

## Documenting the Durability and Service Life of Pressure-treated Wood

Stan Lebow

Bessie Woodward

Patricia Lebow

USDA, Forest Service, Forest Products Laboratory  
Madison, Wisconsin

### ABSTRACT

Estimates of service life are increasingly used to compare life cycle costs of building materials. Because of a lack of published data for treated wood, some users assume a relatively low service life for wood in comparison to alternative materials. Such bias against durable wood products may cause alternative materials to appear more economical. This paper discusses options for making additional treated wood service life information available to engineers and others who are comparing construction materials. In the short term, existing data and reports could be summarized and published in a format that is both readily accessible and easily understood by potential users. Examples of long-term durability for previous construction projects could also be reported, although these examples do not necessarily reflect typical service life. Additional long-term data may also be available from exposure tests using large specimens such as posts. Surveys of utilities and government agencies that utilize large volumes of treated products may also provide useful data in the short term. In the longer term, and for newer preservatives, the durability of wood used in recent construction projects could be monitored and the results periodically reported to AWWPA committees.

*Keywords: treated wood, life cycle, service life, long term durability*

### INTRODUCTION

The ability of preservative treatments to greatly extend the useful life of wood products is widely accepted. However, there is currently little published data to quantify the expected increase in service life. The need for service life estimates has increased in recent years as the use of life cycle cost analysis (LCCA) to evaluate alternative construction materials has become more commonplace (US DOT, 2002). The Federal Highway Administration (FHWA) is placing greater emphasis on use of LCCA for projects that involve Federal funding. Although originally only required for projects with estimated costs above \$25 million (US DOT, 2002), LCCA has become more widely used, especially for structurally critical facilities such as bridges. As this concept gains traction, LCCA is becoming more common for non-federally funded projects as well (Al-Wazeer, et al., 2005). There has also been a tendency to increase expectations for the service lives of structures such as bridges. Over the last decade the emphasis on use of green building materials has also increased interest in conducting life cycle assessments (LCA's) to compare the environmental impact of treated wood and alternative materials (Bolin and Smith, 2011). Service life estimates are a key part of evaluating these potential environmental impacts.

It also has become increasingly apparent in recent years that some potential users of industrial wood products have relatively low expectations of their durability. There are at least two possible causes for these low durability expectations. In some cases the user has had direct experience with early failures, and even though such early failures are typically the exception, they can lower expectations of durability. The Washington State Department of Transportation recently proposed discontinuing the future installation of wooden guard rail posts because inspection of some posts showed evidence of decay in less than 15 years (Olson, 2012; WSDOT, 2011). Personnel at utilities also sometimes have lower expectations of pole service life than is warranted based on their pole replacement records (Morrell, 2008; Stewart, 1996).

In other situations, users' low expectations of treated product service life appear to be based on limited anecdotal information. In their report prepared for the National Marine Fisheries Service, Stratus Consulting estimated a service life of only 15 years for treated piles based on the opinion of a single engineering firm (Stratus Consulting, 2006). The 15 year life estimate led the authors of the report to conclude that: "*Treated timber piles are by far the least expensive in terms of unit costs for the purchase of the material and for installation, totaling roughly half the cost of the next least expensive alternative (galvanized steel). However, this cost advantage is lost once the longer expected life of other materials is accounted for, along with the need for fewer piles.*" (Stratus Consulting, 2006). Similarly, reports prepared as part of an evaluation of replacement options for a historic wooden drawbridge apparently utilized anecdotal accounts to conclude that wooden piling would last only 20 – 30 years (URS Corporation, 2011a, b). This relatively short service life estimate was clearly at odds with the demonstrated service life of the existing drawbridge piles, many of which have remained in service since 1925. The report attempted to reconcile this conflict with the statement that "*The long service life of many of the existing piles is due to the use of heavy creosote oil-based preservative not permitted for use today*" (URS Corporation, 2011a). Interestingly, the

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only specific example of early failure of timber bridge components provided in the report was a bridge constructed with an untreated tropical hardwood.

