SECTION 7C
PREVENTIVE MAINTENANCE

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7C.1 INTRODUCTION

Preventing a problem always make more sense than curing one. Section 7A discussed the predominant causes of foundation failures. Sections 7B.1, 7B.2, and 7B.4 covered methods for correcting common foundation failures. Obviously, if the cause of the problem does not exist, neither will the problem. This chapter will focus on measures that encourage foundation stability, with a specific focus on those problems relative to expansive soils. Certain maintenance procedures can help prevent or arrest foundation problems if initiated at the proper time and carried out diligently. The following are specific suggestions on how this can be accomplished.

7C.2 WATERING

In dry periods, summer or winter, water the soil adjacent to the foundation to help maintain constant moisture. *Proper* watering is the key and will be discussed in the following paragraph. Also, be sure drainage is away from the foundation prior to watering. Remember, too much water can cause far more problems than too little.

When a separation appears between the soil and foundation perimeter, the soil moisture is low and watering is in order. Water should not be allowed to stand in pools against the foundation. Never attempt to water the foundation with a root feeder or by placing a running garden hose adjacent to the beam. Both represent uncontrolled watering. Sprinkler systems often create a sense of "false security" because the shrub heads, normally in close proximity to the perimeter beam, are generally set to spray away from the structure. The design can be altered to put water at the perimeter and thereby serve the purpose. This is done by replacing the sector heads with strip heads. However, in the end, the use of a soaker hose is still often the best solution. In either event, watering should be uniform and cover long areas at each setting, ideally 50 to 100 linear ft (15 to 30 m). From previous studies of water infiltration and runoff, it is evident that watering should be close to the foundation, within 6 to 18 inches (15 to 45 cm), and timed to prevent excessive watering.

Proper grading around the foundation will also serve to prevent unwanted accumulation of standing water. Sophisticated watering systems that utilize a subsurface weep hose with electrically activated control valves and automatic moisture monitoring and control devices are reportedly available. The multiple control devices are allegedly designed to afford adequate soil moisture control automatically and evenly around the foundation perimeter. Reportedly, the control can be set to limit moisture variations to plus or minus 1%. Within this tolerance, little if any differential foundation movement would be expected in even the most volatile or expansive clay soils. The key to this system is a true and proven ability to control water output and placement.[15–17]*

Avoid watering systems that make outlandish claims. They can often cause more problems than they cure. One example is the so-called water or hydro pier. One claim is that a weep hose with sections placed vertically into the soil on convenient centers (often 6 to 8 feet or 1.8 to 2.4 m) will develop a "pier," which will then support and stabilize the foundation. The "pier" is allegedly the product of expanded clay soil (see Figure 7B.4.16). Some contractors even claim the system will raise and "level" foundations. Outside the other obvious deficiencies, this procedure seems to lack controls capable of either equating water added to in situ moisture or monitoring total soil moisture. Lack of performance here introduces several problems when dealing with expansive soils.[16] First, moisture distribution within the soil is seldom, if ever, uniform. Second, excessive soil moisture approaching the liquid limit (LL) can cause a soil to actually *lose* strength (cohesion). Third, although *consistent* moisture content in the expansive soil will normally prevent differential deflection of the foundation, the method under discussion will not likely meet the requirements. And, fourth, water replenishment into an expansive soil will seldom, if ever, singularly accomplish any acceptable degree of "leveling." (Minor settlement, limited in scope, could be the exception.[16,26])

Where large plants or trees are located near the foundation, it could be advisable to conservatively water these, at least in areas with climatic (C_w) factors below about 25.[36] (These areas are generally classed as "semiarid."[36] Lower C_w values lean toward being more arid). As far as foundation stability is concerned, the trees or plants most likely to require additional water would be those that: (a) are immature, (b) develop root systems that tend to remove water from shallow soils, and (c) are situated within a few feet of the foundation. Refer also to Section 7B.2.

