Appendix 4

2003 International Building Code

As defined in the 2003 International Building Code, Chapter 16, Section 1621, the seismic horizontal force, F_p, shall be calculated per Section 9.6 of ASCE 7:

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

Except that: F_p shall not be less than $0.3\ S_{DS}\ I_p\ W_p$ and need not be more than $1.6\ S_{DS}\ I_p\ W_p$.

Where:

F_p = Seismic Force Level

a_p = Amplification Factor (Table 9.6.3.2 ASCE 7)

R_p = Component Response Modification Factor, (Table 9.6.3.2 ASCE 7) which varies from 1.0 to 5.0

= 1.0 for shallow embedded anchors where the embedment length-to-diameter ratio is less than 8. (Section 9.6.1.6.1 ASCE 7) i.e. a 1/2" diameter anchor embedded less than 4" in concrete.

I_p = Importance Factor (Section 9.6.1.5 ASCE 7)

= 1.5 for Life-safety components required to function after an earthquake, buildings containing hazardous or flammable material, and for storage racks open to the general public.

= 1.0 for all other occupancies

S_{DS}= Design spectral response acceleration at short period several factors: Seismic zone, Soil Property Type, and Distance from known fault. (Section 9.4.1.2 ASCE 7)

Where,

S_{DS} = (2/3) S_{MS} (Section 9.4.1.2.5 ASCE 7)

S_{MS} = $F_a S_S$ Maximum considered spectral response acceleration for short period (Section 9.4.1.2.4 ASCE 7)

F_a = Site coefficient, which is a combination of the Mapped spectral Acceleration S_S and Site Class (Table 9.4.1.2.4a ASCE 7)

S_S = Mapped Spectral Acceleration for short periods (Section 9.4.1.2 ASCE 7)

Site Class = Soil type, "A thru F" (Table 9.4.1.2 ASCE 7)

z = Element or component attachment elevation with respect to grade. Note: (z) shall not be taken less than 0.0

h = Average structure roof elevation with respect to grade.

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Example: Deeply Embedded Anchors

In this example a cable tray system is suspended on the 1st floor of a 40-foot tall, 2-story surgical center. The cable tray is actually suspended from the 2nd floor, which has an elevation of 20 feet above grade. The location of the surgical center is in Memphis, TN with a rock soil profile.

$$F_p = \frac{0.4 a_p S_{DS} I_p}{R_p} (1 + 2 \bullet \frac{z}{h}) W_p$$

a_p = (2.5) for a cable tray (Table 9.6.3.2 ASCE 7)

R_p = (5.0) for a cable tray system anchored with deep embedded anchors (Table 9.6.3.2 ASCE 7)

I_p = (1.5) for an essential facility in Seismic Use Group III which will require continued use following an earthquake (Section 9.6.1.5 ASCE 7)

S_{DS} = (0.4) extended calculations shown below (Section 9.4.1.2 ASCE 7)

Where,

$S_{DS} = (2/3)\ S_{MS} = (0.4)$ (Section 9.4.1.2.5 ASCE 7)

$S_{MS} = F_a S_S = (0.6)$ (Section 9.4.1.2.4 ASCE 7)

F_a = (1.0) using straight line interpolation of the Mapped spectral Acceleration (S_S) and Site Class (Table 9.4.1.2.4a ASCE 7)

S_S = (0.6) Mapped Spectral Acceleration for short periods (Section 9.4.1.2 ASCE 7)

Site Class = B for Rock (Table 9.4.1.2 ASCE 7)

z = 20 feet, for the elevation of the floor used to support the cable tray

h = 40 feet, for the average elevation of the structure roof

$$F_p = \frac{0.4(2.5)(0.40)(1.5)}{5.0} (1 + 2 \bullet \frac{20}{40}) W_p = 0.24 W_p = 0.24g$$

Check if value falls within the allowed limits:

F_p shall not be taken less than, $0.3 S_{DS} I_p W_p = 0.3(.40)(1.5) W_p = .18g$

F_p shall not be greater than, $1.6 S_{DS} I_p W_p = 1.6(.40)(1.5) W_p = 0.96g$

0.24g > 0.18g, thus allowing the use of 0.24g

To convert this F_p from a strength design, as just determined from the building code, to an **A**llowable **S**tress **D**esign (ASD) used in the Cooper B-Line Seismic Restraints Manual divide by 1.4.

$$F_p = \frac{0.24g}{1.4} = 0.17g \text{ (ASD)}$$

0.17g is the **A**llowable **S**tress **D**esign Seismic Load Factor determined from 2003 International Building Code.

