Vibration Isolation and Seismic Control
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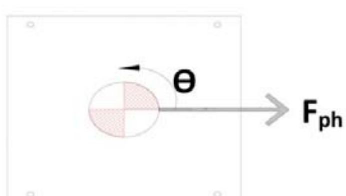
Computing the Horizontal Seismic Load Effects for Nonstructural Components as per ASCE 7-16

Introduction

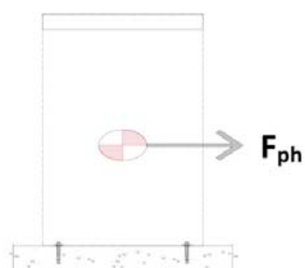
The current building code (2018 International Building Code) adopted the ASCE 7-16 Standard from the American Society of Civil Engineers (ASCE) for calculating the horizontal seismic load effects for nonstructural components. As a result, the analytical method for horizontal seismic demand determination must be validated in accordance with chapter 13 of ASCE 7-16.

Horizontal Seismic Load Effect (F_{ph})

Chapter 13 - Section 13.3 (Seismic Demands on Nonstructural Components) provides a static force approach for approximating dynamic loads from seismic events. Hence, equations 13.3-1, 13.3-2, & 13.3-3 in section 13.3 provide the guidelines for determining the horizontal seismic load effect (F_{ph}) for nonstructural components using the analytical method. Diagram below illustrates the $\mathbf{F_{ph}}$ about the center of gravity.



Plan View



Elevation View

ASCE 7-16, Equation 13.3-1

Equation 13.3-1 provides the horizontal seismic load effect for a value between the upper bound / maximum demand (equation 13.3-2) and the lower bound / minimum demand (equation 13.3-3).

$$F_p = \frac{0.4 * a_p * S_{DS} * W_p}{\left[\frac{R_p}{I_p}\right]} \left[1 + 2\frac{z}{h}\right]$$ …….(ASCE 7-16, Equation 13.3-1)

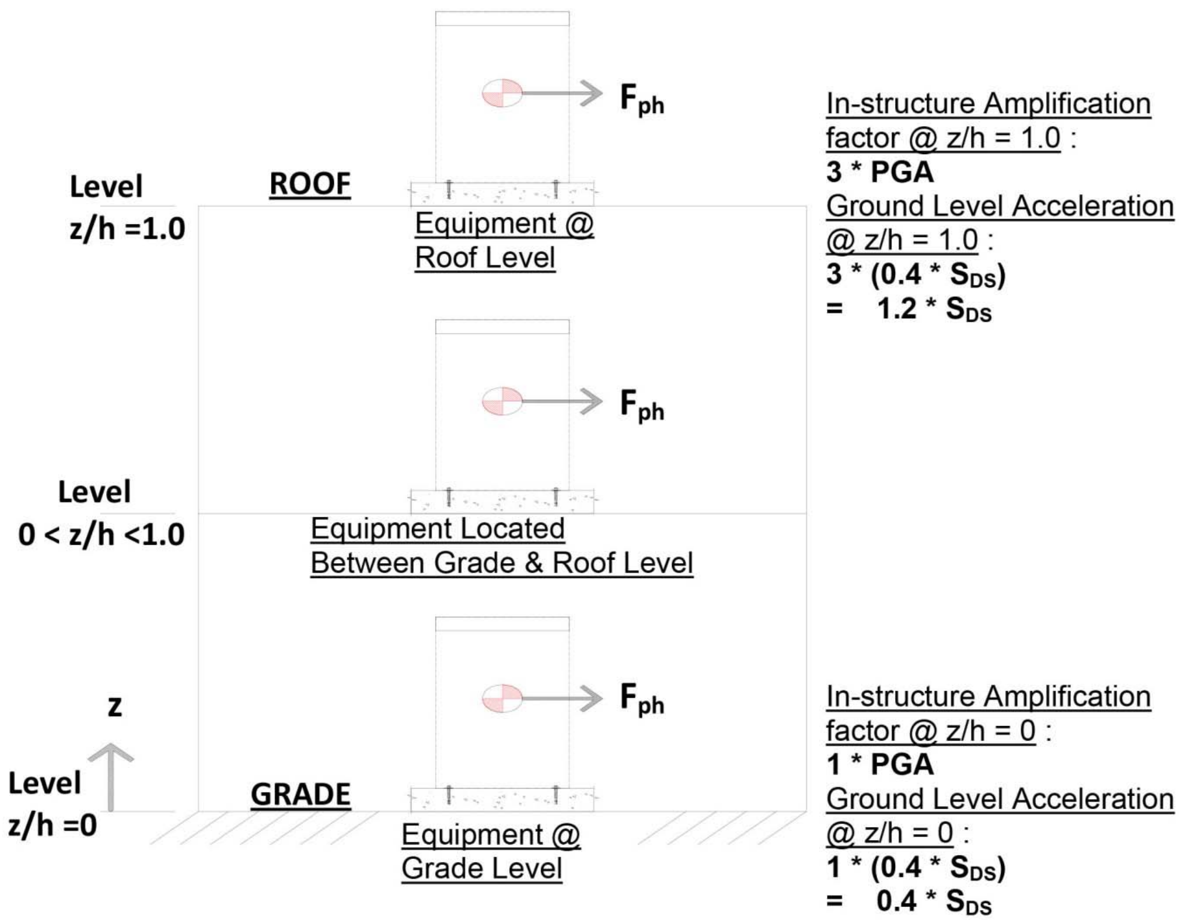
Where:
a_p *is the component amplification factor (value from ASCE 7-16, Table 13.6-1)*
I_p *is the component importance factor (Value from ASCE 7-16, section 13.1.3)*
W_p *is the component operating weight*
R_p *is the component response modification factor (value from ASCE 7-16, Table 13.6-1)*
z *is the height in structure of point of attachment of the component*
h *is the average roof height*
S_{DS} *is the design spectral response acceleration parameter at short periods as (value as per ASCE 7-16, section 11.4.4)*

