CABLING AND BRACING

by Alex L. Shigo and Robert Felix

Abstract. Dissections of tree sections that contained screw rods, lag screws and bolts, and the use of the Shigometer method on living trees that have rods and screws, gave new information and confirmed preliminary data on cabling and bracing published in this Journal. When hardware is put into sound wood, the discolored wood associated with the wound is compartmentalized. When hardware penetrates decayed wood, decay spreads out to the previously sound wood surrounding the decayed wood. This reduces the holding power of the hardware. Where there is decayed wood, rods or eye bolts should go entirely through the stem and oval washers should be placed on each end.

Proper cabling and bracing will increase the time that a tree remains safe, healthy, and attractive. Improper cabling and bracing will increase the spread of decay in a tree, thus weakening the tree and creating more problems than benefits. There are no simple answers that can be applied to every cabling and bracing job, but there are basic guidelines that will help you make the best decision for each job.

When hardware is put into a tree, the tree responds to the wound. By understanding how a tree is constructed, and how it responds to wounds, you can maximize the benefits of cabling and bracing and minimize the injury caused by wounding and by the spread of decay that may already be in the tree.

The purpose of this paper is to give additional information and to confirm preliminary information on cabling and bracing presented in this Journal (Felix and Shigo 1977). Since the earlier paper, many additional tree sections containing various types of hardware have been dissected. The Shigometer® [1] method (Shigo et al. 1975) was used on living trees containing hardware to determine the internal condition of the wood beneath and around the hardware.

For the purpose of inserting rods, eye bolts, and lag screws, it is essential to first review what is meant by compartmentalization of discolored and decayed wood in living trees. Without an understanding of compartmentalization, it would be difficult to describe the details of internal changes in wood after a wound is inflicted into sound or decayed wood.

Basics of Compartmentalization. Compartmentalization is a complex tree survival process by which injured and infected wood is walled off, isolated, or confined. After wood is injured and infected it is never replaced, repaired, or restored to its previous healthy state. In this sense, a tree does not heal wounds into the wood.

There are two major parts to the compartmentalization process: Part 1, in which the injured and infected wood is walled off to the smallest volume within wood present at the time of wounding; Part 2, in which the injured and infected wood associated with the wound is walled off from new wood that will continue to form after the wound.

A model called CODIT (Compartmentalization Of Decay In Trees) has been developed to help clarify the complex three-dimensional process (Shigo and Marx 1977). In the model, each growth ring is considered a "tree' and each "tree" is divided into rooms or compartments. After wounding into the wood, the defense systems of these "trees" are activated to minimize the number of compartments that are infected (Part 1), and later to isolate or separate the infected compartments within the wood present at the time of wounding from the newly forming wood (Part 2). Part 1 is represented by Walls 1, 2, and 3 of the CODIT model, and Part 2 by Wall 4. Walls 1 limit vertical spread, Walls 2 limit inward spread, and Walls 3 limit outward or lateral spread. Wall 4 confines the injury and infection to the wood present at the time of wounding.

[1] The Shigometer is a registered trademark for a pulsed-current meter manufactured by OSMOSE, Buffalo, N.Y. The use of trade, firm, or corporation names in this paper does not constitute an official endorsement or approval by the U.S. Department of Agriculture, the Forest Service, or the National Arborists Association.

Dissections of Tree Sections

More than 25 sections of large trees that contained screw rods and bolts were sent to the USDA Forest Service's Forestry Sciences Laboratory at Durham, New Hampshire, by several cooperating professional arborists. The species included red maple, black cherry, American elm, hickory, white pine, and red oak. Hardware in the trees included lag bolts, forged bolts, eye bolts, and screw rods. The samples were dissected carefully and the cut surfaces were sanded smooth to show the details of the internal condition of the wood.

