Methods for the Preservation of French Colonial *Poteaux en Terre* (Posts-in-Ground) Houses

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A range of intervention methods are considered for the five known examples of eighteenth- and nineteenth-century posts-in-ground construction that remain in the United States.

Of the few surviving examples of French Colonial architecture in the continental United States, most were built with traditional stone foundations known as *poteaux sur sole* (posts on a sill). *Poteaux sur sole* was not, however, the predominant construction technique used by the French in the United States. Rather, *poteaux en terre*, or posts-in-ground, construction, predominated.

Before the Louisiana Purchase in 1803, the French created a series of permanent colonial settlements along the Mississippi River extending as far north as Missouri. The only known surviving examples of posts-in-ground construction are five houses located in this region. Because of their extreme rarity, the preservation of posts-in-ground houses should enjoy widespread attention, yet little has been published on this subject. This project encompassed an examination of the physical threats to posts-in-ground houses and explored possible solutions for their long-term preservation. While no actual preservation or engineering work has been completed, it is hoped that discussion of this subject will spur further dialogue and interest in the preservation of posts-in-ground houses.

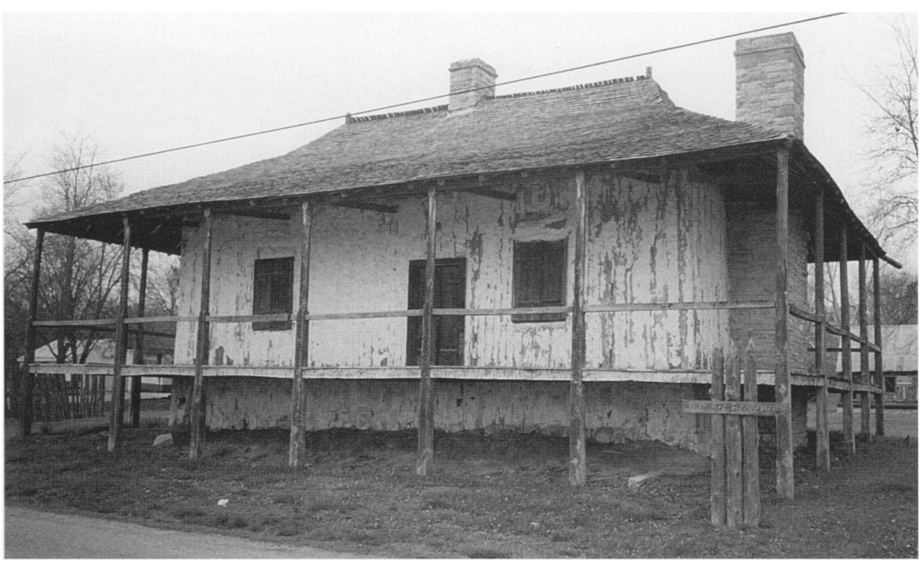

Fig. 1. The Bequette-Ribault house in Ste. Genevieve, Missouri, an example of a posts-in-ground house. All photographs and drawings by the author.

The History of Posts-in-Ground Construction

French immigrants from present-day Canada were the first permanent white settlers of the Mississippi River valley. When they arrived in this region in the early eighteenth century, they introduced the Norman cottage, the indigenous architectural style of Normandy.[1] The Norman cottage is defined by its simple rectangular form; steeply-pitched, thatched pavilion roof; and one-story construction. The French colonists used this design in an essentially unaltered state, but it was commonly modified by the addition of a *galerie* — a veranda (or roofed porch) that surrounded two, three, or all four sides of the house. The roof pitch of the *galerie* was substantially shallower than that of the roof of the main house, resulting in a double-pitched roof. Typically the *galerie* was open on the sides, but examples have been found with partial or full enclosures. This veranda form appears to have originated in the warm climate of the French-dominated West Indies and migrated up the Mississippi by way of Louisiana.[2]

The majority of French Colonial houses incorporated posts-in-ground construction (Figs. 1 and 2). Construction began with digging a trench approximately three feet deep and inserting a row of closely spaced, vertical posts that rose to the full height of the

Fig. 2. Posts-in-ground construction viewed from the cellar of the Amoureux house, Ste. Genevieve, Missouri.

