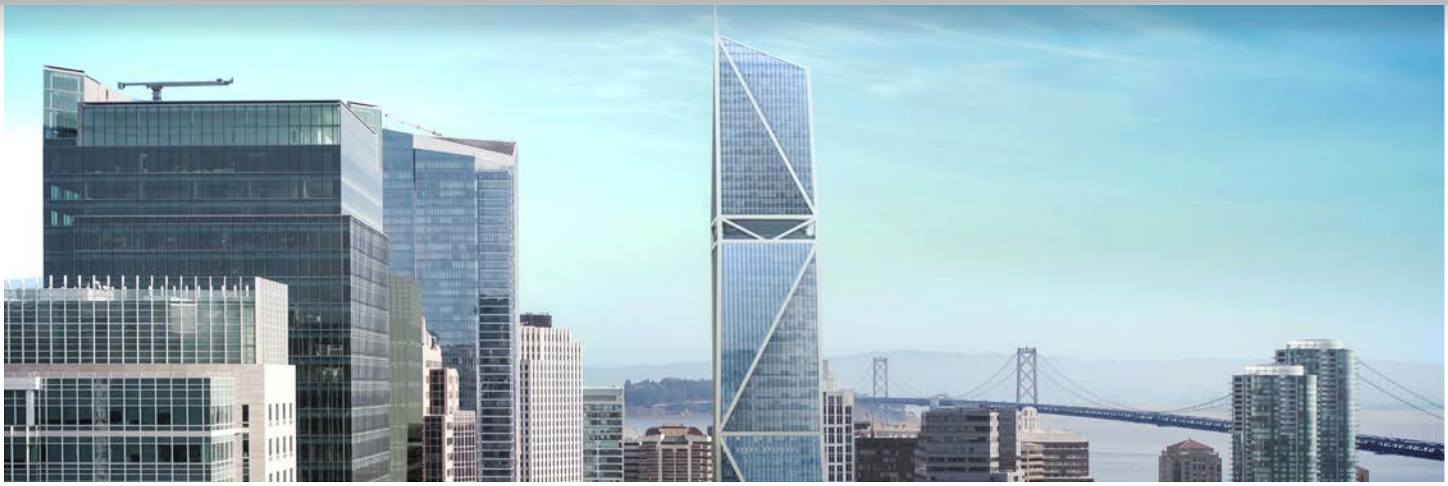
STANDING TALL

TAYLOR SOLUTIONS FOR HIGH-RISE STRUCTURES

Taylor Devices manufacturers damping systems for wind and seismic control of the most demanding high-rise projects.

taylor devices inc.

MEGABRACES

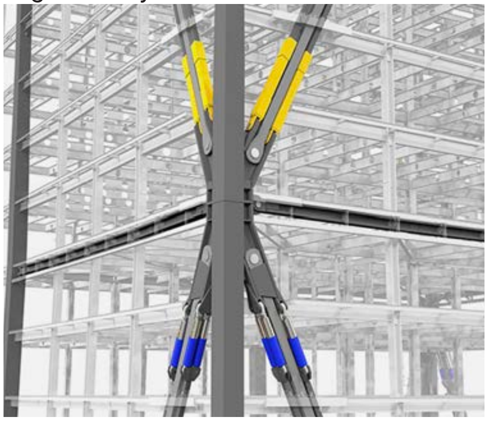


Damped Mega Brace System

A novel strategy for dynamic control of high-rise towers is the damped megabrace system. The system provides damping within the length of megabraces that span multiple floors. The damped megabrace works by placing a fluid viscous damper or a group of dampers at the end of a long bracing element which forms the main lateral resisting system. Since the viscous dampers provide no resistance to static loading, a parallel system of bracing is also used.

The 181 Fremont Street Tower, located in Downtown San Francisco, is arguably the most resilient tall building on the West Coast of the United States. In the heart of San Francisco, adjacent to the Transbay transit center, it is a prime real estate in the city. Given the relative slenderness and the weight of the structure (steel framed), the building is relatively susceptible to wind-induced vibration. Aside from the damped megabrace, both TMD and TSD were considered. While some strategies for reducing accelerations have used TMDs, the location of the building, in a seismic region, favored a robust, distributed damping system. While feasible, TMD and TSD systems were not pursued, in part because of the high value placed upon floor space at the top of the building and the additional steel required to support the weight of the TMD or TSD.

