Heart of the Matter

THERE'S MORE TO LOGS' STRENGTH THAN PITH

A question pops up from time to time that causes an interesting debate: What is the true value of boxed heart in a log versus free-of-heart? Boxed heart is when wood is sawn or milled so that the pith (the small, soft core in the center of a tree and its branches) is contained within the profile. Most lumber production excludes this part of the tree and is termed "free-of-heart center" (FOHC).

For wall logs, is one way better than another?

Start by looking at the tree. Is the heart at the center of the tree over its entire length? Essentially yes, because the exceptions are odd growth characteristics not desirable for use as a wall log, joist, rafter, purlin or other structural timber. In other words, stress grading is likely to filter out those sections of the tree where these exceptions occur.

Still, the pith of the tree is not held true to an axial line from top to bottom of the tree. It moves with a variety of occurrences that affect the tree's growth. In addition, much of the wood supply used for construction comes from conifers, which taper from the trunk's wide butt to its narrower tip.

The next step is the sawing and milling process. Depending on the method and desired results (the yield), the location of the heart becomes a result rather than a goal. For example, the need to utilize the smaller core from a veneer (peeler) log grew into a log-home manufacturing business in Montana in the 1950s rather than sawing the wood into lumber or chipping it for fuel, paper or use in an alternative product. In sawmills, the sawyer uses a combination of judgment, experience and possibly optical scanners with computer analysis to determine how to produce the greatest yield of marketable products from the tree.

In larger diameters, the sawyer is likely to try to maximize the number of high-quality boards from the sapwood, followed by lumber and timber from the heartwood, where knots may be more preva-

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lent. Smaller diameter logs may be run through a chipper-canter that results in a uniform piece ready for re-sawing into timbers or lumber. In all of these examples, the operations are designed to maximize the number and quality of boards, dimensional lumber and timber beams. The key to the sawyer's strategy is production order, which is a function of the mill's sales and the current market for wood products.

The heart is essentially boxed in the center during processing until the use of this core is established. Only quarter-sawing is guaranteed to produce free-of-heart because the log is quartered and sawn into boards to show edge grain. Although the heart is not boxed, it will be visible in several of the pieces because the saw operates in a straight line, while the growth of the tree is not nearly so exact.

When the process of converting a log into a wall log has been completed, it is quite likely that the piece is round or rectangular (cant) and has boxed heart. If the rectangular piece is large enough to produce multiple beams or cants for wall-log milling, sawing will determine which piece contains the heart and pith.

Growth characteristics, processing the log and species of wood all determine resulting characteristics of the wood product. The amount of heartwood and sapwood will vary with species and growing conditions, making it difficult to guarantee that a log will consist only of heartwood.

In conifers, the distinction between heartwood and sapwood will be visible. The heartwood is the dormant center of the tree and is surrounded by the sapwood, which is surrounded by the cambium layer that adds new wood cells to the sapwood as the tree grows. And the cambium layer is protected by the bark. This description is important to distinguish the characteristics of the heartwood and sapwood.

"Heartwood," according to the Forest Products Laboratory's *Wood Handbook*, "does not need to be taken into account in stress grading because heartwood and sapwood have been assumed to have equal mechanical properties. However, heartwood is sometimes specified in a visual grade because the heartwood of some species is more resistant to decay than is the sapwood; heartwood may be required if untreated wood will be exposed to a decay hazard. On the other hand, sapwood takes preservative treatment more readily than heartwood and it is preferable for lumber that will be treated with preservatives."

The orientation of the wall log to the original tree has another, more important consideration: the effect of seasoning. Drying the wood prior to milling helps to control dimensional change as the individual piece gains equilibrium with its installed environment.

When the tree is harvested, a significant amount of free water that has been flowing in the tree evaporates rather quickly. Because the heartwood and sapwood dry at different rates, tension is generated within the piece until the bond between wood cells themselves is exceeded and a separation (check) appears. Anyone who has been startled by the loud pop of a check can appreciate the release of energy that occurred.

Again, according to the *Wood Handbook*, wood products can change in dimension based on where in the tree they are cut. Shrinkage along the length of the log generally is negligible (perhaps 0.1 percent). Our concern is with radial shrinkage (from the heart to the extremes of the piece perpendicular to the growth rings) or tangential shrinkage (along the growth rings). The shrinkage varies with species and the amount of seasoning. Since tangential shrinkage is generally more extreme than radial, it has the potential to produce a larger dimensional change in a FOHC product as it dries.

The International Code Council's *Standard on the Design & Construction of Log Structures* shows the moisture content of selected wood species at fiber saturation, the point at which the free water is assumed to largely be removed, but there is still water bound in the cell walls. The fiber saturation point is important, because the departure of water from the cell wall allows the cell to constrict, and further seasoning will lead to dimensional change and internal stresses in the wood. According to the ICC, the fiber saturation point equals 30 percent except for specific species that wood scientists have found to have lower values. For example, while yellow poplar is 31 percent, Western red cedar is 18 percent. When those poplar and cedar products season to a moisture content of 27 and 14 percent respectively, it can be estimated that they will shrink 1 percent of their milled dimension.

The ICC standard lists about 80 wood species and their shrinkage, both radially and tangentially. Radial shrinkage is used for wall logs because the heart is typically in or nearly contained within the log profile.

These coefficients and the estimates derived from the formulas are far from perfect and tend to produce an extreme picture. Because wood is not homogenous, it does not behave the same from piece to piece or even along the length of a given piece. Therefore, ICC standards call for allowances in design and construction based on the most extreme estimated dimensional change. Some change can occur regardless of where the log is taken.

