APPLICATIONS OF TREATED POLES AND POSTS FOR HOUSE CONSTRUCTION

Donald H. Percival, Research Associate Professor of Wood Technology and Utilization, SHC-BRC

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A building system which is increasing in popularity for house construction makes use of preservative-treated wood poles as the foundation and structural framework. The system, which is an outgrowth of farm building and light construction industries, employs round poles, or in some cases, rectangularly sawn posts, embedded in the earth to serve as the supporting elements of the structure. It is especially suitable for building sites on rough or hilly terrain, and low, flat, flood plains, all of which are sites generally unadaptable to more conventional foundation systems, because maneuvering heavy equipment can be a problem. The poles satisfy two basic functions; they serve as the foundation for the house and provide the structural framework for supporting the floor members, the walls, and roof framing. In essence, the house is "hung" on the poles, as in Figure 1. It has proven to be a practical method of construction, especially on sloping topography. It has also proven to be most effective in resisting major structural damage in high-wind areas (3,7) and on sites where occasional flooding occurs.

Even though the original pole house construction began with larger, more expensive homes, the system has been used successfully for less costly homes and for low-income populations living in remote areas; in houses designed to encourage "self-help" construction, hopefully to further reduce the housing costs of a family.

There are several factors which have stimulated pole house construction. Primarily, there is a definite cost saving in both material and labor. Because the system is adaptable to rough topography, areas are now being considered which were long thought to be unsuitable for house construction. Extensive conventional foundations are not required; therefore, there is a reduction in site preparation and earth moving while the possibility of erosion is reduced. In addition, there is also wider acceptance, and growing confidence by builders, contractors, developers, and prospective homeowners in preservative-treated wood. This is due in part to the history and empirical data being accumulated on treated wood structures, and to the improvements in chemical formulations and treating processes which provide "clean", paintable-surfaced poles, obviously more desirable for house construction.

Wood Preservatives and Treating Processes

The feasibility of pole construction systems is based on the fact that the poles can be used as structural members and can be treated to allow placing them in direct contact with the soil. Untreated wood in soil contact would eventually deteriorate from the action of wood destroying organisms such as fungi and termites. Treatment processes have been developed to impregnate the poles—and other construction lumber—with chemical preservatives which poison the food supply of the wood-destroying organisms. There are a few wood species which exhibit some degree of natural durability for ground contact, but these are not generally recommended for pole construction, which is expected to last for many years.

Historical and empirical data are continually being accumulated and evaluated which add to the confidence in the durability of the treated poles. Quality-control standards for the treating industry have been developed to assure the user of the quality of the product, (6). Identifying marks are usually stamped in the pole, including perti-
nent information such as wood species, treatment processes and preservative, class of pole, and the company doing the processing.

Pressure treatment has proven to be the most effective process of impregnating the wood with preservatives. Several other processes are used, but with less satisfactory results. Soaking in open vats, under varying temperature changes, has been used for certain products. Brushing and spraying wood units with preservatives has also been used, but is not recommended for use in the soil. The durability would be far below the expected long-term requirements usually associated with house construction.

Several types of preservatives are used for the many treated wood products on the market; therefore, the user or designer should specify the treatment best suited to his particular case (1). For pole house construction, one would find it more desirable to design with poles which are relatively "clean", odor-free, and for some cases, paintable. Certain salt formulations developed specifically for ground use, pentachlorophenol in light petroleum solvents, or pentachlorophenol in volatile petroleum solvents, and others, leave the surfaces relatively "clean", paintable and odorless, making the poles more suitable for house construction.

Creosote formulations, alone or in combination with other preservatives, are used for treating utility poles, railroad crossties, bridge members, mine timbers, sea walls, and others, but such treatments are generally not recommended for house poles because the surface remains oily, the poles retain an odor for lengthy periods of time, and the treatment prevents satisfactory painting or staining.

Because of a shifting demand for treated sawn posts, research programs have been planned to study the comparative durability of the "round" poles vs. the sawn posts, (18). Sapwood is more effectively treated than heartwood, and in the sawing process, a good portion of the sapwood is removed. Treating the heartwood of many species is usually not as thorough; therefore, the wood species and preservative retention characteristics should be carefully considered when choosing between round or sawn units.

Poles have also been used which have been squared above the grade line, on either one or two sides, to provide flat surfaces for attaching the subsequent support beams and framing members.