7C.3 DRAINAGE

It is important that the ground surface water drain away from the foundation. Proper moisture availability is the key. Excessive water is frequently detrimental. Proper drainage will help avoid excess water. Where grade improvement is required, the fill should be low clay or sandy loam soil. The slope of the fill need not be exaggerated but merely sufficient to cause water to flow outward from the structure. A 1% slope is equivalent to a drop of 1″ (2.5 cm) over approximately 8 ft (2.4 m). A satisfactory slope is often assumed to be 1–3%. Too great a slope encourages erosion. The surface of fill must be below the air vent for pier-and-beam foundations and below the brick ledge (weep holes) for slabs. Surface water, whether from rainfall or watering, should never be allowed to collect and stand in areas adjacent to the foundation wall.

Along with proper drainage, guttering and proper discharge of downspouts is quite important. Flowerbed curbing and planter boxes should drain freely and preclude trapped water at the perimeter. In essence, any procedure that controls and removes excess surface water is beneficial to foundation stability. Water accumulation in the crawl space of pier-and-beam foundation is also to be avoided. Low-profile pier-and-beam foundations can be particularly susceptible to this problem. Drainage control and adequate ventilation serve as the best preventive measures. As a "rule of thumb," vents should be provided on the ratio of one square foot per 150 square feet of floor space. Where construction design prevents an adequate number of vents, the desired ventilation can be implemented by the use of forced air blowers.

Domestic plumbing leaks (supply and sewer) can be another source for unwanted water.[24,26,51,79,83,86] Extra care should be taken to prevent and/or correct this problem. Water accumula-

*References are in Section 7E.

tion beneath a slab foundation accounts for a reported 70% of all slab repairs.[15–17] Sewer leaks are responsible for a very high percentage of these failures (see Section 7B.1).

7C.3.1 French Drains/Subsurface Water

French drains are required, upon occasion, when subsurface water migrates beneath the foundation. Figure 7C.1 is a drawing of a typical French drain. When the foundation is supported by a volatile (high-clay) soil, the intrusion of unwanted water must be stopped. The installation of a French drain to intercept and divert the water is a useful approach.[15–17,26,79] The drain consists of a suitable ditch cut to some depth below the level of the intruding water. The lowermost part of the ditch is filled with gravel surrounding a perforated pipe. The top of the gravel is continued to at least above the water access level and often to or near the surface.

Provisions are incorporated to remove the water from the drain either by a gravity pipe drain or a suitable pump system. Simply stated, the French drain creates a more permeable route for flow and carries the water to a safe disposal point. If the slope of the terrain is not sufficient to afford gravity drainage, the use of a catch basin/sump pump system is required. The subsurface water commonly handled by the French drain is perched ground water or lateral flow from “wet weather” springs or shallow aquifers.

Where the conditions warrant, the design of the drain can be modified to also drain excessive surface water. This is readily accomplished by adding surface drains (risers) connected to the French drain system. An alternative approach is to carry the gravel to the surface. (A proper drain intercepts and disposes of the water before it invades the foundation.) Water from downspouts should not be tied directly into the French drain; a separate pipe drain system is preferred. The second solid pipe could, however, be placed in the French drain trench.

A French drain is of little or no use in relieving water problems resulting from a spring within the confines of the foundation, as it is almost impossible to locate and tap a spring beneath a foundation. This condition is also rare, since a wet site causes real problems to the builder.

