An Elastic Rocking Steel Shear Wall Concept

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FACULTY OF ENGINEERING

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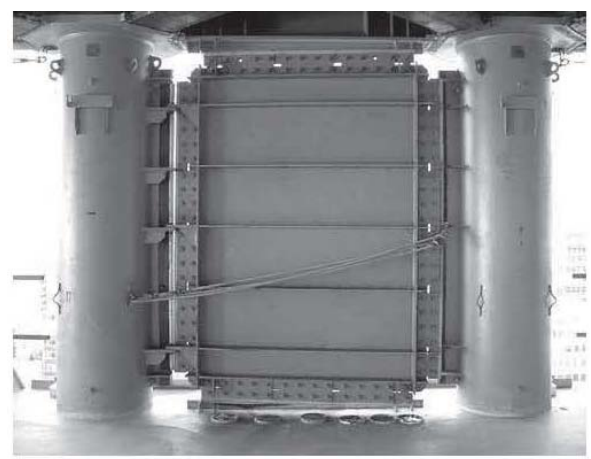
Background

1. Steel shear wall:
   - Developed in the early 1970s.
   - Primary lateral force resisting system.
   - An alternative to braced frames with equivalent strength and stiffness.
   - Excellent performance.
   - Cost-effective solution.
   - Fast construction.

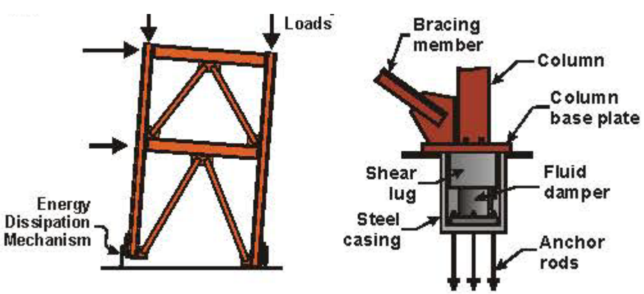
a. U.S. Federal Courthouse, Seattle
(20 Steel Design Guide- Steel Plate Shear Wall)



b. Steel Panel Shear Wall with horizontal stiffeners, Japan (20 Steel Design Guide- Steel Plate Shear Wall)

Background

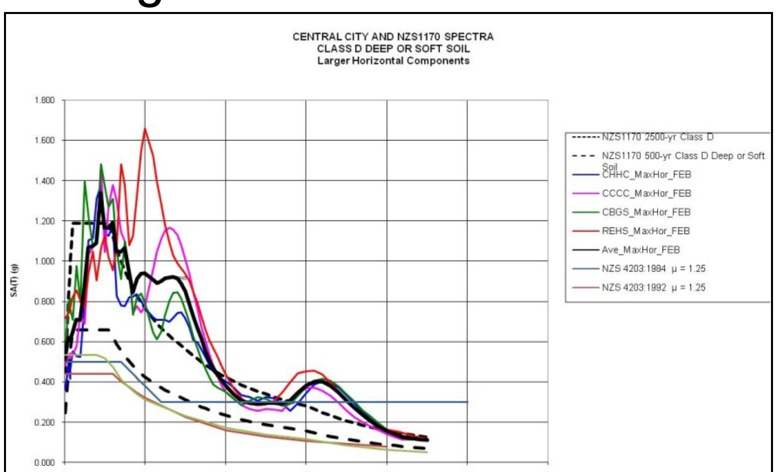
2. Rocking Mechanism
    1. Components that remain essentially elastic and are allowed to rock about the column bases.
    2. Active self-centering elements:
        1. Post-Tensioned Tendons.
        2. Friction Ring Springs.
        3. Viscous Dampers.
    3. Devices that absorb seismic energy as the frames rock.
        1. Structural Fuses.
        2. Friction Ring Springs.
        3. Viscous Dampers.



