Concentrated Boron Rod Diffusion in White and Red Oak Bridge Ties

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ABSTRACT

Currently, most hardwood bridges ties are Boulton conditioned prior to application of an oil borne preservative. However, it has been shown that this process leaves high moisture content within the center of the bridge ties. Since moisture content remains high, this fosters an environment for the development of fungal growth. Thus, the railroad industry has experienced bridge tie decay ranging from 7 years or less – reducing bridge tie service life. Therefore, to address this issue, this study was conducted to examine the efficacy of high concentrated boron (~96%) rod diffusion in Boulton conditioned bridge ties. To examine the diffusion of concentrated boron rods in hardwood, a field test was conducted with white and red oak bridge ties that were Boulton conditioned and treated per AWPA standards. The bridge ties were drilled and implanted with high concentration boron rods and placed in an area that simulated a bridge deck environment then reexamined after 13 months and 16 months, respectfully. After prolonged exposure in the simulated bridge tie environmental, the concentrated boron rods completely diffused and will continue to diffuse so long as moisture content remains above 28%. This study, with hardwood bridge ties, for the first time, reveals that high concentration boron rod gets good diffusion in hardwood bridge ties, which remains within the timber after treatment, assuring that diffusion of the boron meets specified requirements.

Keywords: Moisture Content, Concentration, Diffusion, Boron Rods

INTRODUCTION

Bridge ties are subject to the same fungal growth environments and decay zones as cross ties. Most bridge ties are treated with the Bouton process and, however, due to the size of the bridge ties, a larger untreated center zone remains in the bridge ties after treatment (Lloyd et al., 2014). From previous studies, it is known that wood fibers treated with an adequate amount of borate will extend the service life of bridge ties and cross ties (Amburgey et al., 2003).

The Boulton treatment process artificially seasons a bridge tie by immersing it in an oil-borne preservative under a vacuum to pull sap water out of the wood fiber. The first three inches of the bridge tie is brought down to 50% moisture content (AWPA Standard). This allows space in the wood fiber for the specified oil-borne preservative to penetrate and provide a treated outer barrier. Since most bridge ties are 8”X10” to 10”X10” and greater in cross section, there remains a greater than 50% moisture content in the center zone area of the bridge ties. Seasonal weathering, especially in high decay zones, will cause checking that can break the oil-borne preservative barrier, exposing untreated wood fiber to fungi and, in some cases, insect attack. Therefore, to mitigate bridge tie decay dual treatment systems have been established to extend bridge and cross tie service life (Amburgey et al., 2003).

Since current methods of dual treatment are impractical due to insufficient preservative retention, novel methods are being developed (Lloyd et al., 2014). One of these methods includes the use of boron rods instead of liquid borate. High concentration boron rods (96%+) have proven successful treatment options in the utility pole industry for over 30 years (Cabrera and Morrell, 2009). It is also considerable to note that the higher the boron concentration and moisture content in the wood fibers the better the diffusion (Cabrera and Morrell, 2009). As previously stated, bridge ties have a larger untreated decay zone with a high moisture content (over 40%), which could potentially allow for a more effective method to treat the center of bridge ties. Therefore, the following study examined the diffusion of high concentration boron rods into Red and White Oak bridge ties.

METHODS

Two timber species were selected for the initial test - Red Oak (Quercus rubra) and White Oak (Quercus Alba). The bridge ties sizes were 10”X10”X10’ for the Red Oak and 9”X10”X10” for the White Oak. The bridge ties were in a “Green” condition and were delivered to Appalachian Timber Services located in Sutton, WV. It was estimated that the bridge ties had been sawn 2 to 3 weeks prior to moisture content testing, boron rod application, and treatment.

Since moisture content is needed to diffuse borates, the bridge tie moisture content was checked prior to treatment. The intent was to get a general range of how much moisture was in the bridge ties. Three moisture gradient zones were established from the top surface of the bridge ties, tie surface to the two-inch depth, the two-inch depth to four-inch depth, and four-inch depth to six-inch depth. Moisture contents were checked by using the oven dry method (Reeb and Milota, 1999). The average moisture content prior to treatment was 79% in the White Oak and 93% in the Red Oak, the table below shows the moisture gradient zones.

