Introduction to Earthquake Engineering

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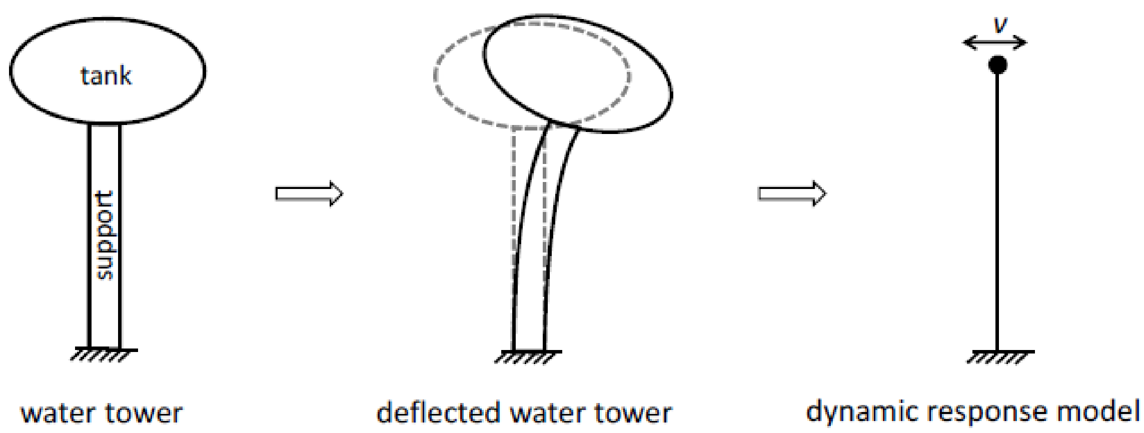
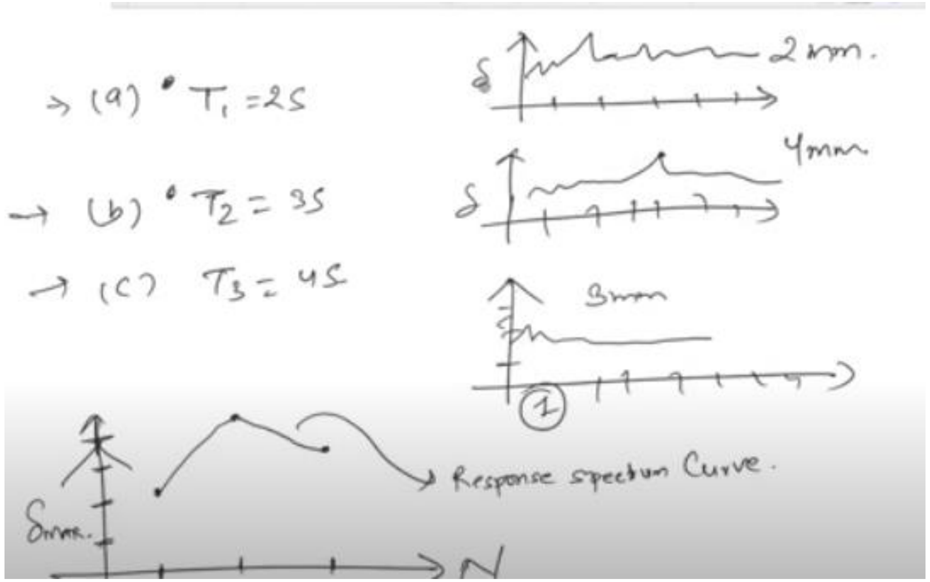
- **<u>Response Spectrum</u>**
- A response spectrum is a function of frequency or period, showing the peak response of a simple harmonic oscillator that is subjected to a transient event.
- The response spectrum is a function of the natural frequency of the oscillator and of its damping.
- Plot of maximum response of linear single degree of freedom oscillator for given component of earthquake ground motion. On X- axis we have Natural period and Y- axis we have Response (Max- Disp. Max Velocity, Max Acceleration.)



