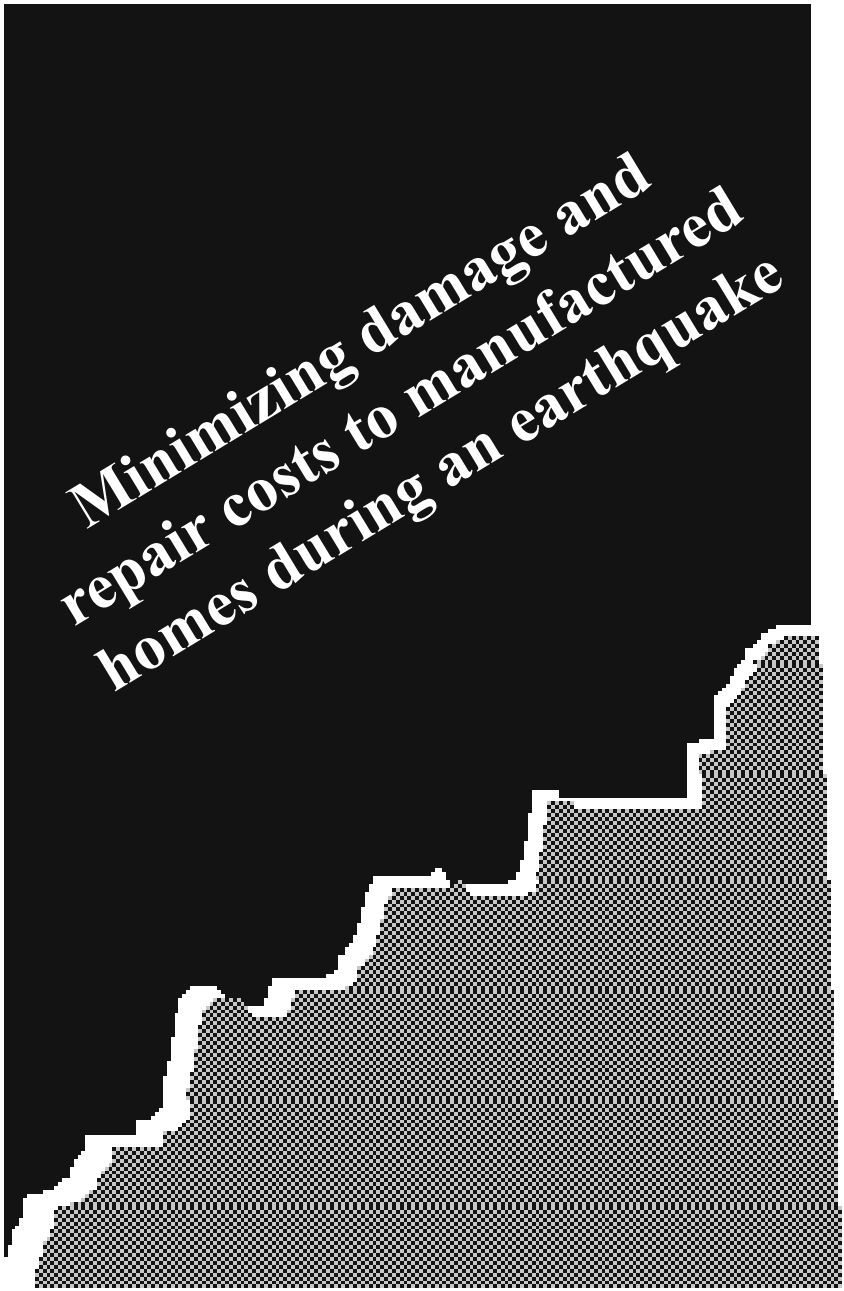
U.S. Department of Housing and Urban Development
Office of Policy Development and Research