Table 1. Moisture Content (MC) Gradient

Bridge Ties Species	First 2 Inch Gradient MC	Second 2 Inch Gradient MC	Third 2 Inch Gradient MC	Average MC
Red Oak	93%	97%	91%	93%
White Oak	77%	82%	80%	79%

The bridge ties had six ports for the boron rod delivery and holes were drilled 13/16” diameter by 6” long. Spacing started from the bridge tie centerline - 10 inches, 20 inches and 40 inches from the center line on both sides (Figure 1). Six boron rods ¾” by 4” long were inserted into the 13/16” ports (Wood Care Systems-BOR8RODS). For testing diffusion, the borate acid equivalent (BAE) loading was in the .17lbs/ft^3 to .16 lbs/ ft^3 range - providing a sufficient borate reservoir in the bridge ties. The application ports were plugged with industry standard 3/4'” by 1-1/4” threaded plastic plugs (Figure 2).

Fig. 1 Boron Rod Drilling Pattern with Plugs

Fig. 2 Plugged Bridge Ties to Treat

The bridge ties were Boulton conditioned to get the 50% moisture content as required by AWPA Standards then pressure treated to 8lbs/ft^3. Before and after treatment the boron rods were weighed with negatable weight loss. All twelve plugs stayed intact with no signs of movement. Since the bridge ties had a moisture content of 50% in the outer three inches of the ties, it was assumed there would be adequate moisture for diffusion and moisture contents were not rechecked. The bridge ties were placed in an outside environment to be subjected to natural weathering.

To monitor diffusion, after six months the plugs were removed from all the ports to examine signs of diffusion. A six-inch measuring probe was used to check diffusion. When the measuring probe was inserted in the ports, the boron rods appeared to have a soft texture. All holes showed that the boron rods were diffusing to a three-inch plus depth and one hole revealed almost complete diffusion. The caps were screwed into the ports and the bridge ties were placed back into the outside environment. (Figure 3 & 4)

Fig. 3 6-Month Boron Rod Inspection

Fig. 4 6-Month Boron Rod Inspection

RESULTS

Red Oak Bridge Tie

After approximately 13 months, the red oak bridge tie was taken to a building and stored to insure there was no surface moisture on the bridge ties. The 10”X10”X10’ Red Oak bridge tie was cut into three sections and labeled A, B and C. The 2”X10X10 Outer Board (A), the 3”X10”X10’ Inner Board (B) and the 5”X10X10 bridge tie half, which was sawn through the boron rod ports to check the rod diffusion (C). The center surface of the bridge tie half with rod ports (C) and the outside surface of the Inner Board (B) were checked with curcumin agent indicator.

Physical observation showed that the ports had approximately 80% to 90% of the boron rods diffused and several ports were completely diffused. It also showed that there was ample creosote penetration from the Boulton treatment process. Observation from the curcumin agent indicator on the center surface of the bridge tie half with ports showed diffusion between the centerline 10” to 20” to 40” boron port locations on both sides of the tie (Figure 5). Furthermore, there was an indication that the borate was starting to diffuse into the Outer Board area (A) (Figure 6).

