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Log Building NEWS

Building & Testing Compound Wooden Beams

By Meinrad Rohner & Robert Chambers

MEINRAD "MEIRI" ROHNER HAD SEEN FANCY OLD WOODEN BEAMS IN CENTRAL EUROPE—ON TRAIN TRESTLES AND BRIDGES—WHERE TWO TIMBERS WERE JOINED TO EACH OTHER TO MAKE ONE DEEPER, STRONGER, MEMBER: A COMPOUND WOODEN BEAM.

This September, Meiri and I taught two hands-on classes in Kuopio, Finland at the Savo Technical University. Most of the participants were log home builders in Finland, and some came from Estonia and Russia.

While Robert was teaching mitered truss construction to half of the students, Meiri and his students were building four different compound wooden beams: three were built with wooden interlocking joinery, and one used only structural screws. Halfway through the courses, the students switched, so they could help both with the beams, and with the truss.

The beams and mitered truss were all constructed to be parts of a building for a customer. All four beams had 7.2m (23' 7-1/2") span, and all were built using Scots pine (Pinus sylvestris) with 26% to 29% moisture content. The round logs had about 290mm (11-1/2") small-end diameter, and the timbers were sawn from logs of about this same size. The trees were more than 200 years old when they were cut down—not surprising, since they had been growing not that far from the Arctic Circle. It was very high quality wood.

The four styles of compound wooden beams that Meiri built during the courses can be seen in Figure A and Photo 19 (page7).

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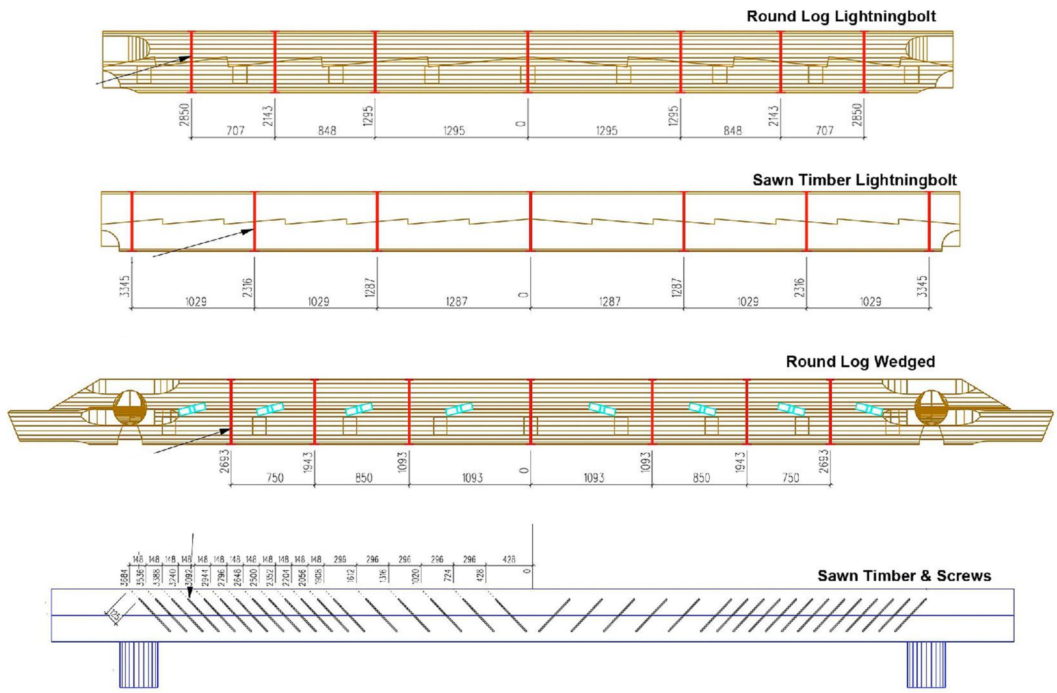

Figure A

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MISSION STATEMENT

This association is a non-profit organization comprised of log crafters and affiliated members from many countries. We are dedicated to the education of both our members and the public. Our association has a mandate to research, develop and share techniques relevant to the construction of superior handcrafted log buildings.