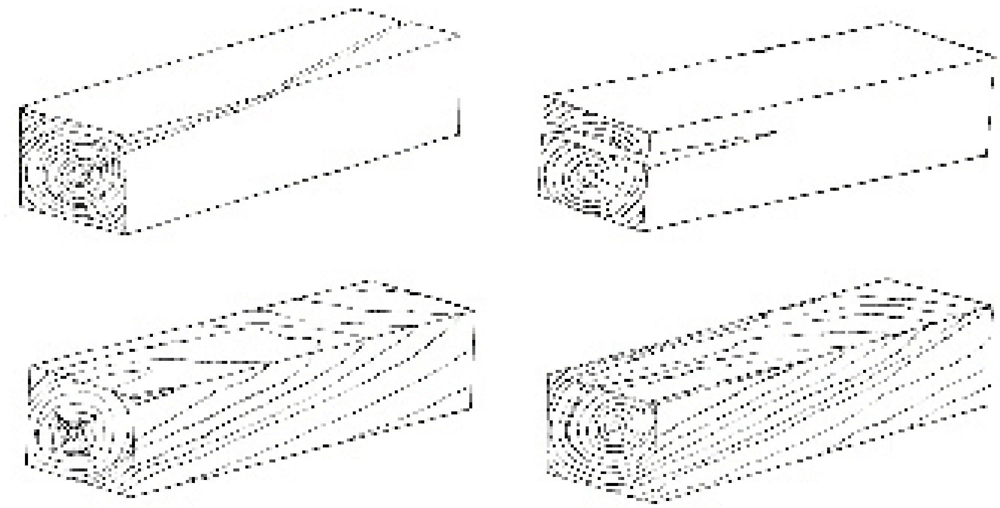
As the wood dries, tension builds between cells in the growth rings, and radial checking appears as the tension breaks weaker structures of the wood. Checks can occur anywhere and appear radially. As the wood dries further, at some point, a succession of small checks, or a line of checks and wood rays will become a large radial check that opens at the surface and narrows to the pith. To control this checking, a saw kerf can be made in a location that will be protected when the logs are stacked. As the log dries, the tension caused by the tangential shrinkage will instead accumulate at the saw kerf, opening it wider.

On round or square shapes, where the pith is nearly centered in the log profile, this theory works beautifully. It also works effectively on logs milled from rectangles where the wall logs bear on the wider faces. When the kerf is located on the narrow face (bearing surface), and the wide faces are profiled for the interior and exterior surfaces, checking may still occur on those visible faces. This is largely because the wide face has less wood fiber to resist the tangential forces and the surface is closer to the heart.

While checking is a fact of life with timbers, methods have been effective in minimizing it. However, it could be argued that checking requires the heart in the piece.

If it is true that checking is minimized by using free-of-heart cants, what are the side effects? Typically sawn from unseasoned logs, is the tangential stress relieved? Again the *Wood Handbook* shows that wood stresses that can result in checking are affected by differences in shell and core drying rates. Checking can appear in free-of-heart timbers, depending on the rate of drying, and these can result in splits rather than radial checks. However, the *Wood Handbook* notes that the differences in drying between shell and core are also affected by juvenile wood, compression wood and other defects that result in warping (cup, bow, twist or crook). Whether boxed heart or free-of-heart, these defects can generate undesirable results and are graded out.

One more perspective should be addressed before we make a conclusion: stress grading. Stress grading is applied to wall-logs to assess the strength of the piece and to provide assurance as to its quality. The strength of the piece is established by the direction, or slope, of the grain relative to its axis, and the extent of knots and other growth factors that cause local deviations in the grain. These strength-related grading criteria are applied equally to boxed heart or free-of-heart logs. This is also true of most of the other character-



The Log Homes Council Log Grading Program Training & Operations Manual.

Common defects in timbers (clockwise, starting top left) are checks radiating from the heart to the surface; splits, which occur due to drying and extend from one face to an opposing face; ring shake; and heart shake.

istics that could limit the wall log from a stress grade, with the exception of checks, shakes and splits.

Figures from the Log Homes Council's Log Grading Program shown on this page illustrate these defects. The upper left shows a check radiating from the heart to the surface. Checks make grading a piece much easier because the direction of the check will always be with the grain. Next to it is a split. Splits occur due to drying and are differentiated from checks because a split extends from one face to an opposing face and does not necessarily go through the pith. Below the check is a timber with heart shake and to its right is one with ring shake. Both forms of shake occur in the living tree as a result of forces from events that occurred while the tree was growing.

If boxed heart is undesirable because of the need to seal checks, the option is to restrict shake in free-of-heart logs. When shake is found on the end of the wall log or visible on the surface, there is no certainty of its extent without cutting the piece into slices. Ring shake can provide enough separation that, if left unrestrained, could experience different rates of drying and open the separation even further. While splits are typically graded out of wall-log production, shakes and checks can be managed with appropriate sealing treatment.

So, after examining all of these factors, what can we conclude? Many methods of processing the tree will leave the pith in the wall log—but not always. Like quarter-sawn boards, the advantage for timbers and cants sawn with boxed heart or close to it is to minimize cupping, twisting and shrinkage in the radial direction. Framing with common plain-sawn lumber or free-of-heart timber joists or rafters is fine when the edges are restrained with sheathing, solid blocking, cross-bridging and proper fastening to prevent the lumber from warping or twisting. Applied to log walls, even unseasoned logs are properly restrained by fastening them in place as soon as possible after arrival on building site and then loaded with the floor and the roof structure.

Practically speaking, boxed heart is a good goal that is harder to consistently achieve as the cant size becomes smaller and should not be used to distinguish one product from another. More important keys to building a quality log home will be to ensure that the wall logs have been graded under an accredited log-grading program and that appropriate design considerations have been given to the potential differential movement of the logs after they have been installed. **LHI**

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