**STRUCTURAL DESIGN**

The design of a pole house entails nothing of an unusual nature, (14). A good approach would be to determine the forces to which the structure might be subjected, starting from the roof and working down to the soil by transferring the forces through the various components and connections to the poles. Consulting with local code or regulatory authorities on design loads and requirements is advisable. Special design considerations may be necessary for a particular locality, especially for pole house construction. In any event, the framework and structural components of the house can be designed by standard procedures to determine the stresses, deflections, and member size and spacing. Knowing the forces, the designer can turn to the design methods which can be developed for choosing the type, size, and spacing of the poles for the particular soil type. Tables have been published which list types, stresses, and species for various classes of poles, soil types, bearing characteristics, depth of embedment, and suggested procedures for "fastening" the pole to the earth, (6).

**CONSTRUCTION**

After the house has been designed, the poles and other structural members and finish materials have been chosen, locating and digging the holes becomes the primary operation. The corner locations are usually determined first with the intermediate locations following. Digging the holes becomes a matter of convenience and is usually done by hand digging or machine drilling. In the more extreme sloping sites, care should be taken to prevent disturbing the ground cover and top soil. Erosion can develop quickly where careless operations occur. An advantage of this construction concept stems from the ease with which the structure can be built while leaving the soil relatively undisturbed, whereas more common foundation systems require more extensive excavation.

After the design loads have been calculated, the pole size and soil characteristics determined, the system of pole embedment should be chosen (Figure 2). In certain soils, the poles are placed and the hole backfilled with the original soil. Backfilling with sand or gravel, which is relatively inexpensive, is also used when embedment with
Dapped poles with tie-plates and barn nails

Floor and roof beams attached to poles with bolts

Spiked grid and bolt arrangement for attaching floor and roof beams, (16)

Figure 1. Pole construction has been used successfully in reducing the cost of housing. It is especially adaptable to steep hillsides and rough terrain.

Figure 2. Pole placement - Soil type and topography will generally dictate the method of pole embedment.

Backfill with earth, sand, gravel or soil-cement

Concrete pad 8" -12" thick

Concrete fill

Figure 3. Three methods of attaching beams to the poles.
the original soil will not provide adequate sup-
port. Backfilling the holes with soil-cement has
also proven to be an economical method. This
would be especially important for construction in
underdeveloped countries and localities where self-
help methods would be convenient. Soil-cement
is a mixture of soil, sifted or screened to re-
move organic matter and large particles, with
cement at a ratio of about 5:1. However, as the
design loads of the structure increase the forces
on the soil, concrete pads must be placed under
the poles to distribute the loads over a larger
bearing area. These pads are usually eight to
diameter of the hole. They can be precast in forms and later placed
in the holes or formed by placing fresh concrete
in the holes and allowing it to cure before the
poles are placed. For certain soil types or for
shallow depth holes, concrete is used to
backfill around the poles. During the backfilling
operation the poles are squared and positioned
as closely as possible to their final location. Often,
when concrete backfill is to be used, much of the
subsequent framing is attached, and the structure
squared and plumbed before the concrete is placed.

SUPPORT BEAMS

Sawn beams are attached to the poles for sup-
porting the floor joists and the wall framing
(Figure 4). For house designs using short posts,
or poles that are cut off at the floor line, the
beams must also be designed to support portions
of the roof loads. In standard pole construction,
the poles are continuous up to the roof line,
where roof beams are attached for supporting
the roof framing.

Good design practice usually dictates that the
support beams be attached in pairs, one on each
side of the pole. The floor loads put the connec-
tors in double shear, providing a more economi-
cal and stable support system. The beams are
usually cantilevered at their ends and are there-
fore exposed to weather. In many designs the
sides of the beams are also exposed, adding to
the likelihood of checking and/or splitting. For
such designs, the beams should be material that
also has been preservative-treated.

At least three attachment systems are used to
connect the floor beams, where the loads
are usually greater, while nailing is often used
for connecting the roof beams in continuous pole
systems. For bolt connections, the beams are
attached to the poles by long, high-strength bolts.
Washers and nuts are used to clamp the assembly
together. It has proven to be more practical to
design joints using two bolts at each support con-
tact. Standard design procedures are recommend-
ed for calculating the stress of the materials to de-
terminate the type, number, and size of bolts, (12).
The spiked grid connectors, (16), are designed
to give added strength to the assembly. They
are literally squeezed between each beam and
the pole. A high-strength threaded rod and
wrench arrangement is used to draw up the mem-
bers, then the rod is removed and bolts, washers,
and nuts secure the connection. The nailing sys-
tem is often used for supporting the roof beams
where the poles have been squared or dapped
(flattened).

Final Framing

The floor and ceiling can be constructed with
standard joists (Figure 4). Larger prefabricated
floor and roof panels are also used but can be
cumbersome to handle where heavy equipment
is not available. The use of most prefabricated
components can reduce the amount of "field"
labor required but more or less defeats the
purpose of "self-help" construction. Prefabri-
cated construction would also be highly unlikely
in many underdeveloped countries and in remote
areas.