Special Note: Installations using concrete anchors installed with an embedment length-to-diameter ratio of less than 8, also referred to as shallow embedment anchors, have an adjusted Component Response Factor. The adjusted factor being R_p = 1.5.

Example Two: Shallow Embedded Anchors

In this example a cable tray system is suspended on the 1st floor of a 40-foot tall, 2-story surgical center in California. The cable tray is actually suspended from the 2nd floor, which has an elevation of 20 feet above grade. The location of the surgical center is in seismic zone 4 with a rock soil profile, however shallow embedded anchors (length-to-diameter ratio of less than 8) are used at brace locations.

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

a_p = (2.5) for a cable tray (Table 9.6.3.2 ASCE 7)

R_p = (1.5) for a cable tray system anchored with shallow embedded anchors (Section 9.6.1.6.1 ASCE 7)

I_p = (1.5) for an essential facility in Seismic Use Group III which will require continued use following an earthquake (Section 9.6.1.5 ASCE 7)

S_{DS} = (0.4) extended calculations shown below (Section 9.4.1.2 ASCE 7)

Where,

S_{DS} = (2/3) S_{MS} = (0.4) (Section 9.4.1.2.5 ASCE 7)

S_{MS} = $F_a S_S$ = (0.6) (Section 9.4.1.2.4 ASCE 7)

F_a = (1.0) using straight line interpolation of the Mapped spectral Acceleration (S_S) and Site Class (Table 9.4.1.2.4a ASCE 7)

S_S = (0.6) Mapped Spectral Acceleration for short periods (Section 9.4.1.2 ASCE 7)

Site Class = B for Rock (Table 9.4.1.2 ASCE 7)

z = 20 feet, for the elevation of the floor used to support the cable tray

h = 40 feet, for the average elevation of the structure roof

$$F_p = \frac{0.4(2.5)(0.40)(1.5)}{1.5}\left(1 + 2 \bullet \frac{20}{40}\right) W_p = 0.80 W_p = 0.80g$$

Check if value falls within the allowed limits:

F_p shall not be taken less than, $0.3S_{DS}I_pW_p = 0.3(.40)(1.5)W_p = .18g$

F_p shall not be greater than, $1.6S_{DS}I_pW_p = 1.6(.40)(1.5)W_p = .96g$

$0.96g > 0.80g > 0.18g$, thus allowing the use of 0.80g

To convert F_p from a strength design, as just determined from the building code, to an **A**llowable **S**tress **D**esign (ASD) as used in the Cooper B-Line Seismic Restraints Manual divide by 1.4.

$$F_p = \frac{0.80g}{1.4} = 0.57g \text{ (ASD)}$$

0.57g is the **A**llowable **S**tress **D**esign Seismic Load Factor determined from 2003 International Building Code.

1999 Standard Building Code

As defined in the 1999 Standard Building Code, Chapter 16, Section 1607.6.4, the seismic horizontal force, F_p, may be calculated using the following formula:

$$F_p = A_v C_c P a_c W_c$$

Where,

F_p = Seismic Force Level

A_v = Peak velocity-related acceleration (Section 1607.1.5)

C_c = Seismic coefficient for mechanical, electrical components and systems (Table 1607.6.4A)

P = Performance criteria factor (Table 1607.6.4A)

a_c = Attachment amplification factor (Table 1607.6.4B)

W_c = Operating weight of the mechanical, electrical component of system

Example

This example is for a primary cable tray system suspended in a surgical center in Memphis, TN.

$$F_p = A_v C_c P a_c W_c$$

A_v = (0.20) for the Memphis, TN area (Table 1607.1.5A)

C_c = (2.0) for a primary cable tray system (Table 1607.6.4A)

P = (1.5) for a primary cable tray system (Table 1607.6.4A)

- Group III for an essential Surgery or Emergency Treatment Facility (Table 1607.1.6)

a_c = Always (1.0) when using a fixed connection type (Table 1607.6.4B)

$$F_p = 0.2(2.0)(1.5)(1.0)W_c = .6W_c = .6g$$

To convert F_p from a strength design, as just determined from the building code, to an **A**llowable **S**tress **D**esign (ASD) as used in the Cooper B-Line Seismic Restraints Manual divide by 1.4.

$$F_p = \frac{0.60g}{1.4} = 0.43g \text{ (ASD)}$$

0.43g is the **A**llowable **S**tress **D**esign Seismic Load Factor determined from 1999 Standard Building Code.

