FAX COVER PAGE

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DATE:	November 18, 1996 9 A.M.

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REFER TO:	LIGO-E9960140-00-E
SUBJECT:	Acceleration Load Spec
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NOTE:

cc:
D. Coyne
Chronological File
Document Control Center

From coyne Fri Nov 15 17:04:13 1996
To: ponslet@rt66.com, thompson@rt66.com
Cc: fjr, fine
Subject: Re: acceleration load spec

Tim and Eric,
Here's the suggested seismic load requirement for the SEI. (As an alternative to this static equivalent load, we could specify an acceleration design spectrum for use in dynamic analysis.) At a minimum failure of the actuators under these loads should not cause failure of the bellows or cause the seismic stack to "drop"; ideally the actuators would survive these loads with no damage.

I'll fax to you a brief _synopsis_ (from a text) of the relevant part of the UBC. If you feel it's necessary, we can have Parsons provide the appropriate sections of the UBC to us.
Dennis

----- Begin Included Message -----

Fax to Tim Thompson
& Eric Ponslet
Hytec Inc.
Fax # 505/662-5179

From coyne Mon Apr 15 09:46:56 1996
To: fjr@ligo.caltech.edu
Subject: Re: acceleration spec

> Although the sites are not suject to the same kind of earthquake
> activity as SoCal, there are occasional earthquakes in the Pacific
> Northwest exceeding magnitude 4 and I would guess a magnitude 6 is
> possible every 100-200 years. I think I need an earthquake restraint
> provision in the seismic isolation DRD. Any ideas ? I was going to ask
> for no significant damage under accelerations of up to 0.1 g.
>
> Fred
>

You should include a statement like the following:

Seismic Restraint
The SEI shall be designed to resist the static equivalent lateral forces defined in the Uniform Building Code (UBC), 1994 edition, for a seismic zone factor Z = 0.15 (i.e. zone 2B, Hanford) and a structure importance factor I = 1. The support structure shall resist the seismic loads without damage. The seismic stack shall sustain the base shear motion of the support structure without collapse or release of any of the stack layers.

So ... what does this mean? Well, if there is no damping or plastic deformation to absorb the seismic loading (Rw = 1), and IF the SEI first frequency was between 2.5 Hz and 10 Hz (i.e. at the peak), then the base shear,

Vb = (Z*I*C/Rw)*W = (0.15*1*2.75/1)*W = 0.41 W

If, as in the case of the Corner Station building, Rw = 6, then (and one uses Z = 0.20 as RMP did), then Vb = 0.092 W The actual loading will depend upon the dynamics of the structure. I think it's safe to say that some sort of restraint against large motion of the stacks may be required. In the interim, a provisional design factor of 0.10 W is OK.

Dennis

----- End Included Message -----

PART A: BUILDING CODES AND STRUCTURAL DYNAMICS

21.1 *UNIFORM BUILDING CODE* (UNITED STATES), 1994

21.1.1 Base Shear

The 1990 edition of the recommendations of the Structural Engineers Association of California, incorporated in the 1994 *Uniform Building Code* (UBC), specify the base shear as

$$V_b = C_s W \tag{21.1.1}$$

where W is the total dead load, and applicable portions of other loads, and the seismic coefficient,

$$C_s = \frac{C_e}{R_w} \tag{21.1.2}$$

This coefficient corresponding to $R_w = 1$ is called the elastic seismic coefficient:

$$C_e = ZIC \tag{21.1.3}$$

C_e is the product of three factors:

1. Seismic zone factor $Z = 0.4$ for zone 4, 0.3 for zone 3, 0.2 for zone 2A, 0.15 for zone 2B, 0.075 for zone 1, and zero for zone 0; the United States is divided into six zones (Fig. 21.1.1).
2. Importance factor $I = 1.0$ or 1.25. For most structures $I = 1$, but for "essential facilities" and "hazardous facilities" $I = 1.25$.
3. The numerical coefficient C is defined as

   $$C = \frac{1.25S}{T_1^{2/3}} \leq 2.75 \tag{21.1.4}$$

   where T_1 is the fundamental natural vibration period of the structure in seconds; and the site coefficient $S = 1.0, 1.2, 1.5$, and 2.0 for soil profiles S_1, S_2, S_3, and S_4, respectively, defined in the code. These coefficients account for local soil effects on earthquake ground motion, a topic not covered in this book.

