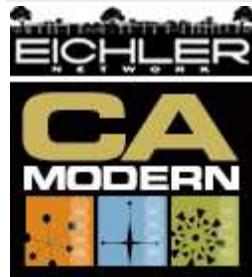


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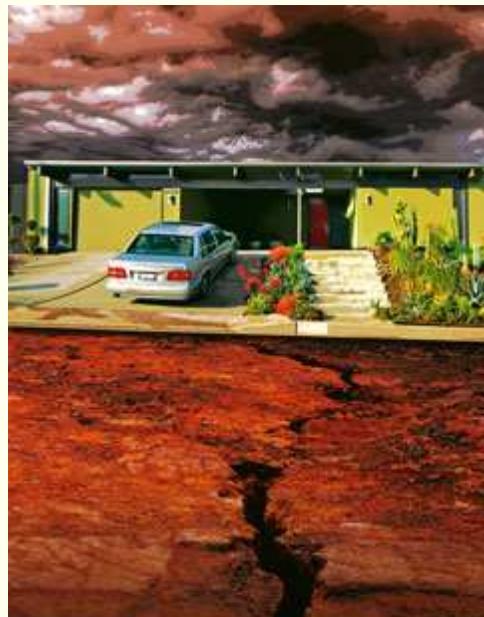
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## Home Improvement Spotlight

**SHAKE, RATTLE...AND RETROFIT**  
Protecting your home and family  
against the next major earthquake

From the pages of the CA-Modern magazine  
By Tanja Kern



It's a grim reality that earthquakes don't kill; collapsed buildings do.

Eichlers and other mid-century modern homes are naturally more vulnerable to earthquake damage than newer structures simply because they emerged in an era of relaxed building codes and in a state with relatively benign climate conditions.

As a result of geological and engineering research, building codes have advanced greatly since the 1950s and '60s; and in California, codes today are taking a much stronger stand against the state's ever-present susceptibility to seismic unrest.

Thankfully, there are things homeowners can do to bring their home's structural integrity into the 21st century. Following California's major earthquakes of the past two decades, several governmental agencies, private engineers, and university research groups have made extensive examinations of failed buildings, and many of their recommendations have been adopted into revisions of the

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#### Uniform Building Code.

Most of the recommended corrective measures can also be added to existing structures, a practice referred to as 'seismic retrofitting,' 'seismic strengthening,' and bolting and bracing.

Although there is no such thing as an earthquake-proof house, experts agree that structural damage can be greatly reduced through earthquake retrofitting. A retrofit provides existing structures with more resistance to seismic activity due to earthquakes. In buildings, this process typically includes strengthening weak connections found in roof-to-wall connections, and installing continuity ties, shear walls, and a roof diaphragm.

Houses that haven't been retrofitted to meet today's codes usually have five major points of vulnerability: an unstable post-and-beam system, oversized glass panels, the chimney, the roof, and plumbing.

Seismic experts, who include structural engineers and qualified contractors, can perform a visual inspection of a home to determine its strengths and vulnerabilities. It's wise to get a detailed proposal with plans and a bid from more than one contractor. Each contractor should explain the work to be performed, referencing appropriate building codes, and present references.

#### Shear wall bracing

Seismic movement is a moment in time when a physical change occurs to the Earth's surface. To illustrate what happens to a house during a seismic event, compare a house's structure to a 'Bozo the Clown' punching bag that is weighted at the bottom. When you punch the bag at particular intensity, the bag remains in place but sways back and forth until it settles into a stationary position again. The intensity of the punch will dictate how much the bag moves. If you hit the bag hard enough, it may just slide across the floor.

Not unlike the extreme punching bag movement, shear failure occurs when the bottom of a building moves under the force of a quake but the top doesn't. The oversized panels of glass in an MCM home can lead to this problem, making shear bracing a top priority in the retrofitting process.

"In an earthquake, a house will tend to slide around on its foundation, and [when it does,] the damage tends to be very high," says Steve Pryor, a structural engineer with Simpson Strong-Tie, an East Bay-based manufacturer of metal hardware used in seismic retrofits.



