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FOUNDATIONS

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Foundations

Let’s assume that the retrofit has been done correctly from the roofline to the top of the foundation. The shear walls have the proper thickness of plywood, adequate plys, plenty of common nails, anchor bolts, and hold-downs. Everything has been done correctly, including the connection between the shear wall and the foundation. However, if the foundation cannot resist the forces imposed on it, there is still a problem. As noted, the horizontal force will tend to make the building or wall slide or overturn. If the foundation is not adequate, it will be the weak link in the continuous load path, and the wall or building could be damaged.

In determining whether or not the foundation can resist the horizontal forces that are transferred to it, it is necessary to investigate foundations in terms of type, material, condition, and embedment.

**FOUNDATION TYPES**

Residential foundation systems can be divided into six general categories:

- No foundation
- Partial foundation
- Post and pier throughout
- Perimeter footing with interior posts
- Continuous perimeter and interior footings
- Continuous footings with a slab floor on grade.

With no foundation, or too small a partial foundation, the horizontal forces in the building cannot be transferred safely into the ground (Fig. 5.1). There is a similar discontinuity in the load path with a post and pier foundation (Fig. 5.2). You will learn more about post and pier systems in the next section, Retrofitting Post and Pier Type Houses.

When a building has a continuous perimeter footing, the horizontal force can transfer from the shear wall to footing and then into the ground. Interior supports are usually posts and girders or continuous cripple walls (Fig. 5.3 & 5.4). Unless there are shear walls above, these systems provide vertical support only and are not part of the horizontal force-resisting system. They are simply part of the gravity force-resisting system.
Contractors frequently pour slabs in a two-step process with the footing being the first pour and the slab being the second pour. (Fig. 5.5) When the joint between the two pours is not properly cleaned and prepared, there will be a poor connection between the concrete layers. The problem is often discovered after an earthquake causes horizontal sliding between the pours. Typical remedies for this condition include installing vertical steel reinforcing dowels that tie the slab to the footing. These remedies must be designed by an architect or engineer.

![Failure of Two-pour Joint](image1)

**Two Pour System**

![Two Pour System Diagram](image2)

**FOUNDATION MATERIAL**

The foundation would normally consist of one or more the following materials:

- concrete
- concrete block
- brick
- stone.

If the concrete block is fully grouted and reinforced, it will tend to act as concrete. If it is not grouted or reinforced, it will act as brick or stone.

Continuous concrete footings and foundation walls are the best material type. This is one reason their presence is required in some prescriptive standards. Expansion anchors require concrete and are not approved for connections to masonry.

Some adhesive anchor products can be used for reinforced masonry. Reinforced masonry is not as strong as concrete but when fully grouted is strong enough to resist the seismic loads of light wood frame buildings. Hollow masonry is usually unreinforced.

When the foundation walls or footings are constructed with any unreinforced material such as stone or pre-1933 brick, retrofitting requires the expertise of an engineer or architect. Many engineers believe that unreinforced masonry materials cannot adequately resist seismic loads. Common retrofit methods for unreinforced masonry foundations include replacement, new parallel systems or strengthening by pneumatically placed concrete (shotcrete or gunite).
There are two concerns for the foundation condition: deterioration and cracking.

**Deterioration**

Deterioration of the foundation wall is normally visible to the naked eye. Before beginning work, a visual inspection of the foundation walls can find excessive concrete or masonry cracking and weathering. Mortar in reinforced masonry should be well pointed and tooled. Existing concrete should be smooth and without separation or exposure of stone aggregates. Poorly finished and consolidated concrete frequently suffers later from excessive weathering. If parging or repointing cannot repair the wall, a full foundation retrofit is required. You will learn more about this later in this section.

**Foundation Cracking**

When concrete foundation walls are constructed without expansion joints, hairline crackling will normally occur. Cracks that are wider at the top than at the bottom are often caused by expansive soil. When the crack is wider at the bottom than at the top, there is likely a problem with soil settlement. These problems can prevent the seismic loads from safely dissipating through the soil (Fig. 5.11).

The effects of expansive soils are best reduced with deepened footings and control of adjacent watering. Keeping roof and surface water away from footings is always a good idea since settlement can also occur with excessive water in the soil. Underpinning, roof gutters with downspouts to yard drains and new concrete paving can help alleviate expansive soil problems. The presence of expansive soils or foundation settlement indicates the need for professional advice. Geotechnical engineers specialize in solving these problems.

Depending on the size of the crack, concrete cracking can be repaired with various epoxy or cementitious mortars. These products require special inspection and careful quality control by the approved applicator. These products should be used only under the qualified advice of an engineer or architect.

**Question:** When is a crack in the footing something to be concerned about?

**Answer:** An architect or engineer should be consulted if the crack is greater than 1/8 of an inch, you can see all the way through the crack, or if it appears that the crack was caused by settlement or the thrust of expansive soils (Fig. 5.12).
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Seismic Retrofit Training

FOUNDATION EMBEDMENT

Footings must be embedded deep enough into the ground so that the foundation can safely resist the vertical and horizontal loads imposed upon it. Shear walls impart compression and sliding forces to the footing. Usually the deeper the footings are, the better the soil condition is and the better the foundation can resist these loads. When poor embedment exists, the load path is incomplete and the building can simply slide along the ground surface.

Foundation embedment is measured below the undisturbed ground surface and does not include the depth through loose topping soils that are commonly added for the garden. The minimum required embedment depth for the footing is based on the number of floors supported and the soil condition. If the existing foundation depth is less than 12, 18 or 24 inches for 1, 2 or 3-story buildings respectively or there is evidence of expansive soils, an architect or engineer should be consulted. (Fig. 5.13)

FOUNDATION RETROFIT

Several options exist to retrofit the buildings footings and foundation walls:

- capping
- replacement
- parallel systems

Capping simply means that concrete is placed over or alongside the existing foundation wall. An engineer or architect must specify the reinforcing steel, anchor bolts and connections between the existing foundation wall and the new capping. The embedment of anchor bolts and placement of reinforcing steel generally follow the standards for new construction. For unreinforced masonry, some of the bricks or stones are removed to help interlock the capping to the existing wall. To provide proper curing of the capping, existing brick foundation walls must be well saturated with water before any shotcrete or gunite is installed over them. Capping is popular when owners wish to maintain the appearance of masonry foundation walls (Fig. 5.14).

Replacement involves shoring up the building and putting in a complete or partial perimeter footing and stem wall. This method is frequently used to reset houses that fell off their foundation during an earthquake but remained intact (Fig. 5.15) Shoring can be omitted when replacement is done in small sections at a time. The latter technique is popular for occupied structures.

Parallel systems are systems of new structural elements that create a parallel horizontal force-resisting system at the foundation level. These systems are designed by an engineer or architect. The new structural elements are typically located near the exterior walls. A sample system using large concrete columns is shown in Figure 5.16.

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