Central Asia Earthquake Safety Initiative

SEISMIC SAFETY FOR ADOBE HOMES:

what everyone should know

Seismic Damage to Adobe Homes

Central Asia is known for periodic large earthquakes. Strong earthquakes can cause damage or destruction to adobe buildings, causing death, disability, serious injuries, and economic losses.

Damage to an adobe building in the January 2000 Kamashi Earthquake, Uzbekistan, (Khakimov Sh.A., Nurtaev B.S.)

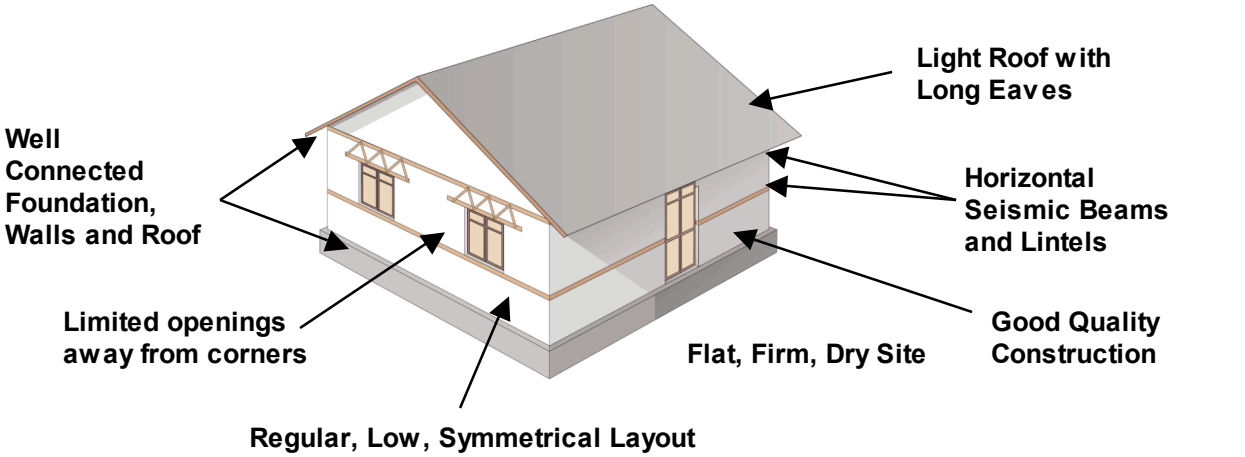
Strong earthquakes in seismic regions are inevitable!
Build your house safely to avoid future disaster!

Adobe Homes Can be Built to Resist Earthquakes

In order to resist earthquake damage any type of construction must be well-designed, use proper materials and be well-constructed. Every additional measure taken to increase seismic-resistance, will improve safety for building users. When you are going to construct adobe buildings, do as many of these steps as possible! **EVERY LITTLE BIT HELPS!**

Adobe material is brittle and weak and more vulnerable to earthquake damage than well-built buildings reinforced with wood columns and diagonal bracing (synch), or masonry buildings with reinforced concrete columns or reinforced-concrete frame-buildings with infill walls. Because adobe is brittle and weak, adobe construction is not legal in many high seismic zones or in urban areas.

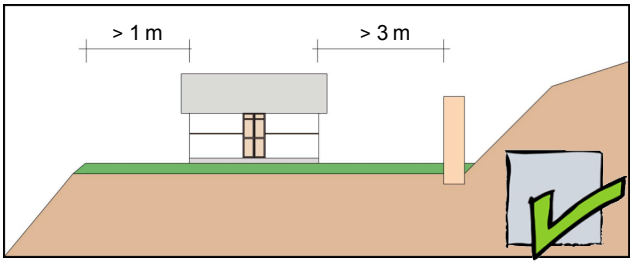
The techniques shown in this booklet are intended to 1) reduce damage to adobe homes in small and medium earthquakes, and 2) help reduce collapse of adobe homes in earthquakes. They MAY NOT PREVENT COLLAPSE in strong earthquake. This advice is intended for seismic regions less than or equal to MSK 8.