first story. The spaces between the posts were filled with *bousillage*, a mixture of mud and grass, or with *pierrotage*, a mixture of mud and stones. The walls were then whitewashed or plastered; plastering was more common in the south. The vertical posts were often made out of decay-resistant mulberry (*Morus rubra*), eastern red cedar (*Juniperus virginiana*), and cypress (*Taxodium* spp.), although less durable woods, such as oak (*Quercus* spp.), also were used.[3] The use of posts-in-ground construction is unknown in France and Canada and appears to be unique to the Mississippi River valley. It is likely that the construction technique was adopted either from the Spanish settlers or Native Americans living on the Gulf Coast.[4]

The five known extant posts-in-ground houses are in Mississippi, Louisiana, and Missouri. The La Pointe-Krebs house, built between 1772 and 1780 of vertical cypress and eastern-red-cedar posts, is located in Pascagoula, Mississippi, and the Badin-Roque house, built c. 1840, also of vertical cypress and eastern-red-cedar posts, is located in Natchitoches, Louisiana. Three of the houses were built from vertical eastern-red-cedar posts and are located in Ste. Genevieve, Missouri. They are the Beauvais-Amoureux house, built c. 1792; the Bequette-Ribault house, built c. 1808; and the Vital St. Gemme Beauvais house, built in 1792.

Threats to Posts-in-Ground Construction

Fungal decay. The vertical posts of posts-in-ground construction are subject to environmental conditions that are similar to those of utility poles and fence posts. After a post is set into the ground, the transition area between soil and the air will usually be the zone most affected by fungal decay.[5] This soil-line decay typically is caused by the soft-rot fungi Ascomycetes and the fungi Imperfecti.[6] Wood that is in direct contact with the ground in the Mississippi River valley tends to undergo damage beyond the soil line, affected most by Basidiomycetes attack from the species *Coniophora puteana* (brown or cellar rot), *Coriolus versicolor* (white rot), *Serpula lacrymans* (dry rot), *Poria monticola, Lentinus lepideus*, and *Lenzites trabea* (dote). *Coniophora puteana* and *Coriolus versicolor* occur only where the wood is consistently damp. The other species are found in conditions where the wood is subject to varying degrees of moisture content.[7]

Fungi are sensitive to soil type and pH. Sandy, loamy soils high in organic material tend to favor fungi growth, while clay soils will have an inhibitory factor. A high soil pH (>7) will inhibit decay by preventing fungal enzymes from functioning properly. A perfect environment for fungi would be a rich, sandy, loamy soil with an acidic pH (~5).[8] In the Mississippi River valley, the soils tend be quite rich, clayey, and of a neutral pH (~7).

Insect attack. Of the many species of insects that attack wood, three are of major concern in the Mississippi valley: termites, carpenter ants, and carpenter bees. Of these, termites are the major destroyer of wood, especially the Formosan termite, which is found in the southern regions of this area and prefers dry wood. Other termite species found in North America prefer damp wood or wood that already has fungal decay; thus, termites are usually found in wood that is under active attack by fungi.[9]

Carpenter ants, though not as destructive as termites, can cause significant damage. They do not digest wood, but rather bore through it, so the treatment of wood with insecticides may not be effective. Carpenter bees rarely cause structural problems; damage consists of small chambers in which eggs are laid.[10]

Water and anaerobic conditions. Under anaerobic conditions (where no air or free oxygen is present), water can be the most destructive force on wood that is naturally resistant to decay. Archeologists encounter this problem when excavating very old wood from anaerobic soils. The wood escaped decay from fungi that need oxygen to grow, but the water itself has robbed the wood of structural integrity. Anaerobic conditions may exist when posts are continuously immersed in waterlogged soil.

When wood has a high water content, its strength is significantly reduced. If the wood remains moist, as when it is in constant contact with the ground, the cellulose in the wood begins to hydrolyze — a process that is independent of biological decay. The chemical change is very slow, taking centuries to make a significant impact on the integrity of wood. This physical change is permanent, with the end result being wood that is incapable of supporting the structural weight of a building, an important consideration for posts-in-ground construction.[11]

A Note on Wood Durability

Wood durability is an important consideration in posts-in-ground construction. Durability is usually related to the color, density, odiferous qualities, and resin content of the wood. In nearly all cases sapwood, the outer portion of wood in a living tree, is not durable.[12]