For the fundamental natural period of vibration the code provides the formula

$$T_1 = 2\pi \left[\frac{\sum_{i=1}^{N} w_i u_i^2}{g \sum_{i=1}^{N} F_i u_i} \right]^{1/2} \tag{21.1.5}$$

where w_i is the weight at the ith floor, and u_i are the floor displacements due to static application of a set of lateral forces F_i at floor levels $i = 1, 2, \ldots, N$ in an N-story

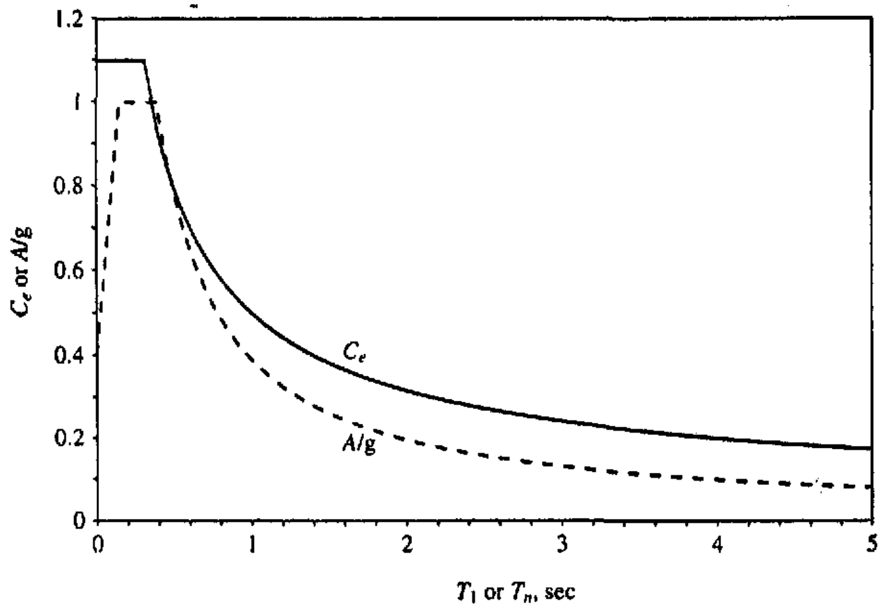

Figure 21.1.2 *UBC* (1994): elastic ($R_w = 1$) seismic coefficient C_e for $Z = 0.4$, $I = 1$, $S = 1$; and pseudo-acceleration A/g for $Z = 0.4$.

21.1.2 Lateral Forces

The distribution of lateral forces over the height of the building is to be determined from the base shear in accordance with the formula for the lateral (or horizontal) force at the jth floor:

$$F_j = (V_b - F_t)\frac{w_j h_j}{\sum_{i=1}^{N} w_i h_i} \tag{21.1.7}$$

with the exception that the force at the top floor (or roof) computed from Eq. (21.1.7) is increased by an additional force, the top force:

$$F_t = \begin{cases} 0 & T_1 \leq 0.7 \\ 0.07 T_1 V_b & 0.7 < T_1 < 3.6 \\ 0.25 V_b & T_1 \geq 3.6 \end{cases} \tag{21.1.8}$$

where h_j = height of the jth floor above the base. These lateral forces are shown in Fig. 21.1.3.

21.1.3 Story Forces

The design values of story shears, story overturning moments, and element forces are determined by static analysis of the building subjected to the lateral forces defined by the foregoing equations.

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