DESIGN SESIMIC FORCES

D2.9 – 3.1 Introduction:

The code based horizontal seismic force requirements for MEP systems and components are either calculated by the seismic restraint manufacturer as a part of the selection and certification process, or may be determined by the design professional of record for the MEP systems under consideration.

This is an informational section. It will discuss the code based horizontal seismic force demand equations and the variables that go into them. This discussion will provide a deeper understanding for the designer responsible for selecting the seismic restraints for MEP systems and their components and the nature of the seismic forces and the factors that affect them.

D2.9 – 3.2 Lateral Design Seismic Force [Sentence 4.1.8.17.(1)][1]:

The seismic force is a mass, or weight, based force, and as such is applied to the MEP component at its center of gravity. Keep in mind that the earthquake ground motion moves the base of the building first. Then the motion of the building will accelerate the MEP component through its supports and/or seismic restraints. The lateral seismic force acting on an MEP component will be determined in accordance with the following set of equations from NBCC 2005.

$$V_P = 0.3 F_a S_{a(0.2)} I_E S_P W_P \qquad \textbf{Equation 3-1}$$

Where:

V_P = the Lateral Design Seismic Force

F_a = the acceleration based site coefficient. Values for this coefficient are given in Table 3-1 based on the site class. Linear interpolation between these values is permitted.

[1] References in brackets [Sentence 4.1.8.17.(1)] apply to sections, tables, and/or equations in the National Building Code of Canada 2005.

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I_E = the Importance Factor for Earthquake Loads for the building. See Section D2.9 – 2.5 of this guide.

S_P = the horizontal force factor for the non-structural component and its anchorage to the building.

W_P = the weight of the non-structural component.

The value for S_P is computed in the following fashion.

$$S_P = \frac{C_P A_r A_x}{R_P}$$ **Equation 3-2**

Where:

C_P = the seismic coefficient for mechanical and electrical equipment. These values are given per component category in Table 3-2.

A_r = the response amplification factor used to account for the type of attachment of the mechanical or electrical component to the building listed by component category in Table 3-2.

A_x = the amplification factor at the elevation of the component attachment point in the building. It is used to account for the increasing flexibility of the building from grade level to roof level.

R_P = the element or component response modification factor listed by component category in Table 3-2.

A_x is computed as follows.

$$A_x = \left(1 + 2\frac{h_x}{h_n}\right)$$ **Equation 3-3**

Where:

h_x = the elevation of the attachment point to the structure of the non-structural component.

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h_n = the elevation of the roof line.

The values for S_P must remain within the following limits.

$$0.7 \leq S_P \leq 4.0 \qquad \text{Equation 3-4}$$

Table 3-1; Acceleration Based Site Coefficient, F_a [Table 4.1.8.4]

Site Class	Spectral Response Acceleration Value at 0.2 Second (Linear Interpolation Is Permitted)				
	$S_{a(0.2)} \leq 0.25$	$S_{a(0.2)} = 0.50$	$S_{a(0.2)} = 0.75$	$S_{a(0.2)} = 1.00$	$S_{a(0.2)} \geq 1.25$
A	0.7	0.7	0.8	0.8	0.8
B	0.8	0.8	0.9	1.0	1.0
C	1.0	1.0	1.0	1.0	1.0
D	1.3	1.2	1.1	1.1	1.0
E	2.1	1.4	1.1	0.9	0.9
F	These values to be determined by site response analysis.				

D2.9 – 3.3 Basis of Design for NBCC 2005 [Sentences 4.1.3.1.(1a), 4.1.3.2.(4), 4.1.3.2.(6), 4.1.3.2.(7), and 4.1.3.2.(8) and Table 4.1.3.2]:

The design of seismic restraints in the NBCC 2005 is based on the Ultimate Limit State. This limit state is used for design when life safety is at issue to prevent building or system collapse. This design basis along with the prescribed loads for earthquake design will produce results which are consistent with LRFD design techniques. Therefore; LRFD allowable loads may be used for the design and selection of seismic restraints for MEP components.

D2.9 – 3.4 Summary:

This section has provided an insight into the way in which the seismic design forces for MEP systems and components are to be computed. It is generally not necessary for a designer to

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actually run the computations for the seismic design forces. These forces are normally computed by the manufacturer of the seismic restraint devices as part of the selection and certification process to ensure that the proper components are selected per the code and the specification.

Table 3-2; Seismic Coefficient, Response Amplification Factor, and Response Modification Factor NBCC 2005 [Table 4.1.8.17]

Category	Non-Structural Component	C_P	A_r	R_P
7	Suspended light fixtures with independent vertical support	1.00	1.00	2.50
11	Machinery, fixtures, equipment, ducts, and tanks (including contents):	-----	------	------
	That are rigidly connected.	1.00	1.00	1.25
	That are flexible or flexibly connected.	1.00	2.50	2.50
12	Machinery, fixtures, equipment, ducts, and tanks (including contents) containing toxic or explosive materials, materials having a flash point below 38°C or firefighting fluids:	-----	------	------
	That are rigidly connected.	1.50	1.00	1.25
	That are flexible or flexibly connected.	1.50	2.50	2.50
13	Flat bottom tanks (including contents) that are attached directly to the floor at or below grade within a building.	0.70	1.00	2.50
14	Flat bottom tanks (including contents) that are attached directly to the floor at or below grade within a building that contain toxic or explosive materials, materials that have a flash point below 38°C or firefighting materials.	1.00	1.00	2.50
15	Pipes, ducts, cable trays (including contents)	1.00	1.00	3.00
16	Pipes, ducts, cable trays (including contents) containing toxic or explosive materials.	1.50	1.00	3.00
17	Electrical cable trays, bus ducts, conduits.	1.00	2.50	5.00
18	Rigid components with ductile material and Connections.	1.00	1.00	2.50
19	Rigid components with non-ductile material or Connections.	1.00	1.00	1.00
20	Flexible components with ductile material and Connections.	1.00	2.50	2.50
21	Flexible components with non-ductile material or Connections.	1.00	2.50	1.00

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