Heartwood is created as cells in the inner portion of the trunk die and collect wastes and toxins. These toxins often have antifungal and insecticidal qualities. During the conversion to heartwood, sapwood becomes more dense and less permeable to solvents, such as water or petroleum, used in remedial preservative treatments. Additionally, denser heartwood also admits less oxygen, which most decay mechanisms need. Rate of growth also influences the durability of heartwood because, in general, slow-growth wood is more dense and has a higher toxin content than fast-growth wood.[13]

Some naturally durable woods used in North America include the redwood (*Sequoia menziesii*), southern cypress (*Taxodium distichum*), western red cedar (*Thuja plicata*), eastern red cedar, and mahogany (*Swietenia macrophylla*), though even trees within the same genus will show variation in durability. For example, red oak (*Quercus* spp.) is not durable, while white oak (also *Quercus* spp.) is, chiefly due to its decreased porosity. It is important to note that if the sapwood of these species is used in construction, the wood will not be durable. Only the heartwood of naturally durable species has any decay resistance.[14]

Characteristics of the Eastern-Red-Cedar Posts

The French Colonial builders of posts-in-ground houses used many different kinds of wood for the vertical posts in the ground, including white oak (*Quercus alba*), eastern red cedar, mulberry, and further south, cypress.[15] Because white oak is not particularly decay resistant, posts-in-ground houses built of this wood have long since vanished. Mulberry was perhaps slightly less perishable; local accounts from the eighteenth century indicate that builders expected this wood to last approximately thirty years in the ground.[16] Today, only eastern-red-cedar posts have survived, proving that the decay resistance of their heartwood can be measured in centuries. Eastern red cedar is discussed in more detail because it is the predominant wood in surviving posts-in-ground houses.

Before Europeans came to North America, entire forests of eastern red cedar trees covered large sections of the Eastern United States. These trees often grew to a height of eighty to ninety feet, with trunks three feet in diameter. The French who settled the Mississippi valley named the tree *baton rouge*, which means "red stick." Most of these forests have since been cut down. Today most eastern red cedar trees are confined to submarginal lands with poor soils, resulting in slow growth and short trees.[17]

The heartwood of eastern red cedar is dark, odiferous, and remarkably durable. It shrinks very little when dried and does not vary appreciably in dimension with changes in humidity. The wood is moderately hard and easy to work, with a straight grain interrupted by frequent knots.[18] Primarily, its decay resistance is due to deposited toxins and the very small pore size of its heartwood. However, the small pore size also inhibits the penetration of water and solvents such as petroleum, making remedial preservation treatments difficult to administer.[19] Thus it is reasonable to expect that even when eastern red cedar is in direct contact with the ground, its heartwood will not necessarily be able to absorb moisture from the soil. This lack of moisture in the heartwood, coupled with its toxicity, effectively wards off both fungal and insect attack for extremely long periods of time.

When a posts-in-ground house was constructed, the bottoms of the vertical posts placed in the soil were debarked and left rounded, and the above-ground portions were squared off.[20] The top portion needed to be square to conform to the dimensions of the wall and to allow *bousillage* or *pierrotage* to be added to the interstices between the posts. The process of squaring off the post improves decay resistance through

Fig. 3. Detail of fungal decay in an eastern-red-cedar post more than two hundred years old that has been removed from the ground.

the removal of less durable sapwood and the retention of more durable heartwood. The relatively unaltered, round portion of the post would be subject to more decay because it retains a higher percentage of less durable sapwood. In addition, the rounded portion of the post is in direct soil contact, as opposed to the squared-off portion. In the houses studied, the rounded lower portions of the posts exhibit a substantial loss of sapwood through decay (Fig. 3).

Therefore, it would be expected that in extant posts-in-ground houses made of vertical eastern-red-cedar posts, the squared-off, above-ground portion would be relatively free of decay if kept dry and free from insect attack, while the rounded below-ground portion would show significant decay in the outer several inches of wood, temporarily slowing at the point where the heartwood begins. Decay should be most prevalent at grade. In addition, any rounded portion of the cedar post left above ground may show some signs of decay. Indeed, when examining a posts-in-ground house, such as the Amoureux House in Ste. Genevieve, this is exactly what is found. Upon exhumation, however, one post was found to have become hollow at the bottom, a result of significant heartwood decay (Figs. 4 and 5). It is important to note that upon examination, all eastern-red-cedar posts that are still in the ground show signs of decay. Posts that were protected by a *galerie* tend to show the least amount of decay.

