Seismic Bracing of Non-Structural Systems

Plumbing and Fire Protection

Haiti 2010
Magnitude 7.0

Chile 2010
Magnitude 8.8
IBC – International Building Code

• Defers to ASCE 7 (American Society of Civil Engineers)
• ASCE updated every 5 years
• 2005 – Change in focus from evacuation to continuous operation.
• Need for seismic based on:
  • Occupancy
  • Component/System importance
  • Likelihood of an earthquake
Determining the Seismic Design Category

1. Building Importance Factor (IP)
   - What is the building being used for?
   - Ranges from 1.0 to 1.5
2. Building Occupancy Category
   - Ranges from I to IV
3. SDS/Ss Factors
   - Ground motion
   - Design Spectral Response Acceleration at Short Period (Anticipated Ground Motion Factor at 1/5 of a Second)
   - Design Spectral Response at Long Period (Ss*1/5)
4. Soil Site Class
   - Hard rock vs. Loose soil
   - Ranges from Class A-F
Determination of need

Determination of the Seismic Design Category (SDC) can be performed as follows:
1. Consult S-001 General notes section
2. Design Spectral Response Acceleration (SDS) value and the Building Occupancy Category

<table>
<thead>
<tr>
<th>Value of $S_{DS}$</th>
<th>Occupancy Category</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I or II</td>
</tr>
<tr>
<td>$S_{DS} &lt; 0.167$</td>
<td>A</td>
</tr>
<tr>
<td>$0.167 \leq S_{DS} &lt; 0.33$</td>
<td>B</td>
</tr>
<tr>
<td>$0.33 \leq S_{DS} &lt; 0.50$</td>
<td>C</td>
</tr>
<tr>
<td>$0.50 \leq S_{DS}$</td>
<td>D</td>
</tr>
</tbody>
</table>
Determining Occupancy Category

ASCE0705 Table 1-1 Occupancy Categories

• I - Agriculture Facilities, Certain Temporary Facilities, Minor Storage Facilities
• II - All buildings and other structures except those in I,III, or IV
• III - Buildings that represent a substantial hazard to human life in the event of failure
• IV- Buildings designated as essential facilities including but not limited to
Determining SDS

ASCE Chapter 11, Section 11.4 Seismic Ground Motion Values.

- Mapped Acceleration Parameters –
  - Ss and S1 are determined from the 0.2 and 1.0s spectral response acceleration.
  - These parameters are shown in Chapter 22 Seismic Ground Motion and Long-Period Transition Maps Figure 22-1 through Figure 22-14

- Site Class –
  - Classified as Site Class A, B, C, D, E, or F.
  - This can be explained in Chapter 20 ASCE.
Seismic Design Category

Example:
• NY City Ground Motions range from a .20 to a .35 according to the USGS
• Typical apartment building:
  • 30 story
  • 10 apartments per floor
  • 900 occupancy count

<table>
<thead>
<tr>
<th>Value of Sds</th>
<th>Occupancy Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 0.167</td>
<td>I or II</td>
</tr>
<tr>
<td>0.167-&lt;0.33</td>
<td>A</td>
</tr>
<tr>
<td>0.33-&lt;0.50</td>
<td>B</td>
</tr>
<tr>
<td>0.50 and greater</td>
<td>D</td>
</tr>
<tr>
<td>Value of S1</td>
<td></td>
</tr>
<tr>
<td>0.75 and greater</td>
<td>E</td>
</tr>
</tbody>
</table>
Breaking down the IBC (International Building Code)

• IBC defers to ASCE 7-05 for IBC 2009 and ASCE 07-10 for the IBC 2012
• ASCE 7 defines the need for seismic bracing of non structural items based on the component’s importance and the structure’s occupancy category as well as the ground motion factors for the area
• High-rise structures are usually automatic occupancy category 4 so even renovations may require bracing regardless of the structural type
• Regardless of the building’s ability to resist seismic loads, supported and braced plumbing systems will require submittal calculations.
• Fire protection systems will need to comply with NFPA 13 requirements. The IFC is adopted along with the IBC and section 903.3.1.1 of the IFC states automatic sprinkler system are to be installed in accordance with NFPA 13 requirements
## Seismic Requirements