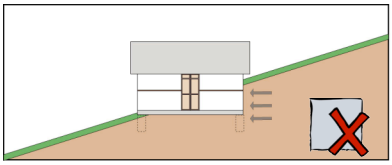


LAYING A GOOD FOUNDATION

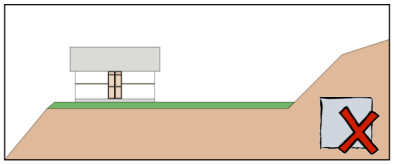
Good Site Selection

Adobe buildings **SHOULD** be built on leveled ground, **at least 1 meter away from the edge of slopes, more if slope is steep** and **at least 3 meters from retaining walls or steep banks.**

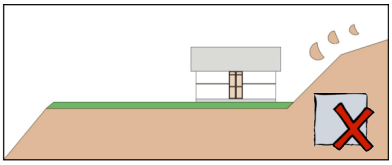




Adobe buildings **SHOULD NOT** be built against a slope where soil pressure may cause building collapse.



Adobe buildings **SHOULD NOT** be built near cliffs where they might slide off due to land slides.



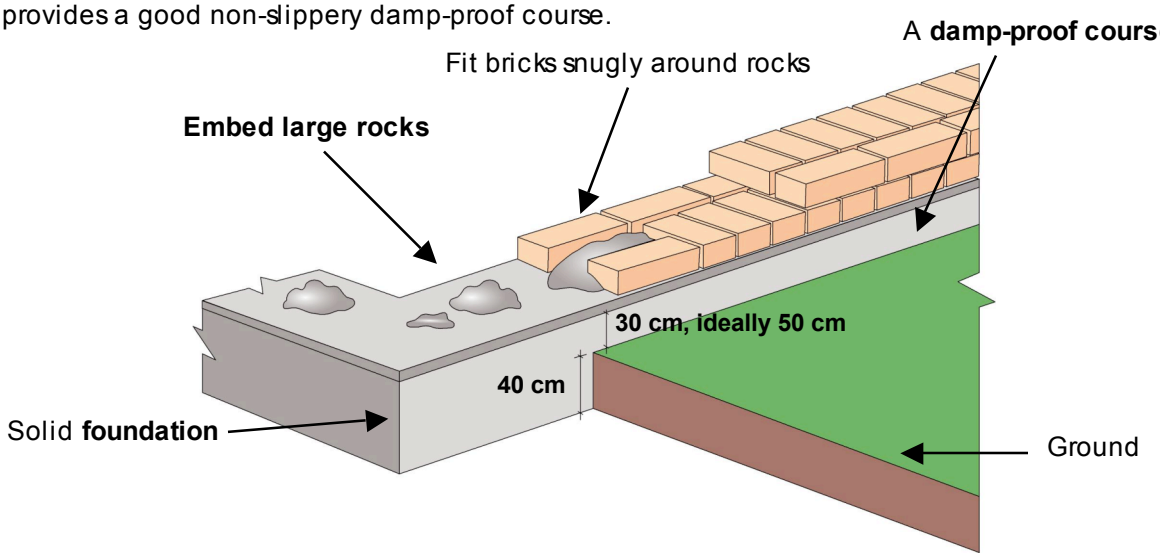
Adobe buildings **SHOULD NOT** be built near steep slopes where falling rocks and debris may damage the house.

Good Foundation

Every seismic-resistant adobe building needs a **solid foundation** that is well connected to the walls. Reinforced monolithic concrete foundations are best. If fired brick or rubble stone foundations are used, add a reinforced concrete beam on the top of the foundation. The foundation should extend 40cm below the ground for stability and ideally 50cm above the ground to protect walls from rain water damage and ensure that adobe bricks remain above the snow blanket in the winter.

The building must be connected to the foundation so that it does not slip off. First **embed large rocks** in the foundation so that they project up to the height of one adobe brick. Then construct the adobe wall to **fit bricks snuggly** against the embedded rocks using full or half size bricks.

