7 NON-STRUCTURAL ELEMENTS

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NON-STRUCTURAL ELEMENTS

CHIMNEYS

The first nonstructural item to be considered is the chimney. There are two types of chimneys:

1. Masonry- reinforced or unreinforced
2. Stud Framed with metal flue.

Stud framed chimneys can be made with wood or metal studs.

Many older residences have chimneys constructed with unreinforced masonry such as brick or stone. Because these chimneys are not reinforced with steel and their mortar tends to deteriorate over time, they usually have little strength to resist earthquakes.

Even moderate earthquakes can cause extensive chimney damage. The portion of the chimney above the roofline is usually the first part to fail. Chimneys can break apart all the way to the firebox (Fig7-1). *Whether masonry chimneys are reinforced or braced to the roof structure, few construction methods have improved their performance during earthquakes* (Fig. 7.2).

Cracks in the chimney flue liner allow hot gases to leak into the wall or roof framing and start a fire. Therefore, a thorough inspection of the chimney after any significant earthquake will be necessary to identify any hidden or less obvious cracks. Video camera inspections and smoke tests may be required.

Question: *What can you do with unreinforced brick chimneys?*

Answer: There is one basic method for dealing with unreinforced brick chimneys:

REPLACE THE CHIMNEY!

Bracing of chimneys has been ineffective in preventing their failure during earthquakes. While replacement of the chimney is a costly solution, it is also the most effective technique to prevent damage (Fig. 7.3). In some cities, such as Los Angeles, full or partial replacements may by the only accepted method. Always check with the local building department for details and information.

Partial replacements remove all of the brick above the firebox. The chimney is then replaced with a reinforced masonry chimney or metal stud framed chimney with a metal flue. This method has often been used to repair earthquake damage. This less-expensive method removes most of the potential problem.

Fig. 7.1 Reinforced Chimney Failure

Fig 7.2 Braced Chimney Failure

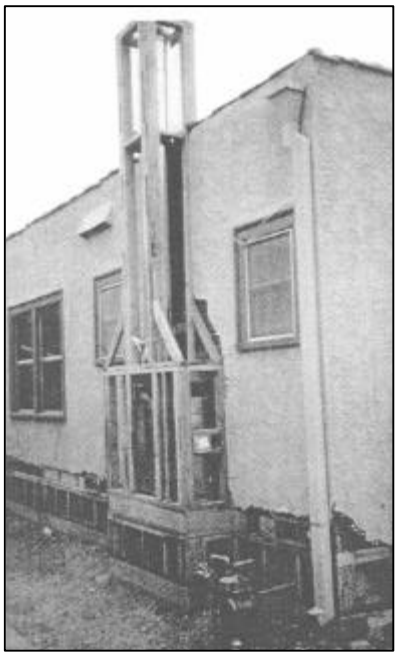

Fig. 7.3 Chimney Replacement

BUILDING APPENDAGES

Fig. 7. 4 Porch Roof Collapse.

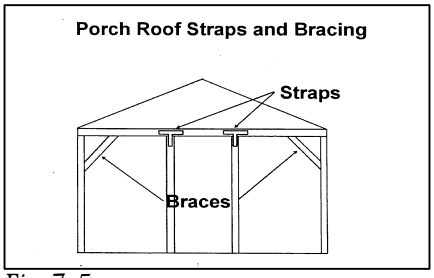

Fig. 7. 5

All portions of the building, including those attached to the outside, experience horizontal earthquake forces. Most houses either have a porch, a deck, an exterior staircase, or other type of framing that is attached to the outside of the house. Few of the appendages are stiff or strong enough to resist the earthquake forces by themselves. Therefore, they need to be braced or adequately attached to the house to resist the earthquake forces.

If the appendage is not braced on its own or adequately attached to the house, it will collapse during an earthquake. This creates a falling hazard if the attachment is a roof. Since most of the attachments are located near the doors, it can also create a hazard for exiting the house if the attachment collapses.

Building appendages are usually connected to the house using nails, lag screws, braces or straps.

