Roundwood Kiosks for 2002 Winter Olympics in Salt Lake City

(by Mark Knaebe January 2002)

Throughout the West, our National Forests face an increased risk of catastrophic wildfire because of an overabundance of dense, overstocked forest stands. This situation resulted from more than 50 years of fire exclusion. To restore the open, park-like settings that existed in pre-settlement times, these stands need thinning. Such restoration is expensive, but if economic uses can be found for this thinned, small-diameter and low-value material, some costs could be offset.

To demonstrate the concept of using small-diameter, roundwood, the USDA Forest Service, Forest Products Laboratory (FPL), worked with several national forests and rural communities to build two roundwood demonstration structures to be displayed as informational kiosks at the 2002 Winter Olympic Games in Salt Lake City.

Background Information

One of the largest incentives to consider in the use of small-diameter roundwood for structures is that many small trees that would have burned while still juvenile in a forest fire are now set to contribute as ladder fuels to take the fire to the canopy (tops of large trees). Large trees in a forest can frequently withstand ground fires when there are not these intermediate-sized trees to take a ground fire to catastrophic proportions. Forest policy in the past was to maintain an active fire suppression policy. Unfortunately, these policies have created a worse situation today. To improve forest health, we need to selectively harvest the small trees.

A different situation related to fires has also produced a need to harvest small-diameter roundwood. In the early 1900s, many forests catastrophically burned. Equal-aged, overstocked stands of low vigor and high mortality resulted, increasing the risk of insects, disease, and wildfire. In these cases, the trees simply need to be thinned.

The cost of harvesting varies, depending on terrain, roads, and other factors, but to generalize, it costs about $70/ton to harvest these small-diameter trees. They are green, meaning alive, and approximately twice their dried weight. Chipped, the value of these small trees for paper is about $35/ton, and for firewood, they are worth about $20/ton. Poles and posts have a higher value (>$200/ton), and in the past, have been the only cost-effective use for this wood. Lumber cut from small trees can have a higher value; however, in addition to the great amount of waste, boards may contain juvenile wood, which is the part of the tree that grows in the first years of its life. Juvenile wood has a cell structure arranged differently than other wood, resulting in much greater shrinkage. A board having juvenile wood on one side is guaranteed to warp in that direction.

With minimal processing (debarking and drying), small wood can have considerable value as engineered components. Small-diameter trees have long been used for constructing dwellings. Before the advent of advanced stonework to construct the roof for structures, the strength for all roofs came from timbers, and the walls were usually made of stone and mud.

With the advent of connectors, engineered systems, such as wood trusses, became feasible. A truss can carry many times the load of a rafter. Another option is to start with the timber frame and create a system that does not require an artisan to build. This appeals to those interested in a rustic and less-expensive style of building.

The FPL has been testing some connectors that would facilitate quick construction. One is called a powder-driven mortised plate where slots are cut in two members to be joined, and a plate of steel is placed in the slots. Nails are shot, using gunpowder, through the logs and plate, resulting in a strong joint that is completed without the machinery or artisanship required in timber framing. Other examples of connectors are dowel-nut, bolted mortised plate, coarse threaded screws, and wooden pegs.

Small-diameter roundwood has several advantages over timber framing—primarily efficient use (less waste) and strength. If you cut the largest square member out of round log, you would end up with less than one-third the strength of the original log. The largest square cut from a “cylinder” would be a third as strong, but a log has a taper, meaning you would be wasting more at the big end. Finally, the wood that you cut off on the outside is the best wood of the log, so when you include the taper and the quality of the wood in making a square member, you end up with far less than one-third the strength.

There may be times when you want a flat surface on the log to make a connection, such as in a roof panel. Removing a small amount of material to create a flat surface is usually all that is needed. Pole and post manufacturers turn logs to the largest straight round piece. This removes some of the good wood on the outside of a log but hopefully not to the extent of attempting to make a square. Turning does create a flat surface along the length for things such as roof panels, so turning can be accepted as a viable alternative to using rough logs.

Another benefit of building structures using small-diameter roundwood is that small operations in depressed communities have the potential to provide employment. The investment in machinery for a business does not necessarily have to be that large. The only machinery that would be required is possibly a small sawmill (moving band saw) and a chain saw and drill. At this point, all connectors must be custom made. For many structures, cutting plate steel to size may be all that is necessary.

Two Kiosks Were Built

Although six informational kiosks for the 2002 Winter Olympics were initially planned, only two were built to demonstrate the use of roundwood. Each kiosk is approximately 25 ft in diameter; round timbers used for the roof trusses are 5 and 6 inches in diameter. Vertical supports (columns) are about 6 inches. The kiosks are enclosed and heated. One kiosk was made from turned logs of lodgepole pine (hereafter referred to as Montana), and the other was made of rough logs of subalpine fir (hereafter referred to as Oregon). Engineering plans permitted the use of powder-driven mortised plate connections. In the future, plans for those wishing to build similar structures will have multiple options for some components.

For example, on the structure of turned logs, the points of contact between logs were coped. Here, all the material is taken from one log.