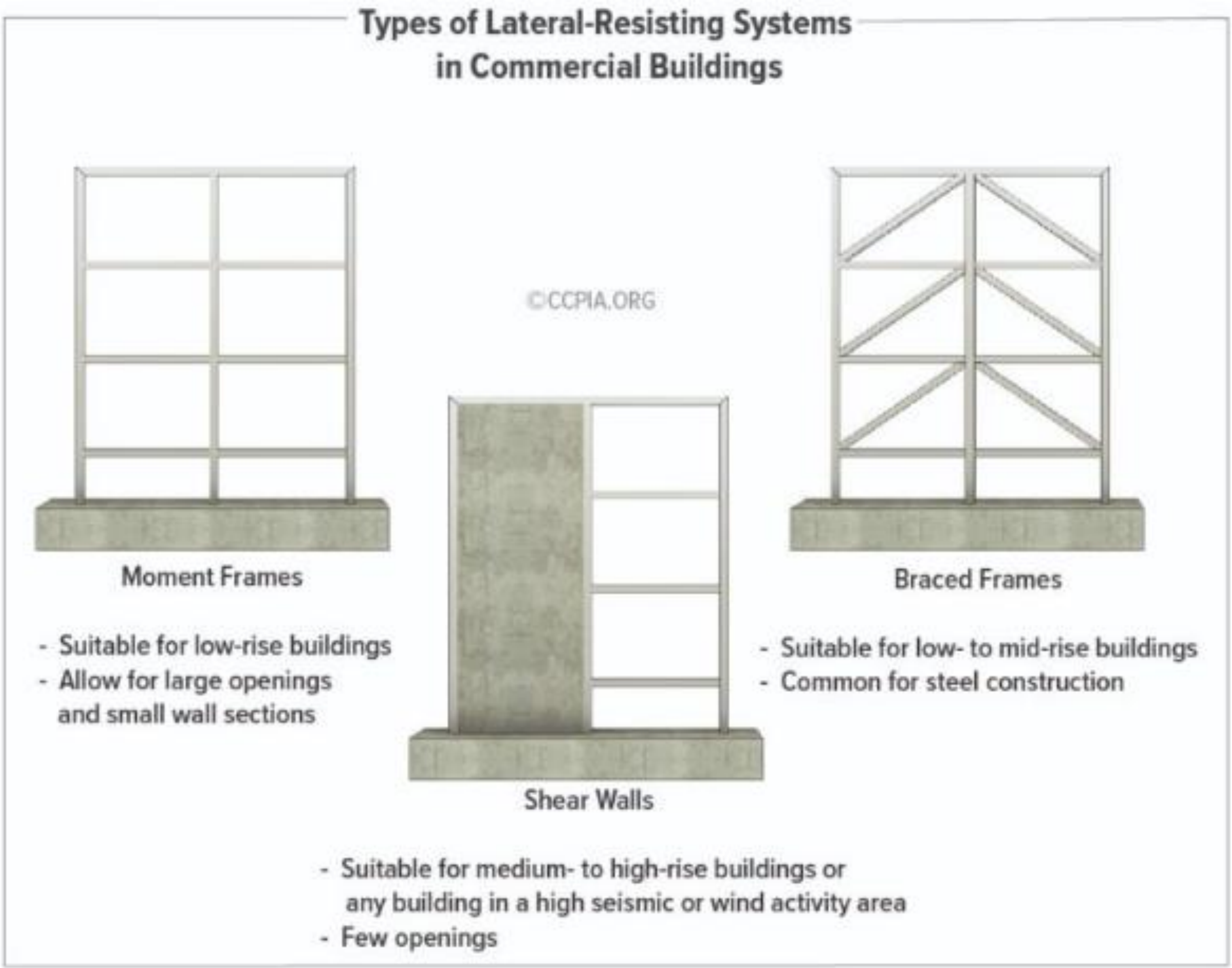
- **Response Spectrum**
- Response spectrum analysis is a method to estimate the structural response to short, nondeterministic, transient dynamic events.
- Examples of such events are earthquakes and shocks.
- Since the exact time history of the load is not known, it is difficult to perform a time-dependent analysis.
- Due to the short length of the event, it cannot be considered as an ergodic ("stationary") process, so a random response approach is not applicable either.

- Let Consider we have three different structure.
- Apply same Ground acceleration
- Each structure exhibit different response in form of deflection at different time period.
- Max deflection of each structure is noted and plotted against frequency.
- Curve obtained is called response spectrum curve.



Response Spectrum Curve

- **Types Of Lateral Force-resisting Systems In Commercial Buildings**
- Every structure must be designed and constructed to withstand lateral loads and horizontal loads. Structures are braced against lateral and horizontal forces in several ways. Bracing is installed perpendicular to the direction of the potential force. Bracing is often installed in every direction because forces can come from every direction.
- The most common bracing methods for resisting lateral forces in commercial buildings include moment frames, shear walls, and braced frames. These are vertical elements that transfer lateral loads, including wind, seismic forces, and stability forces through floor or roof diaphragms to the building's foundation. They help keep a structure from blowing over or collapsing.