**The two Eichler interiors here emphasize three areas of vulnerability in an MCM home: beams, glass, and fireplace.**

### home: beams, glass, and fireplace.

Pryor recommends creating a 'continuous load path.' This is a method of construction that ties your house together from the roof to the foundation using a system of framing materials, metal connectors, fasteners (such as nails and screws), and reinforced walls called shear walls.



**Shear wall bracing.**

This system connects and strengthens the structural frame of the house. If your home is built with a continuous load path, it will be better equipped to resist the forces of an earthquake by transferring these forces from the frame of the house to the foundation.

Contractors regularly turn to shear panels to combat lateral movement in walls in MCM homes. Outfitted with plywood sheets over wood framing, shear panels are bolted into the foundation to help ensure that a building doesn't tip over during an earthquake.

The plywood sheathing, with four-by-eight-foot dimensions, is nailed into the studs and bolted into the foundation with hold-down anchors at each end of the panel. The more areas of glass you have, the more shear bracing your home needs.

"Alone, the skeleton [of the house] is not strong, but when you put a piece of plywood onto it, it creates shear panels that can help resist movement," says Ron Key, owner of Keycon Inc., an Eichler-focused remodeling firm on the San Francisco peninsula.

#### **Post-and-beam reinforcement**

In post-and-beam construction, a wall is constructed with wood dimensional posts and beams that are attached to a metal post base or a piece of wood that is bolted to the concrete foundation. "Here, the strength is being built from the ground up," Key says.

To create that strong foundation, the house needs to be attached to something substantial. Although code requires 12-inch concrete footings, Keycon recommends 20 to 30 inches, and hitting bedrock, which offers a durable base.

Reinforcing the post-and-beam construction relies on installing new bolts through the sill and into the concrete slab. "In the old days [30 years ago], we used to put one-half-inch bolts, that were ten inches long, every 12 feet," Key says.



**Ron Key of Keycon, Inc. demonstrates a metal post-and-beam bracing connection, one of the earthquake retrofitting reinforcements he recently installed in a peninsula Eichler.**

Today's practice is to install five-eighths-inch diameter bolts at four-foot intervals. Additionally, since bolts primarily prevent lateral or sliding movements, other types of hardware, called hold-downs, are installed at shear-panel walls to resist effects of the house lifting off the foundation during seismic movement.

The bolting and anchoring can be done from the inside or the outside of the house. After interior paneling or exterior siding is removed, concrete drills run into the slab, and then the holes are cleaned out with a wire brush and an air blower. The contractor then places an all-thread steel rod into the hole with an appropriate epoxy, which anchors it to the foundation.



**Anchoring to the foundation.**

were used for many years. The larger washers help to clamp the sill from the top instead of relying only on the bolt extending through the wood sill for sliding resistance.

It's important to replace the MCM home's original bolts because steel does not last forever. Many of the original bolts have fallen victim to rust and decay over the years, making them weak. In fact, some experts suggest replacing bolts every 30 to 40 years to ensure strength and durability.

A pressure-treated wood three-by-four plate attached to the foundation using large washers and nuts also makes a big difference in seismic resistance. Following failures observed after the 1994 Northridge earthquake, building code now requires the use of a larger, thicker, square washer in place of the small, thin, round ones that

Another benefit to the larger washer is that it helps compensate for an over-drilling, or instances when the hole drilled for the bolt is too large, allowing the sill around the bolt to shift and split during an earthquake.

### **Chimney reinforcement**

No one should be near the family fireplace during an earthquake. The heavy brick or stone can cause serious physical damage, or even death. Contractors in years past recommended strapping the chimney to the house so that both could move together during a quake.

After the Northridge quake, the Structural Engineers Society in Los Angeles looked into the best way to retrofit a chimney. They determined that retrofitting masonry chimneys with bracing or strapping is not an effective safety measure because many chimneys, even when braced or strapped, typically still fall when exposed to violent shaking.