Shigometer Tests. The study trees included six large American elms and an American ash that had been cabled and braced with lag screws and screw rods approximately 12 years ago. The trees were located on the campus of the Phillips Andover Academy, Andover, Massachusetts. A lift device was used to get to the hardware high in the trees (Figure 1). A hole 3/32 inch in diameter was drilled with a battery-powered drill to a depth of 7 inches at several points near the hardware. A twisted-wire probe attached to the Shigometer was inserted slowly into the hole. An abrupt decrease in electrical resistance was indicated as the probe tip passed from sound to decayed wood. In some elm trees, dark liquid flowed out of the drill holes, and a second hole had to be drilled in 1-inch increments. A measurement with the wire probe was made after each additional 1-inch increase in depth. In some trees, the wood was so decayed that the position of the decayed wood was obvious by the ease of penetration by the drill bit. But, even when this occurred, the wire probe was used to determine the exact boundary of the decayed wood.

Observations

Dissections of tree sections. When lag screws were put into healthy, sound wood, the discolored wood associated with the wounds was compartmentalized to small volumes in nonheartwood forming trees (Figure 2) and in heartwood forming trees (Figure 3). Some purple stain typical of the iron-tannin reaction in wood was obvious in the oaks and hickory (Figure 4).

The discolored wood associated with the lag screws was walled off by Walls 1, 2, and 3 in sound wood. In one hickory, the cambium formed Wall 4, which separated the tissue present at the time the lag was inserted from the tissue that formed subsequently (Figure 4).

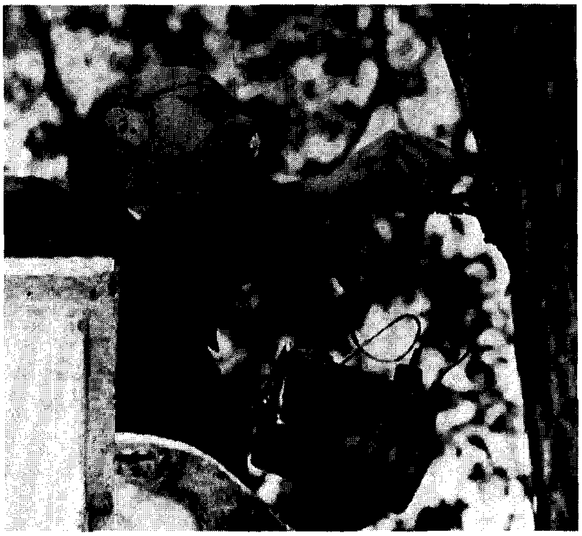

Figure 1. Inspection and Shigometer testing of large elms that were cabled and braced on the campus of the Phillips Andover Academy in Andover, Massachusetts.

When lags and rods touched internal decayed wood, the decay spread out to the tissues surrounding the hardware (Figures 5 and 6). When the tree was growing rapidly, the decayed wood was compartmentalized and the new, sound tissues that continued to form enveloped the protruding eye bolts, hooks, and nuts on the hardware (Figure 5 and 6). When a long screw rod was put through two large limbs in an elm, decay was penetrated in each stem (Figure 7). The large washer on each end continued to support the rod (Figure 8).

The open end on one lag screw was screwed into the bark and caused a large dead spot on the trunk (Figure 9).

Shigometer tests. In all six elms tested, some wetwood or decayed wood was associated with every rod. But, from 1 to 4 inches of sound wood had developed since the rods were inserted, and this wood was still holding the hardware firmly in place. This was similar to the elm section shown in Figure 5. The wood surrounding the rod in the ash was sound.

