This chapter of the "Foundation Crack Bible" discusses in detail How to Evaluate and Diagnose Vertical Foundation Movement - Foundation Settlement Cracks, Foundation Leans, Vertical or "up and down" Shifts in Foundation Walls.

Vertical foundation movement may be foundation settlement, frost heaves, movement caused by expansive clay soils, footing settlement, or severe damage from earthquakes or other more sudden forces. Diagnosing the type of foundation movement and its cause are essential in deciding on the appropriate measures to repair a damaged foundation wall and to prevent future foundation damage.

Leaning buildings: Our photo, courtesy of Tom Smith, shows the Leaning Tower of Pisa - whose foundation has moved both laterally and vertically as the structure began tipping even during construction.

We distinguish among vertical movement, horizontal movement, leaning, tipping, bending, differential and uniform settlement, earthquake and storm damage, and other foundation damage patterns. Our "Foundation Crack Bible" document, of which this web page is a chapter, describes how to recognize and diagnose various types of foundation failure or damage, such as foundation cracks, masonry foundation crack patterns, and moving, leaning, bulging, or bowing building foundation walls.

Also see FOUNDATION CRACK EVALUATION for a discussion of the diagnosis of specific crack patterns in masonry foundations, and see FOUNDATION BULGE or LEAN MEASUREMENTS which explains a simple method for determining how much bulge or lean is present in a foundation or wall, then see FOUNDATION MOVEMENT ACTIVE vs. STATIC which helps determine if the foundation movement is ongoing, and see FOUNDATION DAMAGE SEVERITY for a discussion of just how much foundation movement is likely to be a concern.

To be used properly, this information must be combined with specific on-site observations at the particular building in order to form a reliable opinion about the condition of that building's foundation. Anyone having concern regarding the structural stability, safety, or damage of a building, foundation or other components, should consult a qualified expert. Photographs of types of foundation cracks and other foundation damage: we have a large library of photographs which we're in process of adding to this document. Pending completion of that work, contact the author if assistance is required.
Vertical Movement in Foundations & Walls

Vertical movement in foundations, in the most general cases, is caused by **downwards movement of the wall or wall footings** such as when a wall footing sinks in soft soil, or by an up and down movement of the wall or wall footings such as when a wall is disturbed by frost in a freezing climate or by expansive clay soils which expand or shrink as their water content increases or decreases.

Vertical foundation or slab movement is typically caused by the following conditions or events:

- **Soil Characteristics**: the presence of a footing at all, and footing width and thickness and reinforcement requirements may vary depending on the soil characteristics - different soils have different load bearing capacities, as shown in the sketch provided above by Carson Dunlop.

- **Settlement or differential settlement of the supporting soils** below the footings or foundation walls

- **Frost heave** (in areas of freezing climate) can push up (or in) buried foundation components

- **Frost lensing** (in areas of freezing climate) can lift a foundation wall or post or pier even if the bottom of the structure is below the frost line

- **Inadequate or even absent footings**

Foundation walls or building piers can be lifted vertically by frost heaving, by frost lensing, as well as bulged or pushed inwards by horizontal pressure from frozen soils. See [BUCKLED FOUNDATIONS due to INSULATION?](#) for additional details about these phenomena.

Here are some classes of vertical foundation or building wall movement which we illustrate and discuss in more detail below

**Vertical Frost Pressure, Frost Heaving, & Lensing Movement of Foundations**
Differential foundation settlement: one portion of a building foundation or wall moves up or down separately from its neighbor. See Differential vs. Uniform Settlement Cracks. Differential settlement will damage the foundation or wall by producing (usually vertical, possibly diagonal or stair stepped) cracks and other symptoms of wall movement.

Vertical frost pressure on a foundation wall - Frost heaves and frost lensing also cause vertical movement of a foundation but in both "up" and "down" directions: water freezing to ice in wet soils expands, heaving a foundation footing or concrete floor slab up in freezing weather.

When the weather warms and ground thaws, the same (now damaged) structural components may move downwards again as frozen water (ice) returns to its liquid (water) state. In some conditions the upwards dislocation of a footing or concrete slab is cumulative. That is these structural components never return to their original "down" position, probably due to soil disturbance below the footing or slab. Our sketch at left shows how frost heave can cause both vertical and horizontal foundation movement. Drawing courtesy Carson Dunlop.