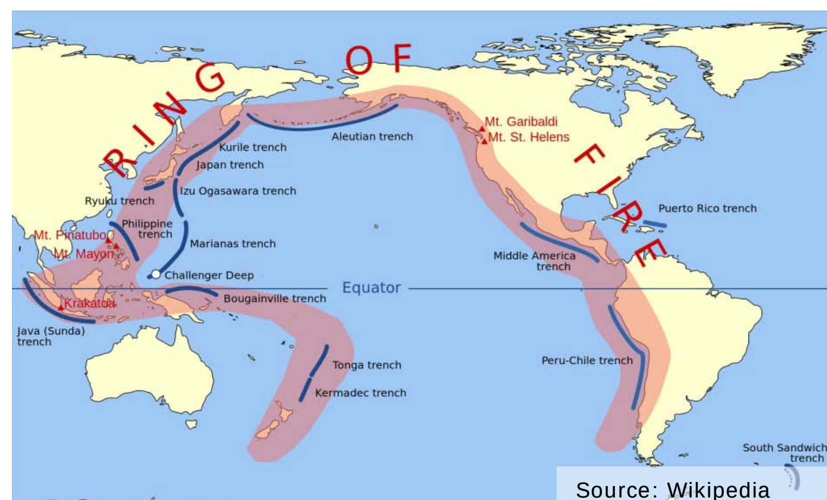
Viscously Damped Controlled Seismic Rocking Braced Frame System
Tremblay (2008)

Proposed Research

1. Advanced steel shear wall.
    1. Lighter than conventional steel shear wall.
    2. Self-centering and remains elastic.
2. Intended for low to medium rise buildings.
    1. Minimize structural damage.
    2. Immediate occupancy following earthquake.
3. Potential good solution for rebuilding Christchurch and other "Ring of Fire" countries.

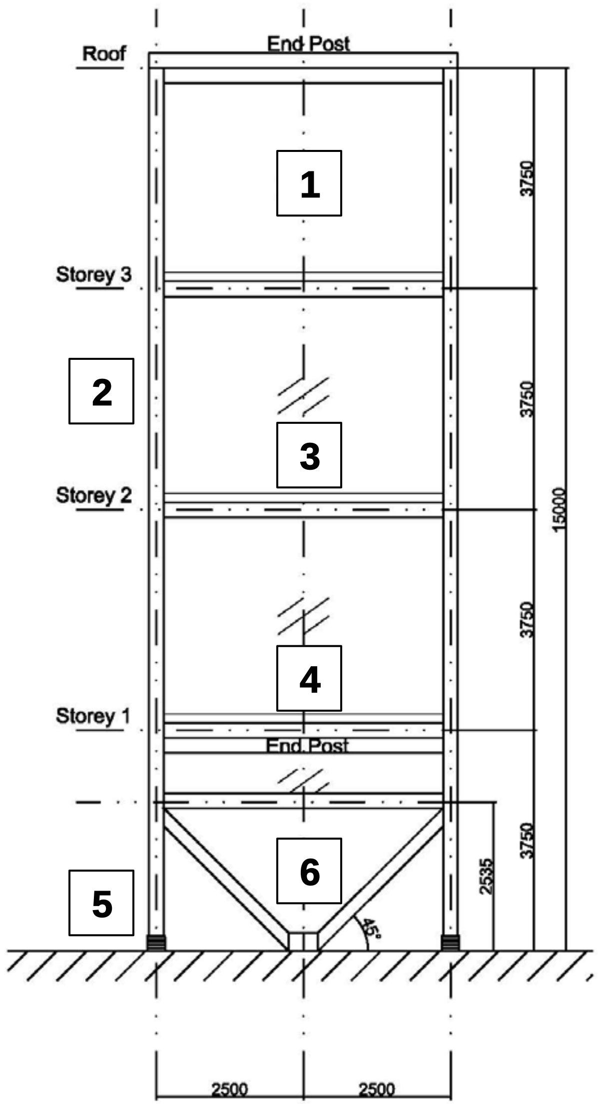


Christchurch Earthquake (February 2011)



