historic structures

Quincy Mine Blacksmith Shop

Condition Assessment of Timbers

By Robert J. Ross and Xiping Wang

The degradation of a wood load-bearing (in-service) member may be caused by any one of several organisms that derive their nourishment or shelter from the wood substrate in which they live. Consequently, it is important to periodically inspect wood structures to determine their condition. A comprehensive manual on the inspection of wood structural elements, Wood and Timber Condition Assessment Manual, was prepared at the request of the American Forest & Paper Association and published by the Forest Products Society. The Manual is now available to assist field engineers and other inspection professionals. This article is a chapter from the Manual.

Scanning Timbers for Deterioration

Fifteen 12- by 12-inch white pine timbers removed from the Quincy Mine Blacksmith Shop were nondestructively evaluated at the USDA Forest Service, Forest Products Laboratory through intensive stress wave scanning. The timbers were part of the original roof truss structure in the Blacksmith Shop. Scan results indicated that some timbers or some sections of the timbers had severely deteriorated and lost structural integrity. It was also found that most of the timbers still contained a substantial amount of solid wood, and some timbers were only slightly decayed or mechanically damaged. Further data analysis indicated that 61 percent of the total materials could be potentially recovered from these timbers and used in the reconstruction project.

Background

The Quincy Mining Company's Drill and Blacksmith Shop, located in the Keweenaw National Historical Park, was constructed in 1900 by the Quincy Mining Company. Of great interest is the preservation and use of the remaining roof trusses and floor joists. The 12- by 12-inch white pine roof truss timbers had been exposed to weather for several years. These structural members, manufactured from old-growth timber, are a tremendous resource that should be appropriately used in the renovation of the Drill and Blacksmith Shop.

Figure 1: Fifteen 12-by 12-inch white pine timbers removed from the Quincy Mine Blacksmith Shop

Condition assessment of the heavy timbers from the Blacksmith Shop was an important first step in the restoration of this structure. During an early on-site assessment, it was found that a substantial amount of timbers contained solid wood in spite of visually observed deterioration of parts of the members. The intent of this assessment was to follow up on the promising cursory assessment results and to further nondestructively evaluate the selected white pine timbers in the laboratory.

Objectives

The objectives of this assessment were:

1. To detect the location and severity of deterioration in 12- by 12-inch white pine timbers removed from the Quincy Mine Blacksmith Shop through intensive scanning using a stress wave transmission technique;
2. To determine how much of the original structural wood from these timbers can be potentially recovered and used in the reconstruction project.

Materials and Method

Fifteen 12- by 12-inch white pine timbers removed from the Quincy Mine Blacksmith Shop were transported to the USDA Forest Service, Forest Products Laboratory (FPL) in Madison, Wisconsin on August 2, 2001 (*Figure 1*). The timber specimens ranged from 25.5 feet to 50 feet in length; 13 of the specimens were about 50 feet long (originally used as tension members in the roof trusses) and 3 of the specimens were from 26 feet to 34 feet long (probably used as pitched chord or web materials). These timbers were part of the original roof structures and had been exposed to weather for several years. Surface decay, splits, mechanical damage, and notches were the major defects observed (*Appendix A: Major Defects Observed in 12- by 12-inch White Pine Timbers*).

Figure 2 shows a typical scanning diagram used to conduct stress wave transmission tests. The timbers were supported on two beams. Each timber was stress wave scanned along three lines (A, B, and C) on the side surfaces, with A, the upper line, B, the middle line, and C, the lower line, through the height of each timber. Since the ends of the timber were usually considered to be the areas having a high risk of decay, stress wave transmission tests were more intensively performed at ends than other parts of the timber. The intervals between the two scanning

