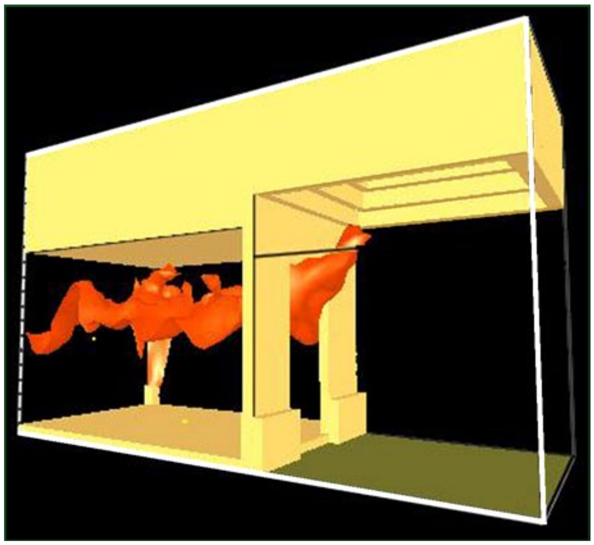
Research in Progress

Advanced Housing Research Center
Forest Products Laboratory
Madison, Wisconsin

Fire Growth Modeling for Performance-Based Building Codes

The trend towards performance-based codes for achieving acceptable fire safety creates a significant demand for improved material properties data and computer fire models. Increasing use of wood–plastic composites for housing applications adds to the challenge because they are more flammable and produce more smoke than do the original wood products. Increasing exposure of homes to wild fires, which is also a homeland security threat, may lead to new building codes regulating exterior components such as decking, siding, and roofing systems. The demand for high structural performance of wood products can conflict with fire safety, thus threatening their marketability.



Room flashover simulation using the Fire Dynamic Simulator.

Background

Prescriptive-based codes have been very successful in increasing fire safety in various building constructions and in promoting the acceptance of retardant treatment of wood-based products. However, they are becoming increasingly inadequate in today's market. Indeed, more situations are being identified where prescriptive-based codes are overly conservative or do not adequately represent some fire scenarios. A more rational approach is to define the fire safety objectives and perform engineering calculations for meeting the objectives. This performance-based engineering analysis is very difficult to achieve for wood-based materials because of their complex physical processes for pyrolysis and combustion during a fire. Current state-of-the-art fire growth models, such as the Fire Dynamic Simulator (FDS) developed at National Institute of Standards and Technology, Building and Fire Research Laboratory (NIST–BFRL), still lack suitable fire properties and mathematical modeling of various wood products. Several fire-testing laboratories in the United States are currently validating fire models, particularly the FDS, but none has the combined expertise and fire-testing experience that is available at the USDA Forest Service Forest Products Laboratory.

Objectives

The overall objective of this research is to develop data and models needed for fire safety engineering of forest products in a performance-based building code environment. The focus will be on fire growth, specifically how wood products are modeled in FDS and validated with our current room/corner fire tests. With this enhanced engineering tool, additional objectives are to simulate fire development in the Steiner Tunnel (ASTM E 84), on the exterior decking and siding of a house exposed to adjacent vegetative fires, and inside a generic townhouse.

Approach

Fire properties will be obtained in various fire test apparatus. The modified cone calorimeter (instrumented beyond what is required in the ASTM E 1354 standard) will be the primary test method for deriving properties of surface ignition, fuel mass loss, and heat release rates of wood volatiles. Combustion properties such as carbon monoxide and smoke production are currently obtained from full-scale tests, such as the room/corner tests (ISO 9705), because for wood-based materials the cone calorimeter provides unreliable data for incomplete combustion properties. The essential properties for creeping flame spread will be obtained from a new bench-scale apparatus that overcomes the limitations of FPL Lateral Ignition and Flame spread Test (LIFT) apparatus (ASTM E 1321). Evaluation of results from these enhanced test methods will include development of computer algorithms incorporated in the FDS source code. Initial validation of the modified FDS model is the prediction of creeping fire growth on the new flame spread apparatus installed in the cone calorimeter.

Expected Outcomes

This research will result in (1) an enhanced and validated engineering tool for use by the fire protection engineering community for evaluating fire scenarios with various wood products, (2) assistance to the Forest Service in Wildland and Urban Interface problems, (3) service to research units within FPL that develop new wood-based composites, and (4) unique capability of FPL to assist the wood industry in evaluating wood products, particularly those with retardant treatments.

Timeline

In the first year, global and crude fire properties of various wood products will be provided as inputs to the current FDS model. We intend to use existing fire property data derived from standardized cone calorimeter and room/corner tests and predict some reasonable fire growth behaviors. This has already been completed for oriented strandboard. In the second and third years, we will develop two fire testing apparatus: (1) the modified cone calorimeter for developing a detailed mechanistic kinetics model of wood pyrolysis that is adaptable to any heating regimen and (2) the creeping flame spread apparatus for developing a creeping flame spread model designed specifically for use in FDS. In the fourth year we will complete changes to the FDS model for its potential adoption by NIST–BFRL.

Cooperators

Primary cooperators are the developers of FDS at NIST–BFRL, who invited us to contribute to their fire growth research. Other cooperators include students from universities involved in educating fire protection engineers, such as Carlton University in Canada.

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