Historically, eastern red cedar has always been sought out as a wood that performs well in direct contact with soil:

Fig. 4. Decayed, hollowed-out lower portion of a nineteenth-century, eastern-red-cedar post from the *galerie* of the Green Tree Tavern, Ste. Genevieve, Missouri.

Fig. 5. Profile of a decayed eastern-red-cedar post.

the original French Colonial builders knew this. Most information on the service life of eastern-red-cedar posts is anecdotal. There are accounts of eastern-red-cedar fence posts lasting thirty or more years in the field. More research needs to be done on the life expectancy of eastern-red-cedar posts of various diameters in various types of soils and climates.

No wood, regardless of its durability, will be able to escape decay indefinitely. Eventually, all of the heartwood will also decay, leaving the posts sitting directly on top of the ground and severely destabilizing the structure. Unfortunately, without further tests and analysis, it is difficult to estimate how much time is left for these rare buildings.

Intervention Philosophy

Unlike construction with a masonry foundation, a posts-in-ground house cannot be stabilized just by ensuring that its existing weather envelope is functional. Its cedar posts have been in direct contact with moist soil for more than two hundred years, and it is unlikely that the posts would be able to endure another two hundred.

An ideal solution would be to stabilize the wood in the posts and keep them in situ. If such a treatment is not viable, then the possibility of a more radical intervention must be considered. Therefore the question becomes one of the degree of intervention required.

Chemical Agents for Preserving Eastern-Red-Cedar Posts

A plethora of wood preservatives are on the international market, but only three — copper naphthenate, zinc naphthenate, and borates — are feasible for remedial treatment of wood in the United States. Other wood preservatives cannot be used in the United States legally or have a toxicity level that is unacceptable. Unfortunately these three preservatives possess characteristics that make them less than suitable for the eastern-red-cedar posts found in posts-in-ground construction. They may lack the ability to control either fungi or insects, not work well with wood in direct contact with soil, change the appearance of the wood, or lack the permanence, fixation, or diffusion necessary to protect the posts.

Because the heartwood of eastern red cedar is impermeable to polar and nonpolar solvents, the preservative must be applied to the outside of the pole in order to be effective. Any application of a preservative to the heartwood of a post would not be able to diffuse to the exterior of the post where the most protection is needed.

Copper naphthenate. Copper naphthenate is a reasonably good fungicide, although some fungi are resistant to copper. In addition, copper naphthenate has little or no ability to control insects. Lastly, any preservative with copper in it will change the appearance of wood and is an undesirable characteristic in preserving historic integrity.

Zinc naphthenate. Zinc naphthenate may be a better choice than copper naphthenate, as it does not stain wood, but it is not as effective an insecticide or fungicide as other preservatives. Additionally, zinc naphthenate, like copper naphthenate, is oil borne, which will impart a certain degree of water-repellency to the wood that will work synergistically with the preservative. However, other wood preservatives offer stronger insecticidal and fungicidal action.

Borates. Were it not for the fact that borates are very water soluble, they would have nearly perfect characteristics for preserving posts in posts-in-ground construction. In conditions where the post stays relatively dry, however, borates may be fairly effective at controlling decay and insect damage. One of the most common remedial treatments consists of placing borate rods in holes pre-drilled into the center of the wood post, although for any application of borates to be effective, the chemical must be able to diffuse to the outside surface of the post, where active decay is more likely to take place. Thus, a secondary application to the surface of the post is required.

Water repellents. Water repellents include paint, varnish, waxes, resins, silicones, and polymers. Polymers may offer the best suitability for wood that is in direct contact with the ground. Vapor permeability would be an important characteristic in order to prevent the retention of water in the wood. Most water repellents are designed to shed water (such as rain) and work best when exposed to the air. However, some progress is being made on water-based emulsion repellents, which may offer increased protection.[21] Tests would need to be done in order to determine the efficacy of a water-repellent treatment for subterranean wood.