The size of the joists can be determined by re-
fering to standard joist span-tables which have
been developed for many structural species to
give lengths and spacings for the various spans.
Local code regulations may also specify joist
size. The joists are usually positioned on the
top edge of the floor beams and can be merely
toennailed to the beams; however, in areas where
uplift and horizontal wind forces are high, spec-
ial joist connectors are recommended, (9). These
are metal units with pre-punched holes and spec-
ial nails designed to tie the framework together
more securely, as shown in Figure 4.

The subfloor or work deck is usually applied
next. The most common subfloor materials
would be 1 x 6 or 1 x 8-inch boards, applied
diagonally, or plywood applied perpendicular,
to the joists, both giving good resistance to ex-
ternal racking forces. Subsequent flooring mate-
rials can be applied to the subfloor after the general rough construction work has been finished. The choice of an underlayment material is dependent upon the finish flooring to be used.

Prefabricated floor and roof panels have been used in pole house construction, and may contain the insulation, subfloor, and finish flooring, but transportation to and storage at remote sites may prove to be impractical, in addition to losing some of the benefits of self-help.

The walls of the structure can be conventional wood studs and plates or prefabricated wall panels. For less complicated dimensioning and finishing problems, the walls should be designed for placement inside the pole-line. This will leave the poles exposed (Figure 1). Some designs have been developed, however, with the poles as part of the wall or exposed inside the house. The variation in the pole dimensions make this approach somewhat more cumbersome. Finishing and trim work becomes quite time-consuming and more costly. The siding or exterior cladding may be any of a number of materials, and by using a sheet or panel material to serve both as the sheathing and the cladding, an economy in construction costs can be realized. The joints at the edges of the panels are usually caulked and covered with wood batten strips.

**Roof Framing**

There are generally three types of roof construction used for pole houses; post and beam, joist and rafter, and roof trusses. The post and beam method requires a center line of longer poles to support beams at the peak of the roof. The upper ends of the rafters are tied to these beams and the lower ends supported by the exterior wall beams. Metal framing connectors are recommended for fastening the rafters to the support beams. A variation of post and beam construction would be larger dimension rafter members, more widely spaced, with purlins spanning between rafters, to which the roof sheathing is attached.

The joists are fastened to the roof beams at the top of the wall, to form the ceiling of the house and to act as tension members in the roof system. The rafters are nailed to the joists at the lower end and to a ridge board at the peak.

The roof truss, commonly accepted in conventional house construction, is easily adapted to pole housing, as in Figure 4, and the center line of full-length poles is not required because of the clear span characteristics of truss design. The trusses are supported at each end by the roof beams and good practice also dictates that metal framing connectors be used as tie-downs and to increase the resistance to wind uplift forces. Most trusses are designed to be spaced 24 inches on center and provide convenient nailing surfaces for interior finish materials, (19). The majority of truss designs require shop assembly; however, designs have been developed which can be built at the house site. The roof sheathing may consist of boards or plywood and, in either case, the roofing can be attached directly to the sheathing.

Round poles are more common in pole house construction, although rectangular sawn poles and shorter posts are entering the market. This is due in part to the more critical requirements for dimensional tolerances and the refinement in finishing materials. A more recent development using shorter sawn posts has been introduced as a means of providing the foundation system for sectionalized houses, mobile homes, and certain types of moveable military housing. The posts are machine driven to a specified height and spacing, an outgrowth of a recent development of driving highway guardrail posts, (10). The American Wood Preservers Institute is currently continuing its investigation of this foundation system for use in varying areas and soil types, (2).

The expanding use of structural design principles to wood structures, the simplicity in the design of pole houses to rough terrain, the confidence in preservative-treated wood, improvement in connection systems and material-handling techniques, and the tremendous demand for housing throughout the world has brought to focus the economy and potential of pole house construction.
Figure 4. Continuous pole and truss construction with platform framing.

2. Wood Preserving. American Wood Preservers Institute, 1651 Old Meadow Road, McLean Virginia 21101.


6. FHA Pole House Construction, American Wood Preservers Institute, 1651 Old Meadow Road, McLean, Virginia 21101.


9. How to Build Storm Resistant Structures, Southern Forest Products Association, P.O. Box 52468, New Orleans, Louisiana.


11. Nail-glued Roof Trusses from Low-Grade Hardwood Lumber, (for use on a pole building) D. H. Percival, Station Bulletin 649, 1957. Agriculture Experiment Station, Purdue University, Lafayette, Indiana.


