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Historic Log Cabin Structural Condition Assessment and Rehabilitation – A Case Study

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Abstract Since 1995, the University of Minnesota Duluth (UMD) and the USDA Forest Products Laboratory (FPL) have worked cooperatively with the American Society of Civil Engineers (ASCE) and other cooperators to develop and teach a short course on inspection of structures. Key to these courses are case study inspections showing the procedures, techniques, assessment strategies and repairs of wood structures. In this paper, we focus on the results of a detailed inspection of a historic log cabin built in Boundary Waters Canoe Area Wilderness during the 1930's by the U.S. Civilian Conservation Corps, now owned and maintained by U.S. Forest Service. This inspection and resulting report was used by the U.S. Forest Service to guide the repair and renovation of the cabin during the summer of 2010. A visual case study of the inspection techniques, equipment, condition assessment results and facility rehabilitation and repairs will be presented demonstrating the importance of in-place nondestructive evaluation techniques for preserving historic wood structures.

Keywords nondestructive evaluation, historic structures, stress wave timing, resistance microdrilling

1. INTRODUCTION

1.1. General information

Since 1995, the University of Minnesota Duluth (UMD) and the USDA Forest Products Laboratory (FPL) have worked cooperatively with the American Society of Civil Engineers (ASCE) and other cooperators to develop and teach a short course on inspection of structures. ASCE has taken the lead by providing overall coordination of these efforts and scheduling and marketing support. The Forest Products Society has provided technical literature, including the recently published "Wood and Timber Condition Assessment Manual (Ross et al. 2004)." The resulting course has been presented over 100 times throughout the United States with over two thousand attendees.

A grant from the USDA Wood Education & Resource Center and Northern Initiatives was received in 2006 and used to develop electronic technology transfer methods by developing a web portal and through web-based seminars (webinars). Our project team conducted inspections of several historic structures during the project period. The inspections included:

- Superior National Forest - East Bearskin Lake cabin; Gunflint Trail, Minnesota
- Ottawa National Forest - inspection of camp/lodges located at Camp Nesbitt; Kenton, Michigan
- 1894 Hoist House and Blacksmith Shop of the Keweenaw National Historic Park, Quincy Mine Unit; Hancock, Michigan
- Cheboygan River Front Range Light Station; Cheboygan, Michigan
- WAPAMA National Historic Landmark, San Francisco National Maritime Park

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- Wood-frame construction homes affected by flooding from Hurricane Katrina; New Orleans, Louisiana

These inspections were completed by members of our project team and our cooperators and served as the basis for the development of technical inspection reports and our webinar series. This paper details the results of a comprehensive inspection and assessment of the Bearskin Lake Cabin owned by the U.S. Forest Service, Superior National Forest.

The Bearskin Lake cabin was constructed on the shores of East Bearskin Lake, along the historic Gunflint Trail in northeastern Minnesota, Bearskin Lake serves as an entry point to the Boundary Waters Canoe Area Wilderness. This handcrafted log cabin, constructed in 1935 by the Civilian Conservation Corps, is located outside the wilderness boundaries and is used as a base for summer portage crews, fire crews and other staff as needed. This cabin has been modernized with electricity and running water. Typical visual inspections are used to develop maintenance plans as necessary.

1.2. Inspection Techniques

The following sections note general techniques used during the inspection. Detailed information on each approach can be found in Ross et al. (2004).

1.2.1 Wood species identification

Small wood samples were collected from several of the log members. The samples were then sent to the USDA Forest Product Laboratory (FPL) for species identification.

1.2.2 Visual inspection

An extensive visual examination of the structure was performed. In particular, we looked for any evidence of fungal growth such as insect damage, fruiting bodies, brown crumbly wood, or evidence of exposure to water. As part of the visual inspection, we used hammers as part of a sounding test. This low impact allows inspectors to identify areas that have a different audible response to a hammer. For instance, a decayed log will have a distinctly different sound than a solid log. Sounding can also help identify loose connectors and agitate insects that are present.