### International Building Code 2006/2009

**Conduit and pipe Bracing** shall be based on the following table:

<table>
<thead>
<tr>
<th>Ip</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>3&quot; and Larger</td>
<td>3&quot; and Larger</td>
<td>3&quot; and Larger</td>
</tr>
<tr>
<td>1.5</td>
<td>None</td>
<td>None</td>
<td>3&quot; and Larger</td>
<td>3&quot; and Larger</td>
<td>3&quot; and Larger</td>
<td>3&quot; and Larger</td>
</tr>
</tbody>
</table>

(ASCE 7-05 13.6.8 w/ Additional Exemptions From 13.1.4)

**Trapeze Supported Pipe, Duct etc. Bracing** shall be based on the following table:

<table>
<thead>
<tr>
<th>Ip</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>10lbs/ft and Greater</td>
<td>10lbs/ft and Greater</td>
<td>10lbs/ft and Greater</td>
</tr>
<tr>
<td>1.5</td>
<td>None</td>
<td>None</td>
<td>10lbs/ft and Greater</td>
<td>10lbs/ft and Greater</td>
<td>10lbs/ft and Greater</td>
<td>10lbs/ft and Greater</td>
</tr>
</tbody>
</table>

(ASCE 7-05 13.6.8 w/ Additional Exemptions From 13.1.4)

Per ASCE 7
What Makes a Good Specification

• Seismic Design Category
• System Importance (IP) Factor
  – IP > 1.5
  – Power and emergency power, med gas, communications
• Building Importance Factor (IP)
• Occupancy Category
• Ss factor if available
• Requires OSHPD Approved Seismic devices and systems
• Requires QA functions/inspection criteria
• Acceptable Current non redundant manufacturers
  – example:(VMC, Vibration Mountings and Controls, Amber Booth and Korfund Dynamics are all one company)
• Vibration isolation
  – List vibration frequencies of each piece of equipment
  – State “vibration isolation should meet the vibration of the piece of equipment”
Design considerations

• Space: Rigid vs. Cable if Rigid can be used it should be due to space and ease of coordination
• Structure: As you will see in the next slide Concrete is no friend to an earthquake
• Allowable anchor embedment depth
“Cracked Concrete Approved”

All anchors used in SUPPORTING and BRACING need to be approved by the ICC (International Code Council) in accordance with ACI 318

THIS IS VERY IMPORTANT

“NO DROP IN STYLE ANCHORS OVERHEAD”
“NO POWDER ACTUATED ANCHORS”
TYPES OF MEP BRACES – Rigid or Cable
NOT Fire Protection
Types of Seismic Braces

**Rigid Brace**
- One Seismic Brace is required per location.
- Most common type of Seismic Brace
- Preferred method of bracing due to decreased material and labor costs vs. cable bracing
- **Maximum Brace Length for Strut is 9ft - 6in (l/r = 200)**
- Cannot be used with Spring Hangers or Vibration Isolation
Seismic Brace Basics

Lateral (Transverse) Braces:
Prevent Movement **Perpendicular** to the Pipe Structure

- Rod Stiffener (if required)
- Cross Bolt Spacer (for Clevis Hangers)

Fastener or Structural Attachment
Upper Brace Attachment
Lateral Brace Assembly
Brace Material
Lower Attachment to Hanger Rod

(Expansion Type Anchor or Concrete Insert)
Seismic Brace Basics

Lateral (Transverse) Braces: Trapeze Hung Pipe
Prevent Movement Perpendicular to the Pipe
Seismic Brace Basics

**Longitudinal Braces:**
Prevent **Axial** Movement **Parallel** to the Pipe

- **Attachment Directly to Pipe**
- **Rod Stiffener** (if required)
- **Structure**
- **Pipe Hanger**
- **Fastener or Structural Attachment**
- **Upper Brace Attachment**
- **Brace Material**
- **Lower Brace Attachment**