Consider replacing your masonry chimney with a modern stud-framed one around a metal flue. Another option is a partial chimney replacement in which all of the bricks above the firebox are removed. The upper portion is then replaced by a stud-framed chimney and a metal flue. This partial replacement has been used to repair chimney damage after earthquakes and removes most of the potential life-safety issues.

If you opt to keep your original fireplace and chimney, have a plan in place to evacuate the main living area during a quake.



**Post-and-beam bracing.**

### **Glass safety**

Your expansive windows and sliding-glass doors are potential hazards if they shatter or implode during a quake. Tempered glass, or 'safety glass,' which breaks into small pieces when struck, has been used in cars since the 1920s, but was not required in the construction of 1950s-era housing.

If you haven't done so already, find some peace of mind (and increased insulation too) by replacing your original glass with tempered glass, or install safety window film over large panes, providing a 'steel curtain' to hold shattered glass in place to protect the family from serious harm. While do-it-yourself installation of window film is possible, professional installation is recommended.



### **Roof support**

Add strength to your roof by installing a roof diaphragm made of solid plywood sheathing that works similarly to the shear bracing method. The roof diaphragm will gather the energy generated by an earthquake at the top of the structure and direct it through the vertical shear panels into

the ground. It makes sense to do this project only when re-roofing your home. A bonus benefit to this project is that the added plywood also provides an extra layer of insulation.

### Plumbing

It's wise to nail down anything that can move during an earthquake, including major plumbing equipment. "The single biggest plumbing problem is the water heater," Pryor says. "In an earthquake, the horizontal shaking can generate fairly large loads."

Mount metal straps around the top and bottom of your water heater and bolt the straps securely to the concrete wall or studs. Block in any gaps between the back of your water heater and the wall. Install an automatic gas shut-off valve at the gas meter, if it doesn't have one already, and know where your water shut-off is in case of emergency.

### Worth the expense?

It's tough to put a price on the cost of retrofits, since each home has its own quirks. A medium-sized home that sits directly to the foundation, as MCM homes do, can have connection improvements installed for \$3,000 to \$6,000, according to contractors at Earthquake Safety. If you opt to do it yourself, you can cut those costs significantly.

Although many homeowners would rather spend money on home improvements they can see and enjoy day-to-day, such as a new kitchen, open floor plan, or expanded back patio, seismic improvements should be part of regular home maintenance.



Water heater strapping.

Property experts say it's tough to see a direct correlation between doing seismic retrofits and an increased value of a home. When buying a home, realtors do suggest having any previous seismic improvements inspected as part of the overall home inspection by calling a qualified structural engineer.

Pryor says it's pays off to invest in both retrofits and insurance. "I do have earthquake insurance, and in an informal poll of people I've done, they say the money spent on retrofits is well worth it," he says. "It has a noticeable impact on the safety of your building."

With the passage of state proposition 13 in



**Collection of hardware typically used in the retrofitting process.**

strong foundation and the walls are properly attached to it, it allows the walls to flex and snap back like a rubber band would."

Do the simplest seismic improvements first and stage others as you have the time and budget to do them -- but you should do them. A home won't experience all the benefits of a retrofit until all the recommended improvements are completed. Some building departments, says Key, do not mandate seismic improvements if you're doing limited projects, and most local building departments won't issue permits for seismic improvements unless it's part of a bigger project. Many city building departments will send out an inspector to review the completed work to ensure that it's been done well -- by inspecting the bolts and hardware that were attached, and the type of plywood and the nailing method used for sheer improvements.

"If your scope of work is a kitchen or bathroom remodel, and you are not moving walls, you are not required by code to improve these houses," Key says. "As soon as you change something, like removing a post, adding a wall, or making an addition, you are oftentimes required to send changes to an engineer."