Types of Lateral-Resisting Systems
in Commercial Buildings
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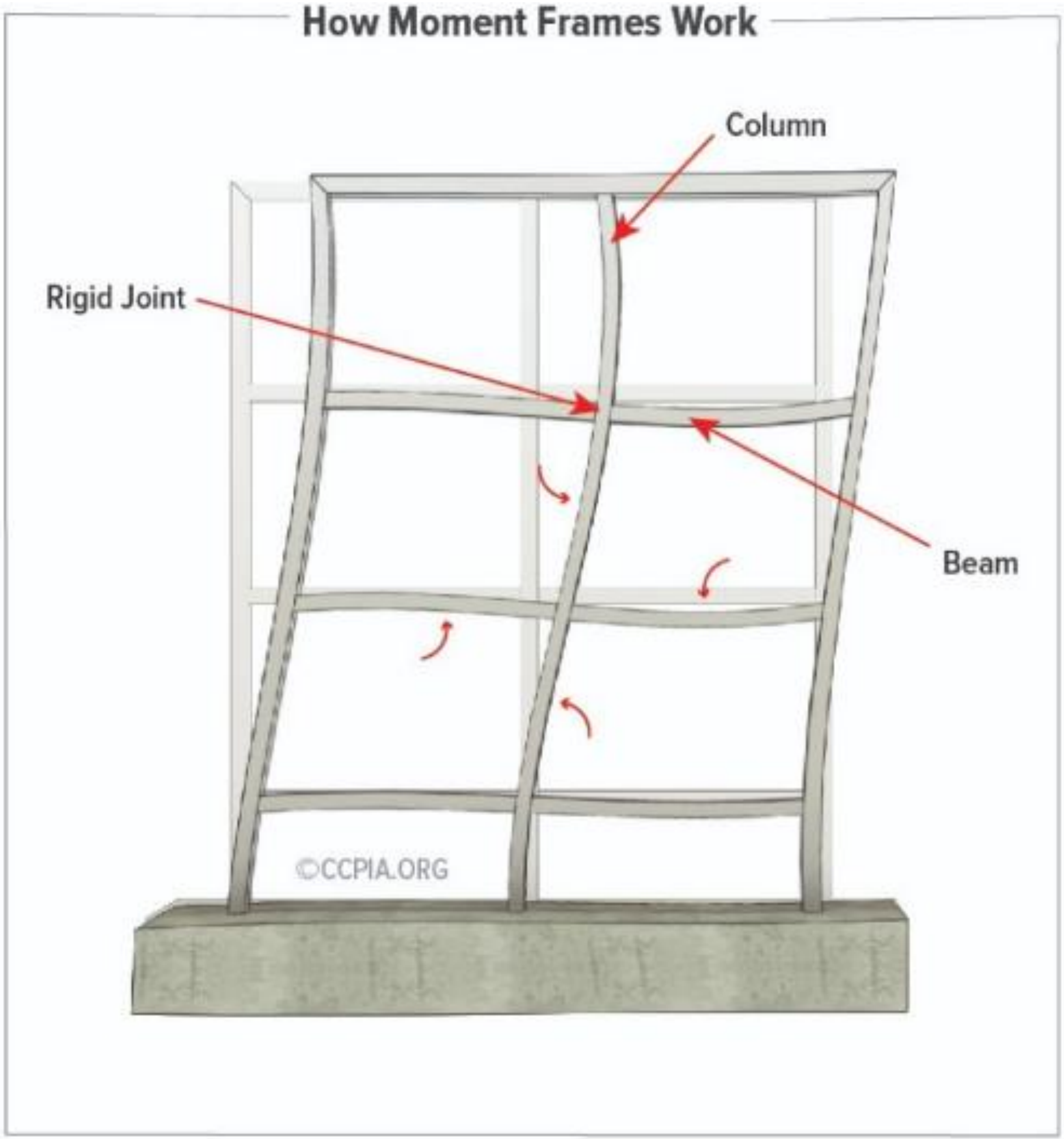
Moment Frames
- Suitable for low-rise buildings
- Allow for large openings
and small wall sections
Braced Frames
- Suitable for low- to mid-rise buildings
- Common for steel construction
Shear Walls
- Suitable for medium- to high-rise buildings or
any building in a high seismic or wind activity area
- Few openings

- **Moment Frames**
- Steel moment frames are vertical frames consisting of traditional and columns that are typically connected by bolts and/or welds. They are more flexible than shear walls and brace frame structures. The rigid connection points permit the frame to resist lateral loads through the flexural strength (bending) and continuity of its beams and columns, such that moments are transferred from beams to columns at the connection points. A moment frame will not move laterally without bending the beams or columns. The three main types of connections are bolted, welded, and proprietary, and there are several variations of each. Concrete frames are also commonly considered moment frames because of their similar continuity.


How Moment Frames Work
Column
Rigid Joint
Beam
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- **Moment Frames**
  - Moment frames have several applications in single-story and m story commercial buildings, but they’re used primarily in low-rise buildings. Moment frames allow for larger openings and small wall sections while still supporting required loads and resisting various forces.
  - Some of the typical applications include:
  - structural steel buildings;
  - large building entryways;
  - walls with large openings; and
  - tuck-under parking.