Meiri writes:

The sawn-timber lightning bolt is a traditional method, which was used by the central-European carpenters in early days. The wedged round log beam and the round log lightning bolt are variations of old techniques, which I figured out because I wanted to use great old ideas in round logs.

The development of these beams is not yet finished. There are things to improve, and tools / jigs could be fabricated to help. But it is very rare that we are asked to do this kind of work, and when we make these compound beams for customers (and with their deadlines) we have little time to build better jigs!

Here are descriptions of how each of the four compound beams was fabricated:

1— Sawn Timbers Connected with Engineered Screws

Sawn timbers, screwed together with a double row of Sihga GoFix XB 8mm x 400mm screws positioned as seen in the Figure A. Each timber was 170mm wide x 230mm deep (6-1/2" x 9"). The screws were installed using the manufacturer's jig to locate and shoot them in at the correct angle (Photo B).

2— Round Logs with Lightningbolt Cogs

The cogs were 70mm (2-3/4") tall. At completion, seven 16mm (5/8") diameter throughbolts and small washers at top and bottom were installed (all bolt locations are shown in Figure A).

Here's the process: set the top log of the beam over the bottom log, and scribe the long groove using a scriber that puts a scribe line on both logs. Remove the top log. Mark the top of the log below for the lengths and positions where you want to have each of the lightningbolt cogs start and end.

Use a block of wood to simulate the cog you will cut into the bottom log. The block should be nearly as wide as the diameter of the log below, and must be longer than the length of the longest cog. Set the block onto the lower log and hold it in place at a slope using wedges.

Photo B

▲ *The sawn timber beams were joined together with long screws. One man holds the guide that positions the screw and gives it the correct angle.*

Now, set a scriber to the distance equal to the height from the top edge of the block down to the long groove line on the log below (photo 1). Lock the scriber at that setting. Now, hold the scriber where you want this cog to end (where this cog 'exits' the log below), and adjust the wedges so that block of wood has the slope that will make the cog exit the log where you want this cog to end. Use the scriber, with its locked setting, to match the bottom surface of the block of wood to the scribe line on the log below (photo 2). In other words, the bottom of the block of wood will meet the scribe lines where the next cog will start.

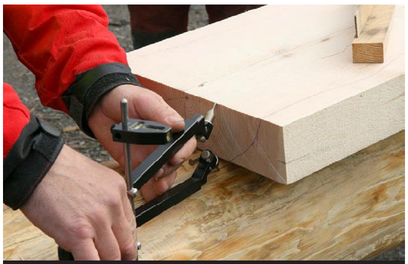

Photo 1

Photo 2

Photo 3

Repeat this process, with the scriber locked at the setting, for the long groove lines on the other side of this block / cog position. Note that the block of wood might not be (and probably won't be) level, side to side. Scribe from the bottom of the block of wood down to the log below, all around.

Move the block of wood along the log and repeat the process for the next cog. Once all the cogs have been marked onto the log below, cut them out (photo 3).

Position the upper log back in its original position above the log below. Re-set the scriber so that its scribe distance matches the long groove scribe line on the upper log with where each cog ends (we'll call this distance SC). Scribe everything you can reach (photo 4), including the part of the endgrain surface that you can reach (photo 5).

Photo 4

Photo 5

Photo 6

Photo 7

Photo 8

To scribe the parts that you weren't able to reach, put the block of wood into the cog of the lower log (photo 6). Mark a plumb line on the edge of the block of wood so you know the plumb thickness of the block—you need this amount to adjust your scribe setting. Re-set your scriber distance to the SC scribe setting minus the plumb height of the block of wood. Scribe the parts you could not reach before (photos 7 and 8). These two photos show why the block of wood must be wide—about as wide as the diameter of the log—because, where the upper surface of a cog is narrow the lower surface is wide, and where the upper surface of a cog is wide, the lower surface is narrow.

Cut the lightning bolt in the upper log, and assemble the compound beam.

3—Round Logs with Wedges

This beam was made of two round logs that were linked to each other with a total of 8 pairs of tipped wedges. This beam also got seven 16mm (5/8") diameter through bolts and small washers. When loaded, these two beams want to push away from each other, and the bolts are necessary (for more on the engineering of compound beams, see the article listed at the end). The wedges were oak, 60mm (2-3/8") deep.