Frost lensing: Masonry walls, masonry columns, or even wooden posts, pilings, or piers can also be heaved upwards by frost, even when the bottom of the post is below the frost line. Lensing describes this phenomenon: wet soil adheres to the vertical surface of the masonry wall, or post or pier, sticking to it, and lifting this structural component as the soil itself heaves upwards during freezing.

A Common Source of Vertical Frost Heave - Un-heated Homes
In northern climates an inspector may encounter a concrete slab basement floor which is remarkably broken up from frost heaves. In the Northeastern U.S. early in the 20th century it was common to route building downspouts carrying roof runoff into drains that passed under the basement or crawl space slab and into the sewer system.

When such houses are left unheated (a likely condition in a period of high heating costs and slow real estate sales market), temperatures can drop sufficiently to cause heaving of the foundation or more commonly the basement floor slab.

If you see a floor which has broken in a rather straight line you might suspect that a stopped drain line under the floor or a broken drain line under the floor added water in that location, causing the more severe frost damage following the line of the buried pipe or drain. Rawing courtesy Carson Dunlop.

Frost and soil pressure can also cause horizontal movement of the building foundation or piers, as we discuss further at HORIZONTAL MOVEMENT IN FOUNDATIONS.

Uniform Building Settlement

- **Uniform building settlement**: an entire building moves up or down together, causing little or no foundation cracking or damage, though there could be important damage to mechanical connections to the building and even dangerous gas line leaks. [See below]

Non-Uniform Building Settlement - Leaning or Tipping Buildings

- **Building tipping or leaning**: a foundation wall, post, pier, or an entire building tips or leans out of level. While we consider this primarily a lateral or horizontal structural movement, in fact one end of a building can move substantially higher or lower than its opposite end - a vertical dislocation as well. For a detailed discussion of the diagnosis of specific crack patterns caused by wall bulging and leaning in masonry foundations, and see FOUNDATION BULGE or LEAN MEASUREMENTS

Other Building Movement Causes & Cracks

- **Earthquake or Storm Damage to Buildings**: can cause complex building movement in multiple directions, as we illustrate at Foundation Movement due to Earthquake.
Vertical shrinkage cracks in foundation walls: If a vertical crack is fairly uniform in width we pose that it was produced either by a non-sloping vertical settlement of one section of the footing or foundation wall, or the crack was produced by shrinkage (in some wall materials like concrete) not by vertical movement at all. We discuss the types of crack or movement patterns produced by shrinkage, expansion, and settlement further at SHRINKAGE vs EXPANSION vs SETTLEMENT.

Differential Settlement vs. Uniform Settlement in a Foundation Wall

Differential settlement in a foundation or wall: We use the term "differential settlement" to describe a condition in which one portion of a building foundation is moving down, (or up and down) at a different rate or in a different amount from other portions of the foundation or wall.

Differential settlement will damage the foundation or wall by producing (usually vertical, possibly diagonal or stair stepped) cracks and other symptoms of wall movement.

The large foundation crack in this poured concrete wall was caused by differential settlement in a new foundation wall. All of this movement occurred during the first 13 months after the home was built.

Differential settlement in a building slab or supporting piers can produce significant and recurrent cracks in the living area as drywall and trim are torn and dislocated during building movement.

This photograph shows a significant crack in an upper floor interior wall which was bending as the center of this home settled downwards. The home had been built over the site of a previous stream bed.
Its basement floor slab and supporting piers was settling downwards at its center. There was some additional movement in some of the building perimeter foundation walls, but the most significant settlement was at the center of the basement floor.

Uniform settlement in a foundation or wall: Some buildings may settle so uniformly that the entire building moves down without producing cracking in the building's foundation or walls.

For example, while it has a few settlement cracks, the Empress Hotel in Victoria BC, a very large masonry structure built on pilings on what was originally a marsh, has settled rather uniformly down over many decades, so that now visitors enter the hotel's "lobby" on what was originally its second floor.