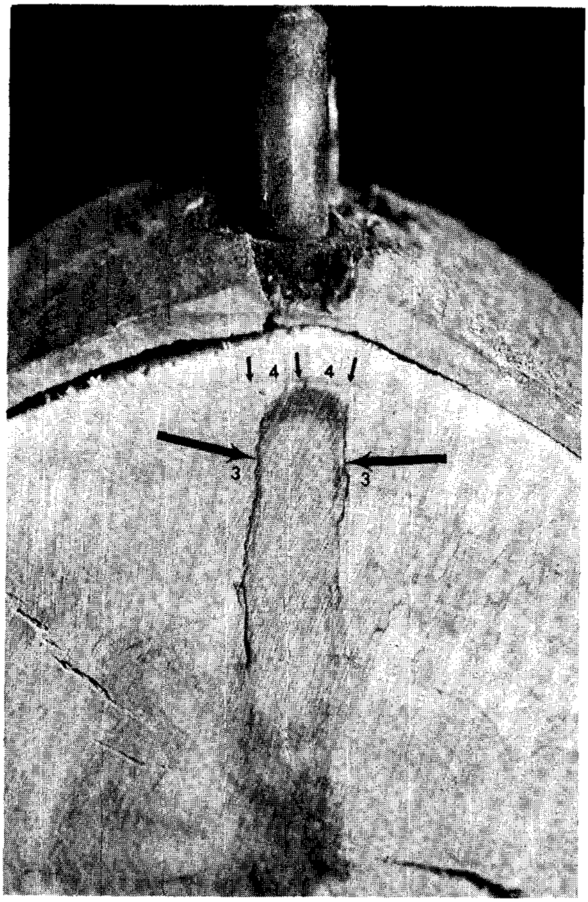

Figure 2. Lag screw after 4 years in a red maple. The discolored wood associated with the wound was well compartmentalized by Walls 3 and 4 as shown on this cross-sectional cut. There was a long bark crack associated with the wound.

Recommendations

Before inserting a screw rod, lag screw, eye bolt or other types of hardware in a tree, determine whether decayed wood is present. The Shigometer can be used for this. In some cases the drilling technique alone will indicate the presence of advanced decayed wood. When hardware is being used to supplement the holding strength of a filled cavity, remember that the center of the tree does have decayed wood, and do not dead-end hardware in such a tree.

Wood screws and rods, eye bolts, and screw lags can be inserted safely in sound, noninfected wood and the wood injured by the hardware will be compartmentalized to a small volume.

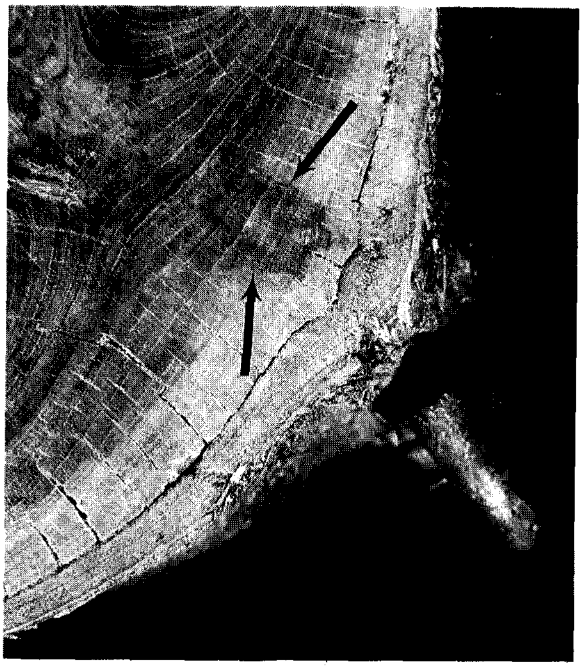

Figure 3. Discolored wood associated with a lag screw wound into the heartwood of a black cherry. The discolored wood was well compartmentalized within the heartwood. The lag was inserted 7 years ago.

Do not turn screw lags so tightly into the tree that the hooked end cuts into the bark. This will cause a large dead spot. Decay could spread into the wood around the lag and the holding power of the screw lag would be greatly reduced.

Do not put lags into decayed wood! Where there is decayed wood, insert an eye bolt or screw rod entirely through the trunk and place round or oval washers at each end. Trace or scribe the bark to allow the washers to fit against the wood. Do not trace into the wood. Do not point the ends of the traced bark. Do not dead-end screw rods in decayed wood.

