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# Nondestructive Testing Technique to Quantify Deterioration from Marine Borer Attack in Sitka Spruce and Western Hemlock Logs

## Observations from a Pilot Test


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## Abstract

Stress-wave nondestructive evaluation (NDE) techniques are used widely in the forest products industry—from the grading of wood veneer to inspection of timber structures. Inspection professionals frequently use stress-wave NDE techniques to locate internal voids and decayed or deteriorated areas in large timbers. Although these techniques have proven useful, little information exists concerning the relationship between stress-wave parameters and deterioration observed as a consequence of marine borer attack. In this pilot test, we examined the relationship between stress-wave transmission time and the quality of wood in Sitka spruce and western hemlock logs that had varying degrees of deterioration as a consequence of attack from marine borers. Stress-wave transmission time, perpendicular to grain, was measured at several locations on each log. The logs were then sawn into lumber, which was then visually evaluated. A relationship was observed between stress-wave transmission time and deterioration of the logs and the yield of lumber from the logs.

Keywords: Nondestructive testing, Sitka spruce, western hemlock, marine borer, stress waves

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# Development of a Nondestructive Testing Technique to Quantify Deterioration from Marine Borer Attack in Sitka Spruce and Western Hemlock Logs

## Observations from a Pilot Test

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## Introduction

Nondestructive evaluation (NDE) has the potential to be of value in Alaska. Many of the major population centers in Alaska are located on the Pacific Ocean. Sawmills in the region often transport logs from harvest areas to mill location via waterways. Once at the mill the logs may be stored for short periods of time in saltwater. These logs may be subject to deterioration from a variety of organisms, including decay fungi and marine borers. NDE methods have the potential to provide sawmills with a method to identify logs that are deteriorated and are not suitable for production of a lumber product. Any NDE method that has the potential to better define the quality of logs and cants is of value to the industry.

Stress-wave nondestructive evaluation (NDE) techniques are used in the forest products industry—from the grading of wood veneer to inspection of timber structures. Inspection professionals use stress-wave NDE techniques to locate internal voids and decayed or deteriorated areas in large timbers. Although these techniques have proven useful, little information exists concerning the relationship between stress-wave parameters and deterioration observed as a consequence of marine borer attack in Sitka spruce and western hemlock logs. The pilot study summarized in this technical note was conducted to examine the potential for using stress-wave NDE techniques to identify deterioration in Sitka spruce and western hemlock logs.

## Materials, Methods, and Observations

Seventeen Sitka spruce and 18 western hemlock logs were obtained from a local sawmill in Alaska and shipped to Michigan Technological University, Houghton, Michigan, for this pilot study. A commercially available stress-wave timing unit (Metriguard Model 239 A) was used to measure stress-wave transmission time, perpendicular to grain (perpendicular to a specimen's fiber axis), at various points along each log specimen. A detailed description of the test setup and results obtained from its use are described in the references. A stress wave was induced by striking a specimen with a hammer instrumented with an accelerometer that emits a start signal to a timer. An additional accelerometer on the opposite side of the specimen sensed the leading edge of the propagating stress wave and sent a stop signal to the timer. The elapsed time for the stress wave to propagate between the accelerometers was recorded. This test was performed near the butt end of each log. The diameter of each log was determined, and the stress-wave transmission time (on a per-length basis, microseconds per foot) was calculated. Log diameters ranged from 12.8 to 23.5 in. (325 to 597 mm). A visual assessment based on the presence of marine borer holes and visible deterioration from decay of each log was then completed. Figures 1–3 show typical log sections that have varying levels of deterioration. Log specimens with no visible evidence of marine borer or fungal attack were labeled as having no deterioration, specimens showing some visible evidence of attack were identified as being slightly deteriorated, and those with approximately one half of their cross section showing deterioration were labeled severely deteriorated.

Each log was then sawn into lumber. A visual assessment of each lumber specimen was completed, and an estimate of lumber yield (based on a Decimal C scale) calculated. This was accomplished using accepted visual grading criteria.