Make blocks of wood that are about the width and length shown in photo 9. On top are the two oak wedges, and underneath is the block of wood we'll use for scribing.

Snap a centerline on the top of the log below. Mark the log below for the positions of all the wedges. Screw blocks to the log below in these positions. The blocks are set so they are approximately 90° to the top centerline on the log below. Little wooden wedges/shims are used to adjust the slope of each block. Position the upper log, and scribe the long groove (everything you can reach). We'll call this scribe setting "LG".

Now, one at a time, adjust the slope and side-to-side tip of each block of wood. The blocks often have to be tipped off to the side because, of course, the long groove scribe

Photo 9

Photo 10

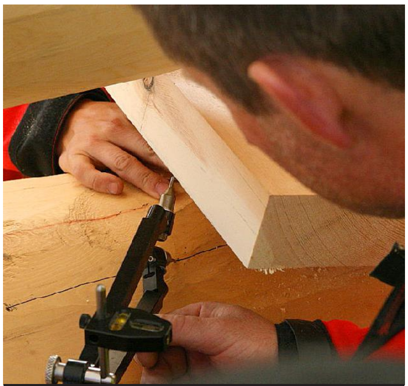

Photo 11

lines are not level side-to-side across a log (photo 10).

Set a scriber so that it has a scribe distance equal to 1/2 of the long groove scribe setting you just used. At the high end of the block of wood, hold the scriber as shown in photo 11, and have a helper adjust the wedges so that at the bottom edge of the block of wood the scriber just touches the scribe line below. Now test it for the upper edge of the block and the long-groove scribe line on the upper log. Adjust and tweak the block's position and slope, and re-check how well the block edges meet the scribe lines. When you are as happy as you can get, scribe the underside of the block (photos 12 and 13). We'll call this setting "L" for 'lower scribe setting.'

Photo 12

Photo 13

continued on page 6

Photo 14

Photo 15

Now scribe the upper surface of the block to the log above using a scribe setting that is equal to the LG setting minus L (photo 14). The scribe setting you use for the below the block (L) plus the scribe setting for the above the block surface (A) must be equal to the long groove setting. L + A = LG. Scribe settings L and A may be slightly different amounts, but when added together they must equal the long groove scribe setting (LG).

This positioning of a block, and scribing the lower and upper surfaces of the block is critical for success. This is because the end of the wedges must not touch both logs, anywhere. In photo 15 the block is in place, where the oak wedges will be. Note that the top surface of the block comes exactly even with the long groove scribe lines on both sides. If the wedges touch both logs at one, or at both, ends, then you can not tighten them.

Once everything is scribed, remove the upper log and cut the cogs on both logs. Instead of a coped or coved long groove, we cut flat across from scribeline to scribeline (photo 15) because we are going to bolt these logs together, and the friction of flat on flat improves the strength of the connection, and flat-on-flat removes as little total wood from the logs as possible (less total wood is removed than would be removed with a coved groove).

4— Sawn timbers with Lightningbolt Cogs

The interlocking portions were 50mm (about 2") tall, and spaced lengthwise by 515mm (20"). Again, we connected the two component beams to each other with seven 16mm (5/8") diameter throughbolts with small washers top and bottom.

The timbers need to be sawn and dressed on at least three, or on four, sides. The two sides that will mate do not have to be planed first, but it is okay if they are. Set the timbers on top of one another. Do not worry about the small gap between the two timbers. Mark the midspan of the beam, and work the layout to the left and right from there. Mark the end of each cog of the lightningbolt pattern with a plumb line along the faces of the timbers (red lines in Figure 16).

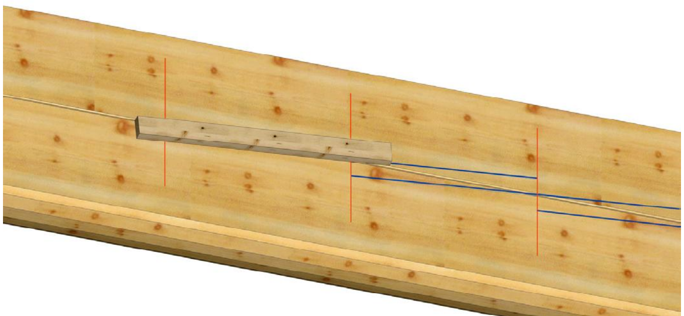

Figure 16

Each cog is traditionally about as long as the total height of the compound beam. Each tooth in the cog is about 1/10th the length of each cog. The end of every cog is a plumb cut. (The engineer would usually prefer that the end cuts be at a sloping angle, not plumb.)