(Expansion Type Anchor or Concrete Insert)
Seismic Brace Basics

**Longitudinal Braces**: Prevent *Axial* Movement *Parallel* to the Pipe - Single Hung Pipe

PIPE USED AS BRACE MATERIAL
Seismic Brace Basics

**Longitudinal and Lateral combination Braces**: Prevent *Axial* Movement *Parallel and Perpendicular* to the Pipe - Trapeze Hung Pipe

![Image of Seismic Brace Basics](image-url)
Types of Seismic Braces

Cable Brace
- Two Seismic Braces are required at each location
- Provides Flexibility for Vibration Isolation & Spring Hung Piping and Longer Brace Lengths
- Increased cost of material and labor vs. rigid bracing, but sometimes the only choice available
- Components Available for Cable Sizes: 1/8”, 3/16” and 1/4”

Example of Upper Sway Brace Attachment

Example of Lower Sway Brace Attachment
Rod stiffeners are required to complete the triangulation of carrying the suspended load.
Rod Stiffener   Guideline Sheet

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<table>
<thead>
<tr>
<th>ROD SIZE</th>
<th>MAX. ROD LENGTH WITHOUT STIFFENER</th>
<th>MAX. SPACING BETWEEN TOLCO FIG. 98</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8&quot;</td>
<td>19&quot;</td>
<td>13&quot;</td>
</tr>
<tr>
<td>1/2&quot;</td>
<td>26&quot;</td>
<td>16&quot;</td>
</tr>
<tr>
<td>5/8&quot;</td>
<td>31&quot;</td>
<td>23&quot;</td>
</tr>
<tr>
<td>3/4&quot;</td>
<td>37&quot;</td>
<td>28&quot;</td>
</tr>
<tr>
<td>7/8&quot;</td>
<td>43&quot;</td>
<td>33&quot;</td>
</tr>
<tr>
<td>1&quot;</td>
<td>50&quot;</td>
<td>38&quot;</td>
</tr>
<tr>
<td>1 1/4&quot;</td>
<td>62&quot;</td>
<td>43&quot;</td>
</tr>
</tbody>
</table>

NOTES:
1.) ROD STIFFENERS ARE REQUIRED ONLY ON HANGER AND TRAPEZE ASSEMBLIES THAT HAVE SEISMIC BRACING ATTACHED AT OR WITHIN 4" OF THE ROD. A MINIMUM OF TWO ROD STIFFENERS (TOLCO FIG. 968) MUST BE INSTALLED.
Seismic Brace Basics

Lateral (Transverse) Braces: Trapeze Hung Pipe
Prevent Movement \textit{Perpendicular} to the Pipe
Seismic Design

MEP Systems - Maximum Spacing of Seismic Braces for category C

Ductile Piping: 40ft Transverse / 80ft Longitudinal
  • Steel Piping
  • Copper Piping
  • Conduit

Non-Ductile Piping: 20ft Transverse / 40ft Longitudinal
  • Cast Iron Piping
  • Fiberglass Piping
  • CPVC

Duct: 30ft Transverse / 60ft Longitudinal
  • Rectangular Duct
  • Round Duct
  • Oval Duct

Life Safety/Hazardous Systems: 20ft Transverse / 40ft Longitudinal
  • Medical Gas
  • Hazardous Waste
  • Fuel Oil, Heating Gas and Other Flammable and/or Hazardous Content Piping
Seismic Design

Longitudinal Bracing

Example based on 80ft Maximum Brace Spacing
Seismic Design

“Dual-Use” Bracing

Diagram showing bracing with labels "T", "T/L", and distances marked as 10 ft, 20 ft, 30 ft, and 50 ft.
Seismic Design

“Dual-Use” Bracing

Obstruction

Obstruction

T

L

T

T

10 ft

20 ft

30 ft

50 ft
Seismic Brace Basics

**Lateral (Transverse) Braces:** Single Hung Pipe

Prevent Movement **Perpendicular** to the Pipe, when placed within 24 inches of the turn a Lateral Brace can act as the opposing directional Longitudinal Brace.
Listings/Approvals

- **Underwriter’s Laboratories (UL) Fire Protection Only**
  - An independent testing agency that follows the NFPA 13 standard. Test standard UL 203 and UL 203A for seismic bracing
  - Monotonic (static) Testing
    Tension/Compression test only, no other motion.