Wood stabilizers. Wood can be impregnated with large amounts of polymers in conjunction with other chemicals in order to stabilize the wood that has decayed or to prevent decay by repelling water. One system for stabilization involves impregnating the wood with resins made from phenolic compounds and polymers such as styrene or polyester, effectively blocking moisture. The wood can also be treated with polyethylene glycol, which permeates the entire wood structure. Then, the wood is exposed to isocyanate vapor, resulting in a chemical reaction that creates polyurethane resin.[22] Much research is being conducted on the usefulness of polymer treatments (such as vinyl polymers) to prevent the migration of water-soluble preservatives in wet conditions, with borate preservatives in particular.[23] Epoxies would be a poor choice for in situ repair of wood because of the propensity of epoxies to trap water at the wood-epoxy interface.

Archeologists use polymer-based wood stabilizers in order to preserve wood that has been underwater or in moist anaerobic conditions.[24] This method could be employed in order to preserve the posts in posts-in-ground houses, although little research has been done on the long-term consequences of introducing polymers into wood. Many polymers undergo destructive changes over time, releasing volatile chemicals that could cause unintended changes to the historical integrity of wood.

Insecticides. In the Mississippi valley, termites are the principal destroyer of wood. In certain areas of this region, the Formosan termite is found in place of, or beside, the native termite species. Formosan termites are far more destructive than native species and establish their colonies above ground. Native termites usually have subterranean colonies and prefer wood that has already been damaged by fungal attack.[25] Insecticides typically are applied by "poisoning" the soil around the foundation of a house or by applying a barrier consisting of the insecticide around the foundation or areas of entry into a house.[26]

In posts-in-ground houses it is especially important to have some kind of termiticide barrier at grade, as the cedar posts provide the termites with access to their preferred woods, such as oak, which was often used for flooring and roof framing.

If conditions allow, metal shields that prevent termites from gaining access to wood can sometimes be effective. These shields are usually placed at the foundation line at the interface between the masonry and the wood sill. However, as posts-in-ground houses lack such a foundation, it is unlikely that metal shields would be effective.[27]

Most insecticides are quite toxic to humans and animals. They tend to have far-reaching and unintended consequences, affecting nontarget species and accumulating in the food chain. For these reasons it is important to choose an insecticide that is effective against termites and other wood-destroying insects but mitigates harmful consequences to desirable, nontarget species. For instance, cyclodienes, such as chlordane, heptachlor, dieldrin, aldrin, and endrin were once extensively used for termite control until their use was banned by the EPA in the late 1980s. These insecticides are very toxic and accumulate in the food chain.[28]

Lindane, or gamma hexachlorocyclohexane (lindane gammaexane), is most often used as a contact insecticide, usually for remedial treatments. Lindane will persist for only one to two years, which is considered limited.[29] It is classified by the EPA as a moderately toxic compound for mammals and is extremely toxic for aquatic life.

Organophosphates used as insecticides include phenthoate, fenitrothion, bromophos, fenchlorphos, and malathion. Malathion is rarely used because of its persistent and unpleasant odor. Fenitrothion and phenthoate are the most commonly used insecticides from this category of chemicals because they break down fairly quickly in the environment and have relatively low mammalian toxicity.[30]

Pyrethroids are significantly less toxic to mammals than any of the other insecticides listed above. Originally these compounds were derived from the pyrethrum daisy, but they are now made synthetically. Permethrin is the most common type of pyrethroid, primarily because of its very low toxicity to mammals. The chief problem with pyrethroids, however, is that they are not particularly persistent on wood.[31] Assuming that a regular application can be applied every one to two years, pyrethroids are the best choice for insect control because of their low toxicity and lack of environmental damage potential.

A Long-Term Solution

Wood preservatives and insecticides alone cannot be considered a long-term preservation solution for posts-in-ground houses. For these buildings to survive into the next century, a solution must be found that will prevent the wood of the posts from contacting soil. This kind of protection has traditionally been achieved with a masonry foundation. Therefore, the introduction of a foundation or a system that performs a foundation-like function must be considered.

Adding a Foundation and Mitigating Changes

The posts in posts-in-ground construction must be kept dry to forestall their decay. A more drastic, but perhaps the most effective, means of accomplishing this requirement is to add a masonry foundation. The easiest way to do so would be to raise the house with jacks, cut the posts off near the floor joists, excavate, and then pour a concrete foundation. Such an intervention, however, is unacceptable as it would have a substantial negative impact on the fabric of the house and its raison d'etre. Therefore, any intervention must preserve the main feature that gives a posts-in-ground house its significance: the posts in the ground.

