
$$A_{\lambda x} = e^{-\lambda x}(\cos \lambda x + \sin \lambda x)$$
$$B_{\lambda x} = e^{-\lambda x} \sin \lambda x$$
$$C_{\lambda x} = e^{-\lambda x}(\cos \lambda x - \sin \lambda x)$$
$$D_{\lambda x} = e^{-\lambda x} \cos \lambda x$$

where $K'_s = k_s B$. In solving the equations, a variable is introduced:

$$\lambda = \sqrt[4]{\frac{k'_s}{4EI}} \qquad \text{or} \qquad \lambda L = \sqrt[4]{\frac{k'_s L^4}{4EI}}$$

Table 9-2 gives the closed-form solution of the basic differential equations for several loadings shown in Fig. 9-10 utilizing the Winkler concept. It is convenient to express the trigonometric portion of the solutions separately as in the bottom of Table 9-2.

Hetenyi (1946) developed equations for a load at any point along a beam (see Fig. 9-10b) measured from the left end as follows:



(a) Infinite length beam on an elastic foundation.

(b) Finite length beam on elastic foundation.

FIGURE 9-10 Beam on elastic foundation.

$$y = \frac{P\lambda}{k'_s(\sinh^2 \lambda L - \sin^2 \lambda L)}\{2\cosh \lambda x \cos \lambda x\,(\sinh \lambda L \cos \lambda a \cosh \lambda b$$
$$-\sin \lambda L \cosh \lambda a \cos \lambda b) + (\cosh \lambda x \sin \lambda x$$
$$+\sinh \lambda x \cos \lambda x)\,[\sinh \lambda L\,(\sin \lambda a \cosh \lambda b - \cos \lambda a \sinh \lambda b)$$
$$+\sin \lambda L\,(\sinh \lambda a \cos \lambda b - \cosh \lambda a \sin \lambda b)]\} \tag{9-12}$$

$$M = \frac{P}{2\lambda(\sinh^2 \lambda L - \sin^2 \lambda L)}\{2\sin \lambda x \sin \lambda x\,(\sinh \lambda L \cos \lambda a \cosh \lambda b$$
$$-\sin \lambda L \cosh \lambda a \cos \lambda b) + (\cosh \lambda x \sin \lambda x - \sinh \lambda x \cos \lambda x)$$
$$\times [\sinh \lambda L\,(\sin \lambda a \cosh \lambda b - \cos \lambda a \sinh \lambda b)$$
$$+\sin \lambda L\,(\sinh \lambda a \cos \lambda b - \cosh \lambda a \sin \lambda b)]\} \tag{9-13}$$

$$Q = \frac{P}{\sinh^2 \lambda L - \sin^2 \lambda L}\{(\cosh \lambda x \sin \lambda x + \sinh \lambda x \cos \lambda x)$$
$$\times (\sinh \lambda L \cos \lambda a \cosh \lambda b - \sin \lambda L \cosh \lambda a \cos \lambda b)$$
$$+ \sinh \lambda x \sin \lambda x [\sinh \lambda L (\sin \lambda a \cosh \lambda b - \cos \lambda a \sinh \lambda b)$$
$$+ \sin \lambda L (\sinh \lambda a \cos \lambda b - \cosh \lambda a \sin \lambda b)]\}$$

The equation for the slope θ of the beam at any point is not presented is of little value in the design of a footing. The value of x to use in the equa from the end of the beam to the point for which the deflection, moment, or desired. If x is less than the distance a, use the equations as given, and measure x from C. If x is larger than a, replace a with b in the equations, and measure x from D (Fig. 9-10b). These equations may be rewritten as

$$y = \frac{P\lambda}{k_s'} A' \qquad M = \frac{P}{2\lambda} B' \qquad \text{and} \qquad Q = PC'$$

where the coefficients A', B', and C' are the values for the hyperbolic and trigonometric remainder of Eqs. (9-12) to (9-14).