PD&R

Minimizing damage and repair costs to manufactured homes during an earthquake



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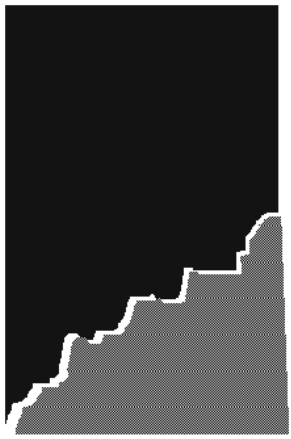
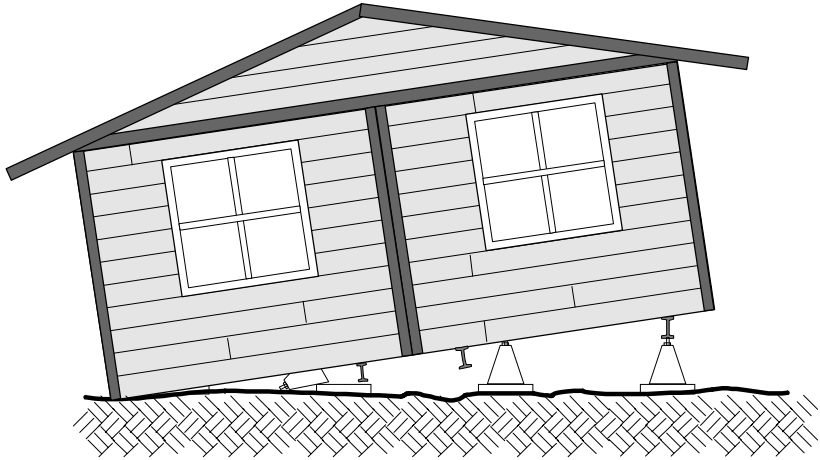
EARTHQUAKES AND MANUFACTURED HOMES

Many manufactured homes sustained damage during a number of recent earthquakes in California. Homes were damaged by falling from their piers or otherwise being moved from their support systems. Much of the damage was to the support systems of the homes, or to structures attached to the homes. Porches, awnings, and garages attached to homes were often separated as the homes moved from their support systems.



The Northridge, California earthquake of 1994 reportedly caused considerable disruption to manufactured home owners in both loss of use and cost to reinstall the home on a support system. One extensive report on nearly 9000 manufactured homes in 69 manufactured home parks revealed that approximately 49 percent of the homes slid off their support systems onto the ground. Another 10 percent shifted but remained on their support system, while two percent of all homes studied were destroyed by fire. Manufactured homes experienced structural and fire damage because standard support systems (piers and pads) were not able to resist the shaking and lifting of homes due to earthquake related movement.

Fires that damaged two percent of the manufactured homes after the Northridge earthquake of 1994 were fueled by broken natural gas lines inside, or leading to, the homes. Broken gas lines inside the home were often caused by gas water heaters that toppled out of the home through an exterior door or access panel to the water heater compartment. Other fires were fueled by natural gas leaking from broken gas meters or from piping located near the manufactured home. As homes fell from their foundation and support systems, they sometimes broke the gas meter or pipe leading to the home. Better installation of the home and better methods to secure appliances, such as water heaters, to stop movement could have prevented many of the fires.



CAN HOME DAMAGE BE PREVENTED OR REDUCED?

Yes. This brochure outlines several suggestions for the manufactured home owner, or park owner, to reduce or prevent damage to the home. The suggestions are presented for both new and existing homes. While these suggestions do increase the cost of home installation they can - if implemented properly - provide significant savings by reducing or eliminating the cost of repairing the home after an earthquake.

IS MY HOME AT RISK?

While California has experienced many of this country's most memorable earthquakes, there are several other states where earthquakes of significant magnitude are anticipated. The map below shows areas most likely to experience damaging earthquakes.

This brochure contains many suggestions for reducing damage to manufactured homes during earthquakes. These recommendations are summarized on the next page to identify those things that should be done to minimize damage to manufactured homes in earthquake zones.