When distress problems exist prior to the installation of a French drain, foundation repairs are often required. In that event, these repairs should be delayed to give ample time for the French drain

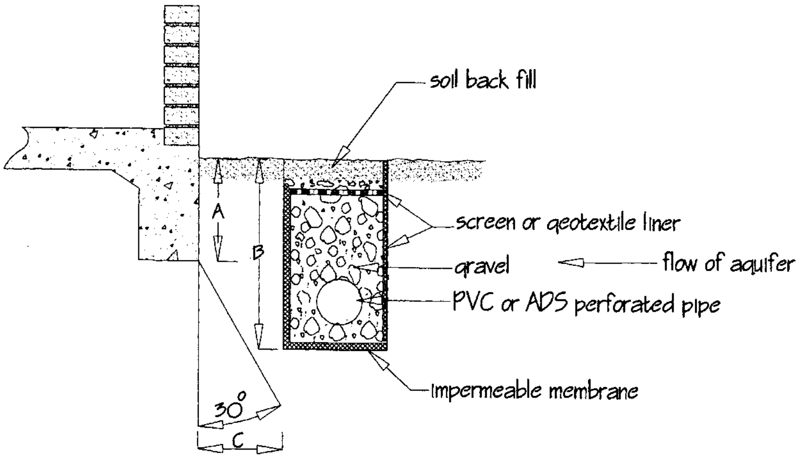


FIGURE 7C.1 Typical French drain. Generally, C is equal to or greater than A, and B is greater than A + 2 ft (0.6 cm). The drain should be located outside the load surcharge area.

to develop a condition of moisture equilibrium under the foundation. Otherwise, recurrent distress (repairs) can be anticipated due to the disturbance of soil moisture introduced by the drain.

7C.3.2 Water or Capillary Barriers

In an effort to maintain constant soil moisture, measures that impede the unwanted transfer of soil moisture can be considered. One such attempt has been the use of moisture barriers. The barriers may be either horizontal or vertical, permeable or impermeable. Refer to the following sections.

7C.3.2.1 Horizontal Barriers

Horizontal, *impermeable* barriers can be as simple as asphalt or concrete paving, or polyethylene film (see Figure 7C.2). These materials are used to cover the soil surface adjacent to the foundation and inhibit evaporation. Coincidentally, the covers could also restrict soil moisture loss to transpiration, since vegetation would neither grow nor be cultivated in the sheltered area.

Permeable horizontal barriers usually consist of little more than landscaping gravel or granular fill placed on the soil surface previously graded for drainage. Moisture within the porous material cannot develop a surface tension and no adhesive forces will exist, both of which are required to create a capillary (or pore) pressure. Gravity (drainage) then becomes the factor dictating free water movement.

7C.3.2.2 Vertical Barriers

The vertical *impermeable* capillary (or water) barrier (VICB) is intended to block the transfer of water laterally within the affected soil matrix. Figure 7C.3 shows typical vertical barriers. Placed adjacent to a foundation, the VICB will hopefully maintain the soil moisture at a constant level within the foundation soil encapsulated by the barrier.[1–4] As an added benefit, this approach will also prevent transpiration, since tree, plant, or shrub roots would be prevented from crossing the barrier. In some cases, the soil moisture within the intended confines of the VICB (prewetting) is increased to a percent or so above the soils' plastic limit prior to construction of the foundation. (This practice is generally exclusive to slab foundations.) This assumes that the soil is preswelled to a point that increased water is not likely to cause intolerable swell and, at the same time, the barrier will, hopefully, prevent a decrease in soil moisture beneath the foundation. Hence, a stable condition may be created.

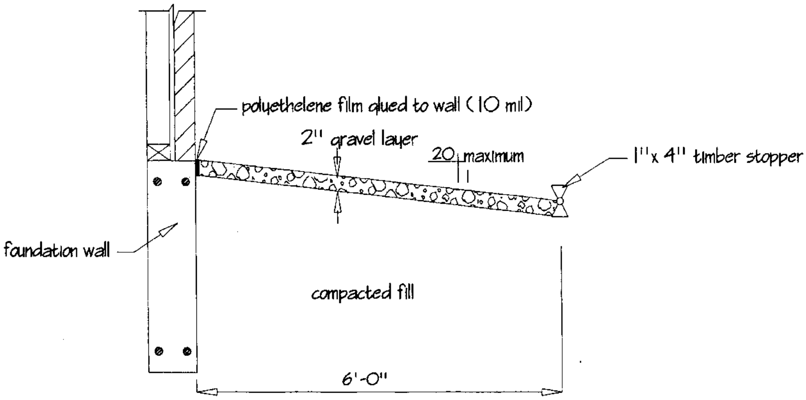


FIGURE 7C.2 Horizontal moisture barrier consisting of a polyethylene membrane overlain by a thin gravel layer (from Chen, ref. 26).