It has been proposed that one could use λL previously defined to determine if a foundation should be analyzed on the basis of the conventional rigid procedure or as a beam on an elastic foundation.

Rigid members:	$\lambda L < \frac{\pi}{4}$	(bending not influenced much by k_s)
Flexible members:	$\lambda L > \pi$	(bending heavily localized)

The author has found the above criteria of limited application because of the influence of number of loads and their locations on the member.

The classical solution presented here has several distinct disadvantages over the finite-element solution presented in the next section, such as:

1. Assumes weightless beam (but weight will be a factor when footing tends to separate from the soil).
2. Difficult to remove soil effect when footing tends to separate from soil.
3. Difficult to account for boundary conditions of known rotation or deflection at selected points.
4. Difficult to apply multiple types of loads to a footing.
5. Difficult to change footing properties of I, D, and B.
6. Difficult to allow for change in subgrade reaction along footing.

Although the disadvantages are substantial some engineers prefer the classical beam-on-elastic-foundation approach over discrete element analyses. Rarely, the classical approach may be a better model than a discrete element analysis so it is worthwhile to have access to this method of solution.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of:	)	Docket No. 72-22-ISFSI
	)	
PRIVATE FUEL STORAGE, LLC	)	ASLBP No. 97-732-02-ISFSI
(Independent Spent Fuel	)	
Storage Installation)	)	December 20, 1999

STATE OF UTAH'S MOTION TO COMPEL APPLICANT TO RESPOND TO STATE'S FIFTH SET OF DISCOVERY REQUESTS

Pursuant to 10 C.F.R. § 2.742, the State of Utah hereby moves the Board to compel the Applicant, Private Fuel Storage, LLC ("PFS") to answer certain requests for admissions propounded in State of Utah's Fifth Set of Discovery Requests Directed to the Applicant (December 1, 1999) ("State's Discovery Requests"). PFS filed its response on December 13, 1999, Applicant's Objections and Responses to State of Utah's Fifth Set of Discovery Requests ("PFS's Discovery Response"). This Motion to Compel relates to Utah Contention GG (Cask Stability) and is supported by the Declaration of Dr. Farhang Ostadan, attached hereto as Exhibit 1. Dr. Ostadan's resume is also attached hereto as Exhibit 2.

FACTUAL BACKGROUND

In its Discovery Requests, the State submitted 20 Requests for Admissions to PFS related to Contention GG - Failure to Demonstrate Cask-Pad Stability During Seismic Event for TranStor Cask. PFS refused to answer 17 of the 20 Requests for Admission and only answered Requests for Admission Nos. 16, 18, and 20(a). In addition, PFS refused to answer portions of certain Document Requests.

The State has reviewed its Discovery Request and believes all the requests are relevant to Contention GG. However, Requests for Admission Nos. 1 through 9, 13 through 15, and 17 also are relevant to Contention L - Geotechnical. Following verbal discussions with counsel for PFS on December 16, 1999, the State agreed to resubmit Requests for Admissions Nos. 1 through 9, 13 through 15, and 17 under Contention L.

Also, on December 16th, the State informed counsel for PFS that Requests for Admission Nos. 10 through 12, 19, and 20(b) squarely address Contention GG and requested PFS to fully respond. Subsequently, the State sent a letter to PFS dated December 17,1999, explaining the grounds for the State's anticipated Motion to Compel. *See* Letter from Connie Nakahara to Paul Gaukler dated December 17, 1999, attached hereto as Exhibit 3. Counsel for PFS informed the State today that it will not answer the disputed requests.