SUMMARY RECOMMENDATIONS TO MINIMIZE MANUFACTURED HOME DAMAGE

- Install support systems designed to prevent or minimize home movement during an earthquake. California has a list of certified earthquake resistant bracing systems.

  Note: See suggestions labeled #4 and #5 on the following pages for additional details.

- Install support systems designed to withstand all earthquake forces under accessory structures such as porches.

- Secure the water heater and other large appliances to wall studs of the appliance compartment.

- Install a six foot flexible gas connector between the gas supply and the gas inlet of the home.

- Install gas detectors or gas shut off devices that can stop gas flow to the home when a gas leak is detected or in the event of an earthquake.

- Homes sited in areas that are both seismic prone and subject to snow loads in excess of 30 psf should be installed on permanent foundations.

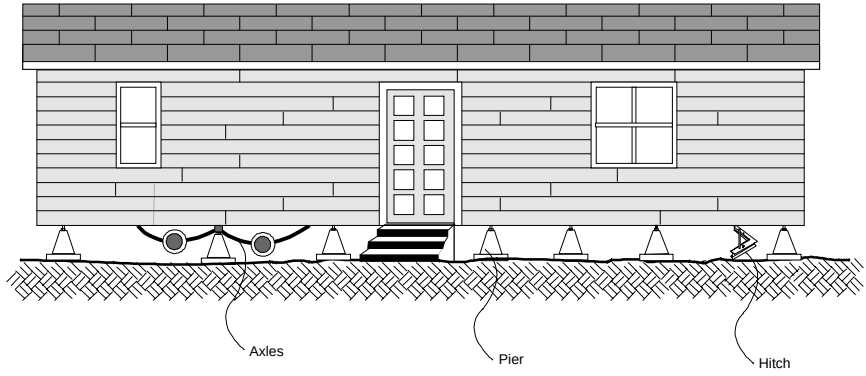
SUGGESTIONS TO REDUCE DAMAGE TO THE HOME STRUCTURE FROM AN EARTHQUAKE

No level of earthquake preparedness can guarantee that an earthquake will not damage a home. However, there are a number of ways you can reduce or prevent damage to a home during an earthquake. The suggestions listed on the following pages can minimize damage to your home and the attached structures by reducing movement of the home during an earthquake. The risk of damage from an earthquake is reduced as the cost of each suggestion increases. The ***least expensive suggestions are listed first***:

1 Keep the axles and hitch under the home after installation.

The axles and hitch alone will not prevent movement of the home during an earthquake and, therefore, will provide only minimal protection from earthquake damage. The axles and hitch may prevent the home from falling completely to the ground, thereby making reinstallation easier. The axles and hitch may also be removed from under the home if an earthquake resistant bracing system or specially designed support system is used to resist earthquakes.

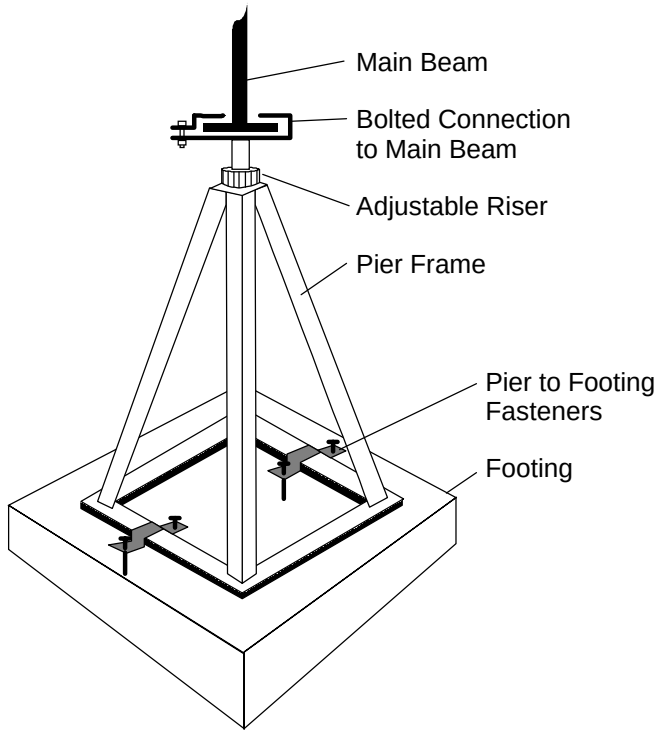
The home owner needs to make it a part of the purchase agreement that the axles and hitch will not be removed. Usually, there should be no additional charge for such an agreement.