Coped

Flat Sawn

Miter

On the second kiosk, flats were sawn on one log and the other log was cut on a diagonal. An option is to miter both connecting members, which might make the most sense for those wishing to set up a production facility. Note that the miter (from an earlier structure built at the FPL) shown (see figure) includes a “key,” which adds shear resistance to the connection.

Foundation

Both kiosks were set on temporary foundations because the kiosks were to be relocated later. One kiosk was placed on piers, the other had a complete ring of 6 by 6 timbers resting on a gravel base. Unless there is a need to move the kiosk, permanent foundations should be used.

Floor and Roof

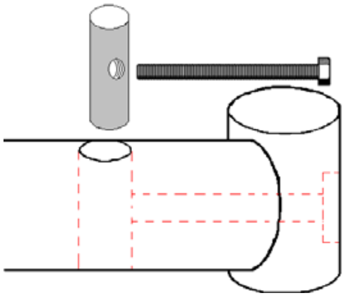
The floor and roof were made of structural insulated panels (SIPs). SIPs are made from polystyrene sandwiched between two layers of particleboard (e.g., oriented strand board (OSB)). This simplified the assembly of the structure; however, 3- and 4-in. timbers could also have been used for floor joist and roof purlins to reduce material costs. The walls are traditional 2 by 4s with plywood on each side. Batons are applied to simulate baton on board siding. Where the structure contacts the ground, either treated lumber or cedar lumber was used. Cedar shakes were shingled to the roof.

The Montana kiosk was built on 8 piers (three, 18 in. treated 6 by 6’s). Anchoring to the piers was not done until the SIP floor was in the final position. The Oregon kiosk was built on treated 6 by 6 timbers placed in an octagon underneath the entire perimeter. Both kiosks had a 4-ft square of treated 6 by 6 timbers at the center of the kiosk. There is a metal connector at each corner of the octagon. It is made up of two steel plates, 4-in. angle iron and two threaded bolts. One connection was to the base, the second to the corner column, and the third to an upside-down T-beam reaching to the center square. The T-beam was made of a 2 by 8 bolted to the bottom of a 3-1/2 by 10-in. laminated veneer lumber (LVL) beam. The bottom of the SIPs rested on the 2 by 8. The top skin of the SIP rested on the top of the LVL.

Another connector was located at the top of each column that connects a ring of timbers (plate logs) and the base of each truss. Because bolts are easy to use, the trusses were bolted together. After setting up with a gunpowder-driven nail gun, the process of using steel plates could be as simple as using bolts.

Load

The roof of the kiosk can carry more than 100 lb/ft^2 snow load—that is almost 20 feet of fresh snow or 2 feet of solid ice. The use of 5/8-in. bolts (in contrast to the powder-driven nails) made some of the connections easy to disassemble so that these structures could be taken apart and moved to another location.



Dowel Nut

Where the trusses connect to the center hub, a dowel nut connector was used. A typical dowel nut is made up of a 4-in.-long, 1-1/8-in.-diameter solid steel rod (dowel) that has a 5/8-in. threaded hole tapped in it. Two holes are drilled in the end of the truss, a large one from the side to slide in the dowel and a smaller long hole that goes up the center of the timber where a threaded rod can connect to the dowel.

Also, small screws (e.g., ¼ diameter) were used for the timber connectors. These small screws can be used where there are no tension stresses (the center hub). (see Timberlok figure).

The top column connector was made of several plates of steel (knives) welded together. One knife was inserted into the top of the column, another into the base of the roof truss, and two were inserted into the plate logs. The plate log has a high degree of tension and holds the roof trusses in place.

To provide racking resistance, the columns need lateral support. In a previous kiosk structure built at the FPL, the columns were buried deep in the soil (cantilevered) to provide this resistance. The Montana and Oregon structures required walls to provide this resistance.

A summer option would be to remove the walls and brace between the columns and the plate log.

For the Montana kiosk, the columns were temporarily braced, the trusses and roof were installed, then the walls were installed. There was some difficulty in getting the bracing perfect so that wall installation led to some alignment problems. For the second structure, three noncontiguous wall sections were installed before the roof SIPs were installed.

Snags/Cautions

Labeling—Usually when a log home manufacturer builds a structure (at their site), the one who labels the pieces is also present at the final assembly. We did not have this privilege. Each piece must be clearly labeled and excessive labeling is recommended. It must be obvious to the erector that the pieces were labeled in a clockwise or counter-clockwise direction, and this labeling should carry through from bottom to top.

Foundation—Each system (piers versus complete ring) had its advantages. The piers (Montana) only needed to be within an inch of the correct location; the floor SIPs dictated the final location of the columns. The connector was bolted to the pier after the column was in place. The location was not exactly correct, resulting in some columns slightly out of plumb. This system was easy to do, but not as dimensionally accurate. The floor was later carpeted and the ¼-inch gaps where floor SIPs met were not a problem.

