Seismic Bracing of Fire, Mechanical and Electrical Systems

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Introduction

Jeffrey Jackson (Worldwide Seismic Director)

Jeff Jackson has been in the seismic and commercial building industry for over 15 years and has been part of product development, software development, and product sales for the nVent CADDY product line. Jeff has an undergraduate degree in Engineering from the University of Cincinnati, and an MBA from Case Western Reserve. Jeff has served on the MSS 403 Manufacturers Standardization Society Hangers and Support Committee. Jeff spent 6 years in the Ohio Army National Guard as a Carpenter & Mason. He resides in Northeast Ohio and is the Worldwide Seismic Business Leader for nVent CADDY.

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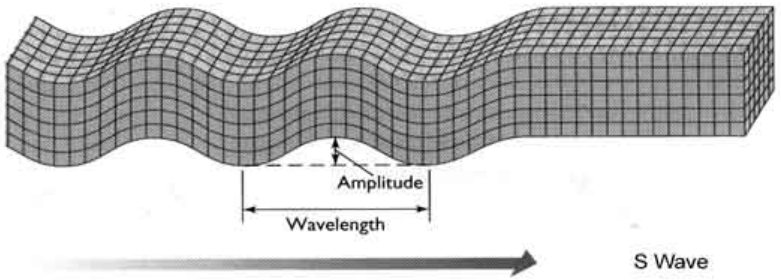
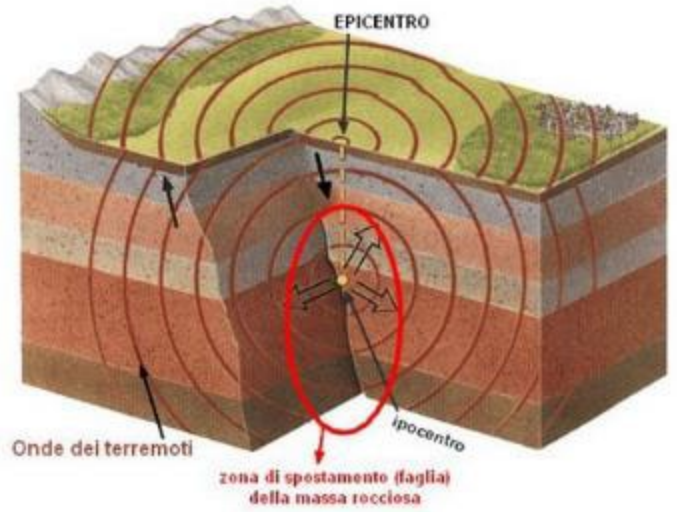
- Passion of educating the market on seismic bracing requirements and codes
- Passion of making seismic bracing simple for end-users through products and services

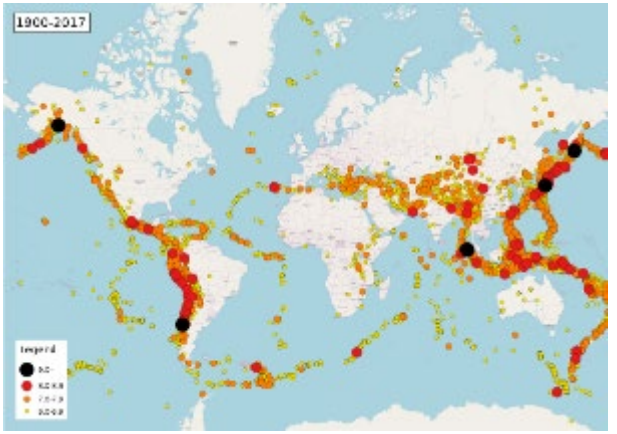
Presentation objectives

- Introduction to Earth Quakes
- Visualizing Seismic Brasing
- Codes and Standards

What is an earthquake?







Earthquake – Rapid vibration of the earth's surface due to the sudden movements in the subsoil, leading to energy release spreading in the shape of waves propagating in all directions

Focus (Hypocenter) – Exact point in the subsoil where a rupture starts and from which the energy generated radiates

Epicenter – Hypocenter vertical projection onto the surface

Source: By Phoenix7777 - Own workData source: Search Earthquake Archives, USGSKml data (earthquake.usgs.gov/fdsnws/event/1/query.kml&kmlcolorby=age?starttime=1900-01-01 00:00:00&endtime=2017-12-31 23:59:59&minmagnitude=6&orderby=magnitude-asc), CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=65386375

Measuring a quake's intensity

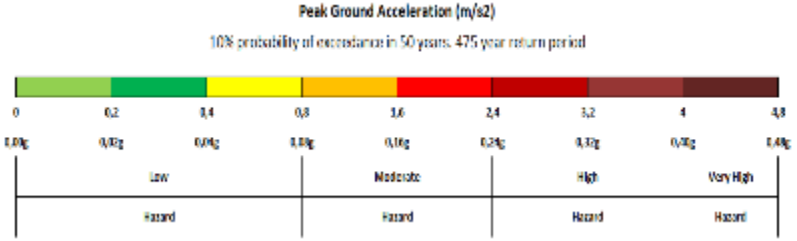
Mercalli Scale

I. Instrumental	Generally not felt by people unless in favorable conditions.
II. Weak	Felt only by a few people at rest, especially on the upper floors of buildings. Delicately suspended objects may swing slightly.
III. Slight	Felt quite noticeably by people indoors, especially on the upper floors of buildings. Many do not recognize it as an earthquake. Standing automobiles may rock slightly. Vibration similar to the passing of a truck. Duration can be estimated. Indoor objects (including chandeliers) may shake.
IV. Moderate	Felt indoors by many to all people, and outdoors by few people. Some awakened. Dishes, windows, and doors disturbed, and walls make cracking sounds. Chandeliers and indoor objects shake noticeably. The sensation is more like a heavy truck striking building. Standing automobiles rock noticeably. Dishes and windows rattle alarmingly. Damage none.
V. Rather Strong	Felt indoors by most or all, and outside. Dishes and windows may break and bells will ring. Vibrations are more like a large train passing close to a house. Possible slight damage to buildings. Liquids may spill out of glasses or open containers. Some to a few people are frightened and run outdoors.
VI. Strong	Felt by everyone, outside or inside; many frightened and run outdoors; walk unsteadily. Windows, dishes, glassware broken; books fall off shelves; some heavy furniture moved or overturned; a few instances of fallen plaster. Damage slight to moderate in poorly designed buildings, at others receive none to slight damage.
VII. Very Strong	Difficult to stand. Furniture broken. Damage light in building of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken or heavily damaged. Noticed by people driving automobiles.
VIII. Destructive	Damage slight in structures of good design; considerable in normal buildings with possible partial collapse. Damage great in poorly built structures. Brick buildings usually receive moderate to extremely heavy damage. Possible fall of chimneys, factory stacks, columns, monuments, walls, etc. Heavy furniture moved.
IX. Violent	General panic. Damage slight to moderate (possibly heavy) in well-designed structures. Well-designed structures thrown out of plumb. Damage moderate to great in substantial buildings, with possible partial collapse. Some buildings may be shifted off foundations. Walls caved in, roofs and collapse.
X. Intense	Many well-built structures destroyed, collapsed, or moderately to severely damaged. Most other structures destroyed, possibly shifted off foundation. Large landslides.
XI. Extreme	Few, if any structures remain standing. Numerous landslides, cracks and deformation of the ground.
XII. Catastrophic	Total destruction – everything is destroyed. Lines of sight and level distorted. Objects thrown into the air. The ground moves in waves or ripples. Large amounts of rock may move. Landscape altered, or leveled by several meters. Even the routes of rivers can be changed.

RICHTER SCALE

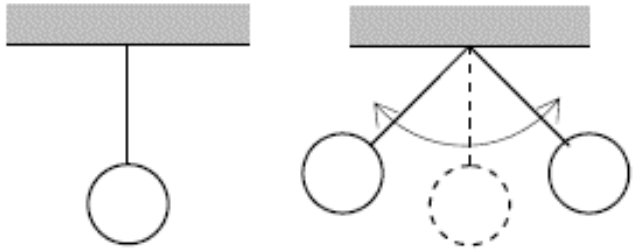
Magnitude	TNT Equivalent	Example
0 1.0	kg / 35 ounces	Breaking a rock on a lab table
0.5 5.6	kg / 12 lbs	
1 31.6	kg / 70 lbs	Large blast at a construction site
1.5 178.0	kg / 395 lbs	
2 1.0	ton	Large quarry or mine blast
2.5 5.6	tons	
3 31.6	tons	
3.5 178.0	tons	
4 1000.0	tons	Small nuclear weapon
4.5 56000.0	tons	Average tornado
5 316000.0	tons	
5.5 178000.0	tons	
6 1.0	million tons	
6.5 5.6	million tons	Northridge, CA quake, 1994
7 31.6	million tons	Largest thermonuclear weapon
7.5 178.0	million tons	
8 1.0	billion tons	
8.5 5.6	billion tons	
9 31.6	billion tons	
9.5 178.0	billion tons	Chilean quake, 1960
10 1.0	trillion tons	Never registered