Detachable hitches may be removed and stored under the front of the home directly under the chassis beams. The axles and hitch will prevent the home from falling completely to the ground in the event of an earthquake.

2 Secure piers to their footings and to the main beams of the home.

Steel piers are easy to install and adjust, but provide little bearing surface to support the home. Therefore, when steel piers are used they should be secured to the main beam of the home and to their footings. These connections will prevent the home from jumping off the pier or footing during an earthquake. Piers designed to be secured to their footings and to the main beams of the home can be installed by many recognized home installers.

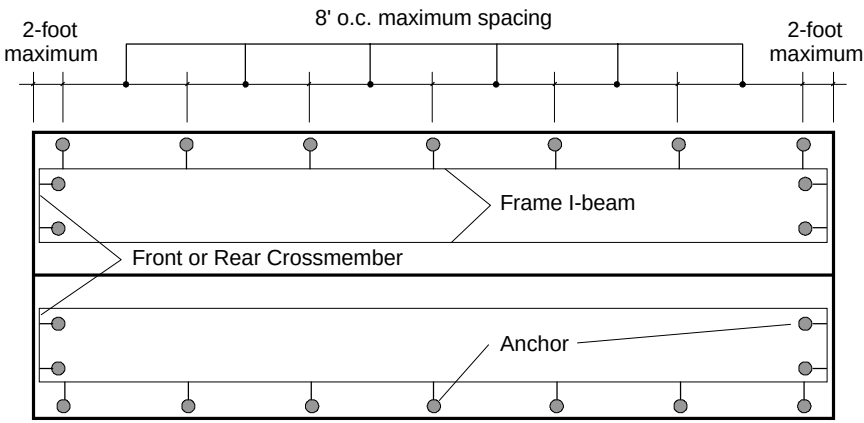


3 Anchor the home to the ground according to the manufacturer's instructions for wind.

Install ground anchors and tie-down straps according to the manufacturer's installation instructions. Ground anchors will help stabilize a home during both wind storms and earthquakes. Generally, anchors are recommended on two long sides of a home to resist movement from high wind. For earthquakes, additional anchors should be added to the two ends of a home (four anchors per home section).

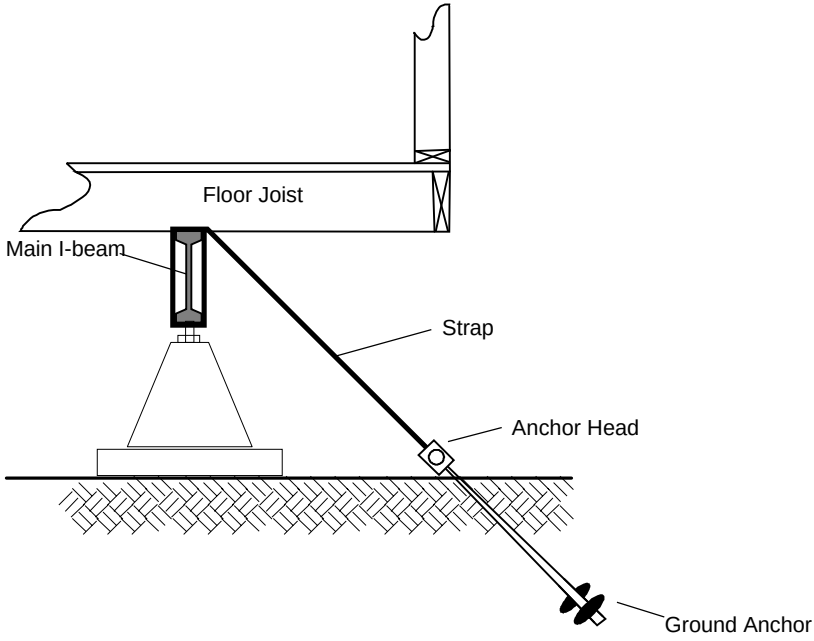
If instructions are not available, anchors and tie-down straps should be installed as follows: a maximum of eight feet on center on the sides of the home, but not more than the maximum spacing distance allowed by the state, and on the ends of each home section near each frame I-beam.