Whether based on limited experience with early failures or anecdotal information, low service life estimates can gain credibility once utilized by state or federal agencies. While it is tempting to criticize estimates based on limited information, use of such estimates is understandable given the lack of published service life data. Accordingly, additional durability/service life data is needed to allow users to more realistically compare treated wood to alternative materials. This paper discusses possible options for obtaining this data.

### DISCUSSION

#### ***Summarize and Publish Available Data***

Perhaps the most expedient way to make additional service life data available is to summarize existing data in a format that is both available and understandable to users. For example, detailed utility pole service life data has been presented to Subcommittee T-4 (Poles) of the American Wood Protection Association on at least 2 occasions (Anon, 1994; Pope, 2004). However, users conducting an internet search for service life data are unlikely to encounter reports attached to the minutes of AWWPA committee meetings. In other cases service life data may have been published in a readily available outlet, but its relevance is not immediately obvious to a user. For example, an article titled “A Cautionary Tale about Weibull Analysis” contains an in-depth statistical analysis of utility pole service life data but does not mention poles in either the title or “Summary and Conclusions” section (Mackisack and R.H. Stillman, 1996). Interestingly, the authors of this report conclude that the service life of utility poles is about 80 – 95 years. Users also might not be aware that data on the durability of some types of commodities could have relevance to other commodities. For example, it may be reasonable to assume that utility pole durability would provide a conservative indication of the durability of terrestrial piles given that the piles are treated to higher retentions with similar preservatives.

#### ***Report on Examples of Lengthy Service Life***

There are accounts of treated wood service life that far exceed the expectations of many treated wood users. For example, foundation piles were reported to be in good condition after nearly 100 years in brackish water in Louisiana (Holt, 1970) and butt-treated cedar utility poles have been in service for over 100 years in Montana (WRCPA). In the latter example, an inspection found that 1355 of the original 1430 poles (95%) were still in service after over 80 years. Admittedly, these types of reports may not reflect typical service life under a broad range of conditions. Using these examples for estimates of service life is somewhat analogous to basing a short service life on a few early failures. However, they do provide evidence that durable wood products can have much longer service lives than commonly believed.

#### ***Representative Inspections***

Perhaps the most useful data on service life of treated wood in a particular application can be obtained by sampling a representative cross-section of those structures. A project of this type has been recently initiated by researchers from the USDA, Forest Products Laboratory, Mississippi State University and others (Wacker and Jalinoos, 2011). This project will evaluate over 100 timber bridges, and the results will be used to forecast the expected service life of timber bridge structures in various climate regions throughout the US. This study may also lay the framework for future monitoring of timber bridges under the FHWA’s Long-term Bridge Performance Program. The obvious downside to this approach for obtaining service life data is the required investment in funding and personnel time.

#### ***Monitoring Projects from Initiation***

The possible perception that certain projects are being hand-selected because they have demonstrated outstanding durability can be minimized by monitoring projects starting at installation. This approach should also allow the collection of treating plant records on preservative formulation, penetration and retention. Prior to the mid 1960’s, AWWPA Service Records Committees actively monitored construction projects for the purpose of obtaining service life data, and periodically reported the results of inspections to the association. For example, the Report of Committee U-6, Pile Service Records published, in the 1965 AWWPA Proceedings, lists over 50 pile installation projects that had been under review. The obvious downside to this approach is the length of time between installation of a project and meaningful service life data. Alternatively, this time frame could be shortened by following projects that were installed in the past, and for which adequate records are available. To avoid the appearance of selecting only favorable or surviving projects for evaluation, the age of the structure should be less than a conservative estimate of service life (i.e. less than 15 years).