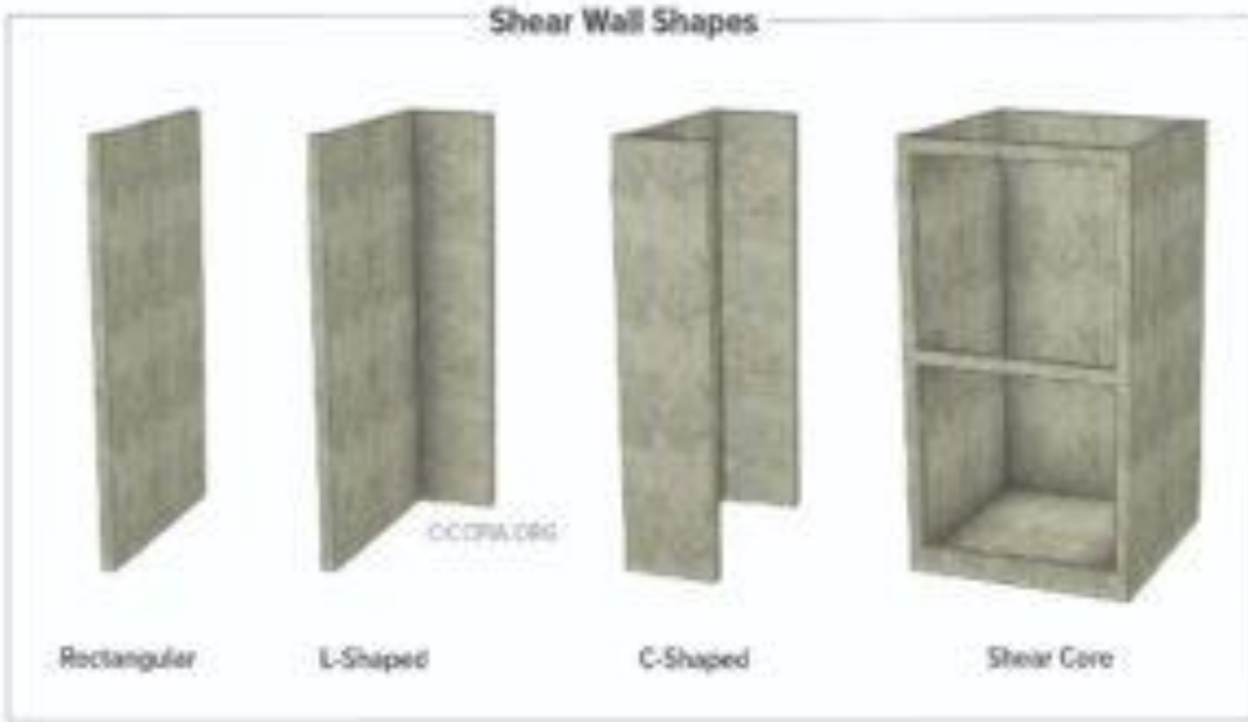
Large building entryway moment frame

- **Types of Moment Frames**
- The three types of moment frames include
- Ordinary moment frames (OMF),
- Intermediate moment frames (IMF),
- Special moment frames (SMF).
- They are classified for use based on zones of seismic activity, such that:
- OMFs are usually used in zones with no or low seismic activity;
- IMFs are usually used in low- to mid-seismic activity regions; and
- SPFs are usually used in mid- to high-seismic activity regions.

- **Shear Walls**
- A shear wall is a structural member that resists cracking thro[illegible] plane shear, such that ground movement enters the building and creates inertial forces that move the floor diaphragms. Shear walls resist this movement, and the forces are transmitted back down to the diaphragm below or to the foundation. It essentially acts as a vertically spanning beam to resist lateral forces. Shear walls typically span from the foundation to the top of a building. They also perform well in areas with seismic activity.

- **Shear Walls**
- Shear walls are typically constructed of concrete, masonry, formed steel, or wood framing. Shear walls are important in medium-to high-rise buildings, or any building located in high wind or seismic activity areas. Many homes have shear walls on the exterior perimeter.
- The strength and stiffness of a building depend on the shape and position of the shear wall. Common positioning includes the building's perimeter or the center of a building encasing an elevator shaft or stairwell. The latter is referred to as a shear core. Other shear wall shapes include a rectangle, L-shape, and C-shape.

- **Shear Walls**
- A shear wall with openings is referred to as coupled shear w this case, the shear wall acts as an individual wall section, and the slabs above and below the openings act as a tie beam that distributes the load. The symmetrical location of shear walls in buildings is desirable.



- **<u>Braced Beams</u>**
- Braced frames are common in steel construction. They use diagonal and/or triangulated steel beams or cables to resist lateral forces. Resistance is provided by vertical bracing or horizontal bracing. Vertical bracing between structural columns transfers lateral forces to ground level. Horizontal bracing at each floor or the roof transfers lateral forces to the vertical bracing, and then it’s transferred to ground level. However, the floor system is usually a sufficient diaphragm without the need for additional steel bracing. Braced frames are suitable for multi-story buildings in the low- to mid-rise range.