1.2.3 Stress wave testing

It has been shown from extensive research studies that deteriorated wood transmits stress waves or ultrasound in a manner that is significantly different than that of non-degraded wood. Specimens with a high stress wave speed are generally of higher quality than those with low stress wave speeds. Stress wave timing tests were conducted, perpendicular to the grain, at most all wall locations in the structure, with specific attention to those areas that showed visual evidence of decay, insect damage, or evidence of moisture. The testing was conducted by using several types of commercially available stress wave timers. A Fakopp microsecond timer and a Sylvatest Duo were used in the inspection. Both pieces of equipment provide similar stress wave test results for both solid and decayed wood.

1.2.4 Resistance microdrilling

Mechanical probing type tests are also useful for locating deteriorated wood. An automated drilling device was used in this inspection. A steel drilling bit penetrates the wood at a uniform speed while drilling resistance is measured, The measured resistance data (recorded on a 0-100% scale) is recorded on a wax paper strip at a scale of 1:1 and can be captured electronically for downloading to a personal computer, Measured resistances could be used to differentiate wood with deterioration from sound wood. The drilling bit has a small diameter, causing minimal damage to the material. An IML Resistograph F300 was used during this inspection.

2. INSPECTION RESULTS

2.1. Wood species identification

The species of the log members used to build the cabin was determined to be spruce (*Picea spp*). It was not determined which species, although it is thought to be white spruce. Samples were taken from several inconspicuous log locations on the inside of the cabin.

2.2. Visual inspection

A visual inspection of the log cabin interior and exterior noted several locations of decay, insect infestation, water damage and bird damage. Figure 1 show the specific locations of the damage noted on the front of the building and figure 2 shows close-up areas of typical damage. The cabin is identified by noting the front had a porch entrance and the rear had a kitchen entrance. The cabin sides were noted as right and left as a person would enter the front porch. Visible decay was present on log ends and log comers around the cabin. It was often located on the lowest log, which was located within 6-10 inches of the ground. These logs receive backsplash from the ground and often had vegetation in near contact. A section was noted on the left side of the cabin where firewood had been stacked in direct contact, providing moisture and insect access points. Several sections of the lower sill logs contained significant insect damage from various types of beetles. There was also log decay noted along the screen windows on the front porch, where moisture entered the logs.

Figure 1 - Front left cabin with visual damage noted within circles or ovals.

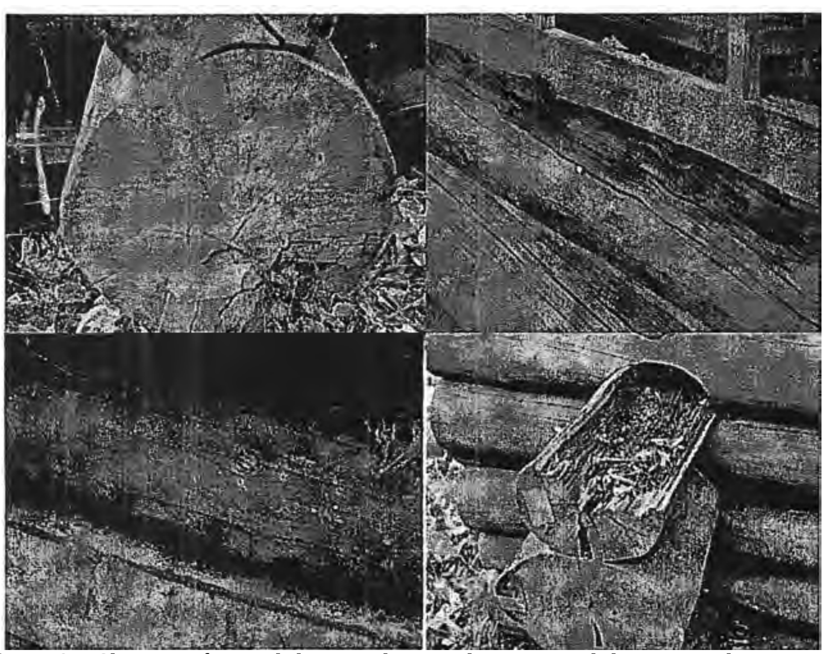

Figure 2 - Close-up of typical decay and insect damage noted during visual inspection