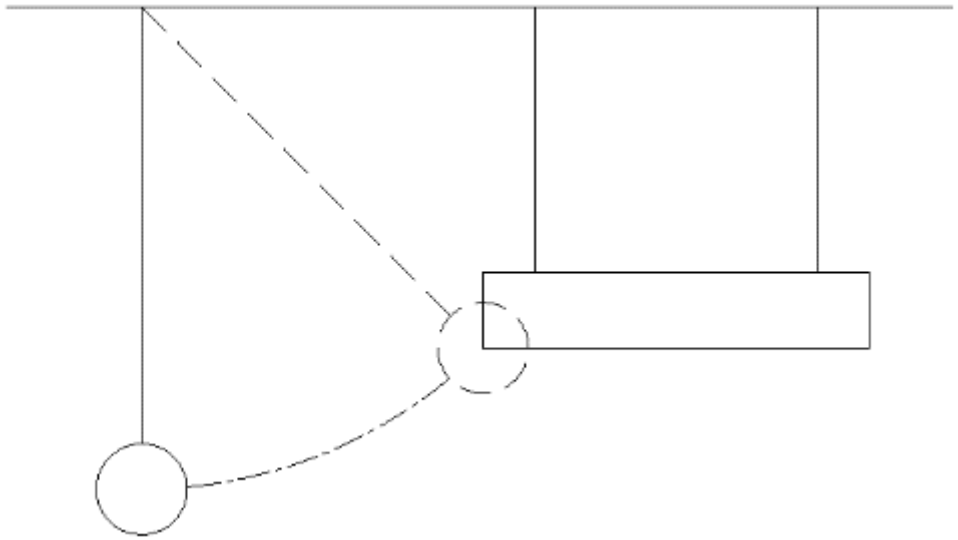
Peak Ground Acceleration (m/s^2)

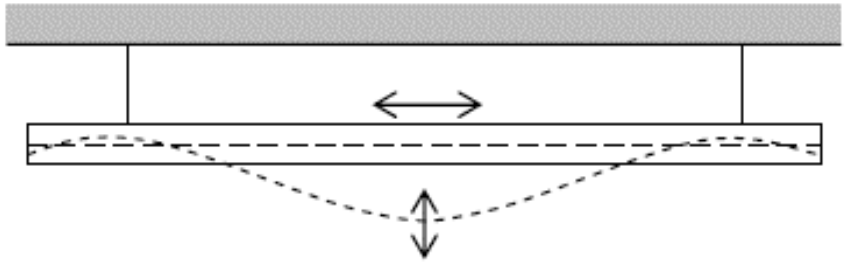


Magnitude Change	Ground Motion Change (Displacement)	Approx. Energy Change
0.1	1.3 times	1.4 times
0.3	2.0 times	3 times
0.5	3.2 times	5.5 times
1.0	10 times	32 times
2.0	100 times	1,000 times
3.0	1,000 times	32,000 times
4.0	10,000 times	1,000,000 times

How does damage occur?

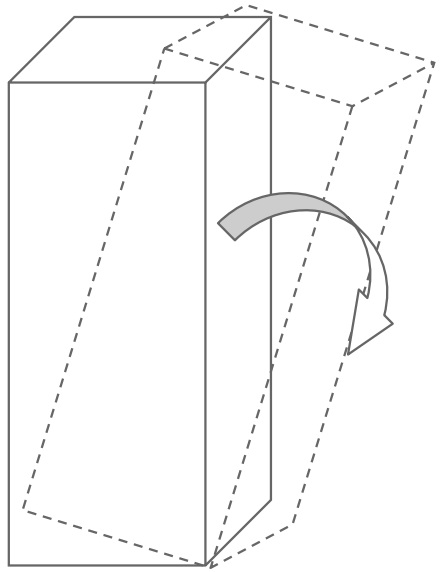


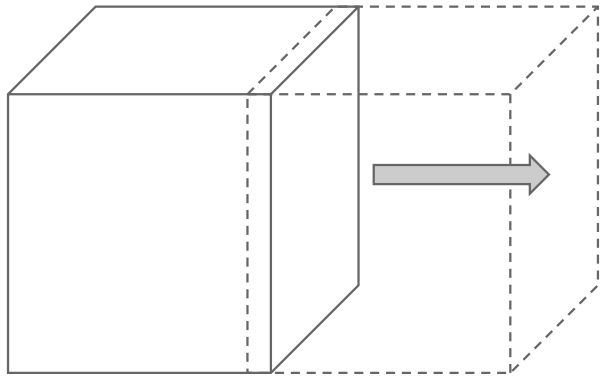


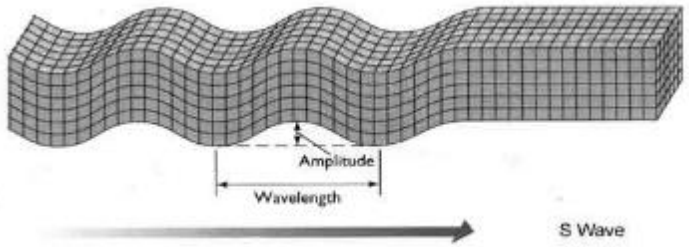


Swaying / Collision

How does damage occur?







- Sliding & Overturning

How does seismic bracing work?

- Sway bracing controls the movement of the non-structural component

Seismic Bracing Value - Code Evolution

No Seismic Code

- **Oldest building:**

No Seismic Requirements

- **Result:**

Building collapses

Structure Reinforcement

- **Later construction:**

Code requiring reinforcement of structures

- **Result**:

Pipe broke generating a flood

Full Seismic Code

- **Newest construction:**

Code requiring protection for both Structural and non-structural

- **Result**:

Installation remains in place and factory is fully functional

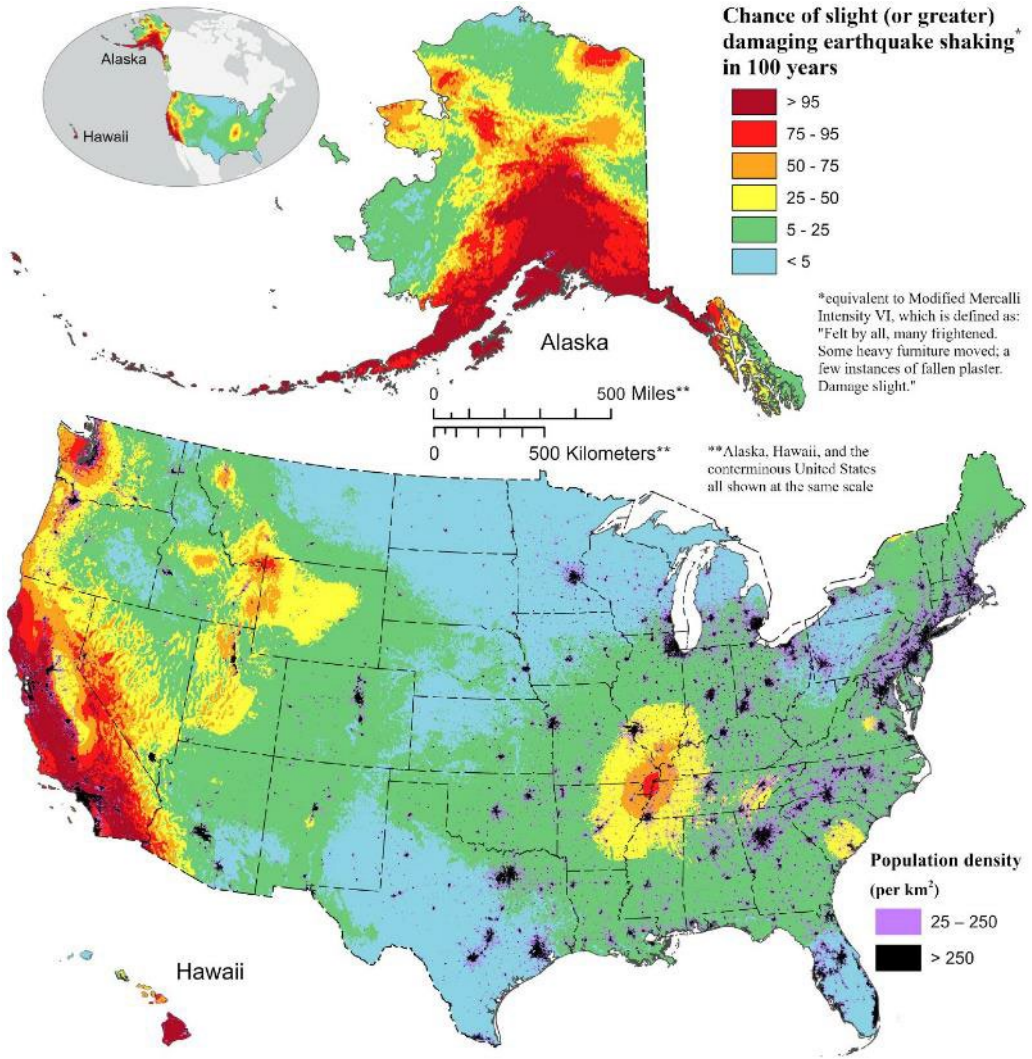
- Three buildings – Same earthquake – Different construction periods – Different consequences!

How does Seismic add Value

- How much did Facebook's 6-hour downtime cost them in October 2021?