John Ortiz improved the structural strength of his 2,100-square-foot Palo Alto Eichler when he and his family signed on for a remodel with Keycon. "It started as a general remodel that moved into a kitchen and house upgrade, and that opened up the great room," Ortiz explains. "Ron [Key] took the opportunity and suggested that we seismically retrofit the house while we were at it."

"At John's house, we did some basic things we could do because we had the walls open and the foundation exposed," Key says. "We were able to bolt into the foundation and strap the posts and beams into the foundation, and we did a sheer wall of the exterior as well."

Both Ortiz and Key said it's hard to quantify how much the seismic improvements cost in this project because they were wrapped into the overall cost of the remodel. "Percent-wise it wasn't huge," Ortiz says. "It made sense to us -- since we're in earthquake country, and since our house hadn't been seismically upgraded -- to make the investment while we had the walls open."

The purpose of bolting and bracing is to help homeowners reduce financial loss, make a faster recovery from a disaster situation, and most importantly, protect the safety of the family. Retrofitting will reduce the cost of repair when an earthquake hits, and may even prevent structural damage altogether.

Doing these improvements will help reduce the amount of time and effort needed for recovery, returning your family quickly back to its normal lifestyle.

June 2010, California law now prohibits tax assessors from re-evaluating new construction for property tax purposes when the point of the new construction is to seismically retrofit an existing building.

#### **'Big picture' approach**

Often, the best time to do earthquake retrofits is during larger home remodeling projects. "When you are opening up walls, it creates an opportunity to do seismic retrofits," Key says. "When you have a

## California's next quake: when is the big question



A little more than 20 years have passed since the Loma Prieta earthquake rocked Northern California. At 6.9 (Richter scale) in magnitude, that 1989 tremor left 63 people dead and 3,000 to 12,000 homeless.

Large seismic occurrences continue to be dangerous and deadly. The 1994 Northridge earthquake (6.7) killed 72 and caused \$20 billion in damage.

It's not a question of if, but a question of when the next big earthquake will hit California. According to forecasts by the Southern California Earthquake Center, the state has a 99.7 percent chance of facing a magnitude 6.7 or larger earthquake in the next 30 years.

For all of California, the southern San Andreas fault -- which passes through the Bay Area from San Francisco to points east of San Diego -- has the highest probability of generating at least one magnitude 6.7 quake or larger in (59 percent in the next 30 years).

In Northern California, the most likely source of such earthquakes is the Hayward-Rodgers Creek Fault (31 percent in the next 30 years), which runs through the East Bay to San Jose.

In SoCal, the Bay Jacinto Fault runs 130 miles through San Bernardino, Riverside, San Diego, and Imperial Counties. It is considered the most seismically active fault area in Southern California. The Elsinore Fault, which is part of the San Andreas fault system, is one of the largest faults in the southern area of the state but also the most quiet. The Imperial Fault, located on U.S.-Mexico border, has been the location of earthquakes in 1979, 1940, 1915, and 1892. The earliest one of the four reached 7.8 on the Richter magnitude scale.

The next question is: are you ready?

## Fire: a disastrous quake side effect



Fires are an unfortunate side effect of earthquakes, and ruptured gas lines can cause huge explosions.

The more than two-dozen fires, caused by ruptured gas mains that resulted from the famous 1906 earthquake in San Francisco, represented an estimated 90 percent of the city's destruction. More recently, in the 2010 natural gas explosion that destroyed the neighborhood of Crestmoor in San Bruno, fire took eight lives and three-dozen homes.

Coincidentally, a month prior to the San Bruno disaster, fire officials in Palo Alto offered a warning to people who own older homes, especially houses with natural gas lines running underneath their foundations, as many MCM homes do. "If you smell gas, take it very seriously," said Palo Alto's Fire Marshall Gordon Simpkinson.

In the 1950s, builders were commonly routing the gas lines in galvanized piped underneath the slab foundations of homes, but it's something that was discontinued when pipe erosion was discovered in the surrounding soil.

Often, the problem is solved at remodeling, as homeowners abandon their original gas lines and install new ones elsewhere in the house. The originals are disconnected, capped off, and re-routed through garages, walls, and outdoors.