Ground anchors and tie-down straps can be installed by many recognized home installers.



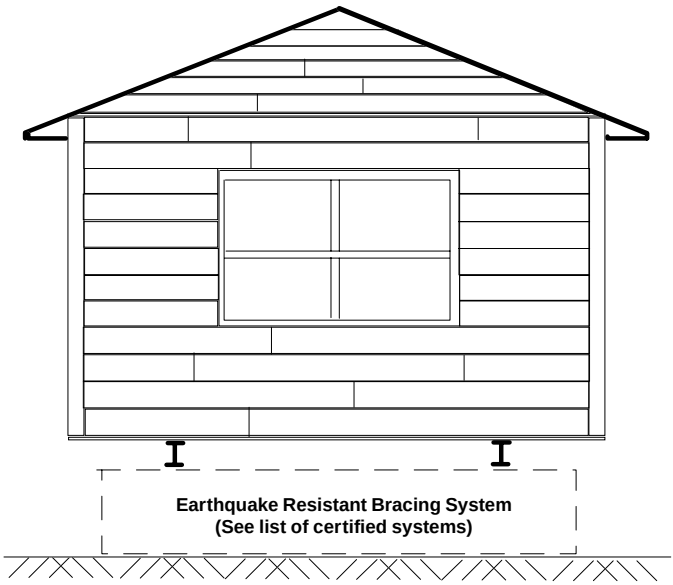
Anchor Minimum Load Capacity 4725 lbs.

Ground anchors and tie-down straps should not be used as a primary earthquake resistant system. The anchors and straps have not been tested for earthquake load. However, use of these anchors and straps will reduce movement of the home and, thereby, may reduce damage to the home. When used in conjunction with piers secured to their footings, and to the main beams of the home (as in suggestion #2), ground anchors may further reduce movement of the home during an earthquake.



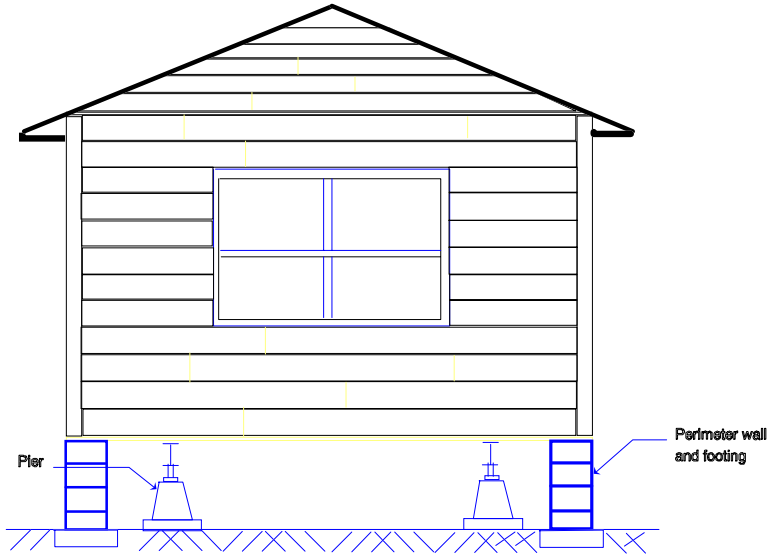
4 Install earthquake resistant bracing systems to minimize movement of the home