- $60 Million USD. And some estimate it at $100 Million,
  - arstechnica.com – "Facebook's outage likely cost the company over $60 million"
- $47Billion in Market cap the next day in the Market

Why is Seismic Bracing Important – Updated Hazard Maps



New map shows where damaging earthquakes are most likely to occur in US by Heidi Koehler and Steven Sobieszczyk, United States Geological Survey, January 16, 2024

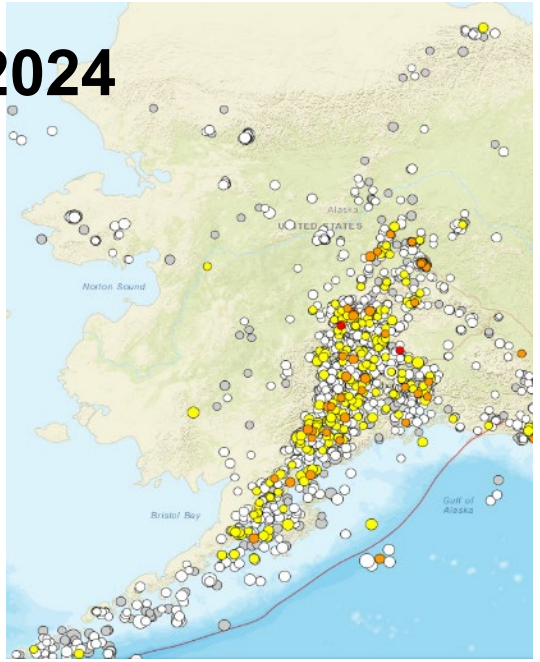
- Nearly 75% of the U.S. could experience potentially damaging earthquakes and intense ground shaking
- 37 U.S. states have experienced earthquakes exceeding magnitude 5 during the last 200 years
- Possibility of more damaging earthquakes along the central and northeastern Atlantic Coastal corridor, Washington D.C., Philadelphia, New York and Boston
- Chance for greater shaking in California and Alaska, greater Hawaii shaking driven by volcanic and seismic unrest

https://phys.org/news/2024-01-earthquakes.html

Petersen MD, Shumway AM, Powers PM, et al. The 2023 US 50-State National Seismic Hazard Model: Overview and implications. Earthquake Spectra. 2024;40(1):5-88. doi:10.1177/87552930231215428

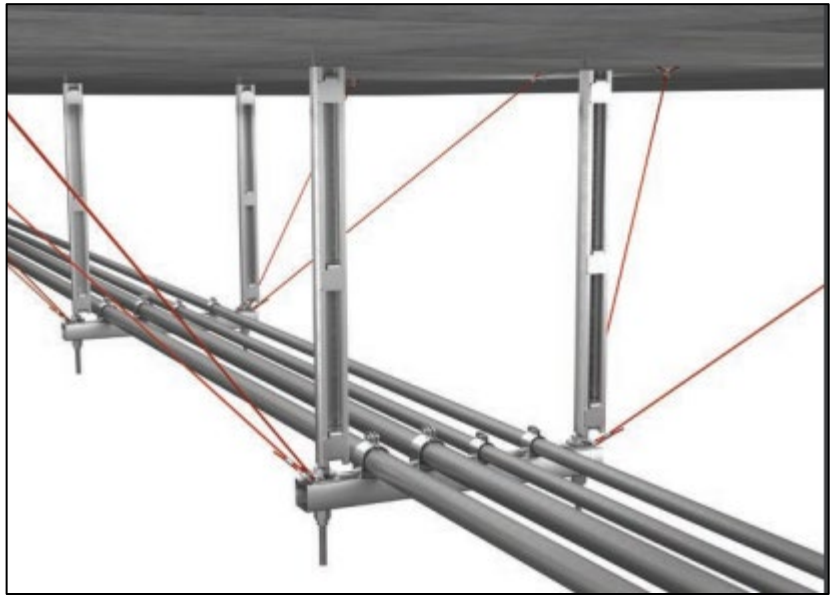
Earthquakes Happen

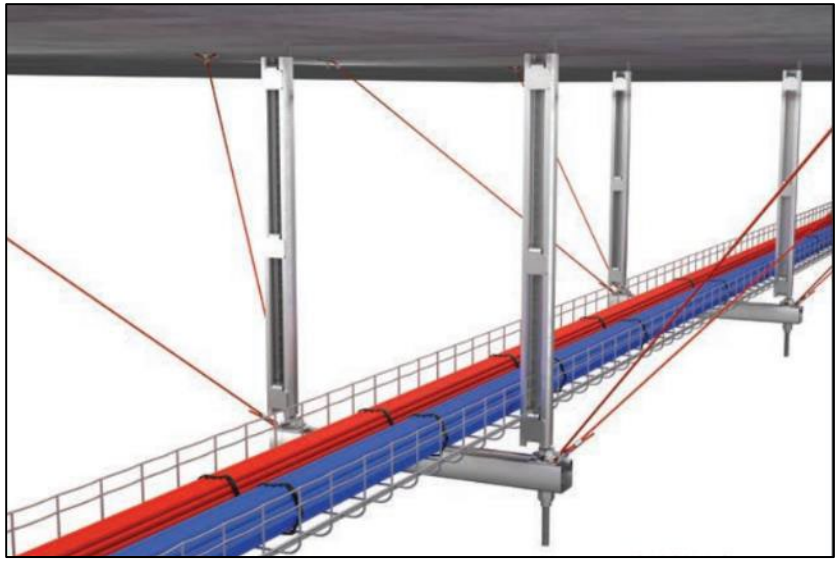
- **How Many Earthquakes in USA since January 1 to - 2/13/2024**
  - **7522 + 3918 + 2327 = 13,767 (cont. US, Alaska, Hawaii)**
- **Earthquakes 5 and Over**
- **1 + 1 + 1 = 3**