In equation 13.3-1, there are several adjustment factors which are applied to the static force equation ***F = m * a*** *(Force = mass * acceleration)* to account for the dynamic behavior experienced by the nonstructural component in a seismic event. The adjustment factors include a tailored peak ground-level acceleration (PGA), an instructure amplification factor, a component amplification factor, a component response modification factor, and a component importance factor.

- Peak ground-level acceleration (PGA) adjustment: This adjustment is determined by setting T=0 seconds in equation 11.4-5. The baseline (or mapped) seismic acceleration is modified by a factor that addresses how different soil types impact the regional (mapped) acceleration. This factor is then reduced by 2/3 to bring the design loads down from those of a maximum possible earthquake to a more reasonable maximum baseline level. The result is "$\mathbf{S_{DS}}$".

Where:
$\mathbf{S_a = S_{DS}} \left(0.4 + 0.6\frac{T}{T_o}\right)$ …………….(ASCE 7-16, Equation 11.4-5)
$\mathbf{PGA = (0.4 * S_{DS})}$
and
S_a is the design spectral response acceleration

- In-structure amplification adjustment: The adjustment factor (1+2z/h) amplifies the peak ground-level acceleration depending on the elevation of the equipment with respect to the roof height of the structure in which it is located. The diagram below illustrates grade level elevation, roof level elevation, and in between grade and roof levels elevation. As per the illustration below, the in-structure amplification factor varies linearly from 1 at the base to a maximum of 3 at the roof.



- Component amplification factor adjustment: This adjustment factor found in table 13.6-1 distinguishes between rigid (natural period less than 0.06 seconds) and flexible (natural period greater than 0.06 seconds) nonstructural components. Therefore, an amplification factor (a_p) of 1 is assigned to rigid & a_p of 2.5 for flexible or flexibility mounted nonstructural components as per table 13.6-1. Hence, higher amplification factors are due to the proximity of the component's natural period to that of the building.

- Component response modification factor adjustment: This adjustment factor varies from a factor of 1.0 (R_p = 1.0) for nonstructural components that exhibit an ability to deform and remain within the elastic range under a seismic event to R_p = 12 for equipment that do not exhibit ductile response (deforms beyond its elastic limit during a seismic event). The larger the number, the more tolerant the component is in its ability to survive a seismic event.

- Component importance factor adjustment: This adjustment varies from for non-essential equipment to 1.5 for essential equipment or facilities (see section 13.1.3 for further details on how to classify essential equipment). This term effectively counters the 2/3 factor in the S_{DS} equation and brings you back to the worst case earthquake.

ASCE 7-16, Equation 13.3-2

Equation 13.3-2 provides the maximum $\mathbf{F_{ph}}$. This value caps the maximum horizontal seismic load effect at four times the peak ground-level acceleration.

$$\mathbf{F_{p,max} = 1.6 * S_{DS} * I_p * W_p} \text{ .... (ASCE 7-16, Equation 13.3-2)}$$

ASCE 7-16, Equation 13.3-3

Equation 13.3-3 provides the minimum $\mathbf{F_{ph}}$. This value caps the minimum horizontal seismic load at 75% of the peak ground-level acceleration.

$$\mathbf{F_{p,min} = 0.3 * S_{DS} * I_p * W_p} \text{ .... (ASCE 7-16, Equation 13.3-3)}$$

Overstrength Factor (Ω_o) (Applies ONLY to Concrete Anchors)

The horizontal force **(F_{ph})** from equation 13.3-1, 13.3-2, or 13.3-3 must be multiplied by the overstrength factor **(Ω_o)** when the nonstructural component is anchored to concrete as per

ASCE 7-16, Table 13.6-1. The result is best represented by equation 12.4-7. Ductile elements such as the steel restraint Housing need not be designed to resist these loads.

$$\mathbf{E_h = \Omega_o * F_{ph}} \text{ ……………………………… (ASCE 7-16, Equation 12.4-7)}$$

VISCMA is a non-profit association representing the manufacturers of seismic restraint, vibration isolation and noise control equipment. The primary objectives of the organization are to educate the construction industry on the proper use and application of vibration isolation and seismic restraint and to develop standards to continually improve the industry.

In partnership with FEMA and ASCE, VISCMA also publishes three Seismic Installation and Inspection Manuals designed to assist field personnel.

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