Some bracing systems simply provide a frame that catches the home if, during an earthquake, the home falls off its piers. After the earthquake, resetting the home back on its piers may be necessary. Other more elaborate bracing systems actually minimize both horizontal and vertical movement of the home through connections between the bracing system, the home, and the footings. Bracing systems that minimize movement of the home will also minimize damage to the home. Pages 18 and 19 of this pamphlet provide a list of questions dealing with earthquake resistant bracing systems that will help a consumer select the most appropriate system. California has a list of certified earthquake resistant bracing systems. This list may be obtained by writing to: **State of California, Department of Housing and Community Development, Division of Codes and Standards, 1800 Third Street, P.O. Box 1407, Sacramento, CA, 95812-1407**. Most of these systems can be added to existing manufactured homes or can be a part of new home installations.



5 Install an earthquake resistant foundation specifically designed to support the home and resist all earthquake and wind forces.

Earthquake resistant foundations will typically have perimeter walls and footings in addition to piers under the main beams of the home and the marriage walls. These foundation systems may be designed to resist earthquake and wind forces and may be built similar to foundations for conventional housing. For further information on this topic see the publication "Permanent Foundation Guide for Manufactured Housing," referenced on page 20 of this pamphlet.



UTILITY SYSTEM CONNECTIONS

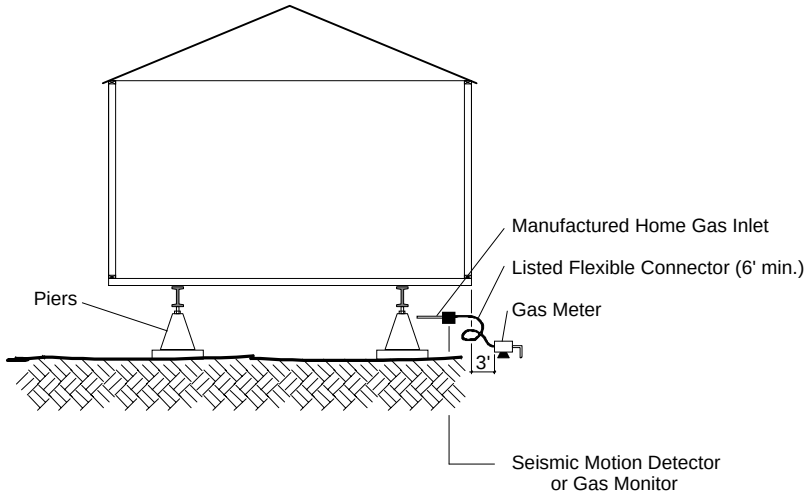
Damage to utility systems will be minimized if the home is prevented from moving. However, many homes currently installed in areas likely to experience earthquakes are on support systems inadequate to resist earthquake forces. Earthquake resistant bracing systems installed under the home often minimize movement of the home, but may not be designed to prevent movement in all directions.

Gas leaks and fires attributable to earthquakes were traced to two general sources. Gas connections to the home were damaged where the home fell from its support system and landed on the gas meter. Gas connections to the water heater were damaged or severed where the water heater fell from its compartment, landing outside the home.

Electrical, water, and drainage connections to a home were also damaged when the home shifted from its foundation system. Damage to a home's electrical system can cause fires. Damage to water and drainage systems, generally, will not pose risk of serious injury. While the Northridge earthquake caused disruption of electrical, water and drainage service to some homes, little other damage was attributable to the disruption of these utility services.

In most installations, the home's gas system must be connected to the meter through an approved flexible connector. This flexible gas connector allows significant movement of a manufactured home without damage to the gas system. However, the length of the flexible connector and the location of the gas meter limit allowable movement of a home before damage occurs. If the gas meter is three feet from the home’s gas system inlet, the home can move three feet toward or away from the meter without significant risk of damage to the flexible connector.