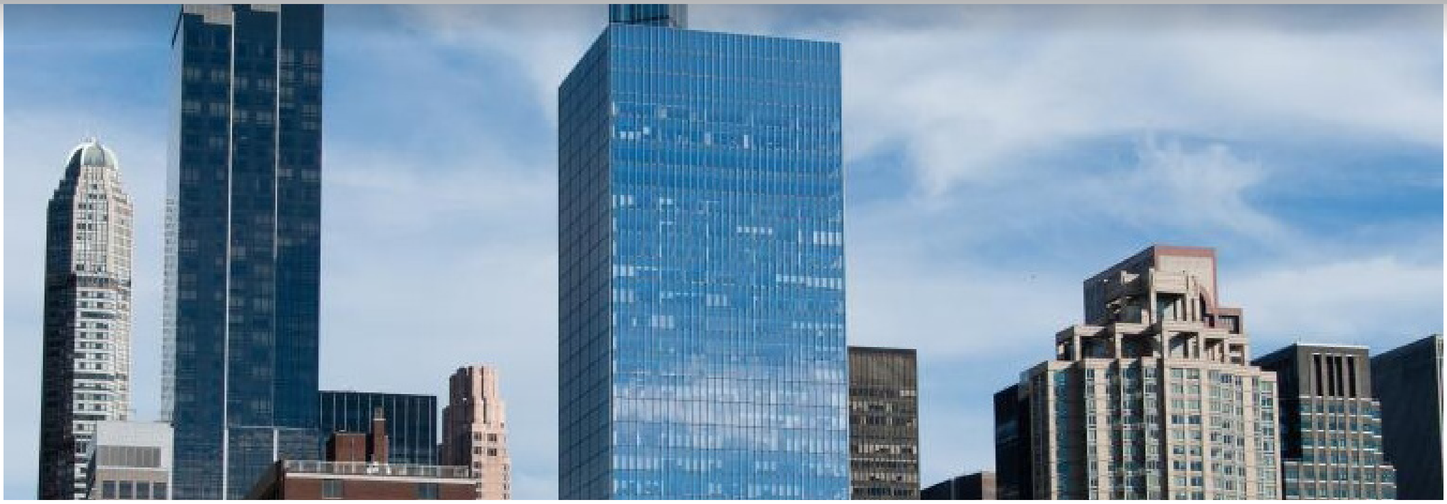
The viscous dampers were placed in eight groups of four within the bracing system. The damping is approximately 8% in two directions for the service level wind. For larger wind events and earthquakes, this effectively increases to 10%–20% because of the beneficial nonlinearity in the dampers. The added damping significantly reduced the overall steel tonnage for the project.



Benefits:

- Fewer dampers in the structure.
- Less steel, reducing cost & improving performance.
- Reduced weight is advantageous in areas where soft soil conditions and liquefaction are a concern.
- Damping can be integrated as an architectural feature of a building.

DAMPED OUTRIGGERS



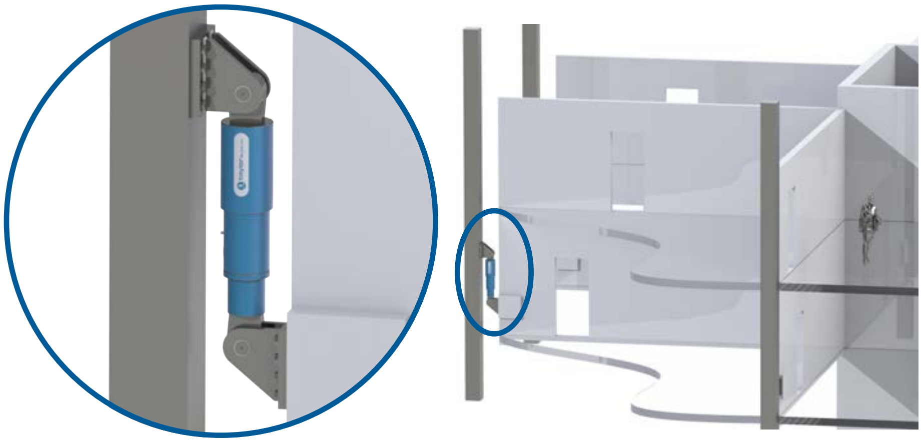
Damped Outrigger Systems

A damped outrigger system is highly efficient in reducing dynamic movements from hazardous winds. This system is based on the concept of total gross movement of the structure, applying vertical tension/compression forces into perimeter columns.