ARGUMENT

I. THE COMMISSION'S STANDARD FOR DISCOVERY IS ONE OF BROAD RELEVANCE TO ADMITTED CONTENTIONS.

The scope of allowable discovery is set forth in 10 C.F.R. § 2.740(b)(1). Unless otherwise determined by the Presiding Officer, discovery extends to "any matter, not privileged, which is relevant to the subject matter involved in the proceeding." *Id.* The Commission gives its discovery rules the same "broad, liberal interpretation" that is given to the discovery rules of the U.S. Federal Courts. *Commonwealth Edison Co.* (Zion Station, Units 1 and 2), ALAB-196, 7 AEC 457, 461-62 (1974). Discovery is considered relevant unless it is "palpable that the evidence sought can have no possible bearing upon the issues." *Id.*, 7 AEC at 462, *quoting Hercules Powder Co. v. Rohn & Haas Co.*, 3 F.R.D. 302, 304 (D. Del. 1943). A motion to compel need not seek information which would be admissible *per se* in an adjudicatory proceeding, and need only request information which "reasonably could lead to admissible evidence." *Safety Light Corp.* (Bloomsburg Site Decontamination), LBP-92-3A, 35 NRC 110, 111-12 (1992); *Cleveland Electric Illuminating Co.* (Perry Nuclear Power Plant, Units 1 and 2), LBP-82-102, 16 NRC 1597, 1601 (1982); *Commonwealth Edison, supra,* 7 AEC at 462.

II. THE DISCOVERY SOUGHT BY THE STATE IS RELEVANT TO THE ADMITTED BASES OF CONTENTION GG

Contention GG, as admitted, asserts that,

> The Applicant has failed to demonstrate that the TranStor storage casks and the pads will remain stable during a seismic event, and thus, the application does not satisfy 10 C.F.R. §§ 72.122(b)(2) and 72.128(a), in that Sierra Nuclear's consultant, Advent Engineering Services, Inc., used a nonconservative "nonsliding cask" tipover analysis that did not consider that the coefficient of friction may vary over the surface of the pad and did not consider the shift from the static case to the kinetic case when considering momentum of the moving casks.

Private Fuel Storage, L.L.C. (Independent Spent Fuel Storage Installation), LBP 98-7, App. A, 47 NRC 142, 251-252 (1998).

For purpose of discovery, the State need only show that its discovery requests are relevant to an issue admitted for hearing or reasonably could lead to admissible evidence. *See* Section I above. As more fully described below, the five disputed Requests for Admissions are directly relevant or could lead to admissible evidence because they address how friction is applied between the cask and the pad or relate to the shift from the static case to the kinetic case. Thus, PFS must be ordered to answer the disputed requests.

Requests for Admission Nos. 10, 11, and 12 relate to the flexible behavior of the pad. There are at least two reasons why the Board should order PFS to answer these requests. First, the friction between the cask and pad is a function of pressure acting at the contact points. The flexible behavior of the foundation, or cask pad, will cause a nonuniform pressure at the contact points and directly impact the variation of friction across the pad. This relates directly to Contention GG. Second, using pad flexible behavior assumptions rather than rigid assumptions in the cask stability analysis could affect the projected motion of the pad, including the transition from the static case to the kinetic case, which also relates directly to Contention GG.

Request for Admission No. 19 relates to the amount of lift off between the pad and the cask. As discussed above, friction between the cask and pad is a function of pressure acting at the contact points. The overturning moment of the cask, or the tendency to uplift off the pad, will cause nonuniform pressure at the contact points. Thus, the lift off between the cask and pad will affect the application of friction on the pad.

Moreover, the lift off of the pad will introduce additional seismic loads which would directly affect the transition from the static case to the kinetic case.

Request for Admission No. 20(b) relates to cold bonding. Over time, cold bonding may create a bond between the cask and the pad and, therefore, may directly and significantly impact transition from the static case to the kinetic case. Accordingly, there is no basis for PFS's refusal to answer the Requests for Admissions on relevance grounds.

CONCLUSION

For the foregoing reasons, the Applicant's legal argument for not responding to the specified portions of the State's fifth set of discovery requests on Utah Contention GG, as describe above, is without merit. Therefore, PFS should be ordered to answer the five disputed requests for admission.

DATED this 20th day of December, 1999.