Photo 17

Use a dressed piece of wood (a lath) or a straightedge to draw the sloping planes. The width of the lath, or the straightedge, must be 5mm to 10mm (1/4" to 1/2") wider than the maximum depth of the teeth. If there is no gap at all between the two beams, then the lath or straightedge can be exactly as wide as the depth of the teeth.

Lay the lath on the faces of the timbers and line up the bottom edge of one end, and the top edge of the other end, where the plumb lines you drew meet the space between the timbers (blue lines, figure 16).

Photo 18

◀ Each of the 4 beams was tested by loading concrete at midpsan and measuring deflection with a stretched string. This beam was made of round logs with wedges.

▼ Nearest to us is the sawn timber lightningbolt beam; then a mitered truss; round log lightningbolt; and, farthest back, round log beam with wedges.

Photo 19

Testing Deflection

After all four beams were built, they were loaded to test for deflection. As mentioned earlier, all beams had the same span, and about the same width and depth (or were sawn timbers made from logs of the same diameter). The beams were loaded at their midspan using concrete counterweights (borrowed from a tower crane)—up to a total of 9590 Kg (21,140 pounds) for three of the beams.

The wedged round log beam can be seen in photo 18 at the start of the deflection test. Photo 17 shows more than 21,000 pounds of concrete on that beam, and a very happy (and relieved) Meiri Rohner.

When Meiri loaded the screwed beam, the structural engineer who was supervising all the tests, stopped the test at 5480 Kg (12,080 pounds) — because adding one more counterweight would have sent the deflection over the maximum he allowed. After all, the goal here was to test deflection of four compound beams, not break them.

Figure B shows the deflection results for all four beams. The steeper the line, the larger the deflection—as can be seen, the compound beam made of two sawn timbers that were screwed together according to the manufacturer's specifications had the greatest deflection. The test on this beam was stopped at 5480 Kg.

The round log lightening bolt was the stiffest of the four beams. At a midspan load of more than 21,000 pounds it had less deflection than the screwed beam had at 9,000 pounds. A very impressive result, and gratifying that traditional joinery methods adapted for round log construction could outperform the deflection of a beam built with modern engineered screws.

For more information:

Watch video of the testing at this website:

www.kantti.net/artikkeli/2012/09/hirsiliitosten-kuormitustesti

For more on the design of "Mechanically Laminated Beams," see the article by Ben Brungraber and Joe Miller, in *Timber Framing* #93, September 2009, pages 14-21.

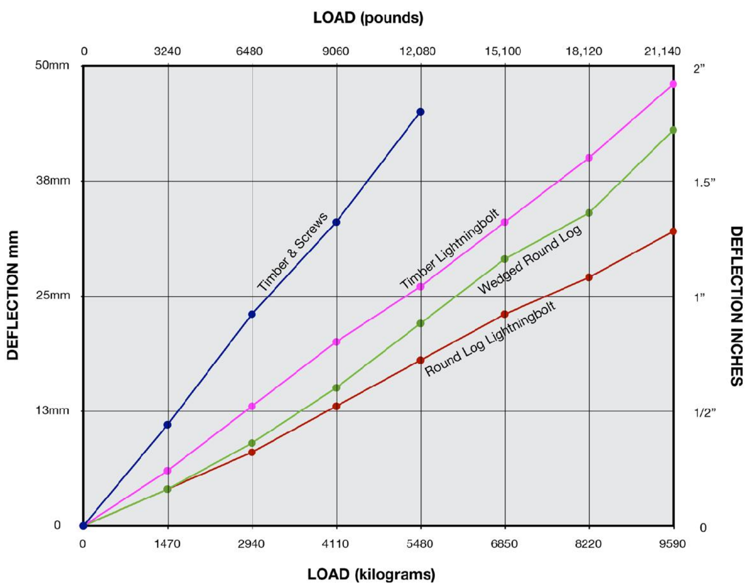

Figure B