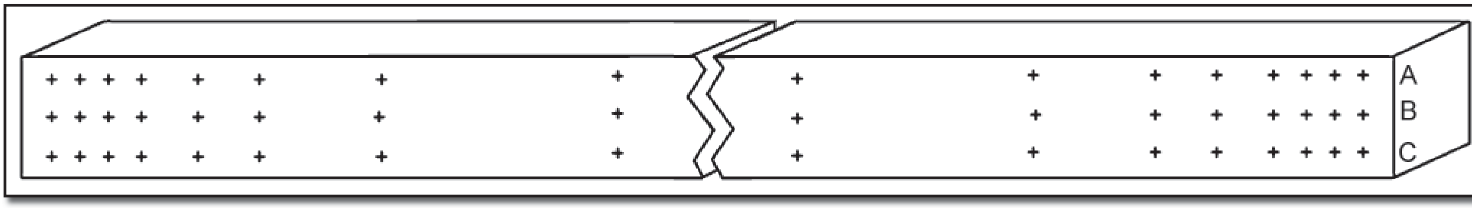

Figure 2: Scanning diagram for nondestructive evaluation of 12- by 12-inch white pine timbers

points in the longitudinal direction changed from 6 inches beginning at the end of the timber to 1-foot, 2-feet, and 4-feet, respectively, as the scanning position approached the middle part of the timber.

A commercially available stress wave timing unit was used to measure wave transmission time, perpendicular to grain, at a series of points as described above. A variety of commercial tools, which cost from US$1,800 to $4,000, are available that perform this type of test. The test set-up is described in detail in FPL-GTR-119 (FPL 2000). A shock wave was sent across the timber, and the time it took to travel from one side of the timber to the other side was measured. Three stress wave readings were taken at each scanning point, and the average wave transmission time for each point was used as an indicator of the soundness of wood in that area.

Results

Results obtained from stress wave scans are shown in two graphs in *Figure 3*. The stress wave transmission time measured, perpendicular to grain, was in microseconds. Given the same width of 12 inches for all timbers, the stress wave data expressed in y-axis can also be deemed as values in a unit of microsecond per foot (μs/ft). Therefore, the scan results for all 15 timbers can be conveniently compared with the baseline data given in previous publications (Ross and Pellerin 1994; Ross et al. 1998, 2001; FPL 2000; Clausen et al. 2001).

Stress wave transmission time may vary from species to species, but it is mainly controlled by the soundness of wood in terms of deterioration detection. For most species, stress wave transmission time perpendicular to grain ranges from 180 μs/ft to 400 μs/ft for solid wood (FPL 2000). This baseline range was used as an evaluation standard to assess scan results obtained from the fifteen 12- by 12-inch white pine timbers.

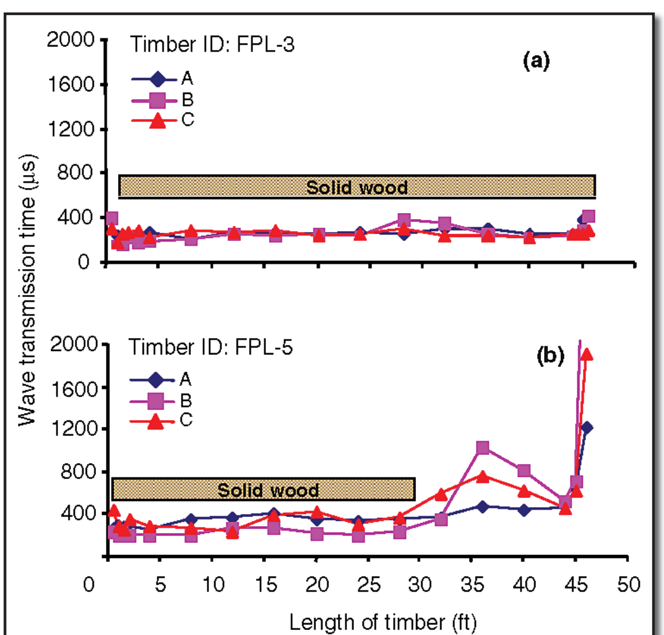

Figure 3: Typical scan results from 12-by 12-inch white pine timbers

As shown in wave transmission-time/length-of-timber graphs, these white pine timbers are in various conditions, from solid, slightly to severely deteriorated, to almost fully deteriorated. As previously mentioned, the deterioration was mainly caused by decay (surface and internal), splits, and mechanical damage. From scans shown in *Figure 3*, it is possible to distinguish whether deterioration occurs in surface areas or inside of timber as stress wave transmission times obtained from three scan lines (A, B, and C) are plotted on the same graph for each timber.