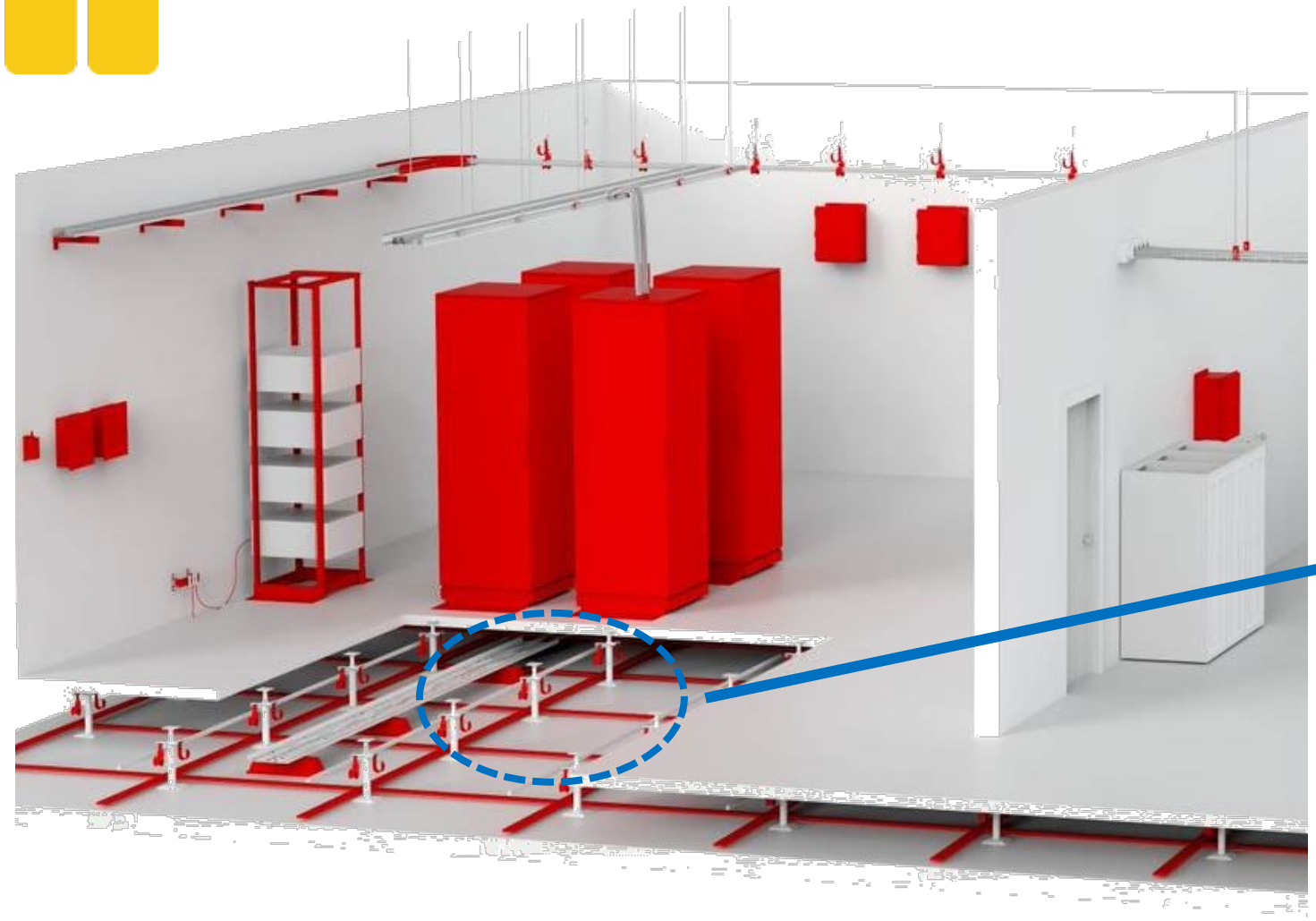
USGS.ORG

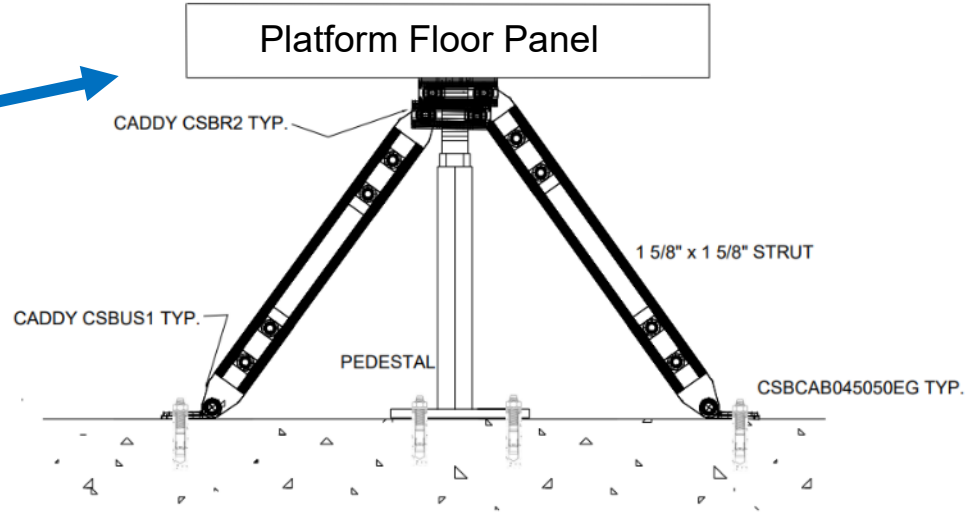
Cable Bracing Applications



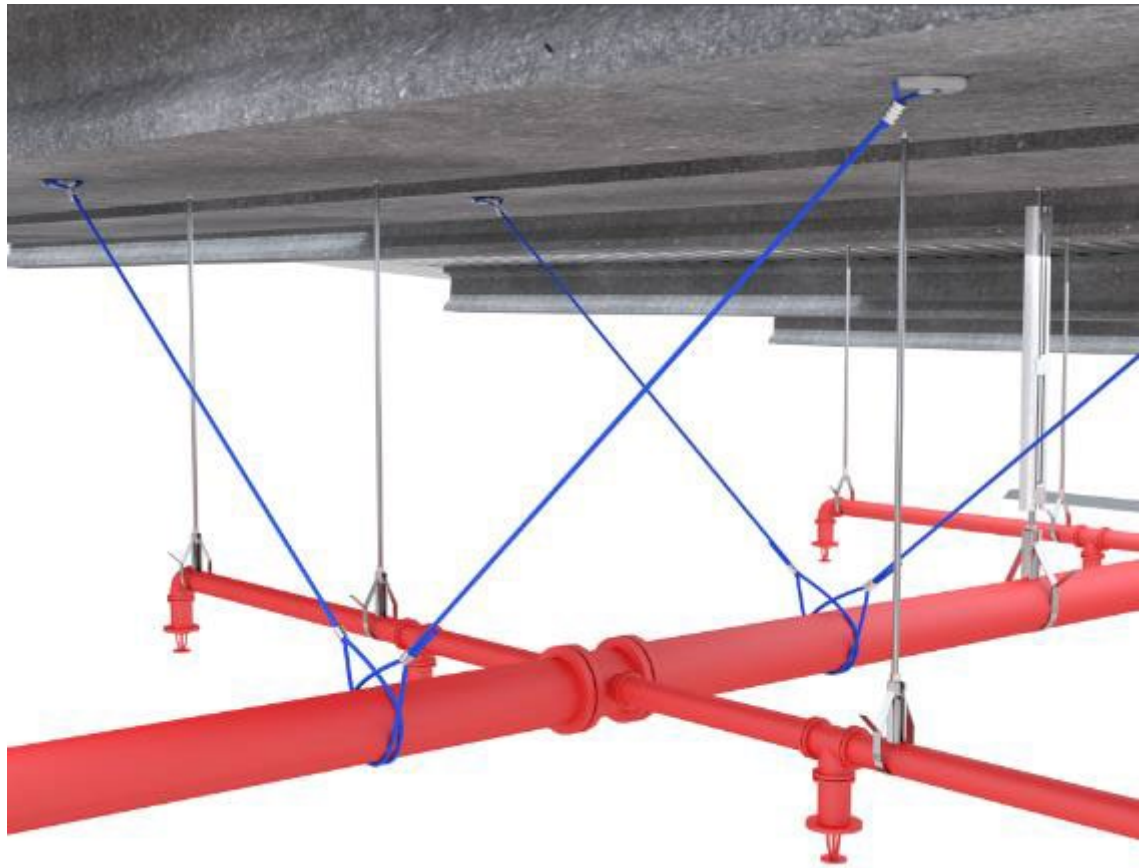


Data Center Solutions



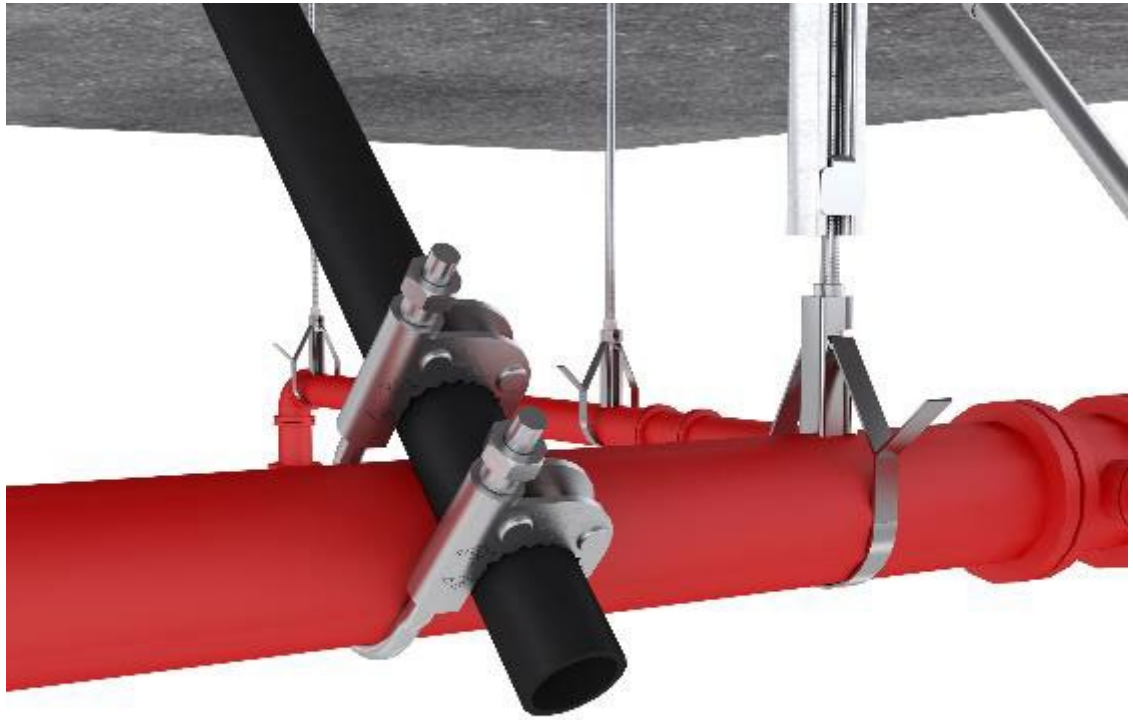


Visualizing braces – Fire Protection



- SPRINKLER PIPING

Visualizing braces – Fire Protection



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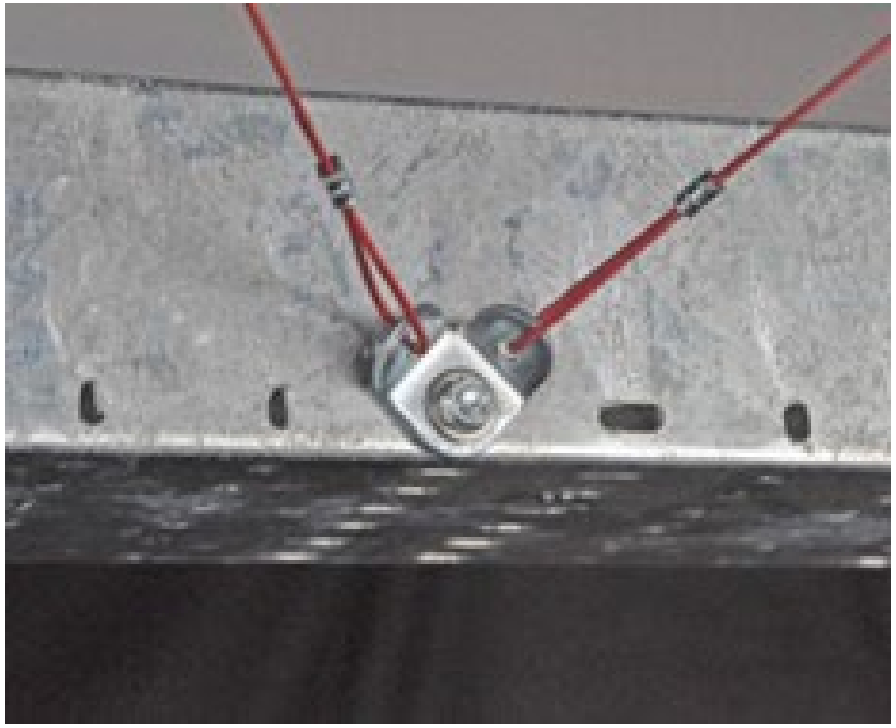
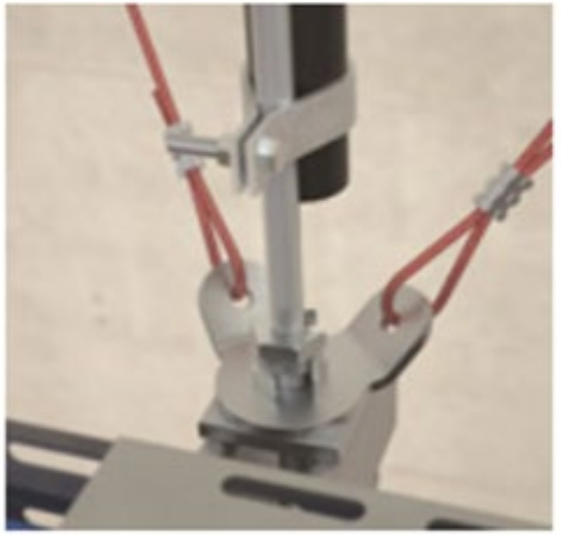