The "bucket" isolation method. While not a foundation in the strictest sense, this method offers primary foundation-like functions such as keeping the posts dry and adding structural support. In order to keep the posts dry and isolated from soil, plastic bucket-shaped containers approximately 12 to 14 inches in diameter and 3 feet deep would be placed in a cylindrical section of soil excavated from around each post (Fig. 6). The bucket would then be filled with coarse sand or gravel to facilitate drainage. The bottom of the bucket should have a hole that connects directly

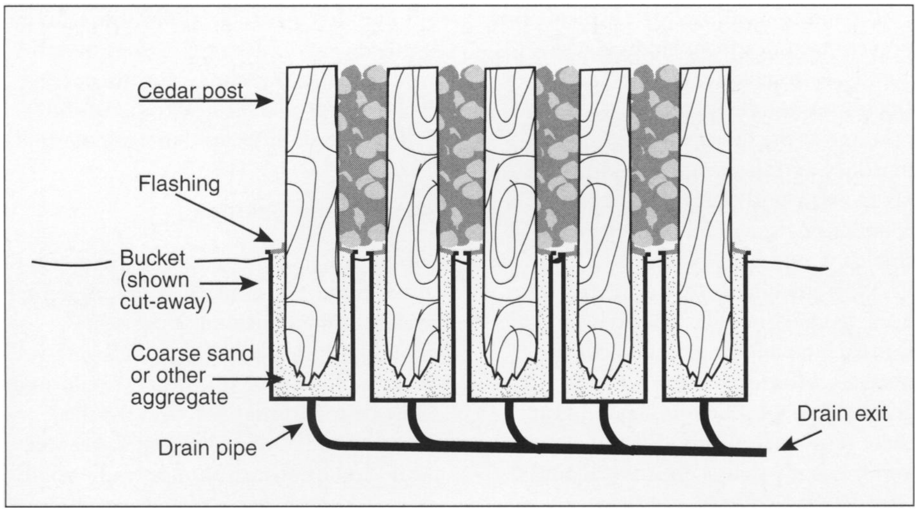

Fig. 6. "Bucket" isolation.

with a drainpipe that is connected to a common drain system. Thus, if any water gets into the bucket, it would immediately flow to the bottom and drain away. The top of the bucket should project about an inch or so above the level of the soil, and flashing of some sort should be installed to prevent water from entering the top of the bucket.

This method is a relatively inexpensive way to keep the posts permanently dry while resulting in minimal changes to the visual appearance of the house. In addition, the fabric of the building is essentially unaltered.

The partial-foundation and structural-support method. Using the bucket-isolation method would keep the posts dry while still giving the appearance that they are in direct contact with the ground. This method does not provide the stability of a masonry foundation, however. To add a traditional foundation without having to remove a significant portion of each post, the posts might be attached to a steel structural-support system and partial concrete foundation. The chief advantage of this system is that it allows the visual inspection of the bottom of the posts on a regular basis, from inside the cellar, while increasing the structural integrity of the building. From the outside, the only visual change would be the addition of flashing near the ground. The appearance of the posts inside the cellar would change dramatically: in effect, they would look like they were hanging suspended in the air (Fig. 7). In some of the posts-in-ground houses, such as the Amoureux House, the cellar is an interpreted space, and such a large change may be unacceptable.

Before the installation of a new foundation would begin, the entire house would have to be raised and braced. Before the new concrete foundation is poured, approximately a foot away from the posts-in-ground wall, soil would be removed around its base. The foundation would extend approximately 5 to 8 feet into the ground, just enough to allow the bottom of the post to be completely exposed and to have several feet of clearance beneath it. Then, a partial concrete floor would be poured from the foundation to approximately one foot inside of the building.