2.3. Ultrasound/stress wave testing and resistance microdrilling

Stress wave inspections were conducted on all log sections of the cabin. This testing was completed across the cross-section of the log. Each exposed log end or comer was inspected. Each cabin wall log was also tested at various locations in an effort to locate decay that was not visually evident. One operator was located outside the cabin and the other on the inside. The cables were run through an open window or door. If decay was noted, the logs were intensively tested to determine the extent and location of the decay. A resistance microdrill was used to confirm the decay in those areas.

Decay was noted in several exposed log comers and ends where decay was not noted during visual inspection. The damaged logs were most often those closest to the ground. We identified hidden decay in several locations on the front of the building and on the rear of the building. The decay on the rear of the building was not visual. Two sensors are used in stress wave timing to determine the time it takes for a wave to travel through the logs. Transit times greater than 200 µs/ft. are indicators of decay. Resistance drilling values ranging from 0-25% confirm varying levels of decay.

Figure 3 shows an overview of the cabin front. The sections of decayed logs identified using stress wave timings and resistance drilling techniques are shown in dark shading if they are categorized as substantial decay and light shading as moderate decay. The stress wave timing data for these sections was inadvertently destroyed, but the resistance drilling confirmed the damage in these locations. Figure 4 shows the resistance drilling data collected from locations 1, 2, 3, and 4 on the log above the porch door. This data shows that there is no internal decay at sections 1 or 4, but that there is a 3-inch diameter decay pocket located above each vertical log at locations 2 and 3. This was an approximately 10-inch diameter log.

Figure 3 - Bearskin cabin front showing decayed sections as identified through visual inspection, stress wave timing and resistance drilling. Dark shading reflects areas of severe decay and light shading areas of moderate decay.

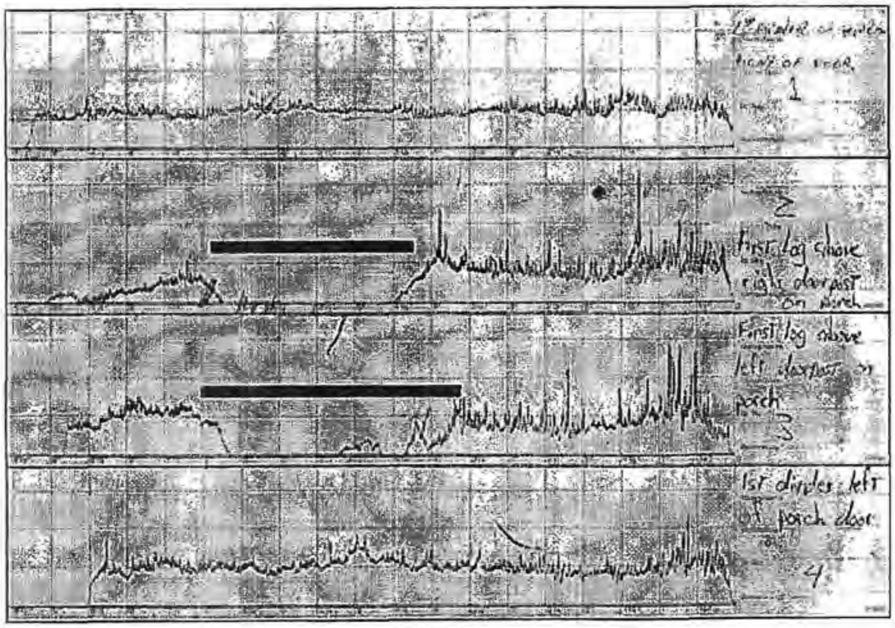

Figure 4 -
Resistance microdrilling results from the log above the porch windows as identified by drilling locations 1, 2, 3, and 4 as seen in figure 3. The dark bar indicates decayed sections.

