

# Earthquake Readiness Is Serious Business

After decades of indifference to the risk, Los Angeles city leaders passed [ordinance 183893](#) in October, 2015. It requires building owners to perform seismic retrofits on their residential and commercial soft-story properties. Building officials call these multi-story structures soft-story because of the tuck-under parking, garages and big-window storefronts that weaken the street-level floor making it more vulnerable to collapse during an earthquake. Updates required by the ordinance must improve the building's structural performance and provide a minimum level of safety for inhabitants during a bigger seismic event.

Soft-story building owners will receive an order to comply with strict deadlines. They'll have two years to show proof of a previous retrofit, submit plans for a retrofit or they'll have to demolish the building. They'll have three and a half years to get a permit to start construction or demolition and seven years to complete the retrofit. Since there are many thousands of West Coast building owners facing similar mandates, there's sure to be a rush to hire contractors. Prefabricated moment frames might be the best way for engineers and contractors to help building owners cope with the anticipated frenzy in retrofit construction.

## Why Los Angeles Leaders Passed Ordinance 183893

The City Council action is no surprise. After every significant quake in LA over the last 30 years, teams including engineers, architects and contractors walked affected areas to inspect buildings. Their goal was to learn why certain building types collapsed, and to determine which architectural designs and seismic upgrades worked, and which didn't. Teams inspecting damage from the 1989 Loma Prieta and 1994 Northridge quakes discovered a major building-failure pattern. Multi-story residential buildings with parking or big-window storefronts at ground level (the soft-story) were more likely to collapse.

These types of structures were commonly built across California in the 1920s and 1930s and have horizontal wood siding, hardwood floors and gypsum wallboard on upper floors. They swing back-and-forth like a building on chopsticks during a severe quake. Solid walls stiffen upper floors causing them to move together as a single block independent of the first floor. But fortunately, prefabricated moment frames can easily be inserted into the open first-floor areas to add necessary strength. When installed, all floors respond as one to seismic shaking.

## Understanding The Cost Of Earthquake Resilience

City planners use the term resilience to describe a community's ability to rebound from natural disaster. Interest in improving resilience was heightened by the tragic losses and socioeconomic effects that New Orleans suffered in Hurricane Katrina's wake.

When LA leaders required seismic retrofits for older buildings that were vulnerable to earthquakes, it was one of several actions of the ["Resilience by Design"](#) initiative - a city-wide effort to prepare the city for the next "big one". Los Angeles Mayor Eric Garcetti said the effort has three goals: to prevent loss of life, avoid population displacement and improve building resiliency that minimizes the cost of repair or replacement.

## **Earthquakes are particularly damaging to buildings with open spaces at street level because they collapse**

Now building owners are busy reviewing their responsibilities to make their properties resilient. And a seismic retrofit isn't cheap. Estimates for these buildings (upgrades to lateral stiffness and strength) run from \$50,000 to \$130,000 just to meet minimum standards. But some might require foundation work, making those top a quarter of a million dollars.

There's a lot at stake, so [structural engineers, building owners and contractors need to work together](#) to decide on the most cost-effective approach for each project. Seismic product manufacturers are doing their part by developing prefab products that increase resilience and cost less than field-crafted repairs.

### **Research Confirms The Value Of Strengthening Soft-Story Buildings**

The push to strengthen soft-story buildings is based on scientific research aimed at saving lives. In a recently published paper, [The Human Impact of Earthquakes: A Historical Review of Events 1980-2009 and Systematic Literature Review](#), John Hopkins University researchers documented death and injuries resulting from earthquakes.

They matched hundreds of post-quake inspections with reported fatalities from those events and found that most deaths occurred indoors at home. Their conclusion was that strategies to prevent earthquake damage must focus on design, construction improvements and enforcement of zoning and building codes.

Studies like these along with results from 30 years of inspections have given researchers like Dr. John Van de Lindt a reason to reconsider the relationship of a building's design and its performance during a substantial quake. As the George T. Abell Professor in Infrastructure at the Colorado State College of Engineering in Fort Collins, Colorado, he studies how to improve structures to survive natural disasters. Recently, he turned his attention to soft-story buildings. Van de Lindt has said, "Earthquakes are particularly damaging to buildings with open spaces at street level because they collapse," making it clear that he understands the issue.

Building design engineers like Van de Lindt have responded globally to these recommendations on how to make soft-story buildings earthquake-ready. He believes many thousands of multi-family buildings across California and much of the U.S. need retrofits. So, it's not surprising that he and fellow researchers view their efforts as a matter of life and death for residents in these structures.

### **Prefabricated Moment Frames Performed Well During Research**

Van de Lindt addressed the issue in 2009 by successfully leading the [world's largest earthquake shake table test in Japan](#). It was part of a research effort to demonstrate that midrise wood-frame buildings can be built to withstand major quakes.

In 2013, he led a team of researchers studying California-style soft-story buildings. They actually built and destroyed a 44,000-square-foot test building on the world's largest outdoor shake table at the Englekirk Structural Engineering Center at UC San Diego. It was built like a typical California soft-building with three stories above an open first floor. The goal was to learn which retrofits would help the test building survive seismic shocks. They hit the building with a series of four simulated

quakes of increasing strength while testing a variety of retrofits. Eventually, the building collapsed during the fourth test after test retrofits were removed.