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- The two main types of braced frames are concentric bracing and eccentric bracing. Concentrically braced frames are typically triangulated and connected at the endpoints of other framing members (joints) to develop a truss. A few common configurations include a cross-brace (X-brace), inverted V-brace (chevron brace), and a single diagonal brace. Eccentrically braced systems utilize diagonal braces with one or two ends deliberately offset to the supporting member such that the bracing isn't centered. The gap between the offset bracing is referred to as the structural fuse region, and it's designed to dissipate a lot of energy during an earthquake event

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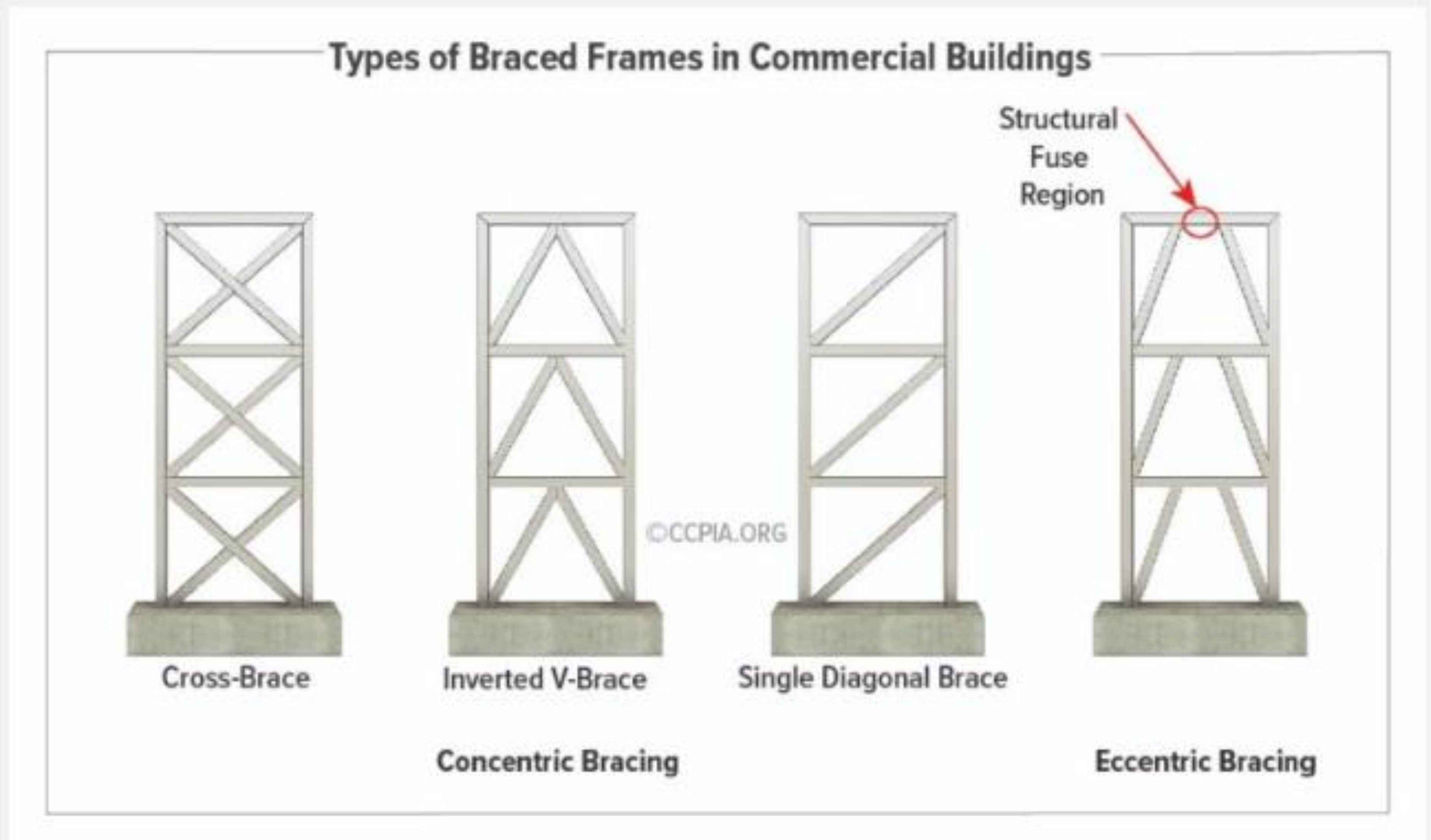
Types of Braced Frames in Commercial Buildings
Structural
Fuse
Region
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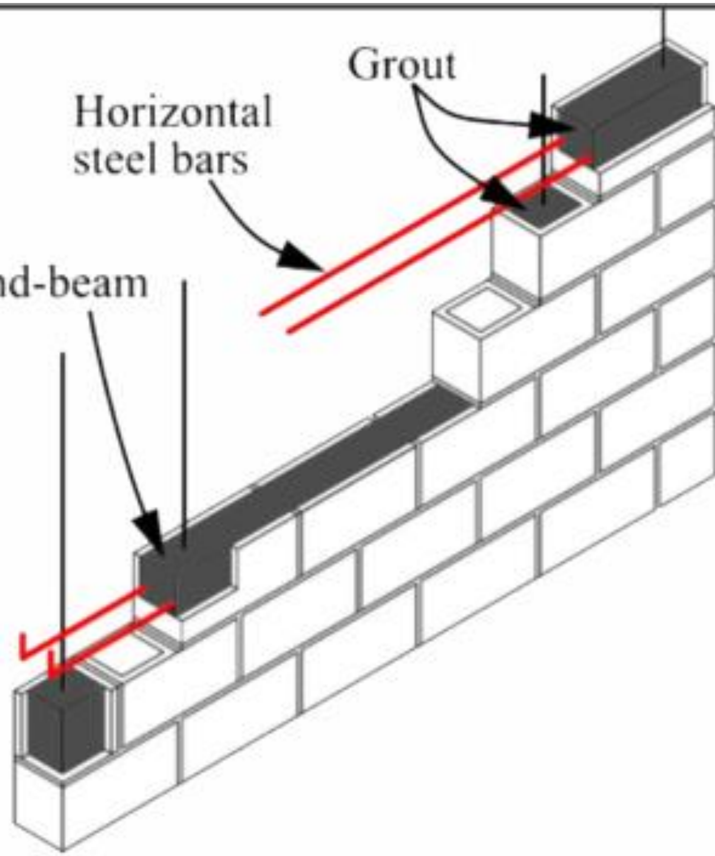
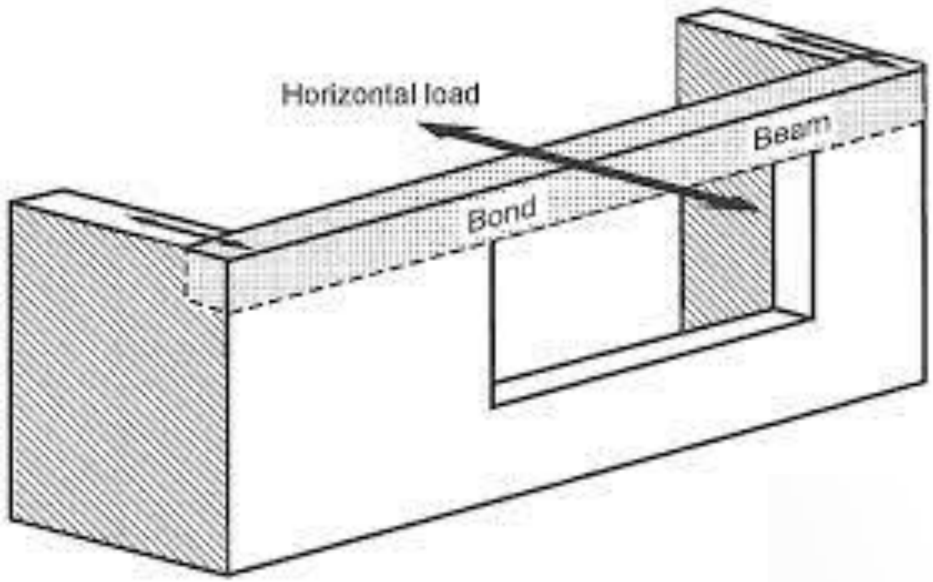
Cross-Brace
Inverted V-Brace
Single Diagonal Brace
Concentric Bracing
Eccentric Bracing