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## Commodity-Size Test Specimens

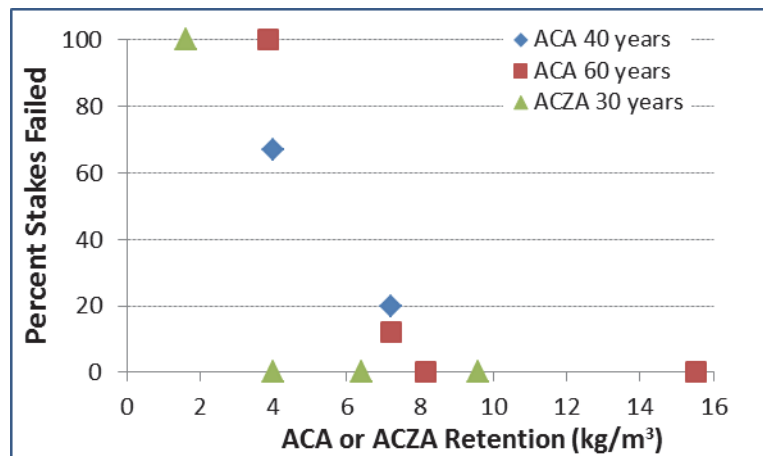
Although not truly “in service” commodity-size test specimens can provide valuable insight into long term durability. Advantages of test specimens include controlled and documented preservative treatment, known exposure conditions and frequent inspections by personnel with expertise in evaluating biodeterioration. The most common examples are round or sawn post specimens whose durability can be related to the potential service life of terrestrial piles or utility poles. Examples of long term post durability data from the USDA Forest Products Laboratory test site near Saucier, MS are shown in Table 1 (Freeman et al., 2005). The estimated years to failure for the posts varied from 54 to 74 years, even at retentions less than half of that specified in AWP standards for terrestrial piles (AWPA, 2011).

**Table 1: Estimated years to failure for southern pine posts in Mississippi (25 replicates per treatment group)**

| Preservative       | Retention<br>kg/m <sup>3</sup> (lb/ft <sup>3</sup> ) | % of AWP<br>Pile Retention | % Failed | Estimated Years<br>to Failure | 90% Confidence Limits |       |
|--------------------|------------------------------------------------------|----------------------------|----------|-------------------------------|-----------------------|-------|
|                    |                                                      |                            |          |                               | Lower                 | Upper |
| Copper naphthenate | 0.48 (0.03)                                          | 21 - 30%                   | 46       | 65                            | 55                    | 78    |
| Coal-tar Creosote  | 89.60 (5.60)                                         | 33 - 47%                   | 65       | 54                            | 47                    | 62    |
| Pentachlorophenol  | 5.12 (0.32)                                          | 38 - 53%                   | 29       | 74                            | 60                    | 91    |
| ACA                | 5.44 (0.34)                                          | 34 - 43%                   | 52       | 60                            | 51                    | 69    |
| Untreated          | 0                                                    | NA                         | 100      | 2.4                           | 2.1                   | 2.7   |

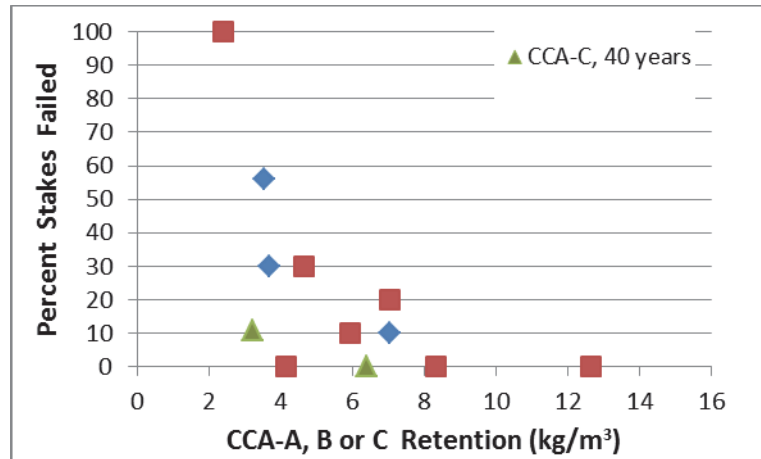
<sup>a</sup>. Adapted from Freeman, et al., 2005

Long term durability data from 38 by 89 mm (2 by 4 in. nominal) stakes is less directly relatable to in-service commodities, because most sawn posts would have dimensions of at least 89 by 89 mm (4 by 4 in. nominal).