Respectfully submitted,

Denise Chancellor, Assistant Attorney General
Fred G Nelson, Assistant Attorney General
Connie Nakahara, Special Assistant Attorney General
Diane Curran, Special Assistant Attorney General
Laura Lockhart, Assistant Attorney General
Attorneys for State of Utah
Utah Attorney General's Office
160 East 300 South, 5th Floor, P.O. Box 140873
Salt Lake City, UT 84114-0873
Telephone: (801) 366-0286, Fax: (801) 366-0292

CERTIFICATE OF SERVICE

I hereby certify that a copy of STATE OF UTAH'S MOTION TO COMPEL APPLICANT TO RESPOND TO STATE'S FIFTH SET OF DISCOVERY REQUESTS was served on the persons listed below by electronic mail (unless otherwise noted) with conforming copies by United States mail first class, this 20th day of December, 1999:

Rulemaking & Adjudication Staff
Secretary of the Commission
U. S. Nuclear Regulatory Commission
Washington D.C. 20555
E-mail: hearingdocket@nrc.gov
(*original and two copies*)

G. Paul Bollwerk, III, Chairman
Administrative Judge
Atomic Safety and Licensing Board
U. S. Nuclear Regulatory Commission
Washington, DC 20555
E-Mail: gpb@nrc.gov

Dr. Jerry R. Kline
Administrative Judge
Atomic Safety and Licensing Board
U. S. Nuclear Regulatory Commission
Washington, DC 20555
E-Mail: jrk2@nrc.gov
E-Mail: kjerry@erols.com

Dr. Peter S. Lam
Administrative Judge
Atomic Safety and Licensing Board
U. S. Nuclear Regulatory Commission
Washington, DC 20555
E-Mail: psl@nrc.gov

Sherwin E. Turk, Esq.
Catherine L. Marco, Esq.
Office of the General Counsel
Mail Stop - 0-15 B18
U.S. Nuclear Regulatory Commission
Washington, DC 20555
E-Mail: set@nrc.gov
E-Mail: clm@nrc.gov
E-Mail: pfscase@nrc.gov

Jay E. Silberg, Esq.
Ernest L. Blake, Jr., Esq.
Paul A. Gaukler, Esq.
Shaw, Pittman, Potts & Trowbridge
2300 N Street, N. W.
Washington, DC 20037-8007
E-Mail: Jay_Silberg@shawpittman.com
E-Mail: ernest_blake@shawpittman.com
E-Mail: paul_gaukler@shawpittman.com

John Paul Kennedy, Sr., Esq.
1385 Yale Avenue
Salt Lake City, Utah 84105
E-Mail: john@kennedys.org

Joro Walker, Esq.
Land and Water Fund of the Rockies
2056 East 3300 South Street, Suite 1
Salt Lake City, Utah 84109
E-Mail: joro61@inconnect.com

Danny Quintana, Esq.
Danny Quintana & Associates, P.C.
68 South Main Street, Suite 600
Salt Lake City, Utah 84101
E-Mail: quintana@xmission.com

James M. Cutchin
Atomic Safety and Licensing Board Panel
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001
E-Mail: jmc3@nrc.gov
(*electronic copy only*)

Office of the Commission Appellate Adjudication
Mail Stop: 16-G-15 OWFN
U. S. Nuclear Regulatory Commission
Washington, DC 20555
(*United States mail only*)

Denise Chancellor
Assistant Attorney General
State of Utah

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of:	)	Docket No. 72-22-ISFSI
	)	
PRIVATE FUEL STORAGE, LLC	)	ASLBP No. 97-732-02-ISFSI
(Independent Spent Fuel Storage Installation)	)	December 20, 1999

DECLARATION OF DR. FARHANG OSTADAN

I, Dr. Farhang Ostadan, hereby declare under penalty of perjury and pursuant to 28 U.S.C. § 1746, that the statements contained in State of Utah's Motion to Compel Applicant to Respond to State's Fifth Set of Discovery Requests dated December 20, 1999, relating to Utah Contention GG, are true and correct to the best of my knowledge, information and belief.

Executed this 20th day of December, 1999.

By: Farhang Ostadan

Farhang Ostadan, PhD