- Cable

Visualizing Braces



- Rod stiffening

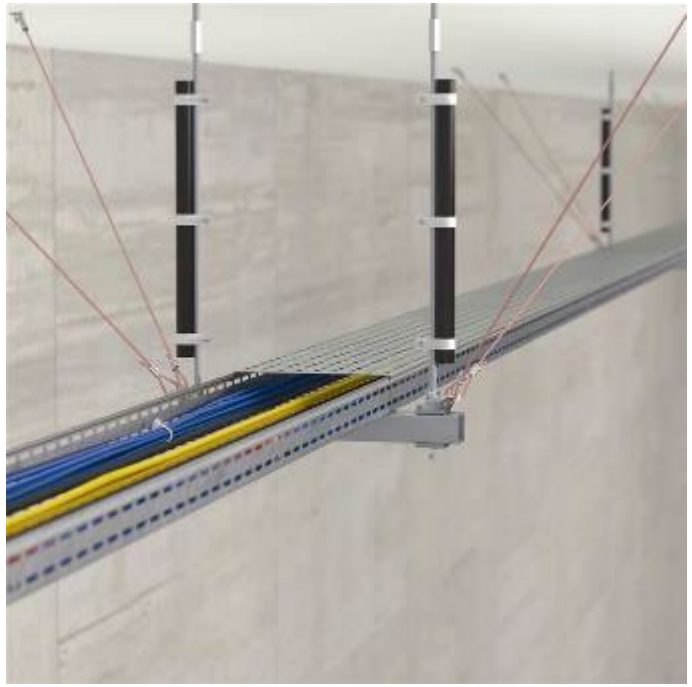
Rigid components – Structural connections