Outrigger damping can be accomplished by constructing a rigid cantilever off the core of the building within a specific floor level, or levels, and connecting fluid viscous dampers between the end of the cantilever and the outer columns. The solution takes advantage of the tension and compression on the opposing outer columns of the building which amplifies the movements of the central core at the location of the outriggers.

250 West 55th Street in New York City is a 40-story office tower. This structure required additional damping based on the potential for higher than anticipated building accelerations due largely in part to both the shielding and wake buffeting caused by the surrounding buildings. The engineers at ARUP opted for the damped outrigger system as it offered the same level of damping as a TMD but without sacrificing valuable real estate at the top of the structure or added weight to the building. The final building design had 10% less steel tonnage than a configuration with no damping, effectively saving the client millions of dollars.

Damped outrigger configuration for concrete structures



Benefits:

- No temperature sensitive viscoelastic materials.
- No failure prone components like valves.
- No need for re-centering, repair or replacement.
- Provides energy dissipation to all frequencies of input vibration.
- Components are small and can be hidden in various locations throughout the structure.
- Avoids large potentially dangerous masses in the structure.
- Can be used to reduce service and strength level demands.

TUNED MASS DAMPERS

Tuned Mass Dampers

Tuned mass dampers (TMDs) are attached to high-rise towers to reduce dynamic response caused by hazardous winds. A TMD is a system composed of a mass, springs and dampers tuned to a specific frequency. When a frequency of wind loading causes dynamic amplification of a tower, the TMD will resonate out of phase with the building, energy will be dissipated by the dampers, and the tower's dynamic response is improved.

432 Park Avenue is an 88-story, 1396ft (425m) tall residential skyscraper with an aspect ratio of 14:1 that overlooks Central Park in New York City. When it was completed in 2015 it was the tallest residential building in the world, and the third tallest building in the United States.

A traditional pendulum type TMD would have taken up roughly eight stories of valuable space at the top of the structure, so another solution had to be found. Engineers at RWDI proposed an opposed-pendulum design that would reduce the required vertical space to three floors by splitting the mass into two equal parts and placing them on either side of the central tower core.

Taylor Devices supplied a total of 16 fluid viscous dampers as a part of this project aimed to improve occupant comfort. The outcome was a design that reduced the required space while maintaining travel of 136 inches peak to peak.

Benefits:

- They do not depend on external power source for their operation.
- They can respond to small levels of excitation.
- Their properties can be adjusted in the field.
- They can also be introduced in structural upgrades or retrofits.
- They require low maintenance.

Direct Acting Damping

While many methods exist to implement distributed damping in a structure, the underlying concept is to connect the dampers where motion will occur, such as between beam and column joints or between floor levels which deform relative to one another in a shearing-type motion. Some common configurations are listed below.

Open Space

While not specifically used for high-rise buildings, Taylor Devices does offer an open space configuration designed to offer more open bays.

