Foundations don't move. Soil moves.
The foundation just goes along for the ride.

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The most general statement one can make about building failures is they occur because something moves, loads or pushes the building beyond its capacity to resist. Cracking in buildings often appears in the finishes. While these are not usually structural, finishes attach to the structure. They are usually thin, brittle and fragile, so their cracking serves as an indicator of underlying structural movement.

Building structures fail under a number of conditions including overloading, improper construction, natural disasters (earthquakes, tornadoes and hurricanes), and foundation movement. Since the focus of this document is foundation failure, the comments from this point will focus on foundation movement. While this is not a complete list of the reasons for foundation movement, it addresses the most commonly encountered situations.

One can make general statements about foundation failures.

- Building cracks are symptoms, not causes. They result from excessive movement.
- Foundation movement is part of a chain of related events.
- Buildings do not crack because soil moves or expands. They crack because the soil under one part of the building moves differently than the soil under another part of the building. This is called *differential movement*.
- One cannot permanently correct symptoms of foundation movement (that is, cracks) without curing the underlying causes.

Active Clay

Owning a building in Texas means having to deal with active clay soil. The terms "active clay" and "expansive clay" refer to the tendency for the clay in this part of the world to react to moisture. This clay expands as it absorbs moisture and shrinks

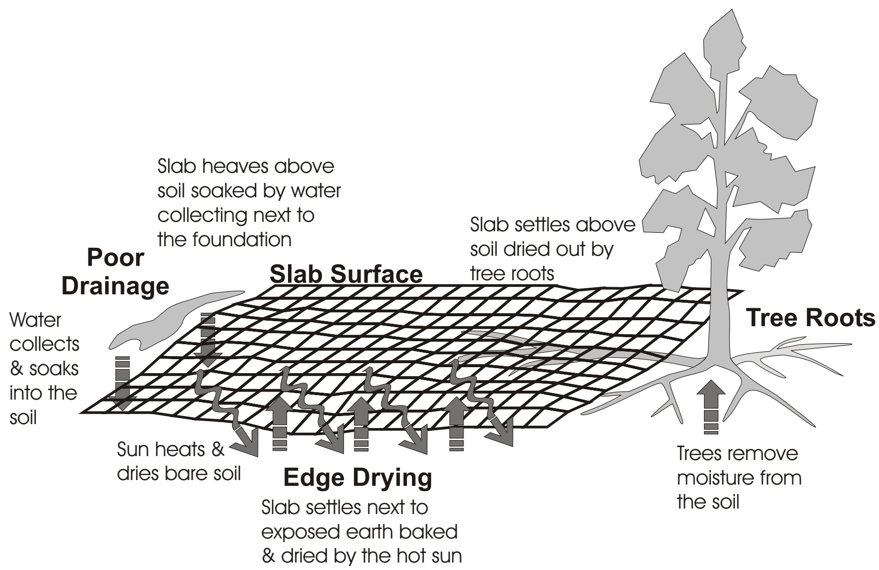

Fig. 1 MOISTURE IMBALANCE

as it dries out. In fact, active clay endlessly cycles through expansion and shrinkage as it gains and loses moisture. It is this change in the volume of the soil after the building is constructed that causes damage.

The real culprits are the tiny mineral particles that make up clay. They attract molecules of water that bind to the clay and repel other clay molecules that have water bound to them. This repulsion at the molecular level makes the clay mass expand and creates huge forces against any rigid object in the way: walls, poles, and foundations. Beginning as a dry dirt clod, the clay mass will expand in proportion to the moisture it absorbs until it becomes just a little wetter than modeling clay. Then, expansion ends.

Moisture imbalance

Placing a slab over the soil creates a relatively constant environment beneath the soil. Over time, the moisture content of the soil there reaches an equilibrium state. However, uniform moisture content is not easily maintained and can be disrupted. When pockets of moist and dry soil form, it is called *moisture imbalance*. If the building sits on active clay, the moisture imbalance will cause the soil, and the foundation along with it, to move differentially. There are several ways that moisture imbalance occurs. (Fig. 1)

Poor drainage. Terrain that causes water to collect next to the foundation causes the soil near that part of the building to swell.