Vertical Crack Patterns Caused by Vertical Foundation Wall Movement

Vertical movement between different sections of a masonry foundation wall, whether it is constructed of concrete, concrete block, brick, or stone, tends to produce vertical cracks or a combination of vertical and step cracks through the wall, though there are definitely exceptions to this rule, as we will point out.

Other vertical or near vertical cracks in poured concrete can occur in a masonry block or concrete or brick or stone foundation wall without leaning or bulging if the entire wall is moving due to footing settlement or frost.

In this photograph notice that the cracking is occurring at a building corner, probably at a garage
The footings at garages are often not buried as deeply as other portions of a home (which has a basement much deeper below grade). There is greater risk that the builder didn't get the garage footers below the frost line or that in addition, the un-heated garage is more vulnerable to frost damage (only in freezing climates of course).

**Uniform Width vs. Tapered Width Foundation Cracks**

We like to look at variations in the width of a vertical crack to try to understand further what's happening to the foundation wall. In general we pose that if a crack is wider at its top than its bottom, differential settlement may be allowing one section of the wall to slope downwards away from its neighbor.

Or in less common cases, for example a footing which was placed mostly on soft fill but which passes over a boulder, might break over the boulder and slope downwards on both sides of the boulder, producing a crack wider at its top than its bottom.

If a vertical crack is fairly uniform in width we pose that it was produced either by a non-sloping vertical settlement of one section of the footing or foundation wall, or the crack was produced by shrinkage (in some wall materials like concrete) not by vertical movement at all.

But unfortunately this "rule" has exceptions. When a masonry wall is "shrinking" such as curing concrete (and some experts pose also drying concrete block), it is not held uniformly in place across its length.

The top of a poured concrete wall is generally unrestrained during the first portion of it's initial 28 days of curing, since nothing has been built atop the wall, or even if someone has started floor framing, the floor framing system does not secure the top of the wall against shrinkage movement.

On the other hand, the bottom of the wall is pinned (or should be) to its previously poured and cured footing. The bottom of the newly poured concrete wall is more secured against horizontal movement along its length than its top.
This might therefore produce some vertical shrinkage cracks that are wider at top than bottom. Why don't we always see this in concrete walls? As a concrete wall shrinks, the stresses produced in the wall are not concentrated at one single point, say the center of the wall; rather, shrinkage cracks may appear in various locations in the wall, not just at its center. Shrinkage cracks may be distributed rather than concentrated. However shrinkage cracks do tend to appear at local stress points in a wall such as at discontinuities in its form caused by windows, doors, or holes left for mechanicals and pipes.

We discuss the types of crack or movement patterns produced by shrinkage, expansion, and settlement further at SHRINKAGE vs EXPANSION vs SETTLEMENT.

**Diagonal Cracks in Poured Concrete Foundations**

Concrete walls tend to display vertical cracks but settlement or frost heaving at a corner of a concrete wall can produce diagonal cracks or breaks in that location.

**Steep diagonal cracks** may also appear in concrete foundations due to unusual point loads that exceed the compressive strength of the concrete (maybe it was weak concrete not high loading), and we've seen steep diagonal cracks in poured concrete and other high-rise masonry buildings exposed to frost damage.

**Steep diagonal shrinkage cracks**: But in this photograph of a diagonal crack in a poured concrete foundation, we are almost certainly looking at a large shrinkage crack. Notice that discontinuity in the crack pattern?

**Diagonal Step Cracking in Concrete block or Brick Walls Caused by Vertical Movement**
Vertical movement in a concrete block or brick wall might appear as either vertical cracks but more often as step cracks in which the crack pattern follows the mortar joints between the masonry units in a stair stepping pattern.

In this photograph, major vertical dislocation, foundation settlement, has caused large step-cracking in the concrete block foundation wall. In addition to diagnosing and correcting the reason for this settlement or foundation movement, this section of wall will probably have to be rebuilt.

Where step cracks are present, if you draw an imaginary line at right angles (orthogonal) to the diagonal formed by the stairstepped cracking, the downwards direction of the line will generally point to the center of the point of downwards (or up and down) movement in the structure.

But unfortunately even this "rule" has exceptions. In Florida we observed a concrete block home with step cracking high in some of its walls. The cracks were traced to settlement at the other end of the building which was responding to soil subsidence over a sinkhole.