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Condition Assessment of Wood Members in a Historic Building at the Veterans Affairs Medical Center in Tomah, Wisconsin

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Abstract

The USDA Forest Service, Forest Products Laboratory, was asked to inspect the main support timbers of a historic building at the Veterans Affairs (VA) Medical Center in Tomah, Wisconsin. This report summarizes the results obtained from the inspection and assessment. It includes a summary of observations, wood species identification, and recommendations.

Keywords: Condition assessment, visual inspection, decay, moisture, timbers

Contents

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Condition Assessment of Wood Members in a Historic Building at the Veterans Affairs Medical Center in Tomah, Wisconsin

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Introduction

The USDA Forest Service, Forest Products Laboratory (FPL), was contacted in 2022 by Stone Group Architects, Inc. (Sioux Falls, SD), to assist in assessing the condition of timbers in a historic building (Building 23, Fig. 1) at the Veterans Affairs (VA) Medical Center in Tomah, Monroe County, Wisconsin. The objective of the work summarized in this report was to assess the condition of the structural timbers that support the building. A visual inspection of the timbers and other wood structural elements was conducted on October 25–26, 2022.

History of Tomah VA Building 23

Tomah Indian Industrial School

Building 23 was originally the boy's dormitory for the Tomah Indian Industrial School in Wisconsin. It is a wood-framed structure, constructed in the 1890s using lumber and timbers from local forests. The school was established in 1891 and opened in 1893. This boarding school was relatively small (150 students and 5 staff in 1899). The school closed in 1941. More than 2,000 students were admitted during the existence of the school.

Army Air Force Radio Technical School

The Army Air Force Radio Technical School was activated on November 30, 1942, to conduct technical training for U.S. Army Air Forces. The 1000 Technical School Squadron (Special) provided technical training to personnel, including radio interception techniques and radio maintenance and operations. Housed in Building 23, it functioned as a sub-base of the radio school at Truax Army Airfield in Madison, Wisconsin, which itself was part of Central (later Eastern) Technical Training Command. The radio school at Tomah was inactivated on April 1, 1944. The facility was transferred to Air Technical Service Command on April 30, 1944. It was then transferred as inactive to the U.S. Army Corps of Engineers on April 1, 1946, for disposition. The airfield associated with the school was turned over to civil control through War Assets Administration (WAA).

Inspection of Tomah VA Building 23

An in-depth, nondestructive inspection of Building 23 was conducted on October 25–26, 2022. Accepted inspection techniques commonly used for wood structures are

Figure 1—Building 23, Tomah VA Medical Center.

Table 1—Species of the samples collected on-site

Sample no.	Common name	Species
1	Douglas-fir	*Pseudotsuga menziesii*
2	Red pine	*Pinus resinosa*
3	White pine	*Pinus strobus*
4	Red pine	*Pinus resinosa*
5	Douglas-fir	*Pseudotsuga menziesii*
6	Douglas-fir	*Pseudotsuga menziesii*
7	Red pine	*Pinus resinosa*
8	Red pine	*Pinus resinosa*

discussed in detail by White and Ross (2014). The simplest method for locating deterioration in wood members is visual inspection. An inspector observes the structure for signs of actual or potential deterioration, noting areas that require further investigation. Visual inspection is useful for detecting intermediate or advanced surface decay, water damage, mechanical damage, or failed members. Visual inspection cannot detect early-stage decay or deterioration.

During visual inspection, the inspector looks for several key indicators: fruiting bodies (evidence of advanced decay), staining or discoloration of members (indicators of water damage), evidence of insect activity (holes, frass, and powder posting), plant or moss growth in a member, deep checks or splits, and failed or missing members.

In our visual inspection of the wood members of Building 23, we specifically looked for

1. evidence of water intrusion and subsequent damage, especially where the timbers were in contact with the foundation and other areas where the wood members were compromised, and
2. evidence of structural failure of the timbers.