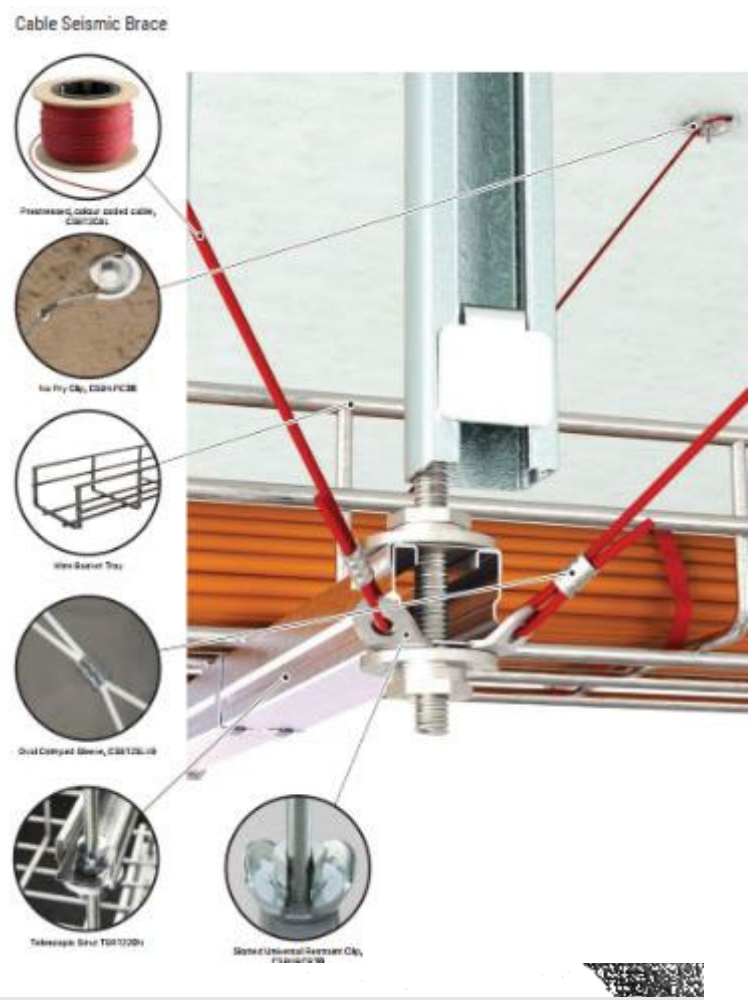
- Strut as brace member

Visualizing braces

- CLOSE UP – RIGID TRAPEZE ATTACHMENT

Visualizing braces- Cable Travs



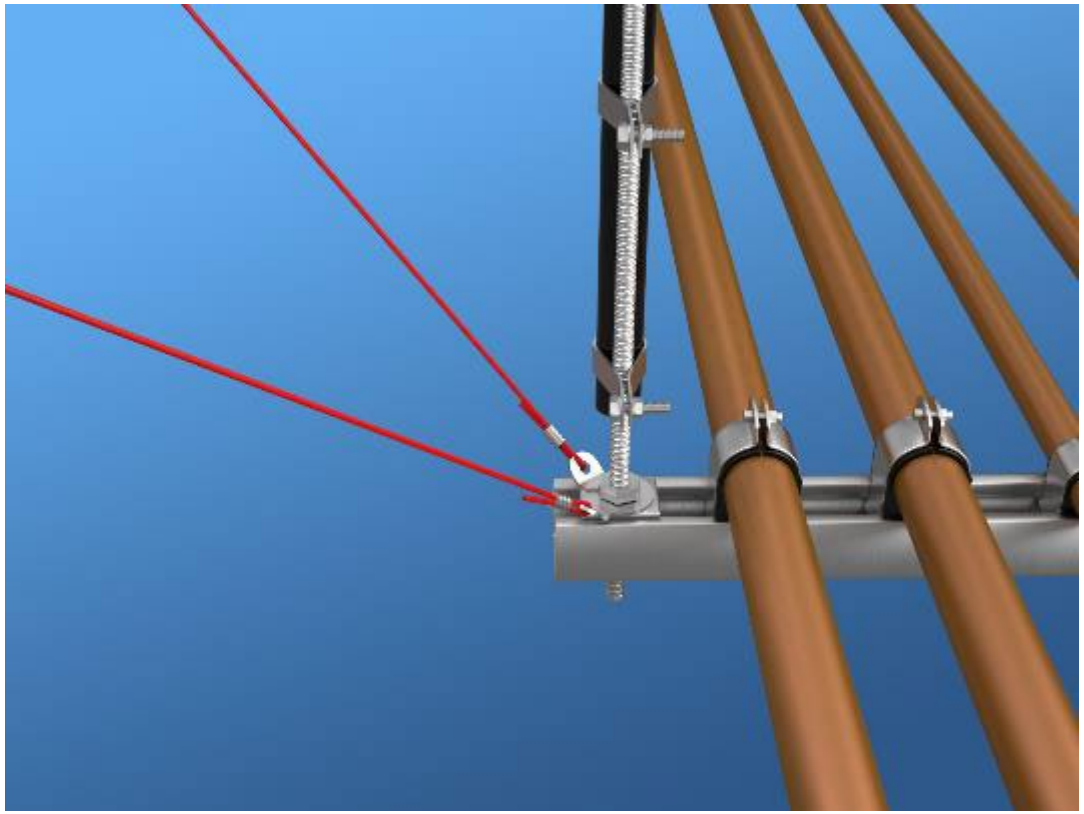


- CABLE TRAYS / BUS DUCT

Visualizing braces- Mechanical Services

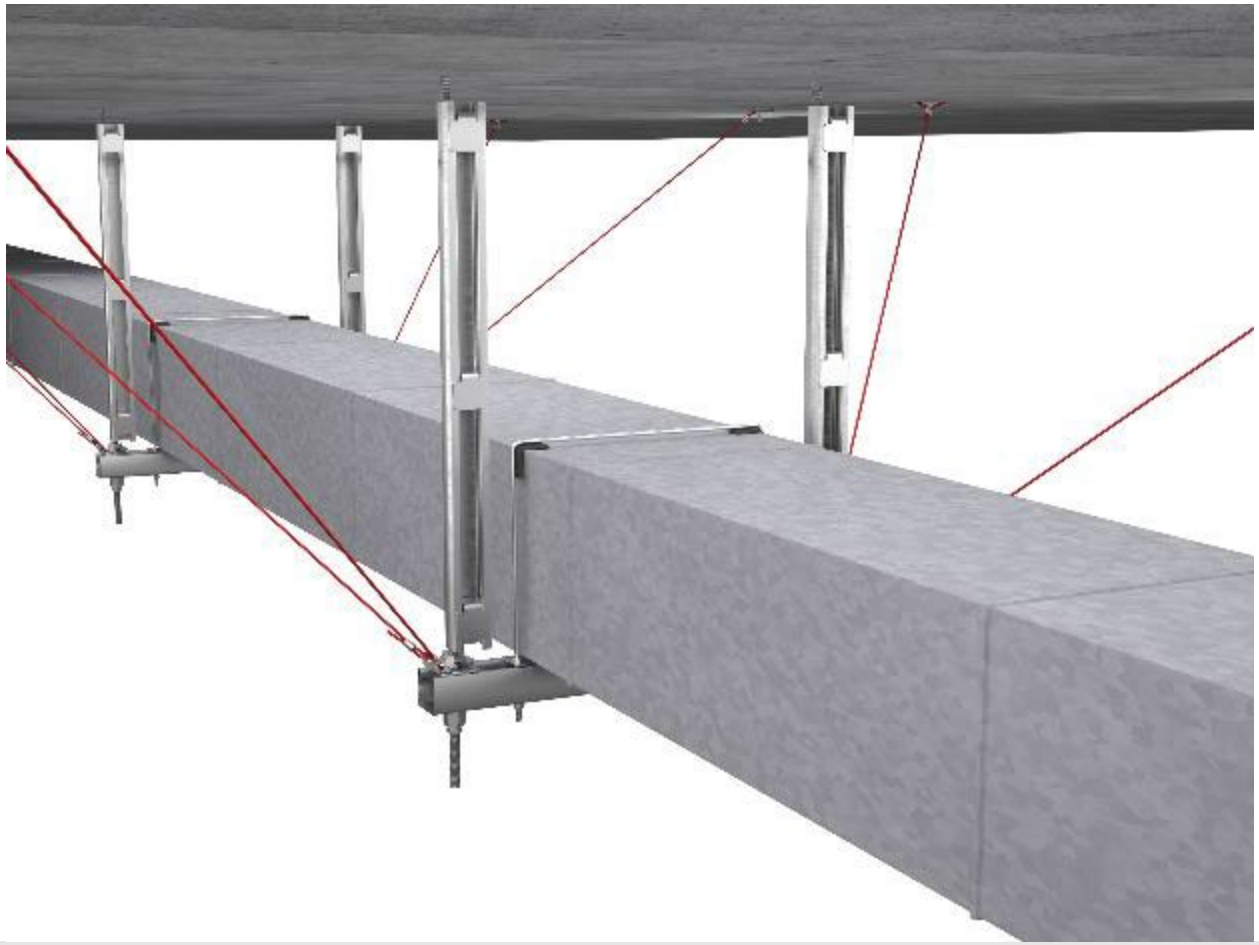
- PIPING SYSTEMS

Visualizing braces- Mechanical Services



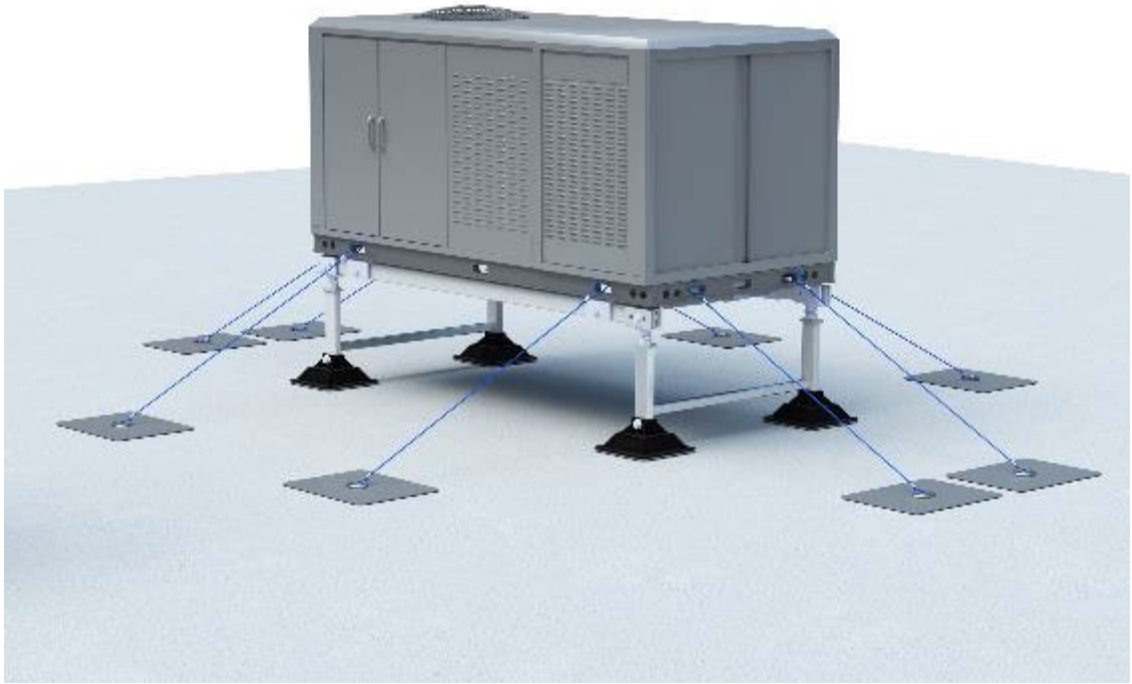
- CLOSE UP – TRAPEZE ATTACHMENT

Visualizing braces - DUCTS



- DUCTS

Visualizing braces – Roof Mounted Equipment



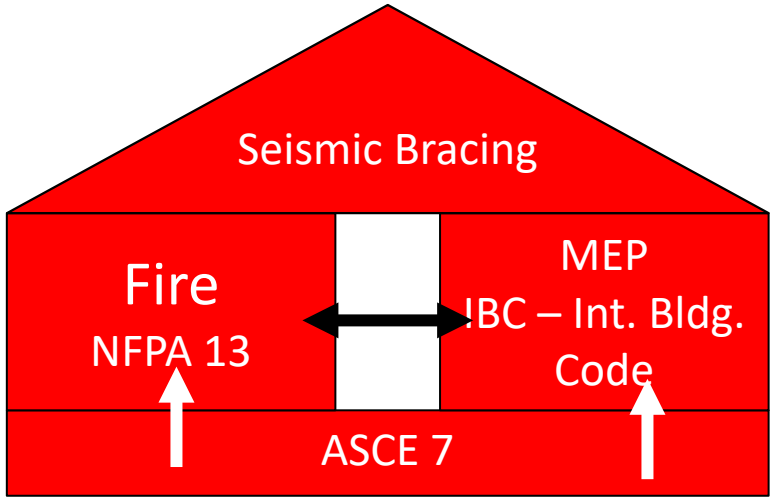
- CABLE TRAYS

Introduction to codes, standards, and guidelines

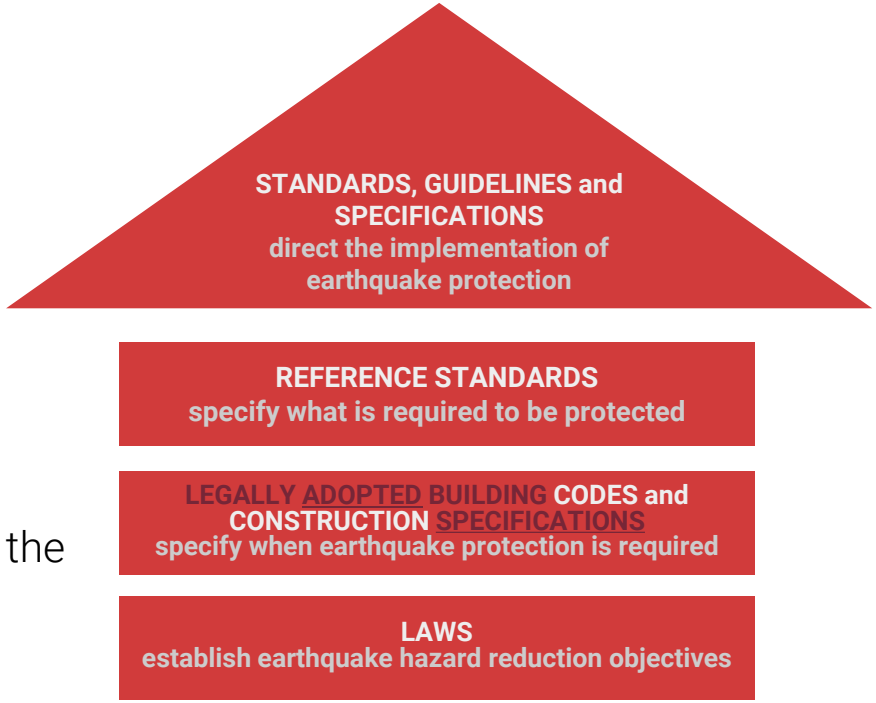
- International Building Code (IBC) Requires Seismic Bracing for critical systems