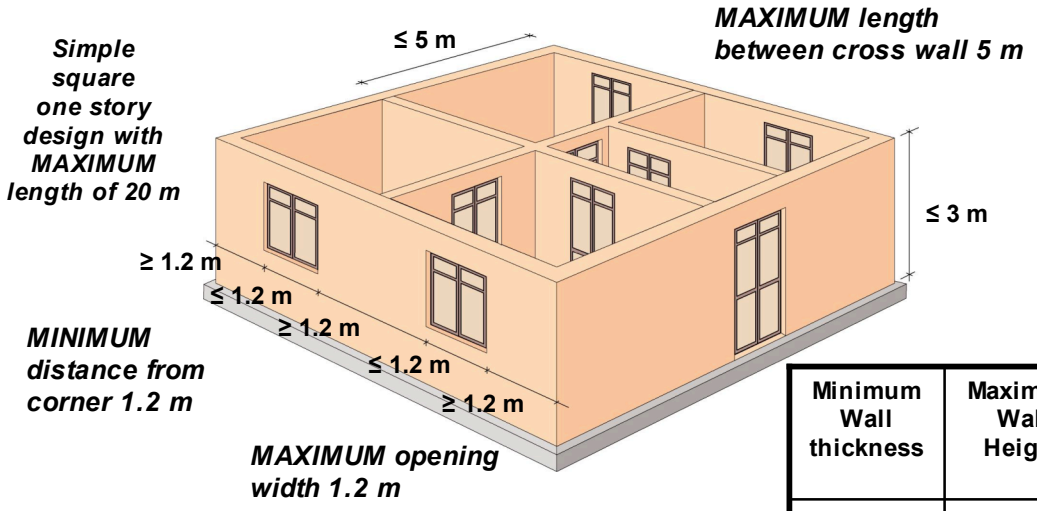
A **damp-proof course** will prevent rising moisture from damaging the walls over time. Bitumen and ruberoid glues are commonly used, but these can be slippery. A thin layer of cement-sand (1:2) provides a good non-slippery damp-proof course.



DESIGN AND MATERIALS

Anti-Seismic Lavout

To resist earthquakes, adobe buildings should have a **simple one-story square design** and be **no longer than 20 meters**. Walls must be short and thick (the thicker the better) to be earthquake resistant and well-supported by interior cross-walls or exterior buttresses. There should be at least one longitudinal interior wall. Window and door openings on each side of the building should take up no more than one-third of the length of the wall. Each opening should be no more than **1.2m** wide, and at least 1.2m away from building corners. Ideally the number and size of openings should be the same on opposite sides of the building.



Minimum Wall thickness	Maximum Wall Height	Maximum Length between Cross Walls
50 cm	3.0 m	5 m

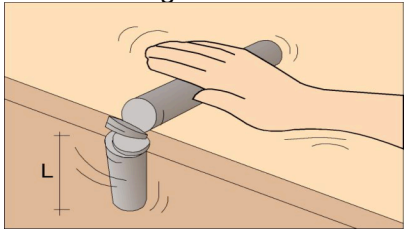
Good Quality Adobe Material

Good quality soil must be used to make all adobe bricks and mortar, or rammed earth walls. **Straw**, especially from rye, can improve the strength of adobe. Straw can reduce cracking, especially when the adobe has high clay content.

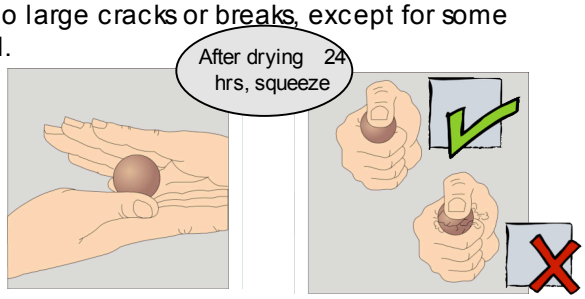
Test your materials!

• Adobe bricks and mortar should not have large visible cracks after drying for 48 hours. To test the mortar, place it between two bricks. After 48 hours, pull the bricks apart and examine the mortar. If there are large visible cracks in the bricks or mortar, increase the amount of course sand in the mix and repeat the test.

• Fully dried bricks (1-4 weeks depending on weather) should be able to be dropped on their edge from 2m height onto the ground. There should be no large cracks or breaks, except for some moderate damage on the corner that hit the ground.



• Roll adobe mixture in your hand or on a table (approximately 2.5cm diameter). Push one end over the table slowly. Measure the length of the piece when it falls. If it is <4cm then add clay. If it is >15cm then add sand.

