Research in Progress

Advanced Housing Research Center
Forest Products Laboratory
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Statistical Aspects for Predicting the Durability and Serviceability of Fire-Retardant-Treated Wood

Impregnating wood with certain types of chemicals can substantially extend its service life in degrading, destructive environments. This type of treatment can extend the utility of wood in new markets. This happened in North America, where fire-retardant-treated (FRT) plywood is sometimes permitted as an alternative to noncombustible materials in structures that require increased fire safety. However, in the mid- to late 1980s, some commercial fire-retardant treatments failed to perform as expected when used in roof sheathing plywood and roof truss lumber. Elevated roof temperatures caused by solar radiation, in combination with moisture, prematurely activated some fire retardants chemicals, often causing the treated plywood to darken in color, become brittle, experience cross-grain checking, and crumble easily. This problem required costly roof replacement. Because of the regional nature of building codes in North America, the problem was most common in the eastern United States on nonresidential commercial and multifamily dwellings built without parapet walls from 1980 to 1995.

To reduce the economic and environmental costs of replacing up to 75 million FRT plywood panels, serviceability assessment methods were needed to evaluate the condition of FRT plywood and to estimate residual service life. An intensive 10-year research program conducted at the Forest Products Laboratory (FPL) defined the mechanism of the problem and contributing factors. Figure 1 illustrates accelerated strength degradation in small, clear, FRT Southern Pine specimens due to elevated isothermal conditions. Similar responses at other isothermal conditions allowed the development of an Arrhenius-based prediction model of strength loss.

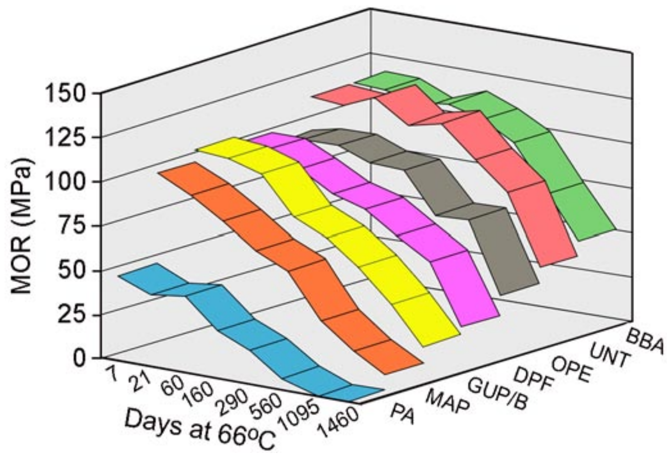

Figure 1. Isothermal degradation models for untreated and FRT wood after up to 4 years at 66°C. (PA, phosphoric acid; MAP, monoammonium phosphate; BBA, borax-boric acid; GUP/B, guanylurea phosphate/boric acid; DPF, dicyandiamide-formaldehyde-phosphoric acid; OPE, diethyl-N,N-bis(2 hydroxyethyl)aminomethyl phosphonate; UNT, untreated.)

Background

Methods for modeling and monitoring product degradation while a product is in use have frustrated statisticians because of the unpredictability of the exposures and cumulative effects. Periodic monitoring of some associated degradation measure would be ideal, but practical impediments to this approach include the extent to which the product is in use throughout a region, extent of record keeping, extent of disruption of residents, and cost. Designed experiments for modeling accelerated degradation and destruction help us with understanding materials properties and responses to controlled environments, but a broader

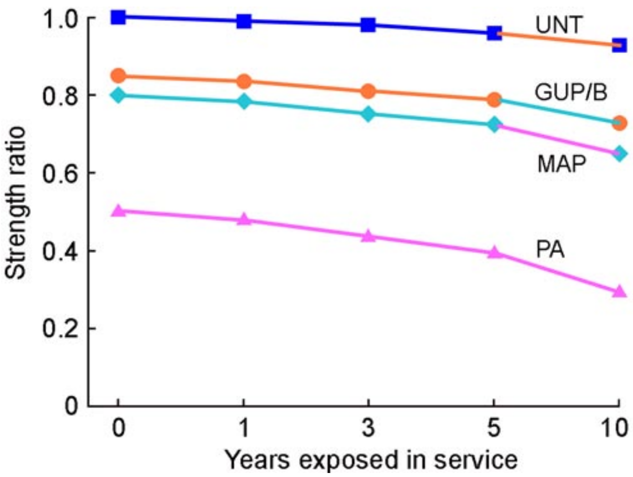

Figure 2. Residual service-life model for untreated and FRT wood used as roof sheathing after 10 years. (PA = phosphoric acid; MAP = monoammonium phosphate; GUP/B = guanylurea phosphate/boric acid; UNT = untreated.)

modeling approach must be adopted for field modeling, monitoring, and replacement strategies.

Objectives

Our objectives are currently focused on combining the environmental and exposure conditions imposed on FRT wood in service as a result of structural design and location with physical models of thermal degrade. This will add some degree of certainty to projections of potential degrade. Our ultimate goal is to finalize the development of a reliable model that predicts residual service life of FRT roof sheathing and incorporates product and environmental uncertainties.

Approach

Unfortunately it is neither feasible nor practical to adopt a continual monitoring program to repeatedly evaluate degradation of in-service FRT roof sheathing to determine when it no longer satisfies its design requirements. Instead, a screening approach that minimizes physical impact on the sheathing and minimizes disturbances to residents was considered optimal. This implies combining a one-time, non-destructive assessment of current strength with physical/mechanistic models and environmental exposure models to predict future degradation. The statistical work has thus far concentrated on physical–mechanistic models, fire-retardant processing effects on strength, non-destructive tests, and environmental exposures. A preliminary model, combining several of our research results, is shown in Figure 2. Further refinement of this model is detailed in Winandy and others (2002). Currently, small-scale variability in environmental exposures is not considered. Resampling approaches, such as bootstrapping environmental time series, could offer the potential to capture small-scale variability should large-scale variability not be sufficient.

Expected Outcomes

The research will result in a comprehensive model to predict in-service degradation of FRT roof sheathing exposed to highly variable environments. We envision a modeling paradigm that can be adapted to other residential wood products.

Timeline

Substantial components of this program have been completed. The in-service prediction model is in development, and a final report is expected by early 2006.

References

Winandy, J.E., Lebow, P.K., Murphy, J.F. 2002. Predicting current serviceability and residual service-life of plywood roof sheathing. Proc. of 9th Durability of Building Materials and Construction. Brisbane Australia. (http://www.fpl.fs.fed.us/documnts/pdf2002/winan02a.pdf)

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