RESEARCH in Progress

Forest Products Laboratory

Char Rates under Design Fire Scenarios

Removing woody biomass from the Nation's forests can reduce the risk of catastrophic wildfires and create healthy, resilient ecosystems. In a report from the Forest Service on the rising cost of wildfire operations, the Forest Service spent over a billion dollars fighting forest fires in 2012 and the cost of fire suppression is projected to rise to 1.8 billion dollars by 2025. In addition to fire suppression costs, intense catastrophic fires can alter forest soil, cause significant erosion, and emit carbon dioxide and particulate matter into the environment. Research has shown that removing biomass from forests (thinning) can reduce the risk of wildfires. However, the costs of thinning can exceed the value of the thinned wood, making it uneconomical. In the United States, wood has been traditionally used in single-family residential construction, and over 40% of the wood harvested each year in the United States is made into building products. Developing and expanding markets for wood in nonresidential and mid- to high-rise residential construction can help to make the removal of woody biomass more economical and lead to healthy, resilient forest ecosystems. However, before wood can be used in these new markets, its fire performance needs to be characterized under new design fire scenarios.

The small vertical furnace at the Forest Products Laboratory.

Background

The fire resistance ratings of structural members and assemblies, wood-based or otherwise, have traditionally been obtained by testing the assembly in a furnace in accordance with ASTM International (ASTM) E 119 and similar standards. ASTM E 119 specifies a time–temperature curve, called the "standard fire," that the furnace needs to achieve. Wood char rates under standard fire exposure are well understood and documented. Ignition occurs in about 2 min; charring into the depth of the wood then proceeds at a rate of approximately 0.8 mm/min for the next 8 min; thereafter, the rate decreases to 0.6 mm/min. The slower rate is attributed to the insulating effect of the char layer. Additionally, char rates have been measured under constant temperature and constant heat flux conditions. However, charring rate is significantly affected by the severity of the fire exposure, and data on charring rates for nonstandard fire exposures have been limited. This

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lack of information on char rates under these conditions makes it difficult to perform fire resistance calculations under nonstandard fires.

Objective

The objectives of this research are to (1) characterize charring rates under design fire scenarios so that these new charring rates can be developed into new, performance-based codes and (2) examine charring rates under several time–temperature profiles so an overarching model of char formation under any loading condition might be developed.

Approach

Several time–temperature curves will be developed, and char rates will be measured in the small-scale vertical furnace located at the Forest Products Laboratory. This furnace was used to develop the standard char rates under the ASTM E 119 time–temperature curve that are now used in the *National Design Specification for Wood Construction* (NDS). Although char rates under new design fires are important for immediate implementation in fire design, the testing performed as part of this proposal is a great opportunity to further explore fundamental mechanisms of char formation and how these change under different time–temperature profiles; part of this research will examine whether a kinetic rate law could be applied to char formation in wood.

Expected Outcomes

Char rates under new time–temperature curves will be implemented when using performance-based design codes and determining the fire resistance ratings of wood-based structural members. Additionally, a universal char rate equation that can be used to predict char rate under any fire loading scenario may be developed and implemented when determining the fire resistance of mass timber elements such as solid sawn wood and cross-laminated timber.

Timeline

This effort was initiated in May 2016. A literature review of char rates under design fires and non-ASTM E 119 fires will be completed by the end of 2016. Developing design fire scenarios and measuring char rates under the selected time–temperature curves will begin in early 2017, with the development of char rate models to shortly follow. A final report will be available in 2018.

Cooperators

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