1997 Uniform Building Code

As defined in the 1997 Uniform Building Code, Chapter 16, Section 1632, the seismic horizontal force, F_p, may be calculated using the following formula:

$$F_p = \frac{a_p C_a I_p}{R_p}\left(1 + 3 \cdot \frac{h_x}{h_r}\right)W_p$$

Except that: F_p shall not be less than $0.7\ C_a\ I_p\ W_p$ and need not be more than $4\ C_a\ I_p\ W_p$.

Where:

F_p = Seismic Force Level

a_p = Amplification Factor (Table 16-O)

R_p = Component Response Modification Factor (Table 16-O)
= 3.0 for electrical, mechanical and plumbing equipment and associated conduit, ductwork and piping.
= 1.5 for installations using concrete anchors with an embedment-to-diameter ratio less than 8.
i.e. a 1/2" diameter concrete anchor with an embedment of less than 4" inches.

I_p = Importance Factor (Table 16-K)
= 1.5 for Essential facilities such as Hospitals, Fire Stations, Police Stations, Aviation Control Towers, etc. consult Table 16-K in UBC for a detailed list.
= 1.0 for most other occupancies

C_a = Seismic Coefficient. This is an accumulation of several factors: (Table 16-Q) Seismic Zone (Table 16-I), Soil Property Type (Table 16-J), and Distance from known faults. (Table 16-S, and Table 16-U)

h_x = Element or component attachment elevation with respect to grade.
Note: h_x shall not be taken less than 0.0

h_r = Structure Roof Elevation with respect to grade.

Example One, Deeply Embedded Anchors:

Cable tray system is suspended on the 1st floor of a 40-foot tall, 2-story surgical center in California. The cable tray is actually suspended from the bottom of the 2nd floor, which has an elevation of 20 feet above grade. Location of the surgical center is in seismic zone 4 with a rock soil profile.

$$F_p = \frac{a_p C_a I_p}{R_p}(1 + 3 \cdot \frac{h_x}{h_r})W_p$$

a_p = 1.0 from Table 16-O

C_a = .40Na from Table 16A-Q, which is combination of Seismic Zone factor and Soil profile type
Where,
Z = .40 for seismic zone 4 applications (Table 16-I)
Soil Profile Type = S_B for rock sediment (Table 16-J)
Seismic Source Type = B for faults other than Type A & C (Table 16-U)
Na = 1.0, for 5 km from known seismic source (Table 16-S)

I_p = (1.5) for an essential surgery and emergency treatment area (Table 16-K)

R_p = (3.0) for cable trays supported with deep embedded anchors (Table 16-O)

h_x = 20 feet, for the elevation of the floor used to support the cable tray

h_r = 40 feet, for the elevation of the structure roof

$$F_p = \frac{(1.0)((0.40(1.0))(1.5)}{3.0}(1 + 3 \cdot \frac{20}{40})W_p = 0.50W_p = 0.50g$$

Check if value falls within limits:

F_p shall not be taken less than, $0.7C_aI_pW_p = 0.7(.40)(1.5)W_p = .42g$

F_p shall not be greater than, $4.0C_aI_pW_p = 4.0(.40)(1.5)W_p = 2.4g$

2.4g > .5 > 0.42g Therefore allowing the use of 0.50g

To convert this F_p from a strength design, as just determined from the building code, to an **A**llowable **S**tress **D**esign (ASD) used in the Cooper B-Line Seismic Restraints Manual divide by 1.4.

$$F_p = \frac{0.50g}{1.4} = 0.36g \text{ (ASD)}$$

0.36g is the **A**llowable **S**tress **D**esign Seismic Load Factor determined from 1997 Uniform Building Code.