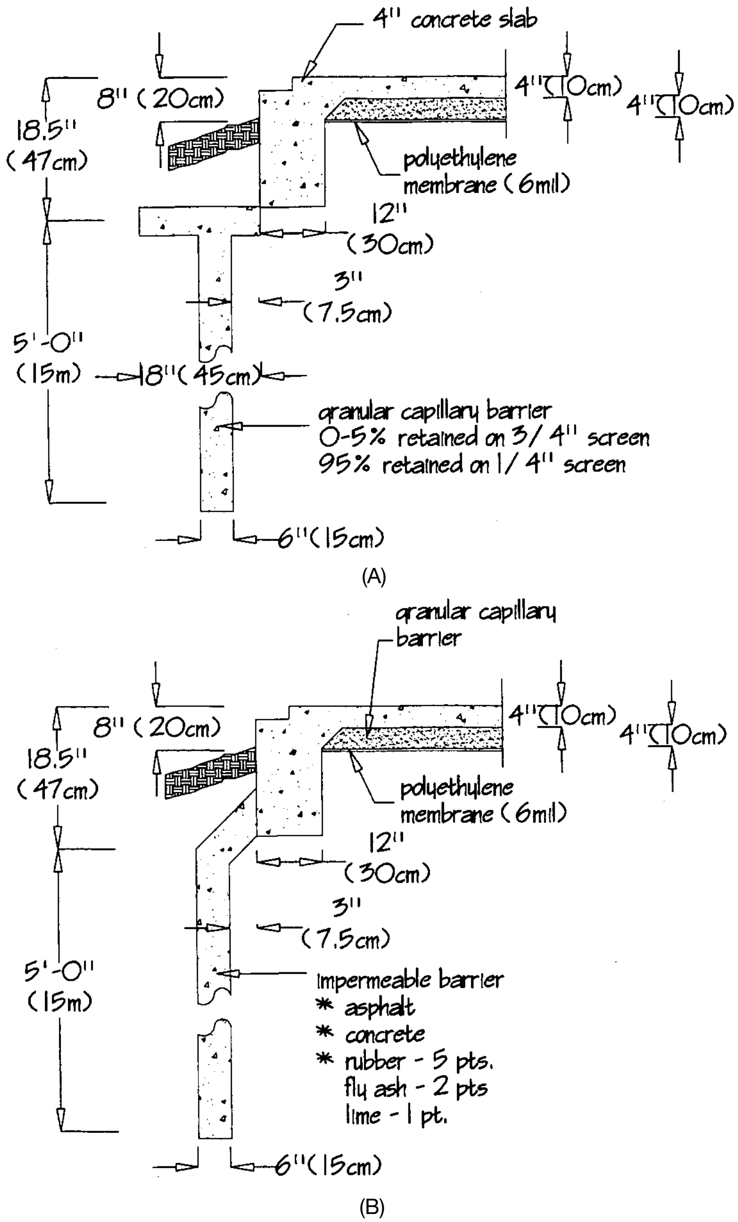


FIGURE 7C.3 Typical permeable (A) and impermeable (B) vertical moisture barriers.