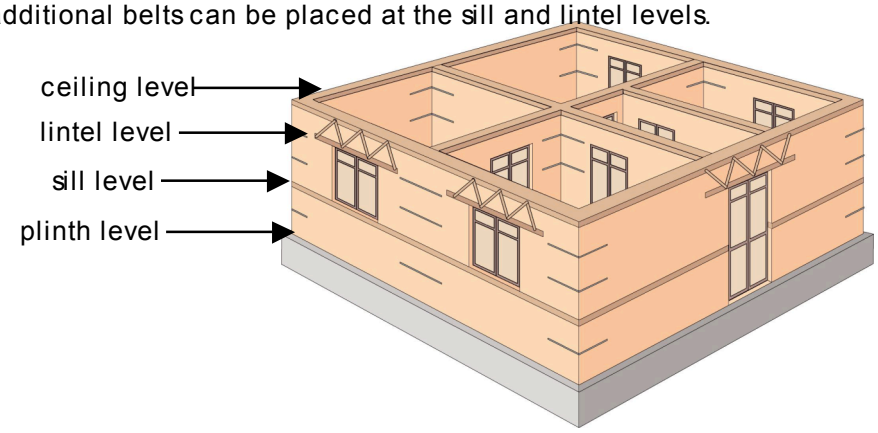


• A 2cm ball of adobe should NOT be able to be broken in your hand after drying for 24 hours. If it can be broken, there is not enough clay. Look for another source of soil.

SEISMIC BELTS FOR STRONG WALLS

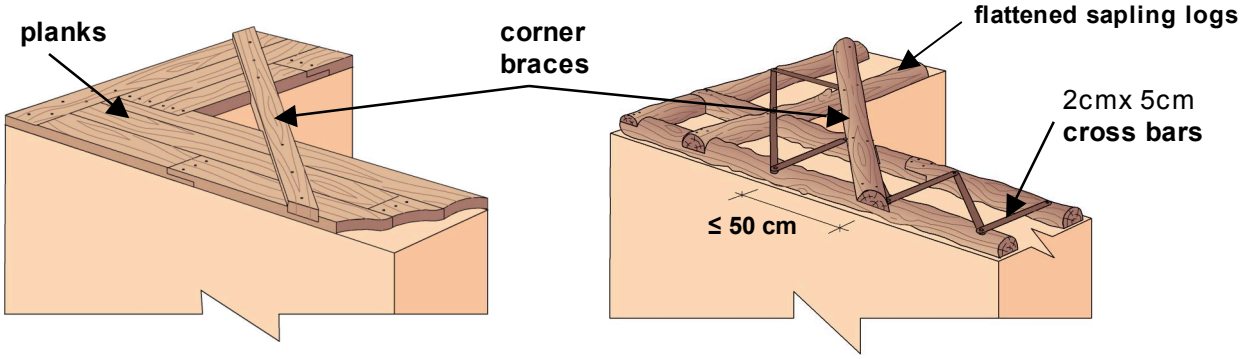
Seismic Belts Placement

"**Seismic belts**" are the most important elements in adobe construction for preventing earthquake collapse. Minimally one continuous wooden seismic belt should be placed at the top of all interior and exterior walls. The concrete foundation acts as a second belt. Ideally additional belts can be placed at the sill and lintel levels.



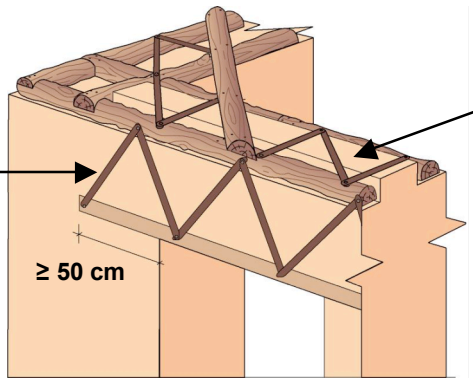
Seismic Belts Construction and Connections

Seismic belts can be made out of **solid wood planks** or **poplar saplings**, joined together with crossbars. The belts should be 20-50cm wide, and approximately 5cm high. Belts should be **braced** at wall corners. Sapling belts should be **flattened** so they rest securely on the wall and 2cmx 5cm cross bars should be placed every 50 cm to create a lattice across the frame. This should later be filled in with adobe mortar.



The roof level seismic belt must be connected to the walls to be effective. This can be done by 1) using diagonal bracing between roof-level seismic belt and the lintel or 2) inserting galvanized steel anchor bolts or wooden dowels (40-50 cm) through the seismic belt into the wall.