  Reference standard ASCE 7 – American Society of Civil Engineers

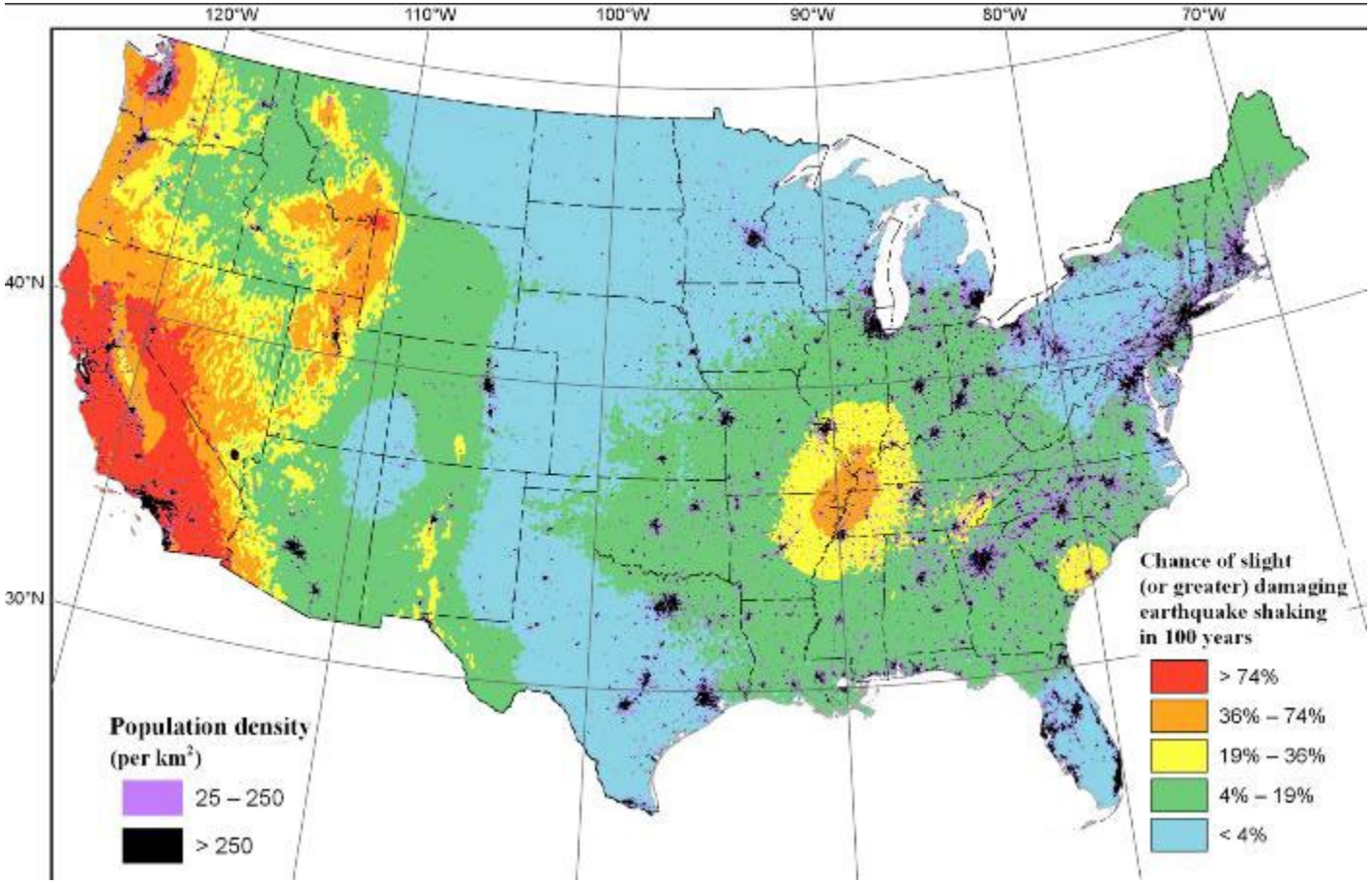
- State Specific Requirements
  - HCAI (California Healthcare Access and Information), – Pre-Approval
  - Formerly OSHPD (Office of Statewide Health Planning and Development)
- The standard/guideline instructs the layout requirements (e.g NFPA13, FM Global Property Loss Prevention Data Sheet 2-8)



- The code determines the formula(s) to use to calculate the seismic forces



USGS Seismic Hazard Map



Is bracing required on this building?

Importance Factor + Site Class/Soil Class + Building Risk/Occupancy Class = Building Seismic Design Category

Components required to function after an Earthquake for life safety, Important Services, hospital, etc. Hazardous, and all other

Range of soil Class from sand and soft soil→ to Hard Rock
Help determine S_{DS} and S_{D1}

- Essential Facilities (Hospitals, fire, police, Lots of people
…..to
- Substantial hazard to human life, 300 people, schools, etc
……to
- All other

A – Very Low Seismic Risk
B – Low to Moderate Risk
C – Moderate Seismic Risk
D – High Seismic Risk
E&F – Very High and near a fault

- If it sounds important…it probably is

Types Of Building That Might Need Seismic Bracing

Hospitals

Resorts

Airports

Stadiums

Data Centers

Dams

Arenas

Schools

Prisons

Military

Casinos

Power

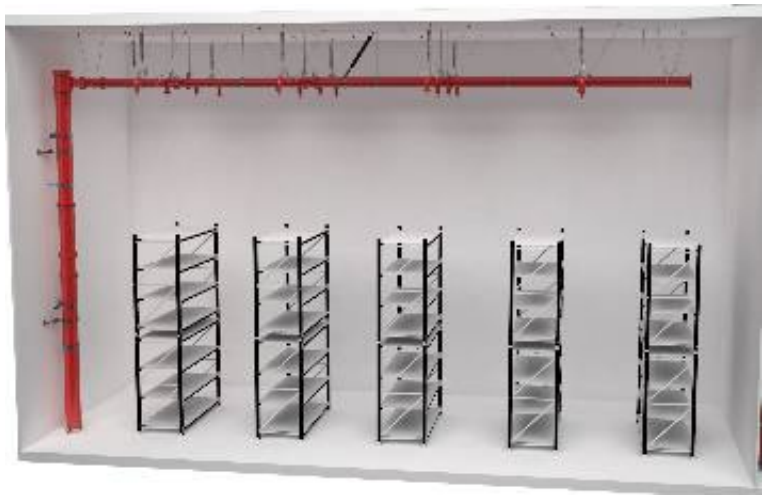
Water Treatment

Pharmaceutical

Government

- Seismic Region and Type of Building = Potential Seismic Bracing

Common components that require Seismic Protection



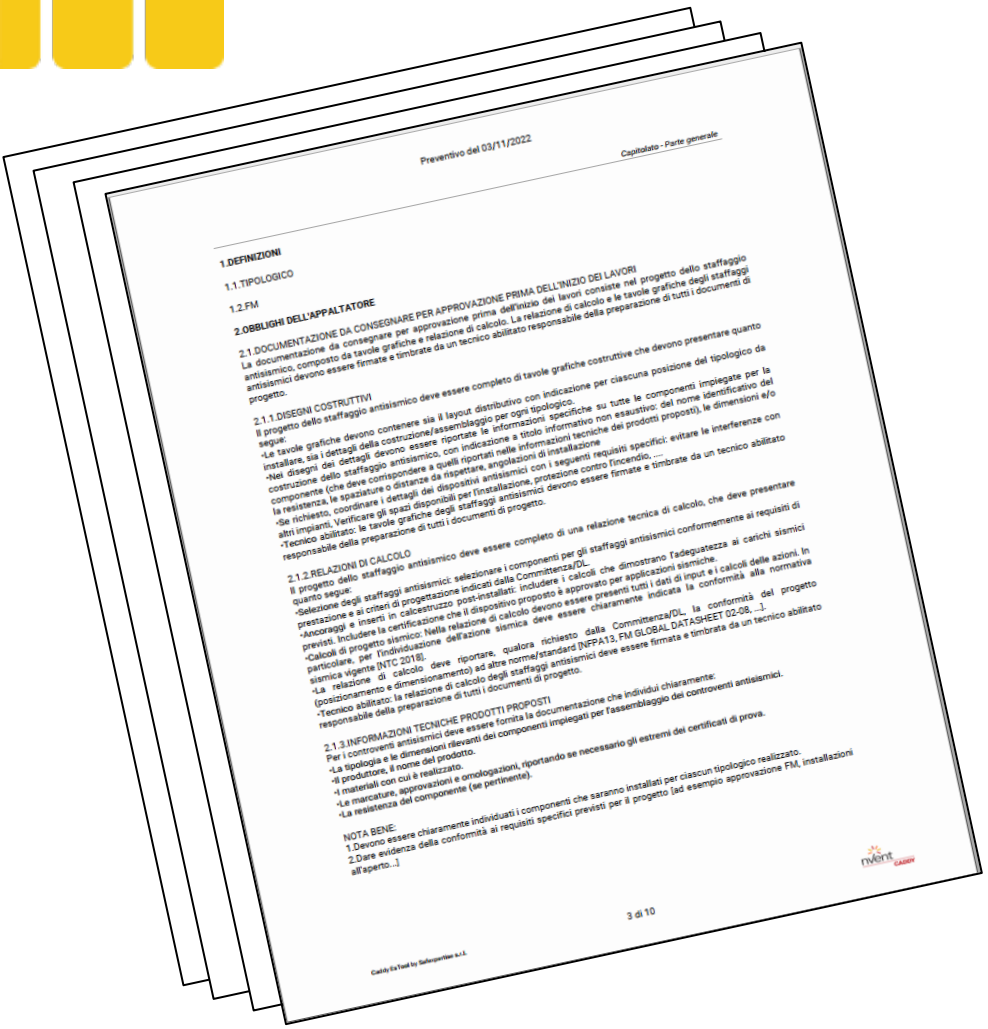
SUSPENDED **Mechanical & Electrical Components**	**FLOOR MOUNTED** **ROOF MOUNTED** **WALL MOUNTED**
• **Piping systems**	• Panel boards
• **HVAC Ductwork**	• Switchgears
• **Conduits**	• Power generators
• **Bus ducts**	• Air conditioners
• **Cable trays**	• Furnaces
• **Suspended Equipment**	• Pumps...

- ANY SUSPENDED EQUIPMENT NOT POSITIVELY CONNECTED TO STRUCTURE
- ANY PROCESS EQUIPMENT OR EQUIPMENT WITH HAZARDOUS MATERIALS

MasterSpec

- What is MasterSpec?
  - MasterSpec is a comprehensive master guide specification system used by Architects and Engineers as a resource for producing specifications.
  - MasterSpec is a copyrighted product of the American Institute of Architects (AIA).
  - MasterSpec is ‘closed’ specification system with pre-screened manufacturer and product listings.

Specifications



- Complete sections

Where to find seismic design requirements – Specifications

MasterFormat Section
Section **210548** – VIBRATION AND SEISMIC CONTROLS FOR **FIRE- SUPPRESSION**
Section **220548** – VIBRATION AND SEISMIC CONTROLS FOR **PLUMBING PIPING AND EQUIPMENT**
Section **230548** – VIBRATION AND SEISMIC CONTROLS FOR **HVAC DUCTWORK PIPING AND EQUIPMENT**
Section **260548.16** – SEISMIC CONTROLS FOR **ELECTRICAL SYSTEMS**
Section **270548.16**– SEISMIC CONTROLS FOR **COMMUNICATIONS SYSTEMS**

being installed in are suitable for the load imposed and shall bring any problems to the attention of the Owner's Representative in writing immediately.