Tables 1–3 summarize results obtained from our tests of Sitka spruce and western hemlock logs. Note that stress-wave times increased with the presence of deterioration for logs from both species. This is in close agreement with results observed in other studies.

## Conclusions and Recommendation

Based on the results of this study, we conclude the following:

1. Stress-wave transmission times in Sitka spruce and western hemlock logs, measured across the grain, are affected by the presence of deteriorated wood from marine borer and decay attack.
2. Sitka spruce and western hemlock logs having elevated stress-wave transmission times yield significantly lower volumes of usable lumber.

Because these results are encouraging, we recommend a larger study on the strength of the relationship. Such a study should include a much larger sample than that used in the study reported here as well as specimens from several sources.

## Additional Information

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**Figure 1—Specimens showing no visual indication of deterioration.**


**Figure 2—These specimens were labeled as slightly deteriorated. Note visual evidence of marine borer attack.**


**Figure 3—Severely deteriorated specimens. Note that nearly half the cross section shows visible signs of deterioration.**

**Table 1—Stress-wave transmission times of Sitka spruce and western hemlock logs perpendicular to stem (µsec/ft).**

| | Species | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sitka spruce | | | | | | Western hemlock | | | | | |
| | None | | Slight | | Heavy | | None | | Slight | | Heavy | |
| Visual deterioration | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 |
| Readings (µs/ft) | 202 | | 251 | 247 | 309 | 545 | 241 | | 393 | 362 | 336 | 336 |
| | 223 | 221 | 243 | 295 | 594 | 328 | 271 | 258 | 253 | 289 | 256 | 255 |
| | 223 | 240 | 228 | 229 | 457 | 236 | 217 | 207 | 213 | 212 | 627 | 1,075 |
| | 264 | 272 | 222 | 230 | 372 | 357 | 300 | 305 | 249 | 216 | 335 | 377 |
| | 355 | 210 | 205 | 230 | 246 | 273 | 269 | 252 | 309 | 309 | 263 | 323 |
| | 199 | 196 | 217 | 235 | | | 348 | 247 | 341 | 235 | 332 | 315 |
| Average | 237 | | 236 | | 372 | | 265 | | 282 | | 403 | |
| Standard deviation | 45 | | 22 | | 117 | | 39 | | 59 | | 223 | |
| Minimum | 196 | | 205 | | 236 | | 207 | | 212 | | 255 | |
| Maximum | 355 | | 295 | | 594 | | 348 | | 393 | | 1,075 | |

**Table 2—Average stress wave times of Sitka spruce and western hemlock logs, perpendicular to stem (µsec/ft).**

| | | Stress wave transmission time (µs/ft) | |
|---|---|---|---|
| Species | Visual deterioration | Average | (Min, max) |
| Sitka spruce | None | 237 | (196, 355) |
| | Slight | 236 | (205, 295) |
| | Heavy | 372 | (236, 594) |
| Western hemlock | None | 265 | (207, 348) |
| | Slight | 282 | (212, 393) |
| | Heavy | 403 | (255, 1075) |

**Table 3—Comparison between Decimal C scale stick predicted lumber yield and measured for sound, slightly deteriorated and heavily deteriorated Alaskan western hemlock and Sitka Spruce.**

| | | | | Potential lumber yield (%) | | |
|---|---|---|---|---|---|---|
| Species | Condition | Number of logs | Average log diameter (in. (mm)) | Decimal C scale | Measured | Yield |
| Sitka spruce | Sound | 6 | 18.6 (472) | 103 | 113 | 109 |
| | Slight deterioration | 6 | 15.7 (399) | 78 | 80 | 102 |
| | Heavy deterioration | 5 | 17.3 (439) | 87 | 68 | 78 |
| Western hemlock | Sound | 6 | 17.4 (442) | 106 | 96 | 90 |
| | Slight deterioration | 6 | 17.6 (447) | 99 | 77 | 77 |
| | Heavy deterioration | 6 | 16.9 ( 429) | 90 | 35 | 39 |