WHITE PAPER

THE USE OF LAMINATED LOGS IN LOG HOME CONSTRUCTION

BY EDWIN J. BURKE, PH.D.

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Logs as a Building Material

Log homes are a fundamental part of the housing industry of the United States and Canada. Built not only as vacation or summer homes, these substantial structures are often the principal residence of families around the world. For hundreds of years, horizontally-stacked log construction has provided safe, secure and long-lasting habitation in the Old as well as New World, and continues to today as an economical and solid choice for residential and commercial construction. Using several species native to North America, American and Canadian log home builders offer many types of construction styles and countless floor plans that suit most budgets and needs.

Today's log home builder/owner has access to dozens of combinations of log species, size, style (natural vs. machined) and exterior finishes. Many choose machined logs because of their more uniform appearance and the ability to choose from a variety of exterior and interior profiles. Profiled log exteriors can present a round, flat or beveled siding appearance, while the inside face can also be round or flat with v-groove edges to give a horizontal paneling appearance. The uniform appearance of these machined logs provides a more "finished" appearance than the rustic countenance of a natural log wall.

Machined logs are generally manufactured from a large timber cut from the center of a tree. These timbers shrink in cross-section dimension when drying, presenting naturally occurring splits along the grain known as seasoning checks. Shrinking of wood is the inevitable result of moisture present in the wood's cell walls leaving during the period of drying after the tree is harvested. The seasoning checks indicate drying or dried wood, and are not a serious structural defect in most applications. Since wood is stronger when it is dry, the checks are actually the indication that the wood is structurally more stable than when harvested. Checks do, however, present appearance and potential longevity problems. While they give a wall a more rustic appearance, checks can also collect moisture when opening upwards, providing the moisture decay fungi need to breakdown the wood into food.

Proper application of a protective wood finish system that includes the checking is an important action that not only enhances the appearance, but also ensures the longevity of a log home. Regardless of the construction style, wood species, type of log or building site, protecting them is the most important step in the design, construction and maintenance of a log structure.

The Significant Use of Engineered and Laminated Structural Beams and Timbers

Engineered structural wood members of large dimension have been in constant production since the early part of the 20th Century. Using mechanical fasteners (such as nails, screws and bolts), combined with adhesive, several thin pieces of lumber were joined together to make large-dimensioned structural

components. As adhesive technology improved, the need for mechanical fasteners to help add strength was eliminated. Today, beams in excess of 100 feet, and capable of supporting hundreds of tons are in use in highway bridges, large factory structures, warehouses, auditoriums, stadiums, domed playing fields, churches, schools and homes across America and Canada.

The adhesive bonds in modern laminated logs allow the full strength of the wood members to be developed; the glue bond is stronger than the two wood members that it joins. Because the strength limiting characteristics are discontinuous and spread throughout the laminated log, laminated logs are typically higher in bending strength, stiffness, shear, compression and tension strength. The ability to engineer and build beams that hold far more than the equivalent cross-section of a timber cut from a single tree is one of the most compelling reasons for their status as one of the most important building components in modern wood and mixed materials construction.

This materials-efficient and cost-effective wood laminating technology has had a major impact on one of the most treasured parts of US history, the USS *Constitution*, "Old Ironsides" has been refitted to 1812 specifications by the manufacture and repositioning of the diagonal risers in the hull to return the ship to its original design. These large timbers are actually laminated white oak, as timbers this large are very difficult to produce today. These one-piece risers restored the legendary handling characteristics to the *Constitution*, and display some of the only modern materials technology in use on the ship today. These laminated risers utilize the same adhesive technology as laminated houselogs, and serve as an example of the acceptance of this proven technology to provide longevity and function.

Use of laminated timbers in critically-stressed vessels is also seen in the World War II-era Navy minesweepers, also made of laminated oak to resist magnetic mine detonation technology. Several of these vessels served with the British Royal and US Navies into the 1970's, years beyond their anticipated service life. Again, laminated timbers are known for their design versatility, durability, strength and cosmetic appeal.

The Houselog Engineering Process

Laminated houselogs are engineered structural wood products built from structurally-graded, kiln-dried lumber that has room-temperature or thermo-setting waterproof adhesive spread on the wide face. Prior to glue spread, the individual lumber laminations are given a final inspection for structural and aesthetic suitability and precisely planed to ensure a chemically-active bonding surface. In laminated houselogs, the laminations are oriented so the gluelines run vertically in the wall, thus giving the outside and inside surfaces of the finished timber a solid, one-piece appearance. Engineered structural laminated beams and timbers, including laminated houselogs, must meet strict quality control standards required by the Building Code. Beyond the engineering of each log design, continuous quality assurance measures include the use of kiln-dried, stress-graded lumber, constant monitoring of the mixing and application of adhesives, and testing of cured gluelines for strength and moisture resistance.

Several times each year, third-party inspection agencies, that are themselves fully-accredited by internationally-recognized accrediting bodies, perform unannounced inspections of the lumber preparation and grading, the specialized adhesive and adhesive-spreading equipment, all laminating procedures and presses and internal quality assurance testing of the finished product. These required

third-party inspections are another part of the total engineering/quality assurance programs used in the production of laminated houselogs.