Figure 5 shows the rear side of the Bearskin guard cabin. There were no visual indications of decay present. The inspection using stress wave timing identified significant levels and areas of decay in the logs under the rear kitchen window. A sink exists in the kitchen and was the likely source of the water damage to the logs under the window. Figure 6 shows the stress wave timing data recorded for sections B and C. Stress wave transit times over 200 microseconds/ft. (μs/ft.) suggests intermediate decay and numbers over 400 μs/ft. suggest significant decay.

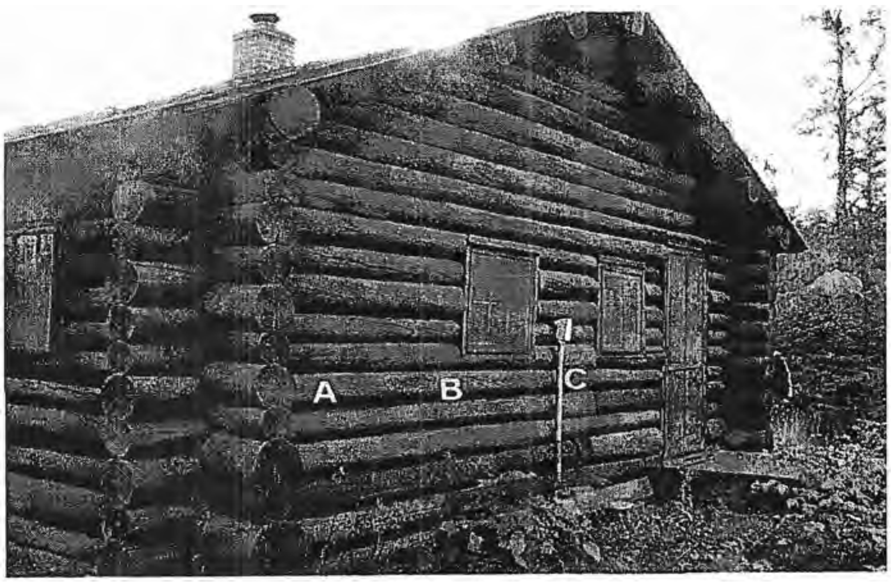

Figure 5 - Rear side of Bearskin cabin showing decayed logs as shaded sections.