Where possible, position the home half the length of the flexible connector away from the meter connection in order to minimize damage to the flexible connector, the meter, or its connections should the home move or fall from its support system.



Lot size and offset requirements may not always allow three feet between the meter and the home. Further, the flexible connector may be damaged by lawn mowers or children playing around the home and must, therefore, be protected from damage.

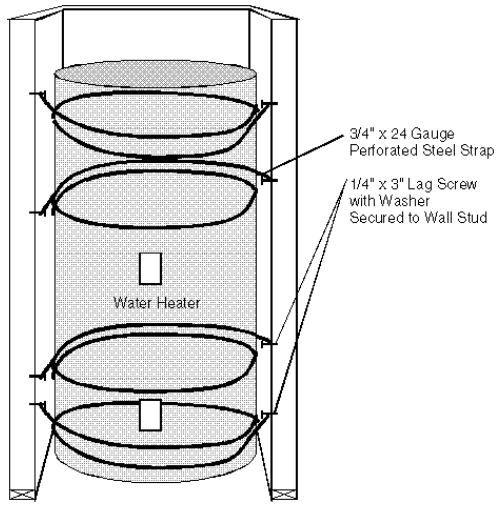
Seismic motion detectors and gas detectors are available for consumer use to minimize the potential hazard of gas leaks. These devices will stop gas flow when either a gas leak is sensed or during seismic ground motion. These devices are currently not required for residential construction in most parts of the United States.

Three different devices are currently being tested in California. A seismic shut-off device is installed in the gas line leading to a manufactured home. This shut-off device will stop gas flow when a predetermined level of seismic ground motion is encountered. A free-flow gas sensor essentially monitors pressure differential between the supply and line side of the sensor. Significant pressure drop on the line side of the sensor, typically caused by a rupture in the gas system, will result in the sensor stopping gas flow. Finally, detectors installed in the home indicate the presence of gas vapors in the air and transmit a signal to an electrically operated valve that can stop gas flow using the home's electrical current or a battery backup in the event of power failure.

EQUIPMENT CONNECTIONS TO THE HOME

A filled water heater may weigh as much as five hundred pounds. Therefore, the water heater needs to be secured to the walls using steel straps or some other method so that it does not fall over during an earthquake. A water heater that falls from its compartment poses a serious risk of fire caused by damage to the gas or electric connections to the water heater.

One good design concept is to wrap the top and bottom of the water heater with two loops of 3/4" 24 gauge steel plumber's tape and to secure the steel tape to a wall stud. (See Illustration below for a suggested method of securing the water heater in its compartment).



If there is significant movement of gas appliances during an earthquake, or if damage to the gas system is suspected, contact your utility company and have your gas system inspected and retested.

UTILITY SERVICE AT PARKS

Some manufactured home communities (parks) are designed so that certain utilities can be turned off from one location. A "master meter" installation is one where a park owner or manager purchases utility service, such as natural gas, in bulk from the supplier. The supplier owns and maintains the gas pipe up to the master meter. All gas pipe from the master meter to the individual home sites is owned and maintained by the park. Each home site has a meter by which each home owner pays the park owner for the amount of gas used.

Where a master meter installation is used, gas supply to the entire park can be disconnected by the park manager in an emergency. Likewise, gas supply can generally be disconnected by the gas utility company before the gas supply enters the park. However, disconnecting supply to a large area or manufactured home park should be done only in an emergency. Once the gas supply is disconnected, each home must be tested for gas leaks before the supply for that home is reconnected. Pilot lights will also have to be relit when the gas supply is returned.

Water and electrical supply can generally be disconnected by the appropriate utility. Re-connection of these utilities does not generally, require retesting of the systems inside the homes.

PREVENT FIRE OR OTHER DAMAGE AFTER AN EARTHQUAKE

Do not operate electrical switches if you smell gas. Natural gas is not itself a source of ignition, but is relatively easy to ignite especially in confined spaces. Natural gas is easily ignited by open flames that exist in a standing pilot light and by sparks from switches and other electrical devices. If you should smell gas, leave all switches in their current position to avoid the possibility of electrical sparks.