Source: Wikipedia

Rocking Steel Shear Wall



Components:

1. Web Plates.
2. Columns/ VBEs (Vertical Boundary Elements).
3. Beams/ HBEs (Horizontal Boundary Elements).
4. End Posts.
5. Energy Dissipation Devices.
6. V Brace & Rocking Point (Base Shear Resistance)

Key Features

1. Cost-effective steel shear wall.

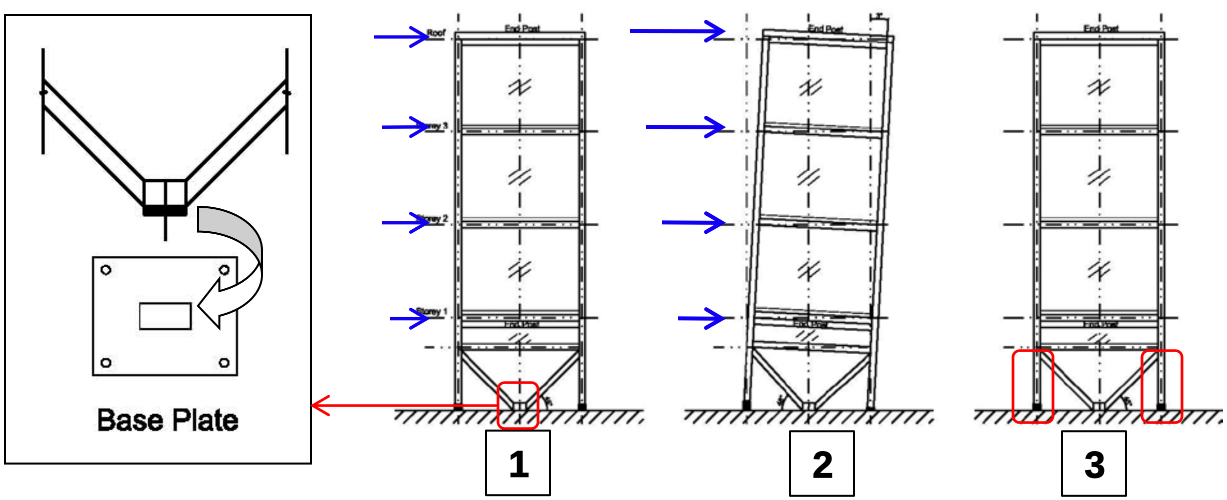
   Thin web plate is approximately 3-5mm and columns (VBEs) are lighter than conventional steel shear wall.

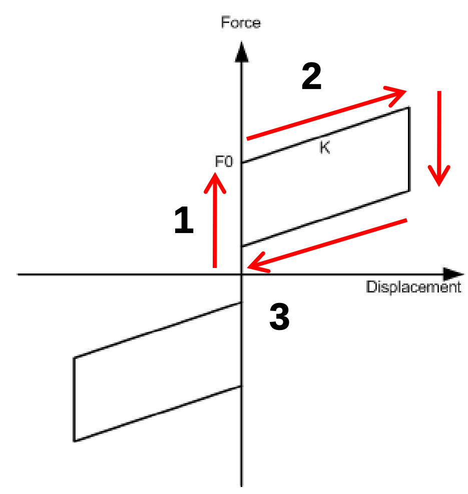
2. The wall is self-centering and remains elastic.
3. Tension field actions and end posts.
4. Energy dissipation and double acting devices:
   1. Ringfeder, Friction Ring Springs combined with post tensioned tendons.
   2. Reston PSD, Preloaded Spring Dampers.

Key Features

Self Centering and Remains Elastic.