diagonal bracing connects roof belts to lintel belt or beam

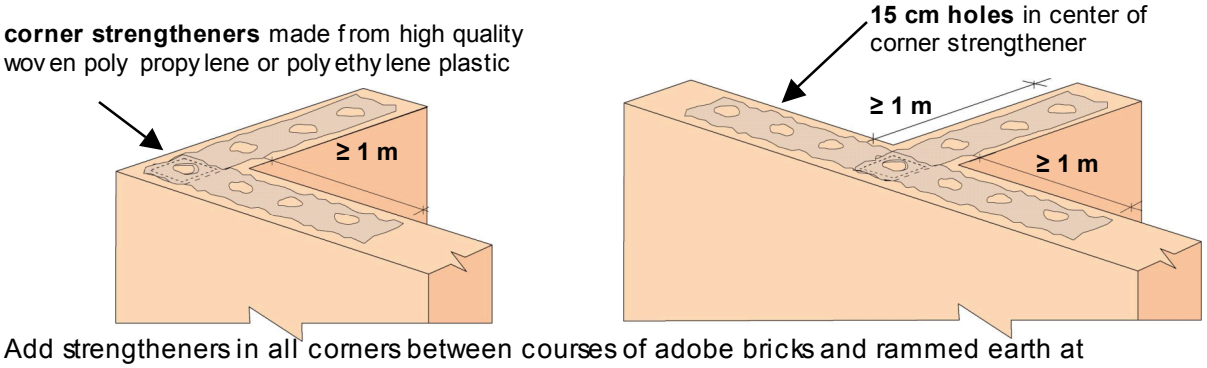


When there is no seismic belt at the lintel level, **lintels should extend a minimum of 50 cm** past the edges of the windows and door.

STRONG CONNECTIONS

Connecting Adobe Walls to Each Other

In the past people used reeds laid along brick courses to strengthen adobe walls. During earthquakes, these reeds helped keep corners and wall intersections from tearing apart. When reeds are not available corner strengtheners can be made from **high-quality woven poly propylene or poly ethylene plastic**.



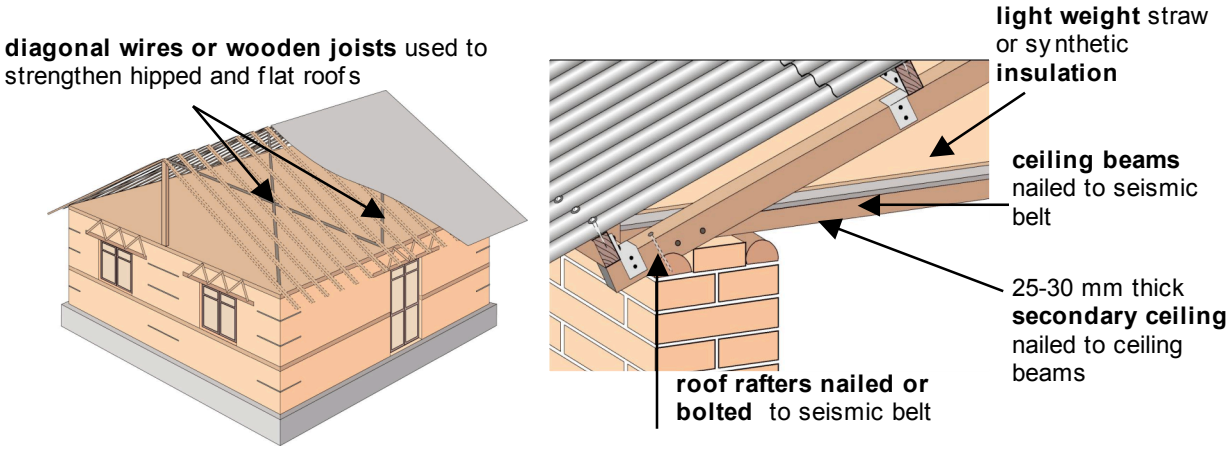
Add strengtheners in all corners between courses of adobe bricks and rammed earth at approximately every half-meter of vertical height. If seismic belts are not used at the window sill and lintel levels, then be sure to include strengtheners at those levels as well

Strengtheners can be made out of **high quality woven poly propylene** or **poly ethylene plastic** (potato/rice) bags cut to size. Holes of about 15 cm should be made in the center of the strengtheners to allow mortar to contact adobe courses above and below. The corner strengtheners should extend **at least 1 m** from the interior face of perpendicular walls.

Ceiling and Roof Construction and Connections

Adobe homes with heavy soil roofs are more easily damaged in earthquakes and more likely to kill occupants. Roofs should ideally be made of **light weight material** like galvanized iron or asbestos tiles. Insulation should be of lightweight material like reeds, straw or synthetics. A thin layer of soil can be added to help hold the insulation in place. 25-30 mm **secondary ceilings** should be nailed to ceiling beams. These beams should be connected to the seismic belt to help hold walls together during an earthquake.