The solid wood in each timber was determined by comparing scan results with the baseline data of stress wave transmission times for solid wood. The approximate length of solid wood for each timber that could have potential structural uses was also determined and indicated below each scan graph. A summary of potential recovery of the solid wood from all tested white pine timbers is detailed in *Table 1*.

From the scans and *Table 1*, it is evident that a substantial amount of solid wood could be recovered from these timbers except for one short timber, FPL-12, which was almost fully deteriorated. The potential recovery rate could be as low as 16 to 17 percent due to severe deterioration found in timbers (such as FPL-4 and FPL-8); it could

Potential recovery of solid wood from 12- by 12-ich (30- by 30-cm) white pine timbers

Timber ID	Length of Timber (ft*)	Length of solid material (ft*)	Potential Recovery (%)	Major Defects of Timber
FPL-1	50	39	78	Decay on end, notch
FPL-2	48.4	28	58	Split of surface
FPL-3	45.8	45	98	
FPL-4	50	8	16	Severe decay, split, notch
FPL-5	47.8	28	59	Decay on end, surface split, notch
FPL-6	50	42	84	Decay on end, surface split, notch
FPL-7	50	26	52	Decay, notch
FPL-8	46	8	17	Severe surface decay
FPL-9	50	42	84	Surface split, notch
FPL-10	48.3	44.5	92	Surface decay on one end
FPL-11	50	24	48	Severe decay, notch
FPL-12	25.5	0	0	Severe decay, split, notch
FPL-13	33.8	22	65	Big split on ends
FPL-14	32	1	50	Decay and split on ends, notch
FPL-15	50	24	48	Severe decay, notch

** 1 ft = 0.3 m*

Table 1

also be as high as over 90 percent (such as timber FPL-3 and FPL-10). Overall, an average of 61 percent of total materials (not including FPL-12) could be potentially recovered from these white pine timbers and used in the reconstruction project.

Conclusions and Recommendations

Fifteen 12- by 12-inch white pine timbers removed from the Quincy Mine Blacksmith Shop were nondestructively evaluated through intensive stress wave scanning. The scan results indicated that some timbers or parts of timbers had seriously deteriorated and lost structural integrity. It was also found that most of the timbers still contain a substantial amount of solid wood, and some timbers were only slightly decayed or mechanically damaged on the ends. Further data analysis indicated that, overall, 61 percent of the total materials could be potentially recovered from these timbers and used or displaced in the reconstruction project.

Based on the preliminary results obtained from the 15 white pine timbers, the following was recommended:

1. Complete stress wave scanning tests on the remaining white pine timbers, including 12- by 12-inch roof truss timbers and 3- by 14-inch floor joists. Use the same procedure as employed in this assessment to determine the location and severity of deterioration that might occur in the rest of the structural members.
2. Cut off deteriorated sections from the timbers and obtain solid material based on scan results.
3. Mechanically proof load all solid wood sections to supply engineering design values for their reuse in the reconstruction project.▪

The complete *Wood and Timber Condition Assessment Manual* is available from the Forest Products Society, 2801 Marshall Ct., Madison, WI 53705-2295. Orders can be placed by phoning 608-231-1361 or online at www.forestprod.org/shop/index.html. Chapters include visual inspection techniques, ultrasound or stress wave based inspection tools, and mechanical probing techniques. A chapter on post-fire inspection and assessment is also included in addition to a sample inspection report and summaries from several inspections. Detailed descriptions of the various available testing tools, guidelines on their use, and interpretation of data obtained from them is included.

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