There are many trade-offs in cabling and bracing. When hardware is put into sound, noninfected wood, a long-term investment in the health and safety of the tree is made. When hardware is put into decayed wood, the trade-offs must be considered. Some decay will spread out to the previously noninfected wood. But the tree may live longer and be more safe and attractive for a longer time. How long will depend on many factors: the age and position of the tree, wounds, root problems, etc.

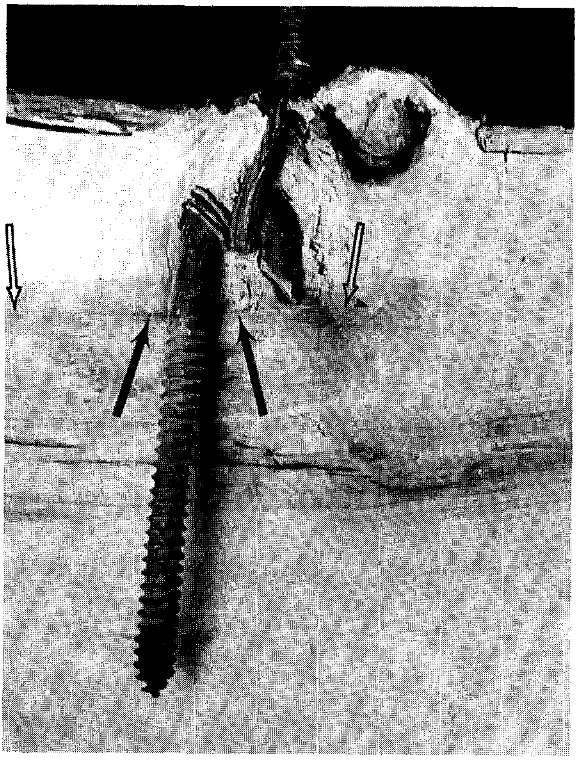

Figure 4. After 30 years, this lag in a hickory was well sealed off. Some purple stain was in the wood due to the iron-tannin reaction. The large open arrows show Wall 4, which formed the year of insertion. A small amount of decayed wood developed but was confined to the inner part of Wall 4 (arrows). Some purple iron stain developed in a few growth rings that formed after wounding.

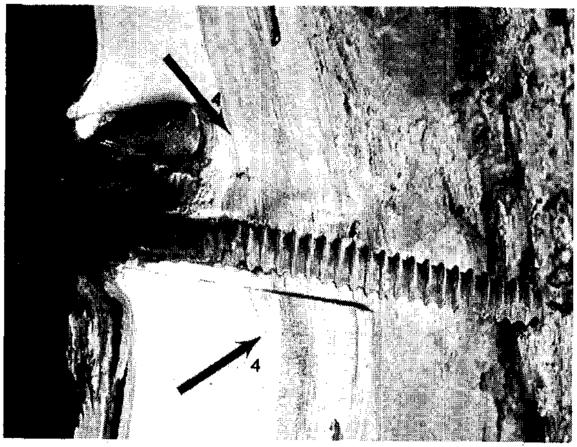

Figure 5. This lag was put into decayed wood in this American elm 20 years ago. The decay spread out to Wall 4, which developed after insertion (arrow). The holding power of the lag was only due to the last inch of the lag and the incasement of the hook end in the tree.

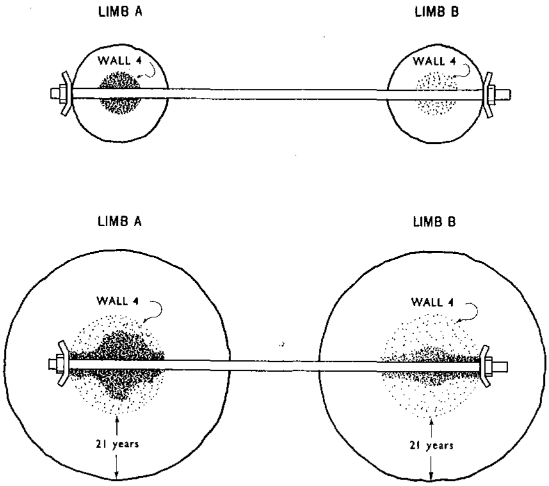

Figure 6. Diagram of two limbs of an elm that received a long screw rod. At the time of treatment (top), Limb A (Figure 7) had more decay than Limb B (Figure 8). Limbs A and B also are shown 21 years after treatment (bottom). Note the spread of decay to Wall 4, which formed after the rod was inserted.