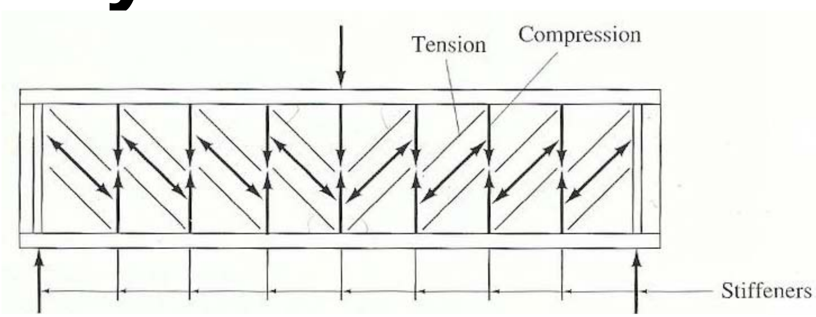
1. Shear wall components are not allowed to yield under earthquake design level.
2. Flag shape hysteresis.
3. Back to original position after earthquake.
4. Columns at the base are subjected to axial force only.
5. Middle support resists shear force and reduce the vertical movement and rotation.
6. Minimize structural damage.



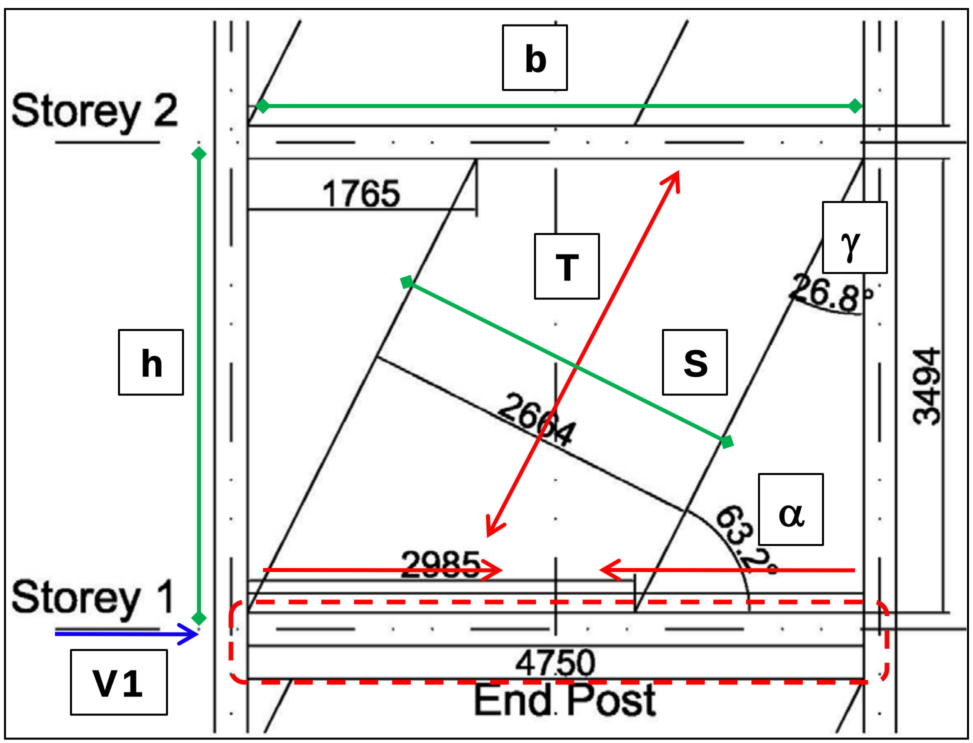


Hysteresis Curve

Key Features



Tension Field Actions on Plate Girder



Tension Field Actions:

1. Plate Girder Analogy.
2. Optimum Direction.

$V = T \sin\gamma$

$T = \sigma_t t_w S$

$S = b \cos\gamma - h \sin\gamma$

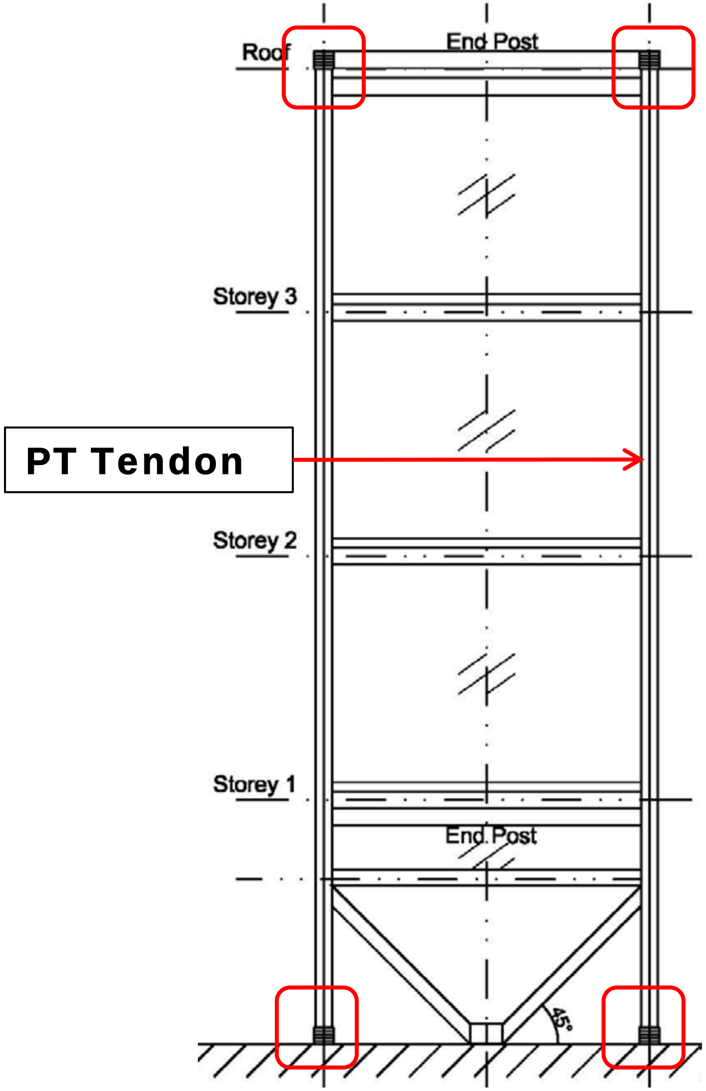
$0 = b \cos 2\gamma - h \sin 2\gamma$; or $\tan 2\gamma = b/h$

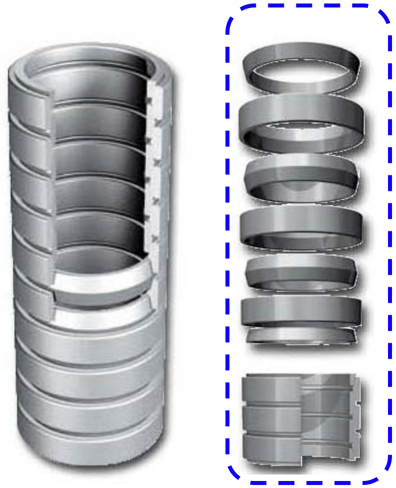
(Salmon & Johnson, 1996)

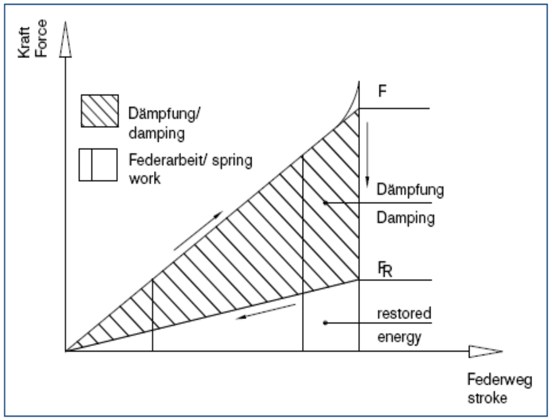
End posts (Double UB):