Laminating Dramatically Reduces Checking

Checking in solid logs is caused by the greater amount of tangential (circumferential) shrinkage as compared to the radial shrinkage (in-out direction of the tree) seen upon drying. Houselogs typically take 1-2 years to dry to the moisture content established when they are in equilibrium with their environment. Numerically, most locations in the United States have exterior Equilibrium Moisture Contents (EMC) of approximately 8 to 12% outside, and 4-8% inside.

Summer-to-winter variance in a log's moisture content can amount to a few percentage points in humid areas, but the initial drying to EMC will routinely cause solid logs to undergo checking to the center of the log.

Lumber, on the other hand, being thinner, can be efficiently dried, with a minimum amount of checking, to a moisture content approaching the EMC of a building log, in a relatively short time. When laminated at 6 to 10% moisture content, the laminated log will undergo very little drying, even in arid climates or inside heated homes during winter. Built without the large checks common in solid logs, the laminated log will retain its smooth, nearly check-free surface through the years.

Freedom from Significant Shrinkage, Settlement and Warping

Laminated logs offer significant advantages over solid logs when considering log shrinkage and warping as well as wall settlement. Because the lumber used in the manufacture of the laminated log has been thoroughly dried to the approximate moisture content of use (10-12%), the completed logs are not likely to shrink in height and settle any more than the typical amount (.5%) allowed for in frame construction. The International Code Council's Standard on the Design and Construction of Log Structures[1] addresses settlement for all types of log structures with prescribed and calculated methods for determining when a construction system requires allowance for settlement. Since the laminated logs are not predicted to shrink and cause enough settlement to warrant them, designed allowances for settling are not required when lumber of the appropriate moisture content is used to engineer and laminate the logs.

Unlike solid logs that rarely have their grain aligned along the longitudinal axis and are, therefore, subject to drying to EMC and subsequent warping, bowing and twisting during storage, construction and final drying to EMC, laminated logs are built straight and square with wood that has completed its drying and will serve with far less movement during normal seasonal moisture cycling. This movement due to slight swelling and shrinking cycling causes joints to loosen and water/air-gaps to open. Since the laminated log is made up of several individual pieces, strength-reducing and movement-producing growth characteristics, such as spiral grain, knots, pitch pockets, reaction wood and other features, are not going to form the strength reducing, warp-producing continuous system pervasive in solid logs. These "defects" have been redistributed when placed in the laminated log, and the results are wall logs

[1] International Code Council. 2007. *Standard on the Design and Construction of Log Structures*. ICC 400-2007 IS LOG. 4051 W. Flossmoor Road, Country Club Hills, IL 60478.

and structural timbers that remain straight, strong and stiff throughout their life.
By mixing the position of lumber cut from a single tree, these characteristics do not occupy a significant volume in any one cross section. Thus, the overall strength of a timber laminated using lumber from a tree whose positioning has been randomized is greater than sawing a solid timber of the same dimensions from the same tree.

Construction and Maintenance Cost Savings with Engineered Logs

Construction time and its labor cost, which amounts to a major portion of the cost of building a home, is affected, in a very positive fashion, with the use of laminated logs. The solid log must have its checks, and other separations between logs, maintained regularly in addition to periodic protective finish application. Long term maintenance costs are likewise reduced with the use of laminated logs, due to the lack of need to maintain the special treatment of the large seasoning checks occasionally seen in the solid logs. Just like the highest quality redwood siding, the smooth, beautiful exterior and interior surfaces will be retained with ordinary routine maintenance of the exterior finish.

The Long-term Durability of Gluelines

Laminated houselogs are produced using the same waterproof, permanent adhesives used for high-stress, exterior structural beams used for timber bridges, construction scaffolding and other high stress, exposed uses. Quality control procedures during lumber selection and drying, adhesive mixing and spreading, log assembly and pressing, finish planing and testing all ensure a long service life and freedom from delamination due to glueline failure. A study at the University of Montana Wood Science Laboratory studying the longevity of eastern hemlock and eastern white pine unfinished and unprotected laminated houselogs has shown no delamination or instances of fungal decay. Surface weathering as a result of constant exposure to the weather for over 10 years can be easily removed using common wood preparation materials and will accept stain and exterior finishes readily. Log homes have their logs protected from much of the weathering seen in these studies, and can expect the same excellent results seen in these tortuous test regimes.

Laminated Logs are an Engineered Wood Product Well-Suited for Log Structures

Laminated houselogs combine the aesthetics of log construction, the longevity of well-finished commercial wood siding and the economics of long-term resistance to weathering, checking and warping. Modern engineering and adhesive technology, combined with long-established manufacturing methods and modern home design and engineering, makes laminated logs a very attractive, logical choice as an economical building material for today's log home buyers and builders.

Edwin J. Burke, Ph.D.
Chair, Dept. of Forest Management
Director, University of Montana Wood Science Laboratory
June 2015