Wood Species Identification and Properties

Building 23 is a wood-framed structure. Based on its age, we believe it was constructed mainly from lumber and timbers from local and regional tree species. Samples from timbers and lumber in the structure were collected and sent to FPL for species identification. Specimens were either eastern white pine, red pine, or Douglas-fir (*Pinus strobus*, *Pinus resinosa*, or *Pseudotsuga menziesii*, respectively*)*. Eastern white and red pine are species that grow in the surrounding area. Douglas-fir grows in the western United States and is commonly used in structural applications. We believe that this species was not part of the original structure but was used in later repairs or building modifications. Table 1 lists samples collected on-site, and Table 2 summarizes some important physical and mechanical properties of these three species. Markwardt and Wilson (1935) summarized one of the first studies at FPL (dating to 1910). The study was designed to establish the properties of 164 species of wood grown in the United States. The test methodologies developed at FPL as part of this fundamental study serve as the basis for the current standardized methods for establishing baseline properties.

Significance of Effect of Decay on Mechanical Properties of Wood

The presence of deterioration caused by decay has significant effects on various properties of structural timbers. The following sections summarize the effects of decay on various strength properties of wood, and Table 3 references the early scientific literature on these effects.

Toughness (Impact Bending)

Toughness, the ability of a wood member to withstand shock loading, is generally considered to be the strength property most affected in early stages of decay. Research dating to 1954 indicates that a loss of only 1% in weight corresponds to a toughness loss of up to 50%.

Static Bending

Research dating to the 1930s has been conducted on modulus of elasticity, modulus of rupture, and work-to-maximum-load in bending mode. Reported results indicated a significant loss in modulus of rupture (strength) after wood had decayed.

Other Strength Properties

Research has shown that compression perpendicular to the grain, compression parallel to the grain, tension parallel to the grain, shear parallel to the grain, and tangential hardness are also impacted by deterioration caused by decay.

Results

Based on our visual inspection, we found the building's condition to be cause for immediate concern. The basement of the building has considerable water damage. The water damage can be seen throughout outside walls, basement internal walls, timber beams, wood framing members, and wooden floors. Figure 2 shows one of the outside walls where a crack extends from the foundation to the roof. Figure 3 shows an exterior view of the building's foundation. Note that the foundation wall is bowing outward.

Water damage was observed in most rooms. Room 02333 presented the worst damage in the building, with severe wood decay and wood and paint discoloration, both caused by high moisture and humidity levels. Figures 4 and 5 show two of the damaged timber beams, and Figure 6 shows water infiltration on the floor system above the basement. Room 02336 was also severely affected by water damage, with evident mold, discoloration, and deteriorated members (Figs. 7 and 8). In addition to the water damage, mechanical failures can also be observed in the basement of the

Table 2—Some physical and mechanical properties of clear wood (no decay) from eastern white pine, red pine, and Douglas-fir species.[a]

		Specific gravity		Modulus of elasticity ($\times 10^6$ lb/in^2)		Bending strength (lb/in^2)		Compression strength, perpendicular to grain (lb/in^2)	
Common name	Scientific name	Green	12% MC	Green	12% MC	Green	12% MC	Green	12% MC
Eastern white pine	*Pinus strobus*	0.34	0.35	0.99	1.24	4,900	8,600	220	440
Red pine	*Pinus resinosa*	0.41	0.46	1.28	1.63	5,800	11,000	260	600
Douglas-fir	*Pseudotsuga menziesii*	0.45	0.48	1.56	1.95	7,700	12,400	380	800

Table 3—Estimated values for strength losses in softwoods and hardwoods at early stages of decay (indicated by weight loss) by brown-rot and white-rot fungi as a percentage of the value for nondecayed samplesa,b