1. Required to anchor web tension forces.
2. Designed to NZS 3404:97 5.15.2.2 and 5.15.9.

Key Features







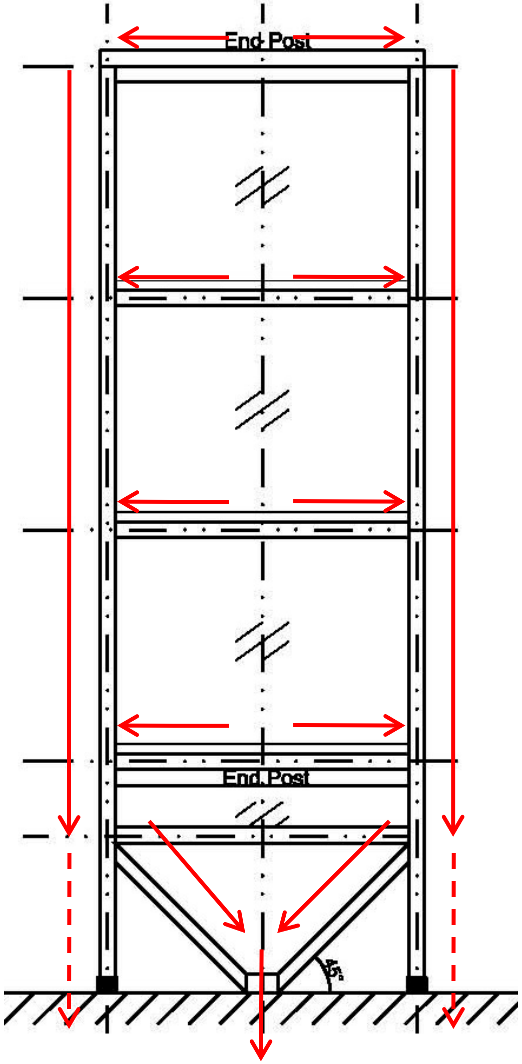
Dämpfung und Federarbeit / *Damping and spring work*

Proposed energy dissipation devices:

1. Ringfeder & PT Tendon:

- $P = K\,\delta$
- Friction between inner and outer ring.
- Compression only.
- Placed at top and bottom to perform double acting mechanism.
- Maintenance free.

Load Paths

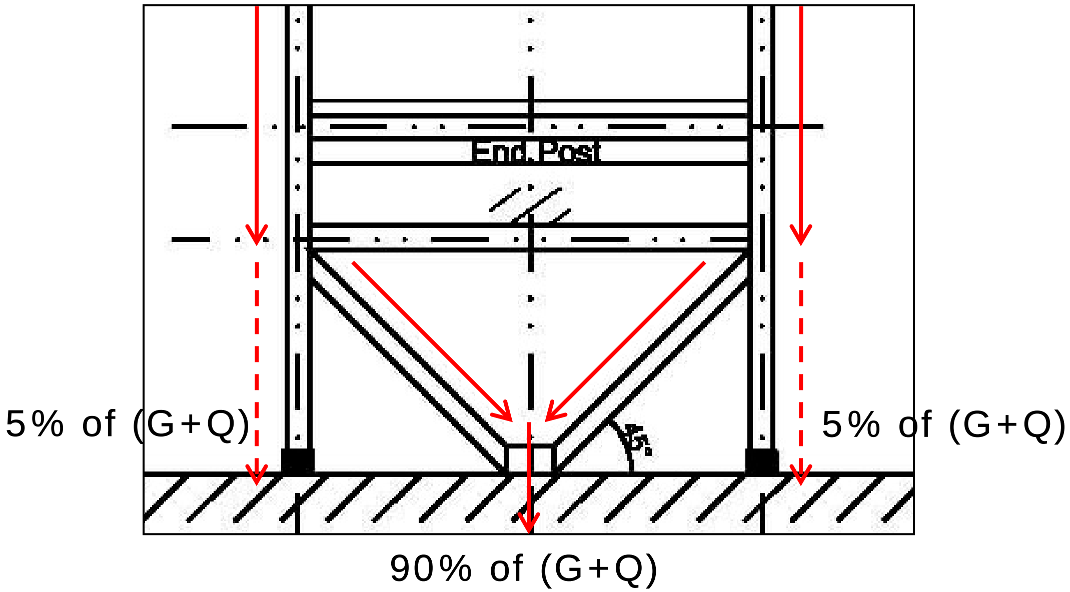


Condition 1 (Gravity Load):

- The Loads are concentrated at the middle support.