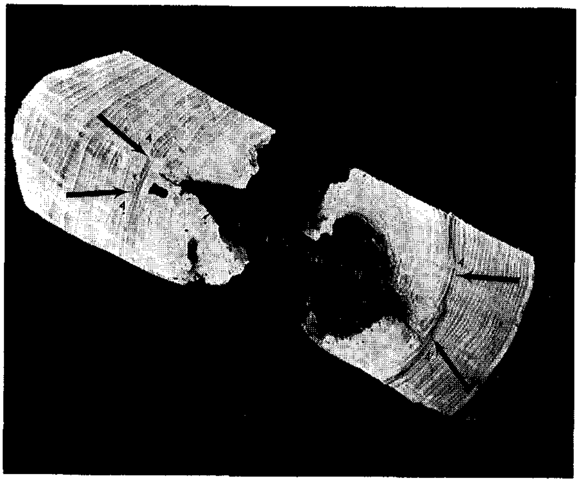

Figure 7. In Limb A, the decay spread to Wall 4 (arrows), which formed after treatment. The washer, which was enveloped at Wall 4 (bottom), maintained the holding power of the rod.

Cabling and bracing is not a cure all. Decayed trees that are braced with lags, eye bolts, or screw rods should be checked periodically. After a tree is braced, everything possible should be done to maintain a high level of vitality.

Acknowledgment

We thank the Frost and Higgins Company of Boston, and especially William Rae and Richard Burns for their help in locating trees and for the use of their aerial lift. We also thank the many arborists who provided samples.

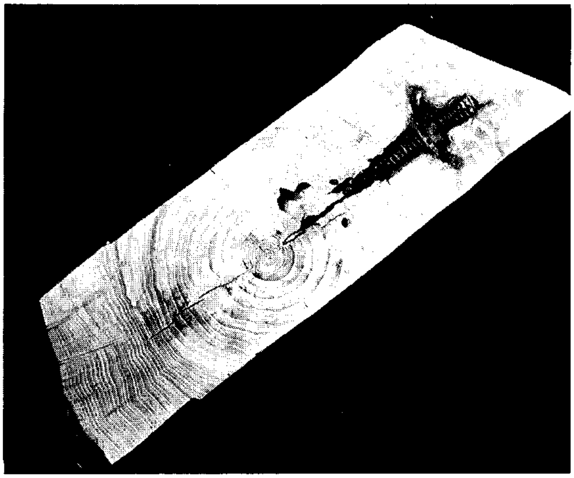

Figure 8. In Limb B, the large washer on the screw rod was well compartmentalized and continued to maintain support. Note the decay around the screw rod.

Figure 9. The hooked end of this lag injured the bark and caused a large dead spot (arrows). Decay developed around the screw. The dead spot slowed the compartmentalization process. The lag was inserted 8 years ago.

Literature Cited

Felix, Robert, and Alex Shigo. 1977. *Rots and rods.* Journal of Arboriculture 3:187-190.

Shigo, Alex, and Harold Marx. 1977. Compartmentalization Of Decay In Trees (CODIT). U.S. Dep. Agric. Inf. Bull. 405. 73 p.

Shigo, Alex, Walter Shortle, and Julian Ochrymowych. 1977. Detection of active decay at groundline in utility poles. USDA For. Serv. Gen. Tech. Rep. NE-35. 26 p.

Chief Scientist,
U.S. Forest Service
Durham, New Hampshire, and
Executive Secretary
National Arborists Association
Wantagh, New York, respectively