Trees. The feeder roots of trees bring moisture to the trunk and the leaves above. They lie in the top two feet of the soil and can extend 25% to 100% beyond the drip line of the leaf canopy. Large trees can require thousands of gallons of water every year. A foundation sitting over the root system of a tree will settle as the tree removes moisture from the soil.

Edge drying. Exposed soil provides a surface from which moisture readily evaporates. As the sun heats dark soil, evaporation accelerates. Edges of the building next to exposed soil will settle as the soil there loses moisture and shrinks.

Plumbing leaks. While the expansive soil can plug small breaks in the plumbing; severe plumbing breaks can contribute significant amounts of moisture to the soil and cause localized soil movement.

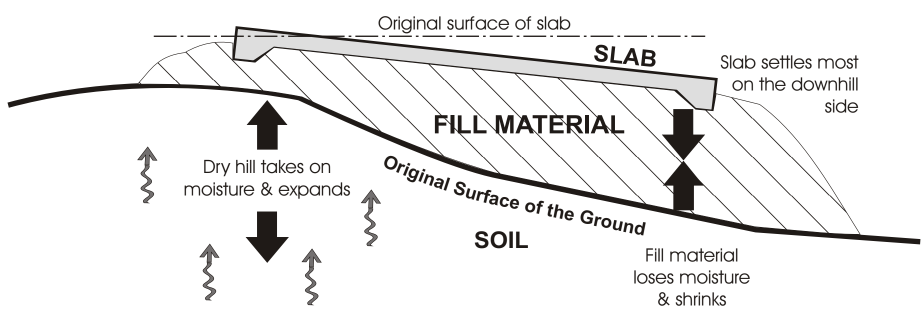

Fig. 2 TILTING OF A SLAB ON A HILL

Center heaving. Covering the surface with a slab interrupts the annual cycle of moisture movement at the surface of the ground. From a moisture perspective the surface of the ground is now located at the perimeter of the slab. In response the constant moisture line beneath the slab migrates from a point about 10' to 12' below the ground to a point closer to the surface. The increase in the moisture content of the soil at the constant moisture line causes the soil to expand and the slab resting on it to heave. This produces the characteristic center heaving.

Pre-existing site conditions

In our previous discussion, the moisture content of the soil was relatively uniform before construction but became unbalanced after construction. But, what happens if the moisture content of the soil is initially nonuniform, then becomes uniform after construction? The soil expands or shrinks and the building moves with the foundation. This is referred to as a pre-existing condition. The following illustrate this:

Pre-existing excess moisture. If a moisture source existed on the site before construction, the soil surrounding that source will be unusually wet and expanded. As the soil dries out after construction, it shrinks and foundations built over that area settle. Typical sources of excess moisture are sewage drainage fields, ponds, creek beds, low areas, and swimming pools.

Pre-existing dryness. The opposite condition occurs when building a foundation over a dry area. After construction, the soil begins to absorb moisture and swell. This heaves the foundation sitting on it. This can occur when a large tree once grew on the site or when buildings are placed on the side of a hill (hills are dry because water runs off them).

Tilting. To build on hilly sites, one must create a level surface. To do this, a wedge-shaped layer of moist fill material is placed over the hill's dry soil. After construction as the deeper layer of material downhill dries out, it shrinks more than the thinner layer of material uphill. At the same time, the dry soil of the hill absorbs moisture and expands. The weight of the fill keeps the downhill side from expanding as much as the uphill side. The surface of the foundation tilts downhill, as the fill shrinks and the native soil expands. (Fig. 2)

Nonhomogeneous subsoil. While we think of soil as being uniform and consistent, it is actually made up of materials laid down under different geological conditions. This creates materials that vary in their characteristics, depth, appearance and behavior. A structure built over nonhomogeneous soil will move differentially as the soil beneath it expands and contracts inconsistently.