- **Factory Mutual (FM Global) Mostly for Fire Protection**
  - A testing agency owned by Factory Mutual group of insurers, that follows NFPA 13 standard.
  - Dynamic Test – Cyclical test - tension and compression cycles to the prescribed load.
    Simulates a seismic event.

- **California Office of Statewide Health and Planning Development (OSHPD)**
  - OSHPD is a state of California approval agency that oversees essential state projects including all hospitals and critical care facilities.
  - OSHPD Principles and Standards are being recognized and applied throughout the world.
Fire Protection

Requirements
Design per NFPA
• Transverse bracing
• Longitudinal bracing
• Branch restraints
FP Seismic

• **International Fire Code section 903.3.1.1**
  – “Automatic Sprinkler System shall be installed in accordance with NFPA 13 requirements”

• **International Fire Code section 903.3.5.2**
  – “Secondary water supply. A secondary on-site water supply equal to the hydraulically calculated sprinkler demand, including the hose stream requirement, shall be provided for high-rise buildings assigned to Seismic Design Category C, D, E or F as determined by the International Building Code. The secondary water supply shall have a duration of not less than 30 minutes as determined by the occupancy hazard classification in accordance with NFPA 13.”
NFPA 13 Seismic Bracing Requirements

- Sprinkler systems are a “web” of piping.
- Bracing is only required on the larger system piping, “mains” and “cross-mains”.
- Smaller pipe runs called “branch lines” are not needed to be braced, but rather “restrained”.
- Lateral or Transverse Braces on mains and cross mains must resist the entire seismic force due to the total load of any branch lines attached within their “zone-of-influence”.
- Longitudinal braces on mains are for the main only and do not include the entire zone of influence piping in their load calculation.
Sprinkler System Bracing

Cross-Mains

System Main

Branch Lines
Orientation of Fastener

FIGURE 3.3.5.9.1: Minimum Loads for Various Types of Fasteners to Structure.

Note: Loads (given in pounds) are keyed to vertical angles of braces and orientation of connecting surface. These values are based on concentric loadings of the fastener. Use figures to determine proper reference within table. For angles between those shown, use most restrictive case. Braces should not be attached to light structure members.

Table: Lag Screws and Lag Bolts in Wood (Load Perpendicular to Grain — Holes Predrilled Using Good Practice)

<table>
<thead>
<tr>
<th>Shank Diameter of Lag (in.)</th>
<th>3/8</th>
<th>1/2</th>
<th>5/32</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 in.</td>
<td>30</td>
<td>32</td>
<td>35</td>
</tr>
<tr>
<td>8 in.</td>
<td>34</td>
<td>36</td>
<td>39</td>
</tr>
<tr>
<td>10 in.</td>
<td>30</td>
<td>32</td>
<td>35</td>
</tr>
</tbody>
</table>

For SI units, 1 in. = 25.4 mm; 1 ft = 0.3048 m; 1 lb = 0.45 kg.
Verification of Proper Installation

• A Brace is only as good as it’s installation.
• Verification of components’ correct installation is critical.
• Critical for the Installer and Inspector.
• UL Listing allows various forms to verify.
Verification of Proper Installation

- **Visual method.** You can see it.
- **Torque method.** You can’t see it.
- **This responsibility shifts to the reviewing authority for verification.**
Bracing vs. Restraint

A **Bracing System** is designed to keep the piping system & building structure moving in unison.

A **Restraint** is a *lesser* degree of protection than a brace and is intended to restrict the excessive movement of branch lines.

What is the Difference?
- A brace can act as restraint but the reverse is not true.
- Bracing components are listed and design loads are required by U.L. to be published.
- Restraints are not listed but NFPA 13 does give guidance.
Beam Clamps & Retaining Straps

All “C” Type Beam Clamps Installed in Earthquake Areas Require a Retaining Strap
Questions?

Thank You,

Alexandra Shivers
Sales Engineer
B-Line by EATON