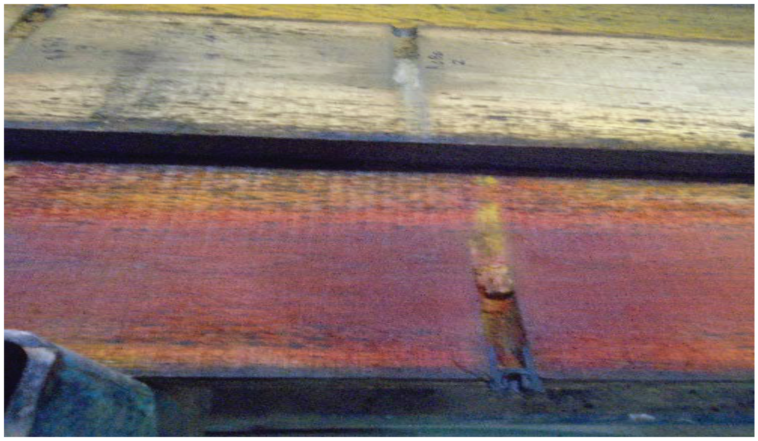

Fig 5 Red Oak Boron Rod Diffusion

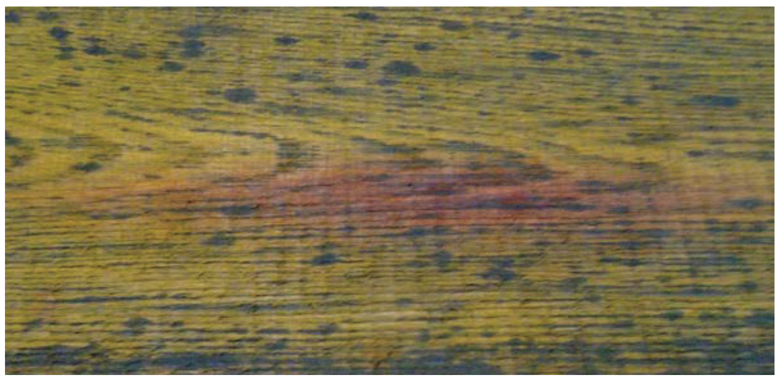

Fig 6 Red Oak Boron Rod Diffusion

White Oak Bridge Tie

Based on the previous observation of boron diffusion in the red oak, it was decided that the white oak would be given more diffusion time. After approximately 16 months, the White Oak bridge tie was taken to a building and stored to insure there was no surface moisture on the bridge tie. The 9”X10”X10’ White Oak bridge tie was sawn into three sections and labeled A, B and C. The 2-1/2”X10X10 Outer Board (A), 3”X10”X10’ Inner Board (B) and the 4-1/2”X10X10 bridge tie half that was sawn through the boron rod ports to check the rod diffusion (C). The center surface of the bridge tie half with rod ports (C) and the outside surface of the Inner Board(B) and the cross-sectional area of the Inner Board (B) were checked with curcumin agent indicator.

Physical observation showed that all the ports had 100% boron rods diffusion. The study also showed that there was good creosote penetration from the Boulton treatment process. Observation from the curcumin agent indicator when applied to a cross-section of the Inner Board(B), confirmed that the borate was diffusing into the Outer Board (A) (Figure 7). Also, the curcumin agent indicator applied on the center board surface of the bridge tie half (C) showed sufficient diffusion between the center line 10” to 20” to 40” boron rod port locations on both side of the bridge tie (Figure 8 - Top Board). Furthermore, there was a good indication that the borate was diffusing into the Outer Board (A)(Figure 8 - Bottom Board).

Fig. 7 White Oak Cross Section Boron Rod Diffusion

Fig.8 White Oak Boron Rod Diffusion Top Board(C)
White Oak Boron Rod Diffusion Bottom Board(A)

CONCLUSION

The results demonstrated that bridge ties treated with the Boulton process, per AWPA Standards, then applied with the high concentration boron rods in the presence of sufficient moisture content center zone in bridge ties enables ample diffusion. With the Boulton process moisture content will be 40% and greater in the bridge tie center after treatment. By applying high concentrated (96.65%) borate rods in the presence of these moisture contents sufficient diffusion can be achieved in the center zone of bridge ties. Indeed, this high concentration of borate reservoir can effectively treat the center portion of the timber and the high moisture content acts as an agent to diffuse the boron.

Furthermore, the application port spacing appeared to be within diffusion ranges of the boron rods. From observations, it appears that the application ports can be reduced to a 13/16” by 5” hole - further reducing strength loss of the bridge tie. The threaded caps with the tooled socket heads stayed in place and only require basic tools to insert, making this process relatively simple and economical to execute. As such, this boron rod system can be applied before or after treatment and to bridge ties in the field.

The results demonstrate that concentrated boron rods can utilize the characteristics of the Bouton process by using the remaining moisture content to diffuse. Clearly, from these observations, there is enough moisture in the Boulton bridge ties to support diffusion over a 6- to 16-month period. With this know adequate borate reservoir available, borate diffusion or movement will continue in the bridge ties as dictated by the moisture content. Therefore, it is apparent that with the required AWPA borate reservoir available and ample moisture content (Boulton process characteristics), the concentrated boron rods will diffuse in bridge ties to extend bridge tie service life and is an additional method to provide dual/supplemental treatment to bridge ties.

REFERENCES

1. Lloyd J, J-W Kim, T Chambers, Cost effective extension of service life of bridge tie (sleeper) – Effectively applying borate during Boulton conditioning and treatment with copper naphthenate IRG Annual Meeting, St. George, UT May 11-12, 2014.

2. Amburgey TL, JL Watt, MG Sanders, Extending the service life of wooden crossties by using pre- and supplemental preservative treatments. 15-year exposure report. Crossties (May/June) 2003, 1-5.

3. Cabrera Y, JJ Morrell, Effect of wood moisture content and rod dosage on boron or fluoride movement through Douglas-fir heartwood, Forest Products Journal Vol. 59, No. 4 2009.

4. Reeb J, Milota M, Moisture content by the oven-dry method for industrial testing. Oregon State University, Corvallis, OR WDKA May 1999.

5. Morrell JJ, CM Sexton, AF Preston, Effect of moisture content of Douglas-fir heartwood on longitudinal diffusion of boron from fused borate rods. Forest Products Journal Vol. 40, No. 4 1990.

TABLE TITLES AND FIGURE CAPTIONS