If you smell gas occasionally, your utilities department will come out with special detection equipment and inspect your home, room by room. In Palo Alto, where there are nearly 3,000 Eichler homes, it's a free service that City of Palo Alto Utilities offers its homeowners. If the smell of gas is strong, however, call 911 and the fire department will spring into action.

### **Shaken in a storm of glass**

If not for the five o'clock telephone call on that October afternoon in 1989, Eichler owner Hermine Horoupien might have experienced the wrath of Loma Prieta face to face.

Instead, the phone call served as a lifesaving alert and, like a lucky star caught by the hand of fate, Horoupien weathered a storm of glass to share her frightening tale of exploding windows and flying shards.

For most of the day, the setting was a typical one at the Horoupien household, a Jones & Emmons perched on a hilltop circle on Stanford campus. Horoupien, a New Jersey transplant who had been living in her Eichler for four years, and her mother-in-law were enjoying the afternoon together, when a friend living a few miles away, in Los Altos, called her on the phone.



While her mother-in-law was busy in the kitchen, Horoupien carried on with her phone call from the family room. The conversation was quiet at first, and then news of the quake shattered the calm.

"My friend told me that an earthquake had hit, but I felt nothing," Horoupien recalled. "I guess the quake had reached her a few seconds before me. And then I felt it. I just threw the phone down, and knew right away that it was the big one."

Her friend's warning allowed Horoupien just enough time to grab her mother-in-law and dart to shelter under a nearby doorframe. And then she couldn't



believe what was before her eyes.

"There was a tremendous noise and a tremendous force," recalled Horoupijan. "Then all the glass at the same time just shot out of the windows. Big pieces of glass shooting across one end of the room to the other. Flying through the living room, and the dining room. It was really scary."

While her home's single-pane glass exploded, the cupboards flew open and dumped their insides onto the floor, and the chandelier in the living room rocked from one side of the ceiling to the other. Frightened and in shock, Horoupijan and her mother-in-law huddled together in the doorway. Somehow they were spared from the barrage of glass all around them.

When her nightmare had ended, Horoupijan discovered the damage was confined primarily to her living and dining rooms, where she counted six large-paned windows that had imploded. Posts had shifted off the center of beams, but the roof appeared undamaged. Personal belongings had been thrown around in the kitchen, family room, and atrium, but the glass in each of those areas remained intact.

"I was surprised at the amount of damage, especially all the glass," Horoupijan said years later, "and I was also surprised that the insurance company called the extent of the damage cosmetic."

Her insurance company's appraisal actually served as a compliment to her Eichler's bolted foundation, which was strong enough to prevent any structural damage to the house. On the other hand, the home next door, which was not an Eichler, did suffer foundation problems. The neighbors on the other side lost a chimney and a few windows.

Nearby, a two-story Eichler suffered damage to its interior staircase and chimney structure. Throughout the Stanford campus, destruction was common; even the church and museum were affected.

Even though her insurance company was most cooperative, Horoupijan's rebuilding and retrofitting that followed was a drawn-out process. "In the craziness of the earthquake, it was very hard to find an architect," Horoupijan said. "The whole repair job was three weeks of work, but it took a year to put it all together.

"Now that it's over, I feel so much more secure today because of the retrofit. Replacing some of the glass panels with shear wall, and adding a few bolts here and there. It gave us back our peace of mind, and good sleep at night."

Photos: David Toerge, Ernie Braun, John Eng

#### FOR FURTHER INFORMATION

Earthquake Safety: [earthquakesafety.com](http://earthquakesafety.com)

Keycon, Inc.: [keycon-inc.com](http://keycon-inc.com)

Simpson Strong-Tie: [www.strongtie.com](http://www.strongtie.com)

California Emergency Management Agency: [oes.ca.gov](http://oes.ca.gov)

Southern California Earthquake Center: [scec.org](http://scec.org)

The Great California Shakeout: [shakeout.org](http://shakeout.org)

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