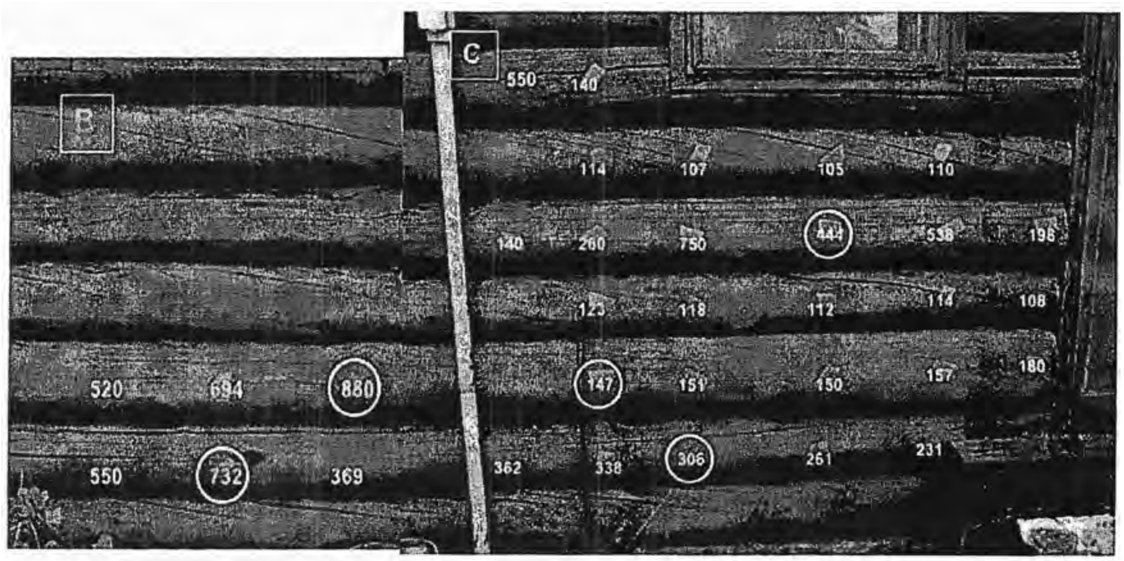

Figure 6 - Rear wall sections B and C show close-up data generated using stress wave timing. The data is shown as microseconds (µs) and the logs were approximately 8 inches diameter.

A resistance microdrill was used to confirm levels of decay as noted using stress wave timing techniques. Figure 7 shows resistance microdrilling data at various stress wave locations as noted.

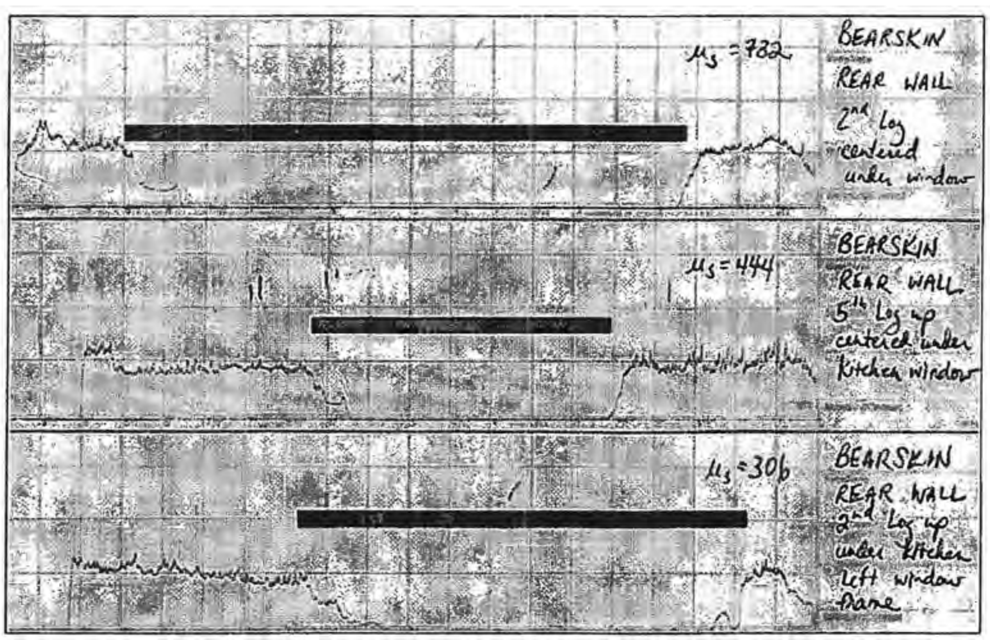

Figure 7 - Resistance drilling data from various locations on rear cabin wall. The microseconds noted on the chart correspond to the drilling location as show on Figure 6.

3. INSPECTION RECOMMENDATIONS

The following recommendations and conclusions were developed following the inspection and assessment of data:

- There was visible decay present on several of the lower log ends, log comers and sill logs. This decay should be addressed through accepted restoration techniques. This may include patching, wooden plugs, wood preservative, insecticides, and replacement of ends, half-logs or full logs.

