LOG BUILDING NEWS

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Reprint Edition

The International Log Builders Association is pleased to provide you with this free reprint from our newsletter, *Log Building News* #35. The ILBA is a not-for-profit, educational association dedicated to furthering the craft of log home construction. It publishes books, articles, *Log Building News* , and the Log Building *Standards* (the "building code" for log homes), and conducts annual conferences and workshops for log home customers and log home builders. Contact information for the ILBA is on page 3.

Fire Resistance of Log Walls

By Dalibor Houdek, Ph.D.

Log construction is growing in popularity, but we don't know much about the fire performance of log walls. Sometimes when a high fire-

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resistance rating of a log wall is needed, a layer of gypsum wallboard is applied over the logs to increase the fire resistance, even though this covers up the logwork.

My experimental research of a scribe-fit log wall proved that it can achieve a very high fire resistance rating by itself, and additional steps to increase its fire resistance are not necessary.

Introduction

The trend is towards performance-based building codes, and this has increased the need for information on the performance of various building systems. Research on the structural fire resistance of wood construction in sorely lacking, and has focused on the light wood frame. Heavy timber construction, especially log construction, has been mostly ignored.

In 1986, Sashco Sealants Inc. sought an Underwriters Laboratories Inc. fire resistance rating for its log wall chinking. Lodgepole pine logs, 9" in diameter, with an average moisture content of about 5% were used. Wall joints were filled with foamed polyethylene backer rods and Log Jam™ chinking was applied. During the burn, the surface unexposed to heat reached 95℃ (200℉). The assembly was judged to afford 1 hour fire rating by ASTM E-119.

The Technical Research Center of Finland performed a fire test according to German DIN 4102 and ISO 834 standards on log walls

Houdek's experimental log wall. Note the many thermocouple wires to record temperatures inside the wall and on its surface.

manufactured by Honka Log Homes. The rectangular, milled logs were 140 mm thick. The wall kept its load-bearing capability throughout the 90-minute test, but failed at 112 minutes.

Various companies have conducted burn-through field tests, and small-scale tests of non-load-bearing

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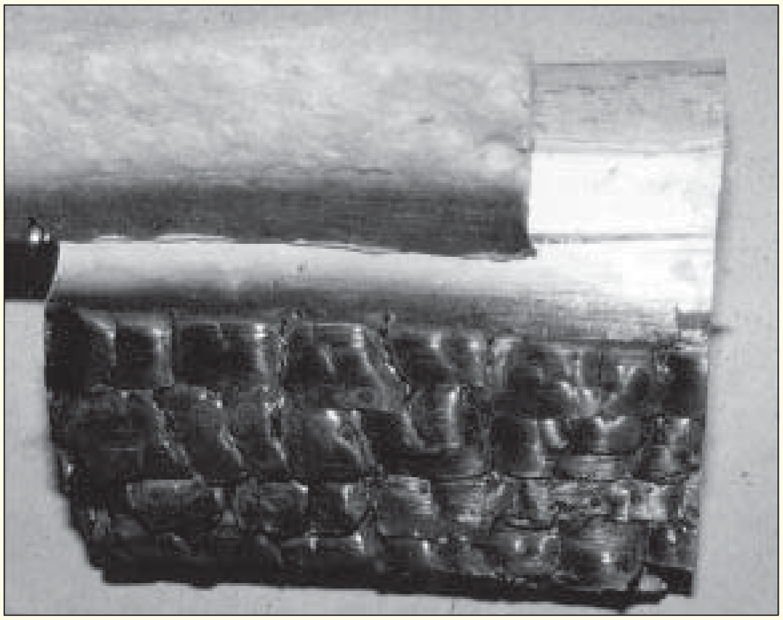
chinked log walls, to display the fire endurance of their products. The overall results showed good fire resistance, but no scientific measurements were done, and the details were not widely published.



Charred log after the test, with mineral wool batt. No flames penetrated the grooves.

All the work done earlier on fire resistance of log walls was conducted on chinked or rectangular log walls. The Technical University of Zvolen, Slovakia, has commenced research to answer questions of fire resistance of a chinkless log wall used primarily in North America, and to develop a model for estimating the fire resistance of log walls. The large-scale experiment according to ISO 834 was undertaken in PAVUS-Fire Research Institute, Czech Republic.

Experiment

The test sample consisted of twelve spruce logs of 257mm (10”) average diameter. They were joined in the traditional chinkless, full-scribe-fit style. The cupped lateral grooves were approximately 15mm (¾”) deeper then necessary, to accommodate the mineral wool insulation. The test wall was 3250 mm (10’-8”) long, and 2800 mm (9’-2”) tall.

Eleven logs were kiln-dried to an average moisture content (MC) of about 19%, and one log was conditioned to 36%. The long grooves were filled with mineral wool insulation (rock-wool type). Due to the natural irregularities of each log, the width of the grooves varied between 89mm and 130mm with an average of 105mm (4”).