20 10 44 SEISMIC RESTRAINT

A. All materials and workmanship shall specifically comply with the above listed Building Code with respect to seismic requirements for the support and anchorage of all mechanical systems and equipment as installed on this project. Lateral forces to be restrained shall be as required by ASCE 7 Section 11 and 13 Architectural, Mechanical, and Electrical Components and Systems. Refer to structural drawings and/or Geotechnical Report for design values.

-Site Class (ASCE 7-05, Table 11.4-1 and 11.4-2) C

- Seismic Use Group III
- Spectral Acceleration, Refer to ASCE or Building Code, Maps or online tools
- Seismic Design Category

Short period (S_{DS})

B. All piping support and restraint details and practices shall conform to the publication "Seismic Restraint Manual Guidelines for Mechanical Systems" by SMACNA, 2008 Edition, and/or "Seismic Restraints" by B-Line systems, Inc.

C. DELEGATED DESIGN: Design hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, herein referred to as Seismic engineer. Prepare drawings, calculations and details for any anchorage, bracing and/or sway bracing for seismic restraint as required by the local codes and Authority Having Jurisdiction. Seismic engineer shall inspect the final installation for compliance with the approved Seismic shop drawings. Seismic engineer to identify items that need to be corrected or changed and provide contractor additional/revised drawings as required.

D. SUBMITTALS:
1.SHOP DRAWINGS: Submit drawings, calculations and details shall be signed and sealed by a Professional Engineer licensed in the State of the Project's location.
2.CLOSEOUT: As-built seismic drawings with Letter from Seismic engineer stating that the completed installation meets the design.

E. INSTALLATION: Contractor shall only use those materials submitted and approved. Contractor shall notify Seismic Engineer when actual installation differs from the approved Seismic shop drawing.

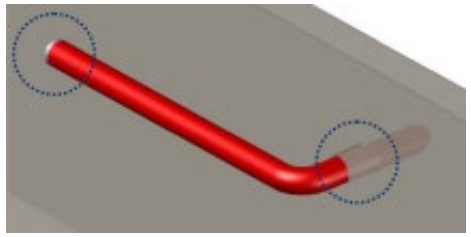
20 10 50 BASIC MECHANICAL METHODS - GENERAL

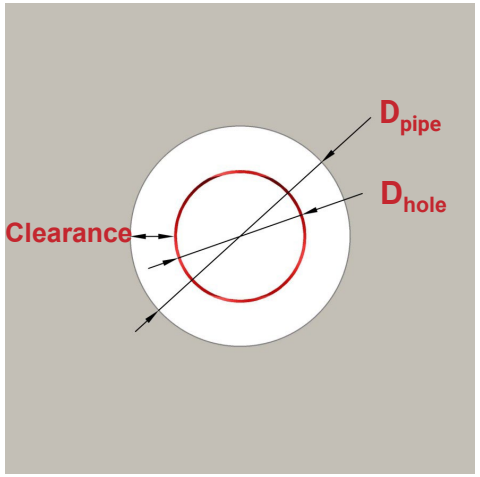
20 10 51 INTENT OF PROJECT DOCUMENTS

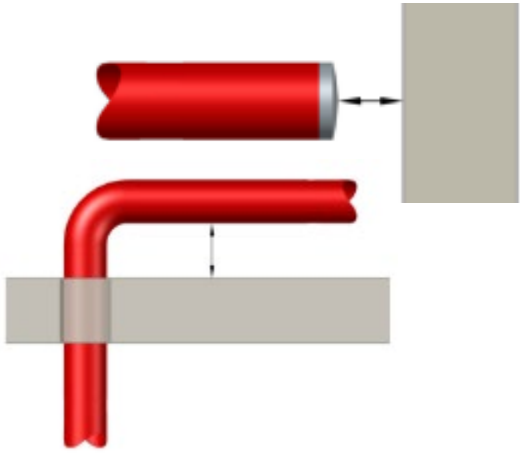
A. Install the Work in accordance with the Project Documentation and considerations enumerated in Subsection 20 00 01, GENERAL (Project Documents).

Clearance Example

- Clearance design approach following pathways of NFPA 13 and FM 2-8



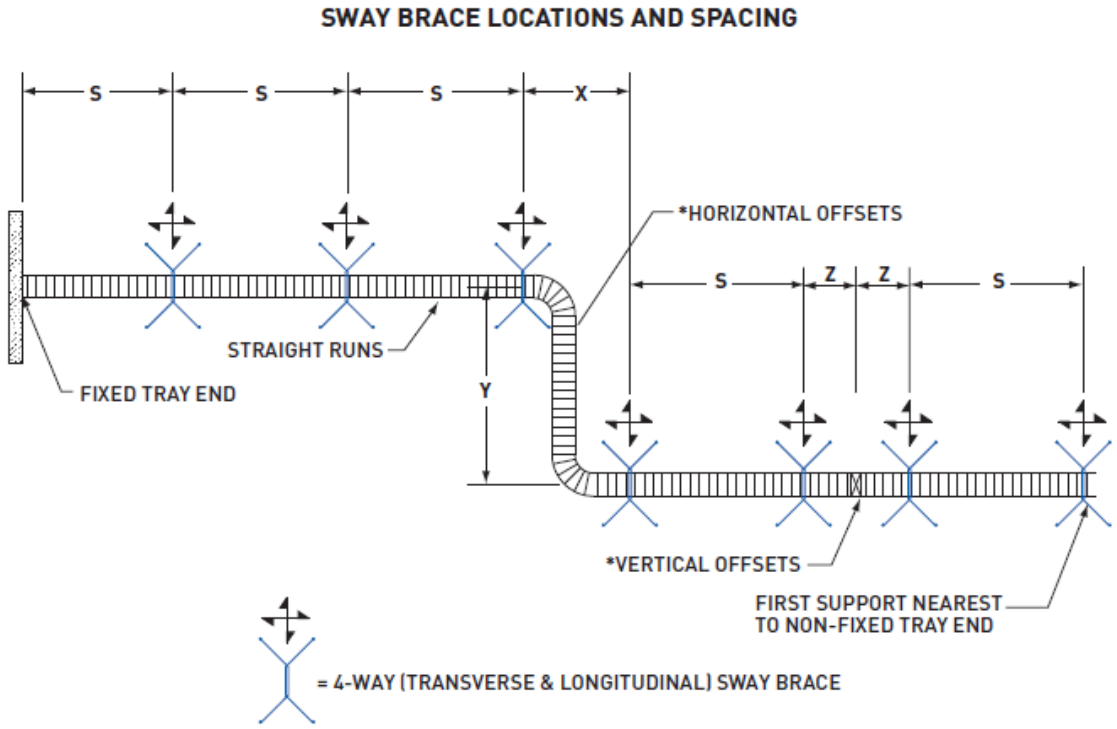


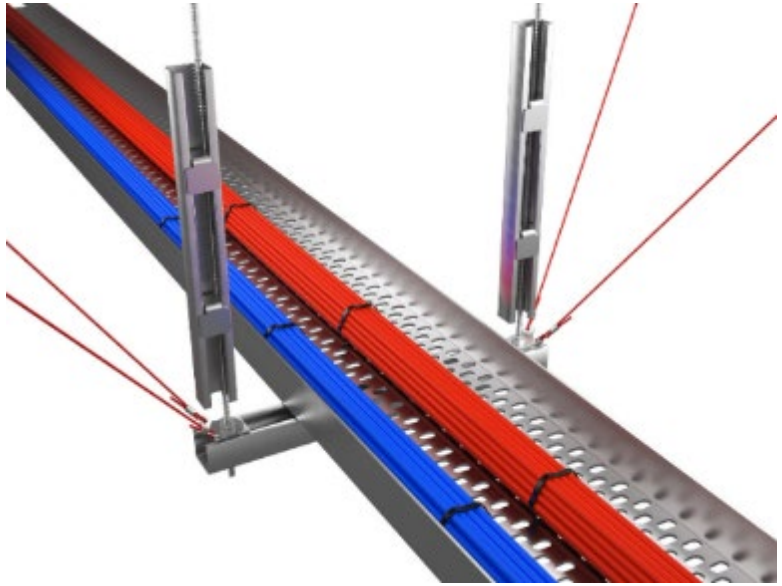


CLEARANCE			
Sprinkler code	**NFPA 13**	**FM 2-8**	**TS 17551**
Passing through walls or celling	Depending on pipe size: 50mm (DN25-DN90) 100mm (≥DN100)	Depending on pipe size: 50mm (DN25-DN90) 100mm (≥DN100)	Depending on pipe size: 50mm (DN25-DN90) 100mm (≥DN100)
Passing through frangible material	No clearance needed	No clearance needed	No clearance needed
Pipe distance from nearest structural member	≥50mm (regardless pipe size)	≥50mm (regardless pipe size)	/
Sprinkler distance from nearest structural member	≥75mm	≥50mm	≥50mm (preferably ≥100-150mm)

- If Clearance is not met, additional flexibility is required

Extrapolation to Cable Trays Bracing - Example





NOTES:

(1) For horizontal offsets, a sway brace should be located at the cable tray support nearest to one end of the offset.

(2) It is recommended that the max. Vertical offset without a sway brace be 30 feet and that the max. Spacing for sway braces on vertical trays should be 40 feet.

BRACED COMPONENT DESCRIPTION	MAXIMUM "S"	MAXIMUM "X" + "Y"	MAXIMUM "Z"
Cable Tray	40 Ft.	40 Ft.	5 Ft.

Questions?

Thank you for Having Me Today