- **Bond Beams**
- Bond beams are a horizontal feature embedded in a wall support to the structure. The bond beam is made up of specialized blocks that are filled with grout to hold a sturdy steel bar in place. They add steel reinforcement to structures that might need more than just traditional CMUs (Construction Masonry Unit)to hold it up sufficiently.



BOND BEAM

“ **A bond beam is a horizontal structural element, usually found as an embedded part of a masonry wall assembly.** ”


Horizontal load
Beam
Bond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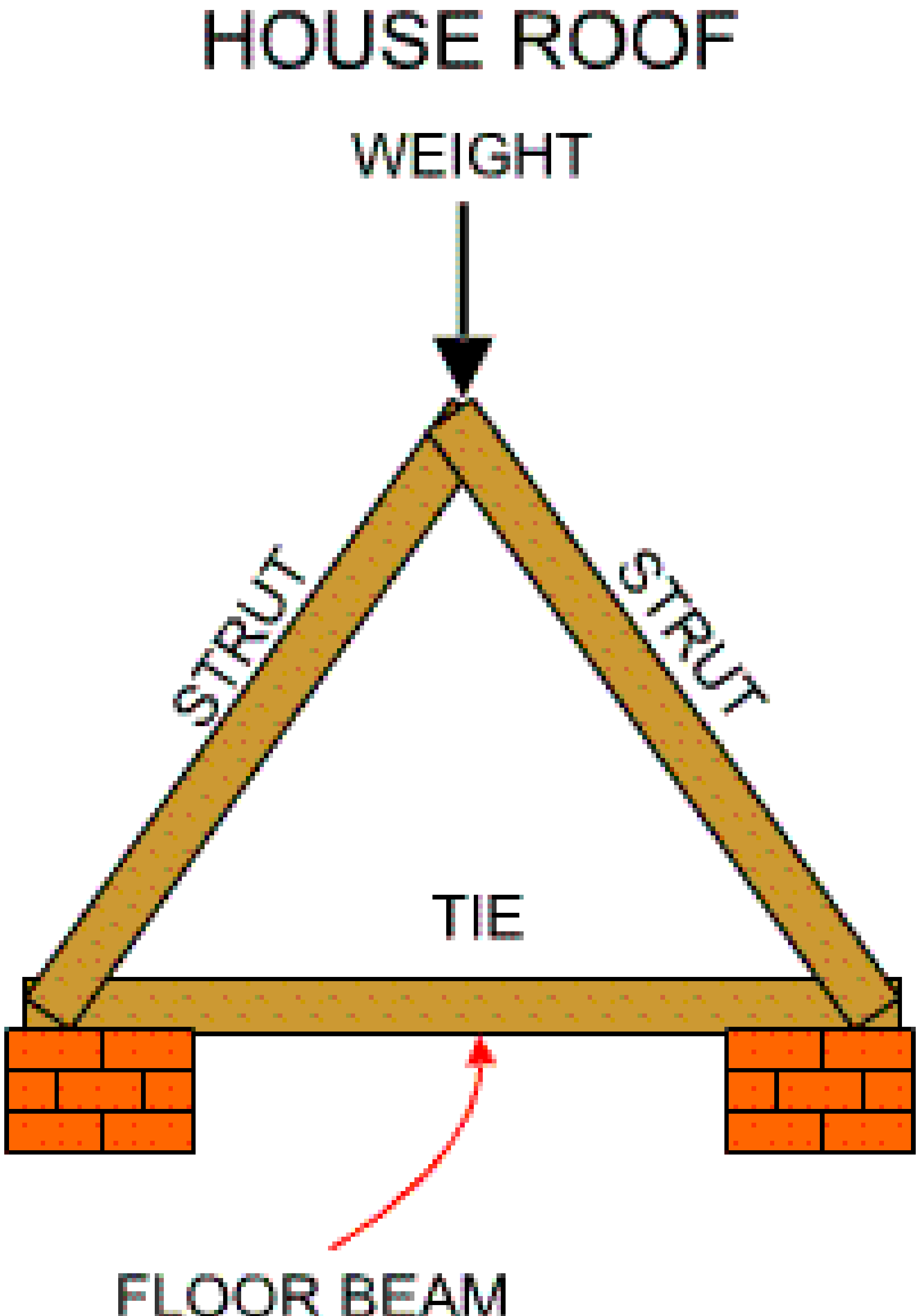
- **Bond Beams**
  - A bond beam is a horizontally reinforced element in a masonry that provides resistance to shear loads and also helps distribute lateral loads throughout the wall section. Reinforcement is placed in special bond-beam units that have reduced-height cross webs and grouted solid. Bond beams are typically one course tall; grout is prevented from filling cells below by placing a mesh-type grout stop material in the bed joint underneath the bond beam. Bond beams are usually seen at the top of foundation walls, tops of walls, and at each floor diaphragm connection. Intermediate bond beams are often required in higher seismic design categories.

