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Seismic Protection TF

R1.1

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Plan b' (bee prime) Summary

In line with ASCE7-10, estimate the most seismogenic area (S_S=3.4) and use the formula of 13.3.1 to set new design force values for S2 section 19.

ASCE (American Society of Civil Engineers) standard "7" appears to be the basis for most other seismic standards such as the UBC and IBC. ASCE7 underwent a significant revision in 2010 → Thus "ASCE7-10". The previous version was ASEC7-05.

ASCE7-10 13.3.1 Horizontal Force Formula

ASCE7-10 § 13.3.1 Equations 13.3-1, 13.3-2, and 13.3-3

$$F_p = \frac{0.4 \cdot a_p \cdot S_{DS} \cdot W_p}{\left(\frac{R_p}{I_p}\right)}\left(1 + 2\frac{z}{h}\right) \quad (1.)$$

a_p (component amplification factor) can vary from 1.00 to 2.50 (per ASCE7 tables)

R_p (component response modification factor) can vary from 1.00 to 12 (per ASCE7 tables)

z Eq. height in building at point of attachment of with respect to the base of the building.

h Average roof height of building with respect to the base of the building.

z/h max value is 1, min is ~0

F_p minimum : $F_p = 1.6 \cdot S_{DS} \cdot I_p \cdot W_p \quad (2.)$

F_p maximum: $F_p = 0.3 \cdot S_{DS} \cdot I_p \cdot W_p \quad (3.)$

S_{DS}: design, 5 percent damped, spectral response acceleration parameter at short periods as defined in §11.4.4 of ASCE7-10

$$S_{DS} = \frac{2}{3}S_{MS} = \frac{2}{3} \cdot F_a \cdot S_s = \frac{2}{3} \times (1.0) \times (3.4) = \frac{6.8}{3} \quad (4.)$$

S_{MS} = Maximum Considered Earthquake (MCE_R) spectral response acceleration parameter for short periods as defined in § 11.4.3 in ASCE 7-10.

ASCE7-10 13.3.1 Vertical Force Formula

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“The force (*Fp*) shall be applied independently in at least two orthogonal horizontal directions in combination with service loads associated with the component, as appropriate. ~~For vertically cantilevered systems, however, the force *Fp* shall be assumed to act in any horizontal direction~~. In addition, the component shall be designed for a concurrent vertical force $\pm 0.2S_{DS}W_p$”

ASCE7-05

Assumptions for § 19

S_S Mapped MCER, 5 percent damped, spectral response acceleration parameter at short periods as defined in § 11.4.3 ASCE 7-10 → **3.4**. The worst case value for S_S known among semiconductor manufacturing sites is adopted because changing equipment design for each delivery location is not realistic. Hsinchu, Taiwan: S_S=2.85; Taichung, **Taiwan: S_S=3.40**; Yokkaichi, Japan: S_S=1.87.

F_a Site coefficient defined in Table 11.4-1 → **1.0** (i.e., Site Class D, $S_S \geq 1.25$)

a_p Component amplification factor → **1.0** (i.e., manufacturing or process equipment in Table 13.6-1 of ASCE 7-10).

R_P Component response modification factor → **2.5** (i.e., manufacturing or process equipment in Table 13.6-1 of ASCE 7-10).

I_p Component importance factor → **1.0** for non-HPM **1.5** for HPM equipment

W_P Component operating weight → **Equipment Weight**

z/h Ratio of install to building height → **0.5** "The building structure is assumed to be single-fabrication-floor facility as major and typical. In single-fabrication-floor facility, for components of equipment supported by the structure of the main fabrication floor at halfway between base and roof height structure."

Japan TF Plan b' (bee prime) S2 Details

1. Horizontal loading for design of HPM equipment (S2 19.2.1) will increased from 94% to **109%** of equipment weight.
2. Horizontal loading for design of non HPM equipment (S2 19.2.2) will increase from 63% to **73%** of equipment weight.
3. Vertical loading for design of all equipment (S2 19.2.4) will change increase from 15% to **45%** of equipment weight
4. A note will be added to Section 19 suggesting users and suppliers agree to alternate values if eqiupment will be installed on an upper floor. S26 has Based on S26 19.5 and 19.5.1, the note needs to be added to Chapter 19 of S2.
5. Related Information 4 of S2 will be re-written in line with Chapter 13.3.1 (Seismic Design Force) of ASCE7-10

Derivation of §19, horizontal details

For HPM Equipment,

$$F_p = \frac{0.4 \cdot a_p \cdot S_{DS} \cdot W_p}{\left(\frac{R_p}{I_p}\right)}\left(1 + 2\frac{z}{h}\right) = \frac{0.4 \times 1.0 \times 6.8/3}{2.5 / 1.5} \times \left[1 + (2 \times 0.5)\right] = 1.09Wp \quad (5.)$$

For non-HPM Equipment,

$$F_p = \frac{0.4 \cdot a_p \cdot S_{DS} \cdot W_p}{\left(\frac{R_p}{I_p}\right)}\left(1 + 2\frac{z}{h}\right) = \frac{0.4 \times 1.0 \times 6.8/3}{2.5 / 1.0} \times \left[1 + (2 \times 0.5)\right] = 0.73Wp \quad (6.)$$

NOTE : In multi-fabrication-floor facility, z / h varies according to the supporting structure height z.

Assumptions Used for Above Derivation

1. Generally equipment is considered rigid. In this case a frequency response analysis is not necessary.
2. Generally equipment does not use vibration isolation. In case of the component supported by vibration isolators, the value of **a_p** should be changed to 2.5 (instead of 1.0) in Equation (1), Equation (2) and Equation (3) and should calculate the F_p for the each case.

Derivation of § 19, vertical details

Vertical Seismic Load — Based on § 13.3.1 in ASCE7-10, the nonstructural component should be designed for a concurrent force $\pm 0.2 S_{DS} W_P$.

$$F_{PV} = \pm 0.2 \cdot S_{DS} \cdot W_p = \pm 0.2 \times \frac{6.8}{3} \cdot W_p = \pm 0.45 W_p \qquad (7.)$$

Based on the current seismic design code for buildings in Taiwan and "Seismic Design and Construction Guideline for Building Equipment" published by Building Center of Japan (BCJ) the vertical design force for the nonstructural components and equipment is defined as follows:

For general sites and Taipei Basin in Taiwan, and for anywhere in Japan:	$F_{pv} = (1/2)\ F_{ph}$
For near-fault sites in Taiwan:	$F_{pv} = (2/3)\ F_{ph}$

Where, F_{ph} is the horizontal force, which is the same as F_p used in ASCE7-10.

HPM Equipment:	½(109% W_p) = 54.5% W_p	2/3(109% W_p) = 72.6% W_p
Non-HPM Equipment:	½ (73% W_p) = 36.5% W_p	2/3(73% W_p) = 48.7% W_p

Derivation of § 19, vertical details

1. Changes also needed to notes 113 and 114 (on assumptions underlying force values)
2. Add Oregon to list of areas surveyed for seismogenic potential – Pauline D. will look this up and provide it.
3. Need to further discuss merits of adding consideration of rigidity / flexibility of equipment to force criteria – may require advice on how to make the decision of equipment being considered rigid (or not).