Following an earthquake, visually inspect piers, anchors, and utility connections to the manufactured home. If problems with the support system or the utility connections exist, do not attempt to correct these problems yourself. Contact a home installer for the necessary repairs to either the support system or to utility connections of the home.

QUESTIONS TO ASK WHEN PURCHASING AN EARTHQUAKE RESISTANT BRACING SYSTEM

Is the earthquake resistant bracing system required to be certified by the California Department of Housing and Community Development?

All earthquake resistant bracing systems offered for sale in California must be certified by the California Department of Housing and Community Development. Other states may have similar requirements for the sale of support systems designed to resist earthquakes.

What is the difference between an earthquake resistant bracing system and an engineered tie-down system?

An earthquake resistant bracing system is designed primarily to reduce damage to a home in the event of an earthquake. An engineered tie-down system is designed primarily to allow the home to resist wind loads.

Does the earthquake resistant bracing system prevent movement of the home in all directions?

Some earthquake resistant bracing systems simply provide a frame that catches the home if, during an earthquake, the home falls off the piers. Other more elaborate earthquake resistant bracing systems actually minimize both horizontal and vertical movement of the home through connections between the bracing system, the home, and the footings. These more elaborate systems that minimize movement are more effective in reducing damage to the home, utility connections, skirting, and attached structures.

Should earthquake resistant bracing systems be connected to the home and footings?

Generally, earthquake resistant bracing systems are more effective when connected to the home's main chassis beams and to the footings. Systems that are designed to prevent movement of the home during an earthquake are more effective in preventing damage. Not all earthquake resistant bracing systems are connected to the home or footings.

Are the support footings connected to the ground?

Manufactured home support footings may often be set directly on the ground surface or just a few inches below the surface. Footings set on the ground surface, often called footing pads, may move during an earthquake unless properly fastened to the ground. An earthquake resistant bracing system that is fastened to the home's main chassis beams and to the footings, should have the footings fastened to the ground to prevent movement during an earthquake.

Will the chassis need to be strengthened?

A manufactured home chassis or I-beam may not be able to withstand the seismic load at the connections with the ground anchors or to the earthquake resistant bracing system. In some cases, reinforcement of the chassis beams at the connections of the earthquake resistant bracing system may be required.

Does the earthquake resistant bracing system rely on the use of ground anchors?

Ground anchors and related tie-down straps and connections are currently used primarily to prevent movement of the home in high wind conditions. When properly installed, ground anchors may reduce movement of a home even during an earthquake. However, ground anchors typically have not been tested under earthquake-like conditions and therefore should not be relied upon as a primary earthquake resistant bracing system.

Does installation of the earthquake resistant bracing system require modification of the utility systems?

Modification of the utility systems may or may not be required depending upon the existing conditions. Modification of utility systems to install an earthquake resistant bracing system will generally create an additional expense to the home owner. Therefore, get an overall cost estimate related to installation of earthquake resistant systems before proceeding with the actual installation.

FOR FURTHER INFORMATION

For more information on utility connections to your home, and prevention of damage to these connections during an earthquake, contact your local utility company.

For a list of earthquake resistant bracing systems certified by the state of California, write to: **State of California, Department of Housing and Community Development, Division of Codes and Standards, 1800 Third Street, P.O. Box 1407, Sacramento, CA, 95812-1407**.

For copies of the technical reports: "**The Effects of Earthquakes on Manufactured Home Installation," (**the supporting report for development of this pamphlet) or the "**Permanent Foundation Guide for Manufactured Housing**," contact **HUD USER:**

Call:	**1-800-245-2691** **1-800-877-8339 (TDD)**
Write:	**HUD USER** **P.O. Box 6091** **Rockville, MD 20850**
Transmit:	**(301) 251-5747 (fax)**

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