**Figure 1: Durability of 38 by 89 mm (2 by 4 in. nominal) stakes treated with ACZA formulations and exposed in southern Mississippi. Each point represents 9 or 10 replicates**

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**Figure 2: Durability of 38 by 89 mm (2 by 4 in. nominal) stakes treated with CCA formulations and exposed in southern Mississippi. Each point represents between 8 and 10 replicates**

However, the data is still of value as durability of 28 by 89 mm stakes could be considered as a conservative indicator of the service life of larger sawn material. Examples of long-term 38 by 89 mm (2 by 4 in. nominal) stake durability for ACZA and CCA formulations are shown in Figures 1 and 2. Even after exposures of over 60 years few failures have occurred in stakes treated to AWP ground-contact retentions and no failures have occurred in stakes treated to AWP retentions specified for poles (9.6 kg/m<sup>3</sup>) or piling (12.8 kg/m<sup>3</sup>). Although average years to failure cannot yet be calculated for these stakes, it is evident that it will be well in excess of 60 years.

Test specimen durability data is not without drawbacks. Exposure specimens typically do not account for variability in retention and penetration that might occur within and between commercial charges, and are not subjected to field fabrication or in-service abrasion that might compromise the treated zones. They also are not subjected to loading as they would be in service. Post specimens are often evaluated with some type of push or pull test to gauge remaining strength, but these evaluations do not replicate in-service stresses. Lumber specimens are typically given a visual rating, and do not “fail” until they are substantially degraded. However, exposure specimens do provide a clear picture of the potential of the treated wood itself to resist biodeterioration.

### *Surveys of User Groups*

Service life (replacement rate) data from large users such as utilities, railroad, and transportation agencies has been a valuable source of service life information in the past (Anon, 1994; Morrell, 2008; Stewart, 1996). In the case of utility poles, analysis of replacement rate data indicates that the average service life of poles is much greater than that perceived by utility personnel. For example, Stewart (1996) noted that his survey group reported an average perceived pole service life of only 33 years, while the replacement rate data indicated a service life in excess of 75 years. Similarly, Morrell (2008) noted that based on reported replacement rates, pole service life would easily reach 80 years in many parts of the United States. The FHWA also has a large national data set on the condition of bridges (including timber bridges) in its National Bridge Inventory (FHWA, 2012). A limitation of these types of survey data is the need to differentiate replacements due to biodeterioration from those resulting from other causes, such as road construction. There is also a concern that the “decay” category may be used as a catch-all for a range of wood defects or discolorations.

### *Use of short-term Test Data for Newer Preservatives*

There are few options for establishing the service life of newer preservatives. Comparison to the performance of conventional preservatives in short-term field tests with small stakes is one option, but it warrants some caution. Previous research has shown that short term stake tests can provide misleading results, although confidence increases with each additional year of testing (Lebow, et al., 2009). More confidence is obtained if the test is of sufficient duration to observe deterioration in stakes treated with low retentions of the standard reference preservative. Interpretation of the test data will be needed to help the user understand how it demonstrates the potential service life of the new preservative.

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## CONCLUSIONS AND RECOMMENDATIONS

There are several possible avenues for making additional service life data available to users of treated wood products. In the short term, the most effective approach may be to summarize, interpret and publish existing long-term data in a refereed journal article (or articles). The summary and interpretation would be intended to help users understand how the available data might be used to estimate service life for their particular end use, and to enable more accurate LCCA evaluations for timber structures. Surveys of user groups and analysis of their replacement rate data could also provide needed service life data in the near term. In the longer term, greater emphasis should be placed on monitoring new or recently installed projects to generate service life data for newer preservatives. Existing or renewed service records task forces within the AWPAA “T” committees are potential stewards of this monitoring effort. Members of the wood treating industry recognize the need for service life data as an emerging issue and recently formed a work group to review the issue, develop a strategy for collecting service life information, and to create documents that can be made readily available to the public. Hopefully, greater awareness of the need for service-life data among AWPAA members will help to bring forward additional data and reports.

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