Special Note: Installations using concrete anchors installed with an embedment length-to-diameter ratio of less than 8, also referred as shallow embedment anchors, have an adjusted Component Response Factor being R_p = 1.5.

Example Two, Shallow Embedded Anchors:

In this example a cable tray system is suspended on the 1st floor of a 40-foot tall, 2-story surgical center in California. The cable tray is actually suspended from the 2nd floor, which has an elevation of 20 feet above grade. Location of the surgical center is in seismic zone 4 with a rock soil profile, however shallow embedment anchors (length-to-diameter ratio of less than 8) are used at brace locations.

$$F_p = \frac{a_p C_a I_p}{R_p}(1 + 3 \cdot \frac{h_x}{h_r})W_p$$

a_p = 1.0 from Table 16-O

C_a = (.40Na) which is combination of seismic zone factor and soil profile type from (Table 16-Q)

Where,

Z = .40 for seismic zone 4 applications (Table 16-I)

Soil Profile type = S_B for rock sediment (Table 16-J)

Seismic Source Type = B for faults other than Type A & C (Table 16-U)

Near Source Factor = 1.0 for 5 km from known seismic source (Table 16-S)

I_p = (1.5) for an essential surgery and emergency treatment areas (Table 16-K)

R_p = (1.5) for cable trays supported with shallow embedded anchors (Table 16-O)

h_x = 20 feet, for the elevation of the floor used to support the cable tray

h_r = 40 feet. for the elevation of the structure roof

$$F_p = \frac{(1.0)((0.40(1.0))(1.5)}{1.5}(1 + 3 \bullet \frac{20}{40})W_p = 1.0W_p = 1.0g$$

Check if value falls within limits:

F_p shall not be taken less than, $0.7C_aI_pW_p = 0.7(.40)(1.5)W_p = .42g$

F_p shall not be greater than, $4.0C_aI_pW_p = 4.0(.40)(1.5)W_p = 2.4g$

2.4g > 1.0g > 0.42g Therefore allowing the use of 1.0g

To convert this F_p from a strength design, as just determined from the building code, to an **A**llowable **S**tress **D**esign (ASD) used in the Cooper B-Line Seismic Restraints Manual divide by 1.4.

$$F_p = \frac{1.0g}{1.4} = 0.71g \text{ (ASD)}$$

0.71g is the **A**llowable **S**tress **D**esign Seismic Load Factor determined from 1997 Uniform Building Code for shallow embedment anchors.

1999 BOCA (Building Officials and Code Administrators)

As defined in the 1999 BOCA, Chapter 16, Section 1610.6.4, the seismic horizontal force, F_p, may be calculated using the following formula:

$$F_p = A_v C_c P a_c W_c$$

Where,

F_p = Seismic Force Level

A_v = Peak velocity-related acceleration (Section 1610.1.3)

C_c = Seismic coefficient for mechanical, electrical components and systems (Table 1610.6.4(1))

P = Performance criteria factor (Table 1610.6.4(1))

a_c = Attachment amplification factor (Table 1610.6.4(2))

W_c = Operating weight of the mechanical, electrical component of system

Example

This example is for a primary cable tray system suspended in a surgical center in St. Louis, MO.

$$F_p = A_v C_c P a_c W_c$$

A_v = (0.15) for the St. Louis, MO area (Figure 1610.1.3(1))

C_c = (2.0) for a primary cable tray system (Table 1610.6.4(1))

P = (1.5) for a primary cable tray system (Table 1610.6.4(1))

- Group III for an essential Surgery or Emergency Treatment Facility (Table 1610.1.6)

a_c = Always (1.0) when using a fixed connection type (Table 1610.6.4(2))

$$F_p = 0.15(2.0)(1.5)(1.0)W_c = .45W_c = .45g$$

To convert F_p from a strength design, as just determined from the building code, to an **A**llowable **S**tress **D**esign (ASD) as used in the Cooper B-Line Seismic Restraints Manual divide by 1.4.

$$F_p = \frac{0.45g}{1.4} = 0.32g \text{ (ASD)}$$

0.32g is the **A**llowable **S**tress **D**esign Seismic Load Factor determined from the 1999 BOCA.

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Date:	Page No.	Sheet Number:
6 - 2 - 06	155	___ of ___

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