- Decay that was not visible was identified through stress wave timing and resistance drilling. This includes logs on the cabin front below the porch screens and door, the cabin left and right sides and the rear of the cabin. The most significant problems were identified on the cabin rear, most likely caused by water from the kitchen sink, and close contact with the ground. This decay should be addressed through accepted log restoration techniques. This may include patching, wooden plugs, wood preservative, insecticides, and replacement of ends, half-logs or full logs.
- All firewood should be stored at least 6 ft. from the cabin. Firewood was noted placed in direct contact with the cabin. Grasses and vegetation should be mowed regularly to minimize direct contact with the cabin logs.
- A strategy should be developed for the roof drip zone around the cabin. Significant splash back is occurring, wetting the lower cabin logs, log ends and log comers. This water increases the moisture content of the logs; leading to decay in these locations.

4. REPAIR OF DETERIORATION

A comprehensive inspection report was provided to the U.S. Forest Service maintenance and historic preservation staff (Brashaw et al. 2007). This report contained detailed pictures and testing results from visual inspection, stress wave timing and resistance microdrilling, and recommendations noted in section 3.0. This report was used by the Forest Service to develop a repair plan for the cabin. During the winter of 2010, an external contractor was selected for the repair of this cabin. The contractor used the inspection report to quickly locate deteriorated sections of the cabin and conduct repairs. Specifically, the contractor replaced logs on the front of the cabin, replaced log ends on the sides of the cabin, filled hollow sections of logs with a two-step epoxy repair system, and then inserted borate rods into logs to kill decay fungi and act as preventive maintenance. Figures 8-9 show visual examples of these repair techniques and the locations where they occurred. A review of the repairs showed that the inspection completed was very accurate in identifying areas of deterioration and that repairs and replacement logs occurred in the exact locations as noted in the inspection report. A final image of the completed repairs is shown in Figure 10.

Figure 8 - Replacement of decayed logs sections on the front and left side of the Bearskin guard cabin. The new logs are light colored and clearly match the decayed sections as identified in figure 1.

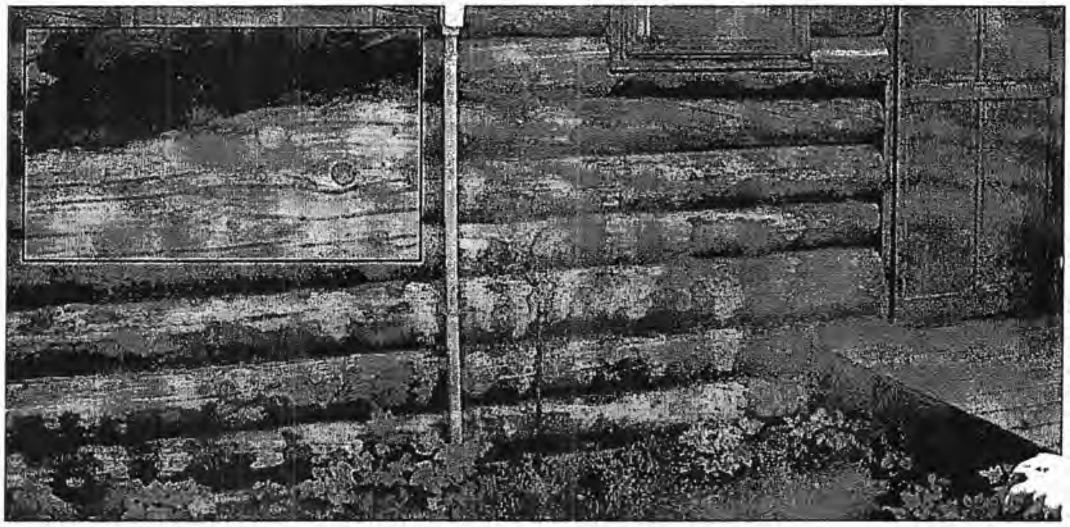

Figure 9 - Back wall logs after filling with a two-part epoxy and insertion of borate diffusion rods (capped with oak dowels) as shown in the inset image.

Figure 10 - Completed rehabilitation to the U.S. Forest Service Bearskin log cabin in October 2009.

ACKNOWLEDGMENTS

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