Nails are typically used to connect the existing house to the building framing for resisting gravity loads. However, nails may not be a sufficient method of attaching for horizontal type forces that also cause withdrawal (pull out).

Lag screws connect a roof or porch to the house in order to resist lateral earthquake forces. An architect or engineer may specify lag screws to attach the ledger to the framing of the house. The lag screw must be anchored into a stud for it to be effective. It will be necessary to drill pilot holes to locate the studs.

Straps are used when a simple attachment detail is not adequate to hold the porch or roof to the house. If the length of the appendage is more than its width, the architect or engineer may require straps at the ends of the appendage to resist the horizontal swaying of the appendage. This is similar to the requirement for holdowns for a shear wall.

Straps or brackets are used to prevent roof overhangs or elevated porches from becoming unstable if they sway too far during the earthquake. If the swaying is too great, the columns or posts supporting the outside ends will become unstable or detach. Many of the posts have little or no attachment to the roof or floor deck.

An architect or engineer may specify a strap or bracket to allow the post to move without separating from the roof or floor deck. This does not increase the strength of the post to resist earthquake forces. The only way to increase the strength of these posts is by adding diagonal braces. If the braces are not installed correctly, they will not be effective (Fig. 7.5).

VENEER

Another nonstructural item is veneer. Many houses have a layer of brick or stone veneer attached to the outside face of the exterior walls. Older houses may not have any attachment of the brick veneer to the wall except for a layer of mortar between the brick and the building paper.


Fig. 7.6 Fallen Brick Veneer

If the attachment of the veneer to the house framing is not adequate, the bricks may become dislodged during the earthquake causing the bricks to fall (Fig. 7.6).

New houses will have the veneer attached to the framing with wire ties embedded in the mortar joint. Even with wire ties in place, they may not be able to adequately restrain the bricks from falling out because they are:

Too widely spaced and the bricks may fall out between the ties.
Corroded or deteriorated.
Attached to the wall with nails that are too small or short.
Mortar may have deteriorated so that the tie will pull out of the mortar joint.

Mortar, especially older mortar, has very little strength for resisting earthquake forces, because mortar deteriorates year after year if not well maintained. When the spacing between the ties is too far, then the force on the ties as they try to restrain the bricks from falling out could exceed the strength of the tie.

Question: *What can you do to limit the hazards associated with brick or stone veneer?*

Answer: In order to limit the hazards associated with a brick or stone veneer, you should:

1. Add new anchors for the veneer.
2. Remove the veneer.
3. Do nothing unless the architect or engineer and owner decide that the veneer is a hazard.

The first option is adding additional restraints to the veneer to re-anchor the bricks or stone to the framing. The bracing must be spaced regularly in both horizontal and vertical directions. The restraints are intended only to prevent collapse of the entire section of the veneer. Since it is not practical to add restraints at every piece of veneer, adding the ties is not a guarantee that all of the veneer will remain intact during the earthquake. Some stones or bricks may become dislodged and fall during the earthquake shaking. The ties are intended only to prevent collapse of the entire section of the veneer.

The second option is the most effective: *remove the veneer.* If the bricks are removed, the area must be replaced with an exterior wall covering. The replacement should be weather tight and securely attached to the building framing.

The third option is to leave the veneer. The owner, engineer, or architect may decide that a section of veneer is not a problem.

GAS LINES

Fig. 7. 7 Automatic Shutoff Valve

Gas lines are a nonstructural item that can pose a serious risk if damaged during an earthquake. Fires often erupt following an earthquake because of broken gas lines. Any spark can ignite the leaking gas and cause a potentially violent explosion and fire. Installing automatic shutoff valves on the gas line can help prevent these catastrophic fires. These valves can be attached on either the inlet or outlet side of the gas meter for the building (Fig. 7.7).

The earthquake shaking causes the valve to stop the flow of gas. Most of the time, the leaking gas dissipates so that there is less chance of a large quantity of gas building up where a spark might develop. If there is a break in the line and a spark develops, the gas remaining in the air can still start a fire. The shutoff valve makes sure that there is no additional fuel to feed the fire so that it is less likely to get out of control.