	Strength property loss (%)										
				Static bending							
Approx. weight loss (%)	Toughness	Impact bending	General bending strength	Work to max. load	MOR[c]	MOE[c]	Compression perpendicular (radial)	Compression parallel	Tension parallel	Shear parallel	Hardness
Brown-rot											
Softwoods											
1	57	20–38	—	—	—	—	—	—	—	2	—
2	—	20–50	5	27	13–50	4–55	18–24	10	23–40	—	—
4	75	25–55	—	—	—	—	25–35	—	—	6	7
6	—	62–72	16	—	61	66	48	25	60	—	—
8	—	78	—	—	—	—	48–60	—	50	15	21
10	—	85	36	—	70	—	66	45	—	20	—
Hardwoods											
1	—	6–27	—	—	—	—	—	—	—	—	—
2	36	31–50	—	54	32	—	6–10	—	56	—	—
4	—	60–70	—	69	49	—	—	—	—	—	—
6	—	80	—	75	61	—	16–25	—	—	—	—
8	—	9–89	13–34	—	—	—	19	—	82	—	—
10	60	70–92	—	—	—	—	—	—	—	—	—
White-rot											
Softwoods											
1	55	—	—	—	—	—	—	—	—	—	—
2	—	—	—	—	—	—	10–20	—	4–38	—	—
4	—	—	—	—	—	—	—	—	8–43	—	—
6	75	—	—	—	—	—	32–61	—	10–49	—	—
8	—	—	—	—	—	—	—	—	14–58	—	—
10	85	—	—	—	—	—	—	—	20–63	—	—
Hardwoods											
1	—	21	—	—	—	—	4	—	—	—	—
2	—	26	—	28–35	13–14	4	5	—	22–42	—	—
4	70	44	—	38	20	—	—	—	17–44	—	—
6	75	50	—	45–53	20–27	10	12–27	14	12–58	—	18
8	—	—	—	—	—	—	—	—	14–49	—	
10	85	60		58	24	14	35	20	20–50		25

[a]From Wilcox (1978). Values obtained from published experimental results and adjusted to equivalent weight loss levels.
[b]Sources: Brown (1963), Cartwright and others (1931), Gillwald and Michalak (1963), Hartley (1958), Henningsson (1967), Kennedy (1958), Kennedy and Ifju (1962), Kubiak and Kerner (1963), Mizumoto (1966), Mulholland (1954), Pechmann and Schaile (1950), Richards (1954), Scheffer (1936), Toole (1971), and Wilcox (1968).
[c]MOR, modulus of rupture; MOE, modulus of elasticity.

Figure 2—Outside wall. Note crack that extends from the foundation to the roof.

Figure 3—Outside wall. Note outward bowing of the foundation.

Figure 4—Room 02333, decayed timber beam and water-damaged floor system.

Figure 5—Room 02333, decayed timber beam.

Figure 6—Room 02333, water-damaged floor system.

Figure 7—Room 02336, water damage.

Figure 8—Room 02336, wall damage.

Figure 9—Room 02305. Note horizontal split in timber beam.

Figure 10—Room 02305. Note horizontal split in timber beam (upper right of photo).

Figure 11—Room 02305. Note that bolt is not in contact with the timber member.

Figure 12—Room 02305. Member shifting off-center.

Figure 13—Room 02305. Note horizontal splits surrounding bolt.

building. Figures 9 and 10 show two wood beams in room 02305 with splitting in the neutral axis going all the way along the longitudinal direction of the beam. Although surface checking is common in wood members, the magnitude of splitting we observed indicates a horizontal shear failure. The horizontal shear capacity of this timber is severely compromised.

Examination of timbers in room 02305 revealed that several bolts and washers were no longer in contact with the timber (Fig. 11), which may indicate internal deterioration of the timber. We also observed some shifting of members and gap openings (Figs. 12 and 13).

Conclusions

The following conclusions are based on our visual inspection of Building 23, Tomah VA Medical Center:

1. Many structural members in Building 23 are deteriorated.
2. Several areas of decay are evident, but with the state-of-the-art in timber inspection, an accurate in-place determine of the extent to which the decay has spread would be difficult.
3. FPL has no data or published reports that specifically relate to design values for decayed wood. The results of several publications relating to the stiffness and strength of nondecayed and decayed clear-wood specimens are summarized in this report. Based on those studies, we assume that decayed wood has zero load-carrying capacity.
4. We offer no conclusions related to the stiffness or strength of decayed timbers in Building 23.
5. We can state with certainty that the load-carrying capacity of the building has been compromised, but the residual load-carrying capacity is unknown.
6. It is difficult to estimate the quantity or quality of recoverable material from the timbers. Many of the members are deteriorated, and they should not be reused in any load-bearing application.

Recommendations

1. If Building 23 is dismantled and reuse of the materials is desired, then each member should be evaluated using nondestructive assessment procedures.
2. None of the members should be reused in any load-bearing application.

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