Toggle

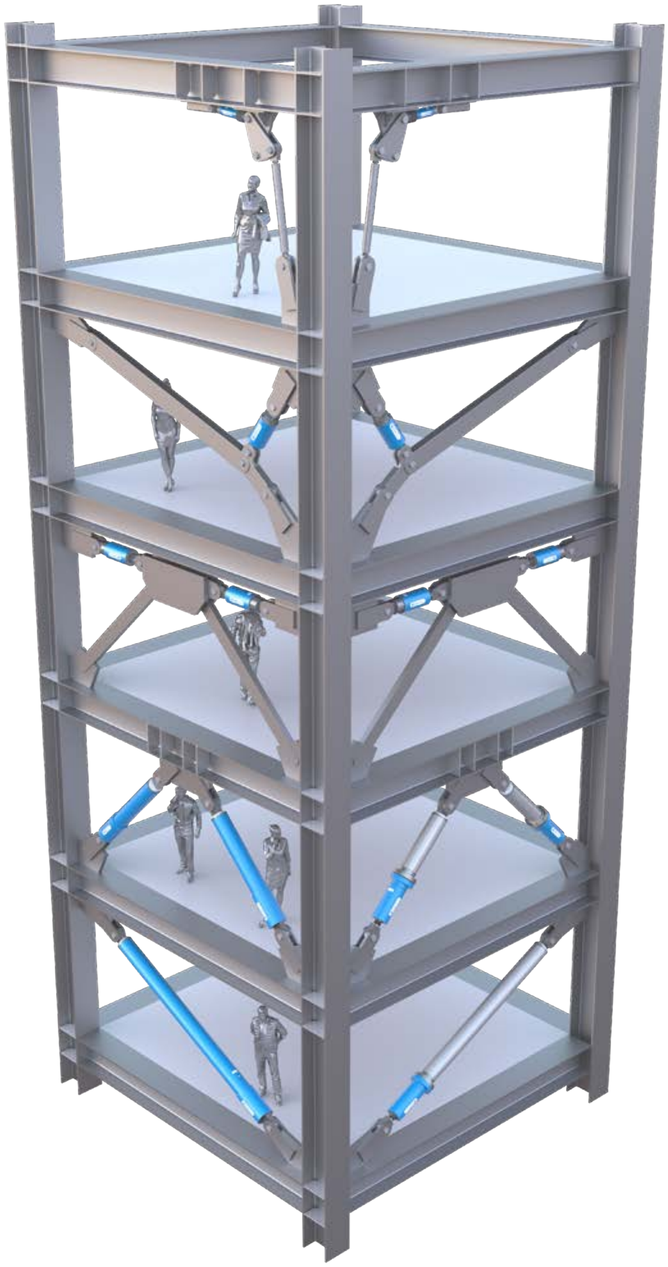
Toggle frames can be used as a mechanism to amplify deflections into the damper in otherwise stiff, or tiny deflection situations, creating a more efficient damping system. Toggle Frames utilize a bent-brace mechanism theory to capture deflections in one plane and translate the deflections into another plane and therefore provide very efficient damping.

Chevron

In this configuration, the dampers are placed horizontally, and connected to a frame (chevron) that is intended to be near-rigid with the floor it is connected to. The advantage with this direct damping orientation is that the horizontal flexibility of the structure injects this full movement directly into the horizontal orientation of the damper. However, a small amount of motion can be lost due to the constraints of the attainable stiffness of an economical chevron frame.

Diagonal

A very common method of applying distributed damping to a structure is to connect the dampers to diagonal corners or center of a structural frame or bay. In this orientation, the horizontal movement of the structure allows an angular component of the full deflection to go into the damper. This takes the motion directly to the next floor level through a strong tension/compression member.



PROJECT REFERENCES

Chicony HQ - Taiwan

A 40-story commercial high-rise in New Taipei City.

Solution: Direct (Chevron Brace)

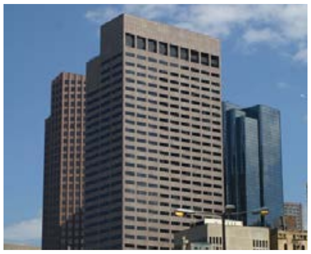
Completion in 2015

111 Huntington Ave - Boston

A 36-story commercial high-rise in Boston, Massachusetts.

Solution: Direct (Toggle & Diagonal Braces)

Completion in 2002



28 State Street - Boston

A 40-story commercial high-rise in Boston, Massachusetts

Solution: Direct (Diagonal Brace)

Completion in 1970
Retrofitted in 1996

217 West 57th Street - New York City

A 100-story mixed-use high-rise located in New York, New York.

Solution: Tuned Mass Damper with Taylor VDDs

Completion in 2020

Millennium Place - Boston

A 37-Story luxury residential high-rise in Boston, Massachusetts.

Solution: Direct (Toggle Brace)

Completion in 2000

Torre Mayor - Mexico City

A 55-story mixed-use high-rise located in Mexico City, Mexico

Solution: Damped Mega Brace

Completion in 2003

Farglory the ONE - Taiwan

A 68-story mixed-use high-rise located in Kaohsiung, Taiwan.

Solution: Direct (Chevron Brace)

Completion in 2019

Park Tower - Chicago

A 70-story mixed-use high-rise located in Chicago, Illinois.

Solution: Tuned Mass Damper with Taylor VDDs

Completion in 2000

About

Since 1955, Taylor Devices, Inc has been a world leader in the shock and vibration control industry. Over 700 buildings, bridges, stadiums and other structures around the world rely on the quality and durability of our products.

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Quality Standards

Taylor Devices holds itself to the strictest national and international standards. Our facilities and Business Management Systems are registered to the current versions of ISO 9001, ISO 4001 and AS 9100. The same level of quality is standard on every product we manufacture, regardless of industry or application, with all structural products being fully tested prior to shipment.

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