The ends of the panel were splined (like a door opening) and 3 spruce pegs per log, 30 mm in diameter, were driven approximately 800mm (30”) apart to support the wall logs. They were driven only through two vertically-adjacent logs

The log wall was exposed to fire, and temperatures inside the logs, inside the grooves, and on the unexposed side were continuously monitored and recorded (*photo on page 1*).

The log wall was continuously vertically loaded on the centerline with 15 kN m^{-1} using a hydraulic loading system built in the furnace loading frame. The load figure derived from the calculation of a one-and-a half story log house.

The Results

According to ISO 834, structural walls can fail in three ways during a fire resistance test:

1) fail in **integrity**, causing ignition of a cotton pad, permitting the penetration of flames resulting in sustained flaming, *or*
2) fail in **insulation**, causing an increase of the average temperature above the initial average temperature by more than 140 °C or increase above the initial temperature at any location by more than 180 °C, *or*
3) fail in **load-bearing capacity** —basically, if the wall loses 1% of its height, it has failed.

Inside the furnace, the log wall surface turned black in the 3rd minute of the test. In the 5th minute the surface ignited and continued to burn for the duration of the test. Large deep cracks developed around the 11th minute. From about the 30th minute the wall surface was red and charred with large deep cracks for the rest of the test. It was observed that when the fire-exposed edge of the lateral groove burned off, the mineral insulation inside the long groove protruded, and expanded to about its initial thickness of 50 mm.

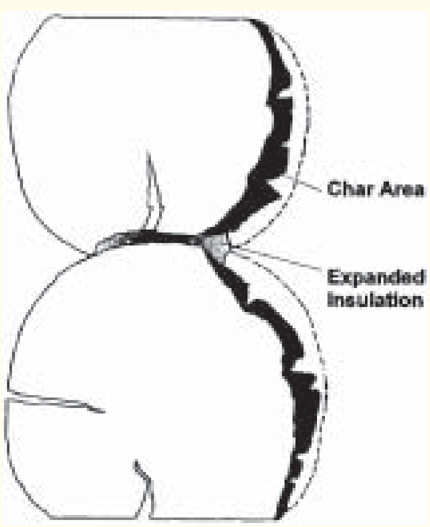
No flame penetration through the wall was observed during the test. The side unexposed to fire showed no visible changes; smoke penetration was not observed through the wall joints.

Comparing the results of chinkless log wall joint with the chinked wall joint tested by Sashco Sealants Inc., the scribe-fit log wall has much higher insulation value. At 60 minutes of the test duration the chinkless log wall showed absolutely no increase in surface temperature, compared to an average 71°C (160°F) temperature increase of the chinked log wall tested by Sashco Sealants Inc.

Glowing logs, separated by mineral wool, at 2000°F in the furnace.

The temperature on the hot side of the scribe-fit log wall exceeded 1100°C (2000°F), but the cool side never got above 48°C (118°F), even after almost 3 hours of burning.

Moisture plays a large role in the temperature rise. A temperature rise inside the moist log leveled off slightly above 100°C (212°F), and



Cross section of log wall after fire test. The mineral wool insulation in the long groove expanded, once the edge of the groove burned off. The insulation created a protective shield against heat penetration through the wall joint.

remained almost unchanged for more then 25 minutes.

Allowed axial compression prescribed by ISO 834, calculated according to the equation C= h/100 was 28 mm (about 1”) (the initial height of the log wall was 2800 mm), reached its ISO 834 allowable limit at the 172nd minute of the test duration.

The shrinkage of the wall logs due to the moisture content changes contributed to the amount of the compression. When moist logs are used for the test, it can affect the wall load-bearing capacity during the fire resistance test. Shrinkage, a natural feature of wood, itself does not decrease the load-bearing capacity.

All professionally manufactured log buildings are fully engineered to account for shrinking and settling. On the other hand, when the load-bearing capacity during the fire test of log walls is evaluated, there is no allowance for wood’s natural shrinking due to moisture content changes.

Conclusions

Knowing how log walls react to fire exposure is important for evaluating newly constructed buildings and existing log structures. A large-scale laboratory test showed that a massive wooden wall with considerable numbers of lateral wood-to-wood joints can maintain the fire safety requirements prescribed by the ISO 834 for as long as 172 minutes. **The log wall withstood 180 minutes from its integrity and insulation viewpoint, and 172 minutes from the point of its load-bearing capacity.**

The handcrafted chinkless log wall constructed in the manner described above shows better integrity, insulation, and load-bearing capacity than the chinked or milled log walls tested by other laboratories and detailed in this article—its properties provide significant fire resistance.

For further information or to obtain a reprint of the original article contact Dalibor Houdek, or refer to the *Journal of Fire Protection Engineering,* Vol. 11, August 2001.

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Photos and drawing courtesy of Dalibor Houdek