## **Community leaders took a proactive role by adopting a building code that required retrofitting older buildings**

One part of their research was to determine how a prefabricated moment frame responded to the simulated seismic events. The structure was equipped with a retrofit moment frame installed in accordance with FEMA P-807 guidelines.

Another part of the study reviewed the structure's response while using a more extensive steel special moment frame and anchor tied-down system. These Simpson-Strong Tie designed retrofit systems performed well. "The larger shakes damaged the building, but with the retrofits in place, the building was still structurally safe enough for occupancy," Van de Lindt reported.

### **Prefabricated Moment Frames Make Soft-Story Buildings Safer, Faster**

Using the results from researchers such as van de Lindt, manufacturers have designed and built new products that transform soft-story buildings into more resilient structures. These modular, prefab special moment frames are custom made to the design specifications of the structural engineer who inspected the soft-story building. A moment frame is a rectilinear assemblage of rigidly connected beams and columns that provide resistance to lateral forces like seismic shaking. Contractors can easily install these factory-made frames by bolting them to existing ground floor walls and columns.

There are important advantages to consider when selecting prefab modular special moment frames for your soft-story retrofit. These include: ease of design, increased quality and ease of installation. Frame manufacturers offer structural engineers hundreds of design drawings for pre-engineered frames. They also provide design software using current FEMA guidelines for more complicated designs. Structural engineers can use this data to provide building owners with the best plan to meet the mandate's requirements.

### **Prefabricated Moment Frames Are Building Owner Friendly**

When a contractor using prefab moment frames presents a bid document, the building owner will know the actual cost of the project. That's because conventional moment frame construction methods typically use lateral bracing with their engineered systems to be code compliant. If a contractor isn't using prefab moment frames to address the issue, unseen site conditions might be revealed after demolition is complete. That makes the final project cost an unknown. There could be extra cost from additional shoring or field changes. Some special moment frame manufacturers offer custom solutions eliminating the need for lateral beam bracing. This feature can also help control job costs and speed up local building approval.

And during installation, tenants are only briefly inconvenienced. Building owners won't have to ask tenants to vacate during the retrofit because of common construction disturbances. These prefabricated moment frames only require snug-tight bolted connections. There are no additional costs for high-strength bolting products with special inspection requirements. And there's no need for field welding that causes toxic fumes and an increased fire risk.

Prefab special moment frames also give engineer and building owner better quality than field-crafted solutions. Frames are manufactured and partially assembled in a production environment with comprehensive quality-control measures. And all specialty tension-controlled bolted connections are performed in the factory under third-party witnessed inspection. Manufacturers can also provide documentation that the frames are code-listed under jurisdictions such as the ICC Evaluation Service, ANSI, and the City of Los Angeles regulation RR25957.

And following a seismic event, engineers can quickly inspect installed frames to determine structural integrity, enabling a quicker tenant return.

## **A Variety Of Effective Solutions Are Available**

Here's the bottom line. Using prefabricated seismic retrofit products gives the building owner the best way to arrive at the most economical bid. They can be used in a variety of design options and answer cost-to-benefit considerations with soft-story retrofits. White Cap carries a wide range of products for soft-story and seismic retrofit applications that are designed to help building owners, engineers and contractors get the job done. They include:

### **Moment Frame Installation For Outside The Existing Wall Line**

These installations are fast, cost-effective answers. Manufacturers provide anchorage components in a "Template Kit" that contractors assemble on site and place into a new footing designed by the structural engineer. The Special Moment Frame is placed on the anchors and secured to the foundation and the contractor connects the frame to the existing structure.

### **Moment Frame Installation Inside The Existing Wall Line**

This type of installation is perfect for soft-story structures where aesthetic appearance is important - or when vertical loads must be considered. The contractor lowers the base plate into a new footing plumb to the wall, raises the frame into place and secures the support to the existing structure.

### **Special Moment Frame For Complex Designs**

Manufacturers also offer prefab special moments frames for buildings with large openings such as garages and storefronts. These products provide higher performance and easier installation than traditional strengthening solutions. Manufacturers can custom fabricate configurations, or member sizes can be designed for soft-story structures utilizing FEMA P-807, IEBC Chapter A4, or ASCE 7. These options include stepped column heights for sloped hillsides, frames in line with varying heights, designs where existing pipes or features cannot be located, and multi-story and multi-bay designs.

### **Four-Sided Special Moment Frames**

A prefabricated element that has special moment connections at all four corners was recently introduced by Mitek USA. The innovative addition of a beam with special moment connections replaces the need for an engineered, steel-reinforced concrete-grade beam and offers the advantages of a fixed base connection. Field installation is easier and the need for inspections is reduced.

## **Shear Walls**

When structural loads are not high enough to require a moment frame, prefab shear walls might be the best choice. These products offer design flexibility to meet ordinance standards even with narrow walls or larger openings. Easy installation saves valuable time on the job.

## **Structural Connections**

For structural connections throughout the building, including anchorage to the foundation, manufacturers offer a variety of steel products and applications to provide earthquake resistance where it's needed the most.

## ***digging deeper***

Check out these links for more information on Soft-Story Retrofit as it applies to [contractors](#), [structural engineers](#) and [building owners](#).