The complete ring (Oregon) was placed on a gravel bed (necessary for height adjustments). A strap was placed around the perimeter of the ring to hold it in place, then adjusted with diagonal ropes and a large hammer to make a perfect octagon. This was more work, but the locations for the columns were very accurate. A laser level was used to level each corner and the center footing. Gravel was rammed under low spots, then the ring was bolted together. The Oregon kiosk had tongue and groove (T&G) flooring attached to the SIPs, and it was necessary to rotate the center square a slight amount to line up the flooring. Fortunately, the LVL beams had not been bolted to the center square on this kiosk so that it could be winched into the correct position from the top. Jumping on the SIPs while straps were pulled, worked well. The final flooring pieces were screwed into place.

For both kiosks, the exterior lag screws to the piers for the corner connectors (foundation/LVL-beam/column) interfered with installing the columns, so these screws were not installed. Instead, smaller screws were installed after the columns were in place.

Lining up the holes for the fastener at the top of the columns was difficult at times. Several correctly sized locators (drift pins) are a must. This was especially true for the plate log. The slot in this log needs to be cut from top to bottom (and any attachment such as a 2 by 4 that might be used to fasten the walls) so that the log can be lowered onto the connector.

Cupola—The cupola (dome) should be placed on scaffolding about an inch below its final height. It will lift off the scaffolding when the bolts of the last truss are tightened. Each truss is slid into the column connector and loosely bolted until connected to the cupola. Only the bottom cupola dowel nuts are installed (and only finger tight) until all the trusses are in place. Then, install the top dowel nuts, tighten bottom, and tighten top. To ensure alignment, it may be best to install 3 or 4 noncontiguous wall sections before tightening the dowel nuts. When the walls are installed, they are centered at the base and attached to the base of each column. A pry bar is used to line up the top of the column (walls are perfect rectangles) before attaching the wall fasteners. Then, when the dowel nuts are tightened, everything should be in the proper place.

*Wall*s—The exterior sheathing of the walls extends 1-½ in. beyond the frame. Prior to installing, 2 by 4s are fastened to the columns. The exterior sheathing is fastened to these 2 by 4s. For the Oregon structure, the flats had been sawn on the columns for these 2 by 4s. For the Montana structure, the 2 by 4s were coped by pushing diagonally (multiple passes) over a table saw blade.

Wall Flashing—To ensure proper water shedding, install “Z” flashing from behind to beneath the wall sheathing to over the water table (the board beneath the sheathing). This can be difficult, depending on the wall design and accurate placement of the floor SIPs. The flashing needs to be installed either on the floor or wall (depending if the bottom plate is pre-attached to the floor) before installing the wall. It is also difficult to install the wall without damaging the flashing; you will need 6 people. Increasing the overhang reduces the dependence on flashing and is always a good idea except in very high wind areas where overhangs provide lift.

Dowel Nuts—Threaded rods from different manufacturers come in slightly different sizes. All nuts should easily accept all rods. The hole in the dowel should be counter sunk to aid in the rod finding it. The first few threads of the rod should be filed enough to aid starting. Great care must be made (a good jig) so that the two holes drilled in the truss meet. If the longitudinal hole is not centered on the dowel hole center, the dowel will twist (the rod hits the side of the hole in the dowel). The bottom chord meets the cupola at a 90° angle so the rod may be shorter than the top chord. If all holes are placed in the trusses so that all rods are the same length, no rods can be placed in the wrong hole. With all rods being the same length, the nut can be welded tight (making it a bolt), which also simplifies the process.

A trailer-able crane is more versatile than a forklift for lifting trusses and roof SIPs, although with the limited reach, it was necessary at times (e.g., fence nearby) to put one foot of the lift on the floor of the kiosk

Roof—The SIPS that made up the roof are fastened only to the trusses, not the plate log. The long square drive ¼-in. screws are placed about 2 in. from the hip edge of the SIPs. By placing a 2 by 4 over the hips (covering the screw heads), the rest of SIPs can be roofed. Two 1 by 8 cedar boards or shakes were going to be screwed into the 2 by 4s for simple removal; however, individual shakes were screwed instead. Felt or metal flashing is first attached to the 2 by 4s. Later, the 2 by 4s can be removed so that the SIPs can be removed. In permanent installations, screws can also be driven into the plate log, and normal hips can be installed. Even though square drive screws are far better than Phillip screws, there were still a lot of ruined screw heads.

Timberlok
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Timberloks are far more forgiving but they leave the hex head exposed, which interferes with the 2 by 4. With careful placement, a grooved 2 by 4 or two 2 by 2s (one each side) could accommodate the exposed heads. For permanent installations, the shakes could be placed over Timberloks.

One log home manufacturer solves the exposed head problem by cutting away a portion of the top skin of the panel, essentially counter sinking. This is done using a circular saw from the edge of the SIPs, removing an arc of the panel. They then use a 2” fender washer to spread the load over the thinned top skin of the panel.

Most buildings have a set pitch for the roof and hips, being longer will have a lower pitch. To simplify measuring, the pitch is determined for the truss, which in this case is the hip. Together, with the building being eight-sided, it is possible to miss-cut the SIPs in the roof.

If you would like to build a kiosk, please also read “Roundwood Kiosks: Construction and Assembly,” which is available on our website.

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