In addition to the plumbing work required to put the valve on the gas line, the valve must be rigidly attached to the building. If the valve is not rigidly attached, someone could accidentally hit the valve, causing it to trip and shut off the gas for the house.

In some jurisdictions, shut-off valves may no longer be an option. The City of Los Angeles requires automatic shutoff valves to be installed when the cost of alterations to a house exceeds $10,000 or upon sale of the residence.

Currently, there are several manufacturers that make automatic shutoff valves. Any shutoff valve should be checked to verify that it meets the American Gas Association s standard. At the present time, this is the only standard available for shutoff valves.

Installation requirements for shutoff valves vary by manufacturer. Some manufacturers require that only approved contractors install the valves. Others allow anyone to install them.

Installing shut-off valves may require a plumbing permit. Check with the building department to find out their requirements for permits and approved manufacturers.

WATER HEATERS

One of the most common causes of fires associated with earthquakes is the rupture of gas lines when the water heater overturns. Water heaters are usually very tall, heavy (because they are filled with water) and narrow. These characteristics make them vulnerable to tipping over during an earthquake and starting a fire by breaking the attached gas or electrical line (Fig. 7.8).

Fig. 7.8 Overturned Water Heater.

Water heaters are usually set on the floor, or on a pedestal. Until recently, codes did not require water heaters to be braced. The earthquake shaking produces lateral forces on the water heater at its center of gravity. The higher the center of gravity, the less force will be necessary for the water heater to overturn.

Question: *How can you prevent a water heater from overturning?*

Answer: To prevent the water heater from overturning:

1. Water heater must be braced at the top and the base.
2. Rigid connectors for the heater gas and water piping must be replaced with flexible connectors.

Fig. 7.9 Braced Water Heater

Because earthquake forces can make a water heater shake in all directions, a water heater must be braced at both the top and bottom. New water heaters are installed on platforms.

The top brace is used to prevent the water heater from tipping over. The bottom brace is necessary so that the base of the water heater will not move far enough to shift and slide out when the earth is shaking. The State of California has approved several typical details (Fig.7.9). There are other pre-packaged systems that have been approved (Fig.7-10).

In the typical details for the smaller water heaters, plumber s tape is commonly wrapped around the top and base area of the water heater. Struts are attached to the plumber s tape and then anchored into the wall framing using lag screws. EMT conduit works well as a strut. The ends can be flattened and drilled to attach the lag screw or bolt. Sample details are included in the Appendix.

Fig. 7.10 Pre-packaged System

For strapping of the water heaters, it is critical that:

- Plumber s tape or strap is wrapped all the way around the water heater.
- Lag screws are anchored into a stud. The stud must be one that is continuous from the sill plate to the top plate.
- Struts are used to brace the water heater to straight sections of walls. Plumber s tape only works in tension and has no strength to resist compression.
- Lastly, gas and water connectors must be replaced with flexible connectors and the flue should be braced. Flexible connections allow the water heater to move several inches without breaking.

During an earthquake, a braced water heater will still make some movements because of the slack and stretching of the straps. Even if the water heater moves only a small distance, the connectors may break if the connections into

the water heater are rigid. The break can cause the water to flood the area or more seriously, cause a gas leak.

TANKS

A water heater is a type of water storage tank. Many houses have tanks to store liquids such as water or fuel. Natural gas is also stored in tanks. Usually these tanks are located outside the house and are raised up off of the ground. Like a water heater, these tanks are vulnerable to tipping over. Tanks that contain any type of fuel are a concern because if they tip over and spill their contents, they can ignite and cause a fire. The seismic retrofit of structural elements like elevated tanks or roof mounted equipment requires the expertise of an engineer or architect.