Condition 2 ($E_{serviceability}$):

- Steel shear wall is designed to undergo low earthquake forces. No rocking wall at this level.
- $N_{ES} \leq F_0$ (F_0 = Pre-load force).



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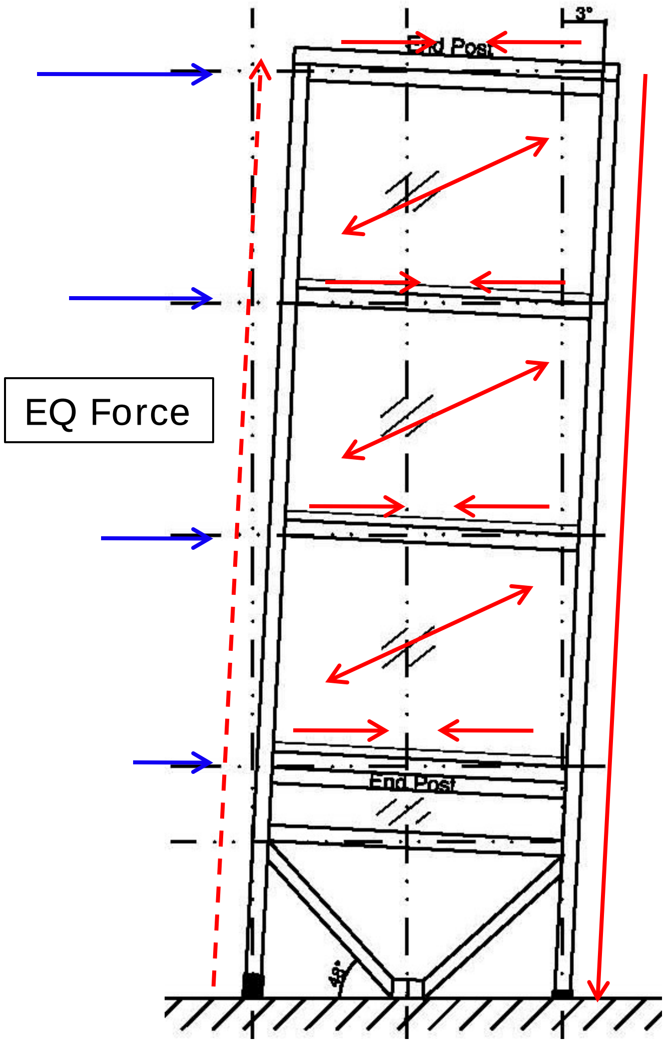
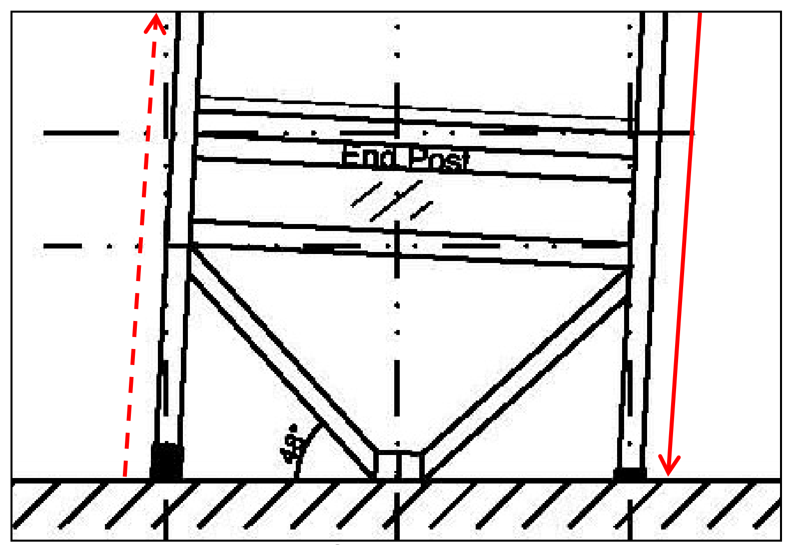
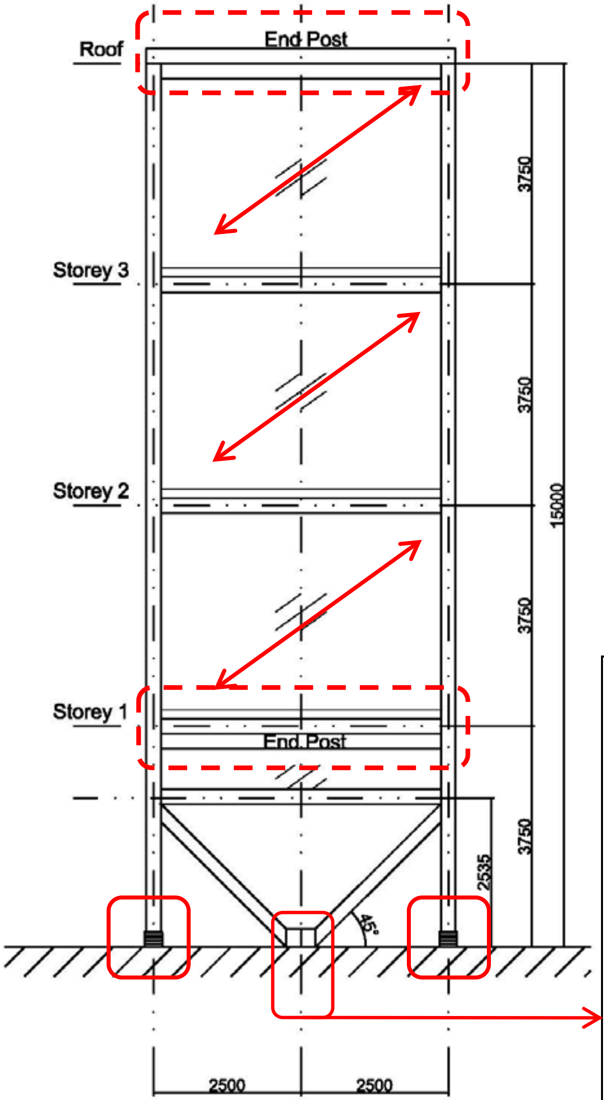


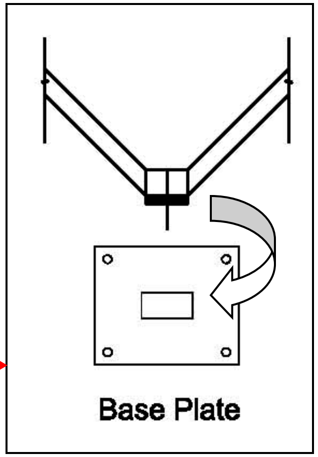
Condition 3 ($E_{ultimate}$):

- Triggering a rocking mechanism.
- Double acting of springs (Compression & Tension) will work.
- Performing self-centering and remaining elastic.



Summary





Rocking Steel Shear Wall:

1. Potential good solution.
2. Tension field actions on web plates.
3. End posts are placed at top and bottom to anchor web tension forces.
4. Double acting devices have to accommodate the arc of the vertical column movements.
5. V Brace & Rocking Point resist shear force and reduce vertical movement and rotation.

Thank You

Question?