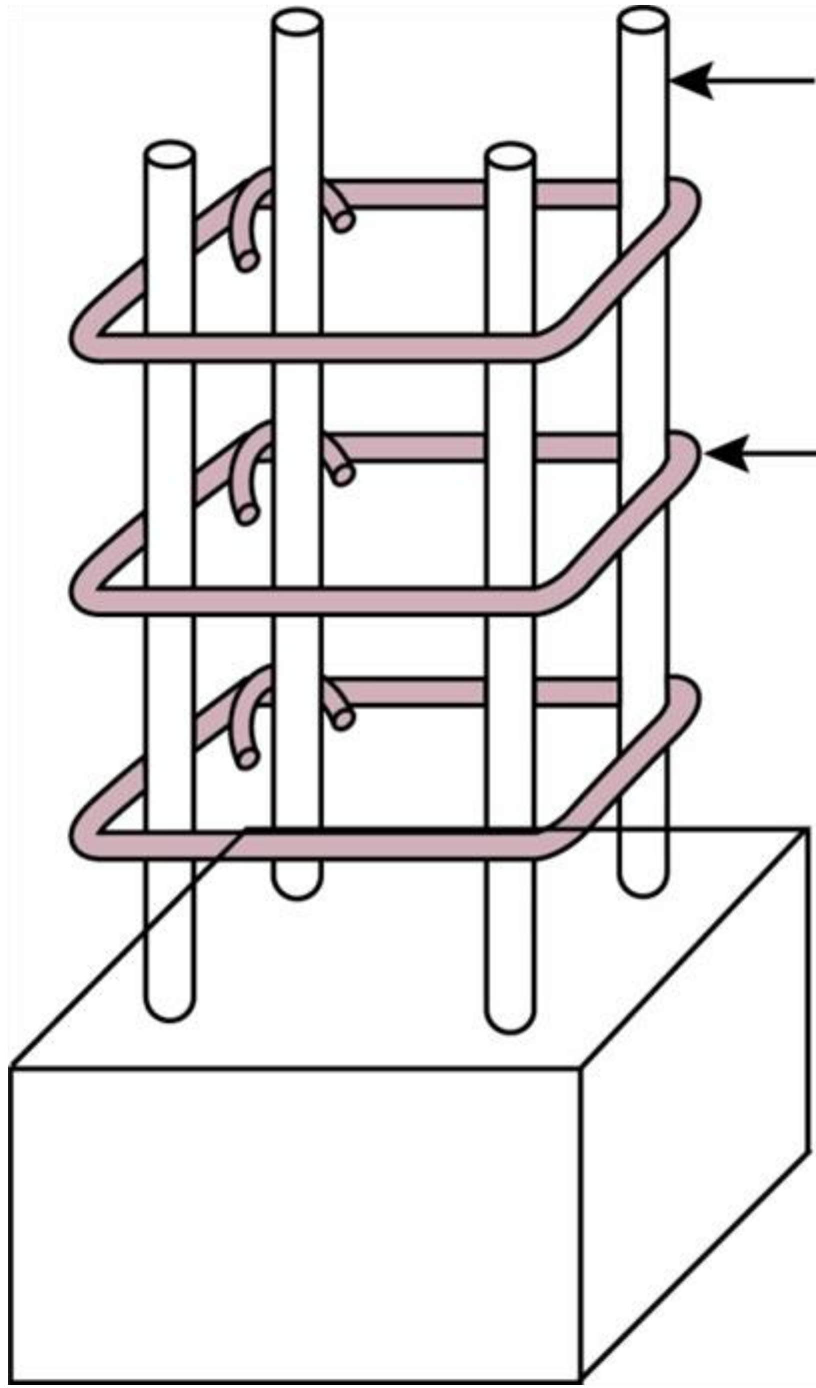
- **Bond Beams**
- STRUCTURAL CONSIDERATIONS
- Bond beams are sometimes arbitrarily placed in walls as a stiffening or tie element, and are recommended at tops of walls, floor connections, and top of foundation walls. Intermediate bond beams are normally not necessary unless required to resist shear stresses or to fulfill minimum seismic reinforcement requirements.

- **Bond Beams**
- CONSTRUCTION CONCERNS
- The intersection of a bond beam with vertically reinforced cells can be very congested, with multiple bars in each direction. Minimize the amount of bond beam steel to improve grout flow and permit proper grout consolidation.
- Use L-shaped corner bars, lapped with the bond beam steel, to provide continuity around building corners.

- **Ties**
- It is the opposite of a struct or column which is designed to resist compression. Tie may be made of any tension resisting material. Ties are continuous tensioned reinforcements that are completely anchored and sufficiently lapped mechanically or using weld.
- Connecting ties that provide a continuous structural load transfer path the top of the building to its foundation, and helping to protect the building. The longitudinal bars could be as long as 12 and would sway at random if they are not tied together. So we can say that lateral reinforcement used to tie individual bars and thus the name is a tie.


HOUSE ROOF
WEIGHT
STRUT
STRUT
TIE
FLOOR BEAM

- **Types of Ties**
- Peripheral ties.
- Internal ties.
- Horizontal column and wall ties.
- Vertical ties.
- **Functions of tie**
- To avoid the cylinder column effect in the structure.
- It increases the stiffness of the overall structure.
- Provide adequate lateral support to each longitudinal bar, thereby preventing the outward movement.
- Ties are shear reinforcement.


Vertical column reinforcement
Steel tie

THANK YOU!