Vertical *permeable* capillary barriers (VPCB) generally consist of a slit trench filled with a permeable material. The VPCB will accept water and distribute it into the permeable barrier. This also tends to block lateral capillary movement of water into the soil matrix itself. (Clay is far less permeable than the material within the barrier). The use of vertical capillary barriers has not met with appreciable success.[15–17,26,58,79] For example, Chen states "it is doubtful that the installation [of vertical capillary barriers] is a sufficient benefit to warrant the cost."[26]

7C.3.3 Conclusion

The use of water or capillary barriers offers possible benefits, but field data made public to date leaves much to be desired.[15–17,26,58,79] The installation of moisture controls (such as the French drain, vertical or horizontal moisture barriers), by intent alters the moisture profile within the foundation-bearing soils. The time period over which the results of this change becomes noticeable might vary from several days to several years. The amount and rate of moisture variation, the particular soil properties, and foundation design each influence the extent of soil volume change and ultimately any foundation movement.

The installation of French drains is frequently followed by "drying" of the foundation-bearing soils. This could ultimately result in a soil moisture regain if extraneous water becomes available. Unless this gain is uniform over the entire foundation area (which is usually true over the long term), some soil swell and resultant foundation upheaval could eventually occur.

As a matter of interest, the *horizontal permeability* (which translates to lateral water migration) in a highly expansive clay varies from something like 1 ft/yr (10^6 cm/sec) to 20 ft/yr (2×10^5 m/sec). (The *vertical* permeabilities are roughly 0.1 ft/yr or 10^7 cm/sec). For sands, the differences between horizontal and vertical permeabilities are much less, with the general readings being in the range of 1000 to 10 ft/yr (10^3 to 10^5 m/sec).[65]

7C.4 VEGETATION

Certain trees, such as the weeping willow, oak, cottonwood, and mesquite, have extensive shallow root systems that remove water from the soil. These plants can cause foundation (and sewer) problems even if located some distance from the structure. Many other plants and trees can cause different foundation problems if planted too close to the foundation. Plants with large, shallow root systems can grow under a shallow foundation and, as roots grow in diameter, produce an *upheaval* in the foundation beam. Construction most susceptible to this include flat work such as sidewalks, driveways, patios, as well as some pier-and-beam foundations. Pruning the trees and plants will limit the root development. Watering, as discussed earlier, will also help.

Plants and trees can also remove water from the foundation soil (transpiration) and cause a drying effect, which in turn can produce foundation *settlement*. [The FHA (now HUD) suggests that trees be planted no closer than their ultimate height. (There is no basis in fact that relates the lateral spread of roots to tree height.) In older properties, this is often not feasible, since the trees already exist. With proper care, the adverse effects to the foundation can however be minimized or circumvented.]

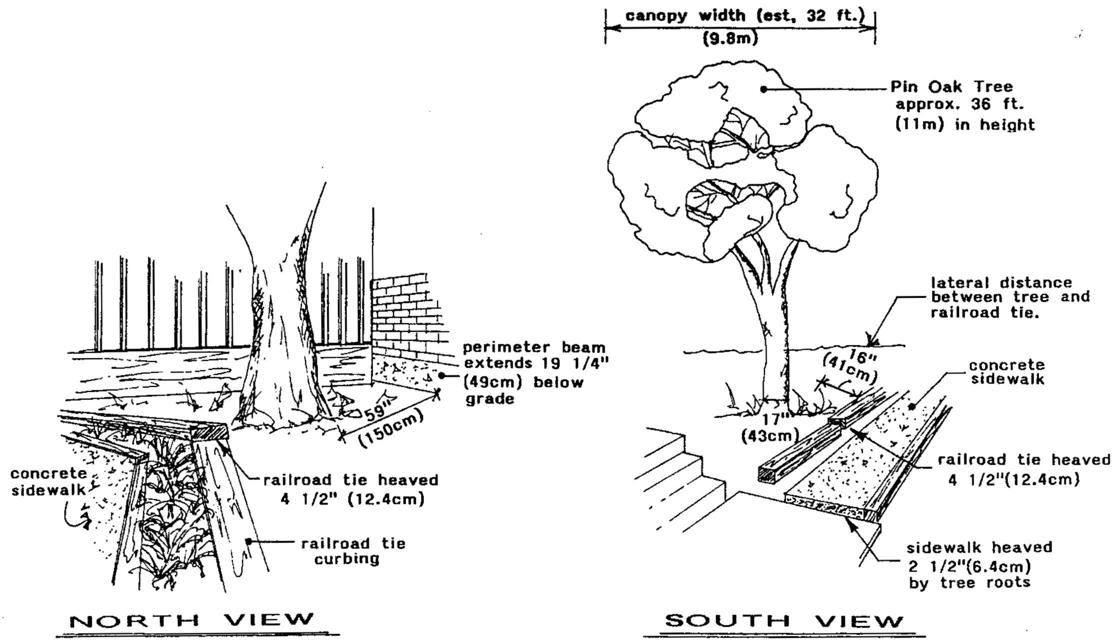
The principal moisture loss that would likely affect foundation stability occurs generally between the field capacity and the level of plant wilt.[16,17,69] Refer to Figure 7A.2. Dr. Don Smith, Professor of Botany at the University of North Texas, Denton, Texas, expresses the opinion that tree roots or other plant roots are not likely to grow beneath most foundations. This is due to several factors, the most important of which are:

1. Feeder roots tend to grow laterally within the top 24 inches (0.6 m).[49,50,98] The perimeter beam often extends to near that depth and would block root intrusion.

2. Roots prefer loosely compacted soil (low overburden).
3. Soil moisture (long range) and oxygen availability, both necessary for plant growth, are less abundant beneath the foundation.
4. These confined and sheltered areas have no normal access to a replenishing source for water. (Roots tend to "grow to water.")

For the foregoing reasons, it would appear that trees pose no real threat to foundation stability other than that noted in the first paragraph. Along these same lines, even in a semiarid area with highly expansive soil, it is seldom that a significant earth crack is noted beneath the tree canopy. This is particularly true with trees exhibiting low canopies. This suggests an actual conservation of soil moisture.107 Also, if trees pose the problems which some seem to believe, why don't *all* foundations with like trees in close proximity show the same relative distress. In literally thousands of instances where foundation repair is made without removal of trees, why doesn't the problem at least sometimes reoccur? Figure 7C.4 depicts an actual condition where trees are growing in close proximity to a slab foundation without mishap. This figure shows a "real-world" representation of the influence of trees on foundations. The tree shown is a pin oak that was planted at the time of construction. The tree is 17 in (43 cm) in diameter, approximately 36 ft (11 m) in height, with a canopy width of about 32 ft (9.8 m). The tree is located 59 in (150 cm) from the perimeter beam, which extends 15¼ in (49 cm) below grade. For the record, there are four pin oaks similarly planted along the west perimeter. The depth of the beam probably accounts for the lack of impact upon the foundation.

Removal of existing trees can create more problems than might originally exist.[15–17,26,42] Cutting (trimming) the roots can induce similar problems, though to a lesser extent.[53] Any extended differ-



(a)

FIGURE 7C.4 Tree in close proximity to foundation with no effect on foundation. (a) Site drawing.

(b)

(c)

FIGURE 7C.4 (*continued*). (b) Photograph looking north; note heave of railroad tie, left center. Tree in close proximity to foundation with no effect on foundation. (c) Photograph looking south; note heave of sidewalk and north end of rail road tie (in the grass).

ential in soil moisture can produce a corresponding movement in the foundation. If the differential movement is extensive, foundation failure will likely result.

Even with proper care, foundation problems can develop. However, consideration and implementation of the foregoing procedures will afford a large measure of protection. It is possible that

adherence to proper maintenance could eliminate perhaps 40% of all serious foundation problems. Anyone who can grow a flower bed can handle the maintenance requirements!

Remember one of the basic laws of physics, nothing moves unless forced to do so. A foundation is no different. This has been emphasized in prior chapters. All foundation repair accomplishes is to restore the structural appearance. If the initial cause of the problem is not identified and eliminated, the problem is likely to reoccur.