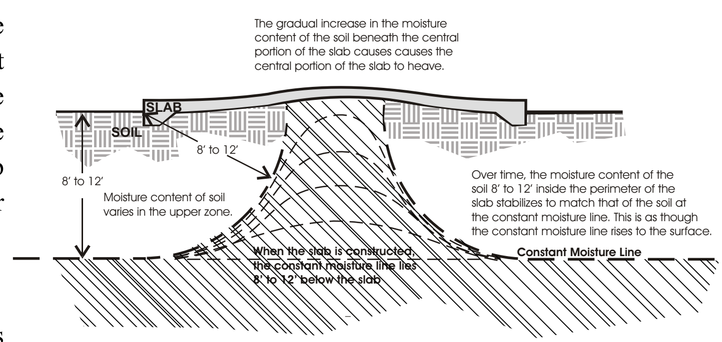

Fig. 3 CENTER HEAVING

Other causes of soil movement

Because soil expansion is such a problem, we forget that other things cause soil to move too. Clay soil is still soil. It also moves for the same reasons that other soil moves.

Settlement. If soil is not properly compacted during construction, it will settle afterward and cause the foundation to move. This can also happen if the building experiences excessive loads. The foundation settles.

Slope failure. When land is contoured and the sides of hills are steeper than allowed by the natural geometry of the soil, the soil on the surface of steep hills will relax and deform. In extreme conditions, the face of the hill may completely separate and slide downhill. This can also occur to soil behind improperly designed or failing retaining walls. Any foundation built on that mass of moving soil also fails when the ground beneath it slides downhill.

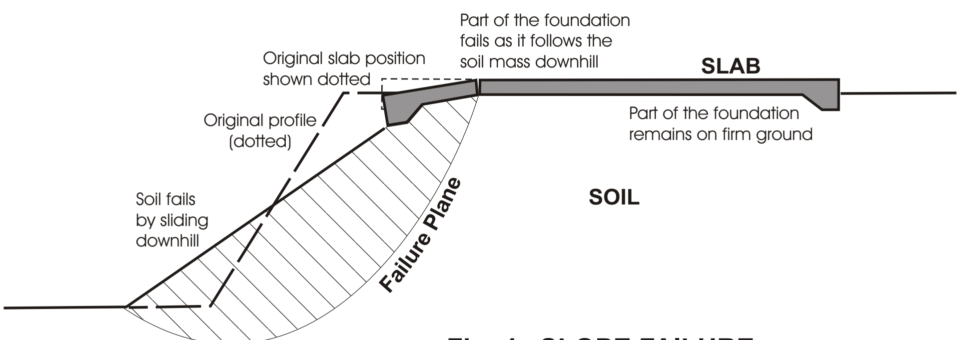

Fig. 4 SLOPE FAILURE

Solutions

When buildings crack because of foundations failure, it does little good to just repair the cracks without first solving the foundation problem. Otherwise, the cracking will recur and nothing will be resolved. Correcting foundation problems is tricky and inexact. An inappropriate solution can exchange today's problems for worse problems tomorrow.

In general, the best approach to foundation repair is as follows:

- Before you fix it, know why the foundation moved.
- Address the cause, not the symptom, of the foundation problem.
- Choose appropriate solutions. Never use permanent remedial solutions (piles, piers or mud jacking) to correct a temporary problem. In other words, if the foundation deforms because of moisture imbalance, correct the reason for the moisture imbalance improve drainage, remove trees growing nearby, and cover the bare ground next to the foundation. Resort to permanent foundation repair solutions only to correct permanent conditions such as settlement, slope failure, or movement caused by a preexisting condition.
- Be patient. Mother Nature has all the time in the world and ultimately she gets her way.
- Be consistent. If the problem demands a remedial foundation solution, then the whole foundation, not just a portion, must be addressed. w