Question: *What are the most important considerations when dealing with elevated liquid storage tanks?*

Answer: The two important considerations for elevated liquid storage tanks are:

1. Brace the legs of the tank.
2. Provide a large enough concrete pad under the tank.

Bracing the legs of the tank is needed for the same reason as bracing the cripple wall of a house. If the tank sways too far during the earthquake, the legs can become unstable and the tank will fall over. Braces need to be provided in both directions on each side of the tank (Fig. 7.11).

The concrete foundation pad is needed below the legs of the tank to spread out the overturning force on the soil to prevent a soil failure that would cause the tank to tip over. A single pad under the entire tank is preferred.

When casting the pad footing, be sure to cast in anchor bolts for attaching the legs of the tank to the concrete. It is usually sufficient to place welded wire fabric in the footing to prevent cracking but be certain it remains in the center of the concrete during the pour.

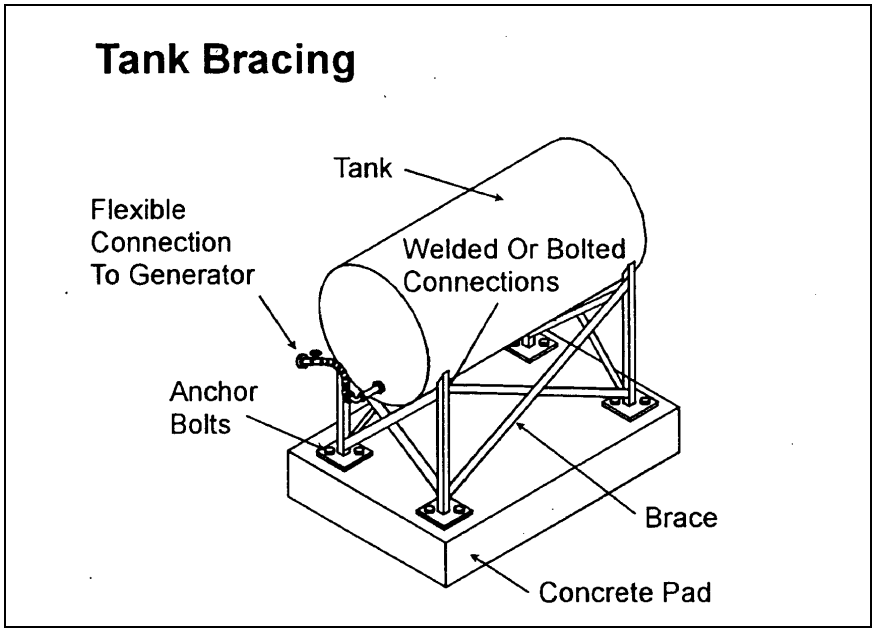

Fig. 7. 11

OTHER TYPE OF NONSTRUCTURAL ITEMS

Houses contain many other items that can be a hazard to the occupants during an earthquake. The two most important types of hazards are:

- Items that may fall and block exits.

- Items that may fall and injure someone.

Question: *What are some examples of other non-structural elements?*

Answer: Some examples of other non-structural elements are:

1. Architectural items like windows, doors, and roofing.
2. Mechanical and electrical equipment like furnaces, roof or window mounted air conditioners, and chandeliers.
3. Furniture like book shelves, file cabinets, refrigerators, and wall hangings.

Fig. 7.12 Earthquake Damaged Air Conditioning Units

FEMA S NON-STRUCTURAL MANUAL

It is easy to brace most nonstructural items and to prevent them from falling over during an earthquake. For more information about how to brace nonstructural items, the Federal Emergency Management Agency has a reference manual called:

Reducing the Risks of Nonstructural Damage: A Practical Approach .

This guide is available through FEMA or at government bookstores. It has recently been updated to include findings from the Northridge Earthquake.

This nonstructural guide includes many standard details for bracing typical nonstructural items in a house or business. A homeowner or a contractor can install most of these techniques.

Some of the more complicated items have been designated as *Engineering Required* ". Bracing of these items are designed by an engineer because engineering expertise is needed to calculate the expected earthquake force generated by the item and the structural adequacy of the bracing that supports the item.

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