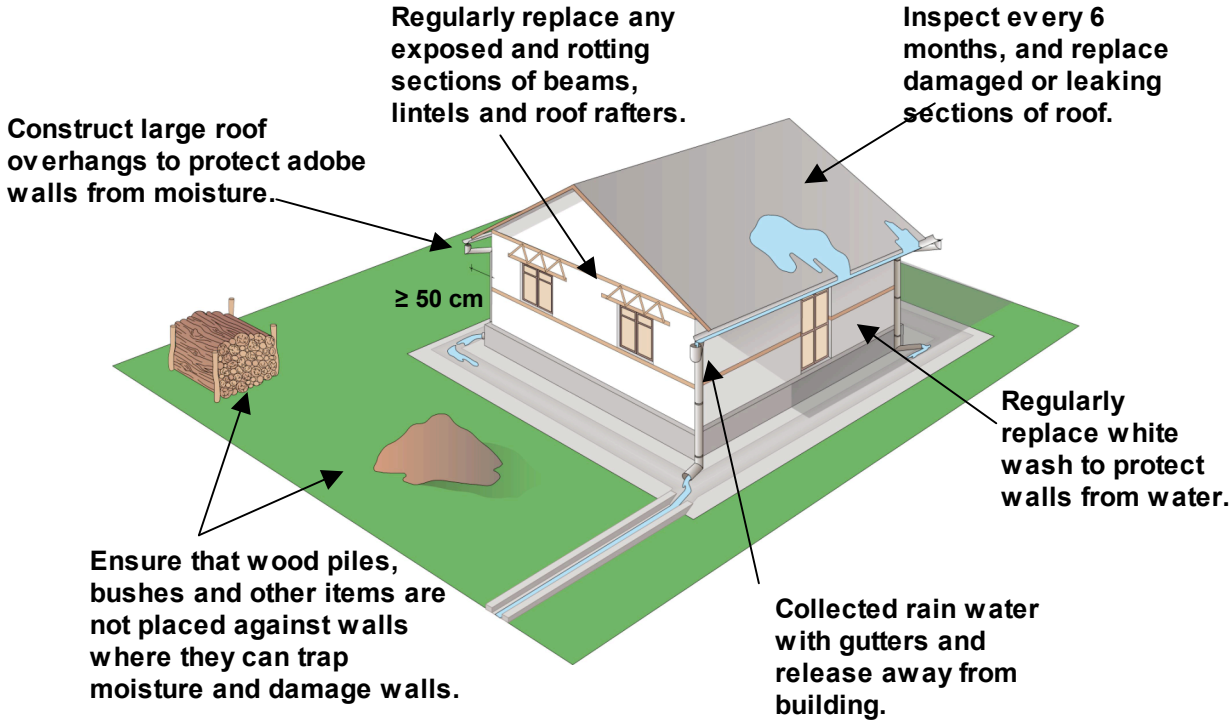
Hipped roofs (a roof that slopes on all four sides) are preferable to pitched (a roof that slopes on only two sides) and flat roofs. If a pitched or flat roof is used it should be braced using **diagonal wires** or wooden braces to connect roof rafters as shown below. Roof rafters should be bolted to the roof level seismic belt. **Eaves should extend at least 50cm past the wall, to protect walls from moisture**.



MAINTENANCE AND RETROFITTING

KEEP HOUSE WELL MAINTAINED

Adobe homes can be seriously damaged by moisture from rain and standing or rising water. However, a well-built and maintained adobe home that has not been seriously damaged may last for decades. Look out for things that can cause your home to deteriorate and become more vulnerable to earthquakes.



RETROFIT WEAK OR DAMAGED ADOBE

Adobe buildings that have not been built with seismic-resistant measures may be strengthened by a variety of techniques. Although this may not save the house, it may prevent collapse and save lives. These techniques are being researched and you should check with your state construction authority, engineers at local institutes of seismic resistant construction, and adobe construction experts for the most reliable and up-to-date information about methods.

Some of these include:

- adding seismic belts
- adding buttresses
- tying roof to walls
- adding vertical reinforcement in the walls or on wall exterior using galvanized wire mesh, cane or wood poles
- adding vertical and horizontal bands of galvanized wire mesh overlaid with shotcrete at corners, tops of walls and around wall openings
- wrapping with polypropylene bands