There are two ways of supporting the posts using this method. One involves "hanging" the cedar posts on a vertical I-beam embedded into the concrete floor (see Fig. 7). The other would use a cylindrical metal post onto which each cedar post would be "spiked" (Fig. 8). Both methods involve the destruction of some of the original wood of the post. Hanging the cedar posts would create a stronger structure than spiking because the support system is more rigid and because there is a greater chance of the hanger itself being supported by sound wood. A spike through the bottom of the cedar post may have to penetrate some distance to get into sound wood.[32] The metal used in creating the support framework should be corrosion-resistant steel such as A242-grade or, preferably, A588-grade steel, in order to insure longevity and minimal maintenance.[33]

The chief disadvantage to building a partial foundation and steel structural-support system is cost. Such a project would be fairly slow because each post would have to be supported temporarily

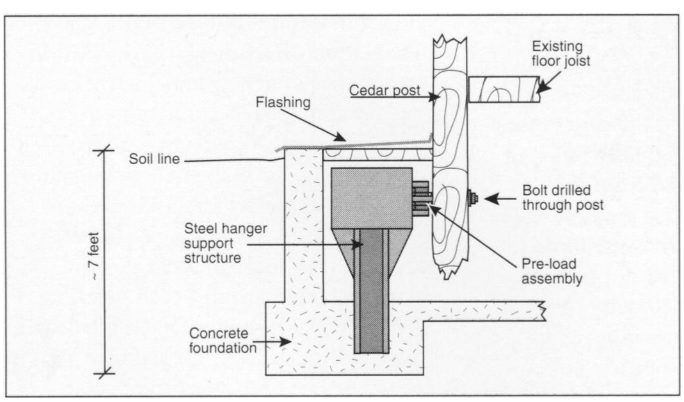

Fig. 7. Hanging method.

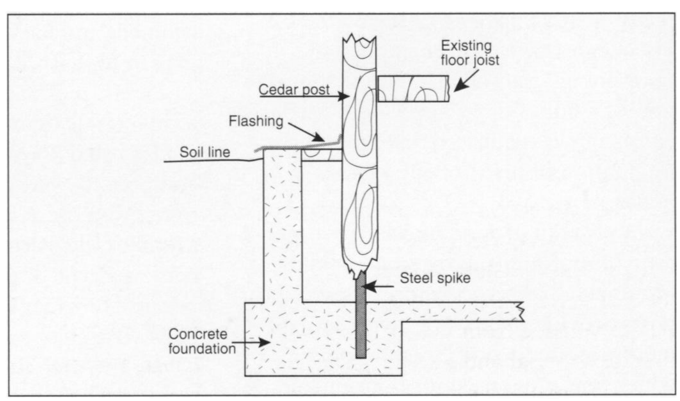

Fig. 8. Spike method.

while the foundation was built, resulting in high labor costs. The steel support systems would have to be custom fabricated. This cost might be offset by the advantages of being able to physically inspect the bottom of the posts and being able to improve the structural integrity of the house. In addition, the ability to see the bottom of the posts might offer an additional opportunity to interpret them. On the other hand, having the posts exposed to the air would certainly violate the original historic integrity of the building.

Disinfecting the posts. For the methods described above, the posts must be disinfected in order to prevent recurrent fungal growth. Having the entire post exposed would offer an excellent opportunity to apply a wood preservative as well as any needed insecticides to the entire post. Borates are the ideal wood preservative for nonleaching environments. While their suitability for posts that are directly in contact with the ground is questionable, in a totally dry environment such as would be created in a foundation intervention, borates are one of the best remedial wood preservatives available, because of their toxicity to insects and fungi and their low toxicity to most animals.

Once the entire bottom of the post is exposed, it should be immersed in a borate-water solution for two weeks to allow for maximum penetration of the borates and for the eventual conversion of sodium borate into boric acid.[34] Once the water immersion treatment is stopped, the wood must be thoroughly dried before placing the post into a bucket as described previously. However, if the partial foundation/structural addition is employed instead, the wood will eventually dry through exposure to the air.

Conclusion

Posts-in-ground construction survives to this day because French Colonial builders chose eastern red cedar for posts of some of these buildings. Posts that were made from this exceptionally durable material and also protected by *galeries* from excess water had a good chance of surviving until today. Like all wood, eastern red cedar will eventually succumb to decay, and the five remaining examples of French Colonial posts-in-ground construction will not survive indefinitely without intervention.

Wood preservatives will only delay the inevitable destruction of wood in contact with the ground. Yet-to-be-developed treatments of wood in direct contact with the ground may be able to prevent fungal and insect attack permanently while also stopping the incessant destruction of cellulose that occurs in damp conditions. However, until such a remedy exists, building some variant of a foundation appears the only way to insure the long-term preservation of these early houses.

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Acknowledgments

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Notes

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